"A LEAN-LED-EVALUATION" OF INFRASTRUCTURE DEVELOPMENT IMPROVEMENT PROGRAMME IN SOUTH AFRICA

"Thabiso Godfrey Monyane"

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Promoter: Prof Gerrit J Crafford

Co-Promoter: Prof Fidelis A Emuze

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DECLARATION

I, "[Thabiso Godfrey Monyane]" , declare that the entire body of work contained in this research thesis is my own original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Nelson Mandela University will not infringe on any third-party rights, and that I have not previously, in its entirety or in part, submitted it for obtaining any qualification.

"TG Monyane"

215222059

DEDICATION

This thesis is dedicated to **ALMIGHTY GOD**, who gave me the strength and the courage to carry on, and without whom this would not be possible.

Not forgetting my dearly departed parents, and my dearly departed brother, Mokes

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ABSTRACT

A doctoral study was embarked upon with the intentions of addressing cost management problems encountered on Infrastructure Delivery Projects in South Africa. Given that poor cost performance constitute hindrance to the realization of project goals, it is imperative to eliminate it from project delivery. The prevalence of cost overrun in public sector projects is a call to all stakeholders to address cost management issues in the construction industry. The predominance of cost overruns in public sector construction projects in South Africa has been observed. With the decline of the current economic conditions in South Africa, project performance is a great concern that needs attention. In addition, ineffective initiatives to curb the abuse of the procurement processes are directly affecting the outcomes of construction projects, and if these status quo remains, the sector will continue to have a bad image and continued waste of taxpayers' money will not cease until the public sector remove non-value adding activities in their operations.

Study adopted a mixed methods designed that collected both textual and statistical data. Semi-structured interviews were undertaken to determine the outcomes of current project management practices in South Africa. In terms of performance of projects, the status quo paints a disconsolate picture. Findings reveal protracted processes, and the use of unqualified and inexperienced contribute to poor performance of public sector projects. Poor performance continues to dominate the construction sector, especially in the public sector. Interviews data were contrasted with evidence from project-related documents. Based on the data, the study produces a vignette of existing cost management frameworks applied to such projects. Encompassing various stages of the project delivery lifecycle, this vignette will enable an identification of the challenges afflicting cost management on projects. Accordingly, this study identified Lean opportunities from existing cost management practices. Such opportunities will enable identification of effective cost management during project delivery. There appears a need for collaborative cost management practices. Lean tools mentioned for improvement include the 5Whys, the big room, target value design, and the integration of design and construction. A collaborative cost management framework was developed through relevant theories to improve the cost management process of public sector projects.

Keywords: Cost, Lean Construction, Infrastructure, Performance, Project, Public Sector

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LIST OF ACRONYMS AND ABBREVIATIONS

AIA	American Institute of Architects
AGC	Associated General Contractors of America
ASAQS	Association of South African Quantity Surveyors
BOQ	bill of quantities
CBA	Choosing by Advantages
CIDB	Construction Industry Development Board
CIMO	Context Intervention Mechanism Outcome
CM	Construction manager
CMR	Construction management at Risk
CPAP	Contract price adjustment provisions
CPM	Construction project manager
CSI	Construction Specifications Institute
CTIP	Cost and time improvement process
CURT	Construction Users Roundtable
DB	design-build
DBB	design-bid-build
DE	Designers
DPW	Department of Public Works
GDP	gross domestic product
IDIP	Infrastructure Development Improvement Programme
IDMS	Infrastructure Development Management System
IGLC	International Group for Lean Construction
IPD	integrated project delivery
JIT	just-in-time
LCA	life-cycle assessment
LCCMM	lean construction cost management model
LPDS	Lean Project Delivery System
MC	Main Contractor
MM	Mixed-methods
MFMA	Municipal Finance Management Act
NDPW	National Department of Public Works
OPR	Owner Project Requirements
PDS	project delivery system
PEP	project execution plan
PFMA	Public Finance Management Act

PM	Project management
PMBOK	Project Management Body of Knowledge
PMI	Project Management Institute
PROCSA	Professional Consultants Services Agreement
PSC	Public Sector Client
PSD	production system design
P2SL	Project Production Systems Laboratory
QS	quantity surveying
SAICE	South African Institute of Civil Engineering
SBD	set-based design
SCM	supply chain management
SIPDM	Standard for Infrastructure Procurement and Delivery Management
TC	target costing
TFV	transformation-flow-value
TIMWOOD	transportation, inventory, motion, waiting, overproduction, overprocessing, defects
TPS	Toyota Production System
TVD	target-value design
TW	Toyota Way
UK	United Kingdom
USA	United States of America
VE	value engineering
VfM	value for money
VM	value management
VSM	value-stream mapping

CHAPTER 1
THE RESEARCH PROBLEM AND ITS SETTING

1.1 INTRODUCTION

The construction industry is notorious for its slowness to adapt, and traditional practices remain the most-used project delivery methods (Fulford and Standing, 2014; Ahiaga-Dagbui et al., 2015). Project success is mainly measured by delivering the project within time, within budget, and to the right quality, delivered safely to the satisfaction of the client or owner. Construction projects are notorious for poor performance, in the form of poor cost performance, poor time performance, and poor quality. The success of a project depends on its performance. The success of a project is primarily dependent upon the iron triangle of cost, time, and quality (Ali et al., 2010). Project performance success is dependent on who is measuring the success. However, "the most important performance indicator on a project depends on the requirements of the client" (Bello, 2018: 13). The reality is that project stakeholders have come to accept this phenomenon as the reality, and as the rule, not the exception (Lavagnon, 2012). Poor performance of projects dates back to the 1950s (Lavagnon, 2012). The World Bank has invested over US$5 billion in more than 700 projects throughout Africa over the past 20 years. Such challenges are delays and disruptions during construction, poor site management, time and cost variations, skills and competence issues, lack of quality improvement processes, and lack of worker participation. Several studies on project performance have mainly concentrated on what the performance indicators for construction projects are, or identifying the critical success factors of construction projects (Chan et al., 2004, Idrus et al., 2011, Iyer and Jha, 2006, Odusami et al., 2010, Sibiya et al., 2015, Takim and Akintoye, 2002, Toor and Ogunlana, 2009).

The decision to build is never an easy one and the cost of the building is an influencing factor on the sponsor's final decision whether to proceed or halt the project. However, all construction projects face similar problems of improving their cost performance. Ali et al., (2010) mention the importance of controlling construction cost because in developing countries, cost management approaches have proven to be the less effective when compared to time management (Mohamad, 2003). Construction projects are unique and they tend to assume a greater dimension of complexity as they increase in size. A project's success is primarily dependent upon the iron triangle of cost, time and quality (Ali et al., 2010, Arcila, 2012). Poor project cost performance ensues when the final costs exceeds the original budget and is conveyed as a percentage cost overrun on the initial budget approved by the project sponsor or project owner (Arcila, 2012). The prevalence of project cost overrun in construction projects have become a norm globally and accepted as part of the process of executing projects, although its magnitude varies from each country. The phenomenon of projects performing poorly in terms of costs was reinforced since 1859 according to Flyvbjerg et al. (2003) dates are: the

Suez Canal constructed between 1859 to 1869 went over budget by 1900%. Brooklyn Bridge constructed from 1869 to 1883 went over budget by 100%. The British Library constructed from 1974 to 1988 went over budget by 333%. The Scottish Parliament constructed from 1997 to 2004 went over budget by 900%, and the Wembley Stadium constructed from 2000 to 2007 went over budget by 375%. Moreover, Flyvbjerg et al. (2003); Arcila (2012);Terrill et al. (2016) conducted similar studies in the developed countries such as Australia and the United Kingdom which, demonstrated that project cost overruns accounts for 25 – 40% of the initial project budget. Other similar studies such as Ameh and Osegbo (2011); Odediran et al. (2012); Chigara and Moyo (2014); Memon et al. (2014) in Nigeria, Zimbabwe and Malaysia, show that poor cost performances can range from 50 - 100 and sometimes exceeding 100 percent cost overrun. The subject of cost overruns seem to be more severe in developing countries. However, there are numerous aspects related with the economic, political and construction environments which can seemingly affect the level of disparity from one context to another.

Similarly, in South Africa, the record of cost performance has been a problem. According to (Ramabodu and Verster, 2010), records in South Africa show that the Soccer City Stadium constructed between 2007 to 2010 went over budget by 174%; the Moses Mabhida Stadium constructed between 2007 to 2010 went over budget by 267%; and the Green point Stadium constructed between 2007 to 2010 went over budget by 483%. Mainly the studies had criticism, in particular, the misconception of awarding contracts solely on the basis of the lowest price bid, only to see the final price for the work increase significantly through contract variations, with projects often completed late. Poor project cost performance affects the client, end user and project team negatively (Mbachu and Nkado, 2004, Odediran et al., 2012). The consequences of cost overruns in a project may force the client to abandon the project, while the contractor and the consultants are affected by the inability to provide value for money for the client, and the end-user might carry the burden of extra costs and thereby make it unaffordable. The severity of the problem of cost overruns brings about the need for effective mitigation measures to address this chronic problem. Numerous studies have identified the factors causing cost overruns in construction projects, such as: design changes, variation orders, unstable market trends, poor financial/cost forecasting, poor cost planning and estimating systems and poor contract/site management to mention a few (Enshassi et al., 2009, Ramabodu and Verster, 2010, Monyane and Okumbe, 2012, Olawale and Sun, 2010, Memon et al., 2014). Consequently, numerous attempts were made to reduce the occurrence of cost overruns in construction projects. Employed strategies relate to technology, procurement, management and policy approaches to name a few; however, most efforts have focused predominantly on the traditional cost management system, which is coherent and contract-based and has brought the separation in the processes of costing/design and production (Namadi et al., 2017). In fact, cost and design processes continue to be treated as independent and separate functions, which are carried out in isolation within the current project delivery system. This neglect, and the lack of a holistic and collaborative approach in costing, arguably accounts for much of the cost overrun that is still prevalent in the construction industry (Namadi et al., 2017). Therefore, developing a collaborative cost management framework for the construction industry in South Africa is consequential to improving the cost performance of projects - especially the public sector projects.

Numerous studies such as Kern and Formoso (2006), Jacomit and Granja (2011), Do et al. (2014), Obi and Arif (2015) highlighted the prominence of effective cost management systems (CMS) on project cost performances. The results emanating from their studies illustrate that the effectiveness of the cost management system mainly governs the impending outcome of project cost management and performances, therefore, indicates that the CMS can be influential. However, CMS emanating from the studies of Kern and Formoso (2006), Jacomit and Granja (2011), Do et al. (2014), Obi and Arif (2015) are CMS developed for low-cost housing projects, which are different to construction projects. Construction projects are unique, and they tend to assume a greater dimension of complexity as they increase in size. Moreover, Namadi et al. (2017) developed a collaborative costing Model using TVD as an example for the United Kingdom construction industry. The Collaborative Cost Management framework proposed for this study is different in the following ways; firstly, it's specific for the South African construction industry, secondly the framework addresses cost management from inception to completion of project. The model of Namadi et al. (2017) focuses on design development phase of projects only and addresses first cost only not the entire value chain through to completion of construction project. The construction project is an inter-organisational process, which requires that all stakeholders contribute to achieving the goal of successfully completing the project within the agreed constraints. Within the South African context, little is recognized about the application of lean thinking strategies to enhance the overall success of the project. Howell and Ballard (1998) describe lean as a value-seeking process that maximizes value and continually redefines perfection. Moving towards this form of perfection requires more than a change in procedure. It requires changing the way we think about and do construction (Howell and Ballard, 1998). Moreover, Howell and Ballard (1998) observed that the current practice of construction is contract-centered, with assignments defining and balancing the objectives of various participants.

Target Value Design (TVD) has been applied to the construction industry elsewhere, and it has provided tremendous value in improving overall project performance (Ballard, 2009, Ballard and Reiser, 2004; Ballard and Rybkowski, 2009; Nicolini et al., 2000; Zimina et al., 2012). Regarding TVD, Zimina et al. (2012) explain that the main idea of TVD is to make a customers' value (design criteria, cost, schedule, and constructability) as driver of design, so as to reduce waste and satisfy or exceed the client's expectations. Hence, this study is important due to the need for development of innovative practices in South African construction. The industry in South Africa is lagging behind in implementing innovative construction methods, despite cost performance issues and poor performance in general in the construction industry. The study will first clearly establish the outcomes of current costing models in use in South Africa, through an exploratory literature review and a survey of stakeholders that are knowledgeable. The study will then go deeper, by defining what lean and integrated development projects are, and the need for collaborative cost management in construction practices. To support the expanded use of collaborative cost management, a research opportunity, therefore, exists to investigate how lean thinking strategies can be systematically applied to public sector projects in South Africa. The lean approach suitable for the study will then be explained, as well as the modifications needed for application of lean in South Africa.

This chapter discusses the background to the research and the issues that led to initiation of the research. In addition, the chapter states the research aim and objectives, and it outlines the scope of the research.

1.2 THE SOUTH AFRICAN CONSTRUCTION INDUSTRY

South Africa, like any developing nation, is confronted with the challenge of improving its infrastructure performance, for boosting the economy. The construction industry is a major sector, which contributes immensely to the GDP of the country. According to the first-quarter results for 2017, published in the annual report of the Construction Industry Development Board (CIDB) (2017), the construction industry contributed around 6% to South Africa's GDP. The past decade has seen low growth and volatility in the markets, and the country has experienced low business confidence, due to many different reasons, including a credit downgrade to junk status. Unemployment remains high, and the construction industry has been a major driver in contributing to employment in past years, before business confidence by investors dropped. The annual report of the CIDB (2018) highlights that the public sector contributes 15% more to projects, because of procurement targets the country is trying to achieve to demonstrate an all-inclusive economic impact. The public sector has accepted that delivering the right infrastructure, at the right time, will ultimately yield the intended outcome, which will boost the economy. The construction industry is still faced with the enormous challenge of improving the delivery of infrastructure within the parameters of successful project management and project success. Construction projects are unique and complex, and this has encouraged researchers to employ new approaches and provide solutions to the chronic problem of poor performance of projects. The Infrastructure Delivery Improvement Programme (IDIP) was implemented as a capacity-building initiative to enhance project delivery. This was followed by the Infrastructure Development Management System (IDMS), because of a need to separate the supply chain for the delivery and new infrastructure and maintenance thereof from the supply chain for general goods and services (Watermeyer et al., 2013). Public sector clients emphasized infrastructure investment as a driver of the economy, but the expected outcomes were not realized because of constraints on project delivery. Watermeyer et al. (2013) argued that infrastructure spending would not necessarily lead to economic growth. They suggested that improved infrastructure, which is delivered and maintained in a way that minimizes waste of materials, time, and effort, so as to generate the maximum possible value, is most likely to contribute to economic growth. Separation of the supply chain for general goods from that of infrastructure procurement was implemented from July 2016. Implementation of the National Treasury's *Standard for Infrastructure Procurement and Delivery Management* (SIPDM) forms an integral part of the Model Supply Chain Management (SCM) policy, issued in terms of the Public Finance Management Act (PFMA). The National Treasury issued the following two documents:

- An instruction in terms of Section 76(4)(c) of the Public Finance Management Act of 1999 (Act 1 of 1999) (PFMA), which requires implementation of the *Standard for Infrastructure Procurement and Delivery Management* (SIPDM) by all organs of state subject to the PFMA, with effect from 1 July 2016, and
- A Model Supply Chain Management (SCM) Policy for Infrastructure Procurement and Delivery Management, in terms of Section 168 of the Municipal Finance Management Act of 2003 (Act 56 of 2003) (MFMA), in support of the MFMA SCM Regulation 3(2), as a National Treasury guideline determining standards for municipal SCM policies.

The Model SCM Policy was issued to trigger a review of current policies, and it is a response to the need that an appropriate SCM policy is in place for infrastructure (South African Institute of Civil Engineering (SAICE) 2016). According to the SAICE (2016), the publication of the two documents was for built environment professionals who will participate in the delivery of infrastructure, to facilitate effective implementation of the SIPDM for all government departments. This study, however, concentrates on new infrastructure projects piloted between the years 2010 and 2018 by the National Treasury, using the IDMS toolkit, for the purpose of improving the delivery of projects. Stages 0 to 4 represent the internal processes of the public sector before professionals can be involved or appointed to take part in infrastructure projects. They represent improvements in the supply chain processes to enhance the internal processes that are deemed to contribute to failure of project delivery. Stages 5 to 9 represent the point where professional services commence with the PROCSA consultant's service agreement. Supply chain management forms part of the theoretical lens of the study, due to the way infrastructure projects were executed and delivered using the new Model SCM Policy, as a pilot before the policy was gazetted in 2016.

1.3 FORMULATION OF THE RESEARCH PROBLEM

Research conducted previously in cost management has identified a wide range of measures that describe the outcomes of a project and the input characteristics that influence those outcomes. Measuring performance is the foundation for continuous improvement. Niven (2002:12) stresses the importance of performance management when he says, “if you cannot measure it, you cannot manage it”. The increase in productivity in construction has been much lower than that of other industries. The sentiments are the same for the public sector, since in many cases it has no competitor for the services it provides, and it is a supplier-led sector without much incentive to change (Bhatia and Drew, 2006). Adapting to new ways of doing business in the public sector is constrained by the rules and regulations related to the operational system, and this hinders any continuous improvement. One of the challenges of the public sector is using an integrated project delivery (IPD) contract with profit sharing with other project stakeholders, as the regulations might not favour such an arrangement. The processes of the public sector are also inherently wasteful. Bhatia and Drew (2006) identified three main sources of losses in the public sector: waste (e.g., long waiting times, idle or overworked resources due to poor scheduling), variability (e.g., lack of consistency and standards to develop work), and inflexibility (e.g., a mismatch between the unchanged capacity of resources and the demand, which fluctuates from day to day).

Rigorous efforts are employed to build greater delivery efficiency in the public sector. Lean construction has emerged due to the failure of current project management, and it has resulted in significant improvement in terms of management and project deliverables (Koskela and Howell, 2002). When it comes to performance improvement in construction projects, lean construction is in the forefront, and it has demonstrated achievement in many countries (Sarhan, 2018).

Traditional approaches to addressing shortcomings identified by the public sector are not appropriate for today’s economic climate. Traditional approaches are reactive to prevalent construction problems encountered, such as cost overruns. Public sector procurement is about spending of public funds, and this has an impact on innovation (Uyarra and Flanagan, 2010). The primary objective of every public sector should be the efficiency of the procurement process, as public resources have become very scarce. Most public sector projects still separate the process of costing/ design and production, and this signifies inefficiency, hence TVD promotes integration of design and construction activities, to reduce waste in the entire process (Song and Liang, 2011). These sentiments are echoed by Namadi et al. (2017), where the development of collaborative approaches such as TVD opens new opportunities for project participants to deliver more value for clients and work collaboratively. Potts (2008) describes cost management as a process that is necessary to ensure that the planned development of a design and the procurement of a project are such that the price for the construction provides value for money (VfM) and is within the parameters anticipated by the client. Potts (2008) asserts that construction is a major capital expenditure, which clients do not commence until they are certain there will be benefits, and that usually clients work with a budget that is part of a larger scheme, and that if the budget is exceeded, the whole scheme fails. Studies by Mukuka et al. (2014) Muianga et al. (2014) have shown that traditional ways of improving cost performance are not providing value and improving the construction industry’s image. Innovative ways of solving this problem, such as lean thinking strategies, which encourage collaboration, provide an opportunity for the South African construction industry to deepen its understanding of the challenges, to develop realistic solutions. Similarly, project delays are also contributing to poor performance of projects as a whole. Research conducted by Aiyetan et al. (2011) identified poor performance practices in the building industry in South Africa, which lead to projects not being completed on time. Completing projects late, or delays in construction projects, contribute to increase in costs for the building owner, which result in poor project cost performance.

In a study conducted by Rust and Koen (2011), findings reported that the South African construction industry is notorious for low levels of innovation towards stimulating technological solutions to provide and maintain future growth of the industry.

Consequently, this research study aims to identify lean opportunities and its implementation as an innovative initiative towards the successful delivery of the projects from inception through to construction phase of public sector projects. Architects normally provide designs which requires comparative costs from quantity surveyors to comprehend cost consequences of their designs (Nguyen et al. 2010). This pre-contract advice is employed to estimate the probable cost of the facility as a working budget for the client before construction commences while providing target values. However, this kind of estimating technique is conceptual and does not explicitly address all the processes of certain logistical arrangements (Nguyen et al. 2008). This kind of practice allow the cost estimator to imagine the process based on prior experience. However, results of the imagined process cannot be verified and varies with levels of experience of the consultant (Nguyen et al. 2010). In brief, existing practices in use in construction are failing to ensure cost performance certainty as part of the deliverables of the construction projects expected by the client. To attempt a remedy, using the principles underpinned by lean construction, as advocated by several authors Nicolini et al. (2000), Ballard and Reiser (2004), Macomber et al. (2007) Forbes and Ahmed (2010) is the idea espoused in this study.

1.4 THE RESEARCH QUESTIONS

In order to address the problem of poor performance recorded on infrastructure projects in South Africa, described in the previous section, the study will attempt to provide answers to the central research question of the study, namely ***"How would lean construction practices eradicate the poor cost performance recorded on infrastructure projects in South Africa?"***

To answer this central research question, the study will attempt to provide answers to the following research questions:

- What are the outcomes of current cost management practices in South African infrastructure projects?

- Why are South African infrastructure projects recording poor performance related to cost and time?
- How will lean thinking strategies make a difference in South African infrastructure projects?
- What are the enablers and barriers to the implementation of lean construction practices in South African infrastructure projects?
- How can the current cost management practices be improved to promote the use of collaborative costing practices in South African infrastructure projects?

1.5 THE AIM AND OBJECTIVES OF THE STUDY

1.5.1 Aim

To develop a lean construction cost management model for the public sector projects in South Africa.

1.5.2 Objectives

This study will evaluate how to eradicate the poor cost performance recorded on infrastructure projects, using known lean construction practices. Accordingly, it will attempt to achieve the following objectives:

- To identify and evaluate the outcomes of current project cost management practices used in infrastructure projects,
- To establish the causes of poor performance on South African infrastructure projects in terms of cost and time parameters,
- To establish and describe how lean construction practices will make a difference in South African infrastructure projects,
- To identify enablers, and barriers for the implementation of lean in South African infrastructure projects, and
- To conceptualize and validate a lean construction cost management model for the South African public sector projects.

1.5.2 Assumptions relating to the study

Assumptions are referred to as situations that are taken for granted without which the research work would not be useful, to be assumed to apply and to be known and accepted widely (Yin, 2009: 25; Fellows & Liu, 2008: 61). Therefore, this research assumed that:

- Construction is an industry with several interested parties and disconnected activities.

- Project performance is not consistent in the construction industry.
- Cost and time overruns have been recorded on construction projects.
- Lean construction is an efficiency-driven production philosophy.

1.5.3 Relationship between Research objectives and questions

Table 1.2 illustrates the relationship between the documented research objectives and research sub-questions of this study.

Table 1.2: Relationship between research objectives and research sub-questions

Research question	Research objective
What are the outcomes of current project management practices in South African infrastructure projects?	To identify and evaluate the outcomes of current project management practices used in infrastructure projects
Why are South African infrastructure projects recording poor performance related to cost and time?	To establish the causes of poor performance on South African infrastructure projects in terms of cost and time parameters
How will lean thinking strategies make a difference in South African infrastructure projects?	To establish and describe how lean thinking strategies will make a difference in South African infrastructure projects
What are the enablers and barriers to the implementation of lean thinking strategies practices in South African infrastructure projects?	To identify enablers and barriers for the implementation of lean thinking strategies in South African infrastructure projects
How can the current cost management practices be improved to promote the use of collaborative cost management in South African infrastructure projects?	To conceptualize and validate a lean construction cost management framework for the South African public sector projects.

1.6 DELIMITATION OF THE STUDY

The study is limited to the South African infrastructure sector, with a particular focus on construction. The study collected data applicable to public infrastructure projects only. Data collected from this research is limited to the responses of the respondents of the survey and semi-structured interviews. This affects generalisability of the data collected, as it may not be representative. Mixed-methods research was thus employed, and it involved unequal sample sizes for each of the strands. Another limitation is the fact that lean construction is not mainstream in South Africa, and this has implications for the generalisability of the data collected. Responses relating to lean construction is limited to theoretical knowledge not based on application of the concept in construction projects. Hence, identifying lean enablers and barriers was best achieved with systematic literature review coupled with a small sample of experts that has applied lean construction in South African projects.

1.7 THE PROPOSITIONS

Within the context of the study, it is assumed that

- Existing design and costing activities in South Africa are using traditional project management practices, which determines the cost of the product, based on its design and the estimated cost of realizing the design,
- Adoption of the strategy of lean thinking will lead to effective cost and time management of infrastructure projects,
- The lean approach is novel to South African construction, and it is, therefore, a work in progress, and it will not be free from initial problems during implementation,
- Compared to the traditional project delivery system, integrated project delivery (IPD) supports prompt participation of teams, including downstream players, in the early phases of design, which would otherwise have been neglected until the construction phase, and
- Cost certainty and time reduction in completion of projects influence the extent of client satisfaction and the value delivered to the client.

1.8 THE IMPORTANCE OF THE STUDY

A recent report of a study by Mace (2019) reports that globally 80% of all large infrastructure projects are going over budget. Similar to the global experience of construction projects experiencing cost overruns, South Africa is also faced with the chronic problems of cost overruns (Ramabodu and Verster, 2010, Baloyi and Bekker, 2011, Monyane and Okumbe, 2012, Mukuka et al., 2014, Akinyede and Fapohunda, 2014, Monyane et al., 2018). To tackle project delivery problems, many proposals that are addressing specific issues are emerging in the construction management literature. In particular, projects delivered with a lean approach have reported cost and time-related benefits (Ballard and Reiser, 2004). Lean construction is a non-existent phenomenon in South African construction in general. The public sector realized the need to improve existing project delivery. However, lean is not a concept that has been explored in infrastructure projects despite the chronic problems of cost overruns.

In 2001, the National Treasury commissioned a review of provincial service delivery systems, with the view to enhancing infrastructure delivery. The review identified various deficiencies, which influenced negatively on the effective and efficient delivery of infrastructure in provincial departments (Madue, 2007). This informed the introduction of the Standard for Infrastructure Procurement and Delivery Management (SIPDM) in 2016. In terms of cost and time, the National Treasury's study confirms the existence of problems in infrastructure projects. This study is important due to the need for the development of innovative practice within the South African construction industry, where project performance of public works projects is notably poor (Madue, 2007). The main aim of this research is to improve the cost management practices in the pre-construction and construction phases of South African infrastructure projects. The implications of this study are to add to the existing body of knowledge in the field of cost certainty. Through critical examination and analysis of relevant case studies, the research will explore the development of effective cost management for promoting collaboration on infrastructure projects in South Africa. Development of the framework will focus on identifying deficiencies in the current way of delivering projects, and it will identify enablers for the adoption of lean thinking strategies in infrastructure projects. The framework will be fine-tuned to give the client what they want, thereby promoting efficiency and value for money for the client. It is expected that evaluation of these variables will contribute to learning, teaching, research, and practice in the construction industry. The results of this research effort will also deepen the debate around lean thinking practice with integrated project delivery (IPD). The study aims to develop a collaborative cost management framework for the construction industry stakeholders to employ for project planning through to construction stage. Therefore, improvement of cost, including other parameters, will create a level of awareness necessary for competitiveness in the industry in South Africa. It is also anticipated that the framework to emerge from the study has the potential to create the needed buy-in for integration of lean thinking strategies in all infrastructure projects. The evaluation could also lead to an intervention that enhances the cost and time performance of infrastructure projects. Lean construction is an interdisciplinary field that is expected to achieve high performance and create value throughout the life cycle of infrastructure projects in developing countries such as South Africa.

1.9 THE SCOPE OF THE STUDY

The study is limited to

- Public sector Infrastructure construction projects in South Africa,
- Ongoing construction projects where the principal team of client, consultant, and contractor is accessible, and
- Design-by-employer type and design-and-build type of contracts.

1.10 STRUCTURE OF THE THESIS

This study is divided into eight chapters illustrated by figure 1.1 including the contents of each chapter. The present chapter one provides an overview of the research context affirming rationale and questions to be responded to in the research. The chapter further defines the aim and objectives of the study. The research importance and scope are clearly specified and outlined in this chapter.

The second chapter delivers a narrative and systematic review of the relevant literature, factors contributing to poor cost and time performance, and further outlining lean thinking concepts application to construction industry and lean tools applied thereof. The chapter finally concludes with a proposed conceptual framework of the study. A chapter about the research methodology of the study follows this chapter.

Chapter 3 presents the research methodology commencing with the type of research, the research philosophy, the research strategy and methods reciting the justification for the choice of adoption in this study.

Chapter 4 of this study presents the findings of case studies through document analysis and results of the semi-structured interviews of the case study's participants.

Chapter 5 presents results from data collected via an electronic survey.

Chapter 6 presents a discussion of the findings that appeared from the results of the analyzed questionnaire, semi-structured interviews, and literature to irradiate their prominence on the research aim and objectives.

Chapter 7 presents the conceptualization and development of the lean construction cost management framework.

Chapter 8 presents the research conclusions and recommendations including specific contributions to knowledge.

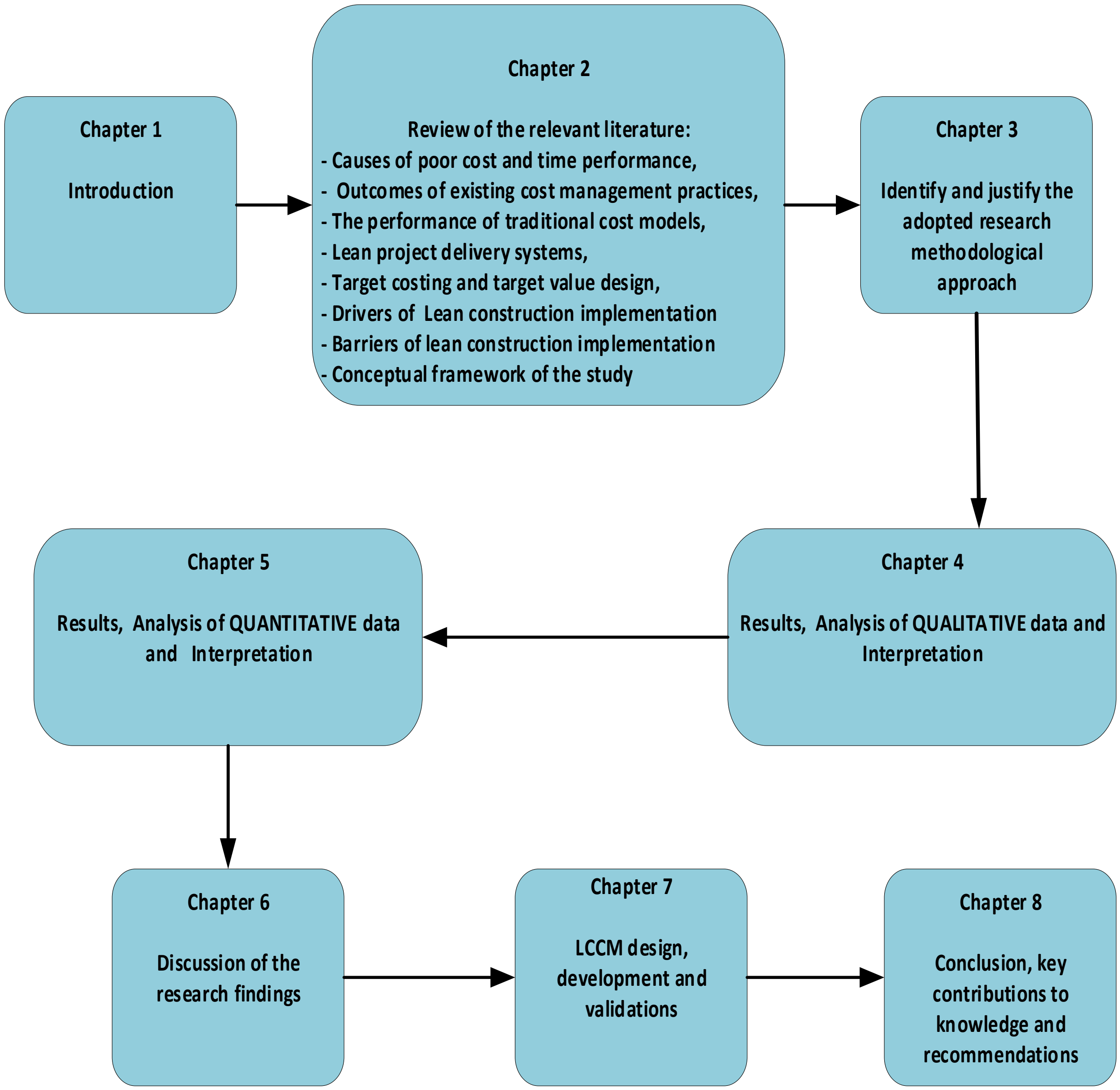


Figure 1.1: Structure of the thesis

CHAPTER 2
THE REVIEW OF RELATED LITERATURE

2.1 INTRODUCTION

The previous chapter introduced the context of this study, albeit briefly. This chapter also assisted with providing insight into the research strategies and methodologies considered appropriate to the research problem and objectives. The current chapter will provide an in-depth description of the context within which this study is situated. This study situates within the context of the delivering current projects with lean thinking strategies adopted for cost performance improvement, the causes of cost overruns, the outcomes of existing cost management practices, and the performance of traditional cost management practices. Numerous studies such as (Hanna et al., 2004, Sambasivan and Soon, 2007) demonstrated that delays in projects contribute to the increase in cost due to their linear relationship. The chapter will include a review of related literature regarding the concepts of lean, the features of lean, the processes of lean, the drivers of lean, and the barriers to and the critical success factors for lean.. The expectation is that by the end of the chapter, a comprehensive understanding of what the Lean Project Delivery System is, the outcomes of existing cost management practices and the conceptual framework for the study to emanate from the literature consulted.

To provide anchors to the theoretical framework underpinning this study, this chapter addressed the causes of poor cost performance in construction projects, the causes of poor time performance in construction projects, the outcomes of existing project cost management practices, the performance of traditional cost models, what the Lean Project Delivery System is, the elements of lean construction, and project performance and project management.

It is believed that these subject areas will create room for systematic contextualisation of the phenomenon being studied.

2.1.1 Project delivery types

While the traditional project delivery is Design-Bid-Build (DBB), two other delivery methods have been gaining in popularity recently: (1) Design-Build (DB) delivery Methods; and (2) Construction Manager at Risk (CM at Risk). Table 1.1 presents a comparison of these methods with the traditional DBB and the new LPD systems based on the project participants and the system structure that organizes these participants.

Table1.1: Various project delivery types in construction

	Design-bid-build	Design-build	CM at risk	Lean project delivery
Contract	PSC has separate contracts with DE and MC. MC selects sub-contractors	PSC contracts with Design/Build Team, who then designs and construct the facility.	PSC has separate contract with DE and CM/MC. CM/MC then contracts with subcontractors	PSC, DE, CM, MC and key trades partners are party to single contract; additional construction and design partners join the team through Joining Agreements to the Contract
Construction contracts held by	Owner	Design/Build Team	CM	Core group of integrated team
Change orders	Increased risk due to the bid environment using the lowest responsive bid	Greater risk, related to locking in prices early in design.	Reduced because of Increased team collaboration during design phase	Minimized due to Increased collaboration during the design phase
Collaboration	Minimal because design is complete before selection of MC	Collaboration within the DB team is maximized, but PSC has less involvement	Increased because of early selection of CM	Maximized due to the nature of the contract.
Project schedule	Maximized due to the nature of the contract.	Fast-track schedule with emphasis on upfront planning with project phase overlap	Fast-track schedule with emphasis on up-front planning with project phase overlap	Similar to DB, but the project team has greater control over the schedule

(DE = designers, PSC = public sector client, MC = Main contractor, CM = construction manager)

Source: adapted from (Forbes and Ahmed 2010)

2.2 THE CAUSES OF POOR COST PERFORMANCE

Poor cost performance in construction projects relates to projects not being completed within the set budget or within the cost objectives planned prior to commencement of the project. Cost overruns are an ongoing phenomenon, and they are referred to by several terms, such as ‘change orders’, ‘cost growth’, or ‘cost escalation’ (Odediran and Windapo, 2014; Zawawi et al., 2010). A cost overrun is defined as the deviation from the amount agreed as per the contract sum divided by the agreed original amount of the contract (Choudhury and Phatak, 2004, Al-Najjar, 2008). Several reports have highlighted the problem of poor cost performance of projects over the years (Ahiaga-Dagbui et al. 2015; Flyvbjerg 2011; Love, Sing, Wang, Irani and Thwala, 2014; Merrow 2011). However, the problem of poor time performance has been similarly reported on such projects as an additional contributing factor to poor cost performance.

Scholars such as Flyvbjerg et al. (2003), Al-Najjar (2008), Enshassi et al. (2009), Danso and Antwi (2012), Baloyi and Bekker (2011), Love (2011), and Love and Sing (2013) have conducted studies to identify the causes of cost overruns in infrastructure projects. A study by Flyvbjerg et al. (2009), demonstrates the severity of cost overruns in large infrastructure projects and includes in its findings that over budgeting and overtime are happening repeatedly. Likewise, explanations of project underperformance in terms of optimism bias and strategic misrepresentation both see high failure rates for projects as a consequence of flawed decision-making (Flyvbjerg et al., 2009). However, Love (2011) argues that to simply assume that strategic misrepresentation and optimism bias are overarching actions that lead to the unsuccessful delivery of social infrastructure projects is misleading, considering the complex array of conditions and variables that interact with one another during the procurement of a project. Social infrastructure is the type of infrastructure meant for social amenities. Understanding the conditions that result in design errors occurring is necessary to reduce the incidence of such errors within projects. Most importantly, solely focusing on addressing such actions may mask the underlying conditions that continually contribute to adoption of opportunistic project and managerial practices. Table 2.1 below displays the percentage of cost overrun experienced by projects in various countries.

Table 2.1 Percentage of cost overrun in different countries

Nr.	Cost overrun percentage	Country of study	References
1	30% and 19%	Slovenia	(Makovšek et al., 2012)
2	from −84% (i.e. a cost underrun) to a maximum of 244%,	Australia	(Love and Sing, 2013)
	11%, and the maximum cost overrun was 109%,	Australia	(Love and Sing, 2013)
3	Range from −40.3% to 164.0%.	Holland	(Cantarelli et al., 2012)
4	13.28%	Australia	(Love and Sing, 2013)

5	7.02% to 48.89%	Nigeria	(Ijigah et al., 2012)
6	25% to 35%	Ghana	(Danso and Antwi, 2012)

Sources: Makovšek et al., (2012), Love and Sing, (2013), Love and Sing, (2013), Cantarelli et al., (2012), Love and Sing, (2013), Ijigah et al., (2012), Danso and Antwi, (2012)

Table 2.1 above deliberate on several projects carried out in various countries. A road construction study by Makovšek et al. (2012) conducted in Slovenia found that in one sample, which covered 20 projects and involved all the project's categories, there was a systematic cost overrun of 30%. Makovšek et al. (2012), in their second sample, which covered 36 projects, reported a systematic cost overrun of 19%. Love and Sing (2013), in a study undertaken in Australia to determine the probability costs of rework, confirmed that the rate of cost overruns for construction projects ranged from a minimum of −84% (i.e. a cost underrun) to a maximum of 244%, thus a total range of 328%. Moreover, for the civil engineering projects sampled, the minimum cost overrun was 11%, and the maximum cost overrun was 109%, thus a total range of 98%. Of the 218 projects assessed by Love and Sing (2013), their study discovered that 79% of projects experienced total rework costs of <16%. Similarly, Cantarelli et al. (2012) reported that the extent of cost overruns on construction projects in a Dutch transport infrastructure database did not vary from that of other countries, as the study found that the range of cost overruns was −40.3% to 164.0%.

The average of cost overruns was 16.5%, and the standard deviation was 40.0, which indicates a rather large variety of individual cost overruns around the mean. Love et al. (2013) analysed 58 transportation infrastructure projects carried out in different states in Australia, and the findings revealed mean rework costs of 11.21%, cost overruns of 13.28%, and schedule overruns of 8.91%. In a study conducted by Ijigah, Ogunbonde and Ibrahim (2012), the results established average percentages of cost overruns and time overruns of Abuja Millennium Development Goals construction projects; cost overruns alone were found to range from 7.02% to 48.89%. Danso and Antwi (2012), in their research conducted on telecommunications tower projects in Ghana, which were constructed between 1992 and 2011, found that from the interviews conducted in the Helios/Tigo Company, their projects experienced an enormous rate of cost overruns. On average, 25% to 35% of projects experienced cost overruns of 40%. The telecoms tower projects were easy to analyse, as the research revealed how construction of these towers was assessed. A tower should have taken 24 to 30 days to complete, but if the company exceeded this duration by taking 36 to 40 days, the average cost to construct the towers also rose. The average cost to construct a tower was $ 23 344, and if a tower was completed after 40 days, the cost would rise to $ 35,000. The interviews found that parties were blaming each other for the exceeded durations and cost overruns. The client felt that consultants were responsible for all the problems encountered on the projects.

Aziz (2013) carried out a study of factors causing cost variation for constructing wastewater projects in Egypt. The study revealed the factors under the categories of “owner”, “designer”, “contractor”, and “miscellaneous” as those contributing to cost overrun of construction projects. Mahamid (2013) carried out an investigation into the effects of projects’ physical characteristics on cost deviation in 74 road construction projects in Palestine. In the analysis of cost underestimation, based on the category of the project, the study showed that small projects had the highest average of cost underestimations, at 24.88%, while large projects had the lowest average, at 15.9%. In the analysis of cost overestimation in the road construction projects, based on the category of the project, large projects had the highest average of cost overestimation, at 8.2%, while medium projects had the lowest average, at 2.15%. The analysis of cost deviation in the road construction projects, based on the category of the project, showed that small projects had the highest average of cost deviation, at 25%, while large projects had the lowest average, at 12.32%. Overall, the study showed that the average of cost deviation in the 74 road construction projects was 16.73%, and that cost deviation ranged from −20.33% to 56.01%. In conclusion, the statistical analysis of cost deviation in the 74 road construction projects indicated that 10% of the projects suffered from cost deviation.

Park and Papadopoulou (2012) conducted research into the causes of cost overruns in 35 transport infrastructure projects in Asia. The cost overruns reported in the study ranged from a minimum of 2.33% to a maximum of 98.23% of the original contract sum. The mean rate of cost overruns for the 35 projects examined was 28.56%. This meant that, on average, additional funds exceeding one quarter of the original contract sum were needed to complete these projects. Results from the survey questionnaire indicated that awarding contracts to the lowest bidder was the most significant frequently occurring cause of cost overruns in transport infrastructure in Asia. The survey also revealed that 64% of the respondents confirmed that they had encountered cost overruns mainly on projects utilizing lump-sum contracts, in contrast to 33% who reported cost overruns primarily in projects using measurement contracts, and 3% who reported cost overruns in projects using cost-reimbursement contracts.

Existing literature assessing project cost overruns continues to stress the global perspective. A study was undertaken by Odediran and Windapo (2014) which involves recent exhaustive systematic literature review of significant factors affecting the cost performance of construction projects provides comprehensive evidence of the magnitude of the problem. Moreover, the study observed that the different authors shared some factors, but their study only extracted the most significant factors that were rated high in these studies. Table 2.2 below is an adaptation of the findings of the study conducted on the causes of poor cost performance in construction projects.

Table 2.2: Factors influencing cost overruns on construction projects

No.	**Author(s)**	**Year**	**Country**	**Top-rated factors**

1	Apolot	2013	Uganda	Inadequate manpower; inadequate/inefficient equipment, tools and plants; rework due to poor work/use of wrong materials by the contractor; bureaucracy; frequent changes in the scope of the work; unreliable sources of materials on the local markets; the contractor's workload; poor schedule management; poor monitoring and control; poor communication; bad weather
2	Abdul-Azis et al.	2013	Malaysia	The contractor's site management, project management and contract administration; design and documentation issues; labour-related issues; materials and machinery; financial management
3	Kasimu	2012	Nigeria	Fluctuation in prices of materials; lack of historical cost data; insufficient time; lack of personal experience in contract work; incomplete drawings; lack of labour productivity; variations; inadequate specifications; the level of competition; terrain or site conditions
4	Mahamid and Bruland	2011	West Bank, Palestine	Fluctuation in prices of materials; insufficient time for estimates; lack of experience in contract work; the size of the contract; incomplete drawings; the political situation; lack of historical cost data; the period of the contract; frequent design changes; the type and the content of the contract; poor quality and project management; market conditions; inflation
5	Ali and Kamaruzzaman	2010	Malaysia	Inaccurate/poor estimation of original cost; construction cost underestimation; improper planning; poor project management; lack of experience; poor contract management; inflation of project costs; the high cost of machinery; fluctuation in the prices of raw materials; unforeseen site conditions; insufficient funds; obsolete/unsuitable construction equipment and methods; mistakes in design
6	Ameh et al.	2010	Nigeria	Lack of contractor experience; the cost of materials; fluctuation in the prices of materials; frequent design changes; economic instability; high interest rates charged by banks on loans received by contractors; the mode of financing; bonds and payments; fraudulent practices and kickbacks; incorrect planning; the high cost of machinery; additional work; contract management; poor financial control on-site
7	Cantarelli et al.	2010	The Netherlands	Forecasting price errors; poor project design; incompleteness of estimations; scope changes; inadequate planning process; deliberate underestimation due to lack of incentives; poor financing/contract management
8	Kaliba et al.	2009	Zambia	Bad weather; inflation; schedule delays; scope changes; local government pressures; strikes; technical challenges; environmental protection and mitigation
9	Enshassi et al.	2009	Gaza Strip	Increases in prices of materials due to border closures; delays in construction; the supply of raw materials and equipment; fluctuation in the cost of building materials; a monopoly on project materials by some suppliers; volatility of the local currency in relation to the value of

				the dollar; design changes; contractual claims (such as extension of time, with cost claims); inaccurate quantity take-off; lack of cost planning/monitoring during the pre- and the post-contract stages; resource constraints – funds and associated auxiliaries not ready
10	Azhar et al.	2008	Pakistan	Fluctuation in prices of raw materials; unstable cost of manufactured materials; the high cost of machinery; the lowest-bid procurement procedure; poor project (site) management/poor cost control; delays between the design and the procurement phases; incorrect/inappropriate methods of estimating; additional work; improper planning; unsupportive government policies
11	Le-Hoai et al.	2008	Gaza Strip	Poor site management and supervision; poor project management assistance; financial difficulties of the owner; financial difficulties of the contractor; design changes; unforeseen site conditions; slow payment for completed work; inaccurate estimates; shortages of materials; mistakes in design; poor contract management; price fluctuations
12	Eshofonie	2008	Nigeria	The cost of materials; incorrect planning; wrong method of estimation; contract management; fluctuation in prices of materials; the previous experience of the contractor; the absence of construction cost data; additional costs; project financing; the high cost of transportation; poor financial control on-site
13	Al-Najjar	2008	Gaza Strip	Increases in prices of materials due to continual border closures; delays in construction; the supply of raw materials and equipment by the contractor; fluctuation in the cost of building materials; volatility of the local currency in relation to the value of the dollar; a monopoly on project materials by some suppliers; resource constraints – funds and associated auxiliaries not ready; lack of cost planning/monitoring during the pre- and the post-contract stages; improvements to standard drawings during the construction stage; design changes; inaccurate quantity take-off
14	Otunola	2008	Nigeria	Inflation; fluctuation in the cost of materials and labour; government policies; delays in approving claims; variations/additional work; delays in the subcontractor’s work; bad estimation; poor planning; poor financial control; under-pricing of tenders
15	Kaming et al.	2006	Indonesia	Inflationary increases in the cost of materials; inaccurate estimating of materials; project complexity
16	Omoreige and Radford	2006	Nigeria	Price fluctuation; financing and payment for completed work; poor contract management; delays; changes in site conditions; inaccurate estimates; shortages of materials; imported materials and plant items; additional work; design changes

17	Creedy	2005	Australia	Design and scope changes; insufficient investigation and latent conditions; deficient documentation; client project management costs; services relocations; constructability; price escalation
18	Wiguna and Scott	2005	Indonesia	High inflation/price increases; defective designs; design changes by the owner; delayed payments on contracts; defective construction work; poor cost control; unforeseen site ground conditions; weather conditions; inadequate compensated variation orders; problems with the availability of labour, materials, and equipment
19	Frimpong et al.	2003	Ghana	Monthly payment difficulties from agencies; poor contractor management; the procurement of materials; poor technical performance; escalation in the prices of materials
20	Nwosu	2003	Nigeria	Insufficient and incomplete drawings; weather conditions; inaccurate and unrealistic establishment of unit rates; inaccurate estimates; the competence and knowledge of the owner; unrealistic schedules; numerous changes; additional work
21	Ogunsemi	2002	Nigeria	Price fluctuation; variations in work; financial difficulties
22	Vidalis and Nafaji	2002	Florida, USA	Plans and modifications; changed conditions; actions and inactions; claims; minor changes; weather damage; utility delays; invalid reasons
23	Jackson	2002	UK	Procurement routes; external factors; claims; the design brief; design changes; people; site conditions; time limits; design team performance; the availability of information
24	Okpala and Aniekwu	1998	Nigeria	Shortages of materials; methods of financing and payment for completed projects; poor contract management; price fluctuation
25	Kaming et al.	1997	Indonesia	The cost of materials is increased by inflation; inaccurate quantity take-off; labour costs increased due to environmental restrictions; lack of experience of project location; lack of experience of project type; unpredictable weather conditions; lack of experience of local regulations

Adapted from Odediran and Windapo (2014)

Table 2.2 clearly demonstrates that cost overrun is a global phenomenon. However, the phenomenon is more common in developing countries than in developed countries. Either this observation may suggest the problem to be more severe in developing countries than in developed ones, or it could be that there is a lack of these studies being carried out developed countries. Table 2.3 is of studies of projects undertaken in South Africa similarly displaying the occurrence of cost overruns in construction projects.

Table 2.3: Factors influencing cost overruns on South African construction projects

26	Ramabodu and Verster	2010	South Africa	Changes in the scope of work on-site; incomplete design at the time of tender; contractual claims (extension of time, with cost claims); lack of cost planning and monitoring of funds; delays in costing variations; additional work
27	Baloyi and Bekker	2011	South Africa	Increases in the cost of materials; inaccurate estimating of materials; shortages of skilled labour; late award of the contract to the client; project complexity; increases in labour costs; inaccurate quantity take-off; the difference between the selected bid and the consultant's estimate; change orders by the client during construction; shortages of manpower
28	Monyane and Okumbe	2012	South Africa	Inadequate project preparation and planning; lack of coordination at the design phase; incomplete design at the time of tender; procurement-related and non-procurement-related factors; delays in issuing information to the contractor during the construction stage; contractual claims, such as extension of time, with cost claims; delays in decision-making by government; failure of specific coordinating; changes in the owner's brief; delays in costing variations, and additional work; improvements to standard drawings during the construction stage; monthly payment difficulties from agencies; poor contractor management; the contractor's unstable financial background; poor workmanship; late contract instruction after practical completion; delays in resolving disputes; delays in final account agreements; work suspended due to safety reasons
29	Mukuka et al.	2014	South Africa	The contractor's project inexperience; poor project management; inadequate planning; the contractor's inefficiency; inadequate financial provision; shortages of skilled site workers; poor workmanship; inaccurate estimates; project complexity; site conflicts; delays from the employer; fluctuation in the prices of materials; lack of executive capacity by the employer; overdesign, shortening of the contract period; unsteady supply of materials; ceaseless variation orders; changes in project design; insufficient time for estimations; unpredictable weather conditions; breaches of local regulations; unstable economy; project site location; inflation
30	Akinyede and Fapohunda	2014	South Africa	Increases in the income of workers; increases in outputs during production; application of ineffective techniques on-site during the production process; the site control structure during the production process; increased construction time during production; site planning processes for production; increased accident rate during the production process; site development during the production process; predictability for effective production; defects in planning during the production process; the influence of workers' behaviour on-site during production; increased capital cost during the production process

Sources: Ramabodu and Verster (2010), Baloyi and Bekker (2011), Monyane and Okumbe (2012), Mukuka et al. (2014), and Akinyede and Fapohunda (2014)

Table 2.3 clearly demonstrates that South Africa is not free from the occurrence of cost overruns in construction projects. Similarly, the studies conducted in South Africa focused on the factors contributing to cost overruns in construction projects only. No studies shown in Tables 2.2 and 2.3 have provided a concrete solution to eliminating cost overruns in construction projects. Instead most studies instead provide ways of minimizing the occurrence of cost overruns, and not eliminating the phenomenon altogether. Hence this study suggests elimination of such phenomena by employing concepts such as lean thinking to improve the cost management of construction projects (Nicolini et al 2000; Ballard and Reiser 2004; Zimina et al 2012).

2.3 THE CAUSES OF POOR TIME PERFORMANCE

Like the ongoing problem of poor cost performance, poor time performance also contributes to poor project performance of construction projects. In fact, the two phenomena are interrelated, in most instances, poor time performance results in increased costs for projects. The interrelatedness of these two phenomena is demonstrated by the saying, “Time is money”. Poor time performance can be defined as a prolonged duration of a project beyond the planned date specified for completion (Aiyetan et al., 2011, Bello, 2018, Gbahabo and Ajuwon, 2017, Kikwasi, 2012, Zou et al., 2007). However, according to Auma (2014), the factors affecting time performance of construction projects were identified as the percentage of late delivery of orders, delays in claims approvals, and delays in payment of valuations to the contractor. A study by Kadiri and Shittu (2015) ranked the causes of poor time performance, and top of the list, from the perspective of the contractors, was “lack of experience of client in construction”. Kikwasi (2012) conducted a study on the causes of poor time performance in Tanzania, and she asked the respondents to rank by order of importance the factors that contributed to poor time performance. The findings reveal that the following causes were ranked high: design changes, delays in payment to contractors, information delays, funding problems, poor project management, compensation issues, and disagreement on the valuation of work done. Similarly, Ameh and Osegbo (2011) carried out a study in Nigeria investigating the causes of poor time performance on construction projects. The five highest-ranked factors from the list of 18 identified factors were the following: inadequate funds for projects, inadequate planning of projects before their commencement, inadequate tools and equipment, delays in delivery of materials, and design changes during project execution (Ameh and Osegbo, 2011).

Table 2.4: The causes of poor time performance on construction projects

No.	Author(s)	Year	Country	Top-rated factors
1	Odeh and Battaineh	2002	Jordan	Inadequate contractor experience; owner interference; finance and payments of completed work

2	Sweis et al.	2008	Jordan	Financial difficulties faced by the contractor; too many change orders by the owner; poor planning and scheduling of the project by the contractor; shortages of manpower; incomplete technical staff assigned to the project
3	Koushki et al.	2004	Kuwait	Change orders; financial constraints of the owner; the owner's lack of experience in the construction business
4	Mezher et al.	1998	Lebanon	The owner has many financial issues; contractors regard the contractual relationship as the most important relationship; consultants consider project management issues to be the most important cause of delays
No.	**Author(s)**	**Year**	**Country**	**Top-rated factors**
5	Assaf et al.	1995	Saudi Arabia	Slow preparation and approval of shop drawings; delays by the owner in paying the contractor; design changes by the owner; labour shortages; inadequate labour skills
6	Al-Khalil and Al-Ghafly	1999	Saudi Arabia	Cash flow problems faced by the contractor; difficulties in financing the project by the contractor; difficulties in obtaining work permits; the requirement of having to select the lowest bidder; the contractor; delays in making progress payments by the owner
7	Kazaz et al.	2012	Turkey	Changes to the design and materials; delays in payment; cash flow problems; the contractor's financial problems; poor labour productivity
8	Motaleb and Kishk	2010	United Arab Emirates	Change orders; lack of capability of the client representative; slow decision-making by the client; lack of experience of the client in construction; poor site management and supervision
9	Chan and Kumaraswamy	1997	Hong Kong	Poor site management and supervision; unforeseen ground conditions; exceptionally low bids; the inexperience of the contractor; the work is in conflict with existing utilities
10	Doloi et al.	2012	India	Slow decision-making by the owner; reluctance of consultants to change; poor labour productivity; poor site management and supervision; rework due to errors in execution
11	Sambasivan and Soon	2007	Malaysia	Improper planning by the contractor; poor site management by the contractor; inadequate contractor experience; inadequate finance and payments by the client for completed work; problems with subcontractors

12	Gardezi et al.	2014	Pakistan	The state of law and order; design changes; lack of funds with the client; war and terrorism; poor site management
13	Haseeb et al.	2011	Pakistan	Changes in regulations; changes in organisation; change orders; inaccurate cost estimation; improper equipment
14	Ogunlana et al.	1996	Thailand	Shortages of materials; shortages of workers; incomplete drawings; problems in the management of materials; deficiencies in organisation
15	Aziz	2013	Egypt	Delays in progress payments; different tactics; bribes; shortages of equipment; ineffective project planning and scheduling; poor site management and supervision
16	Marzouk and El-Rasas	2014	Egypt	Finance and payments of completed work by the owner; variation orders; the effect of subsurface conditions; the low productivity level of labourers; ineffective planning and scheduling of projects
17	Abd El-Razek et al.	2008	Egypt	Financing by the contractor during construction; delays in payment to the contractor; design changes by the owner; partial payments during construction; non-utilisation of professional construction workers
18	Ezeldin and Abdel-Ghany	2013	Egypt	Slow decision-making by the employer; lack of construction coordination and supervision; lack of productivity; economic problems; lack of resources
19	Aibinu and Odenyika	2006	Nigeria	The contractor's financial difficulties; the client's cash flow problems; the architect's incomplete drawings; the subcontractor's slow mobilisation; equipment breakdown and maintenance problems
20	Sunjika and Jacob	2013	Nigeria	Youth unrest, militancy, and community crises; inadequate planning by contractors; delays or non-payment of compensation to the communities; poor choice of consultants and contractors; weather conditions
21	Akinsiku and Akinsilure	2012	Nigeria	Financial/cash flow difficulties; financial difficulties faced by contractors and public agencies; frequent change orders; failure to pay for completed work; shortages of materials
22	Baloyi and Bekker	2011	South Africa	Incomplete drawings; design changes; slow decision-making by the client; late issuing of instructions; shortages of skilled labour

23	Nkobane	2012	South Africa	Design changes; poor communication, and misunderstandings; poor quality of basic engineering, resulting in rework; lack of adherence to the standards for materials; scope changes
24	Kikwasi	2013	Tanzania	Design changes; delays in payment to the contractor; information delays; funding problems; poor project management
25	Oshugande	2016	South Africa	Mistakes and discrepancies in contract documentation; poor communication between the parties; delays in decision-making by the client; employee strikes; unavailability of equipment; rework due to errors during construction; weather conditions; unforeseen ground conditions; delays in the delivery of materials; change orders by the client during construction; delays in approving changes in the scope of work; delays in issuing work drawings

Adapted from Oshugande (2016)

Table 2.4 reveals the causes of poor time performance in construction projects. Similar to poor cost performance of construction projects, the studies in Table 2.4 illustrate majority of poor time performance to be more severe in developing countries than in developed ones. Although poor time performance significantly delays the project completion date, critically it contributes to cost overruns of construction projects as well. It is vital for the cost management process to include ways of dealing with this phenomenon in controlling cost in the post-contract stage of the projects. Cost management in the post-contract stage usually focuses on reporting cost variances to the client (Towey, 2013).

2.4 THE STATE OF PROJECT PERFORMANCE IN SOUTH AFRICA

The severity of ineffective and poor cost management in public sector projects in South Africa is illustrated in Figure 2.1. Cost performance is indicated as being at only 60–80%, instead of the desired 95% (Samuel, 2008)

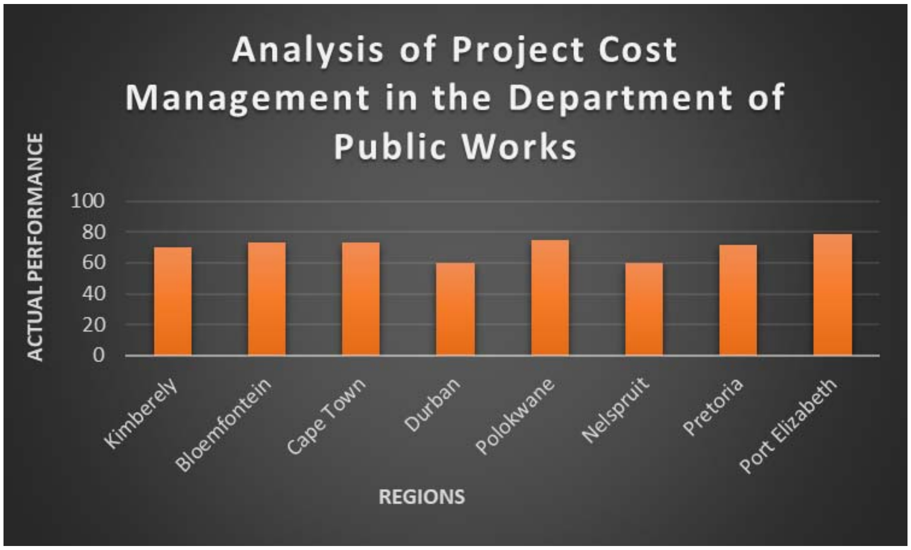


Figure 2.1: Analysis of project cost management in the Department of Public Works (Source: Samuel, 2008)

Figure 2.1 above depicts that public sector projects were performing poorly in terms of cost management. Thirty-two years later, it appears that a shift in performance is yet to occur, as disappointing project cost performance figures are on the increase, particularly in South Africa, hence this study. Research conducted by Ramabodu and Verster (2010) attempted to establish whether construction cost overruns are seen as a problem in the Free State province of South Africa. All the respondents in their study considered cost overruns to be a problem that needs to be addressed. Moreover, the researchers divided the factors determining cost overruns into three categories, i.e. very critical factors, moderately critical factors, and less critical factors. Five factors were considered very critical, with a score of between 70% and 80%, contributing to cost overruns. Changes in the scope of work on-site by the client seemed to be the factor with the most influence, according to the respondents. It cannot, however, be seen as controllable by the design team, and it is thus not seen as a cost overrun related to budget items, but must be accounted for through an approval process driven by the client body. The involvement of the client is vital in project planning to avoid requests to change scope being made and thereby exposing the project to non-value adding activities. Secondly, such practices clearly demonstrate that either the project team did not follow the owner's project requirements (OPR), or the OPR was not clear from the beginning. The second-biggest factor was incomplete design at the time of tender; however, if lean concepts were utilized exercises such as target value design could provide a collaborative approach in using set-based design and alternatives to maximize value for the client (Nicolini et al 2000; Ballard 2007; Ballard 2008). The third-biggest factor was contractual claims, such as claims for extension of time, in lean the last planner system for production, control would facilitate for early completion (Ballard 2000). Lack of cost planning and monitoring of funds was the fourth-biggest factor, hence lean facilitates designing to target cost to avoid project cost overruns. Delays in costing variations and additional work were the fifth-biggest factors, thus implementing the last planner system helps manage the constraints and provide a free workflow to achieve a successful project. Delays in costing variations are not seen as a factor causing cost overruns, but it influences planning related to budgets, because of the lack of timely information, which is constraint-free when LPS is employed as cost management in post-contract stage. Baloyi and Bekker (2011) conducted a study on the causes of cost and time overruns in the upgrading or construction of stadiums in South Africa for the FIFA Soccer World Cup. The top three causes, in descending order of importance, were increases in the cost of materials, inaccurate estimates of materials, and shortages of skilled labour. In addition, late awarding of the contract to the client, project complexity, increases in labour costs, inaccurate quantity take-off, the difference between the selected bid and the consultant's estimate, change orders by the client during construction, and shortages of work force. Evaluating the causes revealed by the study of Baloyi and Bekker (2011), expose the lack of innovation from the project teams due to the usage of traditional methods of executing projects. Lean offers real collaboration, and improvement of cost through TVD, respect for people and best value procurement as a solution to the causes mentioned by the said study.

Samuel (2008) went on to evaluate the project time performance of construction projects for all the regions of the Department of Public Works. Poor planning, lack of a consistent update on the project plan, and failure to apply critical path analysis techniques were singled out as the causes of poor time performance. The expected or desired project performance of 95% was not achieved by any of the regions of the Department of Public Works across the country. Figure 2.2 illustrates how the regions performed, as Samuel (2008) reported in the study conducted.

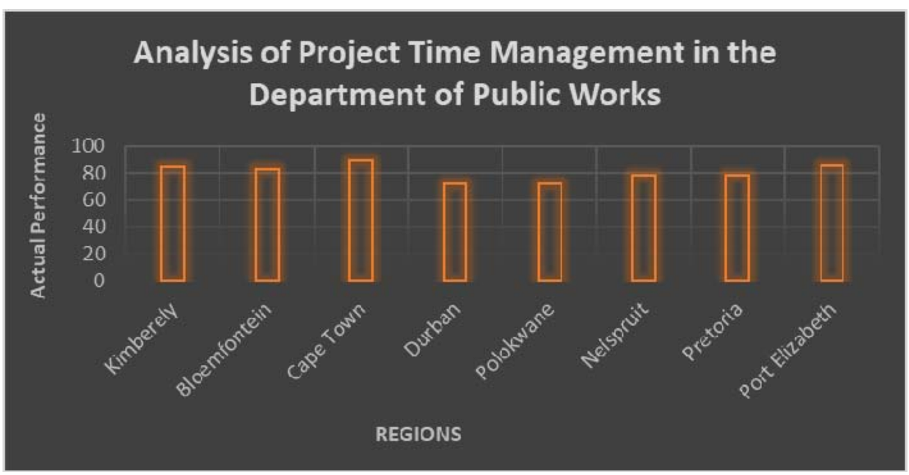


Figure 2.2: Analysis of project time management in the Department of Public Works (Source: Samuel, 2008)

Figure 2.2 depicts that all the regions had a project time performance of between 78% and 85%, which was below the desired 95% project delivery agreement for all the regions (Samuel, 2008).

2.5 THE OUTCOMES OF EXISTING COST MANAGEMENT PRACTICES

Potts (2008) describes cost management as a process that is necessary to ensure that planned development of a design and procurement of a project is such that the price for its construction provides value for money (VfM) and is within the limits anticipated by the client. The management of costs in a project is a common thread running through the entire life of a project. The feasibility of a project depends on its cost and financial viability, and the project is not complete until the last payments and paperwork have been completed. Carruthers et al. (2008) state that the management of costs begins with the financial feasibility study, and it progresses through all the costs that are required to purchase all the resources needed by the project, including cost control to ensure that all work that is done is completed.

2.6 POOR ESTIMATION OF PROJECTS

Cost estimation is utilized as a tool to forecast the probable cost of a project, or as an indication of the approximate cost of a project before it can be constructed. Ashworth and Perera (2015) argue that even if the project has to be constructed as a matter of urgency, the cost may, of course, be of less importance at the time, but it cannot be ignored. Likewise, Ashworth et al. (2013) maintain that there has in general been a move to focus on eliminating waste, and a greater emphasis on use of the world's scarce resources. The traditional method of estimating is unable to cope with the trend towards modern designs and new techniques, materials, and methods of construction to achieve value for money (Ashworth and Perera, 2015). Despite the fact that there is a degree of uncertainty about construction costs in construction projects, the client would still like to know how much the project will cost. Furthermore, the estimated cost cannot be and must not be a misleading figure at the back end of the project.

Current costing models that are used in the construction industry need to be improved for better project performance (Nicolini et al., 2000). The extra cost of construction in South Africa caused by clients in rushing the pre-construction phase according to Ramabodu and Verster (2010), especially the design stage, which is critical to setting targets for the client, is detrimental to the success of the project. Due to extra costs in construction, a design may not provide value for the client.

According to Flyvbjerg et al. (2002), costs are underestimated in almost 90% of projects, and, on average, actual costs are 28% higher than estimated costs. Due to this phenomenon of lack of forecasting, Flyvbjerg et al. (2009) suggest that this can be attributed to three underlying reasons: (1) delusions, or honest mistakes, (2) deception, or strategic manipulation of information or processes, and (3) bad luck. The written word is not the all-powerful instrument, and excessive enthusiasm in relation to the specifications may result in unwarrantable increases in costs, for a degree of perfection which may not, in fact, be a real advantage in monetary terms.

2.7 INABILITY TO PINPOINT IMPROVEMENT OPPORTUNITIES

Construction cost management seems to be failing to offer improvement interventions as affirmed by Hanid et al. (2011) during the design stage in terms of responsive approaches to better designs. According to Rush and Roy (2000), cost-estimating tools need updating in order to deal with the ever-changing construction environment, essentially since cost estimating helps to determine whether one should continue with the project or discontinue it.

Rush and Roy (2000) warn that totally committing to finalize the design and cost early on in the design phase reduces the opportunity to exploit more cost-saving exercises during construction. Hence, the vast majority of authors perceive that 70–80% of the costs are already assigned in the concept phase, so much so that further alterations made later will prove more costly (Rush and Roy, 2000). Target-value design (TVD) techniques can be adopted as a solution to the project delivery process (Ballard and Reiser, 2004).

2.8 COSTS ARE SHAPED BY ACTION

According to Ballard and Reiser (2004), a traditional practice in construction propels the architect to provide a drawing to some degree of completion. Estimators will then estimate the cost of the project, and if the estimate is not to the desired outcome in terms of costs, the design will be altered, so that the costs can be brought up to the desired budget (Ballard and Reiser, 2004). Moreover, Ballard and Reiser (2004) argue that the traditional approach is wasteful, yielding rework and frustration, and that it perhaps generates less value than alternatives for customers and providers. “Cost-control techniques are employed at the design stage to afford the architect the opportunity to be aware of the cost implications of all the design decisions applied to the project, and during the course of construction to mend any blunders emanating from the actions of the parties in the early stages of the project” (Seeley, 1996: 14). The result of this strategic process on the client’s requirements early on before project commencement is referred to as “costs resulting from action”, and it arguably leads to increased inaccuracy, the creation of waste, and failure to achieve cost reduction (Hanid et al., 2011).

Moreover, Hanid et al. (2011) state that it is possible for all involved in the project to contribute positively to costs for the delivery of the project, and that the establishment of costs is shaped by action. Hence, it is possible to guide the design to acceptable project costs, rather than letting the design reflect the cost of the project (Hanid et al., 2011). The adoption of TVD makes it possible to achieve the objective of the project, where the cost acts as an input to design, and the design process is a collaborative iterative process, where the cost is constantly updated, to align the client’s requirements with their constraints. In the first decade of the 21st century, TVD implementation proved to be very successful in delivering the client’s needs in a set target cost below the market price (Ballard, 2009).

2.9 THE NEGATIVE INFLUENCE ON BEHAVIOUR

Several forms of negative influence from cost management systems on behavior have been identified in the literature, ranging from the claim culture to manipulation of bids and performance measurements (Hanid et al., 2011). Behavior relates to the attitude of planning for claims on construction projects for profit-maximizing. Rooke et al. (2003) single out this kind of attitude, where the idea that the industry has a culture that is opportunistic, prone to conflict, and where resistant to change is a byword in construction. It has also been argued that price-competitive tendering has resulted in a tendency among contractors to expend more effort on generating profit from claims than from improved construction methods (Rooke et al., 2003). The same kind of attitude can be seen in the procurement of contractors in the public sector. Accountability constitutes a central pillar of public procurement (Soudry, 2007). The construction industry is notorious worldwide for being high in corruption (De Jong et al., 2009). Research undertaken by Bowen et al. (2012) reports that opportunities for corruption were found to arise across almost the entire range of activities involved in the building procurement process, but that they clustered mainly in the tendering and tender evaluation stages. In addition, Bowen et al. (2012) indicate that the process of appointing contractors and professional consultants is allegedly subject to manipulation at times. Tender interference and tender irregularities were reflected within most of the data in terms of corrupt practices.

2.10 THE RELATIVE NEGLECT OF VALUE CONSIDERATION

Value is defined as “a person’s willingness to pay the price of a good in terms of a cash return for certain product benefits, as found within the economic and business sense of capitalism” (Emuze et al., 2015: 36). Value management (VM) is a concept that is somehow often neglected in construction projects, especially in South Africa, since most projects are concerned with completing the project on time and expecting to complete the project within budget, which almost never happens, due to the relatively small number of quantity surveyors using VM in their projects (Bowen et al., 2010). The paradox of value engineering (VE) being a subset of VM has caused the latter to be explained in a temporal way. VE is a “hard systems” approach to cost reduction, carried out during the design phase (where hard information in terms of technical solutions, drawings, and specifications already exists). VM, on the other hand, is seen more like a “soft systems” approach to developing a common understanding of the project/design objectives or design problem(s) and their solutions (Kelly and Male, 1988, Green and Liu, 2007). It is normally carried out during the project inception or early conceptual design stage, but it relies on the synergetic advantage of probing stakeholder perceptions of these more fluid issues, and it is thus applicable throughout almost the entire procurement process (Kelly and Male, 1988, Green and Liu, 2007). Likewise, McNair et al. (2001) maintain that many studies have dealt with providing “value”, but that they have totally overlooked it from the perspective of the client.

Value management (VM) and value engineering (VE) are concepts sometimes confused between them to have established the value of the project in view of the client (Potts and Ankrah, 2008). VM addresses the value process during the concept, definition, implementation and operation phases of a project. It encompasses a set of systematic and logical procedures and techniques to enhance project value throughout the life of the facility (Potts, 2008). In fact, only the latest edition of the books of Potts (2008); Potts and Ankrah (2008) addresses the value aspect of cost management. Research conducted in South Africa by Bowen et al. (2009) suggests that although VM and VE have been in existence in construction for a long time, there is minimal knowledge about the degree to which these techniques are applied in practice, or how they are used. Bowen et al. (2009), in their study of awareness and usage of VM in construction projects, found that only 35% of quantity surveyors in South Africa used VM on their projects, and only 37% of the respondents found it useful.

The findings also highlighted that quantity surveyors in South Africa are actually applying VE, rather than VM, especially as more respondents (42%) saw the determination of least project cost as the primary use, rather than project value optimization (16%) (Bowen et al., 2009).

2.11 THE PERFORMANCE OF TRADITIONAL COST MODELS

This section is intended to highlight mostly why current traditional cost models are performing poorly, but it also addresses why this study is worth being undertaken. Bowen and Edwards (1985) pointed out that a new paradigm shift or an ‘information explosion’, in the field of cost modelling and price forecasting will take place only from a pursuit of academic knowledge. This phenomenon is intriguing, as Bowen and Edwards (1985) state that there has been no published evidence of demand from consumers for more realistic price forecasting, or of any recent development work on cost modelling being conducted by quantity surveyors in South Africa. Even to date, the status quo continues. The main questions are (1) Do building owners believe that South African cost modelling is performing to their satisfaction? (2) If South African cost modelling is unsatisfactory, do industry stakeholders convince clients otherwise? (3) If the construction industry is ignorant of the fact that South African cost modelling is not working, is it resistant to change to something new? (4) If construction practitioners believe that South African cost modeling is a problem, do they believe the problem lies in implementation and (5) Do they believe rather in the notion of not fixing something that is not broken?

The Association of South African Quantity Surveyors (ASAQS) recently published the second edition of its guide to elemental cost estimating and analysis for building works in 2016, after 18 years. With costs spiralling out of control on so many projects, infrastructure projects of all types are experiencing cost overruns. Flyvbjerg et al. (2003) call this a “performance paradox”. South Africa is not free of projects that are experiencing this phenomenon. What is interesting in the update of the guide to elemental cost estimating is that in the foreword, it states that the update was requested to examine whether there was a need to revise and possibly expand the 1998 and 2003 editions to accommodate changes that have taken place in the industry since those versions were published (ASAQS 2016). The reason posed by the committee for updating the previous editions of the guide to elemental estimating was that it noticed that change was necessary in order for the profession to remain relevant. The committee incorporated international advances in the industry to better guide the quantity surveyors active in Africa and further afield (ASAQS 2016).

The elemental cost estimating guide highlights the list of benefits for users. It is notable that the guide has 12 benefits listed, but the following were of interest to the main questions posed, as Flyvbjerg et al. (2003) also confirm:

- "Elemental estimates provide a more realistic distribution of costs for assigning design-to-cost targets for each discipline than do arbitrary percentage allocations that do not necessarily reflect program requirements or anticipated quality levels", and
- "Cost overruns are detected earlier because costs are monitored frequently, at each stage of the design. This allows necessary corrective design changes to be made early, with little effect on the design schedule and minimum impact on the cost of the design".

If the above two statements are correct, the main question posed is why over the years have projects failed to meet the budgets allocated, and why over the years have construction projects experienced cost overruns? 'Traditional' cost models, such as regression models, bills of quantities (BOQs), and elemental estimating methods, have come under heavy criticism before, as they do not explain the system they represent (Bowen, 1987). Similarly Rakhra and Wilson (1982) attests to further criticism of the reliance of traditional models on the use of historical data to create deterministic estimates of buildings or components, without explicit qualification of their integral changeability and improbability.

The first bullet point describes assigning design first then costing after, which is the traditional way of providing budgets. The traditional way has failed to offer cost improvements, hence target costing was deemed to provide a better solution in refining targets to the client, and achieving value for m Historical cost databases provide average productivity and average cost measured based on completed projects. The difficult is that those projects may or may not have used methods to eliminate process waste or improve productivity. Subsequently, because historical databases may include waste, using these productivity- and cost data will tend to increase estimated durations, drive up estimated resource needs and thus inflate estimated cost.

Using traditional cost models, with inputs from historical cost data and elemental quantities from product design, it is possible to point out which design alternative appears to produce more savings than the others. However, with the consideration of cost implications of process changes in different design alternatives, these savings may be less than anticipated or even negative. Following cost advice as output of traditional cost models, designers may decide to choose an alternative that in effect is more costly to build. Therefore, traditional cost models are incapable of supporting decision making money on TVD process. But target costing needs to be introduced gradually in developing countries. Wilson (1982) also criticized the reliance of these models on the use of historical data to produce deterministic estimates of building or components cost without explicit qualification of their inherent variability and uncertainty. Tommelein (2003) augmented this notion by mentioning “a world in which no variation or uncertainty is recognized gets modeled deterministically thus are too optimistic.” Bertelsen (2003) proposed that construction must be perceived as a complex system, operating on the edge of chaos.

2.12 BACKGROUND TO LEAN CONSTRUCTION

To define the word “lean construction” has been a controversial issue due to the lack of consensus Mossman (2009); Jørgensen and Emmitt (2009) including the International Group for Lean Construction (IGLC) and Lean Construction Institute (LCI) communities. The machine that changed the world Womack et al. (1990) presents a sketch picture of lean production (Mossman, 2009). Moreover, Mossman (2009) implies that the term “Lean construction” emerged two years later through the contribution of Koskela (1992) owing to lean production ideas in construction; however, Nguyen and Chang (2012) contrast this idea to have emanated from the term being coined by the International Group for Lean construction in 1993. Lean production was coined by Krafcik (1988) to differentiate the Toyota production system from the western mass production system and subsequently popularized through the machine that changed the world Womack et al., (1990) book. However, Hamzeh et al. (2016) assert that there is rich literature in case studies demonstrating the worthwhile implementation of LC on real projects, while Koskela (2000) and Mossman (2009) recite numerous benefits such as reduction of construction cost and shortened construction periods witnessed when implementing LC in construction projects. There are several studies undertaken in various countries of lean implementation in the construction industry. Studies found in the literature are from developing and developed countries such as Chile (Alarcón et al. 2002), Uganda (Alinaitwe 2009). Ghana (Ayarkwa et al. 2012), Nigeria (Olatunji 2008), Saudi Arabia (AlSehaimi et al. 2014). Australia (Stewart et al. 2004), Germany (Johansen and Walter 2007), Singapore (Dulaimi and Tanamas 2001), the Netherlands (Johansen et al. 2002), the UK (Mossman 2009), the USA (Nahmens and Ikuma 2009), and Turkey (Tezel and Nielsen, 2012). It is notable that none of the studies are from South Africa, and despite the benefits already cited the level of adoption is still non-existent to very low not only in South Africa but worldwide owing to barriers that may hinder successful implementation (Mossman, 2009).

2.1.3 THE LEAN PROJECT DELIVERY SYSTEM

The introduction of lean for the past two decades has no doubt posed a challenge for traditional project management practice (Alarcón et al., 2013). Traditional project management practice has been defined by Alarcón et al. (2013) as

> *a coherent contracting-based project delivery system (PDS) frameworks developed and accepted by professional organizations such as Associated General Contractors of America (AGC), The American Institute of Architects (AIA), Construction Specifications Institute (CSI), Project Management Institute (PMI), Construction User Round Table (CURT), most academic research, risk management tools such as insurance and bonding, and training and education provided by trade schools, colleges and universities* (Alarcon, et al 2013:248).

There are three basic project delivery systems, namely design-build (DB), design-bid-build (DBB), and construction management at risk (CMR), all of which rely on the activity-centered critical path method-based operating system (Alarcón et al., 2013). The traditional project management practice project delivery system, with all its forms, now relies on the notion of contracting at the lowest cost and then using the critical path method to manage the sequential dependence of activities (Alarcón et al., 2013). However, (Ballard, 2008) first introduced the Lean Project Delivery System. The Lean Project Delivery System (LPDS) is a philosophy Ballard (2008) but it is also a delivery system, where the project team provides what the customer wants, but first to assist the customer to make a decision of what they want (Ballard, 2008). Traditional project management emerged with logic and a promise to change the way projects were being delivered. According to Lichtig (2006), however, owners/customers continue to be displeased, projects remain dangerous places to work, they are delivered late, they cost more than what the anticipated cost was, and they deliver an inferior-quality end product.

In fact, Alarcón et al. (2013) explain that projects were becoming more complex, uncertain, and dynamic and that it was in this environment that lean construction was developed; hence, the LPDS is an innovation. Lean construction development began with the discovery of the obvious: workflow on projects is unpredictable (Alarcón et al. 2013). Additionally, Ballard (2000), the intersection of projects and production systems is the domain for the Lean Project Delivery System.

Ballard (2000) highlights the following essential features of the LPDS:

- The project is structured and managed as a value-generating process,
- There is early involvement of downstream stakeholders in planning and designing the project steps, through cross-functional teams,
- The job of execution is a project control function, as opposed to reliance on after-the-fact variance detection,

- Efforts of optimisation are focused on making workflow reliable, as opposed to improving productivity,
- Pull techniques are used to govern the flow of materials and information, through networks of cooperating specialists,
- Capacity and inventory buffers are used to absorb variability, and
- Feedback loops are incorporated at every level, dedicated to rapid system adjustment, i.e., learning.

Figure 2.3 is a schema of the Lean Project Delivery System, as well as a prescriptive model for managing projects, where project definition means a process of aligning ends, means, and constraints (Ballard, 2008). To achieve alignment, there is a conversation, which starts with the customer stating

- What they want to achieve (the project brief), and
- The constraints (location, cost, and time) on the means for achieving their ends

According to Ballard (2008), the LPDS model consists of 13 modules, nine modules organized in four interconnected triangles of project delivery or phases, extending from project definition, lean design, lean supply, lean assembly, lean use, production control, and work structuring. Each triangle represents a project phase that overlaps, and certain steps are part of two phases. As a result, all the phases of the project have an impact on each other, meaning that the previous phase impacts on the following phase, together with the decisions made in different phases (Ballard, 2008). Relations and dependencies between different phases, which are often ignored, are explicitly exhibited by the LPDS, as compared to traditional project management practice.

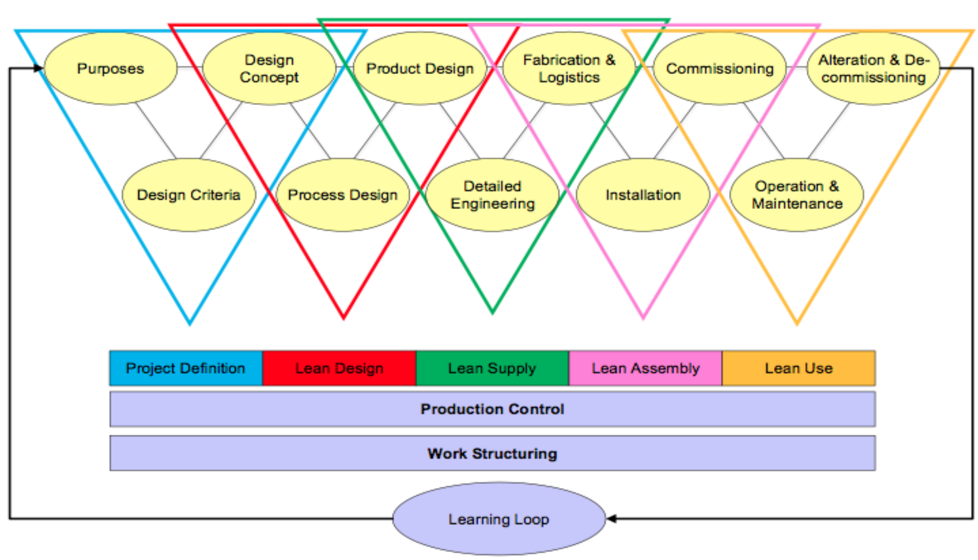


Figure 2.3: The Lean Project Delivery System (Source: Ballard 2008)

The aim of the first phase, which is project definition, is to acquire an enhanced understanding of the project. Thus, the ends (what's wanted), the means (what has to be provided), and the constraints (location, time, cost, regulations) are made clear through the conversation with the customer. The interests of the stakeholders, through values, concepts, criteria, and specifications, are aligned with the 'design concept' step, and the first two phases of the LPDS are connected, as it is the end of the first phase and the beginning of the second phase. The 'lean design' phase carries on the conversation of the customer and/or the stakeholder, to develop the process design and the product design, together based on the conceptual design (Ballard 2008). In this step, decisions are taken at the 'last responsible moment', and with the emphasis on maximizing customer value and minimizing waste, in order to have the most information and the best knowledge about alternatives. The project can revert to project definition phase should new opportunities arise during the conversation. The lean design phase transitions into the lean supply phase. Based on the product design, detailed engineering will be done to manufacture and deliver the components and materials. This phase involves a logistical concept to minimize the inventory and reduce lead time.

Lean assembly continues with the delivery of information, components, and materials, as well as tools, machinery, and labour for installation. To avoid change orders and rework, construction activities are executed at the 'last responsible moment' during this phase of the LPDS. According to Ballard, (2000), and Ballard and Howell, (2003), the phase ends with the commissioning and use of the facility after installation, and it transitions into lean use. The last phase consists of end-user value. To achieve a lower total cost of ownership, complete information about the asset, such as operation, maintenance, alteration, and decommissioning, has to be known from the start of the project, in order to deliver end-user value. It is important that this phase is taken into account and that it continues after lean assembly, in order to maximize the value of the asset. This phase is often neglected in traditional project management practice, or traditional project delivery, which often leads to displeased end-users.

Work structuring and production control are involved in every phase of the project. By breaking work into smaller parts, work structuring has the purpose of obtaining a reliable workflow and production units, and production control use the look-ahead process to manage workflow (Tsao 2005).

Criticism received by lean

According to Green (1999) lean has received a surmountable criticism over the sluggishness of the debate over what lean and what lean is not. Similarly, Jørgensen and Emmitt (2008) believes that there has not been a significant effort by researchers to address the shortcomings of lean. Scholars such as Green (1999, 2002) is one of the few academics to assert that scholars have ignored a crucial argument regarding lean construction. Essentially, most of Green's (1999, 2002) apprehensions are linked to the impending effects on the eminence of working life that the lean method could convey. Such warnings are recorded on literature about lean production. Yet, such warnings have been ignored on literature from scholars of lean about the human resource management implications of lean (Green 1999; 2002). Furthermore, Green (2002) cautioned that if the construction industry devastatingly concentrated on waste eradication and improving efficiency - without, however, explicitly bearing in mind the human resource management implications - construction companies and professional firms would find it gradually problematic to draw intelligent, creative young professionals to join the industry. Green's (2002) criticism has had eloquent effect on the lean construction community.

Waste as defined by lean

According to Womack and Jones (2003), waste is defined as "specifically any human activity which absorbs resources but creates no value". Waste impacts negatively on the social, economic and environmental well-being of society, by taking in inputs without providing beneficial outputs. Corfe (2013) contends that 'waste' assumes a wider meaning when discussed in the context of 'lean'; it has a specific meaning that is wider than material waste alone. The process of achieving a task or project that we undertake can be seen in three ways. There are the value-adding activities that the customer or end-user is prepared to pay for. Then there are the non-value-adding activities, often referred to as essential activities, to make value happen. Lastly, there is 'waste', which is the activities that are carried out with adverse effects on cost, time, quality, or sustainability, and that adds no specific value to the process.

Lean is a process that "eliminates waste through delivering continuous improvement in a collaborative way, where the principles can be directed at sustainability objectives to good effect" (Corfe, 2013). Waste can occur at any stage of the production process/value stream. Waste includes time, energy, resources, whole-life cost, and physical waste, among others. In conceptualizing the phenomenon of waste, the acronym "TIMWOOD" has been developed for easy identification of the seven common lean wastes (transportation, inventory, motion, waiting, overproduction, over-processing, and defects) in the construction industry in relation to the associated sustainability benefits of removing them (Corfe, 2013) .

The philosophy of lean is defined as follows by (Terry and Smith, 2011)

- a way of thinking and delivering value, innovation and growth by:
    - ✓ doing more with less –Less human effort, less equipment, less materials, less time and less space
- aligning effort closer to meet customer value expectations

- at the heart of lean are flexible, motivated team members continuously solving problems (Terry and smith 2011:47).

Corfe (2013) offers five principles of lean, to be used as a roadmap for embedding lean in practice. See Figure 2.4 below.

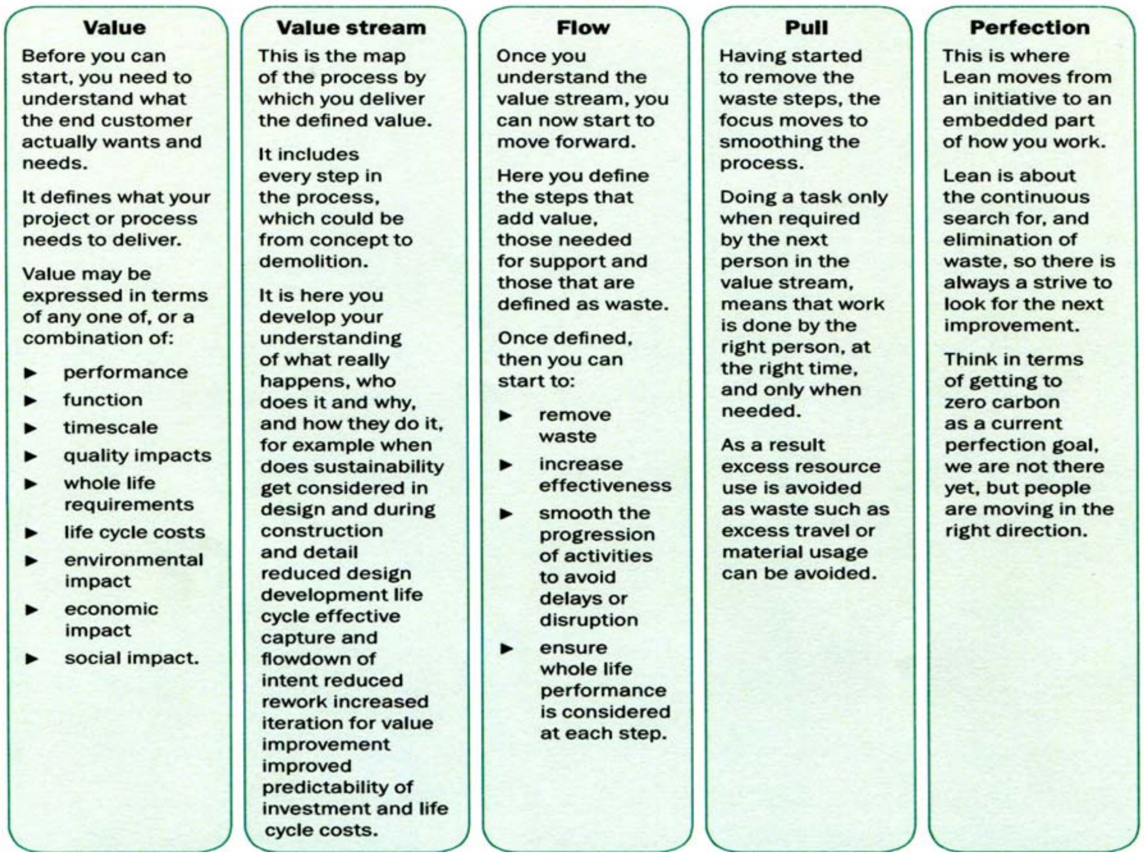


Figure 2.4: Five principles of lean
(Source: Corfe, 2013)

Corfe (2013) reports that the above principles offer a framework for identifiying how the goals of value can be achieved in a balanced way. Lean production provides a competitive edge, by minimising waste and improving efficiency (Kumar et al., 2013). This philosophy of production combines unique tools, practices and strategies, which can be applied to identify major efficient and effective production systems, which employ fewer resources, to create higher quality and generate more profits (Pettersen, 2009).

According to Aziz and Hafez (2013), the philosophy of lean production, also known as the Toyota Production System, emerged in the 1950s after World War II, when Toyota realised it had to do more with less. The idea of lean originates from the Japanese manufacturing industry, and it involves a set of principles and tools that assist in the identification and steady elimination of the waste process

(Womack et al., 1990). There has been considerable disagreement about whether lean concepts are suitable for the construction industry, considering that they emanated from the manufacturing sector, an industry which contrasts sharply with the construction industry (Forbes and Ahmed, 2010). However, lean construction emerged from the mid-1990s as a new concept, both in the construction management sector and in the practical aspects of construction (Koskela, 1992; Koskela et al., 2002). Support for lean philosophy's suitability/applicability to construction can be traced to a study titled *Application of the new production philosophy to construction* by (Koskela, 1992). Production theory is predicated on the principles of transformation-flow-value (TFV) (Koskela, 1992). Three schools of thought receive recognition from lean construction and have emerged from production management; the views are orthogonal yet complementary:

- The first school of thought assumes the transformation view, "T",
- The second school of thought assumes the flow view, "F", and
- The third school of thought assumes value view, "V".

Unlike the traditional project delivery method, lean is a structured, controlled, and improved method that seeks to achieve all three goals: transformation, flow, and value (Koskela, 2000). As a standard of perfection, lean accepts production system design criteria (Howell, 1999). According to Howell (1999), the father of the Toyota Production System, Taiichi Ohno, understood that there was a better way to design and make things, and that management of construction under lean differs from typical contemporary practice because management of construction under lean

- Has a clear set of objectives for the delivery process,
- Is aimed at maximizing performance for the customer at the project level,
- Concurrently design product and process, and
- Applies production control throughout the life of the project.

Lean is a process that eliminates waste, through delivering continuous improvement in a collaborative way. Table 2.5 helps to create awareness of the wastes in the delivery process. It sets out seven wastes, using the acronym "TIMWOOD" to enable one to remember them easily. Corfe (2013) states that alongside the seven wastes there is often an eighth waste, cited in addition to the already mentioned ones. Table 2.5 also depicts the eighth waste.

Table 2.5: Seven wastes

The seven wastes	Definition	Sustainability examples	Benefits of removing waste
Transportation	Excessive movement of physical or virtual things	◆ double handling of materials on site due to poor planning of deliveries and storage areas ◆ excessive mileage due to non-local suppliers being used ◆ excessive deliveries to site because of poor planning.	◆ reduced cost and emissions of handling equipment, eg cranes ◆ reduced risk of handling damage, so reduced physical waste ◆ safer site ◆ lower energy consumption.
Inventory	Storing too much or too little of something, poor storage conditions, excessive work in progress	◆ ordering too much concrete and having to dispose of it ◆ lengthy reports where the information you need is hidden in the middle ◆ using more space than is necessary for a building due to poor design.	◆ better cash flow for supply chain ◆ improved safety ◆ reduced material handling and transportation, with associated emission and fuel cost reduction ◆ less risk of damage, excess waste and resource use.
Motion	Excessive personal motion or difficult working conditions	◆ static site welfare facilities only available at one point on a large site ◆ site engineer repeatedly driving around a site to sign off permits ◆ poor ergonomic design of a space.	◆ less work related injuries and absence ◆ safer working environment ◆ improved productivity ◆ reduced fuel use through reducing unnecessary travel.
Waiting	People or equipment inactivity, flow of a process stopping because the right information or resource is not available	◆ waiting for the design detail for an airtightness tape around a window, delaying installation ◆ delayed results of an ecology survey ◆ site stoppage due to an accident or incident ◆ waiting for materials because of late ordering or poor planning.	◆ improved productivity ◆ reduced energy use from more efficient working ◆ improved flow of work ◆ less frustration.
Over-production	Doing too much too soon, or out of sequence	◆ fully completing a design before considering specialist input ◆ mixing too much mortar for the shift ◆ downgrading insulation causing over specification of the heating system ◆ excessive packaging material being used.	◆ reduced waste rates ◆ reduced transportation of original and replacement materials ◆ reduced cost associated with excess materials ◆ reduced rework and potential for damage, reduced resources used.
Over-processing	Using an overcomplicated or incorrect process for a task, not having the right resource, equipment or plant breakdown	◆ installing complex, maintenance heavy systems ◆ failing an air test through not having adequate quality checks throughout ◆ lengthy pre-construction lead in ◆ complex deconstruction requirements ◆ exceeding specified requirements for no benefit.	◆ reduced resource and energy use in unnecessary processes ◆ improved quality and repeatability ◆ safer working methods ◆ work planned at right time to take into account all ecology impacts.
Defects	Having to repeat an activity more than once before it is to the right quality	◆ poor workmanship ◆ completed drainage failing a test ◆ damage to materials or completed work ◆ re-running energy calculations because of poor air pressure test results late in the build process.	◆ improved customer satisfaction ◆ project on time with no faults ◆ lower rates of waste disposal ◆ less environmental incidents ◆ reduced transportation of original and replacement materials.
Skills ..'isuse	The waste of not utilising the skills and knowledge of people within your team, organisation or community to get the best solutions If we ignore this key element, we can inadvertently introduce significantly more waste into the process	◆ consider the last time you were told that you had to change the way you were doing something and compare that to the last time someone asked your opinion and worked with you to come up with a solution. They were most likely very different outcomes and you may well have been more inclined to work with the latter ◆ respect for people is a key principle both for Lean and sustainability, and should never be overridden by the desire to adopt Lean tools regardless.	◆ better buy-in to improvement activities, and ultimately better, and more sustainable solutions.

(Source: Corfe 2013)

Researchers have recorded some important improvements on the implementation of lean production/philosophy practices, in the construction industry as well (Erik Eriksson 2010; Perez et al., 2010; Wee and Wu, 2009). A study by Morrey et al. (2013) suggests that lean cannot be defined in isolation of contexts, because it can be adapted to suit the needs of the business and its culture and objectives. In short, the lean philosophy promotes “doing what the customer wants, in no time, with nothing in stores” (Womack and Jones, 1996). The theory concentrates on value streams (recognizing how, where, and when the value gets created in the process of transforming raw materials into finished goods).

Experience and literature in this field have shown that the said stages provide significant opportunities to generate value for the benefit of all projects; however, such opportunities are not being taken advantage of (Orihuela et al., 2015).

All these are the common process wastes within the industry, which have made it important ground for continuous improvement. Through, the use of various lean tools and concepts – such as just-in-time, continuous visualization, the Last Planner System, and TVD, among others – wastes can be eliminated, and sustainability benefits can be achieved for the client. The capacity of lean to enhance the maximisation of value and cost and time efficiency for the client explains the viability and the relevance of considering the phenomenon of lean in this study.

2.13 TARGET COSTING IN CONSTRUCTION

Target costing was originally introduced in Japan under the name *Genka Kikaku*, as an expression that clearly suggests that it is an overall strategic approach to reduce costs and that it is not only a costing technique (Nicolini et al., 2000). The origin of target costing is depicted in Figure 2.5. In the views of Feil et al. (2004), it became apparent that the Japanese themselves do not agree on the true meaning of *Genka Kikaku*. It would seem that VE was first used in Japan. It was known as *Genka Kikaku*, and it occurred at Toyota in 1963, although it was not mentioned in Japanese literature until 1978. Later, *Genka Kikaku* was translated to mean “target costing”, the term now used throughout the world (Tani et al., 1996).

Target costing is a product development practice that converts cost into a design criterion, rather than a design outcome (Ballard and Reiser, 2004).

Ballard (2007) defines target costing as follows:

> *Target costing in the construction industry is the practice of constraining design and construction of a capital facility to a maximum cost. It is an appropriate practice for all clients with financial constraints (maximum available funds or minimum ROI requirements) that a capital facility project must meet in order to be considered successful by that client.*

Ballard (2007) demonstrates the differences between current practice and the target costing method (see Table 2.6).

Table 2.6: Normal practice vs target costing

Normal practice	**Target costing**
▪ What do I want? ▪ What will it cost me? ▪ Can I afford it?	▪ What am I trying to accomplish? ▪ What do I need in order to achieve my purposes? ▪ What is that worth to me? ▪ What can I afford to pay to get it? ▪ What can I expect to pay? Is expected cost less than or equal to the allowable cost?

(Source: Ballard 2007)

The definition of TC in construction terms, in the exact words of Ballard, (2007), is the practice of constraining design and construction of a capital facility to a maximum cost. Moreover, Ballard, (2007) explains that it is an appropriate practice for all clients with financial constraints (maximum available funds or minimum return-on-investment requirements) that a capital facility project must meet in order to be considered successful by that client. This definition fits perfectly with the needs of the local construction sector in South Africa and beyond. Conversely, Cooper and Slagmulder (2004) define target costing as a technique that is used to manage the future profits of firms. Once this target cost has been established, VE is used to find ways to improve the product design, so that the target cost can be achieved. The target costing process reverses the traditional method of costing, where the market price is first determined if the product will sell, and the desired profit is then subtracted, to give the designers the cost to which they must design the final product.

Target costing played a substantial role on a case study project in the United States of America (USA), which suggests that it contributed to delivering the project within budget and on time, more value was provided to the client than would otherwise have been provided, and the provider made a reasonable profit (Ballard and Reiser, 2004). From the literature, it was noted that target costing was a management practice used in Japanese manufacturing for profit planning in the 1980s (Do et al., 2014).

The formula below clearly explains the concept better. The word “must” cannot be stressed enough in the definition of TC, because if the designers cannot design the product and produce it at the required cost, the project must be abandoned (Clifton et al., 2003). Figure 2.5 illustrates the origin of target costing.

Target cost = target price (revenues) − target margin

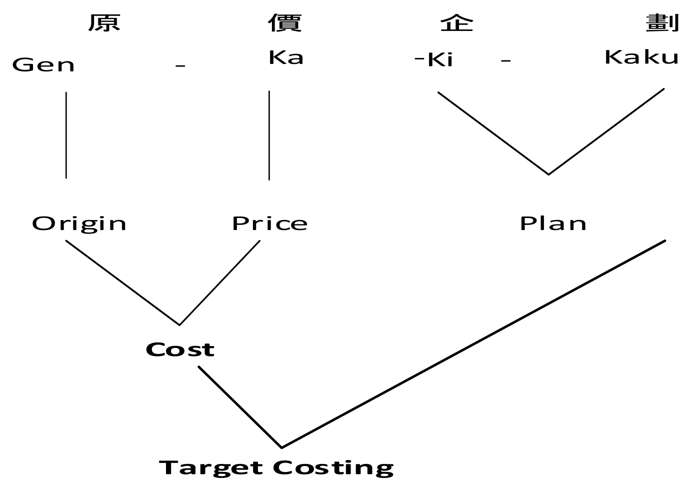


Figure 2.5: The origin of target costing
(Source: Feil et al. 2004)

Nicolini et al. (2000) stress that all stakeholders need to be involved throughout the planning process of a project. In addition, a cost-plus approach takes a shortcut in providing what the client really wants, and usually the burden is pushed to the subcontractors. Table 2.7 outlines the differences between cost-plus pricing and target costing.

Table 2.7: Comparison of cost-plus pricing and target costing

Normal practice	**Target costing**
▪ Cost determines price ▪ Performance, quality, and profit (and more rarely inefficiencies and wastes) are the focus of cost reduction ▪ Cost reduction is not customer-driven ▪ Cost accountants are responsible for cost reductions ▪ Suppliers are involved late in the design process ▪ No focus on life-cycle cost ▪ Supply chain required to cut costs	▪ Price determines cost ▪ Design is key to cost reduction, with costs managed out before they are incurred ▪ Customer input identifies cost-reduction areas ▪ Cross-functional teams manage costs ▪ Early involvement of suppliers ▪ Minimises cost of ownership for client and producer ▪ Involves supply chain cost planning

Source: Ballard (2007)

The principle of target costing began because of the need to improve production control by the Toyota production team (Shingo and Dillon, 1989). Like construction, designing first then estimating the cost based on the design, the manufacturing sector was also working on the formula of the cost of a product and profit equals selling price (Shingo and Dillon, 1989). However, Shingo and Dillon (1989) reports that the Toyota production team used a different formula to improve the cost performance of a product:

Selling price − cost = profit

Shingo and Dillon (1989) explains that the customer is the one that decides the selling price, and that profit is what remains after subtracting the cost from it. The only way to increase the profit, then, is to reduce the costs; in addition, consequently, cost-reduction activity should have the highest priority. Adoption of the non-cost principle and elimination of waste have permitted Toyota to often take the lead in reducing the selling prices of its cars over the past 35 years Shingo and Dillon (1989). The importance of cost reduction cannot be stressed enough, according to Shingo and Dillon (1989), as any company can make an effort to eliminate waste, but as long as it operates by adding profits to cost to determine price, its efforts are likely to be superficial. Similarly Clifton et al., 2003) state that target costing has consistently been shown to reduce product costs by up to 20–40%. Clifton et al. (2003) explain the basic process of target costing as a four-stage process. It begins with definition of the product, followed by setting of a target, followed by finding ways to achieve the target. The process then begins, and, last of all, manufacturing occurs, at a competitive cost, during the life cycle of the product. The process begins at the front end of the product's realisation, when the product is being conceived. There is one other case where target costing should be applied early in the cycle: when the existing product is about to undergo a major revision, release or redesign. In all cases, Clifton et al. (2003) explain that product definition is strongly market-based. Likewise, Clifton et al. (2003) stress that setting target costing is based purely on starting with price first. This means you must know what the customer is willing to pay for the product and its capabilities. This is exactly the same scenario you will have for a construction project of an asset to be leased to the potential lessee. It will be important for the client of the project not to overspend on the costs of the project, in order for the development to be feasible and viable for the location. This also means the owner is aware of what the competition is charging, and what the structure of their cost is. Only after determining the price and the required profit margin necessary for business health can you determine the target cost, and it is important to state that the cost is a dependent variable; price and profit margin are the independent variables (Clifton et al., 2003). While target costing has proved very successful in new product development in the manufacturing sector, its application in a capital-intensive sector such as construction has been somewhat limited. Ballard and Reiser (2004) delivered the first construction project using the target costing process; the project was credited with achieving savings, as compared to a similar project, which was completed late and was more expensive than the one that used target costing.

2.14 TARGET-VALUE DESIGN

Target costing metamorphosed into target-value design (TVD). TVD became an adaptation of TC to project production systems (Nguyen, 2010). TVD became more than just costs, and it added more value, such as constructability, time, safety, and work structuring (Lichtig, 2006). TVD is seen as a management practice that enables the design to deliver customer value within agreed project parameters, it rests on a production management paradigm, and it treats cost as an outcome (Ballard, 2009). TVD turns current design practice upside-down: (1) setting the target cost for design Aziz, (2013); Park and Papadopoulou, (2012) rather than estimate based on a detailed design, design based on a detailed estimate (2) work structuring: “rather than evaluate the constructability of a design, design for what is constructible”.

Most important (3) collaboration: “rather than design alone and then come together for group reviews and decisions, work together to define the issues and produce decisions then design to those decisions” this resonates with the aim of this study. This study rather aims to deliver Target Value Delivery, *which entails design to cost and build to cost as well*. (4) set-based design: “rather than narrow choices to proceed with design, carry solution sets far into the design process”, and (5) collocation: “rather than work alone in separate rooms, work in pairs or larger groups, face to face” (Macomber et al., 2007).

Instead of working out costs for a specific design, target-value design (TVD) increases the value delivered to the client when a project team collaboratively designs to a “detailed estimate” based on a given target cost/“allowable cost” (Rubrich, 2012). Therefore, in TVD, the design follows the allowable cost, instead of the cost following the design, as practised in traditional estimating methods.

Before the concept of TVD became popular in the lean construction lexicon, Nicolini et al. (2000) reported the use of target costing in construction. Target costing is understood to be a cost management process for reducing the overall cost of a product over its entire life cycle, with the help of top management and active contribution of members of the supply chain (Nicolini et al., 2000).

The first successful TVD project was documented by (Ballard and Reiser, 2004) and later Do et al. (2014) in the USA. The case study project was delivered based on a design-build contract that integrated lean construction principles and practices, including target costing and the Last Planner System (LPS) of production. The role of the cost managers during construction is limited to monitoring and control of the cost in comparison to the initial estimate only. Rather than cost managers being limited to such tasks, a framework that enables cost managers to collaborate and contribute to early completion of projects to curb extension of time, which, drive cost increases, offers more value to the customer. In comparison, a similar project, constructed in a non-TVD method, was delivered 10 months late and cost 15% more than the case study project (Ballard and Reiser, 2004). The non-TVD project may have been delivered late because Howell and Ballard (1998) have observed that the traditional practice of construction is contract-centred, with assignments defining and balancing the objectives of various participants in terms of time, health and safety, costs, errors, and quality. In addition, the non-TVD project lacked innovation, as it was 'business as usual'.

The advantage of following the integrated project delivery (IPD) approach is that it allows for early participation of contractors and suppliers in the design phase. Collocation simplifies communication and the team decision-making process. Set-based design helps to engender alternatives. Production system design helps to integrate product and process design. Target costing helps to close or reduce the expected allowable cost gaps. TVD is not to be seen as a project delivery system on its own, but it forms one of the important elements of the Lean Project Delivery System. The Project Production Systems Laboratory (P2SL) has developed the process of target-value design see Figure 2.6 . TVD uses fundamental tools and principles of lean, such as set-based design (SBD), production system design (PSD), target costing, an IPD team (collaboration), and collocation (see Figure 2.6).

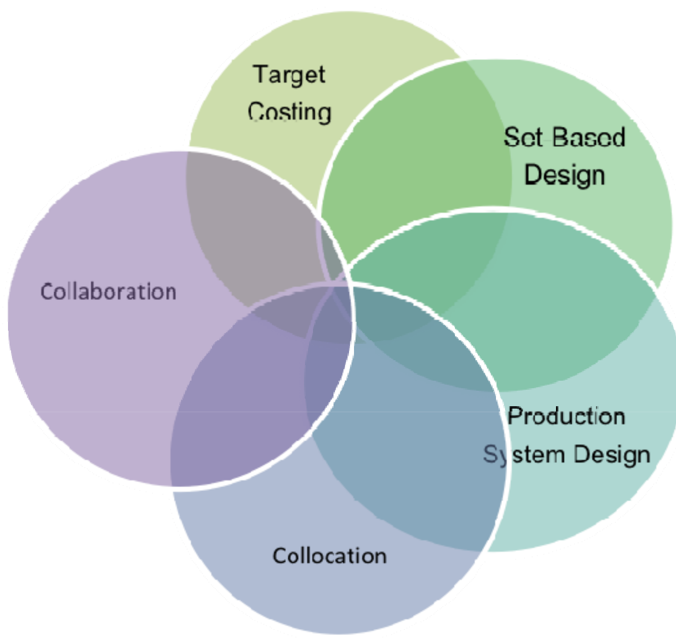


Figure 2.6: The fundamental components of TVD
(Source: Nguyen et al., 2010)

The steps to implement TVD in the project definition and lean design phases are specified in Figure 2.7 below (Ballard, 2009). The diagram below clearly provides the steps to follow when implementing target costing in construction projects. TVD process below clearly contributes to the pre-contract phase of the project and limited to that stage only. A comprehensive cost management framework will provide a more collaborative option for cost managers to add more value in the construction stage.

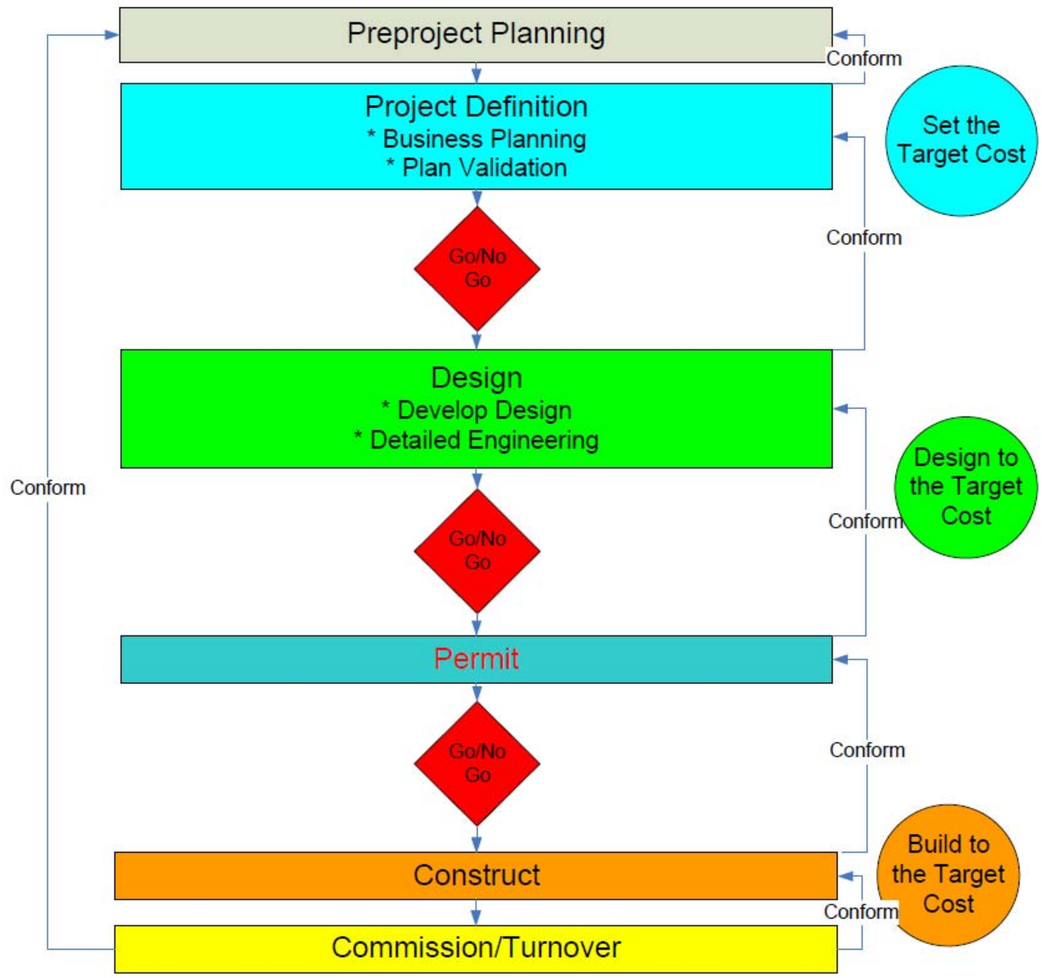


Figure 2.7: The phases of the TVD process (Source: Ballard 2009)

The steps that Ballard (2009) argues should be followed when implementing TVD, especially in the project definition and lean design phases, are as follows:

- Set the target cost lower than the budget that followed the current best practice,
- Form TVD teams by system and allocate target cost to the respective teams,
- Hold a kick-off workshop,
- Start a meeting schedule,
- Use a set-based-design approach, and evaluate sets of designs against target values,
- Provide cost and constructability guidelines for design, e.g. product/process standardisation,
- Promote collaboration, and have designers get cost input before developing design options,

- Do rapid estimating, and hold frequent budget alignment sessions,
- Utilise value engineering proactively, and
- Hold design reviews with permitting agencies.

2.15 CONSTRUCTION PROJECT PERFORMANCE

The literature indicates various terminologies related to performance, such as "performance indicators", "performance measures", and "performance measurement" (Love and Holt, 2000, Mbugua et al., 1999). Additionally, Mbugua et al. (1999) suggest that performance indicators stipulate the measurable evidence essential to prove that a planned effort has accomplished the anticipated outcome. This means measuring indicators with some degree of precision and without ambiguity. They are referred to as measures. Conversely, when it is not probable to obtain an accurate measurement, it is natural to refer to performance indicators. By contrast, performance measures are the mathematical indicators (Sinclair and Zairi, 1995). Likewise, performance measurement is a systematic way of evaluating the inputs and the outputs in manufacturing operations or construction activities, and it acts as a tool for continuous improvement (Mbugua et al., 1999; Sinclair and Zairi, 1995).

According to Omran et al. (2012), construction project success is dependent on its performance, which is measured based on completing the project within time, within budget, and with the required quality. Cost, time, and quality are the most important indicators to measure project success, although other performance indicators, such as safety, functionality, and satisfaction, appear to be attracting increasing attention (Chan et al., 2004). However, the dominant mode of assessment of a construction project's success has continued to be the iron triangle of project management (cost, time, and quality), with the inclusion of meeting client satisfaction (Baker et al., 1983, Morris and Hough, 1987; Slevin and Pinto, 1986; Turner and Müller, 2003).

Project managers and clients attach great importance to measuring the performance of construction projects (Idrus et al., 2011). However, there seems to be an overlap between project management and projects, in that the former is a subset of the latter (Munns and Bjeirmi, 1996). Three factors could have contributed to this confusion, as Munns and Bjeirmi (1996) suggest. The first is time frame – project success is usually assessed at the end of the project management phase. At this stage, the iron triangle of project management works as a yardstick to measure success. It is convenient to judge success at this time by whether the project management criteria, rather than the project success criteria, have been satisfied. The second is confusion of objectives – the objectives of both project management success and project success are often intertwined. Instead of the two being clearly identified as separate groups, they are represented as a single homogeneous set. The lack of distinction between the two sets of objectives creates the perception that they are related. An example of such a case is the budget and profitability. The budget is primarily a project management issue, but profitability is a project objective. The suggestion that a client instigates a project just to see it completed to budget reduces the importance of the project objectives. The third is ease of measurement – compliance with the budget and the schedule are the two objectives within project management that are common across all projects, and they are easy to measure quantitatively. It is easy to concentrate on project management and its success, rather than on the wider context of the project, because of the two readily identifiable measures. Many of the project objectives will tend to be either qualitative or not easily measured in any objective manner, or longer-term and not measurable immediately. This makes it convenient to use measures of project management success as a means of determining overall project success. Measuring the progress of project performance is very important in envisaging whether the outcome of a construction project is a success or a failure (Bello, 2018).

The public sector has also realised the importance of project performance, and has applied efficiency strategies through a series of reports that were carried out in parallel with the famous Egan and Latham reports in the UK (Gale, 2013). All reports had a dominant theme that focused on efficiency strategies – enacted through engagement with information technology and standardisation. The secondary theme relates to the growth prospects offered by the construction sector to energise a national economy (Gale, 2013). Achievement of the said objectives varied from country to country, but a common thread among all the reports was spending profiles from clients and longer-term relationships between parties, through teamwork methods. The significant reports from countries other than the UK are listed in Table 2.8.

Table 2.8: Significant overseas construction reports 1994–2000

Country	**Report**	**Date**
Australia	Building for Growth, Building and Construction Industries Action Agenda	1999
Finland	Re-engineering the Construction Process Using Information Technology	1997
Ireland	Building Our Future Together – A Strategic Review of the Construction Industry in Ireland	1997
Japan	Future Directions of the Construction Industry, Coping with Structural Changes of the Market	1998

Singapore	Construction 21: Re-inventing Construction	1999
South Africa	Creating an Enabling Environment for Reconstruction, Growth and Development in the Construction Industry	1997
United States	National Construction Goals	1994

(Source: Gale 2013)

Table 2.8 clearly shows that South Africa, like other countries, was concerned about the performance of projects, emanating from execution of public projects at the time. This clearly provides the impetus for this study to be conducted, by evaluating current project management practices using lean thinking and lean concepts, and by suggesting improvements. To fully understand what accounts for the performance of infrastructure (a particular issue in Africa), Gowda and Mamatha (1997) argue that there is a need to understand its institutional arrangements and the incentives governing its delivery. On the other hand Luiz (2010) makes a compelling argument that Africa is faced with a massive challenge to deliver infrastructure, and the need is much more than financial resources – it requires the capacity to deliver massive, complex projects in an efficient manner. While other studies have rather proved through failure of projects that the impetus to improve is a necessity, this study aims to achieve its objective of evaluating extant project cost management practice through tools that will evaluate and bring about improvement, such as lean tools. Despite poor performance, Ngacho and Das (2014) argue that projects have traditionally been evaluated according to an approach popularly known as the "iron triangle", namely cost, time, and quality. Thus, this study argues against the convention of the iron triangle, on the basis that cost on its own cannot be put on the same scale as time and quality. While time and quality are key performance indicators (KPIs), this study argues that these two key performance indicators are directly related to cost as an outcome of the other two KPIs of the iron triangle.

2.17 Lean Assessment Tools and Improvement of the Workflow Process

According to Koskela (2000), lean and lean-related tools have been established either deliberately or otherwise over time, and are aimed at stimulating continuous improvement in the production process. The principles of lean construction seek to reduce the share of non-value-adding activities, lead time schedules and supply chain variability, and at the same time increase flexibility and transparency in the production process. As a consequence, these actions, where performed diligently, culminate in a reduction of process and material wastes, advancement of continuous improvement, and provision of enhanced value for stakeholders, all of which resonate with the tenets of the lean philosophy. Twenty-first-century industry is plagued by fierce competition, due to the challenges of the existing highly dynamic and fast-moving environment (Belhadi et al., 2018). Therefore, the need arises for organisations to improve the effectiveness and efficiency of their operations for business survival (Belhadi et al., 2018). To have strong knowledge of how lean production theory can be embraced for improvement in the planning and construction phases of projects, it is essential to first appreciate how the lean philosophy is being used for performance improvements in the manufacturing industry. A typical example of this is the Toyota Production System (TPS), or the Toyota Way (Forbes and Ahmed, 2010). The TPS represents an important foundation of lean construction, and it has emerged since the 1960s (Forbes and Ahmed, 2010). The TPS uses four elements, specifically the just-in-time (JIT) and creative thinking, to provide outstanding levels of production, high quality, and low costs (Forbes and Ahmed, 2010). Table 2.9 provides a summary of the four basic aspects of the TPS and the way lean thinking applies to each aspect.

Table 2.9: A representation of lean thinking in the Toyota Way

Toyota Foundation	Principles
Problem solving (continuous improvement and learning)	Continual organisational learning; view the situation first-hand, to thoroughly understand it; make decisions slowly by consensus (consider all options, and implement rapidly)
People and partners (respect, challenge, and grow them)	Grow leaders who live the philosophy; respect, develop, and challenge people and teams; respect, challenge and help suppliers
Process (eliminate waste)	Create process ‘flow’ to reveal problems; use a pull system to avoid overproduction; level out the workload; stop when there is a quality problem; standardise tasks for continuous improvement; use visual control (transparency); use only reliable and tested technology
Philosophy (long-term thinking)	Base management decisions on a long-term philosophy, even at the expense of short-term financial goals

(Source: Forbes & Ahmed 2010)

In the four basic aspects of the TPS shown in Table 2.10, the process (waste elimination) is the most applicable to the cost and time improvement process (CTIP) (Forbes and Ahmed, 2010). The various process wastes that are being eliminated in the TPS, which are also applicable to the CTIP, are defects or corrections, overproduction, over processing, transportation, inventory, motion, and waiting time (these wastes and their causes have been elucidated in this chapter of this report). Scholars globally have examined how the above-mentioned wastes can be eradicated in the CTIP, through application of different lean tools, such as the A3 problem-solving report, value-stream mapping (VSM), the 5 Whys, Kanban, Kaizen, TVD, and the Last Planner System (Forbes and Ahmed, 2010, Huovila et al., 1997, Ko and Chung, 2014, Marzouk et al., 2011, Nave, 2002, Osmani, 2011, Sacks and Barak, 2008, Schlueter and Thesseling, 2009). The reviewed literature indicates that attention is focused mainly on the construction process of projects. The construction cost management phase has not been broadly covered. This study observes that as of the time this research was conducted, none of the above-mentioned tools has been adequately adopted for waste identification and reduction during project cost management activities. Table 2.10 depicts the lean tools and their associated benefits and limitations.

Table 2.10: Lean tools and their benefits and limitations

Lean tools	**Benefits**	**Limitations/weaknesses**
Kanban	Kanban enables a process to be streamlined, which enables a problem in the system to be resolved quickly.	On various occasions, Kanban can cause a potential loss of sale. Additionally, Kanban can only be effective if it is sufficiently scrutinised in a system, and it may be challenging for an observer to grasp the root cause of a problem in a process where it is applied.
A3 problem-solving report	The A3 problem-solving report enables a process to be transparent and comprehensible in a manner that creates adequate thinking and learning. Moreover, the tool does not require long hours of specialised training.	Any form of interruption in the A3 process can create unnecessary delays in a system. In addition, A3 problem-solving efforts often fail in application in a process.

The 5 Whys	It is simple to use and can be adopted easily by investigators, without the need for any form of training.	Its simplicity can make investigators incorrectly apply it in a system and ignorantly arrive at an erroneous conclusion in the system.
Kaizen	Kaizen is a lean tool that can be implemented in many ways. It is largely self-motivated, as it is driven by individual input and execution.	One main weakness of Kaizen is that it can only bring enhancement in a system when people are eager and ready to make suggestions.
VSM	VSM is the only lean tool that can be used to identify overproduction, waiting, transportation, inappropriate processing, unnecessary inventory, unnecessary movement, and defects in a process. Therefore, it is the only lean tool that can be used to identify the root causes of the seven forms of waste in a process/product design.	VSM cannot be used to sufficiently understand what the future state of a procedure in which it is applied should look like. Hence, perfection in adoption of VSM in a system solely depends on the skill of the user.

Source: Aka (2017)

According to the table above, VSM has benefits greater than other lean tools to analyse virtual inefficiencies in a construction process (Belova and Yansong, 2008, Mossman, 2009, Nielsen, 2008, Rother and Shook, 1998). Moreover, VSM permits an evaluator to visibly identify any unseen problem and the origin of the problem in a system (Mossman 2009; Nielsen 2008; Rother & Shook 1998). Based on these benefits of VSM over other lean tools deliberated in this study, the researcher observed that the tool might be suitable or less challenging for waste identification in the workflow process of the project management stages.

The 4P model of lean

The 4P model of lean was developed to demonstrate the 'Toyota Way', and it incorporates 14 key management principles in a pyramid format (Liker, 2004). The main principles are continuous improvement and learning, which sit at the top of the pyramid, followed by development of people and partners, the process orientation, and long-term thinking at the base (see Table 2.11). (Liker, 2004) asserts that managing the 4P model can be seen as a prerequisite for sustainable improvements in an organisational set-up. The 14 principles are grouped under each of the 4Ps, as shown in Table 2.11.

Table 2.11: The principles of the 4P model of lean

4Ps	**Principles**
Philosophy	- Base management decision on a long-term philosophy, even at the expense of short-term financial goals
Processes	- Create continued process flow to bring problems to the surface - Use a pull system to avoid overproduction - Level out the workload - Build a culture of stopping to fix problems, to get quality right the first time
People and partners	- Grow leaders who thoroughly understand the work - Live the lean philosophy - Teach the lean philosophy to others - Develop exceptional people and teams who follow the organisation's philosophy - Ensure respect for the organisation's extended network of partners and suppliers, by challenging them and helping them improve
Problem solving	- Go and see for yourself, to thoroughly understand the situation - Make decisions slowly by consensus, thoroughly considering all options; implement decisions rapidly - Become a learning organisation, through relentless reflection - Continuous improvement

Source (Liker 2004)

2.18 KEY BENEFITS, DRIVERS AND BARRIERS TO LEAN IMPLEMENTATION

Lean construction (LC) has been hailed as one of the most innovative construction methods ever created since the 1990s (Koskela, 1992). Due to the poor performance recorded continuously on construction projects, lean concepts have been recommended as a way to improve efficiency and effectiveness of project's execution.

However, despite all these achievements, South Africa has not adopted the lean concepts for the construction industry's performance improvement. Cano et al. (2015) realized that to integrate LC completely in a construction organization, the recommendation is to comprehend and anticipate the barriers that might be opposed to a proper implementation. A barrier in this case is a step or an action that prevents the attainment of the desired objective. Comprehension of such barriers is vital to propose remedies, mitigate their impact, or forewarn their occurrence and strengthen the identified conditions that contribute to the successful implementation of lean construction (Cano et al., 2015). Based on this argument, identifying the barriers that may hinder successful implementation of lean construction initiatives will subsequently follow.

2.18.1 Barriers of lean implementation

As previously outlined, a barrier in the context of this study is a challenge, a hurdle or obstacle, which does not assist, or restricts, progress to achieve a successful integration and implementation of lean (Cherrafi et al., 2017). To address the research questions and objectives Kitchenham and Charters (2007) opines identification of barriers through an adoption of systematic review of the existing literature owing to its detailed, replicable, clear and meticulous approach (Kitchenham and Charters, 2007). Moreover, Denyer and Tranfield (2009) suggests to follow the five sequential phases of a comprehensive literature review. These five phases entailed the following: (1) objective/question formulation, (2) locating studies, (3) study selection and evaluations, (4) analysis and synthesis and (5) reporting and using the results.

The phenomenon under investigation guided the location of articles through usage of search strings linked to the main topic. According to Briner and Denyer (2012), to facilitate an exclusion/inclusion criterion of the search strings a Context –intervention-mechanism-outcome (CIMO) can be followed, hence such was carried out in this study. Further relevant papers were identified using a combination of search strings such as barriers, challenges, failures, obstacles, and pitfalls, and Boolean operators (i.e. AND & OR). A specific search could be focused upon and this allowed the exclusion of irrelevant articles. When the same articles continued to re-appear a saturation point was considered to have been reached as a result. Input of search strings were done from various academic journals and proceedings in Emerald, ASCE, Scopus and Science Direct databases from 1990-2018. Academic books, Google Scholar and credible proceedings website of the IGLC on the topic are also included because of their impact on the advance of the field. Focus of the systematic literature included only lean implementation in construction and excluded implementation of lean in other sectors completely. The search criteria, a final sample of 177 articles that relates to lean implementation was identified. Conversely, only 86 of these discussed implementation barriers, and hence were further considered appropriate in this study. Table 2.12 illustrates the barriers identified from a comprehensive literature review surveyed on the subject area.

Table 2.12. Identification of Barriers to Lean construction implementation.

No	Barriers	References
1	Lack of technical capabilities	(Forbes and Ahmed, 2004), Alinaitwe (2009), Olatunji (2008), (Bashir et al., 2010), Ayarkwa et al (2012), (Shang and Sui Pheng, 2014), (Asri et al., 2015)

2	Heavy reliance on poorly skilled foreign workers,	Dulaimi and Tanamas (2001)
3	Non related work background to construction	Dulaimi and Tanamas (2001)
4	Language and education barrier	Dulaimi and Tanamas (2001), Olatunji (2008), Bashir et al. (2010), (Sarhan and Fox, 2013), Brady et al. (2011) Jara et al. (2009); Mossman (2009), Asri (2015), (MOVAGHAR, 2016)
5	Extensive use of subcontractors	Dulaimi and Tanamas (2001), Forbes and Ahmed (2004), Kim and Park (2006), Olatunji (2008), Mossman (2009), Sarhan & Fox (2013), Abdullah et al. (2009), Gao & Pheng (2014), Movaghar (2016), (Aziz and Hafez, 2013), Choudhry et al. (2012), (Elazouni and Metwally, 2000),Forbes et al. (2004), (Johansen and Walter, 2007), (Miller et al., 2002) Mossman (2009), Olatunji (2008),
6	Lack of long term commitment to change and Innovation	(Oviedo-Haito et al., 2013), Sarhan and Fox (2013), (Tam et al., 2011)
7	Price oriented tendering system	Dulaimi & Tanamas (2001), Olatunji (2008), Alinaitwe (2009), Jorgensen & Emmitt (2009), Sarhan & Fox (2013), Abdullah et al (2014), Gao & Pheng (2014), Movaghar (2016)
8	Long term relationships with suppliers for fear of complacency	Dulaimi & Tanamas (2001),Forbes & Ahmed (2004)
9	Limited communication via contract	Forbes and Ahmed (2004)
10	Lack of quality management	Kim and Park (2006), Ainaitwe (2009), Jorgensen & Emmitt (2009), Alarcon et al (2005)
11	Too many meetings and too much information	Forbes and Ahmed (2004)

12	Lean beneficial to large projects not small projects	Kim and Park (2006)
13	Extra resources required specific to deal with lean issues	Kim and Park (2006)
14	Difficult to tracks tasks from all planning forms	Kim and Park (2006), Cudney and Elrod (2010),
15	Lack of understanding of the concepts	Kim & Park (2006), Olatunji (2008), Ayarkwa et al (2012), Gao and Pheng (2014), Friblick et al. 2009; Sarhan and Fox 2013; Viana et al. (2010), Movaghar (2013), Alarcon et al (2005), Demeter and Matyusz (2011), Eswaramoorthi et al. (2011), Haupt and Whiteman (2004), Poksinska (2010), Theagarajan and Manohar (2015),Young and McClean (2008), Abdullah et al. (2009), Alinaitwe (2009), Aziz and Hafez (2013), Bashir et al. (2010), Eriksson (2009), Green (1999), Johansen and Walter (2007), Jørgensen and Emmitt (2008), Mossman (2009).
16	Lack of training	Olatunji (2008), Ayarkwa et al (2012), Gao & Pheng (2014), Brady et al. 2009; Cerveró-Romero et al. 2013; Porwal et al. 2010), Alarcon et al (2005).
17	Lack of support from Management	Jorgensen & Emmitt (2009), Bashir et al. (2010)
18	Inflexible Legislation	Olatunji (2008), Ayarkwa et al (2012),Sarhan (2013),Mossman (2009), Bashir et al (2010), Sarhan (2013), Movaghar (2013), Alarcon et al. (2005)
19	Lean not part of University curriculum	Mossman (2009)
20	Inability to deal with change management	Mossman (2009)
21	Lengthy approval process by client	Abdullah et al (2014), Gao and Pheng (2014)

22	Culture and social issues	Mossman (2009), Jorgensen and Emmitt (2009), Bashir et al (2010), Abdullah et al (2014), Gao and Pheng (2014), AlSehaimi et al. (2009) Cerveró-Romero et al. (2013), Nesensohn et al. (2012), Sarhan and Fox (2013), Movaghar (2013)
23	Transparency	Jorgensen and Emmitt (2009), Alarcon et al (2005)
24	Active client, user stakeholder involvement	Jorgensen and Emmitt (2009), Ayarkwa et al (2012), Gao and Pheng (2014), Asri (2015)
25	Financial Issues	Bashir et al. (2010), Sarhan and Fox (2013), Asri (2015)
26	Lack of time for implementing new practices in the Projects	Alarcon et al. (2005), Enshassi et al. (2006), Eswaramoorthi et al. (2011), Jasti and Kodali (2016), Mane and Jayadeva (2015), Mossman (2009), Olatunji (2008),Osaily (2010),Zainul (2009)
27	Challenge to create organizational elements	Alarcon et al. (2005)
28	Lack of self-criticism to learn from errors	Alarcon et al. (2005), Aziz and Hafez (2013), Ballard et al. (2007),
29	Resistance to change	Alarcon et al. (2005)
30	Procurement routes	Codinhoto et al., (2008)

A total of 30 barriers were identified from a comprehensive literature review. Lean construction is still a novel approach in South Africa and the knowledge gained from identification of barriers will assist in promoting the drivers of implementing lean in the future. Moreover, the contribution emanating from the identification of barriers is advancing the knowledge of assisting the construction industry and forewarning on the possible pitfalls when lean gains momentum in the country. Knowledge attained from other industries will go a long way towards guiding the South African construction sector not to make the same mistake already identified in other construction contexts.

2.18.2 Benefits of lean construction implementation

The construction industry has reported many benefits of lean. Several studies have extensively researched the benefits of lean and its achievements for over 27 years since the inception of the International Group for Lean Construction. The benefits derived by numerous studies include: improved productivity and reliability, better quality and customer satisfaction, and improved forecasting. In addition shortened schedules, waste minimization, cost effectiveness and additionally the application of lean principles has contributed to improved safety with the application of lean principles (Koskela, 1992, Ballard and Howell, 2003, Howell and Ballard, 1998, Nicolini et al., 2000, Ballard and Reiser, 2004, Ballard, 2008, Babalola et al., 2018, Bajjou et al., 2017, Mossman, 2009).

Research conducted by Sarhan (2018) investigating benefits of lean in Saudi Arabian construction demonstrated that the construction in that the industry is concerned with customer satisfaction, quality improvement, increased productivity, reduced construction time, process improvement, better health and safety record, and improved supplier relationships among other benefits prioritized by the respondents. However, in South Africa, Oke et al. (2016) carried out a similar study to identify the benefits of using lean construction. There is a vast difference of the results obtained in Saudi Arabia as opposed to those reported in South Africa. The Saudi Arabian study reported on organization's benefits of using lean construction, while the South African study identified benefits of using lean in the South African construction industry. Benefits identified by Oke et al. (2016) includes: Lean construction focus on continuous improvement, lean promotes two-way communication, lean improves the quality of services and lean promotes team planning, just to name a few.

2.18.3 Drivers and /or Enablers of lean construction implementation

A study by Ogunbiyi (2014) identified various drivers of lean such as waste elimination, process control, flexibility, optimisation, people utilisation, continuous and efficiency improvement and value to customer were identified as some of the drivers of lean. The study identified a number of internal and external drivers of lean in organisations. The drivers were identified through interviews and reported competitive advantage as a key driver in implementation of lean in an organisation. Perhaps in a South Africa context such a direction could prove successful if contractors could be drivers of change in lean implantation in their organisations. Since contractors are all about profitability, that in itself is an enablers for lean adoption. Contractors are under enormous pressure to improve their operations and thereby forced to adopt new ways of executing projects. Several studies have revealed empirical data of lean being used as a competitive advantage in an organisation (Billesbach, 1994, Oliver et al., 1996, Taleghani, 2010).

Moreover, respondents identified continuous improvement as one of the drivers in implementing lean in their organisations. Organisations are striving to eliminate waste in all their systems and employ continuous improvement as a culture embedded in their practice. According to Mossman (2009) lean thinking application require long term thinking. When implanting lean, the philosophy of continuous improvement plays vital role in achieving success. Ogunbiyi (2014) additionally identified the following driver of lean implementation in an organization: business pressure through cost reductions. Competitive pressure will force organisations to strive to achieve agility as a response to such pressures. Moreover, meeting customer needs was deemed important for organisations to continue to build business relations with the client. Ballard et al. (2007) carried out case studies of the early adopters of lean in the construction industry to identify drivers of lean at project level.

2.19 CONCEPTUAL AND THEORETICAL PERSPECTIVES

2.19.1 Introduction

A conceptual model is the current version of the researcher's map of the phenomenon under investigation (Miles and Huberman 1984). It provides a theoretical overview of a researcher's proposed study and order within the research process (Weaver-Hart 1988). Jabareen (2008) contends that the main functions or objectives of a conceptual framework are to help a researcher refine the research goals, develop a realistic or relevant research problem and questions, select appropriate methods, and identify the prospective validity threats that may come up in the conclusion section of the research. Robson (2011) adds that a good research conceptual framework is expected to be constructed, not found.

Based on the assertions of the above-mentioned researchers, value forms the initial part of the process of improving project performance and eliminating non-value-adding activities.

2.19.2 Theoretical lenses

In this chapter, existing cost management processes are examined and observed in order to make sense of the status quo and identify lean opportunities. Furthermore, the lean construction cost management model is about enabling a contextual understanding of the existing processes within the infrastructure delivery system. The rationale is to examine the nature of the current processes of cost management of infrastructure delivery and identify inefficiencies and ineffectiveness to infuse lean principles from inception to completion of projects only. Upon the identification of the non-value adding activities, the study aims to propose a conceptual framework suitable for cost management of infrastructure projects for the public sector in South Africa.

2.19.2.1 Theories to move from traditional thinking to lean thinking

McGregor (1960) argued that the basic belief of managers had great influence on how the organsations are operated, and assumptions about the behaviour of people are at the centre of this thinking. With respect to the workforce attitudes towards a transformation from the traditional thinking to moving beyond lean thinking, it is necessary to apply motivational throries to achieve the objective. Moreover, Mc Gregor (1960) maintains that the assumptions made by managers about the workforce fall into two borad categories of theory of X and theory of Y.

2.19.2.2 Theory of X and theory of Y

Theory of X had basically three propositions according to (Forbes and Ahmed 2010). These propositions are:

a) Responsibility of organising the elements of productive enterprise in the interest of economic needs lies with management.
b) To fit the organisation’s needs management has to direct the efforts of the workforce, motivate them, contro,their actions, and modify their behaviour.
c) Workers puts little effort to doing their job and lacks ambition and prefers to be led. Moreover, workers are resistant to change and are negative towards the needs of the organisation.

However, these theory of X was adavanced with the philosophy of theory of Y that made a shift from treating the workforce as children to treating them as mature adults (Forbes and Ahmed 2011). Lean construction requires that production workers be trained on management techniques, but theory of Y does not possess such an expectation (Forbes and ahmed 2011). Based on the expectation of lean from production workers the theory of Y does not seem suitable for this study as lean requires commitment from workers to carry out their assignments. Moreover, the theory of Y does not guarantee that learning has taken place from moving from the traditional thinking to lean thinking. In a South African context simply moving a workforce from their traditional thinking to a new thinking requires incentives and learning hs to happen from an individual’s perpective and be self directed in order to achive success because our thinking is mostly what it is today (Daszko and Sheinberg 2017). A different culture is a necessity when it comes to a lean concept, coupled with lean coaching of leaders at all levels which is may seem to illustrate management lead paradigm shift and this notion might actually push workers back to a theory of X due to workers’ uncertainty of the future. Again theory of Y makes an assumption that the workers are positive towards achieving the goals of the organisation without any measurement whatsoever Hanson (2003), and assuming such for moving from the culture of traditional practice by the workforce to lean thinking will require much more than just an assumption. In conclusion manangers have come to understand that either theories might be right in particular situations Ndlovu (2009), and that poses a complication in the usage of this theories in this study. Somewhat a transition had totake place and eventually transform the workforce from sate A to state B was considered the necessity to achieve success.

2.19.2.3 Transformation theory

Mezirow (1990) defines transformation theory as theory of adult learning addressed to teachers. Daszko and Sheinberg (2017) refers to transformation as change in form, appearance or structure. Mezirow (1990) belives that as adults we have developed a set of believes about the world, other people and ourselves. Morevover, these belief systems serve as boundary structures for perceieving and understanding new information. They further develop into our frame of reference and they affect how and what we learn as adults. This then situates adut learning distinctive from that of learning in childhood.(Mezirow 1990). The “meaning perspectives” are immensely weightedd by the progression of children attaining the culturally set of tenets and principles considered vital to become a fully accountable adult meaning to learn through social interaction (Mezirow 1990). The most significant developmental task of adulthood is this transformative learning of an individual being full capable of critically examining these taken for granted belief systems (Mezirow 1990).

For an effective transformation in the context of management of organisations and systems it first has to commence with the individual and then to the organisation. Daszko and Sheiberg (2017: 1) clearly defines transformation as “the creation and change of a whole new form, function or structure. To transform is to create something new that has never existed before and could not be predicted from the past. Transformation is a “change” in mindset”. Also, transformation is said to be continuous and cannot be recognised as the cycle is unknown. According to Daszko and Sheinberg (2017) only few individuals really understands transformation and why there is an imperative for transformation, not merely an incremental or transitional change. Moreover, there has been considerable confusion of what transformation is to any kind of change, technology breakthrough, innovation, process improvement or transition. Transformation theory depends largely on the leadership and profound knowledge and if it fails then so does transformation (Daszko and Sheinberg 2017). Lean construction is a novel approach in South Africa, so there might be minimum support for coaching of the organisations to fully comprehend the phenomenon and applications for achieving success.

This study requires individual adults to learn and self direct to change from the traditional thinking to lean thinking - means individuals will make a choice of to either hold on to their tradition, make an incremental change to avoid rocking the boat (Daszko and Sheinberg 2017). This is a content stage for the workforce, complacent, and arrogant or unaware. The amount of change expected from individuals at this stage depends on waves made by competition. the workforce tends to measure the time they have before they are forced to change by how many years they will survive in the current state. And if the workforce decides to move to the next level of change, yet be safe, they will make transitions and change from state A to stage B. Changes at this time are usually planned and the work plan is changed. In the end the most difficult and challenging strategy will be adopted by the workfore because change is imminent.(Daszko and Sheinberg 2017). The construction industry in South Africa is used as a vehicle for job creation and communities tends to play a major role in dictating terms of the projects unders the auspices of the public sector projects. Moreover, transformation is motivated by survival. Leaders often lead in a direction where the "destination" is unknown.

2.19.2.4 Theory of Project Management

Project management (PM) has been in existence since the days of the Egyptian pyramids or the Tower of Babel; the Manhattan Project in the 1940s is considered the first application of project management, as it is known currently, with separation of responsibilities between project manager and functional manager (Almeida, 2017). The use of PM has, however, only become fashionable since the mid-1990s (Meredith and Mantel Jr. 2011).

Munns and Bjeirmi (1996) define PM as the process of controlling the achievement of the project objectives, through employment of the existing organisational structures and resources, by applying a set of tools and techniques. Similarly, the PMI (2013) defines PM as "the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements". This conceptualisation can be supported by arguing that PM aims to meet the project objectives throughout five process groups or phases. These five process groups are initiating, planning, executing, monitoring and controlling, and closing (PMI, 2013). Finally, Meredith and Mantel Jr (2011) suggest that PM provides an organisation with tools to improve the ability to plan, implement and control the ongoing activities. Although conceptualisations of the concepts of the project and PM are oriented towards completion of an endeavour, the term "project" denotes selection of an activity or task to benefit the company, while the term "PM" refers to planning and control (Munns and Bjeirmi, 1996).

In the 1990s, traditional project management received increased criticism for its lack of impact and benefits (Aziz, 2013). Moreover, (Morris, 2010) contends that project management theory remains "stuck in a 1960s time warp". Barnes, 2002) connotes that a theory-based approach is necessary for developing project management further:

> We enthusiasts for project management have a choice. We can already manage projects well – not always, but we know how to do it. One route is for us to let the science stabilize and to concentrate on broadening its range of application – applying currently defined best practice. The other route is development of the science itself letting its application go where it will. Choosing the first route is likely to lead to the end of project management.

Following a similar line of thinking, Koskela and Howell (2002) dispute that "the underlying theory of project management is obsolete". Harsh criticism is evident, but this criticism may also become the primary basis for identifying new ways of managing projects and/or integrating existing ways for managing projects. As mentioned by Winter and Szczepanek (2008), the pattern now emerging in research on project management around the world is one of increasing concern about the relevance of conventional project management theory and how it relates to the growing practice of managing projects across different industry sectors.

2.19.3 Integrated Project Delivery

The construction industry had trouble with large projects dating back to the 1960s, and as a result, the construction project management originated as a response to remedy productivity issues (Forero et al., 2015). The traditional design-bid-build model used in the 1960s by the United States experienced inefficiency and capacity problems for large projects Forero et al. (2015), hence the country began to shape idea of establishing the concept of construction management as a solution to overcome such problems. Owing to such development Forero et al. (2015) opines that design-build model later emerged entailing in awarding the design and construction processes to a single entity, providing security improvements for the client on costs and time objectives. Likewise, Sakal (2005) asserts that the Australian construction industry also commenced to use Project Alliancing through collaboration, team work and group goals, looking forward to the project development. Excellent results were reported in each of the project were the approach was implemented, initiating the solution and arriving to the United States where it was called Integrated Project Delivery or IPD (Forero et al., 2015).

The definition of IPD according to the American institute of Architects (AIA) as a “focus of Project execution integrating people, systems, business structure and practices inside a process that collaboratively takes advantage of talents and ideas of all the involved, reducing waste and increasing the efficiency through the design, fabrication and construction stages” (AIA 2007: 5). One of the pioneers in the field is Sutter Health and Will Lichtig (2006), and they have documented their lean journey and described it the chapter “The Integrated Agreement for Lean Project Delivery” of the book “Improving Healthcare through Built Environment Infrastructure”. In which, they also pronounce the five big ideas of Sutter Health’s Lean Project Delivery (figure 2.8) and the integrated form of agreement used in IPD projects.

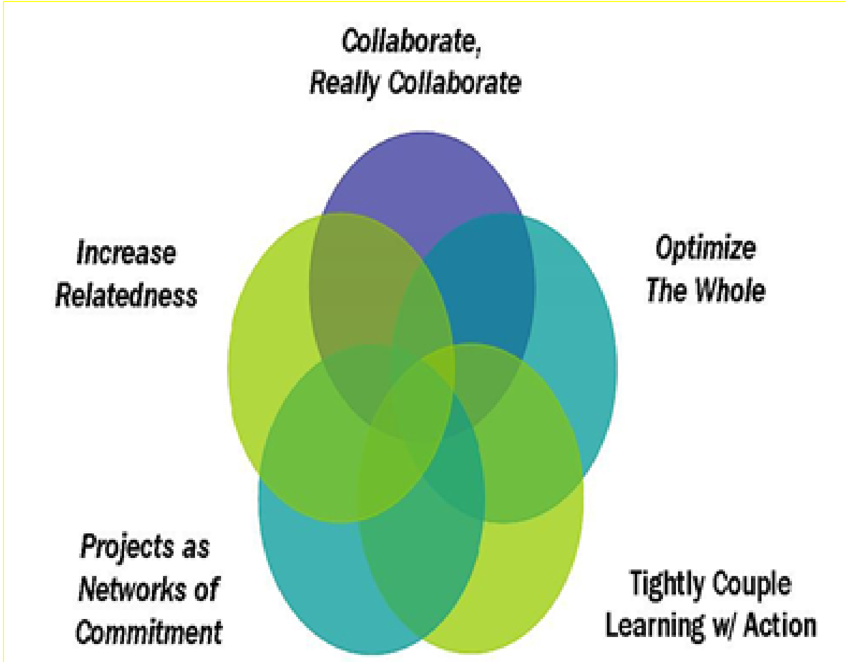


Figure 2.8 The Five big ideas of lean project Delivery (Source: Lichtig, 2006)

Interestingly enough Ibrahim (2013) argues that the whole industry has not reached a consensus regarding the IPD definition. Consequently, Villanueva (2018) contest that although the definition remains elusive, and an ongoing development from some authors have proposed the following definitions in the literature illustrated in table 2.13.

Table 2.13 definition of IPD from different authors

Author	**Definition**	**Authors supporting the same definition**
AIA/AIACC (2007), AIA (2009)	"IPD is a project delivery approach that integrates people, systems, business structures, and practices into a process that collaboratively harnesses the talents and insights of all project participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction".	AIA, 2007; Sarkar and Mangrola, 2016; Pishdad-Bozorgi and Beliveau, 2016a; Khemlani, 2009; Ballard et al., 2012; Mah et al., 2016; Zhang et al., 2015; Kim et al., 2016; Teng et al., 2017; Forero et al., 2015; Duke et al., 2010; Ke et al., 2015; Sun et al., 2015; Moynihan and Harsh, 2015; Azhar et al., 2014; Nawi et al., 2014b; Zhang and Li, 2014; Rached et al., 2014; Alp and Franz-Joseph

		vonWerssowetz, 2013; Aapaoja et al., 2013; Zhang et al., 2013; Melo et al., 2013; Smith and Rybkowski, 2012; Tillmann et al., 2012; Aapaoja et al., 2012; Nanda et al., 2016; Gokhale, 2011; Ghassemi and Becerik-Gerber, 2011; Kent and Becerik-Gerber 2010; Zhang and Wang, 2009; Gupta et al., 2009
Cohen (2010)	"IPD is a method of project delivery distinguished by a contractual arrangement among a minimum of owner, constructor and design professional that aligns business interests of all parties. IPD motivates collaboration throughout the design and construction process by tying stakeholder success to project success and embodies contractual principles and behavioural principles".	Cohen, 2010; Cheng et al., 2012; Pishdad-Bozorgi and Beliveau, 2016a; Mossman et al., 2010; Collins and Parrish, 2014; Cho and Ballard, 2011; Ghassemi and Becerik-Gerber 2011
AIA (2014)	"IPD is defined as a project delivery method that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to reduce waste and optimize efficiency through all phases of design, fabrication and construction"	AIA 2014; Hall, 2017; Fakhimi et al., 2016; Ma et al., 2017
Mossman et al., (2011)	"IPD has emerged from rethinking the end-to-end design, construction and use where value is the raison d'etre and	Mossman et al., 2011; Mossman et al., 2010

	it works when individuals make and keep commitments”	
Cheng et al., (2016)	“IPD is a contractual project delivery method used by project teams that created shared risk/reward structures, fiscal transparency, and release of liability”	Cheng et al., (2016)
Liu and Bates, (2013)	“IPD is a trust-based, risk and reward sharing, highly collaborative system with open communication and transparent accounting strategy”	Liu and Bates, (2013)
Anderson, (2010)	“IPD as a business model for design, execution, and delivery of buildings by collaborative, integrated and productive teams composed of key project participants such as designer, client, contractor, manufacturer, and supplier”	Anderson, (2010); Nawi et al., (2014b)
El Asmar et al., (2013)	“IPD as an emerging construction project delivery system that collaboratively involves key participants very early in the project timeline, often before the design is started. IPD is defined as a delivery system distinguished by a multiparty agreement and the very early involvement of key participants”	El Asmar et al., (2013); El Asmar et al., (2015)
Ballard, (2000a)	“LPDS is envisioned as a project delivery method that conceptualizes design and construction projects as lean production systems”	Ballard, (2000a); Khanzode et al., (2006)

Matthews and Howell, (2005)	"IPD is an alternative project delivery that supports aligning interests, objectives, and practices, and it explicitly promotes shared risk and reward and extensive collaboration between project parties"	Matthews and Howell, (2005); Kim et al., (2016); Teng et al., (2017); Sun et al., (2015)
P2SL Glossary	"A delivery system that seeks to align all project team members' interests, objectives, and practices (even in a single business), through conceiving the Organization, Operating System and Commercial Terms governing the project. Team members would include the architect, key technical consultants as well as a general contractor and key subcontractors. It creates an organization able to apply the principles and practices of the Lean Project Delivery System"	P2SL, (2018)
P2SL Glossary	"A delivery system that seeks to align interests, objectives and practices, by reconceiving the organization, operating system and commercial terms governing the project. The primary team members would include the architect, key technical consultants as well as a general contractor and key specialty contractors. It creates an organization able to apply the principles and practices of the Lean Project Delivery System."	LCI, (2017)

Adapted from Villanueva (2018)

IPD necessitates a paradigm shift that supports lean thinking throughout the entire lifecycle of the project (Lichtig, 2006, Azhar et al., 2014, Nanda et al., 2017, Naney et al., 2012) and most definitions support this statement. Moreover, a suggestion by Khanzode et al. (2006) that the lean project delivery system or integrated project delivery system offers a framework to structure the project in a way in which the lean ideal and principles will be better implemented.

The method of IPD is hailed for its ability to improve cost and time results in a project (Forero et al., 2015). In addition, the method is legendary in nurturing individual work of all involved parts where the traditional idea of searching an individual goal is eliminated and it is replaced with objectives and guidelines focused in a common goal, the project profit and the value creation for the involved stakeholders. Kent and Becerik-Gerber (2010) reports that the AIA proposes the following as key principles of IPD: trust and mutual respect, shared risk and reward, collaborative innovation and decision making, early involvement of the key participants, early definition of the goals, intensified planning, open communication, organization and leadership and multiparty agreements.

According to Forero et al. (2015) IPD resonates with project information sharing and provision of ease of access for all team members. Technology plays a crucial role in supporting with efficiency and intelligent means of communication; hence, Building Information Modelling (BIM) is one of the main components necessary to execute IPD projects in ensuring the team can visualize the project early on and through detail model coordination. The application of IPD in executing projects resonates with the aim of this study to develop a collaborative cost management framework for the South African construction industry. IPD has made significant progress for the construction industry with estimated savings of 30% (UKOGC 2007) if construction costs by stimulating stakeholder's teamwork and profit. One of the enablers of IPD is on a Design-build contract where all the stakeholders are present. IPD encourages all parties' involvement in the early stages of the project Teng et al. (2019), and reaching a multiparty agreement. This can be achieved by sharing the risk and reward through collaborative behaviour (Kent and Becerik-Gerber, 2010). Despite the benefits of IPD in construction projects, (Forero et al., 2015, Matthews and Howell, 2005) number of projects using IPD remains small (Sive, 2009). This study aims to improve project outcomes through a collaborative approach of aligning incentives with goals of a project team, with the aid of a delivery method named integrated project delivery (IPD). IPD has contributed to improvement and controlling cost, time and quality. Teng et al. (2019) affirms that IPD model development is promoted through a strategy of a fair and rewarding profit or cost savings distribution scheme.

2.19.4 Cost management process model

Figure 2.9 is a cost management model developed by Kern and Formoso (2004) for the general cost management process for the Brazilian building industry. Focus of the model is mainly on improving the technical aspect of the building industry in Brazil. The model was developed through case studies of building projects consisting of low cost housing projects. This model depicted in figure 2.9 relied on the platform of the conventional cost management systems process and was used by the researchers to revise the model to figure 2.10.

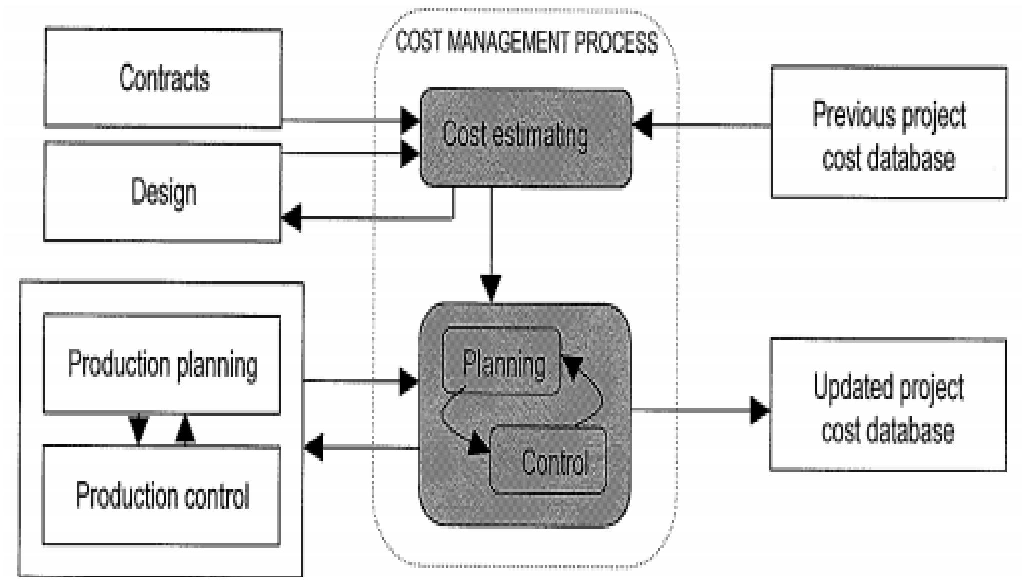


Figure 2.9: Cost management process model
Source: Kern and Formoso (2004)

Target costing, operational estimating and S-curve were the techniques integrated into extant conventional cost management process model depicted in figure 2.11. Target costing encourages making decisions early on project designs, supply chain and production system design (Obi, 2017). The decisions made must consider establishment of target cost for the project during the planning and estimating stages (Obi, 2017). By integrating target costing, the model developed into the cost management system. The operational estimating technique uses the information from the design and planning programme to advance activity costs and evaluate the effect on target project costs and interval. The S-curve technique used in the cost planning and control sub-process, help in monitoring, forecast, and control of cost resources at numerous milestones on the project (Obi, 2017). An area of strength for this framework as viewed by Obi (2017) is succeeding in detailing some technique processes and implementation success factor drivers in a cost management system reflecting the project delivery phases. On the other hand, the study was conducted over 15 years ago and could not withstand the current challenges and strategies used in South Africa in Infrastructure projects, and secondly, could not distinguish the system input from process and outline their relationships and the success factors to maintain implementation (Obi, 2017). Although the integrated CMS model covered the entire life cycle of the project from inception to completion, model was designed for low cost housing projects, which there is a vast difference between them when compared to infrastructure projects.

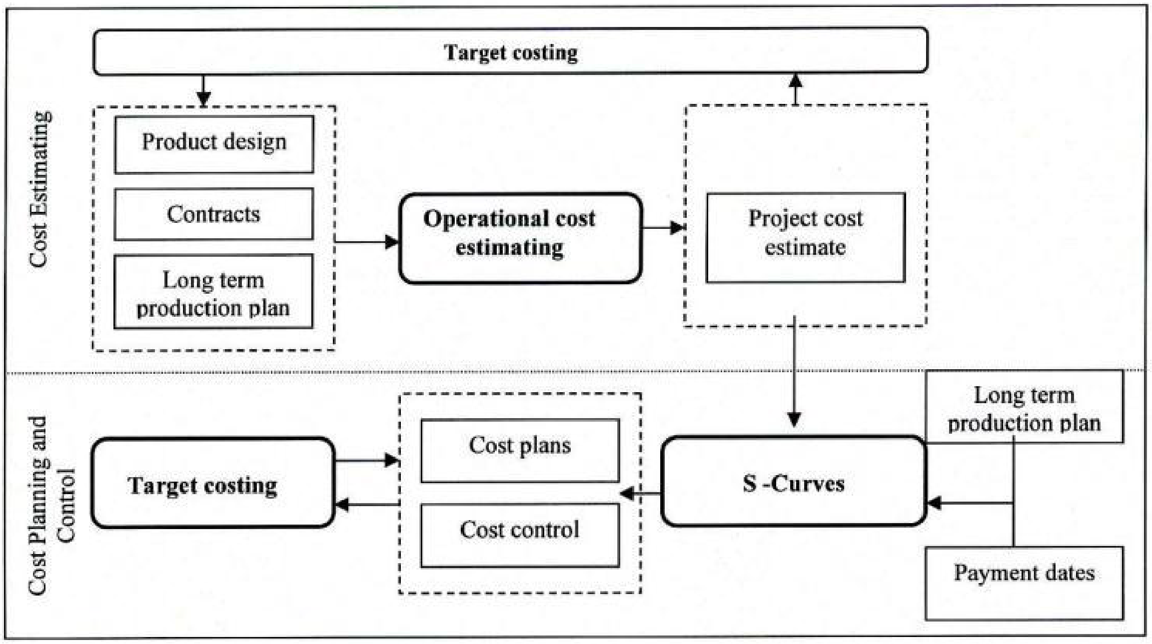


Figure 2.10: Integrated cost management model
Source: (Kern and Formoso, 2006)

2.19.5 Target costing Framework

Jacomit and Granja (2011) attempted to improve the cost management system of Brazilian low cost housing projects and developed the target-costing framework depicted in figure 2.11.

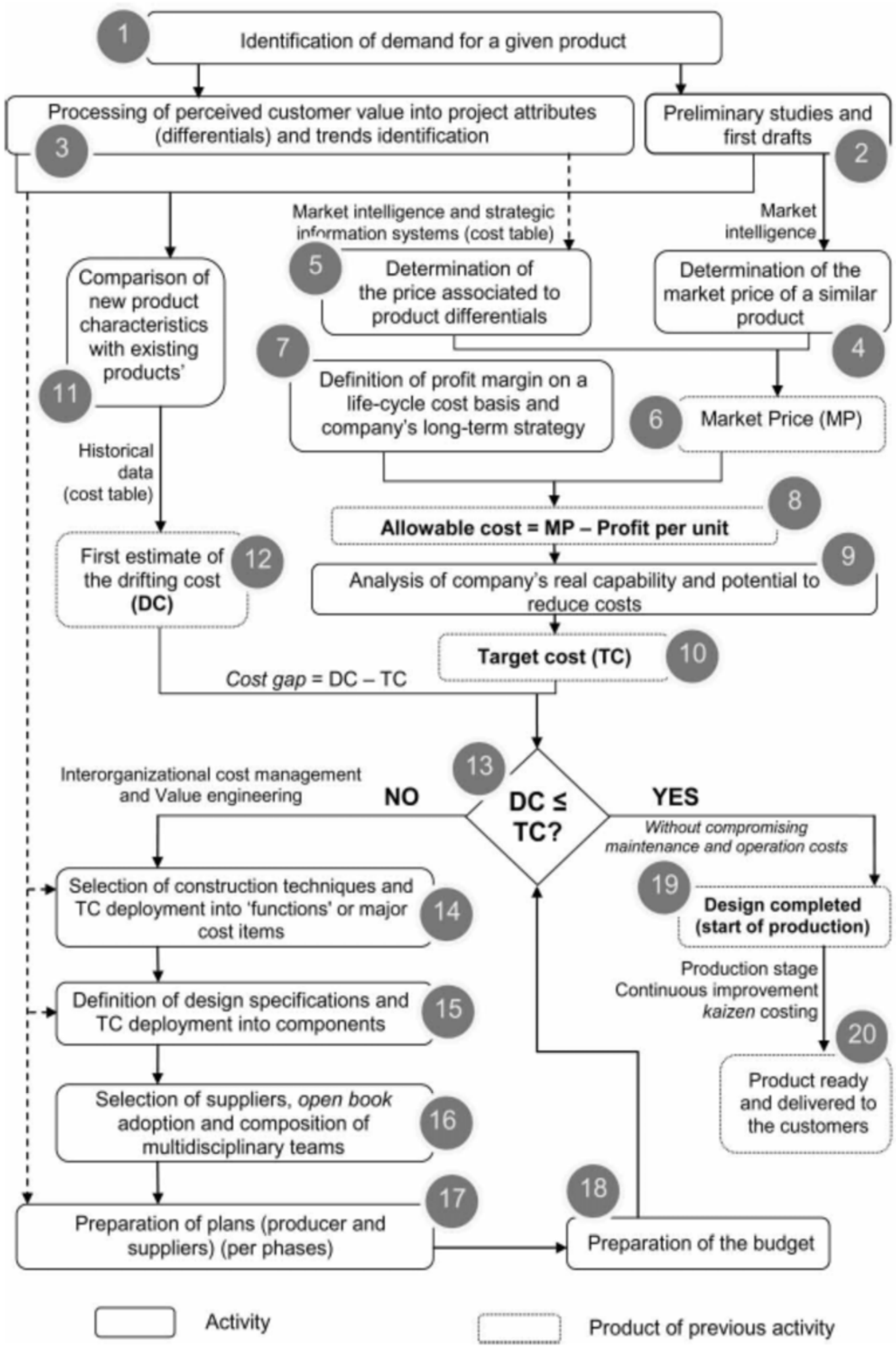


Figure 2.11: Target costing framework
Source: Jacomit and Granja (2011)

Target costing framework was integrated in the cost management system to improve the project cost performance of the Brazilian public social housing. According to Jacomit and Granja (2011) Target costing served as an improvement in the technical considerations of the extant cost management system. Due to low cost housing having standard and replication of the design, those were identified as opportunities for TC adoption. However, the bidding process and the outsourcing design will reduce the applicability of TC on projects. Consequently, infrastructure projects are unique and their complexity increase in size. TC framework provided detailed implementation in the planning stages of the cost management process; however, the model is not comprehensive in its details about the production stages of construction.

2.19.6 Collaborative costing Model

The aim of the collaborative cost management is to ensure that the design process is waste free steering design to cost, fully collaborating down to production as well as clearly defining the owner project requirements and value streams to achieve the success requirements of the project (Namadi et al., 2017). Moreover, the lean thinking and practices such as lean project delivery system, building information modelling, big rooms, pull planning among others; have well integrated the idea of collaborative costing. Figure 2.12 below illustrates the integrated team formation early on, and this in turn validates the cost target in relation to the allowable costs wishes of the client Namadi et al. (2017), this limits the stakeholders to operate within the confines of the market.

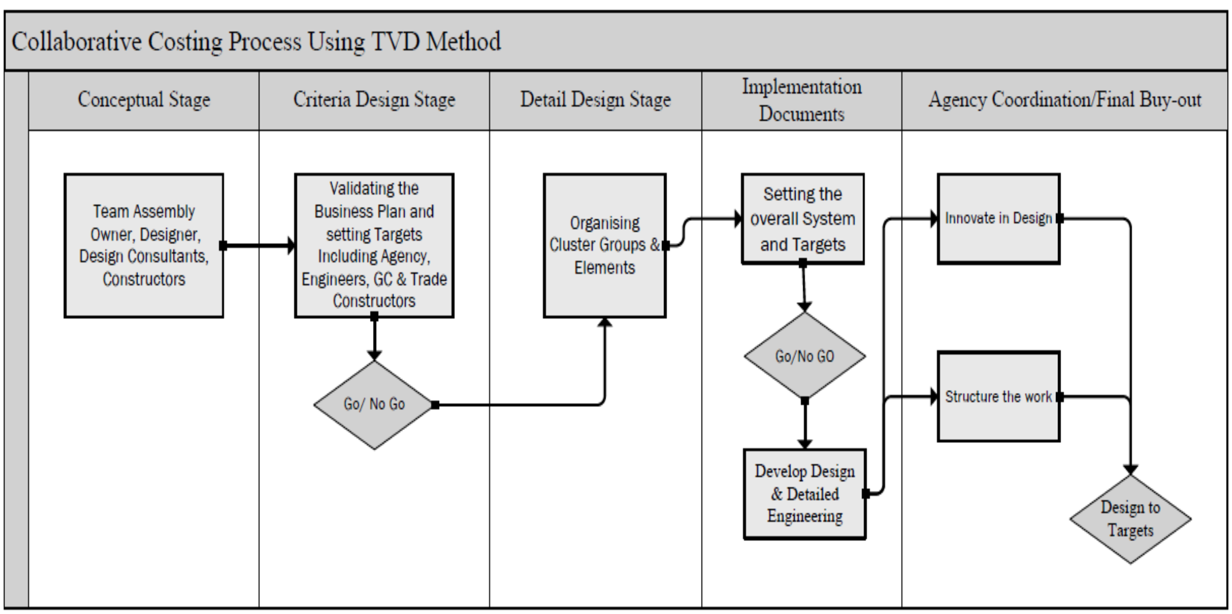


Figure 2.12: Collaborative costing model using TVD
Source: Namadi et al. (2017)

Collaborative costing model has been used as a matured approach in collaborative costing that continue to strive and change cultural behaviours, identify values, and waste during cost management processes (Namadi et al., 2017). The model is suitable for infrastructure projects and developed recently as well. The strength of this model lies in being able to support a more collaborative costing approach and significantly, the customer is not the only client to the project as all information sharing happens early on. Moreover, the cross functional teams manage the costs together with the supply chain during the product design (Namadi et al., 2017). However, it is notable that the model emphasize its contribution to the design stage of the construction projects and no mention of its contribution beyond the planning stage of the projects. The study admit to using TVD alone for collaborative costing approach, emphasis being on costing rather than cost management. Namadi et al. (2017) recognises "other approaches such as IPD that integrates that integrates people, systems, business structures and practices into a more collaborative process to optimize project results and increase value, reduce waste and maximize efficiency throughout the phases of design, fabrication and construction" (Namadi et al. 2017:8). This study attempts to employ TVD together with IPD approach, which is a more comprehensive method when compared to the usage of TVD alone. Additionally the model is not comprehensive especially in the decision phases, no clear indication that steps to take if the gate closes due non-compliance and suggesting going back. For example in the criteria design stage of RIBA, the model applies a Go/No, but this process does not clearly indicate which stage to go back to? Hence, this study possess some limitations for application in a South African context.

2.19.7 Profit Distribution framework (share risk and reward in no blame culture)

The expectation of IPD projects is to foster a participative process in all phases of the construction project and expand the design of the project and explore diverse means to achieve the project' objectives (Tillmann et al., 2012). Team success ties to project success and manages risk jointly and properly shared generating an environment where everyone aims to reach the project targets (Mossman et al., 2010, Gupta et al., 2009). Numerous authors (Hanna, 2016, Sarkar and Mangrola, 2016, Cheng and Johnson, 2016, Pishdad-Bozorgi and Beliveau, 2016a, Teng et al., 2019) propose a framework of profit distribution in IPD projects based on cooperative game theory. Figure 2.13 beneath is employed to Cathedral Hill project as an example were shared risks and their associated costs are allocated amongst the same pool members and an incentive scheme mechanism was employed (Parrish et al., 2008). Construction projects requires people with dissimilar expertise to advance the objective of the projects collectively. In view of Sumner and Slattery (2010) a no blame culture in such environment and organizations foster confidence and allow people to speak up and feel safe to express concerns and continuous learning while doing.

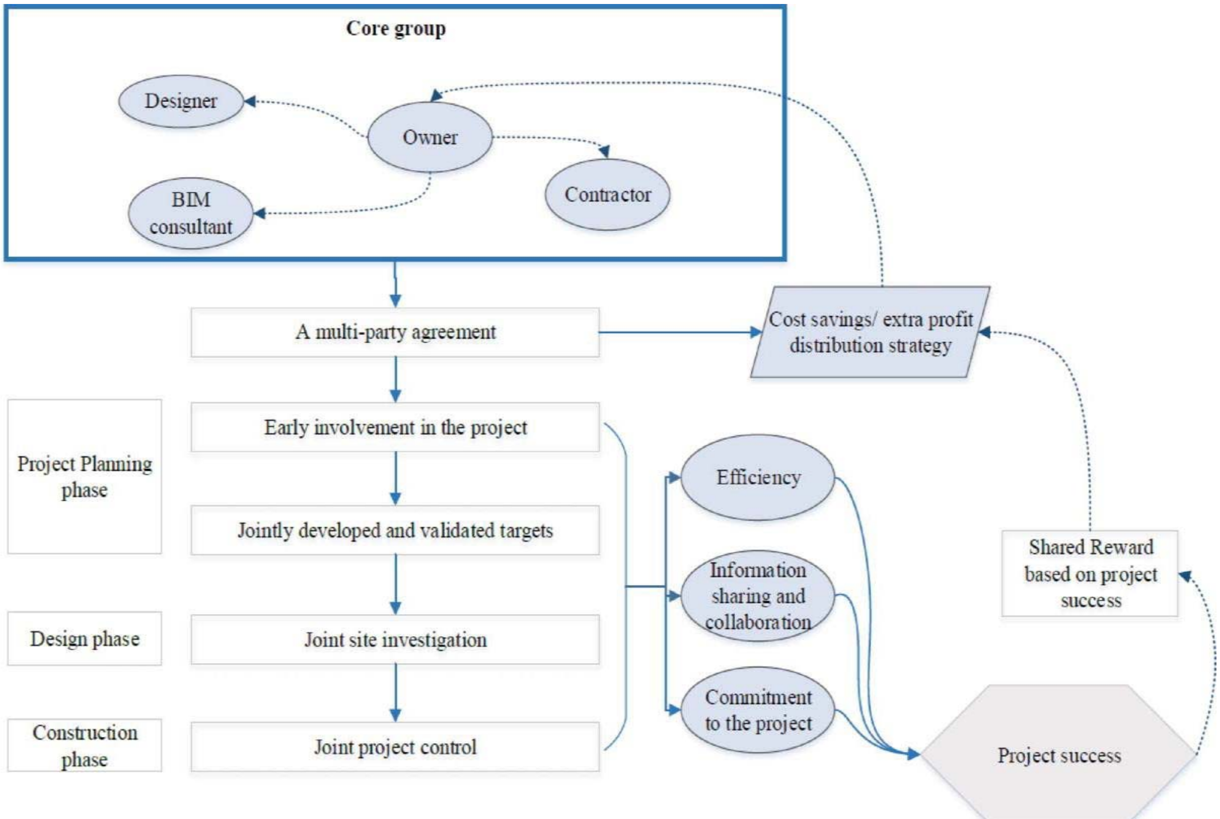


Figure 2.13: A framework of profit distribution in IPD projects based on co-operative game theory

Source: (Parrish et al., 2008)

Empowering stakeholders plays a critical role in encouraging collaborative approach for making key decisions as it enables all team members to feel a sense of belonging and aim to get more involved in work discussions (Pishdad-Bozorgi and Beliveau, 2016). Moreover, the project structure of the IPD depends on the scope of the project and the size of the organization involved (Teng et al., 2019). Figures 2.14 and 2.15 respectively display a summary of the various governance structures in an integrated project such as the IPD leader, cluster teams, core group, and the senior management team. Both figures aim to assist readers comprehend how one group integrates the others in some way, showing the high interdependency between project stakeholders (Villanueva, 2018).

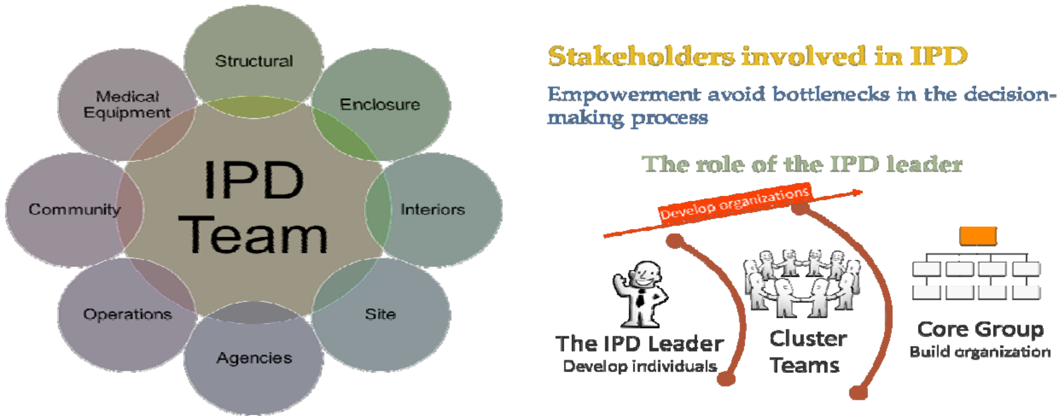


Figure 2.14 Project Governance Structure in IPD Teams (After Do et al., 2005. "The Application of Target Value Design in the Design and Construction of the UHS Temecula Valley Hospital")

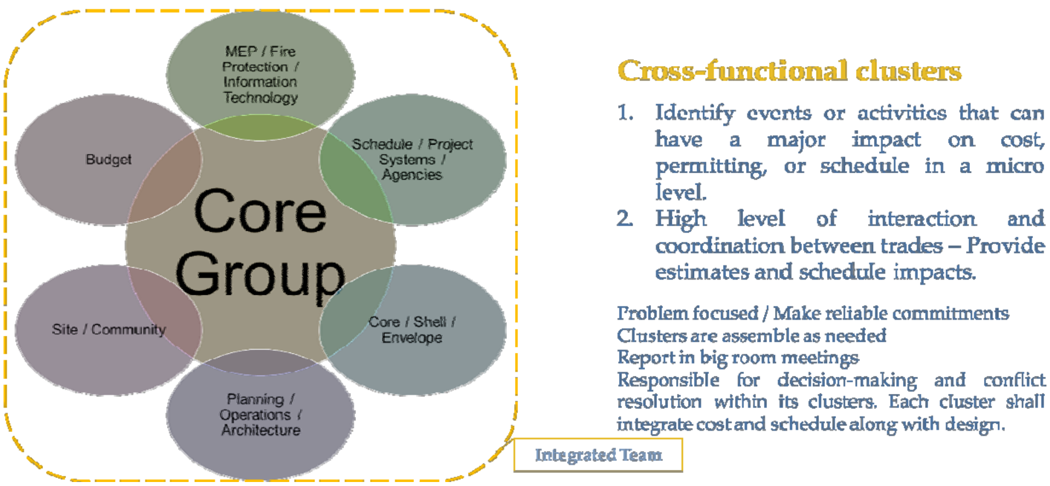


Figure 2.15 Project Governance Structure in IPD Teams (After Do et al., 2005. "The Application of Target Value Design in the Design and Construction of the UHS Temecula Valley Hospital")

As portrayed in the above figures IPD's structure is according to the type of project chosen and a core group and an IPD team is necessary to realise the objective of collaboratively aligning the team's goals. This type of practice bolds well with the existing design-build type of project present in the South African construction industry.

Value proposition

Value shares the same characteristics as efficiency, which is based on the preferred desirable outputs from resource inputs. Value is context-specific, relative, and subjective in nature (Salvatierra-Garrido et al., 2010). The measurable qualities (output) of infrastructure components are commensurate to the total cost (input) (Womack and Jones, 1996). Under the lean philosophy, continuous improvement of value has been the main pivot of the production process, thus value streaming by defining waste. Similarly, (Koskela, 1992) proposed transformation-flow-value model of construction management, a more integrated and balanced approach would aid value streaming and support elimination of non-value-adding activities through flow management (Koskela, 2000, Novak, 2012). Industry stakeholders and shareholders have different perspectives to the concept of value, all of which are embedded within a continuous value chain, and being part of the global system, value must be viewed in the context of both natural and social systems (Novak, 2012, Salvatierra-Garrido et al., 2010). These tensions between value drawers and systems add to the complexity of the construction industry. Hence, the future industry model is of a 'value-enhancing' construction process, which will transform the industry and support a transition to resource revitalisation and sustainable value creation in a competitive landscape.

Industry operators need a holistic approach to drive stakeholder and shareholder values, in order to create and sustain competitive advantage, through identification of new opportunities and the associated risks (Laszlo et al., 2005). Creating sustainable value is a way for industry to advance its business priorities, drive innovation, and achieve competitive advantage (Laszlo et al., 2005). The emergence of sustainable value can occur only through delicate balancing of opportunities and risks and creation of positive value for both shareholders and stakeholders, such as the clients and the communities. Managing the two dimensions is fundamental to industry performance and a sound sustainable model (Laszlo et al., 2005). Ultimately, stronger engagement and collaboration between shareholders and stakeholders leads to discovery of new sources of value, through innovation.

Value should be the template through which stakeholders navigate between natural and social systems to achieve a broader vision of sustainability (Du Plessis, 2007). The challenges of global infrastructural issues can be unravelled using value as an appropriate construct of change in the context of construction process improvements (Novak, 2012). However, in order for infrastructure values to be fully harnessed, the process of value creation should pass through the product life cycle (Bilec et al., 2009). Life-cycle assessment (LCA) is essential for infrastructure risk aversion – and more so when considering the general barriers to infrastructure sustainability uptake of costs and affordability. One of the pioneering works of Corfe (2013) earlier demonstrated the lean integrated value stream through the project life cycle (see Table 2.14). Lean integration created value throughout the project life cycle, and a holistic infrastructure evaluation is best carried out across phases of the life cycle (Pearce and Ahn, 2017).

Table 2.14: Infrastructure value stream through lean integration

Project life cycle	Lean integration value stream
Brief	Define the 'value' of the project, including performance and sustainability criteria; identify user needs.
Concept	Develop the best concept to meet the value; bring together specialists to define areas for innovation; define systems and set concept design to optimise criteria.
Develop design	Develop the construction design, the collaborative design, and integration of value; develop the programme and define key quality and hold points.
Production	Manufacture of off-site elements and components; control of quality and supply; multi-discipline and supply chain integration, to develop optimal systems.
Installation	On-site operations; monitor and improve efficiency and resource use; collaborative working to improve delivery and reduce waste.
As constructed	Commission and handover period; integration with client and end-users, learning from output performance against as planned.
In-use	Monitoring and efficient use of building and systems; feedback and review of actual performance, learning into future projects.
Deconstruct	Optimise reuse and recycling of components; learning into future projects; efficiency of the deconstruction process.

Adapted from Corfe (2013)

2.19.8 Need for Lean Construction Cost Management Model in South Africa

Tanaka et al. (1993) clearly define project cost management as the process that comprises of initiating and making decisions that will improve the cost-effectiveness of an organisation by understanding the concepts of cost within the context of their own business. Project cost management is fundamental to staying competitive in the construction industry and is defined as the process of planning, estimating, coordination, control, and reporting of all cost- related aspects of a project to ensure project completion within the approved budget (Kern and Formoso, 2006, Ashworth and Perera, 2015). Thus, project cost management is not about cost reporting, accounting or maintaining records of expenditure, but understanding what activities and associated cost will be incurred; why, how, and taking appropriate proactive actions in light of all the relevant related information. Hence, involves identifying all the costs associated with the various elements and activities in the project from predesign to design and the construction stages and managing those costs to ensure cost effective performance and achieve the maximum amount of work at a specified level of quality. A considerable low productivity has been reported as such in construction. The increase in productivity in construction has been much lower than that of other industries. The same can be said of the public sector in South Africa, since in many cases it has no competitor for the services it provides, and it is a supplier-led sector without much incentive to change (Bhatia and Drew, 2006). Adapting to new ways of doing business in the public sector is constrained by the rules and regulations related to the operational system, and this hinders any continuous improvement. Moreover, is value to the end user a factor frequently considered especially in the public sector? Innovative ways of solving this problem, such as lean and IPD, provide an opportunity for the South African construction industry to deepen its understanding of the challenges, to evolve realistic solutions.

A construction project is an inter-organisational process, which requires all stakeholders' contribution to achieve the goal of successfully completing the project within agreed constraints. According to Namadi et al. (2017), the current project delivery system still treats design and cost as a separate and independent function carried out discretely. Similarly, the United Kingdom (UK) and South Africa traditionally assign cost management duties to the chief Quantity Surveyor (QSs). Namadi et al. (2017) further reiterate that this practice of assigning cost management mainly to the chief QS accounts for much of the cost overruns that is prevalent in the construction industry due to its lack of collaborative approach to costing. The Quantity Surveying (QS) fraternity traditionally conduct cost management functions in South Africa (many other Commonwealth countries). The contribution of QSs has traditionally being to offer cost advice, assist with alternative designs solutions, providing cost estimates of preliminary designs and procurement using elemental cost planning and checking (Kirkham, 2014). In addition, (Ashworth and Perera, 2015) further list duties of the QSs to encompass post contract cost management tasks such as interim valuations, change control and to assess variations in final account. Quantity surveyors employ traditional cost planning. A study by Zimina et al. (2012) views traditional cost planning as ineffective and inadequate for effective cost management that produces value for money. The authors express their view as a challenge since the initial decision-making is solely dependent on the Architect rather than a collaborative decision making from all project participants. Thus, it is presumed that the reduced cost performances observed from public sector projects could be because of the lack of adequate techniques employed.

To attempt a remedy, using the principles underpinned by lean construction, as advocated by several authors (Ballard and Reiser, 2004, Forbes and Ahmed, 2010, Macomber et al., 2007, Nicolini et al., 2000), is the idea espoused in this study. The conceptual lean construction cost management model (LCCMM) in this study seek provide a holistic picture of techniques, processes and key implementation success factors apposite to drive effective cost management on public infrastructure projects. Moreover, to assist in shifting the current practice of cost management to a more innovative and sustainable construction practice appropriate for the South African construction industry especially the public sector projects. Based on the literature findings, it is the researchers initial thought that the relationship within the various components of the comprehensive cost management could be represented in the LCCMM as portrayed in Figure 2.16. It is expected that this conceptualisation of the LCCMM provide the researcher the prospect to evaluate the interactions of the various subsystems within contextual settings. Key

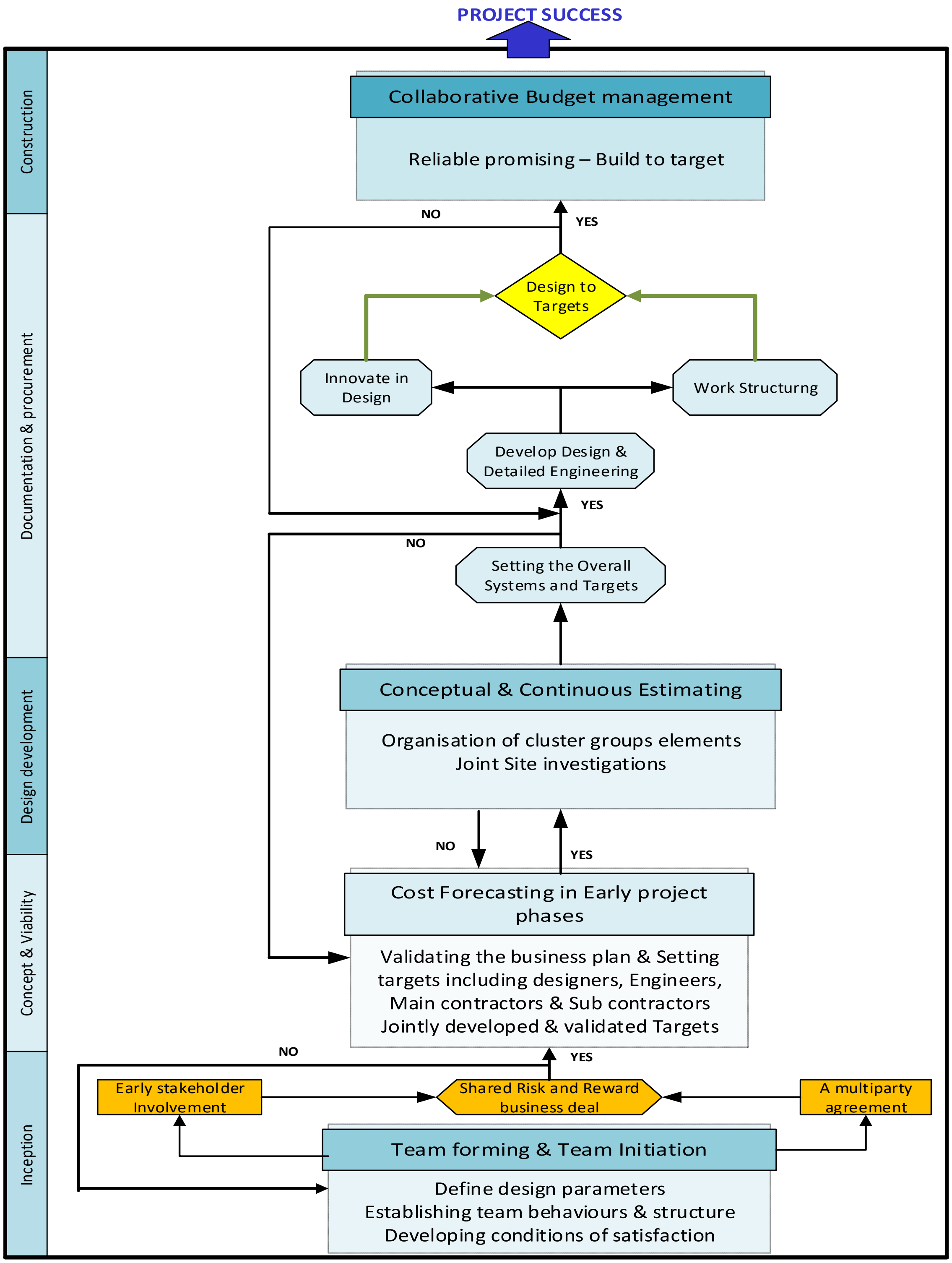


Figure 2.16: The proposed conceptual model for the study

The proposed model above comprise of the various lean construction tools available for application of a complete lean designed and constructed projects. However, application of all lean tools is not possible in a project due to the unique characters of each project. This study has however, able to infuse the following lean tools as depicted in the LCCMM figure 2.16 above:

1. Team forming and team initiation,
2. Early stakeholder involvement,
3. Shared risk and reward,
4. Cost forecasting in early project phases,
5. Conceptual and continuous estimating,
6. Work structuring and
7. Collaborative budget management

2.20 CHAPTER SUMMARY

Effective cost management is a key parameter, which could either bring confidence to the investor to continue with the investment or totally abandon it. Accurate estimation of costs is of the utmost importance, so that the investor is not deceived into investing in a scheme that will end up in bankruptcy. Therefore, in order to provide accurate guidance to the decision-maker in initiating and making their decision, it is very important that consideration of value, maximum accuracy, and reduction in costs achieved through every cost-estimation exercise. Estimation of projects has proved to have shortcomings in ensuring that clients possess an accurate forecasting of how much the project will eventually cost after construction. This creates the necessity to apply methods such as lean construction, to ensure a structured way costing the projects reflect the exact amount expected at the final account stage. The chapter has established the causes of poor cost and time performance. Then outcomes of existing cost models were outlined and lean project delivery and its tools narratively outlined. Lastly, the proposed conceptual model for the study was presented and depicted in this chapter as well.

CHAPTER 3
THE RESEARCH METHODOLOGY

3.1 CHAPTER INTRODUCTION

The aim of this chapter is to present the methods and the nature of the data collected to answer the research questions. The overall decision involves which approach should be used to study a phenomenon. Informing this decision should be the philosophical assumptions the researcher brings to the study, the procedure of inquiry (called the research design), and the specific research methods of data collection, analysis and interpretation.

As such, this chapter provides a justification for the philosophical stance that underpins the study. The structure of the chapter is as follows: first the research approach, the research strategy, the mixed-methods research methodology employed, and the justification for use of the selected research methods are stated. The chapter then explains the sampling method process, the data-collection methods, and the data-processing procedures, including the methods of data analysis employed in the study. The methodological framework on which the entire study is based is then explained. The expectation is that at the end of the chapter, the methodology applied in the data collection and analysis, and the rationale for the adoption of such a methodology, will have been adequately presented.

The purpose of research is to provide an answer to questions and attain new knowledge using a science-based tool. In this context, science is used as a method of study rather than the object of the study, consequently derived as a logical approach to acquire valid answers and obtaining new knowledge.

3.2 RESEARCH TECHNIQUE

To meet the objectives of the study it is essential adopt an appropriate research methodology. There are numerous conflicting classifications within the body of research methodology literature for describing the several components of such methodologies. Various researchers have used different classifications and expressions to define and/or describe the same components. For example, although Saunders et al. (2012) classifies deduction, induction and abduction as research approaches, Blaikie (2010) refers to them as research strategies. Due to the need to preserve a pronounced degree of uniformity during the course of this research study as it concerns the classification of the various components of the research methodology guidelines, this research relies solely on the taxonomy utilized by Saunders et al. (2012) as depicted in the research onion in figure 3.1.

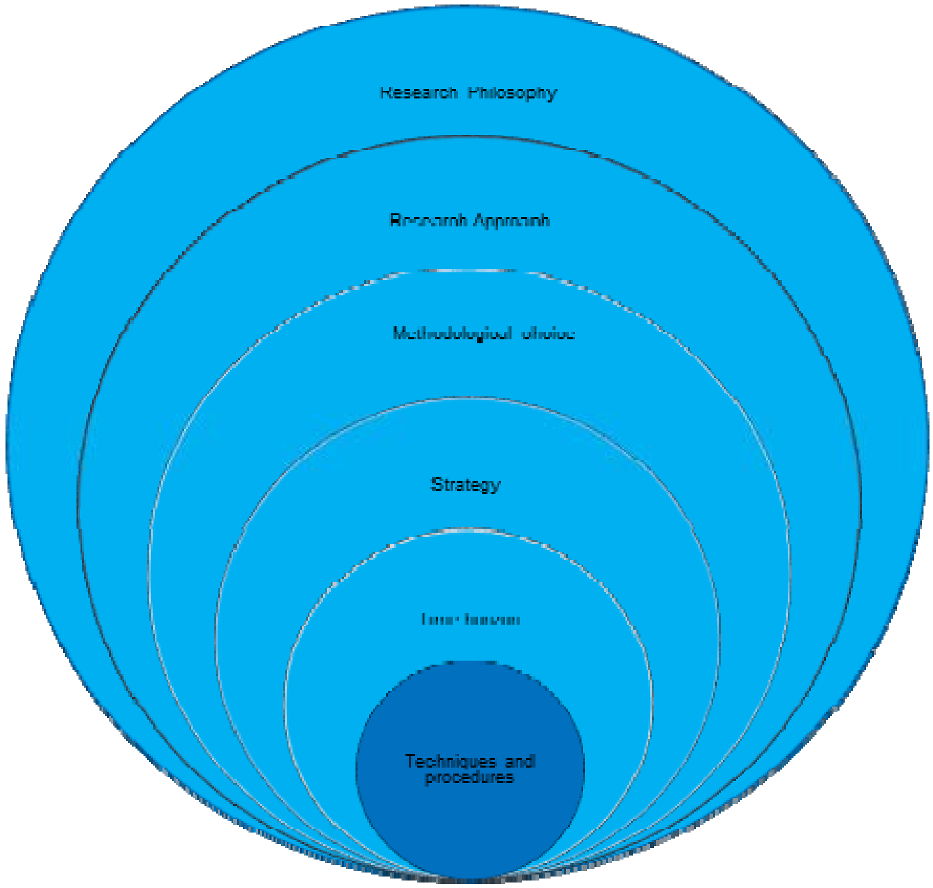


Figure 3.1 Research onion:
Adapted from (Saunders et al., 2012)

3.3 RESEARCH PHILOSOPHY

Bryman (2012) asserts that research philosophy suggests assumptions about different perspectives of the world, and that it informs the choice of research strategy and the procedure for executing the research. Therefore, in executing a research project, it is essential for the researcher to have a clear understanding of the general philosophical issues about research. Easterby-Smith et al. (2008) advance three important reasons why exploration of philosophy is significant to research methodology, namely:

- A good understanding of research philosophy assists the researcher to assess different methodologies and methods, with the view to avoiding wrong methodology and unnecessary work;

- It enables the researcher to carefully select the appropriate research methods, including the type of data needed and where to find it, how the data will be collected, analysed and interpreted, and how it provides answers to the research questions;
- A thorough grasp of research philosophy may aid the researcher to be creative in adopting methods that were previously outside the researcher's experience; this may also help to generate further questions on the subject being researched.

To select the appropriate philosophy for the research, it is vital for the researcher to recognise the influence of issues related to epistemology, ontology, and axiology for achievement of the set research objectives (Saunders et al., 2012).

3.3.1 Ontological considerations

Knight and Ruddock (2009) suggests that scientific inquiry of any kind is based on a particular paradigm, which can be described as a worldview. Ontology is defined as the study of the existence of things Slevitch (2011), or the study of being, i.e. the nature of existence (Gray, 2013). However, Bryman (2012) defines ontology as a theory of the nature of social entities, or it is assumptions that we make about the nature of reality (Easterby-Smith et al., 2008). Moreover, Bahari (2010) asserts that assumptions of ontology relate to the nature of the phenomenon to be explored, and that different ontology makes different assumptions. Reality is subjective and multiple as seen by the participants in the study, and Cunliffe (2011) suggest that assumptions about the nature of reality can be thought of in terms of the subjective-objective dimension (Bryman, 2012).

Subjectivism: Saunders et al. (2012) define subjectivism as understanding of the meanings individuals associate with social phenomena. This refers to the fact that social phenomena are created from perceptions and following actions of those social actors concerned with their existence, and this can be regarded as a continual process.

Objectivism: The objectivists believe that "social phenomena and their meanings have an existence that is independent of social actors" (Bryman, 2012). However, Saunders et al. (2012) define objectivism as how social entities exist independently of social actors. This means that the reality of social entities exists outside of social actors concerned with their existence. Briefly, it can be stated that for objectivists the social world is as concrete and real as the natural world (Bahari, 2010).

Constructivism: 'Reality' is not objective and external, but is socially constructed and provided with meaning by people (Easterby-Smith et al., 2008). The focus of a constructivist researcher is with what people think and feel, the way they communicate among themselves, and an attempt to understand and describe why people have different views (Bahari, 2010). Figure 3.1 provides a summary of "the network of basic assumptions characterising the subjective-objective debate within social science", as suggested by (Cunliffe, 2011).

	Subjectivist Approaches to Social Science					Objectivist Approaches to Social Science
Core ontological assumptions	Reality as a projection of human imagination	Reality as a social construction	Reality as a realm of symbolic discourse	Reality as a contextual field of information	Reality as a concrete process	Reality as a concrete structure
Assumptions About Human Nature	Man as pure spirit, consciousness, being	Man as a social constructor the symbol creator	Man as an actor the symbol user	Man as an information processor	Man as an adaptor	Man as a responder
Basic Episte-mological Stance	To obtain phenomenological insight, revelation	To understand how social reality is created	To understand patterns of symbolic discourse	To map context	To study systems, process, change	To construct a cositivist science
Some Favored Metaphors	transcendental	Language game, accomplishment, text	Theater, culture	Cybernetic	organism	machine
Research Methods	Exploration of pure subjectivity	hermeneutics	Symbolic analysis	Contextual analysis of Gestalten	Historical analysis	Lab experiments, survey

Figure 3.2: A network of basic assumptions characterising the subjective-objective debate (Source: (Morgan and Smircich, 1980)

The notion mentioned earlier about different worldviews of researchers reflects different grounds for knowledge about the social world (Morgan and Smircich, 1980).

For instance, looking at the right end of the continuum in the illustration, "an **objectivist** view of the social world as a concrete structure promotes an epistemological view that highlights the importance of studying the nature of relationships among the dimensions forming that structure". At the left end of the continuum, the **highly subjectivist** view sees reality "as a projection of human imagination", and it "argues against the positivist grounds of knowledge in favour of an epistemology that justifies the importance of understanding the processes through which human beings concretize their relationship to their world".

3.3.2 Epistemological considerations

Bryman (2012) explains that epistemology is concerned with the question of what is (or should be) viewed as adequate knowledge in a discipline. Epistemology comprises all the processes through which the researcher has obtained knowledge about reality (Lincoln et al., 2011). However, Gray, (2013) refers to epistemology as trying to understand what it means to know, and, again, it provides a philosophical stance to decide what kind of knowledge is adequate and legitimate. According to

Easterby-Smith et al. (2008), it is imperative to have an epistemological perspective, for various reasons, one being that it can help to elucidate issues of research design. Epistemology describes the overarching structure for the research, including the kind of data to be collected, where it is to be collected from, and how it is to be interpreted (Gray, 2013). There are three broad categories in most literature about epistemology: positivism, interpretivism, and realism (Denscombe, 2014, Maxwell, 2012).

Positivism advocates application of the methods of the natural sciences to the study of social reality and beyond (Bryman and Bell, 2011). Conversely, Saunders et al. (2012) posit that positivism pays attention to credible data generated through direct observation of a given phenomenon. Positivism consists of the following features: the supremacy of usage of current theory in the advancement of hypotheses; its affirmation of the researcher's neutrality to the data-collection process, due to his externality to the process; and the value-free nature of the collected data, as a result of the researcher's non-interference in the collection process. Bryman (2012) states that, this category of epistemology prides itself on adhering strictly to the following tenets: restriction of application of the knowledge terminology to phenomena that can be sensed (touched, felt, seen, tasted, and heard), and utilisation of theory to generate testable hypotheses, thus enabling the various explanations of laws to be studied. There is a distinction between scientific and normative statements; and the conduct of scientific research in such a way that it is value-free, not value-laden.

Realism, according to Saunders et al. (2012), is concerned with the notion that there exists a reality that is quite independent of the mind. Realism is divided into critical realism and direct realism, with the former connoting the fact that we experience sensations and images of the real world, not reality, while the latter posits that what we experience as reality is, in fact, reality. Amaratunga and Baldry (2001) assert that realism is concerned with the appreciation of the different perceptions of people of their own experiences, and deduction of the reasons for the differences in perceptions. The philosophy of realism seeks to understand and explain a phenomenon, instead of seeking to search for external causes or fundamental laws.

Interpretivism developed from phenomenology, which is the study of how human beings make sense of the world around them, and symbolic interactionism. While portraying Interpretivism as an epistemological orientation in direct contrast to positivism, Bryman (2012) states that Interpretivism developed out of the seeming need for a strategy that appreciates the dissimilarities between people and natural science objects.

Pragmatism: According to Saunders et al. (2012), pragmatism differs from other categories of research philosophy, as it believes that the philosophical orientation to be utilised should be entirely dependent upon the type of research questions the researcher intends to answer. In their earlier work, Saunders et al. (2012) described pragmatism as appealing due to its tendency to remove the researcher from the contentious position of having to argue in support of his philosophical position similar to a definition of (Tashakkori and Teddlie, 2010).

3.3.3 Axiological considerations

According to Saunders et al. (2012), axiology refers to a paradigm of research that focuses on judgement of value, and it can be divided into value-laden axiology and value-free axiology. The philosophical approach selected by the research study indicates the kind of value that the author intends to bring to the study. Saunders et al. (2012) highlight the role of the researcher's values in the credibility or the validity of the research findings, and they stress that it is important that the researcher state his values and the impact of these values on the research process ab initio. Researchers can either engage in value-laden or value-free research. Seemingly, the epistemological and ontological positions of the researcher serve as a major determinant of the degree of value that the researcher brings to his study.

3.3.4 The philosophical stance of this research

For the appropriate research philosophy to be chosen, the researcher must make an effort to take a reflective look, not only at the aim of the research, but, more importantly, at his personal views on the creation of knowledge and about the nature of reality (Bryman, 2012). The sections above provide an understanding of the various research philosophy paradigms. To select an appropriate philosophical stance for this study, it is vital to understand that the study is deeply embedded in old ways of doing things, and in introducing new and effective methods in order to improve the intended outcomes of projects. Existing practices will be evaluated in order to report on the status quo, and succinctly the outcomes emanating from existing practices to be introduced to lean construction concepts to improve the cost efficiency and effectiveness of project delivery in South Africa. The study will be driven by perceptions and experiences of project participants, and it will be juxtaposed with lean concepts identified from the pitfalls of the traditional method of project delivery. The study is also concerned with developing a cost management logic model using lean tools, emanating from existing project outcomes delivered in the traditional way of project delivery by public sector clients.

According to Saunders et al. (2012), ***"pragmatism argues that the most important determinant of the epistemology, ontology and axiology you adopt is the research question – one may be more appropriate than the other for answering particular questions"***.

The importance of pragmatism as a philosophy underpinning mixed-methods research is the focus of attention on the research problem, and then using multiple approaches to derive knowledge about the problem. Creswell (2014) suggests that pragmatism provides a philosophical basis for mixed-methods research:

- Individual researchers have freedom of choice. In this way, researchers are free to choose the methods, techniques and procedures of research that best meet their needs and purposes.
- Pragmatists do not see the world as an absolute unity. In a similar way, mixed-methods researchers look to many approaches for collecting and analysing data, rather than subscribing to only one way (e.g. either quantitative or qualitative research).
- Pragmatist researchers look to the 'what' and the 'how' to research based on the intended consequences – where they want to go with the research. Mixed-methods researchers need to establish a purpose for their mixing, a rationale for the reasons why quantitative and qualitative data need to be mixed, in the first place.

The researcher believes that one's philosophical stance should be entirely dependent upon the type of research questions one intends to answer. Pragmatists agree that research always occurs in social, historical, political, and other contexts (Creswell, 2014). Thus, for the mixed-methods researcher, pragmatism opens the door to multiple methods, different worldviews, and different assumptions, as well as different forms of data collection and analysis (Creswell, 2014). The paradigm of pragmatism arises out of actions and situations, and their effects, as against the worldview of post-positivism (Creswell, 2014). The researcher can therefore, claim to be a pragmatist, as he believes that knowledge and the nature of reality is dependent upon the type of questions to be answered and, as such, reality will be created by the answers emanating from those questions, from an accumulation of the individual perceptions of the members of a particular society. It is pertinent to note that the researcher will be able to answer questions and remove himself from the contentious position of having to argue in support of his philosophical position. Essentially, pragmatism is all about what works, finding solutions to problems, and the researcher's ability to justify the combined use of both qualitative and quantitative approaches in a research study (Bryman, 2012). Although, Tashakkori and Teddlie (2010) argue that pragmatism is all about interest or value to the researcher, flexibility within what is appropriate, and applying the outcomes in ways that can bring about positive consequences within your value system. Thus, the pragmatic paradigm is such that the research design resonates with the demands of a particular inquiry, and which method is best suited for the researcher. It is more about 'action' than 'philosophy', and it is better positioned to use quantitative research to throw more light on an aspect of qualitative research, by revealing and/or corroborating certain opinions within the context, and vice versa. The truthfulness of any methodological interpretation will only pertain when it is practically tested (Creswell, 2014, Gill and Johnson, 2010, Tashakkori and Teddlie, 2010). These features of the pragmatic paradigm make it more suitable for this study, in addition to the aforementioned research philosophy.

3.4 RESEARCH APPROACH

Creswell (2014) defines research approaches as “plans and the procedure for research that span the steps from broad assumptions to detailed methods of data collection, analysis, and interpretation”. Moreover, states that the research approach adopted is based on the nature of the research problem, the researcher’s personal experience, and the audience of the study (Creswell, 2014). However, Bryman (2012) argues that adoption of a research approach is imperative for linking theory with the research during the course of the research. Easterby-Smith et al. (2008) offer the following reasons for why the choice of research approach is important:

- The choice of research strategy allows the researcher to arrive at an informed decision about the structure of his research design; and
- It enhances the choice of the appropriate research approach and strategy, alongside the methods required for conducting that particular endeavour, and it allows the researcher to make provision for constraints, which might arise in the course of the research exercise.

Equally, the logic utilised to expand new knowledge – with the steps and procedures that this encompasses, and with the philosophical and theoretical ideas and conventions about what constitutes social reality and how knowledge of it is produced – involves approaches that need to be applied when conducting an enquiry (Blaikie, 2007). Theory is pivotal to the success of the research endeavour, because it is responsible for the provision of a foundation and rationale for the research. This leads to various considerations. Blaikie (2007) asserts that prior to a researcher undertaking an enquiry numerous choices have to be made, namely:

- The research problem to be investigated; the research question(s) to be responded to; the research strategy(ies) to be employed to respond to these questions;
- The position to be adopted by the researcher towards the research; and
- The research paradigm, including conventions about reality and how it can be examined.

As Blaikie (2007) mentions, after the specificity of the research problem and questions, the selection of a research strategy, or a combination of strategies, is the most important decision a researcher must make.

3.5 RESEARCH STRATEGY

Denscombe (2014) defines a research strategy as a plan of action, a process or a design underlying the choice and use of particular methods. It links the choice and use of methods to outcomes. Evidence shows that no particular research strategy is inherently superior or inferior to another; therefore, it is possible to adopt a combination of strategies (Saunders et al., 2012). The literature documents commonly used research strategies, such as the survey, case study, mixed-methods research, archival research, and action research (Creswell, 2014, Saunders et al., 2012, Denscombe, 2014, Yin, 2014). Below is an overview of research strategies (designs) that are applicable to this study.

The ***survey strategy*** is also associated with quantitative studies. It is adopted where an enormous amount of data is needed to describe and explain a phenomenon, rather than explore the context of the phenomenon, and it can be used to support other strategies (Collis and Hussey, 2003, Yin, 2014). Similar to experiments, it adopts the deductive approach, and it can be used to provide responses to the questions "what", "where", "how much", and "how many", which may be used to collect numerical data.

Case study as a research strategy can be adopted in both qualitative and quantitative research. According to Patton and Appelbaum (2003), the aim of case studies is to *"uncover patterns, determine meanings, construct conclusions and build theory"*. The peculiarity of this strategy is the identification of the case to be studied, which can be an individual, an event, a process, or an entity (Yin, 2014). It is mostly adopted in exploratory research, and it can apply to descriptive, illustrative, experimental or explanatory research (Denscombe, 2014, Yin, 2014) to answer research questions on how, what, or why. It also involves extensive study of a single instance of a phenomenon of interest, and it is concerned with understanding the dynamics that exist within a particular setting (Collis and Hussey, 2003, Yin, 2014). Likewise, Kathleen (1989) explains that a case study starts with a deductive approach and moves on to an inductive approach to build a theory. One of the strengths of case studies as compared with other strategies is their ability to collect multiple sources of data and a chain of evidence. This evidence allows for triangulation (evidence from different sources to corroborate the same fact or finding).

Archival research as a strategy uses administrative documents and records as the main source of data for explanatory, descriptive and exploratory research (Yin, 2014). Moreover, Bryman (2012) states that although archival research indicates historical documents, recent documents can also be studied. This strategy further allows for research questions encompassing history and changes over time to be answered. However, this strategy relies on secondary data, and where problems of lack of access arise, this can be a major limitation to the research.

3.6 CHOICE OF METHODOLOGY

Research has some critical features, including the testing of hypotheses, thoughtful reflection and measurement, methodical assessment of data, and portraying valid and unwavering inferences that can be simulated (Fellows and Liu, 2015). Methodology refers to the principles and procedures of logical thought processes applied to scientific examination, and it guides the research process in its entirety (Fellows and Liu, 2015). Consequently, research methodology includes all the procedures applied in the course of a research activity to achieve its aim and objectives. Ahmed et al. (2016)

argue that research methodology provides the researcher with the possibility to position their research problem within a suitable philosophy. To cultivate a proper strategy to confront the problem. To choose an appropriate research approach that leads to appropriate methods for data collection. In addition, to confront the right unit of study, while ensuring the reliability and validity of the study. Gray (2013) believes that the choice of research methodology is determined by a combination of several factors: if the researcher believes that there is some sort of external 'truth' out there that needs solving, or whether the task of research is to explore and unpick people's multiple perspectives in natural, field settings. Therefore, research methodology exhibits the foundation rationale for the employment of specific values, approaches, methods and approaches within a research environment. Selecting the research methodology that is best for the research setting is vital, not only as it will meet the set objectives of a research study, but also as it will help in justifying the needed reliability of the work. The choice of research methodology is determined by a combination of several factors, where the procedure for data collection and analysis is either quantitative (QUAN), qualitative (QUAL), or mixed-methods (Saunders et al., 2012). Often the difference between qualitative research and quantitative research is framed in terms of using words (qualitative research) rather than numbers (quantitative research)(Creswell, 2014). Likewise, Johnson et al. (2007) define mixed-methods research as follows:

- A collection and analysis of both quantitative and qualitative data in a single study in response to the research questions;
- It includes the analysis of both forms of data;
- The procedures for both QUAL and QUAN data collection and analysis need to be conducted rigorously;
- These two forms of data are integrated in the design analysis through merging the data, connecting the data, or embedding the data;
- These procedures are incorporated into a distinct mixed-methods design that also includes the timing of the data collection (concurrent or sequential) and the emphasis (equal or unequal) for each database; and
- These procedures can also be informed by a philosophical worldview or a theory.

Gray (2013) however, points out that Yin (2014) argues that mixed-methods research could also involve using a combination of two qualitative methods without the use of quantitative methods, or using a combination of two quantitative methods. This study follows the logic of Johnson et al. (2007) in using collection and analysis of data using both quantitative and qualitative methods, and the priority is equal between the two procedures, as they happen concurrently. Creswell, (2014) provides several reasons for choosing a mixed-methods design, namely:

- Answering related questions in a complementary way,
- Comparison of different perspectives drawn from QUAL and QUAN data, and
- Understanding of the need for an impact of an intervention programme.

Insights are drawn from the questions posed, and therefore a strategy of a convergent parallel mixed-methods procedure is most appropriate for this study. Both QUAL and QUAN methods are employed concurrently to collect data, and a comparison is then drawn from the two methods, and it is interpreted for better understanding of the phenomenon being investigated. Thereafter, a lean construction cost management logic model (LCCMM) was developed from the data collected, to represent the essential characteristics of reality, through either a system or a process (Fellows and Liu, 2015).

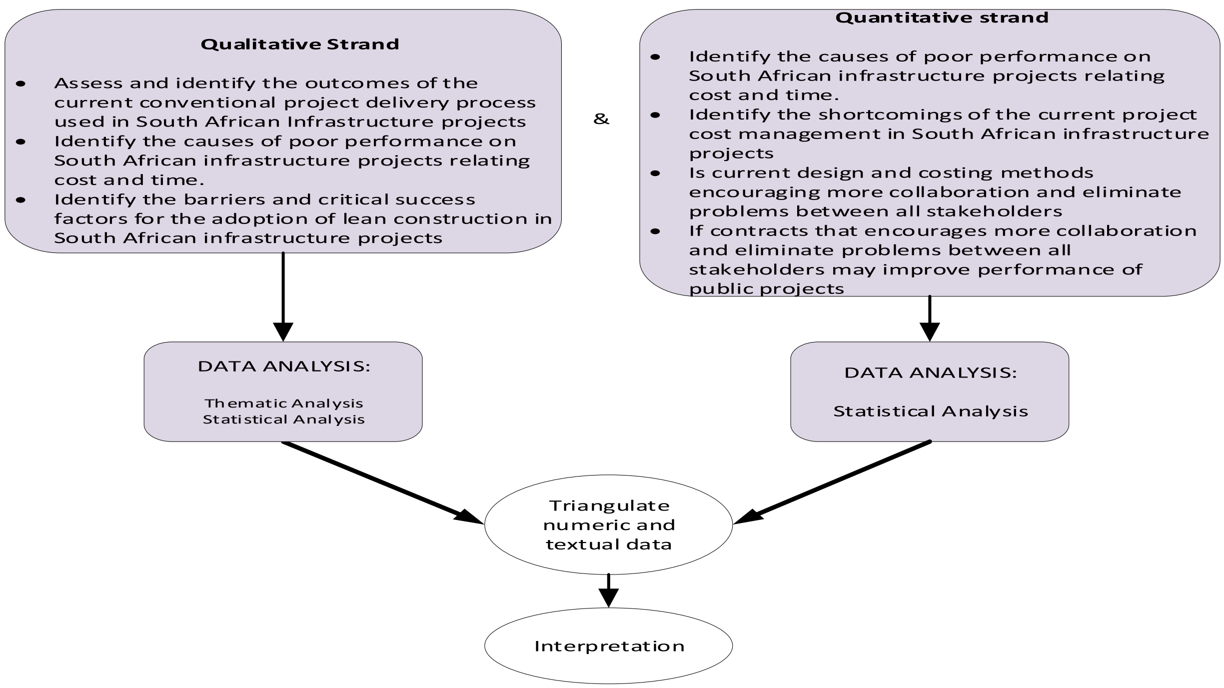


Figure 3.3: Convergent parallel mixed-methods design procedure
(Source: Adapted from (Creswell and Plano Clark, 2011)

This research study follows a convergent parallel mixed-methods design, as depicted in Figure 3.3 above. The above chosen method is explained as the most common type of the basic and the advanced mixed-methods strategies (Creswell, 2014, Creswell and Plano Clark, 2011). The purpose of this mixed-methods design is to use concurrent timing to implement the quantitative and the qualitative strands during the same phase of the research process. To prioritise the methods equally, to keep the strands independent during data analysis, and then to mix the results during the overall interpretation, as illustrated in Figure 3.3 (Creswell, 2014, Creswell and Plano Clark, 2011). Mixed-methods research methodology was adopted for this study after considering the differences between

QUAN and QUAL methods, and their strengths and weaknesses, as depicted in figure 3.3 and table 3.3.

Table 3.3: Mixed Method approach adopted for this study (Author)

	Data collection source	Form	Type	Approach	Target
1	Comprehensive literature review	N/A	Secondary	N/A	N/A
2	Questionnaire (electronic)	Structured	Primary	Quantitative	200
3	Pilot Study	Structured	Primary	Quantitative and qualitative	5
4	Interviews (face to face) and Skype	Semi-structured	Primary	Qualitative	30
5	Focus group	Semi-structured	Primary	Qualitative	6

3.6.1 Rationale for choosing mixed-methods research

According to Creswell and Plano Clark (2011), several definitions of mixed-methods (MM) research have emerged over time, incorporating various elements, such as methods, the research process, the research philosophy, and the research design. (Tashakkori and Teddlie, 2010) define mixed-methods research as a type of research design in which QUAL and QUAN approaches are used in the type of questions, the research methods, data-collection and -analysis procedures, and/or inferences. Johnson et al. (2007), after analysing 19 definitions of mixed-methods research, concluded that mixed-methods research is “the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration”. The simplest definition of mixed-methods research is that it is a research approach that combines multiple qualitative methods (interpretivist views) and quantitative methods (post-positivist views) into a single approach (Creswell, 2014, Creswell and Plano Clark, 2011, Johnson et al., 2007). The utility of employing mixed-methods research concerns why we employ the method in our studies. The ultimate goal of mixed-methods research, according to Tashakkori and Teddlie (2010), is to answer the questions posed at the beginning of the research being conducted. There appears to be three areas identified by Tashakkori and Teddlie (2010) where mixed-methods research is superior to the single-approach designs:

- MM research can simultaneously address a range of confirmatory and exploratory questions with both the qualitative and the quantitative approaches,
- MM research provides better (stronger) inferences, and
- MM research provides the opportunity for a greater assortment of divergent views.

In this study, multiple methods are combined, as the need exists to enhance the study with a second method, to complement data from a different source (Creswell and Plano Clark, 2011). Moreover, this delivers multiple approaches to unravelling and offering more explanations to a research problem, and it also enhances the credibility and the validity of the research results (Creswell and Plano Clark, 2011, Easterby-Smith et al., 2008). Similarly, Creswell (2014) maintain that quantitative data can be used as supplementary evidence for an interpretive study, and that adoption of both qualitative and quantitative methods offers a richer contextual basis for interpreting results. According to Tashakkori and Teddlie (2010), the combination of qualitative and qualitative methods can be complementary; use of either a quantitative or a qualitative method has its own pros and cons.

This study seeks to explore the characteristics and the effectiveness of current cost and time management practices in use, and to provide an explanation of why current project management practices are unable to deliver the expected cost and time performance. Consequently, the questions posed of what, why, and how will require both QUAL and QUAN procedures. The objective in choosing mixed-methods research is to compare different perspectives drawn from both QUAL and QUAN data sets, and for both convergent and divergent views.

The main focus of the study is lean construction. A breakdown of lean construction research studies reveals that there is a lack of applied lean research in construction (Jacobs, 2011). This means that more research should be conducted by means of the mixed-methods approach (Jacobs, 2011). However, the use of conceptual research cannot be neglected, as the proportion of conceptual research studies is high, as shown in Figure 3.4.

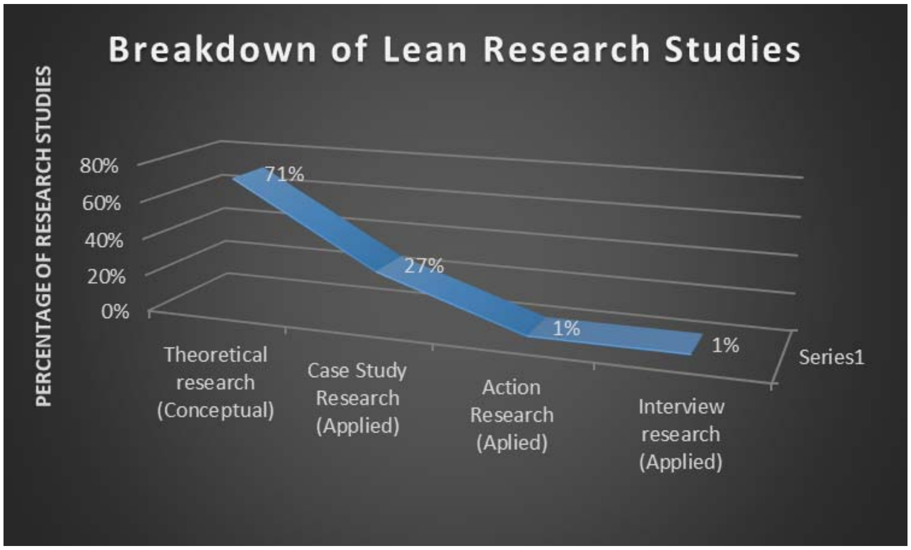


Figure 3.4: A breakdown of lean research studies
(Source: Jacobs 2011:9)

Jacobs (2011) suggests that lean research in construction is more representative of conceptual research than applied research, and that the success of lean research in construction is essentially dependent on both theory and practical knowledge. Fellows and Liu, (2015) suggest that mixed-methods research may be employed to reduce or eliminate the disadvantages of each individual approach, while gaining the advantages of each, and that the combination of research methods ensures a multidimensional view of the subject, gained through synergy. Moreover, Fellows and Liu (2008) refer to mixed-methods research as triangulation, which may be used by investigating a topic from several alternative paradigms and/or research methodologies, or for individual parts of a study, such as collecting quality performance data from archival records of defects, questionnaires administered to project participants, and results of participant observation.

3.6.2 Time frame

There are two timeframes mentioned by both (Gray, 2013, Saunders et al., 2012) in a research which are: the cross sectional and the longitudinal timeframes / horizons. It is pertinent to recognise that these timeframes/horizons are independent of the research strategy together with the choice of method (Saunders et al., 2012). Thus this study is positioned in a cross-sectional timeframe/ horizon. The reason behind such a choice is that this study is an academic study, which has to be completed within a timeframe (Gray, 2013, Saunders et al., 2012)

3.6.3 Study Population, Sampling Technique and sample size

Prior to determining the appropriate sampling size it is advisable to comprehend about the terms ‘population’ and ‘sample’. Easterby-Smith et al. (2012:11) define population as “[…] *the whole set of entities that decisions relate to* […]”. In addition, further describe “[…] the *term sample refers to a subset of those entities from which evidence is gathered*”. In order to obtain the sample size the entire population must be identified, in some cases it is possible to collect data from each respondent, but often it is not possible (Easterby-Smith et al., 2012) due to populations happens to be too large for one research project. The researchers are required to think of a more appropriate sampling strategy (Bryman, 2012, Easterby-Smith et al., 2012). Hence, if the population is recognised, a sample can then be designated, which will permit one to draw generalisations about the acknowledged population. Sampling strategies, which have this characteristic, are called “probability samples” (Easterby-Smith et al., 2012, Bryman, 2012, Fellows and Liu, 2015).

The study population for the ***quantitative strand*** of this research was professionals and contractors of the construction industry such as Architects, Engineers (Mechanical, Electrical, Civil, and Structural), Construction project managers, Quantity Surveyors and contractors with experience of executing public sector projects in South Africa. Given an extremely large population of the universe targeted for this study, appears to be actually finite, but for practical considerations of time, cost, resources, etc., for this study the population is considered infinite. For the purpose of this study and from a practical consideration, we then use the term infinite population for a population that cannot be enumerated in a reasonable period of time (Kothari, 2004). This research aim to make generalisations to the LCCMM using lean tools rather than population. Bryman (2012) argue that if it is the case that the sample is too large and the focus is more on generalising theory rather than about population, then non-probability sampling techniques are appropriate, hence chosen selected for this study. In addition, cases where population is sufficiently large “random sampling” (also known as probability sampling) is deemed appropriate for this study. However, a “structured sample” might work in this instance, and could be more convenient. Nevertheless, such a structured sampling needs a ‘sampling frame’ to be produced unequivocally (Fellows and Liu, 2015). The reason is that if the sampling frame is unsuitable (i.e., a subjective representation of the population), it will result in a systematic bias; where the latter causes incorrect inferences (Coughlan et al., 2007, Kothari, 2009). Within this sampling frame, random sampling, judgement sampling, or non-random sampling may be used (Fellows and Liu, 2015). Electronic questionnaires were placed on an electronic media for responses and no specific sampling frame available due to the study considering the population infinite. 97 useable questionnaires were received.

For the ***qualitative strand*** of this study, a within case sampling of participants was used. This research adopted a non-probability sampling technique based on a strategic process to ensure that the participants selected for the semi-structured interviews were able to provide in-depth information on the lean construction cost management model. The study population was obtained from the case studies selected. Respondents selected for the qualitative strand (interviews form case study participants). This then ruled out bias of selection of respondents Five case studies were selected and with six respondents from each case totalling 30 interviewees as a target population. Interviewees were selected from due to their involvement and participation of the selected cases. Thus, implying a purposive selection of the participants representing quantity surveyors, architects, numerous engineers excluding contractors. 30 participants were approached for and 15 agreed to participate. In addition, the focus group participants were drawn from a mixture of the case study participants and public sector professionals approached for taking part in the process. Non probability sampling was applied for the focus group discussion of validating the model.

3.7 DATA-COLLECTION PROCEDURE

Data are pieces of information in an unorganised manner. Data is a finite set of information that must be sorted processed and presented in a recognised research format, in order to draw a valid conclusion (Leedy and Ormrod, 2010). In order to collect all the relevant data, the researcher actively investigated the projects from inception to completion.

First, site visits were conducted regularly for meetings, during which numerous site observations were carried out. A complete set of project management documents was then collected, which enabled a comprehensive analysis of project events, including minutes of meetings, change orders, conditions of contracts, drawings, and specifications. The researcher then participated in various discussions, precise analyses of procurement process problems at the project briefings, and closeout meetings. When visiting the site, informal conversations were conducted with the professionals, to better understand about project performance. Semi-structured interviews were also carried out with the project team members, to corroborate data obtained from the projects. A survey was then sent to the construction professional members at large, to elicit perceptions from a wider group of respondents, to compare the findings of the qualitative strands. Finally, the model validation included semi-structured interviews and a focus group discussion of the public sector professionals.

3.7.1 Qualitative data collection

The qualitative strand adopts a phenomenological research design. The choice of this design was an afterthought, as a qualitatively driven case study research design had initially been proposed. The research techniques used under qualitative data collection seek to gain in-depth understanding of the research problem. The qualitative strategy gathered unstructured data, which tends to be detailed and rich in both content and scope (Fellows and Liu, 2015). This data was systematically gathered, keeping in mind the analytical procedure that would reveal patterns, insights, or concepts that seemed promising (Yin, 2014). These promising concepts emerged through various forms of data manipulation.

Yin (2014) suggested four basic strategic guides to data collection for analytical ease. The first strategy is *"relying on theoretical propositions"*, which is following the theoretical propositions that led to the case study, where the propositions would have shaped the data-collection plan to yield analytical priorities. The second strategy involves *"working your data from the 'ground up'"*, where the researcher pores through the data, finding out that some part of the data suggests a useful concept or two. The third strategy entails *"developing a case description"*, in order to organise case studies according to some descriptive framework that can serve as an alternative to working from questions and propositions. The fourth strategy involves *"examination of plausible rival explanations"*, in order to define and test plausible rival explanations, as awareness of rival explanations can influence the data from the outset.

3.7.1.1 Data collection from case studies

Actual case studies were undertaken at different stages. First, intra-case analysis was performed to explore the specific pattern of each case, using explanation building to reflect on cost management outcomes, and to analyse how the team learnt to better manage these events. Cross-case analysis was then conducted to explore the continuous poor performance learning process of the project participants in the selected cases. Narratives were used, because they retained the full richness of the learning process (Loosemore, 2015). Finally, two points should be mentioned: (1) the researcher tried not to disrupt normal production of the projects during the data-collection process, to avoid any possible biased impact on the research result due to the Hawthorne effect (Bernold and Lee, 2009) and (2) for purposes of confidentiality, the case analysis would not disclose names of the parties involved.

According to Yin (2014), there are six sources of data commonly used in case study research (see Table 3.1). Table 3.1 illustrates the strengths and weaknesses of the various sources of data available for use in case study research. These sources of data collection can be more beneficial by adopting the four data-collection principles (Yin, 2014). These principles are the use of multiple sources of evidence, creating a case study database, maintaining a chain of evidence, and exercising care when using data from electronic sources.

Table 3.1: The strengths and weaknesses of sources of data

Sources of evidence	**Strengths**	**Weaknesses**

Documentation	• Stable – can be reviewed repeatedly • Unobtrusive – not created as a result of a case study • Specific – can contain the exact names, references, and details • Broad – can cover a long span of time and many events	• Irretrievability – can be difficult to find • Biased selectivity if collection is incomplete • Reporting bias – reflections • Access – deliberately withheld
Archival records	• [Same as in documentation] • Precise and usually quantitative	• [Same as in documentation] • Accessibility due to privacy reasons
Interviews	• Targeted – focuses directly on case study topics • Insightful – provides explanations as well as personal views (e.g., perceptions, attitudes)	• Bias due to poorly articulated questions • Response bias • Inaccuracies due to poor recall • Reflexivity – interviewee gives what interviewer wants to hear
Direct observations	• Immediacy – covers actions in real time • Contextual – can cover the case's context	• Time-consuming • Selectivity – broad coverage difficult without a team of observers • Reflexivity – actions may proceed differently because they are being observed • Cost – hours needed by human observe
Participant observation	• [Same as in direct observations] • Insightful into interpersonal behaviour and motives	• [Same as in direct observations] • Bias due to observer's manipulation of events
Physical artefacts	• Insightful into cultural features • Insightful into technical operation	• Selectivity • Availability

(Source: Yin 2014:106)

The researcher was mindful of the aforementioned strengths and weaknesses of the various tools in the adoption process. Likewise, most of the weaknesses were limited by the adoption of the multiple cases selected.

This research is aimed at proposing a lean construction cost management model (LCCMM) for operationalising lean construction in the built environment: the case of the building infrastructure sector in South Africa. This lean construction pertains to meeting of project success parameters in terms of cost, time, and quality that will bring competitiveness and create value in public projects. It involves both the internal and the external stakeholders exploring the interaction between the natural and the social systems in the built environment. The case studies selected have previously been justified for the work, because of the peculiarity of the research area; lean construction is still developing, and the numbers of prime actors are minimal in the South African context. These peculiarities tend to limit the sampling methods to theoretical sampling (purposive sampling) in the research within the selected cases.

Purposive sampling means that participant selection is according to a defining characteristic that makes them role players of the data needed for the study (Maree, 2007). This logic of the sampling is different from statistical sampling, because the idea is to select cases that are replicable or that will be able to further the emergent theory. The sampling methods employed were, however, independent of each other, in that for the quantitative design snowball sampling of the wider group of professionals was used, while purposive sampling of the project participants was used for the qualitative design (Teddlie and Yu, 2007). Moreover, Creswell and Plano Clark (2011) state that it is beneficial for the two strategies of data collection to have different sample sizes for the two data procedures, as this helps the researcher to achieve in-depth qualitative exploration and robust quantitative examination of the research problem.

3.7.1.2 Face-to-face interviews

As the term suggests, face-to-face interviews involve direct contact between the researcher and the respondent. Denscombe (2014) states that when compared with telephone interviews, researchers might anticipate the data acquired through face-to-face interviews to be more comprehensive and richer, and face-to-face contact offers some immediate means of authenticating the data. According to Hesse-Biber and Leavy (2011), interviews can be seen as a conversation between an interviewer (the researcher) and the interviewee (the respondent), which requires the use of probing questions and paying attention to answers. The researcher’s mode of data collection in interviews is the verbal information from the case participants; typically, interviews are conversational in nature, and they are normally guided by the researcher’s mental agenda (Yin, 2014). Interviewing is used to elicit interviewee experiences, opinions, attitudes, values and processes. Essentially, the interview is the favoured approach where there is a need to achieve highly personalised data, where opportunities for probing are required, and where a good return rate is important. The categories of interviews identified by Hesse-Biber and Leavy (2011) include structured and semi-structured interviews, open-ended interviews, and focus group discussions.

The semi-structured interview variants were deployed for the interview sessions in this stage of the research, with adoption of both closed and open-ended predetermined questions (see Appendix 2). The semi-structured interview approach enhances the reliability of the research, through process standardisation and replicability (Hesse-Biber and Leavy, 2011). The choice of semi-structured interviews was considered appropriate, as it enabled the use of similar questions instead of identical questions, as would be the case if structured interviews were adopted (Denscombe, 2014). The selected role players in the project teams answered the predetermined questions. Purposive sampling was also used to determine the project participants in the group selected to be interviewed, as they were chosen from within cases selected. During August and September 2018, the researcher did qualitative fieldwork. To reach theoretical saturation the researcher initially anticipated conducting 30 semi-structured interviews with project participants through this sampling technique, for the initial six selected cases for the research. However, due to the challenges of availability of participants, only 15 interviews were conducted. The interviewees were construction project managers, quantity surveyors, and architects. The number of interviews was considered appropriate, based on the views of Leedy and Ormrod (2010), who suggest that interviewees between 5 and 25 individuals are appropriate and defensible in the view of Mason (2010), based on the study reaching saturation.

Prior to the main interview session, a pilot study (interview) was carried out among academics and experienced role players in the construction industry to test and refine the interview protocol. This refinement was necessary in order to obtain the input of experts on the research instrument. This protocol was then sent to the project participants of the infrastructure projects of the selected cases before obtaining invitations for the interview session. The interviews lasted an average of 45 minutes to an hour, they were recorded, and notes were taken. The permission of the interviewees was sought and obtained for recording before commencement of the interviews.

3.7.1.3 Focus group interviews

Another qualitative data-collection method is a focus group interview. It enables the gathering of relevant information on a subject of research interest based on expert and personal experiences of a selected group of individuals accumulated by a researcher (Powell and Single, 1996). Employment of this method is to provide assistance to the researcher in gathering information for the enhancement of a process, or as an adjunct to quantitative data collected (Gill and Johnson, 2010). The number of experts who shared similar characteristics or common interests ranged from 6 to 12 individuals gathered to participate in a focus group interview. The focus group participants were drawn from two different samples. The first sample was from case study participants, and the second one was drawn from the national Department of Public Works as a client of the projects. The researcher acted as the facilitator guiding the group, based on predetermined sets of topics. This method has the benefit of allowing the researcher to elicit information on why an issue is relevant, and what makes it relevant.

3.7.1.4 Archival Document Analysis (unobtrusive measure)

While the use of semi-structured interviews enabled the collection of data pertaining to the stakeholders' views within the bounded context of the case studies (Kvale, 2006), the use of archival records provided information which helped in drafting the interview guide as well as resolving any biases established from the interviews (Saunders et al., 2012). The public works departments in six of the provinces in the country, a sector responsible for execution of projects for other client departments within the public sector in South Africa, and archives of all certified completed projects within the region were reviewed for the selected cases.

3.7.1.5 Physical evidence (unobtrusive measure)

The selected live project cases were physically observed through a tour of the facilities. The purpose was to help confirm the various claims made about the facility, using the observation protocol developed based on the claims on the archival records. Physical observation allows the researcher the ability to physically see the design concepts and ask relevant questions about the effectiveness of the deployed technologies. This qualitative evidence will be deployed to make sense of the thread of narratives observed in the mixed data sources emanating from the five selected cases in this study (Gray, 2013).

3.7.1.6 Analysis of qualitative data

Qualitative analysis involves the process of data reduction, to reveal the characteristic elements and structure of the data, by gaining new insights into the data. There are various analytical strategies to analyse qualitative data, with different data mechanics, such as content analysis, grounded theory, narrative analysis, and thematic analysis, among others (Gray, 2013). This research adopts the phenomenological approach in analysing data obtained from semi-structured interviews. The choice of the phenomenological research design was predicated on the design's usefulness in eliciting views about the worldviews as well as shared experiences of individuals concerning a particular phenomenon (Creswell and Poth, 2017). Leedy and Ormrod (2010) define a phenomenological study as a study that attempts to understand people's insights and viewpoints of a particular situation. It is a research method in which human proficiencies are examined through detailed descriptions provided by the people being studied (Creswell, 2014). The key focus is on the subjective experience of the individuals studied. The key advantages of this approach are that

- It recognises the fact that the researcher will interpret what is being studied in a particular way, and
- It provides a means of describing the interrelationship of many factors found in real life.

The main disadvantage of this approach is that despite making the prejudice of the researcher known, it could still cloud the interpretation of reality and thus make the research conclusions subjective (Galliers and Huang, 2012). The interview sessions were recorded with the express permission of the interviewees, and were subsequently transcribed verbatim. Thematic analysis was applied in making sense of the data (Kulatunga et al., 2007). Thematic analysis moves beyond counting explicit words or phrases and focus on identifying and describing both implicit and explicit ideas within data that is themes (Guest et al., 2011).

According to Obi (2017) thematic analysis is an aspect of content analysis that facilitates both conceptual and relational analysis of the data. Thematic content analysis was used to make sense of data obtained from interviews. Thematic content analysis involves conducting interviews and probing final account reports, bills of quantities and site instruction books extracting valuable data from numerous sources, summarising information, grouping data into themes and presenting data, this was substantiated by prior studies (Fellow & Liu, 2008; Yin, 2009). Audio-recorded sessions and field notes from the semi-structured conducted were transcribed by the researcher. This process allowed the researcher to gain insight into the thoughts and reflections of the interviewees. The researcher read the transcripts several times to identify areas of relevant information in the data. Subsequently, common concepts were identified from data and assigned descriptive codes where appropriate. These studies described the data collection process in qualitative research as including extracting general and unique themes from all the interviews and making a composite summary (Fellow & Liu, 2008; Yin, 2009). Common themes and sub-themes were formed and coded in line with research constructs. The coding system employed is strongly prejudiced by the researcher's opinion and worldview.

For case studies, Yin (2014) suggests that, irrespective of the specific analytical strategy, four principles underlie high-quality data analysis in good social science research: attend to all evidence, address all plausible rival interpretations if possible, address the most significant aspect of the case study, and adopt prior expert knowledge. As multiple sources of evidence improve the quality of analysis, findings, and conclusions Yin (2014), four main methods of data collection were utilised in this study: (1) project document analysis, (2) project discussions, (3) informal conversations with the site professionals, and (4) semi-structured interviews with the project participants. Use of multiple methods is commonly known as triangulation (Yin, 2014). Moreover, Yin (2014) suggests that cases using multiple sources of evidence are rated more highly, in terms of their overall quality, than those that rely on only single sources of information. Data triangulation in the context of this study pertains to collection of information from multiple sources, but it is aimed at corroborating the same findings.

3.7.1.7 Profile of the selected cases

Table 3.2 below depicts a profile of all the selected case studies obtained from the public sector project management system. The table provides a brief overview of the selected cases by conveying information about the project cases in general, as more details will be provided in the following chapter, the chapter on the data analysis. Projects are coded for confidentiality purposes, and they will be referred as “Case 1”, “Case 2”, “Case 3”, “Case 4”, and “Case 5”.

Table 3.3: Level of CIDB grading for selected project cases

Case	**Contract value**	**CIDB grading designation**	**Status of the project**
Case 1 (C_1)	R458 million	Level 9	Completed
Case 2 (C_2)	R98.9 million	Level 8	Completed
Case 3 (C_3)	R117 million	Level 8	Under construction
Case 4 (C_4)	R202.8 million	Level 9	Under construction
Case 5 (C_5)	R50 million	Level 8	Terminated and reappointment

3.7.2 Quantitative data collection

The research technique used under the quantitative data procedure is administration of questionnaires obtained through the survey design. The survey design, according to Creswell (2014), collects numerical descriptions of phenomena such as trends, attitudes, or opinions of selected samples that can be generalised to the population. The researcher first invited respondents through emails to populate the survey, which were drafted from Google Forms software. However, the response rate to the emails sent to potential respondents was low. The researcher further used the Internet as a platform to elicit more responses from potential respondents.

An Internet survey as a web-based questionnaire with the aid of Google form was considered appropriate for this study due to the low response rate usually associated with this type of data collection. The questionnaire was placed on the host site of LinkedIn, (ASAQS) Association of South African quantity Surveyors website, (SACPCMP) South African Council for the Project Management Profession website due to the wide coverage of such mediums as a platform for professionals to engage on industry issues. The instruments were reviewed with the promoter several times prior to the pilot study, and with two other people – a postdoctoral fellow, and a senior academic with prior experience in the field. Furthermore, part of the outcome is a peer-reviewed conference paper, to fine-tune the variables of the instrument. The research instruments (the questionnaire for the role players) were pilot-tested in accordance with suggestions by (Gill and Johnson, 2010, Leedy and Ormrod, 2010, Hoxley, 2008). The suggestions of these experts were incorporated in the final instruments before the first set of questionnaires was drafted.

3.7.2.1 Quantitative data analysis

The quantitative data was analysed statistically, and both descriptive and inferential analytical tools were adopted. The study deployed the Statistical Package for the Social Sciences (SPSS) version 20 to analyse various statistical tests, such as the mean item score (MIS), to reduce the data to reasonable units for gaining meaningful insight. The MIS was utilised to rank the variables according to the participants' perceptions from the survey.

- *Mean item score*

According Audu and Kolo (2007), the mean item score is the process of assigning numerical values to respondents' ratings of the importance of certain variables, for example "strongly agree" (5 points) and "agree" (4 points). The mean item score (MIS) of the importance of every variable was computed using the following equation:

$$MS = \sum \frac{(f \times s)}{N} \quad 1 \leq MS \leq 5 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..1$$

Where:

S = the score assigned to each factor by the respondents; its range depends on the ordinal scale in use (in this case 1–5);

f = the frequency of responses to each rating (1–5); and

N = the total number of responses in the respective score.

3.7.2.2 Kruskal-Wallis test

A non-parametric test for independent samples was conducted on the data set to compare the variables across the categories of parties involved on projects that the respondents had experienced. Kruskal-Wallis test was preferred as an alternative to the one-way between groups analysis of variance McCrum-Gardner (2008) which is non-parametric test of various themes that is used to evaluate whether different categories of respondents differ by comparing scores of a particular theme (Pallant, 2005b). In this research, the difference among respondents of consultants and contractors' were evaluated to determine the disparity between the mean ranks. p-value below 0.05 in Kruskal-Wallis test indicates that there is a significant difference between the groups of participant about the affected variable at 95% confidence level. Any p-value above 0.05 indicates that there is no significant difference among the groups.

3.7.2.3 Data triangulation

Mixed methods potentially offer depth of qualitative understanding with the reach of quantitative techniques. While the qualitative analysis adopted thematic content analysis, the triangulation process was aligned with this approach for mixing qualitative and quantitative data sets. Fielding (2012) states that results are analysed independently, and the findings are then compared. However, some want to convert coded qualitative data into variables for statistical analysis. Bazeley (2006) suggests two main ways:

- Combination of data types within an analysis, e.g. using categorical or continuous variables both for statistical analysis and to compare coded qualitative data and
- Conversion of data, such as converting qualitative codes to codes used in a statistical analysis.

Hower, Bazeley (2006) asserts that there must be a clear rationale for using such analytic techniques, for example, demonstrating data convergence (triangulation).

3.8 THE RELIABILITY AND THE VALIDITY OF THE METHODS USED

According to Onwuegbuzie and Johnson (2006), “research needs to be defensible to the research and practice communities for whom research is produced and used”. They refer to validity as the parts of the research study, including the conclusions drawn and the applications based on the study, and they assert that it can be high or low or somewhere in between (Onwuegbuzie and Johnson, 2006). However, Tashakkori and Teddlie (2010) proposed the term “inferences” as nomenclature for integrative methods such as mixed-methods research, to represent the complexity and the inclusiveness of combined qualitative and quantitative designs. (Tashakkori and Teddlie, 2010) define inferences as “conclusions and interpretations that are made based on collected data in a study”.

Reliability refers to consistency. Internal consistency is a way of assessing reliability (Pallant 2013). Internal validity refers to the degree to which an instrument provides acceptable coverage of the research questions (Yin 2014). The statistical data collected from this study were checked for reliability by using Cronbach’s alphas, which are widely used as a measure of internal reliability. The method assists to determine the extent to which the items in the questionnaire are related to each other. Cronbach’s alphas were considered appropriate for this study as a measure of internal reliability of the survey items, using SPSS version 20. To use Cronbach’s alphas as a measure of the internal reliability of the factors itemised in the survey questionnaires, it is noteworthy to mention that the higher the value of the coefficient, the more consistent the items in the survey questionnaire.

Pallant (2013) documents the generally acceptable coefficient value indicators for reliability (see Table 3.4). A low coefficient indicates that the sample items fail to correlate properly, while a large alpha indicates that the given items correlate properly.

Table 3.4: Cronbach's alpha measurement scale

Interpretation	**Value**
Excellent	$\alpha \geq 0.9$
Good	$0.9 > \alpha \geq 0.8$
Acceptable	$0.8 > \alpha \geq 0.7$
Questionable	$0.7 > \alpha \geq 0.6$
Poor	$0.6 > \alpha \geq 0.5$
Unacceptable	$0.5 > \alpha$

(Source: Pallant 2013)

According to Saunders et al. (2012), validity is a requirement to ensure that the research findings confirm what the researcher aims to achieve. It demonstrates the appropriate nature of the data-collection techniques and the research design. It strongly connects data-collection and -analysis procedures. Yin (2014) recognises two forms of validity, namely construct validity and internal validity. Construct validity is achieved by the use of multiple sources of evidence, establishing a chain of evidence, the use of key informants to review drafts of case study reports, and a convergent line of inquiry. This study has employed multiple source of evidence through evaluation of documents, observations and semi-structured interviews. Internal validity deals with pattern matching and explanation building; this study has achieved such validity by suing multiple case studies to replicate findings. In general, the researcher used different sources of data, namely literature, documents, semi-structured interviews, questionnaires, and focus groups, to collect a variety of information on the traditional project delivery methods from public sector clients. These methods provided in-depth insight into the poor performance of current project management practices, and they explained why such poor performance occurred in the project cases selected.

3.8.1 Validity and trustworthiness of research findings

Research validity and the degree of trustworthiness look to be crucial issues in conducting of any research study. According to Saunders et al. (2012) the validity within the body of research implies that the research findings conforms to what the researcher intended to achieve. It also shows the appropriate nature of the data collection techniques and the research design for answering the research questions. A lot of criticism has been labelled against qualitative strand research specifically on the validity (Shenton, 2004). However, Shenton (2004) refuted these claims of qualitative methodology could be hardly evaluated for validity, and stated that whereas quantitative research possessed a structured methodology which could be assessed for validity, qualitative had a similar methodology as well. Table 3.5 below depicts the constructs by Guba as outlined by (Shenton, 2004).

Table 3.5 Criteria for ensuring Validity of qualitative research

Quality criterion	*Possible provision made by researcher*
Credibility	Adoption of appropriate, well recognised research methods Development of early familiarity with culture of participating organisations Random sampling of individuals serving as informants Triangulation via use of different methods, different types of informants and different sites Tactics to help ensure honesty in informants Iterative questioning in data collection dialogues Negative case analysis Debriefing sessions between researcher and superiors Peer scrutiny of project Use of "reflective commentary" Description of background, qualifications and experience of the researcher Member checks of data collected and interpretations/theories formed Thick description of phenomenon under scrutiny Examination of previous research to frame findings
Transferability	Provision of background data to establish context of study and detailed description of phenomenon in question to allow comparisons to be made
Dependability	Employment of "overlapping methods" In-depth methodological description to allow study to be repeated
Confirmability	Triangulation to reduce effect of investigator bias Admission of researcher's beliefs and assumptions Recognition of shortcomings in study's methods and their potential effects In-depth methodological description to allow integrity of research results to be scrutinised Use of diagrams to demonstrate "audit trail"

Source: (Shenton, 2004)

Because valid and trustworthy has to be conducted in this research, this researcher made considerable efforts to adhere the views stated in Table 3.5.

3.9 THE RESEARCH PROCESS FLOW CHART

Research methodology is a description of the process followed by the researcher in conducting the research. This study is inclined towards pragmatism, and it adopts a mixed-methods research design. The strategy followed by the researcher offered the opportunity to gain an in-depth understanding of the current practice of project cost management. Moreover, infusing lean will lead to cost-efficient projects, as an outcome of the improved lean-infused process. Several change management models were compared and evaluated for suitability for the study. Then a lean led cost management model will be developed suitable for this study.

A convergent mixed-methods procedure provided the opportunity for the researcher to collect, analyse, and interpret data at various stages of the research process. A mixture of semi-structured interviews, focus group interviews or discussions, and a survey questionnaire facilitated in-depth contextual data from the case participants and a wider coverage of professionals with experience in executing public sector projects on relevant issues regarding the lean construction cost management model (LCCMM) at various stages of the research process. The qualitative data collected followed a phenomenology approach, and thematic content analysis was employed for sense making of the data. The quantitative data collected via the web-based questionnaire survey was analysed using descriptive and inferential statistics, with the aid of the SPSS application package. The LCCMM validation stage provided refinements where they were necessary, and it allowed for proposal of the LCCMM to the South African construction professionals for adoption. The contribution of the study is development of a theory of cost-efficient project delivery through lean-led design in a South African context. A summary of the research process framework is presented in Figure 3.4 below, with the three stages shown.

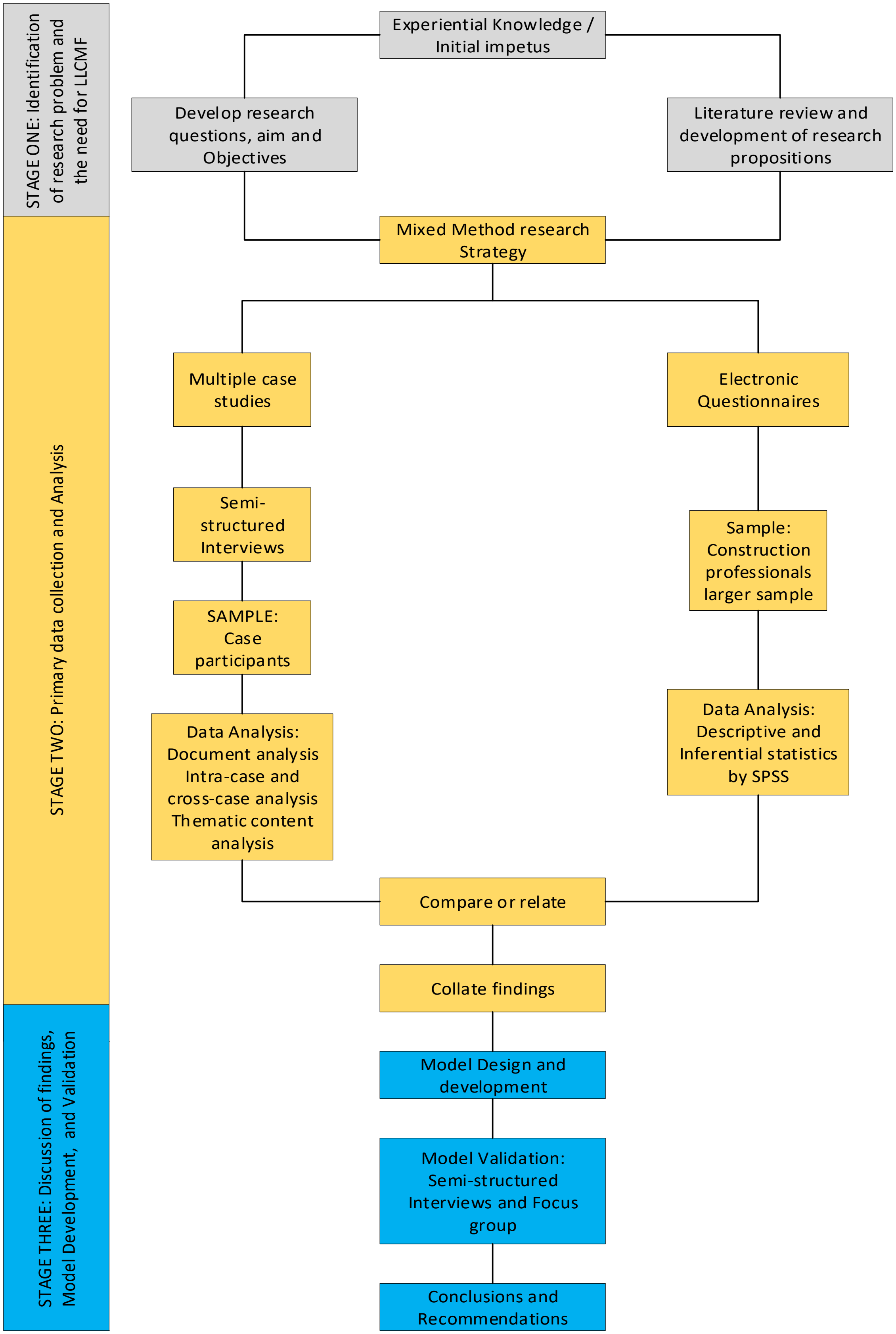


Figure 3.1: The research process framework

3.10 LINKING THE RESEARCH OBJECTIVES TO THE RESEARCH METHODS

This study is aimed at evaluating how to eradicate the poor performance recorded on infrastructure projects using known lean construction practices. The study will evaluate infrastructure projects delivered through traditional project management practices in South Africa using known lean construction concepts. The study attempts to develop appropriate lean construction practices for implementation, supported by robust research, to manage and implement projects in a more efficient and effective manner that brings value to the client.

The expectation is that a lean construction cost management model can be developed as a guide to aid the poor cost performance outcomes of current projects delivered through traditional project management practices. The study evaluates current project cost management practices and their outcomes through multiple cases and semi-structured interviews. The study then reports on the status quo, with the aim of identifying lean opportunities for the improvement of project performance going forward. The research questions assisted in understanding the factors contributing to poor performance and the shortcomings of current project management practices, which led to the research objectives of the study. The objectives of the study are

- To identify and evaluate the outcomes of current project cost management practices used in infrastructure projects,
- To establish the causes of poor performance on South African infrastructure projects in terms of cost and time parameters,
- To establish and describe how lean construction practices will make a difference in South African infrastructure projects,
- To identify drivers and /or enablers, benefits and barriers for the implementation of lean in South African infrastructure projects, and
- To conceptualise and validate a lean construction cost management model for the South African public sector projects.

From the investigation of current project management, practices and their outcomes to proposing a solution with the aid of lean construction principles, it is essential to link the research objectives to the research methods applied in this study (see Figure 3.5).

Firstly, relevant literature described the status of the South African construction industry, and it identified the factors contributing to poor performance of projects. The literature described not only the status of the construction industry, but also the shortcomings of current project cost management practices. Since the study proposes to find solutions through lean construction principles, it was necessary, through the literature, to identify the barriers to and the critical success factors for lean construction implementation in South Africa. The literature led the researcher to proceed to more active and participative methods, by way of case studies, semi-structured interviews, and an electronic survey. Case studies provided archival data, supplementary evidence of outcomes of current project management practices, and evidence of the barriers to and the critical success factors for lean adoption in South Africa. Qualitative and quantitative data was gathered from the cases and the interviews to compare with the findings of the literature review. Robust findings were then applied to answer objectives 1, 2 and 3. To achieve objectives 3, 4 and 5, semi-structured interviews were conducted with a few of the lean practitioners in the country. Lean is a new approach in South Africa, and it is still in its infancy as far as implementation is concerned. Thus, the researcher selected a few individuals that have applied lean construction, to provide a realistic response to the barriers to and the critical success factors for lean construction, and also to describe how lean will make a difference in South African construction infrastructure projects, as well as to validate the (LCCMM). Focus group interviews with professionals employed by the public sector were then conducted to elicit responses, as the framework will be suitable for public sector projects, as the final step. Findings from the case studies and the interviews were then compared with the findings from the survey, to triangulate the results of both data sets. The findings from all the methods provided an opportunity to develop a framework/protocol, using the knowledge gained, as well as the experiences of practitioners who have applied lean construction in South Africa. Broken lines in Figure 3.2 specifies secondary data obtained through literature.

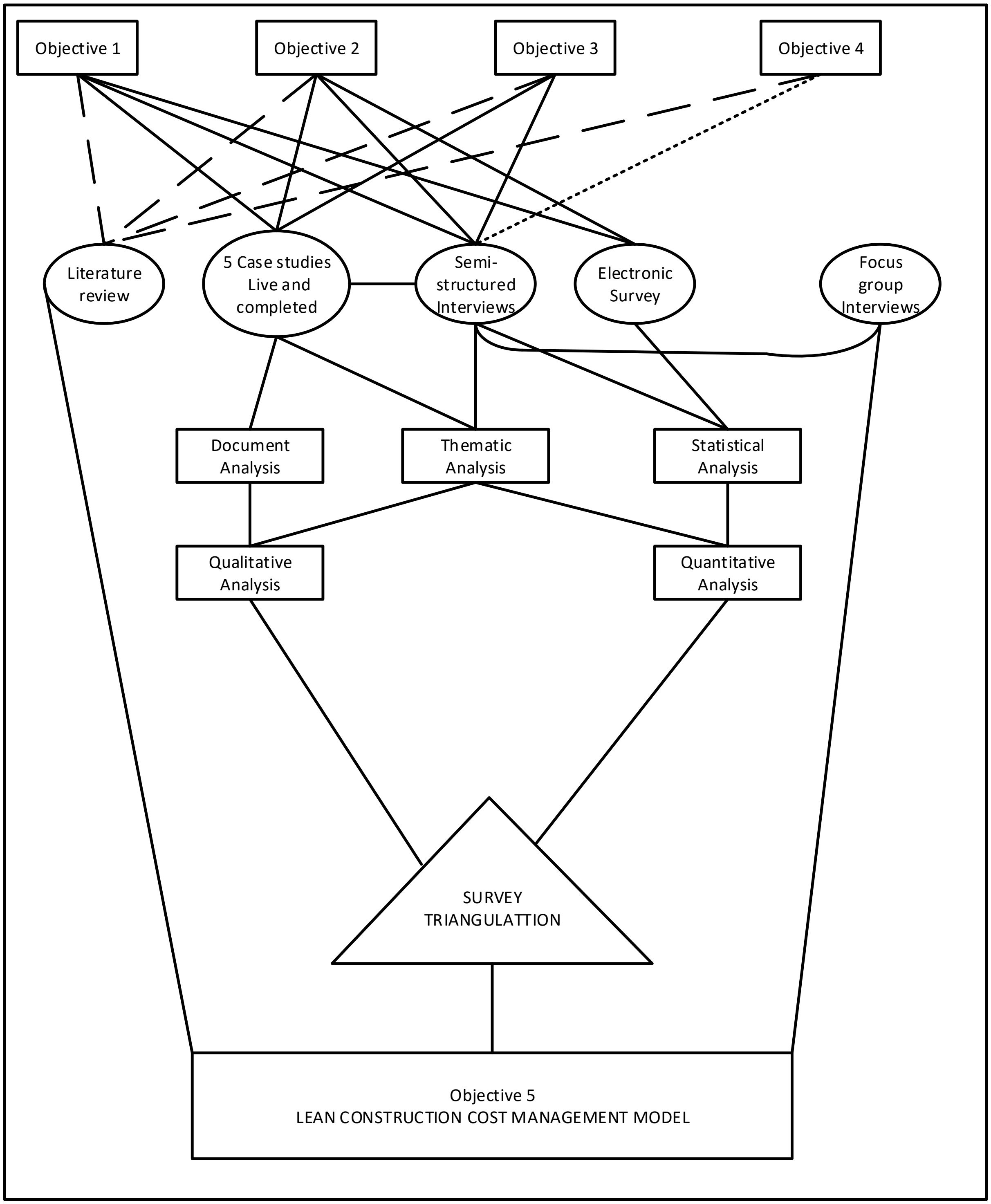


Figure 3.2: The link between the research objectives and the research methods

3.8.1 Method of data collection for validation of the LCCMM

The lean-led project management protocol will be utilised to improve the process of project planning and construction, through the infusing of lean tools. The improvements in the activities undertaken are cost centres, and therefore eventually they will offer cost-efficient projects. Explicit explanations of the design of the cost management protocol is presented in chapter 6. Firstly, semi-structured interviews were employed with different experts from the industry worldwide to validate initial model. The traditional way of project delivery and then the proposed lean-led project management protocol were presented to the experts to elicit their opinions, to define the salient on the development and validation of the LCCMM. Lean experts from the USA and the UK and Canada were identified through electronic media (Skype) to request their participation. The initial validation was sent to lean experts via an email survey for their opinions on the initial protocol developed. Six experts were sent the protocol for validation, and 100% of the respondents responded to the request. Further requests were made to other lean experts for their opinions, but responses were not forthcoming. However, only five of the 10 agreed to participate and were available for interviews. Table 3.6 provides details of the participants.

Table 3.6: Demographics of the initial validation sample

Contacted experts	Consenting experts	Industry	Area of expertise / job role	Location	Code
10	5	Academia	Professor	University of California, Berkeley, USA	E_1
		Industry and academia	Lean practitioner	Regen50, Pretoria, RSA	E_2
		Industry	Lean practitioner	Johannesburg, RSA	E_3
		Academia and practitioner	Chief lean performance officer	University of Michigan, USA	E_4
		Practitioner	Controls Engineer and Lean practitioner	Sakatoon, Saskatchewan Canada	E_5

3.11 ETHICAL CONSIDERATIONS IN THE RESEARCH

One of the most important aspects in the field of research is consideration of ethical issues, as a sound design and carefully constructed data-gathering tools can be jeopardised by unethical reporting (Gray 2014). Ethical consideration was necessary to promote the quality of the research and to guard against impropriety, and to protect the participants and their organisations (Creswell 2014). The research accorded due consideration to ethical issues governing research and publishing in the study.

The researcher is also mindful of the established codes of conduct and regulations guiding research work of this nature. In line with several authors such as (Fellows and Liu, 2015, Mitchell and Jolley, 2010), for ethical reasons this study gave due consideration to transparency, privacy, confidentiality and truthfulness in the conduct of the research. Since this study entails participation from the public sector, the researcher ensured that consent was granted and that the privacy, integrity and confidentiality of participants were respected at all times. The letter from the head office of the national Department of Public Works granting permission for this study to be conducted is attached as an appendix G.

Becker and Denicolo (2012) contend that the reputation of a researcher does not only rest on the quality of the research output, but on the level of respect given in the process of producing the research from other people's intellectual property rights. In this research, full disclosure of the purpose, the methods and the intended possible uses of the research was revealed to the participants in the study. The right to be contacted and to withdraw from the study at any time was an exclusive right of the participants. The research instruments provided for confidentiality. The collected data were deployed purely for academic purposes. All the research findings were presented in an honest manner, without any misrepresentation, to the best ability of the researcher. The researcher at Nelson Mandela University undertook an application for ethics clearance. The process entails submission of the relevant forms for ethical considerations, including self-evaluation checklist in the appendix of the proposal. Furthermore, the application will be tabled at the faculty ethics committee for approval depending on the risks assigned to the application submitted. If the proposal is assigned a medium to high risk it will require institutional clearance for approval. However, this study was assigned a medium risk hence approved at faculty ethics committee. This study received the approval of Ethics in Research committee of the Faculty of Engineering and Built Environment at the Nelson Mandela University **Ref: H18-ENG-BQS-004** for data collection and compilation refer to appendix B.

3.12 CHAPTER SUMMARY

This chapter has presented the research methodology applied to this study, and the rationale for choosing such a methodology. Mixed-methods research was chosen as the research methodology for this study. The study collected data through a literature review, semi-structured interviews, case studies, and a questionnaire survey. The mixed-methods design contributed to highlighting convergent and divergent views obtained from both the qualitative and the quantitative strands of the study. Case studies and a questionnaire survey served similar purposes. They were used to gain a proper understanding of the poor outcomes of current project management practices, and why such poor performance occurred, while semi-structured interviews were used to corroborate the results obtained from the document analysis and to identify the barriers to and the critical success factors for lean adoption in South African construction infrastructure projects.

The subsequent chapter 4, presents the results from data collected through qualitative methods and techniques outlined above.

CHAPTER 4

RESULTS, ANALYSIS OF QUALITATIVE DATA AND INTERPRETATION

4.1 INTRODUCTION

The purpose of this chapter is to report on the results of the data captured, by applying the selected research instruments used to address the research questions. The two stages of the case design, presented earlier in section 3.6, are presented and analysed to obtain findings that meet the research objectives. The outcomes of these stages are triangulated during the data analysis to gain insight into the research questions. The outcomes of existing cost management practices, the reasons for poor project management performance, lean enablers, and an identification of lean opportunities within the selected cases are presented. Specifically, objectives 1 to 4 are achieved in this chapter, which serves as part of the prototype for the development of the framework (objective 5) in chapter 6 of this study.

4.2 QUALITATIVE DATA ANALYSIS

The findings of the case studies selected for this research are presented. Document analysis was used to evaluate archival reports of projects, to understand why infrastructure projects were performing poorly in terms of cost and time. Results from semi-structured interviews were analysed thematically to gain deeper insight into how the conventional method of project delivery contributes to the expected performance of public sector infrastructure projects.

4.2.1 Case study findings

Initially 15 projects were randomly selected for the study from 11 regional offices of the national Department of Public Works (NDPW). However, due to the fact that some of the information was missing on 10 of the projects, the study could only evaluate five of the projects, which had credible data to evaluate. The author requested the public sector official to randomly select projects, in order to rule out bias into all the projects executed under the auspices of the NDPW. The projects were selected from the project management system and were uniquely coded, starting with the word "case", and then a number was assigned to each project for identification, e.g. "Case 1", "Case 2", "Case 3", etc. The project management system was then employed for the data obtained from the planning stage until the completion stage of each project. The system is utilised to keep all project management information, which gets regularly updated by project managers countrywide. The project management system is also prominently employed by the NDPW for decision-making and for monitoring and evaluation of projects, and also as a reporting tool for the status of projects undertaken within the department. Internal and external auditors also offer audit opinions on the information found in the project management system. Most of the reports emanating from the project management system had enough information to evaluate project performance in its entirety, from inception to completion. However, there were a few instances where the archival records were physically checked, namely the instances where additional information was not kept in the project management system. A profile of the selected cases is presented below in Table 4.2, to outline the level of complexity and the Construction Industry Development Board (CIDB) grading for qualification of the level of experience required by contractors bidding for such projects. All contractors executing construction projects must register with the CIDB and be graded according to the works capability, as well as the financial capability to bid for a class of work, for eligibility. There are about 20 CIDB classes of construction works of various specialisations. The selected case study project types are kept anonymous, to prevent them from being identified by external parties not privy to the information, as they are kept confidential (see Table 4.2). First, Table 4.1, indicating the CIDB grading table, will be presented, to show the guidelines of grading contractors for the value of work they can execute.

Table 4.1: Values of the rating for the CIDB grading

Designation	**Contract value range**
CIDB 1	R0 – R200,000
CIDB 2	R200,000 – R650,000
CIDB 3	R650,000 – R2 million
CIDB 4	R2 million – R4 million
CIDB 5	R4 million – R6.5 million
CIDB 6	R6.5 million – R13 million
CIDB 7	R13 million – R40 million
CIDB 8	R40 million – R130 million
CIDB 9	R130 million and above

(Source: CIDB)

Table 4.2: Profile of the selected cases

Case	**Contract value**	**CIDB grading level**	**Status of the project**
Case 1 (C_1)	R458 million	Level 9	Completed
Case 2 (C_2)	R98.9 million	Level 8	Completed
Case 3 (C_3)	R117 million	Level 8	Under construction during data collection
Case 4 (C_4)	R202.8 million	Level 9	Under construction during data collection
Case 5 (C_5)	R50 million	Level 8	Terminated and reappointment

Table 4.3 below illustrates the process used by the NDPW to determine the status or the stages of construction projects. This table explains the process to be followed from the commencement of proposal for projects to be undertaken, according to the new SIPDM.

Table 4.3: Process for status or stages of construction projects

Status Code	Status Description
1	Service registered (with priority number)
2	Service registered (without priority number)
3	Pre-design stage
3A	Pre-design planning
3B	Planning instruction issued
3C	Planning instruction rejected
4	Design stage
4A	Funds approved stage: Preparation of documents
4B	Tender stage
4C	Design stopped
5	Tender recommendation stage
5A	Pre-site handover stage
5B	Construction stage
5C	Quotation services
5D	Consultant own resources
6A	First delivery stage
6B	Concurrent and emergency services
7	Final delivery stage
8	Construction completed
9	Service inactive

(Source: Researcher's fieldwork)

The project management system encompasses all the reports, according to the status outlined in Table 4.3 above. Reports are downloaded for each selected project. The process of downloading the reports took approximately 80 days, and it conveniently facilitated interaction with the officials responsible for the project management system.

Table 4.4 shows how the DPW planned for execution of the projects. The user departments are at the centre stage of the process.

Table 4.4: Project execution plan (PEP)

Milestone description
Request of accommodation particulars
Accommodation particulars received from the client
Accommodation particulars approved
Preliminary estimate
Determine size of site
Identification and clearance of site
Issue planning instruction
Accept final planning instruction
Nomination and appointment of consultant
Briefing of consultant
Submit planning schedule
Sketch plan and issue to disciplines
Estimates and reconciliation
Sketch plan completion date
Approval by the client
Final work drawings/estimate
Final engineer’s layout
Draft bills, final estimates, and space norms
Planning completion date
Confirmation by the client
Funds final approval
Advertise tenders
Award tender
Handing over of site
Practical completion certificate

The randomly selected projects were categorised into projects under construction and completed projects, which were subsequently each analysed within the respective category. The DPW prepares the project execution plan upon receipt of accommodation requirements of the user department. The requirements of each user department are subjected to the proper analysis.

The DPW checks the requirements against state-owned properties and performs a feasibility study of all possible options. The best option is then decided on based on the outcome of the feasibility study. The decision to construct, refurbish, or lease is the outcome of the feasibility study.

4.3 PROJECT CASE 1 – COMPLETED PROJECT

Table 4.5: Project case 1

Project information	Data
Contract value	R458 million
Procurement method	Design-bid-build
Date contractor appointed	24 February 2012
Site handover date	23 March 2012
Change order amount	R46 million
Scope change amount	R13 million
Amount for extension of time claim	R21 million
Contract duration	24 months
Date of practical completion	23 July 2014
Revised date of practical completion	3 August 2015
Current status	Construction stage (5B)
Final contract value	R643 million
Cost overrun	R185 million (40.4%)
Time lapsed	24 months
Time overrun	17 months
CPAP	R98.8 million
Contingencies	R6.8 million

The project incurred cost overruns to the value of R185 million, which amounts to 40.4% of the original contract value on the date of award of the bid to the contractor. The final contract amounted to R643 million. Again, this is attributable to change orders and extension of time claims, with costs to the contractor and escalation in costs. The major increase was due to a list of variation orders amounting to R46 million, contract price adjustment provisions of R98.8 million, and contingencies of R6.8 million.

The project management system recorded the project execution plan as follows:

Funds final approval was 20 February 2009; the actual date was 29 July 2011, which is 29 months later than the PEP.

Table 4.6: Project execution plan for project case 1

Milestone description	System date	Plan date	Actual/revised date	Slippage days
Needs received	14-Jan-07	15-Aug-08	15-Aug-08	0
Needs approved	15-Mar-07	07-Sep-07	07-Sep-07	0
Appointment of consultants	13-Jan-08	18-Apr-08	07-May-08	−19

Funds approval	31-Oct-09	20-Feb-09	29-Jul-11	−889
Advertise tender	31-Dec-09	06-Mar-09	28-Oct-11	−966
Award tender	31-Mar-10	24-Apr-09	24-Feb-12	−1036
Handing over of site	14-Apr-10	28-Apr-09	23-Mar-12	−1059
Practical completion certificate	24-Mar-14	24-Apr-14	04-Dec-15	−589

Contributing factors to poor performance, and their reasons

- The project was not developed according to the needs of the user department. The user department was identified towards the completion of the project.
- Funds confirmation was done late
- Poor contract management by project manager
- Poor site management
- Unforeseen site conditions
- Lack of community support
- Too many changes of scope during construction
- Poor performance by contractor
- A strike by the community
- Bad weather
- The lease agreement was R11 million (the lease agreement was extended for six months owing to delays)

4.4 PROJECT CASE 2 – COMPLETED PROJECT

Table 4.7: Project case 2

Project information	Data
Contract value	R98.8 million
Procurement method	Desing-bid-build
Date contractor appointed	17 April 2012
Site handover date	9 May 2012
Change order amount	R42.4 million
Scope change amount	R13 million
Amount for extension of time claim	R21 million
Contract duration	24 months
Date of practical completion	26 November 2014
Revised date of practical completion	30 November 2015
Current status	Construction stage (5B)
Final contract value	R141.2 million

Cost overrun	R42.4 million (42.9%)
Time overrun	12 months
CPAP	R8.4 million
Contingencies	R6.8 million

Project 2 incurred cost overruns to the value of R42.4 million, which amounts to 42.9% of the contract amount on the date of award of the bid to the contractor. The final contract amount was R141.2 million. The project management system recorded the project execution plan as follows:

Table 4.8: PEP for project case 2

Milestone description	System date	Plan date	Actual/revised date	Slippage
Needs received	01-Feb-04			0
Needs approved	19-Jan-05			0
Appointment of consultants	29-Mar-04	15-Apr-05		−380
Funds approval	30-May-05	25-Oct-08	20-May-11	−920
Advertise tender	30-Jul-05	20-Sep-11	18-Nov-11	−58
Award tender	28-Oct-05	20-Sep-11	18-Nov-11	−2190
Handing over of site	11-Nov-05	20-Jan-12	09-May-12	−122
Practical completion certificate	06-Dec-06	22-Jan-14	26-Nov-14	−2555

Contributing factors to poor performance, and their reasons

- Slow pace in decision-making by all project teams
- Funds confirmation took a long time
- Poor contract management by project manager
- Unrealistic contract duration
- Poor cash flow management
- Slow procurement process
- Site clearance
- Poor planning by the contractor (sequence scheduling of work on-site)

4.5 PROJECT CASE 3 – UNDER CONSTRUCTION PROJECT

Table 4.8: Project case 3

Project information	Data
Consultants appointed date	7 December 2005
Contract value	R117 million
Date contractor appointed	8 January 2013

Site handover date	17 January 2013
Contract duration	24 months
Date of practical completion	16 January 2015
Current status	Construction stage (5B)
Expenditure to date	R22 million (18.8%)
Time lapsed	24 months
Time overrun	30 months (123%) as at 30 June 2017

The project is at construction stage (5B), according to the status codes in Table 4.3. The construction is at an early stage, given the spending percentage as at 30 June 2017. The construction contract period was scheduled for 24 months, and the construction was supposed to have been completed on 16 January 2015. However, 30 months later, the project is still under construction, and the payment to date is at 18.8% of the total contract value, which shows the slow pace of the construction. The consultants were appointed on 7 December 2005, which is eight years before construction started, and funds for the project were approved on 30 October 2011 (six years later). As a result, there is a potential risk to increase the contract amount, owing to contract price adjustment provisions (CPAP) and penalties to be levied on the contractor for late completion.

Factors contributing to the poor performance of the project, and their reasons

- Funds confirmation by the client took a long time
- Slow pace in decision-making by all project teams
- Slow pace in making decisions by the client
- Poor contract management by the project manager
- Unrealistic contract duration by the client
- Poor planning by the contractor (proper sequencing of scheduling of work, especially with subcontractors)
- Late payments

The contract amount has not been affected at this point, despite the delay of two years. Evaluation of the project as at 30 June 2017 shows that the project is behind by 30 months, while it is still under construction. The project is likely to issue an instruction for extension of time, which will result in the project realising a cost overrun.

4.6 PROJECT CASE 4 – UNDER CONSTRUCTION PROJECT

Table 4.9: Project case 4

Project information	**Data**
Contract value	R374.3 million
Date contractor appointed	27 August 2008

Site handover date	22 October 2008
Contract duration	30 months
Date of practical completion	22 April 2011
Current status	Construction stage (5B)
Expenditure to date	R65 million (14.9%)
Time lapsed	30 months
Time overrun	75 months (248%) as at 30 June 2017
Contract value as at 30 June 2017	R437.6 million
Contract price adjustment provisions (CPAP)	R44.9 million
Contingencies	R18.7 million

The project is at stage 5B, according to the status codes in Table 4.3, still in the beginning of the construction stage, hence the expenditure is at 14.9%, evaluated as at 30 June 2017. The construction contract duration was planned for 30 months, and construction was to achieve completion on 22 April 2011. Six years later, after the contract period, the spending was at 14.9%, which shows the snail's pace at which the construction is proceeding. The needs of the client were received on 14 June 2005 (12 years before). The project remains incomplete, at stage 5B. There is an increase of R63.3 million (16.9%) between the contract amount of R374.3 million on the date of award of the bid and the final contract amount of R437.6 million as at 30 June 2017. The aforementioned amount has a potential risk to increase beyond R437.6 million, especially for CPAP and penalties.

Factors contributing to the poor performance of the project, and their reasons

- Slowness in decision-making by all project teams.
- Funds confirmation took a long time.
- Slow pace in making decisions by the client.
- Poor contract management by the project manager.
- Poor cash flow management.
- Poor site management.
- Poor planning by the contractor (sequence scheduling of work on-site).
- Wrong appointment of contractor.

An increase of R63.3 million is principally owing to the delays in the project. CPAP would have been incurred even if the project were on time. Therefore, the delays have inevitably resulted in a significant CPAP, which could have been avoided.

The project has an amount of R44.9 million for CPAP and R18.7 million for unforeseen expenses. The final contract value as at 30 June 2017 is R437.6 million. The project is at stage 5B, and the expenditure as at 30 June 2017 was R65 million (14.9%). As at 30 June 2017, the project is behind by 106 months, and it remains in the construction stage. The extension of time will result in additional financial loss.

4.7 PROJECT CASE 5 – CONTRACTS TERMINATED WITH APPOINTED CONTRACTORS, AND APPOINTMENT OF A CONTRACTOR MADE

Table 4.10: Project case 5

Project information	**Data**
Contract value	R27 million
Date contractor appointed	8 November 2013
Site handover date	15 November 2013
Contract duration	16 months
Date of practical completion	9 April 2015
Current status	Construction stage (5B)
Time lapsed	30 months
Time overrun	5 months (31.25%)
Cost overrun	R4 million
Contract value	R27 million
Contract price adjustment provisions (CPAP)	R2.5 million
Final contract value	R31 million

Factors contributing to poor performance, and their reasons

- A mora (termination) letter was sent, requesting the property owner to remedy the default within 10 working days of the notice.
- The contractor was found to be in default in February 2015, not proceeding with work with due diligence, skill, or regularity and expedition.

In order to bring the work to practical and final completion, the following urgent matters were included in the letter, for the contractor to address with immediate effect:

- Subcontractors to return to site.
- Provide a revised programme to complete the project.
- Submit a business rescue plan, and demonstrate how such a plan will be financially managed, as well as cash flow for the subject project.
- Update the Health and Safety Mandatory Agreement, to be signed by the current contractor.

One-hundred-and-sixty-three calendar days was approved, and the revised contract completion date was set at 19 August 2015. There was noteworthy progress from the contractor until June 2015, when the majority of the subcontractors abandoned the site owing to non-payment by the main contractor. The contractor appointed new subcontractors, which affected the progress of the project. There was also a dispute over payment certificates, and the contractor was not satisfied with the dispute resolution, as it was not in his favour, and he decided to vacate the site. A notice to cancel the contract was issued on 25 September 2015.

The contractor was unable to pay the subcontractors, owing to cash flow problems, and the subcontractors vacated the site. The contractor ignored the first notice, and a second notice was issued in November 2015.

The NDPW has not appointed a second contractor to complete the project. The loss suffered by the NDPW has been determined. The contractor was not an emerging contractor. At the time of appointment, the contractor was at grade 8GB. Despite the grading of the contractor, adequate support was provided to the contractor.

Factors contributing to poor performance

- Slow pace in decision-making by all project teams
- Poor cash flow management
- Unforeseen site conditions
- Low tender price
- No payments to subcontractors
- Poor planning by contractor
- Poor site management

The financial loss as a result of the delays is not yet fully determined, except that a letter has been received from the factory manager, complaining about the impact of the stopped project:

- Unable to execute order worth R70 million
- Unable to operate; toilets and cables were left without interim measures
- Customers unable to come to the factory, which affects the operation of the factory
- Unable to appoint more staff

The above findings from case studies demonstrate projects that have failed and that have realised poor performance in terms of completion within the stipulated budget and completion within the planned duration of the project. The above information was collected from documents perused of the sampled projects from public works departments in different provinces of South Africa. In the following section the semi-structured interviews conducted with the participants of the projects have been analysed to gain a deeper understanding of the perceptions of participants on the poor performance of the projects. Below is figure 4.1 indicates the results concerning the performance of public projects in terms of cost.

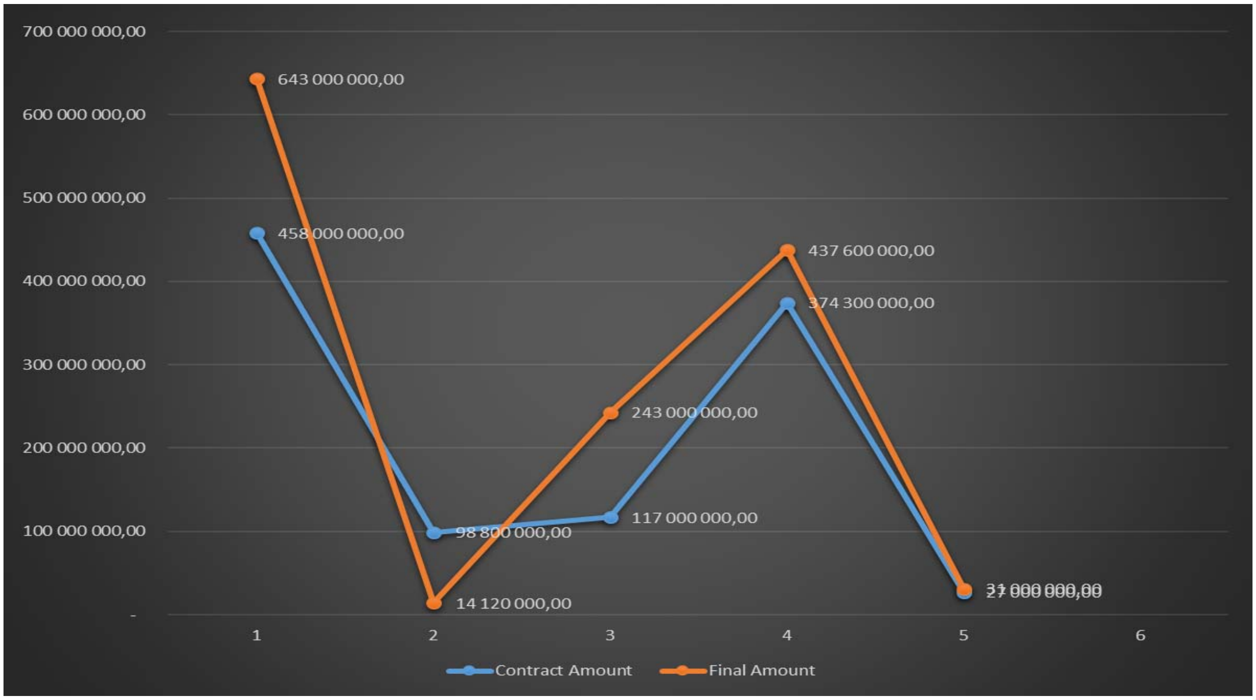


Figure 4.1: Performance outcome for case study 1 to case study 5

Source: Author's research field work

All projects were general building projects from the DPW, ranging from various buildings such as offices etc. In amounts, they ranged from R27 000 000.00 to R458 000 000.00 in original tender amounts, and the durations were from 12 months to 24 months, excluding extension of time. The figure shows that overruns ranged from 15% to 40% of the total project. The reasons cited in the projects were additional work request by the client, extension of time, re-measurements and variations. Moreover, none of the remedial measures was applied to the projects.

4.8 CHARACTERISTICS OF THE INTERVIEWEES

Table 4.11: Profile of the respondents

	No.	Qualification	Position	Years of experience	Position on project	Code
Case 1						
	1	Honours	QS	24	Consultant	QS_1
	2	Master's	Architect	30	Consultant	$Arch_1$
	3	Honours	CPM	33	Client rep.	CPM_1
Case 2						
	1	BTech	QS	15	Consultant	QS_2
	2	Master's	Architect	20	Consultant	$Arch_2$
	3	Honours	CPM	6	Client rep.	CPM_2

	No.	Qualification	Position	Years of experience	Position on project	Code
Case 3						
	1	BSc	QS	30	Consultant	QS_3
	2	Master's	Architect	16	Consultant	$Arch_3$
	3	Honours	CPM	30	Client rep.	CPM_3
Case 4						
	1	Honours	QS	25	Consultant	QS_4
	2	Diploma	CPM	10	Client rep.	$Arch_4$
	3	Master's	Architect	28	Consultant	CPM_4
Case 5						
	1	Honours	QS	18	Consultant	QS_5
	2	Master's	Architect	29	Consultant	$Arch_5$
	3	Honours	CPM	7	Client rep.	CPM_5

(Source: Researcher's fieldwork)

The analysis of the background information of the respondents that participated in the study shows an unbalanced distribution in the sample of the interviewees. Only three professionals per project were represented in the sample of professionals, with the exception of the engineers. This is attributable to the perception that engineers do not form part of the cost management process. However, other similar studies have shown that engineers play a significant role in the cost management process of projects. Further studies could evaluate why such a perception exists in South Africa for architectural projects.

4.8.1 Analysis of the interview responses

To analyse the qualitative data, a frequency distribution was used to interpret the responses to questions in which participants were asked to give a rating, supported by reasons. To analyse responses to the open-ended questions, key words that the respondents used were placed in categories, which were then interpreted using a frequency distribution (minor variances in total percentages were the result of rounding the frequency percentages). The results have been tabulated, with the interviewees' explanations paraphrased briefly in the comments column. In each case, the summary interpretations of the responses took the respondents' reasons and explanations into consideration. The analysis of the data is presented according to the questions under their respective themes.

4.8.2 Theme 1: Outcomes of current project management practices

Table 4.12: Overall project performance

Performance / Respondent	Poor	Under-performing	Average	Good	Comments
QS_1	X				• The cost of some projects doubles by the time the projects are finished. • Many projects are abandoned, and new contractors have to be appointed at extra cost. • Sometimes a third contractor is brought in after the first and second contractors failed to rescue the project.
$Arch_1$	X				• Many problems are experienced with contractors. • Overruns pertain more to completion time than budget.
CPM_1			X		• Some projects are completed over budget. • Projects are performing much better than expected, although there is room for improvement.
QS_2		X			• Projects are under budget, as they are not happening. • Upcoming contractors are inexperienced, and they cannot control finances, so projects are cancelled. • The points system is unreliable in identifying contractors according to the class of work for which they are registered under the CIDB gradings.
$Arch_2$		X			• Many delays in construction are experienced, which lead to escalated costs.
CPM_2	X				• Inexperience of the client and the project manager results in architects overdesigning, to inflate costs, to maximise their billing.

In terms of the overall performance of projects, as shown in Table 4.12, most of the respondents (83%) indicated that projects are underperforming or are performing poorly. Only one respondent felt that project performance is average, with room for improvement. The main reasons given for the poor performance were the inexperience of contractors, clients, and project managers, which results in poor project execution, poor financial control, projects overrunning time, leading to escalated costs, and projects being abandoned.

The aim of the next question (see Table 4.13) was to understand the frequent outcomes of current project management practices in comparison with the case studies, and especially to understand the perceptions of the interviewees regarding project outcomes.

Table 4.13: Outcomes of current project practices

Rating / Respondent	Very poor	Poor	Average	Fairly good	Good	Comments
QS_1	X					• Outcomes are very poor in terms of what happens in projects executed for the public sector.
$Arch_1$		X				• Lack of experience and qualifications are the main cause of many problems experienced on-site.
CPM_1	X					• Outcomes are very poor when compared with the standard of practice. • Change orders in the public sector are delayed by infrequent national committee meetings.
QS_2				X		• Projects are performing as well as can be expected, especially public sector projects.
$Arch_2$			X			• Very few projects are completed without complications.
CPM_2		X				• The processes of the public sector have a lot to do with the poor performance.

As shown in Table 4.13, most of the respondents (66%) felt that the current outcomes of project practices are poor to very poor. Two respondents (34%) felt that the outcomes are average or fairly good. On the one hand, respondents explained that generally, few projects are ever completed without complications, and that projects in the public sector are performing as well as can be expected. On the other hand, respondents believed the performance of projects in the public service is poor, because of the processes in the sector, and that lack of experience and qualifications is the main cause of many problems experienced on-site.

The responses in Table 4.14 are to the question of why the existing cost management practices are leading to poor performance in projects.

Table 4.14: Reasons why current cost management practices lead to poor performance in projects

Category / Respondent	Public sector processes	Skills, experience & qualifications of contractors	Inflation of costs	Non-technical briefing sessions	Legislation	Comments
QS_1		X				• Most contractors are not suitably skilled for the type of projects for which they are appointed. • There is a skills gap between running a smaller business and running a medium business. • This results in mismanagement of finances and being unable to complete the projects.
$Arch_1$		X				• Lack of experience and qualifications are the main cause of many problems experienced on-site. • Some of the key personnel do not have the technical expertise of the built environment. • They do not have qualified supervisors to oversee the running of the projects.
CPM_1	X					• The public sector system is very slow in responding to requests for information. • The process from the inception to the construction stage is very long. • Other factors, such as market fluctuation and currency exchange, affect the process.
QS_2	X	X				• The current procurement systems and contracts are not flexible enough to deal with other factors, which indirectly contributes to the poor performance of projects. • Some contractors do not have the resources to execute projects, in the first place.
$Arch_2$		X			X	• Mainly, contractors are incompetent to handle the type of projects for which they are appointed. • The management and supervision of projects by the contractors leaves much to be desired. • Legislation forces us to include small to medium contractors, who sometimes do not have the expertise required by the building industry.
CPM_2			X	X		• Some decisions by external professional consultants are questionable and result in extra costs for the projects.

Category / Respondent	Public sector processes	Skills, experience & qualifications of contractors	Inflation of costs	Non-technical briefing sessions	Legislation	Comments
						• Briefing sessions are attended by finance-related employees of the public sector, instead of by technical professionals, who will provide better briefs for project execution.

The most frequently mentioned reasons for why cost management practices are leading to poor performance in projects (see Table 4.15) were the inadequate skills, experience and qualifications of contractors (45%) and delays caused by public sector processes (22%). Other reasons mentioned were questionable inflation of costs, non-technical project briefing sessions, and legislation.

The responses shown in Table 4.16 are suggestions about the direct causes of poor cost performance in projects, in order to understand the constraints experienced by professionals when executing projects.

Table 4.15: Direct causes of poor cost performance in projects

Category / Respondent	Delays in public sector processes	CIDB grading of contractors	Tender bid pricing	Day-to-day project management	Project panning by contractors	Comments
QS_1	X	X	X			• Grading of contractors by the CIDB needs to be reviewed. • Contractors' bids are not priced appropriately in relation to the tender documents. • The internal processes of the public sector take a long time to make a final decision on which contractor has won the bid, by which time the tender validity period has lapsed, and inflation contributes to extra costs.
$Arch_1$	X			X	X	• Day-to-day management of the project is not being done well. • Insufficient planning by the contractor will eventually lead to poor cost performance. • The internal processes of the NDPW take longer to appoint consultants than before,

						and they contribute to poor cost performance.
CPM$_1$	X					• There are delays in receiving instructions to implement projects in the public sector.
QS$_2$				X		• Individuals who do not have the expertise required by the industry operate construction companies without being aware of the potential risks.
Arch$_2$	X					• The delays experienced in the pre-contract stage in the public sector add to the escalation of project costs.
CPM$_2$	X					• The internal processes of the public sector are very slow in commencing a project, which escalates costs.

As shown in Table 4.16, the most frequently mentioned direct causes of poor cost performance in projects are delays in the public sector processes (50%) and inadequate day-to-day project management (20%). Other causes mentioned are the unreliable CIDB process of grading contractors, inappropriate pricing of tender bids, and insufficient planning of projects by contractors.

In addition, the interviewees were asked to explain the indirect causes of poor cost performance in projects, to gain insight into specific issues that indirectly hinder progress and provision of value. The responses are presented in Table 4.17.

Table 4.16: Indirect causes of poor cost performance in projects

Category / Respondent	**Procurement processes**	**Economic factors**	**Expected discounts**	**Overregulation by the NDPW**	**Contract terms and conditions**	**Comments**
QS$_1$		X	X			• The economy contributes to contractors cutting profits too much in order to win bids, to keep afloat. • The discounts that consultants are expected to provide demotivate them, so that they limit their input to projects, and clients have to rely on a minimum contribution from them.
Arch$_1$				X		• The NDPW prides itself on obtaining clean audits, by imposing restrictive precautionary measures to ensure proper governance in executing projects, with the result that few projects get to construction stage within a year.
CPM$_1$	X					• Procurement processes are also contributing to the longer period taken to appoint a contractor to commence construction.

Category / Respondent	Procurement processes	Economic factors	Expected discounts	Overregulation by the NDPW	Contract terms and conditions	Comments
QS_2					X	• We cannot overrule the current tender system, and this is where the problem lies. • We need to do more in terms of improving the contracts we use to support the growing number of small and medium companies in the market. • We should consider advance payments to assist them to start a project.
$Arch_2$			X			• Consultants are expected to offer discounts on their activities, to be competitive, which indirectly affects the quality of work received. • In South Africa all consultants use a fee scale provided by the councils with which they are registered as professionals under the act promulgated by the government.
CPM_2			X			• Currently a tender must go out even for the same consultants to tender for a project, and they are expected to offer discounts on their activities, to be competitive. This indirectly affects the quality of service received.

The most frequently mentioned indirect cause of poor cost performance in projects was the discounts that consultants are expected to give on their activities, which negatively affects the quality of their input. Other causes mentioned were delays in the procurement processes, economic factors, overregulation by the NDPW, and contract terms that are not supportive of emerging contractors.

4.8.3 Theme 2: How lean construction could make a difference in South Africa

The purpose of the questions under theme 2 was to create awareness of waste and to test the proposition that existing projects are inherently wasteful in terms of lean construction.

Table 4.18 shows the responses of the interviewees to the question of whether they agreed that poor time and cost performance is a wasteful (non-value-adding) activity for clients, contractors, and the entire project team. If they agreed, they were asked to discuss other activities that contribute to poor cost performance and do not add value to the progress of the project work.

Table 4.17: Poor time and cost performance is wasteful in terms of lean construction

Rating / Respondent	Definitely no	No	Yes	Definitely yes	Comments
QS_1			X		• Normally the public sector would finally appoint a contractor a year after cost estimates were made. The estimates are not updated, and they require a budget from Treasury. The result is that there is no time to revise the estimates based on costs at the time the contractor is appointed.
$Arch_1$			X		• Even if proper planning has been done, if the contractor is not available, it will not add value.
CPM_1			X		• The internal processes that take so long are not because of precautionary measures, but because of bureaucratic issues causing delays.
QS_2			X		• The time it takes to get to the construction stage is a waste, and more so when a new contractor has to be appointed if the first one has to be taken off site.
$Arch_2$			X		• Mostly client departments are affected by the inconvenience caused by such activities not adding value to the projects. • The current project delivery method has to be improved for better service delivery to the public and the client departments.
CPM_2				X	• We are not adding value to the asset we are constructing.

All of the respondents (100%) agreed that poor time and cost performance are wasteful activities in a project. The main activities mentioned that contribute to poor cost performance were the time it takes to get a project to construction stage and the delay between when cost estimates are prepared and when a contractor is appointed.

The interviewees were asked whether design contributes to poor cost performance in projects. The purpose of the question was to connect design with costing activities and to determine the extent to which there is a silo mentality in the project process. The responses are shown in Table 4.19.

Table 4.18: Design contributes to poor cost performance

Rating / Respondent	No	Not necessarily	Possibly	Yes	Comments
QS_1		X			• The design is usually approved by the client, so design cannot be singled out as the contributor.

Rating Respondent	No	Not necessarily	Possibly	Yes	Comments
$Arch_1$	X				• It happens very rarely, but if there is a problem, we apply for a variation order and fix it. • The designs have not been a problem, but the execution has been.
CPM_1				X	• The design plays a big role in cost performance in the public sector, because the response to any request for information during construction will be slow and will delay the project severely.
QS_2				X	• If the contractor cannot read the drawing plans, then the design will contribute to poor cost performance.
$Arch_2$	X				• Design very rarely contributes to poor cost performance on projects. If it happens, the design can be revised, unlike non-performance by the contractor, which happens regularly. However, the NDPW is very strict about approving variation orders, and it is a time-consuming exercise.
CPM_2			X		• The public sector sometimes experiments with cost-effective initiatives, and it is a good idea to try to save costs. However, sometimes architects try to include features which do not add value because they are too expensive to maintain.

The opinions of the interviewees were divided, with 50% saying that design does not contribute to poor cost performance, and 50% saying that it does. Both architects were insistent that design does not contribute to poor cost performance, although $Arch_2$ acknowledged that when a problem arises, applying for variation orders to be approved is a time-consuming exercise. However, the architects noted that design errors can be revised, which is not the case with construction problems, which occur frequently.

Lean construction was suggested to the interviewees as a possible solution to the current poor performance they described earlier. The interviewees were asked to identify how design influences project cost, to what extent cost could influence design, and whether active steering of the design towards an acceptable project cost, rather than the cost reflecting the design, would affect overall project performance.

Table 4.19: The relationship between design and project cost

Rating / Respondent	Design has a significant effect on project cost				Active steering of design towards acceptable cost could improve project performance				
	Disagree	Somewhat disagree	Somewhat agree	Agree	Disagree	Somewhat disagree	Somewhat agree	Agree	Comments
QS_1				X				X	• Designing to a cost would be a good experiment in terms of planning the design. • There are many instances where architects overdesign to compensate for the discounts they had to offer in order to win the bid. If architects design within a budget, the practice of overdesigning can be eliminated. • The other issue is the way their fees are paid. By the time the design is approved, 70% of their fees have been paid, with 30% to be claimed after completion of the project, which leads to less commitment for the remainder of the project.
$Arch_1$		X			X				• Usually before a project starts, the architects already have an estimate from the quantity surveyor (QS), based on the preliminary sketches. The architect then budgets according to the estimate, which is updated when specifications have been provided.
CPM_1			X				X		• This would be a new phenomenon for the public sector, which, if implemented, might improve the current cost outcome.
QS_2				X				X	• In the construction industry, 80% of the cost is committed in the design stage, and only 20% of the

									cost can be changed in the construction stage.
Arch$_2$	X				X				• Before the design starts, architects have an estimate from the quantity surveyor, and they budget accordingly. • During the project briefing, we receive instructions on what is required.
CPM$_2$			X				X		• Sometimes designs are unnecessarily expensive for the public sector, and they lead to huge costs for the projects.

As shown in Table 4.20 above, 66% of the interviewees agreed or somewhat agreed that design has a significant effect on project cost. The architects disagreed or somewhat disagreed. The key word in the second question was “active”, and most of the interviewees (66%) agreed or somewhat agreed that active steering of the design towards an acceptable cost could improve project performance. The architects disagreed, and they explained that already they receive an estimate from the quantity surveyor, based on their preliminary sketches, and that they budget accordingly.

The interviewees were asked to suggest a solution to how project parties could use flexibility to address costing matters in construction.

Table 4.20: Using flexibility to address costing matters in construction

Category / **Respondent**	**More accountability for industry practitioners**	**More frequent site visits**	**Review internal public processes**	**Collaboration on final design**	**Comments**
QS$_1$		X			• Require project managers and consultants to make frequent site visits on a daily/weekly basis to check on progress and mentor the contractors.
Arch$_1$			X		• There are so many committees in the NDPW that response to the needs of the projects is very slow.
CPM$_1$	X				• More accountability needs to be placed on all participants to improve the industry.
QS$_2$			X		• Change the tender system. The points system is exposing the weaknesses in the process itself. We need an approach

					that is more value-driven than price-driven.
$Arch_2$			X		• Shorten the periods in the public sector's internal processes, and allocate enough time for planning projects, with value in mind.
CPM_2				X	• We have space norms and cost norms for every asset to be constructed for the public sector. We cannot continue to see the reality of what we construct through the eyes of the designers alone. There has to be collaboration on final design.

As shown in Table 4.21, most of the interviewees (50%) suggested that the internal processes of the public sector should be reviewed in order to address costing matters in construction. Other suggestions were that there should be more accountability for industry practitioners, that there should be more frequent site visits, and that there should be more collaboration on final design, to conform to public sector norms. It appears that an underlying issue was whether the public sector should have more control, or whether there should be more accountability for industry practitioners.

The interviewees were asked to suggest a solution to how project parties could use responsiveness to address costing matters in construction, with specific reference to design and cost activities.

Table 4.21: Using responsiveness to address costing matters in construction, with reference to design and costs

Category **Respondent**	**A more collaborative approach by industry**	**Simplify the process of compliance**	**Incentive schemes to engender collaboration**	**Comments**
QS_1		X		• Reduce the long internal public sector time frames for making appointments, to accelerate spending on allocated budgets.
$Arch_1$		X		• Compliance issues delay the process of project delivery. Too much paperwork is making the process very slow, and there is little time to do the actual work of project planning.
CPM_1	X			• The industry needs to take more responsibility as a collective. • There needs to be a more collaborative approach, rather than a fragmented approach. Contracts should combine all project participants on the same level, and not separate designers and contractors.
QS_2	X			• Find ways to eliminate the fragmented nature of the industry and focus more on collaboration.
$Arch_2$	X		X	• More collaboration by all project participants is needed. • Moreover, discounts discourage consultants from performing at an optimum level to cut their costs.

CPM$_2$			X	• We need incentive schemes that will engender more collaboration on public sector projects. • Currently, exposing professionals to a competitive tendering system is not yielding good morale and commitment by the professionals whom we expect to deliver good service. The morale is very low, and forcing them to discount their fees is actually hindering progress.

As shown in Table 4.22, there was a fairly even frequency distribution for three suggestions, namely a more collaborative approach by industry, simplify the process of compliance, and provide incentive schemes to engender collaboration, with three interviewees mentioning the need for more collaboration by the industry. Overall, 72% of the suggestions favoured more collaboration throughout the project process.

To gain further insight into the interviewees' perceptions of current projects, they were asked whether, based on the current outcomes of projects that have been undertaken, the projects are performing well or poorly.

Table 4.22: Performance of projects based on current outcomes

Rating **Respondent**	**Very poor**	**Poor**	**Average**	**Good**	**Very good**	**Comments**
QS$_1$			X			• Mostly average.
Arch$_1$	X					• Very poorly. • We regularly have had to cancel some projects because of non-performance by the contractor. We have had to levy penalties on many projects that cost more than anticipated. It is worse when cancellation happens, because it already takes long to initiate a project.
CPM$_1$				X		• They are performing well, but there is still room for improvement. • We are very slow in following up the maintenance of assets.
QS$_2$			X			• Average, although there are projects making an impression because of how they have been executed.
Arch$_2$			X			• In general, I would say that it is on an even scale.
CPM$_2$	X					• More needs to be done to find innovative ways to boost the image of the industry.
Frequency distribution and %	2 (33%)		3 (50%)	1 (17%)		

Based on the current outcomes of projects undertaken, 67% of the interviewees felt the performance is average to good (see Table 4.23), of which 50% felt the performance is average. Two interviewees (33%) felt the performance is very poor. In comparison with tables 4.13 and 4.14, these results show considerable changes in the perceptions of the interviewees. In Table 4.13 (overall project performance), 83% of the respondents indicated that projects are underperforming or are performing poorly, and only one respondent felt that project performance is average. In Table 4.14 (outcomes of current project practices), 66% of the respondents felt that the current outcomes of project practices are poor to very poor. Only one respondent felt that the outcomes are average, and one felt that they are fairly good.

The comparative variances of the interviewees' perceptions of project performance are shown in Table 4.23.

Table 4.23: Comparative variances of interviewees' perceptions of project performance

Respondent	**Table 4.13: Overall project performance**	**Table 4.14: Outcomes of current project practices**	**Table 4.22: Performance of projects based on current outcomes**
QS_1	Poor	Very poor	Average
$Arch_1$	Poor	Poor	Very poor
CPM_1	Average	Very poor	Good
QS_2	Underperforming	Fairly good	Average
$Arch_2$	Underperforming	Average	Average
CPM_2	Poor	Poor	Very poor

QS_1, CPM_1, and QS_2 showed the greatest variance in their perceptions of project performance.

The interviewees were asked to identify the causes of poor project performance, since this is one of the objectives of this study.

Table 4.24: The causes of poor project performance

Category / Respondent	Delays in project completion	Slow project implementation processes	Lack of support for small and medium contractors	Poor communication	Perceptions of public/private sector projects	Expected discounts	Incompetent contractors	Influence of designers	Comments
QS_1			X						• We need to do more for the small and medium contractors to enable them to execute projects effectively.
$Arch_1$				X	X	X			• There is minimum communication by the project parties on a construction project. • There is a perception that professionals treat a public sector project less seriously than a private sector project. • Some professionals come into public sector projects demotivated because of the discounts expected in order to win a bid, to keep afloat.
CPM_1	X	X							• Projects experience delays in completion. • Project implementation processes are very slow.

Category / **Respondent**	**Delays in project completion**	**Slow project implementation processes**	**Lack of support for small and medium contractors**	**Poor communication**	**Perceptions of public/private sector projects**	**Expected discounts**	**Incompetent contractors**	**Influence of designers**	**Comments**
									There is a long delay of 18 months, on average, between when we receive an instruction and the actual start of construction.
QS_2							X		• Technical skills are lacking nowadays.
$Arch_2$							X		• Contractors are being appointed frequently to projects which they are not qualified to undertake.
CPM_2								X	• Designs include features that do not add value in the public sector.

As shown in Table 4.25, each respondent mentioned a different cause of poor project performance. However, the most frequently mentioned cause (23%) was the lack of technically skilled construction contractors. The other causes were delays in project completion, slow implementation processes, lack of support for small and medium contractors, poor communication, the perception that public sector projects are not regarded as seriously as private sector projects, consultants being demotivated by the discounts expected to win a bid, and designers including features that do not add value in the public sector.

The purpose of lean construction is to eliminate non-value-adding activities. The next question was asked to determine whether the participants recognise non-value-adding activities when they arise, and whether they agree that such poor performance can be regarded as waste.

Table 4.25: Non-value-adding activities can be regarded as waste.

Rating **Respondent**	**No**	**Not necessarily**	**Yes**	**Definitely yes**	**Comments**
QS_1				X	• Overdesigning is another form of waste, by using expensive materials when an economical alternative can do the same job as, or sometimes a better job than, the expensive materials.
$Arch_1$				X	• We cannot keep spending so much time on projects only to have unwanted outcomes. We will end up contributing to the bad image of the construction industry, or building the perception that the public sector is useless.
CPM_1		X			• Some waste can be attributed to the long process of establishing a construction project. But not everything in the process can be regarded as waste.
QS_2				X	• We are wasting a lot of money on wasteful expenditure.
$Arch_2$				X	• Any activities undertaken that do not add value for money are wasteful expenditure on the part of the public sector.
CPM_2				X	• If project role players do not 'take ownership' of the project, they will not have the best intention to get value for money. • There is scope for innovation by the designers, who should optimise their designs to add value to the project owner.

As shown in Table 4.26, five of the six interviewees (83%) agreed that non-value-adding activities can definitely be regarded as waste.

The interviewees were asked to identify lean opportunities in the current construction cost management system, and whether TVD would be an option to consider when planning a project, allowing for active steering of the design towards an acceptable overall project cost.

Table 4.26: TVD would be an option to consider when planning a project

Rating **Respondent**	**No**	**Not necessarily**	**Possibly**	**Yes**	**Comments**
QS1	X				• Architects have too much freedom of choice to provide the client with what they think the project owner wants, rather than what the project owner needs.
Arch1				X	• We must try and change the way we execute projects.
CPM1			X		• Such an approach has not been tried in the national Department of Public Works, but it is worth considering. • Currently, we design a building and cost it afterwards. Most often, the market is cheaper than what we estimate, so we cannot really say our approach is wasteful. • Overall, TVD is a better way of budgeting for projects, and it will work if implemented gradually.
QS2		X			• We already have estimates before the construction project starts, based on sketch plans from the architect. In the pre-planning stage the NDPW works out what is needed, and the architect produces some sketch plans that go to the QS, who will produce a preliminary budget. The architect provides drawings based on such costing. A cost-cutting exercise is done if the design is not within the acceptable budget.
Arch2	X				• It is not something that has been tried in the public sector. It might be happening in the private sector because they are more worried about profits for the project owner.
CPM2	X				• The designers are protective of their design freedom.

From Table 4.27 it is evident that most of the interviewees (50%) felt that TVD would not be a feasible option, either because it has not been tried in the public sector or because designers have too much freedom of choice and are protective of their freedom. One respondent said it is not necessary, because in the current system the architect already designs according to estimates prepared by a QS, based on the architect’s sketches. Two respondents said the TVD option would be worth considering. CPM_1 acknowledged that TVD is a better way of budgeting for projects, and that it could work if implemented gradually. $Arch_1$ agreed that it is necessary to change the way projects are executed.

4.8.4 Theme 3: Identification of lean barriers and enablers

The interviewees were asked whether a more flexible and responsive approach to budgeting and completion in construction cost management is needed to enhance construction project management.

Table 4.27: A more flexible and responsive approach to budgeting and completion in construction cost management is needed

Rating / Respondent	No	Not necessarily	Yes	Definitely yes	Comments
QS_1			X		• The design contributes to most of the cost of the project. We should revise the system to require architects to be innovative in their designs, to provide what the project owner needs to provide value.
$Arch_1$				X	• We need a system that can enhance accountability for the outcomes of projects. • We need a system that will build more collaboration, to enhance the outcomes of projects and produce innovative ideas. • Technology is changing fast, and we are behind when compared with other countries.
CPM_1				X	• Projects are continually performing poorly, because of the declining market. • Contractors reduce their profits to win a project, but execution is not on a par with the risks identified when tendering.
QS_2	X				• Although the public sector has a different objective, projects are failing to achieve the same standards as the private sector, but the same professionals work for the public sector as service the private sector. How do we ensure getting the same service?
$Arch_2$			X		• More risk assessments must be done on the appointment of contractors, as the public sector appoints the contractor with the highest points, and usually they are the lowest-priced bid. • Sometimes there is a huge response from contractors, which contributes to more time being needed to finalise appointment. • Legislation directs us to give every bidder a chance to be competitive, and that sometimes makes it difficult

Rating Respondent	No	Not necessarily	Yes	Definitely yes	Comments
					to get the right contractor with the right resources to execute the project.
CPM_2			X		• How are we going to achieve the best possible outcome for projects when professional teams have to offer discounts on the work they have to do? This approach does not favour public sector projects.

Lean barriers	Comments
QS_1	This interviwee outlined few barriers that hinder the successful implementation of lean construction: lack of education of the concepts, in industry and in universities as well. Although benefits seems favourable no incentives are in place to encourage buy-in from stakeholders. If the concepts lacks political support it will fail in the public sector. Still new to recent graduates and not all Universities have infused it in their curriculum. Hierachy is still prepdominantly the management system of operation is the construction industry, respect for people will suffer due to autocratic processess. The national department of public works pretty much stll operates under the lowest bidder gets the tender. However, I guess provincial public works departments standa a good chance of being the first implementers.
$Arch_1$	Aggressive training courses are required and incentives to be provided by the public sector to encourage buy-in. thereis a serious challenge of resistance to change that will have to be overcome. Lack of political support will render the concept useless. It faces a huge challenge from a cultural behaviour asociated with the construction industry. Already exisitng contractors are unable to comprehend the basics of construction, if such a concept is added to the mix, it spells disaster.
CPM_1	Lack of project management skills is a huge challenge on the side of the contractor. Most contractors do not have the basic construction skills, and education is a problem. If fragementation can be addressed this concept will be more successful.
QS_2	Most construction profssionals will only adopt a method if is cutting costs for them, and lean is not a cost cutting exercise. It will save you money but is not for that purpose. The focus might be only on cutting cost and ignoring the value for the client.
$Arch_2$	Firstly, most stakeholders might think it will be time consuming, and time is what they do not have to implement a new strategy. Construction stakeholders usually opt for quick solutions, so education is key. Lack of basic undeerstanding of the concept will be a real challenge.
CPM_2	Lean training will require more time to be spent on learning, which might face resistance to change. lack of planning from the contractors is a big challenge. Already most contractors start construction without any sort of plan in place. Myabe, this might help as there would some sort of planning required.
QS_3	Most stakeholders are selfish when looking at a new concept. The usual question is what is in it for them, rather than what the value will client obtain from such a new method. Everyone look at the resources they will require and how much that will cost them without even thinking about the client providing them with work.
$Arch_3$	I can safely say most dsigners will see this as extra work for them and will somehow try to add extra cost to the client. Designers would like to do as less as possible in developing dsigns as most of the revisions are their responsibility, hence would complain about more work without being compensated for extra effort.
CPM_3	Perhaps the concept mus commence with the universities adding such a concept as part of their curriculum. Education plays a major role in driving innovation.
QS_4	Lack of support by top management will not assist with the implmentation of this concept. Additionally, the political support for this concept is key, without it the concept will not even get off the ground.
$Arch_4$	There are so many innovations already, which have not even got of the ground by the private sector, let alone the public sector. if we have to mention programs such as BIM, which indicates immense benefits to the consyruction indsutry, but the implementation is still very low if not at all. We are yet to find a complete BIM project in South Africa currently. The construction industry is very slow in adapting to new innovative ways.
CPM_4	The culture of the construction industry kills the future of this sector due to leaders who are not ready to accept change. the industry is full of gate keepers, hecne the slow progress made by the sector. Again the construction indusrty in South Africa is dominated by players who do not

Rating Respondent	No	Not necessarily	Yes	Definitely yes	Comments
	even possess the applicable qualification of the industry, and this are the people driving the industry with political agendas of ensuring the industry is ungovernable.				
QS_5	Due to pressure experienced by some contractors to complete the project this might prove to be time consuming if it had to be tried during a live project. Chances of people reverting back to old ways is easy as most are lazy to try new ways. Long term beneits by top managers I hard to sell, unless the benefits can be realized early they are not interested. Lack of education about the concept, and not a lot of people are aware of the method. It will take along time before such methods can be adopted due to legislation by the public sector. the public sector seldom make changes to how they execute projects, and political interference normally dictate terms.				
$Arch_5$	The concept seems to be showing long term benefits, but the time factor might not be favourable for all stakeholders to come on board. The present economic conditions forces everyone to try and do more with less and this concept demonstrate a possibility in achieving that. However, clients have to start forcing professionals to implement then adoption will be quicker. Educating the client is key. Usually if clients are happy with certain concepts, they tend to demand such practices from professionals and that is the way to start.				
CPM_5	Successful projects that have implemented the concept might assist with creation of awareness for educating the industry. The industry is not always receptive to new methods, and this is due to the fact that most experienced professionals do not want to learn new methods, so they shoot any innovation and make excuses why it would not work.				

Most of the interviewees (83%) agreed that a more flexible and responsive approach to budgeting and completion in construction cost management is needed to enhance construction project management. Aspects of the current system that require more flexibility and responsiveness, as mentioned by the respondents, are innovative designs that are economical and add value based on what is needed, greater collaboration and accountability and use of technology, the expected discounts, the points system for appointing contractors, and legislation, which all affect project outcomes negatively. QS_2 stated that a more flexible and responsive approach is not needed at all, and he argued that a stricter approach requiring higher expectations of consultants is required in order to obtain the same service that they render to the private sector.

In order to identify lean opportunities and lean thinking, the interviewees were asked whether eliminating waste (as advocated in lean construction) is accounted for sufficiently in the current approaches to construction project management.

Table 4.28: Eliminating waste is accounted for adequately in current approaches to construction project management

Rating Respondent	Definitely no	No	Yes	Definitely yes	Comments
QS_1		X			• The current approach to projects is more fragmented than collaborative. • Since the introduction of bidding by consultants, no one is trying to eliminate anything. • Most consultants are demotivated when executing projects for the public

					sector, and there is minimum commitment to such projects.
Arch$_1$		X			• It seems nobody cares about what the outcome of the project will be when it comes to public sector projects. • Many senior managers do not want to change systems and be held accountable. Hence, only committees make decisions.
CPM$_1$		X			• The public sector strives to improve the inefficiencies in its processes, but generally, senior management at head office are expected to bring about such changes.
QS$_2$		X			• The public sector does not produce assets to make a profit, which exposes them to abuse. • The project owners in the public sector do not have time to be accountable for the projects of which they are in charge, let alone account for waste elimination. • The public sector is expected to produce jobs and alleviate poverty, rather than account for how much a project will cost.
Arch$_2$		X			• The public sector is very slow in implementing any new systems.
CPM$_2$	X				• People with limited knowledge of the construction industry handle contractual matters, which affects the industry negatively. The industry is not protected at all. It is open to anyone who wishes to start such a business and does not attract people that care about the industry at all.

None of the interviewees (0%) believed that elimination of waste is accounted for sufficiently in the current approaches to construction project management. The reasons mentioned were a lack of commitment to public sector projects, unwillingness by senior management in the public sector to be held personally accountable, and other non-profit expectations, such as job creation and poverty alleviation.

The interviewees were asked whether the current situation, where waste is not acknowledged, results in failure of the current cost management approaches and systems.

Table 4.29: The current situation, where waste is not acknowledged, results in failure of the current cost management approaches and systems

Rating **Respondent**	**Disagree completely**	**Disagree somewhat**	**Agree somewhat**	**Agree fully**	**Comments**
QS$_1$				X	• Everyone just accepts the situation as it is. Most decisions to implement such changes are made at head office, and there is

Rating Respondent	Disagree completely	Disagree somewhat	Agree somewhat	Agree fully	Comments
					limited power assigned to the regional offices of the NDPW.
$Arch_1$			X		• Unfortunately, when something has been neglected for a very long time, the chances are it will remain the same for a very long time.
CPM_1		X			• It is very much acknowledged, but it is treated as a necessary part of the process of delivering projects, rather than a constraint to project delivery. • Clients have come to accept that each project is different, with its own unique challenges, which need to be minimised as far as possible.
QS_2	X				• Even if waste is acknowledged, there are several other factors to consider. Communities expect the public sector to create jobs, and sometimes good performance is compromised to accommodate social challenges.
$Arch_2$			X		• It is difficult for anyone to take the lead, for fear of being held accountable for changes in the system. • In the public sector, all decisions are made by committees, which leads to non-value-adding activities.
CPM_2			X		• No one wants to risk making drastic changes. • A more collaborative approach needs to be adopted with the communities, where projects are undertaken or have a structure in place to include other stakeholders.

Although 67% of the interviewees agreed that not acknowledging waste results in failure of the current cost management approaches and systems, their opinions were divided (see Table 4.30). The respondents who agreed explained that decisions to make changes are made at head office, and everyone has just accepted the situation for a long time. A more collaborative approach is needed to include other stakeholders. CPM_1 and QS_2 disagreed and argued that waste is acknowledged but it is accepted as part of the project process, which needs to be managed. Furthermore, they argued that waste is only one of many factors that can result in failure of the system. Other factors include socio-economic challenges, which the public sector is expected to address.

4.9 FINDINGS ON CURRENT PROJECT MANAGEMENT PRACTICES

Value-stream mapping was employed to evaluate the extant design and costing activities or current project management practices for the public sector projects in the cases above. Firstly, the study evaluated current practice and produced a vignette for the current mode of project delivery and design and cost management activities carried out for public sector projects. The vignette is derived from semi-structured interviews conducted in the case studies. It is notable that the process of delivering public sector projects can be classified as a "design-bid-build" or "traditional design by employer" project delivery system, according to the Integrated Development Management System toolkit used by the National Treasury. However, despite the difference in project delivery method, recorded cost performance experienced by some of the design-bid-build projects was poor, and another one was exceptionally good. Figure 4.1 shows stages 1 to 6 of the Professional Consultants Services Agreement (PROCSA) signed between the client and each professional team mentioned in the vignette. The stages detail what service is expected from every professional appointed, and the outcomes expected in each stage to enable an opportunity for claim fees after each stage is completed. Consultants carry out tasks related to the project in each stage, and after the stage has been completed, a claim for fees can be submitted for payment to the professional. These stages are critical in identifying cost management approaches employed by professionals and the various tasks carried out to highlight opportunities for lean thinking strategies to improve the status quo of how professionals deliver projects to clients within the intended outcomes and project parameters. Each stage represents the activities carried out for each project delivered by these professionals. The vignette below shows the fragmented approach for public projects.

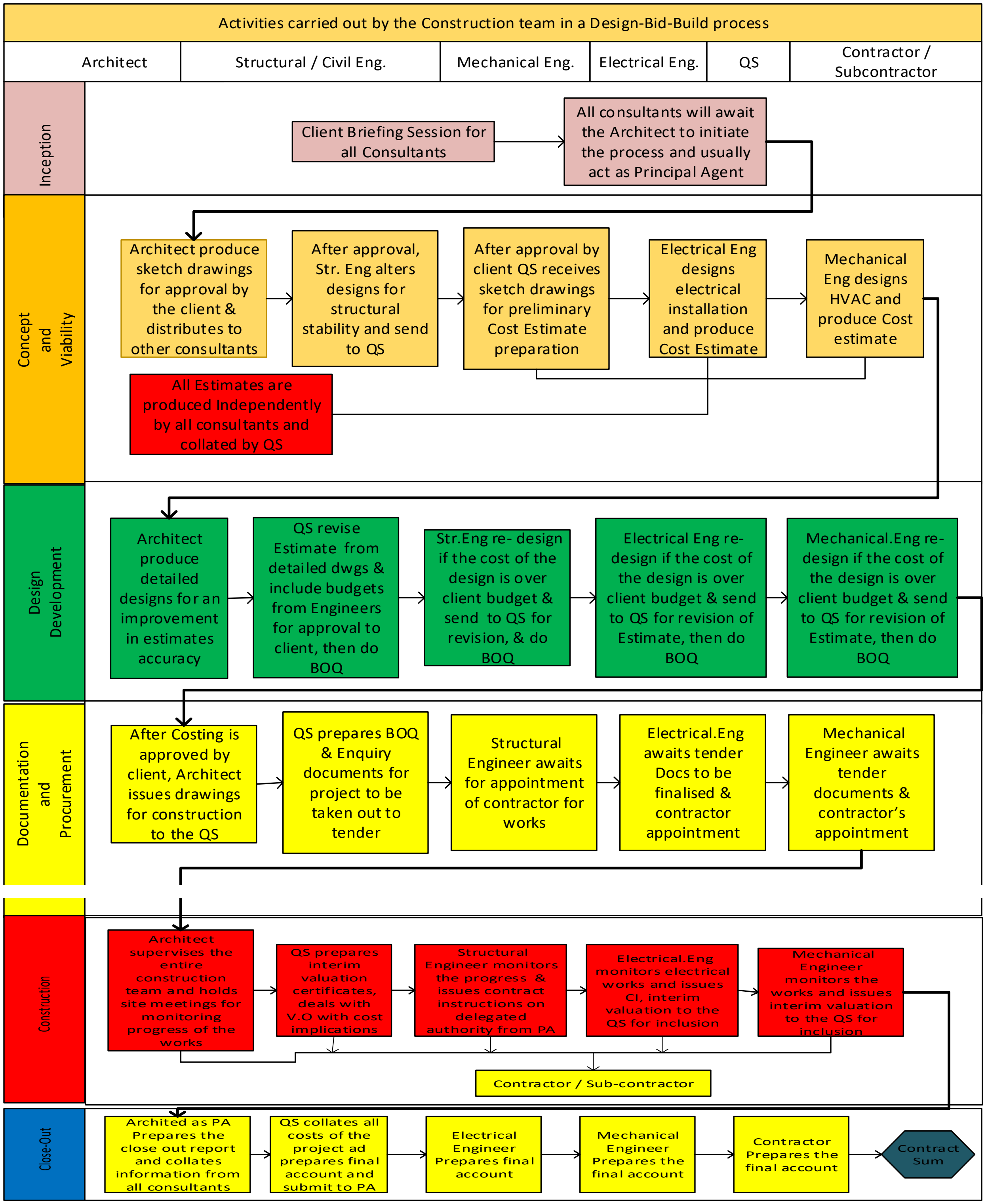


Figure 4.1: Current project management practices (Source: Researcher's fieldwork)

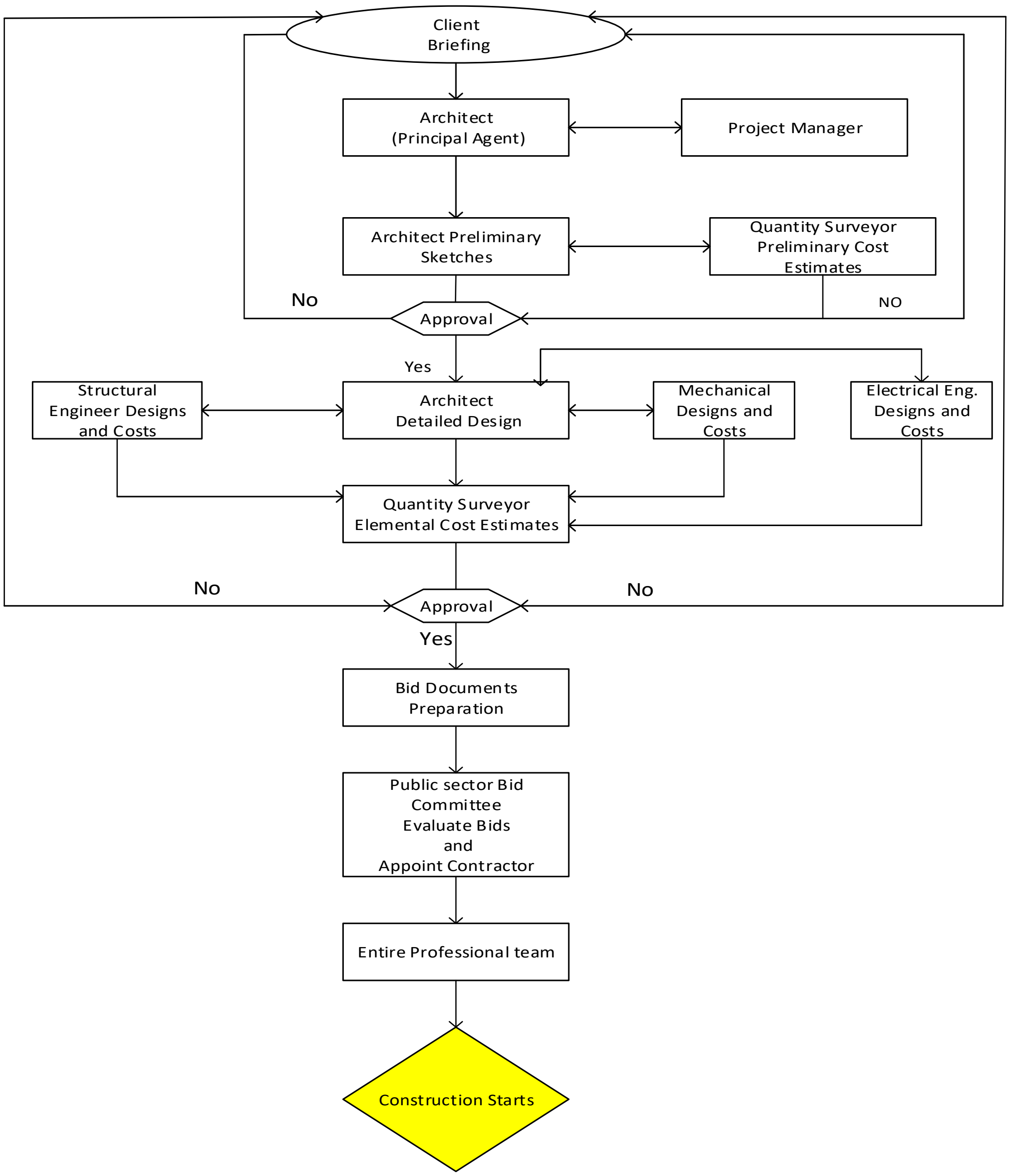


Figure 4.2: A workflow of existing design and costing activities of projects in South Africa

Figure 4.2 illustrates the workflow activities derived from the vignette, to better understand the approval processes and stoppages by the client, either to approve the designs and costing or to instruct the teams to rework the designs and costing to the client's desires or the budget. A fragmented approach is evident in the way projects are executed, which does not make for any kind of collaboration. It is evident that the current practice of executing public projects has certain limitations, and it creates the opportunity for later design changes and many variations to costs of the projects. The professional team raised concerns about the long process taken before a contractor can be appointed. Table 4.31 below shows data collected for a project approved for planning in 2016, where it was recorded that it took 426 days before a site could be handed over to the contractor to commence with construction activities. This confirms the concern of the professional team about delays resulting from internal public sector regulations.

Table 4.30: Project time frames until completion

	Service type:	**Construction**			
	Issue date of planning instruction:	**2016/03/12**			
CODE	MILESTONE DESCRIPTION	RESPONSIBILITY	From 0.00 days	Total days	Estimated date
	Issue of planning instruction	**KAM**	**0**	**0**	**2016/03/12**
	Accept planning instruction	**Director of projects**	**7**	**7**	**2016/03/19**
	Site visit	PM with professions			
	Send planning instruction to PS (advice)	*PS*			
	Nomination of consultants	**PM**	**2**	**9**	**2016/03/21**
	Estimating QS fees				
	PRM 004				
	PA 028 (PSB)				
	PA 02.1	*SCM*			
	DPW 19 (PSB)				
	Checklist pre-procurement phase	*PM/SCM /compliance*			
	Tender documents (own supporting docs)				
	Method of procurement	*SCM*			
	Quotations received	*SCM*			
	PA 02	*SCM*			
	PA 20.7 (scoring model)	*SCM*			
	PA 20.7 (functionality)	*SCM*			
	CSD	*SCM*			
	CIPC	*SCM*			
	Register for tender defaulters	*SCM*			
	VAT verification	*SCM*			
	Security screening	*SCM*			
	BBBEE verification	*SCM*			
	PA 18.1	*SCM*			
	PA 25.3 (QET)	*SCM*			
	QET (minutes of meetings)	*SCM*			
	PA 22 (QET)	*SCM*			
	Checklist post-procurement process	*SCM/compliance*			
	Compliance checklist	*SCM*			
	PA 12 (approval/award)	*RBAC*			
	Appointment of consultants	Legal services	70	79	2016/05/30
	Appointment letter				
	Briefing of consultants	PM	7	86	2016/06/06
	Briefing of meets				

	Layout plans – issue to disciplines	Consultants	20	106	2016/06/26
	Sketch plans and elemental estimate	Consultants	30	136	2016/07/26
	Sketch plans completion date	Consultants	30	166	2016/08/25
	SP (professional forms) SPM				
	Approval by department's SPC	SPC	10	176	2016/09/04
	PRM 16/15				
	Arch. 1/100 sections to engineers	Consultants	30	206	2016/10/04
	Final architectural working drawing	Consultants	30	236	2016/11/03
	Final engineer's layouts	Consultants	30	266	2016/12/03
	Draft bill of quantities and final elemental estimate	Consultants	30	296	2017/01/02
	PA 25.1 (BSC)				
	PA 00 (code of conduct)				
	PA 18 (declaration of interest & confidentiality)				
	Checklist for approval of procurement doc				
	BSC minutes				
	Checklist pre-procurement phase				
	Bid execution plan				
	BSC approval	BSC	2	298	2017/01/04
	Advert date (internal memo)				
	DPW 19(EC) procurement certificate				
	Approved document: 30 copies				
	Register for collection				
	CIDB registers				
	PA 20.7 (scoring model)				
	PA 20.7 (functionality)				
	PA 02				
	PA 25.2 (Ghassemi and Becerik-Gerber)				
	BEC approval	BEC	2	2	2017/01/02
	Procurement strategy approval by RBAC	PM	10	308	2017/01/14
	Funds final approval	KAM	2	310	2017/01/16
	Final bid documents to SCM	PM	3	313	2017/01/19
	Advertise tenders	SCM	1	314	2017/01/20
	Tender closing date	SCM	21	335	2017/02/10
	Tender evaluation period	PM	56	391	2017/04/07
	Submission of bid evaluation report to RBAC	PM/SCM	7	398	2017/04/14
	Award of bid	Legal services	7	405	2017/04/21
	Handing over of site	PM	21	426	2017/05/12
	Practical completion certificate	PM	120	546	2017/09/09
	Final delivery certificate	PM	14	560	2017/09/23
	Final completion report	PM	90	650	2017/12/22
	Final payment certificate	PM	7	657	2017/12/29
	Project closure	PM	10	667	2018/01/08

(Source: Researcher's fieldwork)

4.10 CHAPTER SUMMARY

This chapter presented the qualitative findings of the study. Five project cases were analysed through document analysis, and 15 interviews were were audi recorded and subsequently transcribed into verbatim. The transcribed data was analysed through thematic content analysis. The qualitative results covered mainly the four objectives to be reached by this study. Five projects were evaluated through document analysis, to establish the status quo of how professionals deliver projects to clients in South Africa, with the aim of improvement from the findings of the extant practices of managing projects. Results from the qualitative data indicate that a high level of fragmentation exists in current project management practices, and that contracts utilised by the public sector act as a barrier to innovation. Lean opportunities are not being taken advantage of, due to low morale among professionals. Professionals are frustrated by the depressed economy, which pushes some to subscribe to offering excessive discounts, just to survive and keep the business running.

CHAPTER 5
RESULTS, PRESENTATION OF QUANTITATIVE DATA ANALYSIS AND INTERPRETATION

5.1 QUANTITATIVE DATA ANALYSIS

The purpose of this section is to analyse data collected from an electronic survey of a wider group of professionals who were involved in the construction industry executing public projects in South Africa. This data was used to triangulate the qualitative data gathered from case studies and semi-structured interviews. It was expected that data would be captured from the survey to show (a) what stakeholders in the wider construction industry perceive to be the contributing factors in cost and time overruns in South Africa, and (b) whether the stakeholders agree that the conventional methods of project delivery need to be changed to adopt new methods that will improve the outcomes of public sector infrastructure projects in South Africa. The quantitative data was analysed using descriptive and inferential statistics. Professional participants in South Africa returned 97 completed questionnaires representing a 49% response rate. The survey required respondents to indicate their answers on a five-point Likert scale, which included a “not sure” option.

The quantitative data analysis is structured as follows:

- Demographics of the respondents,
- The causes of poor cost performance at various stages of the project’s life cycle,
- The shortcomings of current cost management practices,
- The causes of poor time performance,
- Whether current design and costing methods need new innovative methods (yes or no?), and
- Whether a new integrated form of agreement will improve performance.

5.1.1 Background of the respondents

The respondents were asked to indicate whether their organisation belongs to the private sector or the public sector. Figure 5.1 shows that 72% of the respondents were working in a private sector organisation, while 28% of the respondents were working in a public sector organisation. The private sector is represented extensively, which is a realistic result, because more professionals operate in the private sector than in the public sector. table 5.1 further demonstrate the numbers of respondents as per the electronic survey distributed to the construction industry in South Africa.

Table 5.1: Sector representation of respondents

Sector	Frequency	Percent
Private	70	72.2
Public	27	27.8
Total	97	100.0

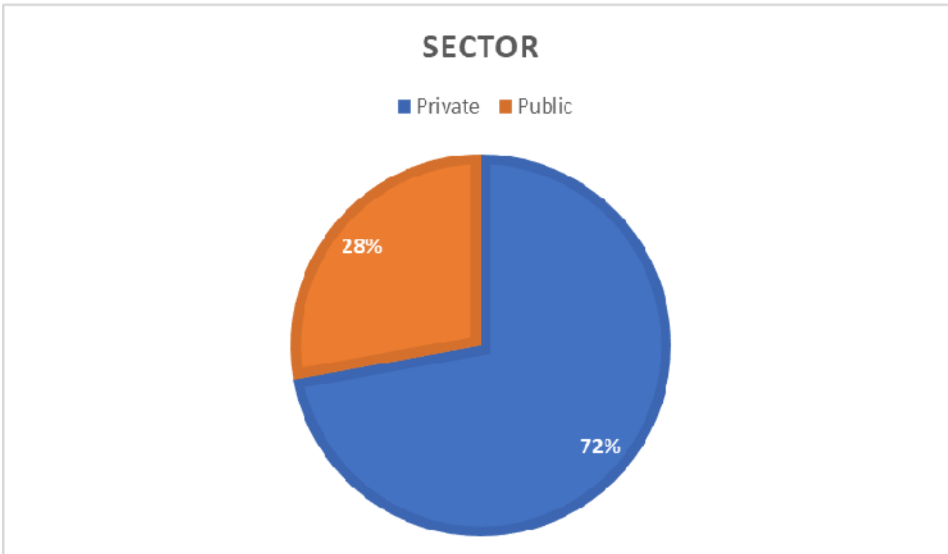


Figure 5.1: Sectors of the respondents (Source: Researcher's fieldwork)

5.1.2 Length of the organisation's existence

The respondents were asked to indicate how long their organisations had been in existence. This was to ascertain how long their organisations had been operating in the construction industry in South Africa. It also shows the experience of the business in surviving the challenging economy of the country. Figure 5.2 shows that 19% of the organisations had been in existence for 0–5 years in the South African construction industry, 18% had been operating for 6–10 years, and 11% had been in existence for 11–15 years. Eight percent of the organisations had been operating for 16–20 years. Most of the organisations (44%) had been in existence for more than 20 years, which indicates the rich experience behind the data obtained from the respondents.

Table 5.2: Length of organisation's existence

	Frequency	Percent
0–5 years	18	18.6
6–10 years	17	17.5
11–15 years	11	11.3
16–20 years	8	8.2
More than 20 years	43	44.3
Total	97	100.0

(Source: Researcher's fieldwork)

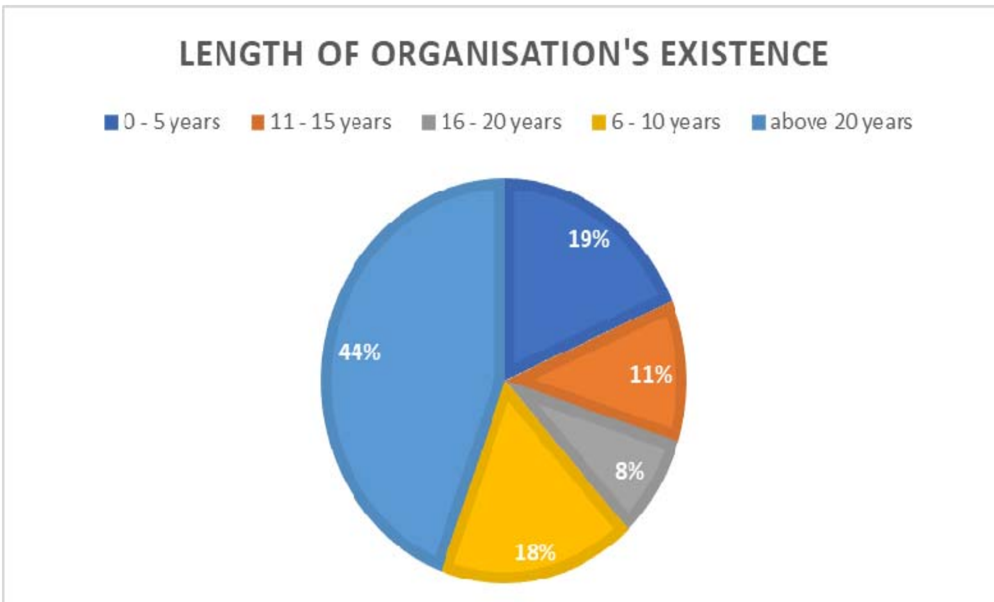


Figure 5.2: Length of organisation's existence (Source: Researcher's fieldwork)

5.1.3 Number of employees in the organisation

Figure 5.3 indicates the number of employees in the respondents' organisations. The results show that 45% of the organisations had 1–20 employees, 7% had 21–50 employees, 8% had 50–100 employees, and 35% had more than 200 employees. The data indicates a good mix of small and large organisations.

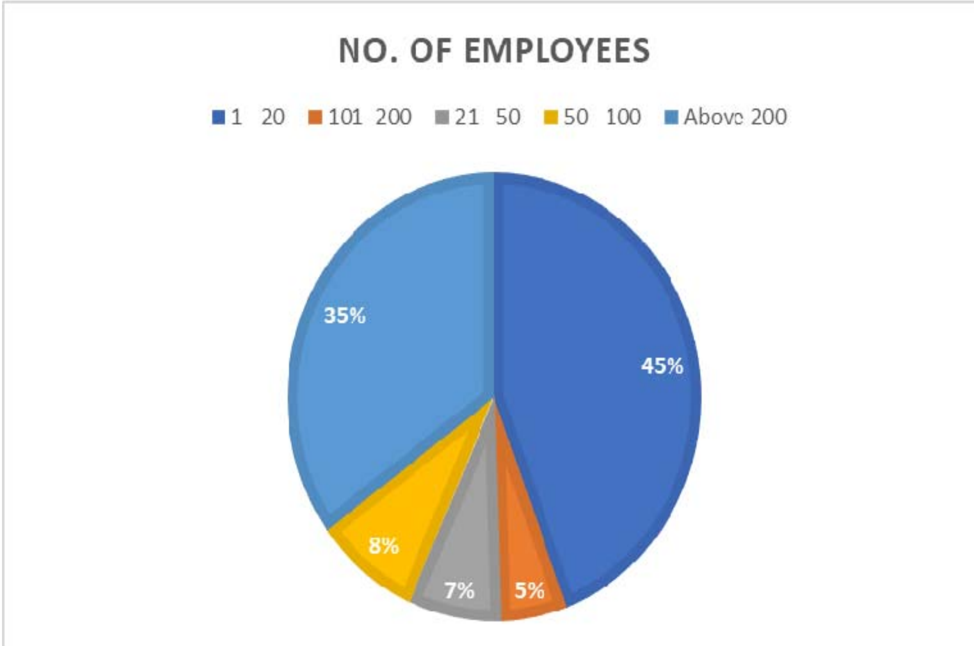


Figure 5.3: Number of employees in the organisation (Source: Researcher's fieldwork)

5.1.4 Respondents' positions in the organisation

Figure 5.4 below shows the positions held by the respondents. The results show that 6% of the respondents were architects, 4% were civil engineers, 4% were construction managers, 16% were construction project managers, 8% were contractors, 3% were electrical engineers, 6% were mechanical engineers, 45% were quantity surveyors, and 2% were structural engineers. The data show that while most construction industry professions were represented, most of the responses came from quantity surveyors and construction project managers.

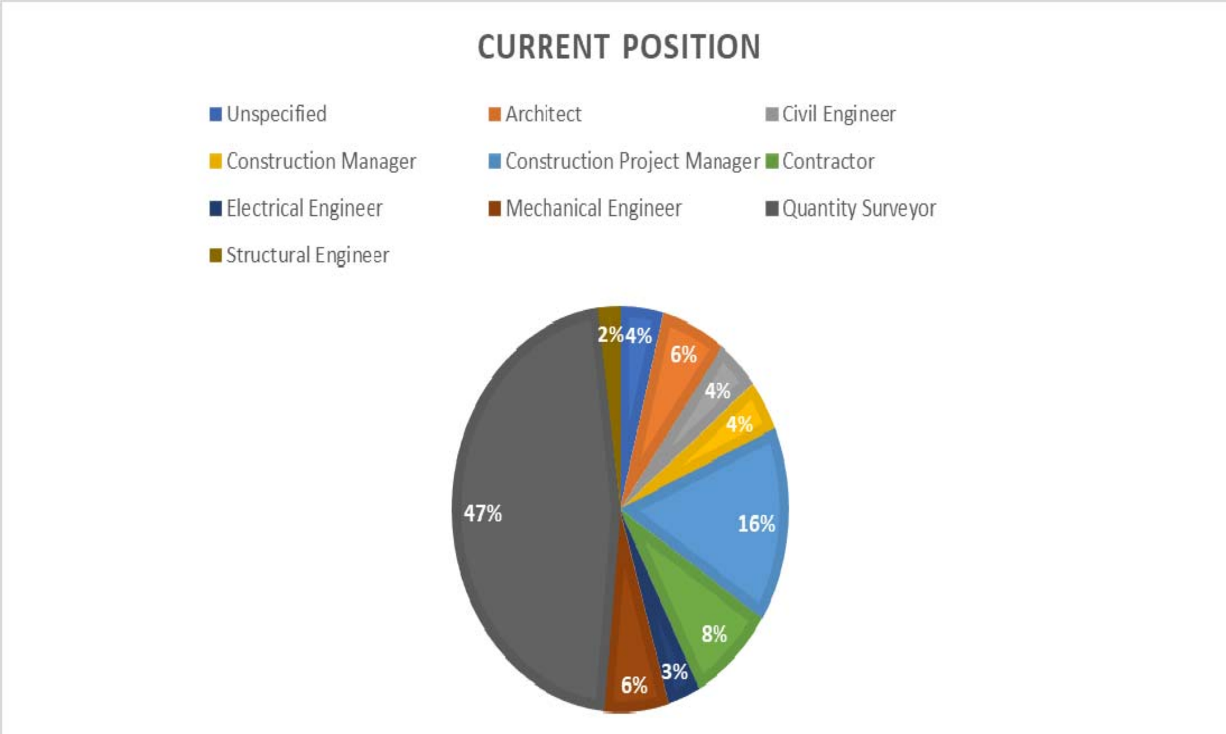


Figure 5.4: Current positions of the respondents (Source: Researcher's fieldwork)

5.1.5 Years of experience in the construction industry

Figure 5.5 below shows the respondents' years of experience. The results show that 30% of the respondents had 0–5 years' experience in the construction industry, while 15% had 6–10 years' experience, 26% had 11–15 years' experience, 10% had 16–20 years' experience, and 20% had more than 20 years' experience. The data indicates a good mix of highly experienced respondents and young professionals.

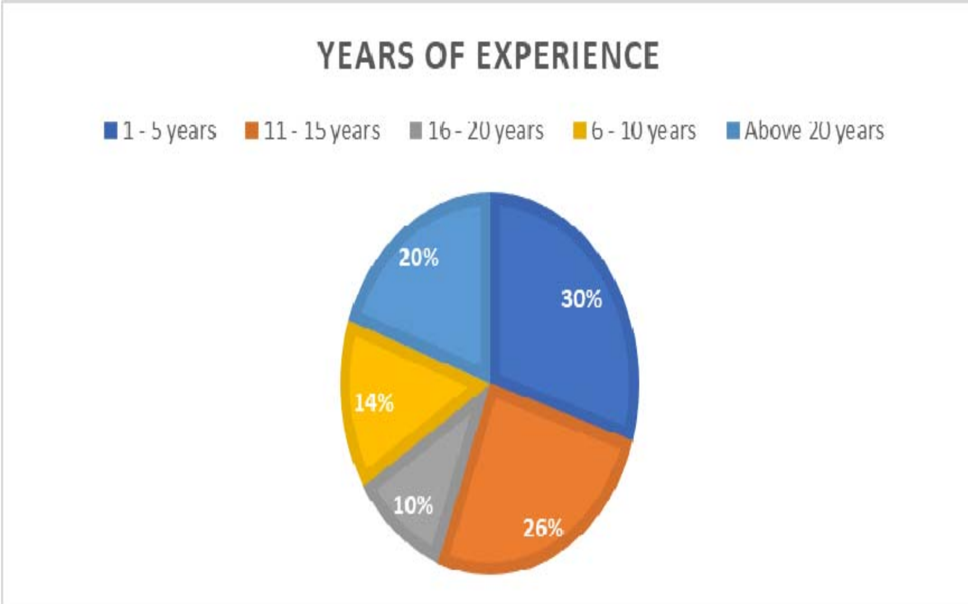


Figure 5.5: Years of experience of the respondents (Source: Researcher's fieldwork)

5.1.6 Educational qualifications of the respondents

Figure 5.6 below shows the educational qualifications of the respondents. The results show that 20% of the respondents held a BSc degree, 30% had a BTech degree, 27% held a BSc Honours degree, 15% had a master's degree, and 7% held a PhD. The data show that the respondents were qualified to respond to the survey.

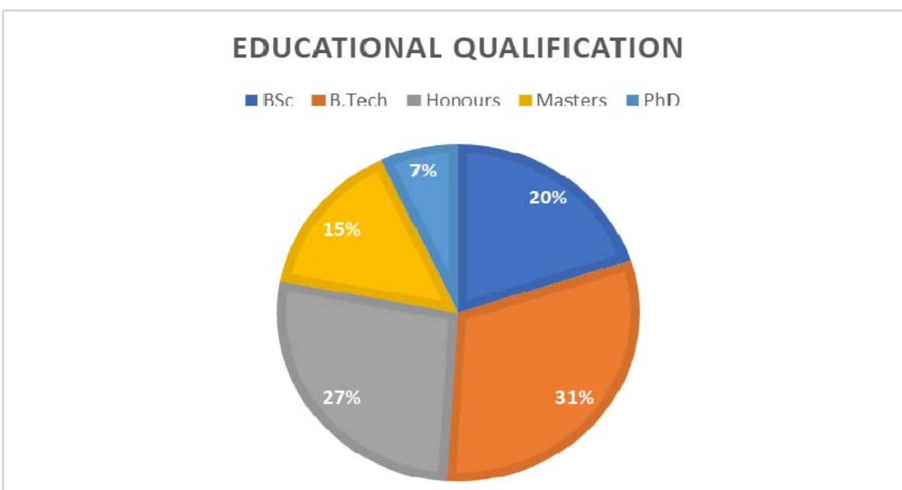


Figure 5.6: Educational qualifications of the respondents (Source: Researcher's fieldwork)

5.1.7 The causes of poor cost performance in the design stage (Section A)

Table 5.3 below shows the causes of poor cost performance in the design stage, as ranked by the respondents. Based on the results, “ignoring items with abnormal rates during tender evaluation, especially items with provisional quantities” was ranked first, with a mean of 3.78. Other causes were ranked in descending order as follows: “lack of coordination by professionals in design stage” was ranked second, with a mean score of 3.73; “inadequate project preparation planning” was ranked third, with a mean score of 3.70; “incomplete design at time of tender” was ranked fourth, with a mean score of 3.64; “procurement-related factors, such as delays in appointing a contractor” was ranked fifth, with a mean score of 3.51; “technical omissions in design stage” was ranked sixth, with a mean score of 3.51; “differences between allowance of underground conditions” was ranked seventh, with a mean score of 3.41; “lack of experience of project type” was ranked eighth, with a mean score of 3.34; and “limited knowledge of project location” was ranked ninth, with a score of 3.07. A Cronbach’s alpha was used to measure the reliability of the data, where values of 0.7 or higher indicate good internal consistency. As shown in Table 5.4, the Cronbach’s alpha for the causes of poor cost performance in the design stage was 0.892, which indicates that the results have high reliability (Tavakol and Dennick, 2011)

Table 5.3: The causes of poor cost performance in the design stage

Causes of poor cost performance	Mean	Std deviation	Rank
Ignoring Items with abnormal rates during tender evaluation, especially items with provisional quantities	3.78	1.322	1
Lack of coordination by professionals in design stage	3.73	1.395	2
Inadequate project preparation planning	3.70	1.346	3
Incomplete design at time of tender	3.64	1.344	4
Procurement-related factors, such as delays in appointing a contractor	3.51	1.294	5
Technical omissions in design stage	3.51	1.274	6
Differences between allowance of underground conditions	3.41	1.274	7
Lack of experience of project type	3.34	1.301	8
Limited knowledge of project location	3.07	1.357	9

(Source: Researcher’s field survey)

Table 5.4: Reliability statistics for the causes of poor cost performance in the design stage

Questions	Cronbach’s alpha	No. of items
The causes of poor cost performance in the design stage	0.892	9

(Source: Researcher’s field survey)

5.1.8 Exploring the differences in the opinions of public and private sector respondents regarding the causes of poor cost performance in the design stage

There is a need to answer the following question: “Is there a significant difference in opinions of the causes of poor cost performance in the design stage between respondents that belong to the private sector and those that belong to the public sector?” In order to answer this question, a non-parametric Mann-Whitney U test was performed on the data. The test computes the ranks for the two groups, in this case the private sector respondents and the public sector respondents, as shown in Table 5.5. It is therefore necessary to evaluate whether or not the ranks for the private and the public sector respondents do differ significantly. As such, the Mann-Whitney U test statistics as presented in Table 5.6 give the z-scores and their corresponding p-values [asymp. sig. (2-tailed)] for the causes of poor cost performance in the design stage of construction projects. The p-values for all the variables as shown in Table 5.6 are greater than 0.05, and none of them is less than or equal to 0.05. Therefore the results are not significant. It is thus safe to say that there is no significant difference in the opinions of the causes of poor cost performance in the design stage between the respondents that belong to the private sector and those that belong to the public sector.

Table 5.5: Ranks from the Mann-Whitney U test for the causes of poor cost performance in the design stage

Ranks					
	Please select from the categories below the sector to which your organisation belongs		N	Mean rank	Sum of ranks
DESIGN STAGE [Lack of coordination by professionals in design phase]	Dimension 1	Private	70	47.39	3,317.00
		Public	26	51.50	1,339.00
		Total	96		
DESIGN STAGE [Incomplete design at time of tender]	Dimension 1	Private	70	47.54	3,327.50
		Public	25	49.30	1,232.50
		Total	95		
DESIGN STAGE [Technical omissions in design stage]	Dimension 1	Private	69	46.17	3,186.00
		Public	24	49.38	1,185.00
		Total	93		
DESIGN STAGE [Ignoring items with abnormal rates during tender evaluation, especially items with provisional quantities]	Dimension 1	Private	68	43.82	2,980.00
		Public	22	50.68	1,115.00
		Total	90		
DESIGN STAGE [Limited knowledge of project location]	Dimension 1	Private	68	46.67	3,173.50
		Public	24	46.02	1,104.50
		Total	92		
DESIGN STAGE [Lack of experience of project type]	Dimension 1	Private	70	47.97	3,358.00
		Public	25	48.08	1,202.00
		Total	95		
DESIGN STAGE [Inadequate project preparation planning]	Dimension 1	Private	70	45.95	3,216.50
		Public	21	46.17	969.50
		Total	91		
DESIGN STAGE [Procurement-related factors, such as delays in appointing a contractor]	Dimension 1	Private	66	46.16	3,046.50
		Public	25	45.58	1,139.50
		Total	91		
DESIGN STAGE [Differences between allowance of underground conditions]	Dimension 1	Private	67	45.51	3,049.00
		Public	21	41.29	867.00
		Total	88		

Table 5.6: Mann-Whitney U test statistics for the causes of poor cost performance in the design stage

Test statistics[a]				
	Mann-Whitney U	Wilcoxon W	Z	Asymp. sig. (2-tailed)
DESIGN STAGE [Lack of coordination by professionals in design phase]	832.000	3,317.000	−.678	.497
DESIGN STAGE [Incomplete design at time of tender]	842.500	3,327.500	−.285	.776
DESIGN STAGE [Technical omissions in design stage]	771.000	3,186.000	−.515	.607
DESIGN STAGE [Ignoring items with abnormal rates during tender evaluation, especially items with provisional quantities]	634.000	2,980.000	−1.130	.259
DESIGN STAGE [Limited knowledge of project location]	804.500	1,104.500	−.105	.917
DESIGN STAGE [Lack of experience of project type]	873.000	3,358.000	−.017	.986
DESIGN STAGE [Inadequate project preparation planning]	731.500	3,216.500	−.034	.973
DESIGN STAGE [Procurement-related factors, such as delays in appointing a contractor]	814.500	1,139.500	−.096	.923
DESIGN STAGE [Differences between allowance of underground conditions]	636.000	867.000	−.681	.496
a. Grouping variable: Please select from the categories below the sector to which your organisation belongs				

5.1.9 Exploring the differences across respondents' years of experience regarding opinions of the causes of poor cost performance in the design stage

Further analysis is performed on the basis of the years of experience of the respondents regarding opinions of the causes of poor cost performance in the design stage. In order to explore the differences in the opinions of the respondents across the five categories of years of experience, a non-parametric Kruskal-Wallis H test was performed. The test was performed to answer the following question: "Is there a significant difference in respondents' opinions of the causes of poor cost performance in the design stage across the five categories of years of experience?" The Kruskal-Wallis H test results presented in Table 5.7 show the values for chi-square, the degrees of freedom (Clifton et al. 2003), and the significance level (indicated as asymp. sig.). An inspection of the results as presented in Table 5.7 indicates that the significance values for opinions of all the causes of poor cost performance in the design stage are greater than 0.05, except for "procurement-related factors, such as delays in appointing a contractor", which has a p-value of 0.037. For those significance values that are greater than 0.05, the results imply that there is no significant difference in respondents' opinions of the causes of poor cost performance in the design stage across the five categories of years of experience. However, there is a significant difference for "procurement-related factors, such as delays in appointing a contractor" across the five categories of years of experience. As such, there is a need to inspect the mean ranks as presented in Table 5.8, in order to know which of the groups had an overall ranking that corresponds to the highest score for "procurement-related factors, such as delays in appointing a contractor". The results in Table 5.8 show that respondents with 6–10 years of experience had the highest mean rank, followed by respondents with 16–20 years of experience, and then respondents with 11–15 years of experience. This is attributable to the fact that respondents with 6 to 10 years industry expereince contributed to the study.

Table 5.7: Kruskal-Wallis H test statistics for the causes of poor cost performance in the design stage

Test statistics[a,b]			
	Chi-square	df	Asymp. sig.
DESIGN STAGE [Lack of coordination by professionals in design phase]	1.768	4	.778
DESIGN STAGE [Incomplete design at time of tender]	2.115	4	.715
DESIGN STAGE [Technical omissions in design stage]	.376	4	.984
DESIGN STAGE [Ignoring items with abnormal rates during tender evaluation, especially items with provisional quantities]	3.064	4	.547
DESIGN STAGE [Limited knowledge of project location]	1.730	4	.785
DESIGN STAGE [Lack of experience of project type]	.145	4	.997
DESIGN STAGE [Inadequate project preparation planning]	.420	4	.981
DESIGN STAGE [Procurement-related factors, such as delays in appointing a contractor]	**10.226**	**4**	**.037**
DESIGN STAGE [Differences between allowance of underground conditions]	1.098	4	.895
a. Kruskal-Wallis H test			
b. Grouping variable: Please indicate your years of experience in the construction industry			

Table 5.8: Mean ranks from the Kruskal-Wallis H test for the causes of poor cost performance in the design stage

Ranks				
	Please indicate your years of experience in the construction industry		N	Mean rank
DESIGN STAGE [Lack of coordination by professionals in design phase]	Dimension 1	1–5 years	29	46.33
		6–10 years	13	51.54
		11–15 years	25	53.06
		16–20 years	10	48.75
		More than 20 years	19	43.61
		Total	96	
DESIGN STAGE [Incomplete design at time of tender]	Dimension 1	1–5 years	29	52.81
		6–10 years	13	41.04
		11–15 years	25	48.20
		16–20 years	10	48.45
		More than 20 years	18	44.75
		Total	95	
DESIGN STAGE [Technical omissions in design stage]	Dimension 1	1–5 years	28	46.27
		6–10 years	13	50.81
		11–15 years	24	46.46
		16–20 years	10	44.85
		More than 20 years	18	47.31
		Total	93	
DESIGN STAGE [Ignoring items with abnormal rates during tender evaluation, especially items with provisional quantities]	Dimension 1	1–5 years	27	48.46
		6–10 years	12	53.25
		11–15 years	23	44.63
		16–20 years	10	42.10
		More than 20 years	18	38.89
		Total	90	
DESIGN STAGE [Limited knowledge of project location]	Dimension 1	1–5 years	29	44.45
		6–10 years	12	54.79
		11–15 years	23	47.70
		16–20 years	10	45.65
		More than 20 years	18	43.22
		Total	92	
DESIGN STAGE [Lack of experience of project type]	Dimension 1	1–5 years	29	48.31
		6–10 years	13	46.81
		11–15 years	25	48.10

		16–20 years	10	50.45
		More than 20 years	18	46.86
		Total	95	
DESIGN STAGE [Inadequate project preparation planning]	Dimension 1	1–5 years	27	43.69
		6–10 years	13	45.23
		11–15 years	24	47.94
		16–20 years	9	47.44
		More than 20 years	18	46.72
		Total	91	
DESIGN STAGE [Procurement-related factors, such as delays in appointing a contractor]	Dimension 1	1–5 years	27	37.94
		6–10 years	13	58.65
		11–15 years	25	50.98
		16–20 years	9	55.56
		More than 20 years	17	36.74
		Total	91	
DESIGN STAGE [Differences between allowance of underground conditions]	Dimension 1	1–5 years	25	48.10
		6–10 years	11	46.82
		11–15 years	24	43.13
		16–20 years	9	41.06
		More than 20 years	19	41.79
		Total	88	

5.1.10 The causes of poor cost performance in the construction stage (Section B)

Table 5.9 below shows the causes of poor cost performance in the construction stage of the project life cycle, as indicated by the respondents. The causes were ranked as follows: “poor management of the project by the contractor” was ranked first, with a mean score of 3.99; “contractual claims, such as extension of time with cost” was ranked second, with a mean score of 3.91; “the contractor’s unstable financial capacity” was ranked third, with a mean score of 3.90; “monthly payment difficulties from the client” was ranked fourth, with a mean score of 3.76; “delays in issuing information to the contractor during construction” was ranked fifth, with a mean score of 3.76 (which is the same as that of the previous cause, but the standard deviation is lower); “lack of cost monitoring during the post-contract stage, and being reactive to changes, instead of being proactive” was ranked sixth, with a mean score of 3.74; “revision of issue for construction drawings by the architect” was ranked seventh, with a mean score of 3.72; “delays in costing variations, and unforeseen additional work” was ranked eighth, with a mean score of 3.63; “labour unrest” was ranked ninth, with a mean score of 3.56; “community interference” was ranked tenth, with a mean score of 3.55; “rework due to errors during construction” was ranked eleventh, with a mean score of 3.52; “new information on existing site conditions” was ranked twelfth, with a mean score of 3.52; “change orders from the owner” was ranked thirteenth, with a mean score of 3.51; “lack of experience of local regulations” was ranked fourteenth, with a mean score of 3.39; “logistics due to site conditions and location” was ranked fifteenth, with a mean score of 3.31; “changes to safe working procedures” was ranked sixteenth, with a mean score of 3.24; “labour cost increases due to scarcity in remote areas” was ranked seventeenth, with a mean score of 3.24; “fluctuations in the cost of building materials” was ranked eigtheenth, with a mean score of 3.18; “remeasurement of provisional work” was ranked nineteenth, with a mean score of 3.15; “poor site or soil conditions” was ranked twentieth, with a mean score of 3.09; and “unpredictable weather conditions” was ranked twenty-first, with a mean score of 2.99. The Cronbach’s alpha for the causes of poor cost performance in the construction stage was 0.956 (see Table 5.10), which indicates excellent reliability and internal consistency (Pallant, 2005a, Nunnally and Bernstein, 2007, Field, 2013).

Table 5.9: The causes of poor cost performance in the construction stage

Causes of poor cost performance	**Mean**	**Std deviation**	**Rank**
Poor management of the project by the contractor	3.99	1.173	1
Contractual claims, such as extension of time with cost	3.91	1.186	2
The contractor’s unstable financial capacity	3.90	1.241	3
Monthly payment difficulties from the client	3.76	1.327	4
Delays in issuing information to the contractor during construction	3.76	1.276	5
Lack of cost monitoring during the post-contract stage, and being reactive to changes, instead of being proactive	3.74	1.293	6
Revision of issue for construction drawings by the architect	3.72	1.171	7
Delays in costing variations, and unforeseen additional work	3.63	1.262	8
Labour unrest	3.56	1.307	9
Community interference	3.55	1.378	10
Rework due to errors during construction	3.52	1.288	11
New information on existing site conditions	3.52	1.277	12
Change orders from the owner	3.51	1.274	13
Lack of experience of local regulations	3.39	1.292	14
Logistics due to site conditions and location	3.31	1.215	15
Changes to safe working procedures	3.24	1.184	16
Labour cost increases due to scarcity in remote areas	3.24	1.288	17
Fluctuations in the cost of building materials	3.18	1.185	18
Remeasurement of provisional work	3.15	1.264	19
Poor site or soil conditions	3.09	1.334	20
Unpredictable weather conditions	2.99	1.284	21

(Source: Researcher’s field survey)

Table 5.10: Reliability statistics for the causes of poor cost performance in the construction stage

Questions	Cronbach's alpha	No. of items
The causes of poor cost performance in the construction stage	0.956	21

(Source: Researcher's field survey)

4.10.11 Exploring the differences in the opinions of public and private sector respondents regarding the causes of poor cost performance in the construction stage

As asked in the design stage (Section A), there is a need to ask and answer the following question: "Is there a significant difference in the opinions of the private and the public sector respondents regarding the causes of poor cost performance at the construction stage?" In an attempt to answer the question, a non-parametric Mann-Whitney U test was performed on the data. The test computes the ranks for the two groups, namely the private and the public sector respondents, as shown in Table 5.11. It is therefore necessary to evaluate whether or not the ranks for the private and the public sector respondents do differ significantly. As such, the Mann-Whitney U test statistics as presented in Table 5.12 give the z-scores and their corresponding p-values [asymp. sig. (2-tailed)] for opinions of the causes of poor cost performance in the construction stage of construction projects. The p-values for all the variables as shown in Table 5.12 are greater than 0.05, and none of them is less than or equal to 0.05. Therefore, the results are not significant, except for the cause "change orders from the owner", which has a z-score of −2.135 and a p-value of 0.033. For the causes of poor cost performance other than the cause "change orders from the owner", it is thus safe to say that there is no significant difference in opinions of the causes of poor cost performance in the construction stage between respondents that belong to the private sector and those that belong to the public sector. However, the opinions of the private and the public sector respondents do differ regarding the cause "change orders from the owner". This is due to lack of commitment from owners in the planning process.

Table 5.11: Ranks from the Mann-Whitney U test for the causes of poor cost performance in the construction stage

Ranks					
	Please select from the categories below the sector to which your organisation belongs		N	Mean rank	Sum of ranks
CONSTRUCTION STAGE [Unpredictable weather conditions]	Dimension 1	Private	69	48.63	3,355.50
		Public	26	46.33	1,204.50
		Total	95		
CONSTRUCTION STAGE [Rework due to errors during construction]	Dimension 1	Private	68	46.87	3,187.00
		Public	24	45.46	1,091.00
		Total	92		
CONSTRUCTION STAGE [Fluctuations in the cost of building materials]	Dimension 1	Private	67	45.97	3,080.00
		Public	25	47.92	1,198.00
		Total	92		
CONSTRUCTION STAGE [Change orders from the owner]	Dimension 1	Private	65	49.04	3,187.50
		Public	25	36.30	907.50
		Total	90		
CONSTRUCTION STAGE [Lack of cost monitoring during the post-contract stage, and being reactive to changes, instead of being proactive]	Dimension 1	Private	64	42.87	2,743.50
		Public	25	50.46	1,261.50
		Total	89		
CONSTRUCTION STAGE [Poor site or soil conditions]	Dimension 1	Private	63	43.52	2,742.00
		Public	23	43.43	999.00
		Total	86		
CONSTRUCTION STAGE [Remeasurement of provisional work]	Dimension 1	Private	67	43.28	2,899.50
		Public	24	53.60	1,286.50
		Total	91		
CONSTRUCTION STAGE [Community interference]	Dimension 1	Private	63	44.48	2,802.50
		Public	23	40.80	938.50
		Total	86		
CONSTRUCTION STAGE [Logistics due to site conditions and location]	Dimension 1	Private	66	46.63	3,077.50
		Public	24	42.40	1,017.50
		Total	90		
CONSTRUCTION STAGE [Delays in issuing information to the contractor during construction]	Dimension 1	Private	69	47.21	3,257.50
		Public	25	48.30	1,207.50
		Total	94		
CONSTRUCTION STAGE [Contractual claims, such as extension of time with cost]	Dimension 1	Private	67	46.08	3,087.50
		Public	23	43.80	1,007.50
		Total	90		
	Dimension1	Private	66	46.27	3,053.50

CONSTRUCTION STAGE [Revision of issue for construction drawings by the architect]		Public	24	43.40	1,041.50
		Total	90		
CONSTRUCTION STAGE [Delays in costing variations, and unforeseen additional work]	Dimension 1	Private	67	46.59	3,121.50
		Public	24	44.35	1,064.50
		Total	91		
CONSTRUCTION STAGE [Labour cost increases due to scarcity in remote areas]	Dimension 1	Private	64	45.89	2,937.00
		Public	25	42.72	1,068.00
		Total	89		
CONSTRUCTION STAGE [Lack of experience of local regulations]	Dimension 1	Private	66	45.68	3,015.00
		Public	26	48.58	1,263.00
		Total	92		
CONSTRUCTION STAGE [Labour unrest]	Dimension 1	Private	63	42.89	2,702.00
		Public	23	45.17	1,039.00
		Total	86		
CONSTRUCTION STAGE [Monthly payment difficulties from the client]	Dimension 1	Private	68	45.35	3,084.00
		Public	22	45.95	1,011.00
		Total	90		
CONSTRUCTION STAGE [Poor management of the project by the contractor]	Dimension 1	Private	65	45.95	2,987.00
		Public	24	42.42	1,018.00
		Total	89		
CONSTRUCTION STAGE [New information on existing site conditions]	Dimension 1	Private	68	46.65	3,172.50
		Public	23	44.07	1,013.50
		Total	91		
CONSTRUCTION STAGE [Changes to safe working procedures]	Dimension 1	Private	65	44.58	2,898.00
		Public	23	44.26	1,018.00
		Total	88		
CONSTRUCTION STAGE [The contractor’s unstable financial capacity]	Dimension 1	Private	67	47.80	3,202.50
		Public	25	43.02	1,075.50
		Total	92		

Table 5.12: Mann-Whitney U test statistics for the causes of poor cost performance in the construction stage

Test statistics[a]				
	Mann-Whitney U	Wilcoxon W	Z	Asymp. sig. (2-tailed)
CONSTRUCTION STAGE [Unpredictable weather conditions]	853.500	1,204.500	−.373	.709
CONSTRUCTION STAGE [Rework due to errors during construction]	791.000	1,091.000	−.230	.818
CONSTRUCTION STAGE [Fluctuations in the cost of building materials]	802.000	3,080.000	−.321	.748
CONSTRUCTION STAGE [Change orders from the owner]	**582.500**	**907.500**	**−2.135**	**.033**
CONSTRUCTION STAGE [Lack of cost monitoring during the post-contract stage, and being reactive to changes, instead of being proactive]	663.500	2,743.500	−1.299	.194
CONSTRUCTION STAGE [Poor site or soil conditions]	723.000	999.000	−.015	.988
CONSTRUCTION STAGE [Remeasurement of provisional work]	621.500	2,899.500	−1.687	.092
CONSTRUCTION STAGE [Community interference]	662.500	938.500	−.625	.532
CONSTRUCTION STAGE [Logistics due to site conditions and location]	717.500	1,017.500	−.699	.485
CONSTRUCTION STAGE [Delays in issuing information to the contractor during construction]	842.500	3,257.500	−.178	.858
CONSTRUCTION STAGE [Contractual claims, such as extension of time with cost]	731.500	1,007.500	−.380	.704
CONSTRUCTION STAGE [Revision of issue for construction drawings by the architect]	741.500	1,041.500	−.479	.632
CONSTRUCTION STAGE [Delays in costing variations, and unforeseen additional work]	764.500	1,064.500	−.370	.712
CONSTRUCTION STAGE [Labour cost increases due to scarcity in remote areas]	743.000	1,068.000	−.538	.591
CONSTRUCTION STAGE [Lack of experience of local regulations]	804.000	3,015.000	−.480	.631
CONSTRUCTION STAGE [Labour unrest]	686.000	2,702.000	−.387	.698
CONSTRUCTION STAGE [Monthly payment difficulties from the client]	738.000	3,084.000	−.098	.922
CONSTRUCTION STAGE [Poor management of the project by the contractor]	718.000	1,018.000	−.608	.543
CONSTRUCTION STAGE [New information on existing site conditions]	737.500	1,013.500	−.418	.676
CONSTRUCTION STAGE [Changes to safe working procedures]	742.000	1,018.000	−.054	.957

CONSTRUCTION STAGE [The contractor's unstable financial capacity]	750.500	1,075.500	−.806	.420
a. Grouping variable: Please select from the categories below the sector to which your organisation belongs				

5.1.12 Exploring the differences across respondents' years of experience regarding opinions of the causes of poor cost performance in the construction stage

As in the design stage, further analysis is required based on the years of experience of the respondents regarding opinions of the causes of poor cost performance in the construction stage. In order to explore the differences in the opinions of the respondents across five categories of years of experience, a non-parametric Kruskal-Wallis H test was performed. The test was performed to answer the following question: "Is there a significant difference in respondents' opinions of the causes of poor cost performance in the construction stage across the five categories of years of experience?"

The Kruskal-Wallis H test results presented in Table 5.13 reveal a statistically significant difference in respondents' opinions of the following cause of poor cost performance in the construction stage across five categories of years of experience: "rework due to errors during construction" (chi-square = 15.809; df = 4; p-value = 0.003). For opinions of this cause of poor cost performance, there is a need to inspect the mean ranks across the different categories of years of experience. As such, Table 5.14 shows that respondents with 1–5 years of experience had the highest mean rank, followed by respondents with 11–15 years of experience. Respondents with more than 20 years of experience had the lowest mean rank. This means there is a need to conduct post-hoc tests for this variable, because the statistics obtained from the Kruskal-Wallis H test could not reveal which of the groups are statistically different from one another. There is no statistically significant difference in the responses of the respondents across the categories of years of experience regarding all the other causes of poor cost performance in the construction stage.

Table 5.13: Kruskal-Wallis H test statistics for the causes of poor cost performance in the construction stage

Test statistics[a,b]			
	Chi-square	df	Asymp. sig.
CONSTRUCTION STAGE [Unpredictable weather conditions]	6.747	4	.150
CONSTRUCTION STAGE [Rework due to errors during construction]	**15.809**	**4**	**.003**
CONSTRUCTION STAGE [Fluctuations in the cost of building materials]	3.687	4	.450
CONSTRUCTION STAGE [Change orders from the owner]	2.710	4	.607
CONSTRUCTION STAGE [Lack of cost monitoring during the post-contract stage, and being reactive to changes, instead of being proactive]	4.807	4	.308
CONSTRUCTION STAGE [Poor site or soil conditions]	9.375	4	.052
CONSTRUCTION STAGE [Remeasurement of provisional work]	9.358	4	.053
CONSTRUCTION STAGE [Community interference]	4.130	4	.389
CONSTRUCTION STAGE [Logistics due to site conditions and location]	3.285	4	.511
CONSTRUCTION STAGE [Delays in issuing information to the contractor during construction]	4.472	4	.346
CONSTRUCTION STAGE [Contractual claims, such as extension of time with cost]	3.569	4	.467
CONSTRUCTION STAGE [Revision of issue for construction drawings by the architect]	.440	4	.979
CONSTRUCTION STAGE [Delays in costing variations, and unforeseen additional work]	3.808	4	.433
CONSTRUCTION STAGE [Labour cost increases due to scarcity in remote areas]	4.608	4	.330
CONSTRUCTION STAGE [Lack of experience of local regulations]	3.090	4	.543
CONSTRUCTION STAGE [Labour unrest]	5.323	4	.256
CONSTRUCTION STAGE [Monthly payment difficulties from the client]	4.127	4	.389
CONSTRUCTION STAGE [Poor management of the project by the contractor]	1.040	4	.904
CONSTRUCTION STAGE [New information on existing site conditions]	7.554	4	.109
CONSTRUCTION STAGE [Changes to safe working procedures]	3.721	4	.445
CONSTRUCTION STAGE [The contractor’s unstable financial capacity]	1.371	4	.849
a. Kruskal-Wallis H test			
b. Grouping variable: Please indicate your years of experience in the construction industry			

Table 5.14: Mean ranks from the Kruskal-Wallis H test for the causes of poor cost performance in the construction stage

Ranks				
	Please indicate your years of experience in the construction industry		N	Mean rank
CONSTRUCTION STAGE [Unpredictable weather conditions]	Dimension 1	1–5 years	28	52.18
		6–10 years	13	54.35
		11–15 years	25	52.42
		16–20 years	10	35.55
		More than 20 years	19	38.24
		Total	95	
CONSTRUCTION STAGE [Rework due to errors during construction]	Dimension 1	1–5 years	27	56.98
		6–10 years	13	51.85
		11–15 years	24	49.17
		16–20 years	9	39.61
		More than 20 years	19	27.84
		Total	92	
CONSTRUCTION STAGE [Fluctuations in the cost of building materials]	Dimension 1	1–5 years	26	44.54
		6–10 years	13	54.08
		11–15 years	25	50.58
		16–20 years	10	46.30
		More than 20 years	18	38.31
		Total	92	
CONSTRUCTION STAGE [Change orders from the owner]	Dimension 1	1–5 years	24	39.54
		6–10 years	13	52.31
		11–15 years	24	47.04
		16–20 years	10	49.90
		More than 20 years	19	44.11
		Total	90	
CONSTRUCTION STAGE [Lack of cost monitoring during the post-contract stage, and being reactive to changes, instead of being proactive]	Dimension 1	1–5 years	25	51.04
		6–10 years	12	51.46
		11–15 years	24	41.58
		16–20 years	10	45.40
		More than 20 years	18	36.64
		Total	89	
CONSTRUCTION STAGE [Poor site or soil conditions]	Dimension 1	1–5 years	25	47.94
		6–10 years	10	56.30
		11–15 years	23	45.80
		16–20 years	9	37.67
		More than 20 years	19	30.89
		Total	86	
CONSTRUCTION STAGE [Remeasurement of provisional work]	Dimension 1	1–5 years	26	53.27
		6–10 years	12	52.79
		11–15 years	25	48.12

		16–20 years	10	39.65
		More than 20 years	18	31.56
		Total	91	
CONSTRUCTION STAGE [Community interference]	Dimension 1	1–5 years	24	36.81
		6–10 years	10	52.10
		11–15 years	24	44.48
		16–20 years	9	39.28
		More than 20 years	19	48.18
		Total	86	
CONSTRUCTION STAGE [Logistics due to site conditions and location]	Dimension 1	1–5 years	25	43.82
		6–10 years	12	50.88
		11–15 years	25	48.68
		16–20 years	9	32.83
		More than 20 years	19	46.13
		Total	90	
CONSTRUCTION STAGE [Delays in issuing information to the contractor during construction]	Dimension 1	1–5 years	29	49.17
		6–10 years	13	56.38
		11–15 years	24	49.13
		16–20 years	9	34.61
		More than 20 years	19	42.92
		Total	94	
CONSTRUCTION STAGE [Contractual claims, such as extension of time with cost]	Dimension 1	1–5 years	26	43.83
		6–10 years	13	56.04
		11–15 years	25	45.26
		16–20 years	9	36.83
		More than 20 years	17	44.94
		Total	90	
CONSTRUCTION STAGE [Revision of issue for construction drawings by the architect]	Dimension 1	1–5 years	28	46.27
		6–10 years	13	48.12
		11–15 years	22	43.52
		16–20 years	9	42.61
		More than 20 years	18	46.28
		Total	90	
CONSTRUCTION STAGE [Delays in costing variations, and unforeseen additional work]	Dimension 1	1–5 years	27	47.31
		6–10 years	12	51.17
		11–15 years	25	49.98
		16–20 years	9	43.11
		More than 20 years	18	36.50
		Total	91	
CONSTRUCTION STAGE [Labour cost increases due to scarcity in remote areas]	Dimension 1	1–5 years	27	46.57
		6–10 years	10	51.40
		11–15 years	24	47.08

		16–20 years	9	49.78
		More than 20 years	19	34.50
		Total	89	
CONSTRUCTION STAGE [Lack of experience of local regulations]	Dimension 1	1–5 years	27	50.33
		6–10 years	12	53.46
		11–15 years	25	42.70
		16–20 years	10	48.60
		More than 20 years	18	40.22
		Total	92	
CONSTRUCTION STAGE [Labour unrest]	Dimension 1	1–5 years	26	41.63
		6–10 years	11	56.64
		11–15 years	24	38.98
		16–20 years	9	37.28
		More than 20 years	16	47.78
		Total	86	
CONSTRUCTION STAGE [Monthly payment difficulties from the client]	Dimension 1	1–5 years	26	51.81
		6–10 years	12	48.67
		11–15 years	24	41.67
		16–20 years	9	34.61
		More than 20 years	19	44.87
		Total	90	
CONSTRUCTION STAGE [Poor management of the project by the contractor]	Dimension 1	1–5 years	26	44.38
		6–10 years	12	49.46
		11–15 years	23	44.11
		16–20 years	9	39.33
		More than 20 years	19	46.79
		Total	89	
CONSTRUCTION STAGE [New information on existing site conditions]	Dimension 1	1–5 years	27	53.89
		6–10 years	12	51.46
		11–15 years	24	46.21
		16–20 years	9	38.06
		More than 20 years	19	34.84
		Total	91	
CONSTRUCTION STAGE [Changes to safe working procedures]	Dimension 1	1–5 years	25	49.58
		6–10 years	13	45.77
		11–15 years	24	41.94
		16–20 years	9	50.67
		More than 20 years	17	36.41
		Total	88	

CONSTRUCTION STAGE [The contractor's unstable financial capacity]	Dimension 1	1–5 years	27	45.85
		6–10 years	13	49.96
		11–15 years	24	42.38
		16–20 years	9	46.06
		More than 20 years	19	50.47
		Total	92	

5.1.13 The causes of poor cost performance in the completion stage

Table 5.15 below shows the causes of poor cost performance in the completion stage of the project's life cycle, as indicated by the respondents. The causes, ranked in descending order, were as follows: "variation orders given to the contractor but not communicated to the quantity surveyor" was ranked first, with a mean score of 3.75; "late contract instructions after practical completion" was ranked second, with a mean score of 3.68; "extra work" was ranked third, with a mean score of 3.65; "delays in final account agreement" was ranked fourth, with a mean score of 3.32; and "work suspended due to safety reasons" was ranked fifth, with a mean score of 3.24. The Cronbach's alpha for this stage was 0.891, as shown in Table 5.16.

Table 5.15: The causes of poor cost performance in the completion stage

Causes of poor cost performance	Mean	Std deviation	Rank
Variation orders given to the contractor but not communicated to the QS	3.75	1.280	1
Late contract instructions after practical completion	3.68	1.270	2
Extra work	3.65	1.306	3
Delays in final account agreement	3.32	1.282	4
Work suspended due to safety reasons	3.24	1.276	5

(Source: Researcher's field survey)

Table 5.16: Reliability statistics for the causes of poor cost performance in the completion stage

Questions	Cronbach's alpha	No. of items
The causes of poor cost performance in the completion stage	0.891	5

(Source: Researcher's field survey)

5.1.14 Exploring the differences in the opinions of public and private sector respondents regarding the causes of poor cost performance in the completion stage

The same question asked in the design stage (Section A) and the construction stage (Section B) is asked for the causes of poor cost performance in the completion stage, namely "Is there a significant difference in the opinions of the private and the public sector respondents regarding the causes of poor cost performance in the completion stage?" The Mann-Whitney U test was also performed on the data in order to answer the question. The test explores the differences in the opinions of the public and the private sector respondents and therefore computes the ranks for the two groups, as shown in Table 5.17. The ranks for the private and the public sector respondents were evaluated to find out whether or not the two groups do differ significantly. As such, the Mann-Whitney U test statistics as presented in Table 5.18 give the z-scores and their corresponding p-values [asymp. sig. (2-tailed)] for the causes of poor cost performance in the completion stage of construction projects. The p-values for all the variables as shown in Table 5.18 are greater than 0.05, and none of them is less than or equal to 0.05. Therefore the results are not significant. This, by implication, means that the opinions of the private and the public sector respondents do not differ significantly.

Table 5.17: Ranks from the Mann-Whitney U test for the causes of poor cost performance in the completion stage

Ranks					
	Please select from the categories below the sector to which your organisation belongs		N	Mean rank	Sum of ranks
COMPLETION STAGE [Extra work]	Dimension 1	Private	66	44.67	2,948.00
		Public	23	45.96	1,057.00
		Total	89		
COMPLETION STAGE [Late contract instructions after practical completion]	Dimension 1	Private	68	48.54	3,301.00
		Public	25	42.80	1,070.00
		Total	93		
COMPLETION STAGE [Variation orders given to the contractor but not communicated to the QS]	Dimension 1	Private	69	48.27	3,330.50
		Public	26	47.29	1,229.50
		Total	95		
COMPLETION STAGE [Delays in final account agreement]	Dimension 1	Private	69	47.54	3,280.50
		Public	26	49.21	1,279.50
		Total	95		
COMPLETION STAGE [Work suspended due to safety reasons]	Dimension 1	Private	69	45.94	3,170.00
		Public	25	51.80	1,295.00
		Total	94		

Table 5.18: Mann-Whitney U test statistics for the causes of poor cost performance in the completion stage

Test statistics[a]				
	Mann-Whitney U	Wilcoxon W	Z	Asymp. sig. (2-tailed)
COMPLETION STAGE [Extra work]	737.000	2,948.000	−.214	.830
COMPLETION STAGE [Late contract instructions after practical completion]	745.000	1,070.000	−.943	.346
COMPLETION STAGE [Variation orders given to the contractor but not communicated to the QS]	878.500	1,229.500	−.161	.872
COMPLETION STAGE [Delays in final account agreement]	865.500	3,280.500	−.270	.787
COMPLETION STAGE [Work suspended due to safety reasons]	755.000	3,170.000	−.943	.346
a. Grouping variable: Please select from the categories below the sector to which your organisation belongs				

5.1.15 Exploring the differences across respondents' years of experience regarding opinions of the causes of poor cost performance in the completion stage

As in the design stage and the construction stage, opinions of the causes of poor cost performance in the completion stage of a project's life cycle were analysed based on the years of experience of the respondents. In order to explore the differences in the opinions of the respondents across five categories of years of experience, a non-parametric Kruskal-Wallis H test was performed. The test was performed to answer the following question: "Is there a significant difference in respondents' opinions of the causes of poor cost performance in the completion stage across the five categories of years of experience?"

The results of the Kruskal-Wallis H test presented in Table 5.19 reveal significance values of greater than 0.05 for opinions of all the causes of poor cost performance in the completion stage of a project's life cycle. The implication of these results is that there is no significant difference in respondents' opinions of the causes of poor cost performance in the completion stage across the five categories of years of experience.

Table 5.19: Kruskal-Wallis H test statistics for the causes of poor cost performance in the completion stage

Test statistics[a,b]			
	Chi-square	df	Asymp. sig.
COMPLETION STAGE [Extra work]	.705	4	.951
COMPLETION STAGE [Late contract instructions after practical completion]	.699	4	.952
COMPLETION STAGE [Variation orders given to the contractor but not communicated to the QS]	1.252	4	.870
COMPLETION STAGE [Delays in final account agreement]	2.470	4	.650
COMPLETION STAGE [Work suspended due to safety reasons]	5.243	4	.263
a. Kruskal-Wallis H test			
b. Grouping variable: Please indicate your years of experience in the construction industry			

5.1.16 The shortcomings of current cost management practices

Table 5.20 below lists the shortcomings of current cost management practices as ranked by the respondents. Ranked first was “a limited budget, treated as a constraint”, with a mean score of 3.80, while “poor estimation” was ranked second, with a mean score of 3.70, and ranked third was “costs are an outcome of the design, rather than costs steering the design”, with a mean score of 3.69. In descending order of importance, ranked fourth was “relative neglect of value consideration”, with a mean score of 3.56, while ranked fifth was “failure to support improvement opportunities”, with a mean score of 3.53. Ranked sixth was “costs are the responsibility of the quantity surveyor, not the collective”, with a mean score of 3.43, and ranked seventh was “negative influence on behaviour”, with a mean score of 3.34. Table 5.21 below indicates a high reliability as the Cronbach’s alpha was 0.897, which indicates excellent reliability and internal consistency (Field 2013; Nunnally & Bernstein 2007; Pallant 2005).

Table 5.20: The shortcomings of current cost management practices

	Mean	**Std deviation**	**Rank**
A limited budget, treated as a constraint	3.80	1.251	1
Poor estimation	3.70	1.225	2
Costs are an outcome of the design, rather than costs steering the design	3.69	1.270	3
Relative neglect of value consideration	3.56	1.229	4
Failure to support improvement opportunities	3.53	1.171	5
Costs are the responsibility of the QS, not the collective	3.43	1.463	6

Negative influence on behaviour	3.34	1.186	7

Table 5.21: Reliability statistics for the shortcomings of current cost management practices

Questions	Cronbach's alpha	No. of items
The shortcomings of current cost management practices	0.897	7

(Source: Researcher's field survey)

5.2 THE CAUSES OF POOR TIME PERFORMANCE

Table 5.22 below shows the causes of poor time performance in the life cycle of the project, as indicated by the respondents. The causes, ranked in descending order, were as follows: "poor site management and supervision by the contractor" was ranked first, with a mean score of 4.08; "low productivity of the labourers" was ranked second, with a mean score of 3.95; "poor communication and coordination by the contractor with other parties" was ranked third, with a mean score of 3.93; "improper construction methods implemented by the contractor" was ranked fourth, with a mean score of 3.93; "ineffective planning and scheduling of tasks by the contractor" was ranked fifth, with a mean score of 3.91; and "limited details in drawings" was ranked sixth, with a mean score of 3.83. "Lack of a skilled workforce" was ranked seventh, with a mean score of 3.81; "rework due to errors during construction" was ranked eighth, with a mean score of 3.78. "Mistakes and discrepancies in design documents" was ranked ninth, with a mean score of 3.78; and "poor qualifications of the contractor's technical staff" was ranked tenth, with a mean score of 3.75. "Changes in material types and specifications during construction" was ranked eleventh, with a mean score of 3.62; and "change orders by the owner" was ranked twelfth, with a mean score of 3.60. "The complexity of the project's design" was ranked thirteenth, with a mean score of 3.56; and "damage caused by sorting materials while they are needed urgently" was ranked fourteenth, with a mean score of 3.50. "Site uncertainties" was ranked fifteenth, with a mean score of 3.26; and "non-use of advanced engineering design software and tools" was ranked sixteenth, with a mean score of 3.10. The Cronbach's alpha for this stage was 0.949, as shown in Table 5.23.

Table 5.22: The causes of poor time performance

	Mean	Std deviation	Rank
Poor site management and supervision by the contractor	4.08	1.173	1
Low productivity of the labourers	3.95	1.152	2
Poor communication and coordination by the contractor with other parties	3.93	1.230	3
Improper construction methods implemented by the contractor	3.93	1.240	4
Ineffective planning and scheduling of tasks by the contractor	3.91	1.274	5
Limited details in drawings	3.83	1.331	6

Lack of a skilled workforce	3.81	1.157	7
Rework due to errors during construction	3.78	1.267	8
Mistakes and discrepancies in design documents	3.78	1.263	9
Poor qualifications of the contractor's technical staff	3.75	1.176	10
Changes in material types and specifications during construction	3.62	1.265	11
Change orders by the owner	3.60	1.299	12
The complexity of the project's design	3.56	1.364	13
Damage caused by sorting materials while they are needed urgently	3.50	1.280	14
Site uncertainties	3.26	1.264	15
Non-use of advanced engineering design software and tools	3.10	1.198	16

Table 5.23: Reliability statistics for the causes of poor time performance

Questions	Cronbach's alpha	No. of items
The causes of poor time performance	0.949	16

(Source: Researcher's field survey)

5.2.1 Exploring the differences in the opinions of public and private sector respondents regarding the causes of poor time performance on construction projects

There is a need to answer the following question: "Is there a significant difference in opinions of the causes of poor time performance on construction projects between private sector respondents and public sector respondents?" To answer this question, a null hypothesis was postulated to test the level of agreement between private and public sector respondents regarding the causes of poor time performance on construction projects. The hypothesis stated that there is no significant difference in the ranking of causes of poor time performance between private and public sector respondents. A Mann-Whitney U test was employed to test the hypothesis. According to Statistics (2018), the Mann-Whitney U test is a rank-based non-parametric test used to compare differences between two independent groups when the dependent variable is either ordinal or continuous, but not normally distributed. The results of the analysis are indicated in Table 5.24. The hypothesis is accepted for all values of $p>0.05$, while it is rejected for all values of $p<0.05$. The results show that the hypothesis is accepted for all the causes of poor time performance, except one. For those causes where $p>0.05$, the results in Table 5.24 indicate that there is general agreement in the ranking of the causes of poor time performance. However, there is a significant difference in the ranking of the cause "non-use of advanced engineering design software and tools".

Table 5.24: Ranks from the Mann-Whitney U test for the causes of poor time performance in the completion stage

Test Statistics[a]				
	Mann-Whitney U	Wilcoxon W	Z	Asymp. sig. (2-tailed)
[Rework due to errors during construction]	895.000	1,273.000	−.311	.756
[Change orders by the owner]	764.000	1,115.000	−.737	.461
[Poor site management and supervision by the contractor]	835.000	3,250.000	−.560	.575
[Poor communication and coordination by the contractor with other parties]	718.500	3,064.500	−.920	.357
[Ineffective planning and scheduling of tasks by the contractor]	879.000	3,364.000	−.271	.787
[Improper construction methods implemented by the contractor]	791.500	3,276.500	−.750	.453
[Poor qualifications of the contractor's technical staff]	656.000	3,071.000	−1.571	.116
[Mistakes and discrepancies in design documents]	719.500	3,065.500	−1.461	.144
[Non-use of advanced engineering design software and tools]	**519.000**	**2,535.000**	**−2.069**	**.039**
[Limited details in drawings]	735.500	3,013.500	−.948	.343
[The complexity of the project's design]	741.000	3,087.000	−1.248	.212
[Changes in material types and specifications during construction]	822.500	1,200.500	−.814	.416
[Damage caused by sorting materials while they are needed urgently]	872.000	3,017.000	−.049	.961

[Lack of a skilled workforce]	850.500	3,196.500	−.295	.768
[Low productivity of the labourers]	830.500	1,155.500	−.065	.948
[Site uncertainties]	676.000	976.000	−.561	.575
a. Grouping variable: Please select from the categories below the sector to which your organisation belongs				

5.2.2 Exploring the differences across the respondents' years of experience regarding opinions of the causes of poor time performance on construction projects

It is also important to explore the differences across respondents' years of experience regarding the causes of poor time performance on construction projects. As such, the following question is asked: "Is there a significant difference in respondents' opinions of the causes of poor time performance on construction projects across the five categories of years of experience?" To answer this question, a null hypothesis was postulated to test the differences in the opinions of the respondents. A Kruskal-Wallis H test was used to explore the differences. The results of the Kruskal-Wallis H test are presented in Table 5.25. The results reveal that there is no statistically significant difference in respondents' opinions of all the causes of poor time performance across the five categories of years of experience.

Table 5.25: Kruskal-Wallis H test statistics for the causes of poor time performance in the completion stage

Test statistics[a,b]			
	Chi-square	df	Asymp. sig.
[Rework due to errors during construction]	4.248	4	.373
[Change orders by the owner]	5.647	4	.227
[Poor site management and supervision by the contractor]	.331	4	.988
[Poor communication and coordination by the contractor with other parties]	1.409	4	.843
[Ineffective planning and scheduling of tasks by the contractor]	1.281	4	.865
[Improper construction methods implemented by the contractor]	5.051	4	.282
[Poor qualifications of the contractor's technical staff]	.864	4	.930
[Mistakes and discrepancies in design documents]	7.031	4	.134
[Non-use of advanced engineering design software and tools]	4.689	4	.321
[Limited details in drawings]	.414	4	.981
[The complexity of the project's design]	2.779	4	.595
[Changes in material types and specifications during construction]	4.144	4	.387
[Damage caused by sorting materials while they are needed urgently]	7.567	4	.109
[Lack of a skilled workforce]	2.193	4	.700
[Low productivity of the labourers]	2.575	4	.631
[Site uncertainties]	.509	4	.973
a. Kruskal-Wallis H test			
b. Grouping variable: Please indicate your years of experience in the construction industry			

5.3 A NEED FOR INNOVATIVE WAYS TO IMPROVE THE PERFORMANCE OF PROJECTS

Based on the causes of poor performance selected in the previous sections, the respondents were asked whether there is a need for innovative ways to improve project performance in South African public infrastructure projects. Figure 5.7 below shows that 85% of the respondents agreed that innovative ways are needed to improve the current poor project performance displayed by public infrastructure projects. Ten percent of the respondents disagreed, while 5% were unsure.

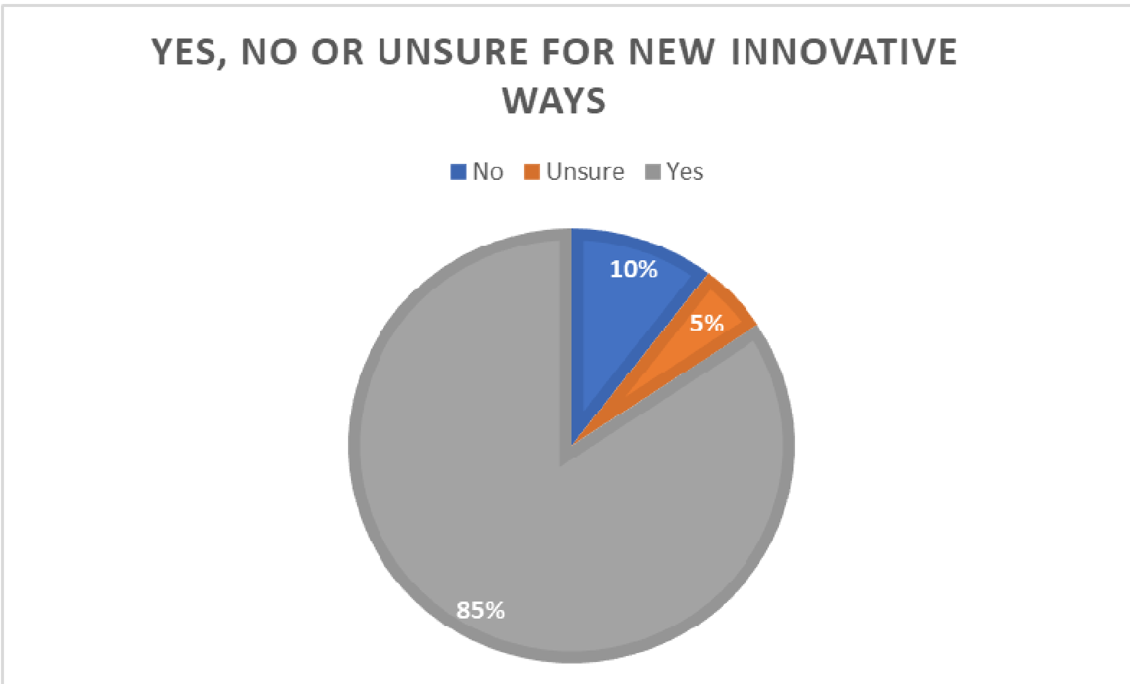


Figure 5.7: Innovative ways to improve performance (Source: Researcher's field survey)

5.4 COLLABORATIVE CONTRACTS AS A MEANS TO IMPROVE THE PERFORMANCE OF PROJECTS

Based on the causes of poor performance selected in the previous sections, the respondents were asked whether employing collaborative contracts, as such, would improve project performance in South Africa's public infrastructure projects. Figure 5.8 shows that 90% of the respondents agreed that contracts such as integrated forms of agreement might improve the poor project performance of public infrastructure projects. Four percent of the respondents disagreed, while 6% were unsure.

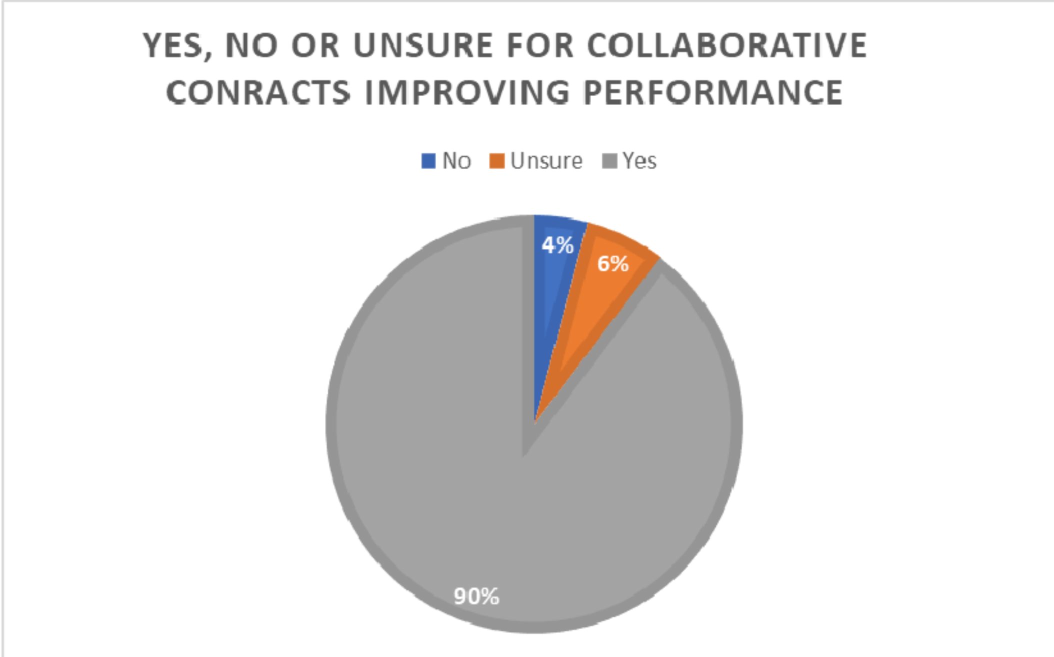


Figure 5.8: Collaborative contracts to improve performance (Source: Researcher's field survey)

5.4.1 ANOVA: SINGLE FACTOR IN COMPARISON TO THE DIFFERENT STAGES OF THE PROJECT

Table 5.26 shows the overall scores for the three phases, which were calculated by averaging the scores of each individual factor. This provides a general idea of the average effect that design phase factors, construction phase factors, and completion phase factors have on performance. A one-way ANOVA was conducted to determine if there was a statistically significant difference between the three phases with regard to their factors' average effect on performance. Table 5.27 shows that the effect across the phases was not statistically significantly different based on $F(2, 286) = 0.029$, $p = 0.972$. This means that the factors in the design phase that affect performance are not perceived as being more influential than those in the other two phases. The same is true for all phases.

Table 5.26: A summary of the results of the different stages of construction

SUMMARY				
Group	**Count**	**Sum**	**Average**	**Variance**
Design	97	343.052	3.536618	0.923196
Construction	96	339.1968	3.533018	0.788206
Completion	96	336.55	3.505729	1.145677

(Source: Researcher's field survey)

Table 5.27: ANOVA between groups of results

Source of variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Between groups	0.054909	2	0.027455	0.028831	0.971583	3.027332
Within groups	272.3457	286	0.952258			
Total	272.4006	288				

(Source: Researcher's field survey)

5.5 CHAPTER SUMMARY

This chapter presented the quantitative findings of the study. The qualitative data acts as a triangulation of the results of the quantitative data, to relate the findings. The findings of the quantitative data show neglect by professionals to fully commit to improving the performance of projects. In the design stage, "ignoring items with abnormal rates during tender evaluation, especially items with provisional quantities" was ranked as the greatest contributor to poor cost performance. The construction stage presented a similar finding on the causes of poor management of the project by the contractor. In the completion stage, "variation orders given to the contractor but not communicated to the quantity surveyor" was ranked the highest, based on the responses from the survey. Low morale, as mentioned in the cases, was a similar finding of the shortcomings of current cost management practices, as respondents saw a limited budget as a constraint, rather than as an opportunity. This can be attributed to a finding in the cases of overdesign by architects being singled out as one of the major contributors to poor performance. The chapter clearly draws key findings, necessary to answer the questions asked in chapter 1 of this study. In the opinion of the researcher, the findings directly relate to objectives 1 to 4 of this study.

CHAPTER 6
DISCUSSIONS OF THE RESEARCH FINDINGS

6.1 INTRODUCTION

The aim of this research is to establish how to eradicate the poor cost performance recorded in infrastructure projects in South Africa, using known lean practices. The focus is on infrastructure projects in South Africa. Previous chapters have presented the empirical findings, while this chapter proceeds to discuss the key findings, triangulating, literature, questionnaires and semi structured interviews findings to respond to the research questions and propositions towards an analytical generalisation. The key findings of the research relate to the development of the LCCMM concepts and discussion of themes evolving from the results of the study presented in chapter 4 and chapter 5 of this research.

6.2 DISCUSSION OF THE QUALITATIVE FINDINGS

Data obtained from qualitative case studies provided a clear picture of the severity of project cost overruns. The findings reveal project overruns ranging from 18% to 40% of the total project (Makovsek et al. 2012; Love and Sing 2013; Cantarelli et al. 2012). All projects reported cost overruns inclusive of those projects under construction during data collection. The projects were executed using design-bid-build type of delivery system. This type of project delivery system has revealed to be a complex type of method to control change orders. This type of project delivery is a fragmented approach and does not encourage collaboration amongst the stakeholders. The status quo of South African construction remains a challenge to get projects to enhance their performance. Projects performed poorly in terms of cost and time from the cohort of case studies above. Three of the five projects that performed poorly, resulted from revision of drawings by the architect on instructions from the client. This brought about variations with cost implications to the projects. Other reasons are request for information by the contractor to the client which response was very slow therefore halting certain tasks by the contractor due to lack of information forthcoming. There is an initiative by the regional public works to employ early contractor involvement to be part of the design and cost management process, but the challenge is on how it should be implemented. The question was around whether the contractor should be a consultant to the project or should be appointed early, this is based on which criteria the public sector has a challenge with using competitive bidding as per the Public Finance Management Act. The contractor's aim is to maximise profits however if the contractor is appointed based on price, then the contractor might not agree for the project cost to be revised lower, which brings a challenge of revising the traditional design-bid-build system. The challenge brought by the traditional design-bid-build is that it does not allow multi-party agreements and to use incentives to promote collaboration between project participants.

Data obtained from case studies was evaluated using value stream mapping to identify lean opportunities from existing project cost management practices of the South African construction industry. Within the South African context, little is known about the application of Lean thinking strategies to better the overall success of the project. Lean introduction for the past two decades has no doubt posed a challenge for the traditional project management practice (Alarcon, Mesa, and Howell 2013). The identified lean tools from traditional design-bid-build case studies were suggested to the Interviewees for them to comment on whether they will assist to overcome the poor performance recorded based on time and cost on the public-sector projects in South Africa. This study produced a vignette for the status quo of cost management process for the delivery of the public project is South Africa. The public works execute projects with the mandate from other national client departments. As such, the public works projects are only allowed to use competitive bidding system from contractors according to the Public Finance Management Act. This hinders an opportunity to introduce early contractor involvement and appoints based on lowest price. And then contractors are hesitant to revise prices lower than appointed costs, due to fear of losing out on profit margins. The lean opportunities identified, have the highest chance of improving the cost management process and the projects in its entirety as some were deemed appropriate but due to limited times sometimes offered to implement projects respondents ruled them out on projects were time was limited to implement but appropriate for mega projects. The researcher believe that the most significant challenge of achieving lean in South Africa will mainly be culture change before lean construction can flourish as a philosophy to bring about change. The vignette makes provision for the proposed lean construction cost management model development as a key contribution of this study. The model takes cognisance of the findings of the vignette to further identify opportunities for infusing lean in the current cost management practices in South African construction industry. Lastly, the researcher identified root causes for such poor performance with the aid of the technique '5 Whys' is used (Ohno, 1988). 5Why's is a problem solving technique that asks "WHY" five times to get to the root cause of a problem (Basu, 2009). It helps to avoid putting band aid solutions in place that will only be a temporary fix. Technique was applied with the project participants for obtaining their opinions on the different causes and effects underlying each reason under analysis. The following 5 Why's analysis for over budget: (1) Why – poor coordination of design development, (2) Why – so many design changes, (3) Why poor communication, (4) Why – poor cost management of project, (5) Why – interface of design and construction misunderstood. The five questions posed to project participants assisted in gathering causes relating to planning, management and coordination in the category of processes applied to cost management of the selected project cases. Reasons obtained are used to propose a collaborative cost management framework for the public sector projects in South Africa.

Table 6.1: "5 why's" Analysis of project case studies

5 Why's questions for projects running over budget	**Corresponding Level of Countermeasure**
1. Why is there poor coordination of design development	Owner operating requirements are not clear
Because Design development is done in isolation	Organise a boot camp for introduction of team members
Because Various designs use Architectural preliminary sketches, specialists brought in late for fixing errors	Pull plan the design
Because Contractors are not brought in early	Bring the contractor early
2. Why are there so many design changes	Discuss the owner project requirements
Because Client involvement is minimal	Get commitment from the owner
Because owner uses Non- technical staff for representation	Involve all stakeholders of the project form the onset
Because clients transfer their responsibilities to the consultants	Clients clarify the value required from the project
Because of Unclear owner project requirement, and no project success criteria.	Discuss the deliverables of the project with all stakeholders
3. Why do poor communication persist in construction projects	No proper communication platform.
Because not all can see changes as and when they happen, waiting too long for feedback from client owner	Create a platform that all can see changes in real time
Because stakeholders only care about their bottom line in the projects	Build transparency and honesty among team members
Because both consultants and contractors want different things in a projects	Introduce Incentives to encourage collaboration
Interference from administrators	Assign roles of all stakeholders involved
Because interaction of all stakeholders happen once a month	Do a big room meeting regularly
4. Why do poor cost management persist in construction	Cost are responsibility of the cost manager
Culture of assigning cost to QS alone	Use collaborative cost management
Because Contractor not part of the design,	Use best value procurement
Because of non-collaboration of project teams,	Use integrated project development
Because contractor profit driven, blame game, safeguarding of interests by consultants, risk transferred to contractor	Put the profit margin at risk and incentivise performance and use target value delivery
5. Why is the interface between design and construction misunderstood	Change the contract to include IPD
Because Procurement without best value,	Provide Best value procurement

Because contractor not appointed early,	Use IFOA to encourage collaboration
Because Lack of trust between consultants and contractor,	Create a transparent environment and respect for people attitudes
Because Cost management in construction phase is reactive and has no control of costs, delays contributing to cost overruns.	Use target value delivery

Source: Researcher's fieldwork

Semi-structured interviews confirmed findings of the case studies regarding poor performance recorded on South African construction practices. In terms of the overall performance of projects, thirteen of the respondents indicated that projects were under-performing or performing poorly. Only one respondent felt that project performance was average with room for improvement. The main reasons given for the poor performance were the inexperience of contractors, clients and project managers that results in poor project execution; poor financial control; projects over-running time leading to escalated costs; and projects being abandoned (Mukuka et al, 2014, Ramabodu & Verster, 2010). Ten of the respondents felt the current outcomes of project practices were poor to very poor. Two respondents felt the outcomes were average or good. On the one hand, respondents explained that, generally, few projects are ever completed without complications and that projects in the public sector were performing as well as could be expected. On the other hand, respondents believed the performance of projects in the public service was poor because of the processes in the sector and that lack of experience and qualifications was the main cause of many problems experienced on site.

The procurement process of the public sector contributed to longer delays, which allowed cost escalation adjustments. Therefore, the project already inherited overruns before it commenced. Most professionals seemed to put the blame on the contractor as the leading cause of the poor performance. Overall, the project displayed a total of 2555 days of slippage times from the original date scheduled for the project to be completed. This exhibits poor project performance, which negatively affect the image of the construction industry. It is evident that poor performance is a normal day-to-day business for public sector projects and this requires new ways to eliminate such occurrences. Clearly, these outcomes are calls for concern for the industry to commence with collaborative practices and employ technology to improve project outcomes.

Similar to the ongoing problem of poor cost performance, poor time performance also leads to lack of project success in construction. In fact, both phenomenon is interrelated in most times that poor time performance has cost implications. An easier example of the interrelatedness of the two phenomenon is a common statement saying, "Time is money". Poor time performance can be referred to a prolonged duration of a project beyond the planned date specified for completion (Zou et al., 2007, Aiyetan et al., 2011, Kikwasi, 2012, Gbahabo and Ajuwon, 2017, Bello, 2018).

Additionally, Auma (2014) says that the factors affecting time performance of construction project include the late delivery of orders, delay in claims approval and delay in payment of valuations to contractor. A study by Kadiri and Shittu (2015) ranked causes of poor time performance and top on the list from contractors' perspective was "lack of experience of client in construction".

The study further identified drivers of lean and barriers to adoption and implementation in South African construction industry through semi-structured interviews. Lack of education of the concepts, in industry and in universities as well (Dulaimi and Tanamas 2001; Olatunji 2008; Bashir et al., 2010; Sarhan and Fox, 2013; Brady et al., 2011; Jara et al. 2009). Although benefits seems favourable, no incentives are in place to encourage buy-in from stakeholders (Sarhan 2018). If the concepts lacks political support, it will fail in the public sector. Still new to recent graduates and not all Universities have infused it in their curriculum (Mossman 2009). Hierarchy is still predominantly the management system of operation is the construction industry, respect for people will suffer due to autocratic processes (Sarhan and Fox 2013).

Aggressive training courses are required and incentives to be provided by the public sector to encourage buy-in. thereis a serious challenge of resistance to change that will have to be overcome. In addition lack of political support will render the concept useless. The concept faces a huge challenge from a cultural behaviour associated with the construction industry. Already exisitng contractors are unable to comprehend the basics of construction, if such a concept is added to the existing, it spells disaster. Moreover, lack of project management skills is a huge challenge on the side of the contractor. Most contractors do not have the basic construction skills, and education is a problem. If fragmentation can be addressed this concept will be more successful. Most construction professionals will only adopt a method if is cutting costs for them, and lean is not a cost cutting exercise. It will save you money but is not for that purpose. The focus might be only on cutting cost and ignoring the value for the client (Sarhan 2018). Most stakeholders might think it will be time consuming, and time is what they do not have to implement a new strategy. Construction stakeholders usually opt for quick solutions, so education is key. Lack of basic understanding of the concept will be a challenge (Forbes and Ahmed 2004).

Lean training will require more time to be spent on learning, which might face resistance to change. Lack of planning from the contractors is a big challenge. Already most contractors start construction without any sort of plan in place. Maybe, this might help as there would some sort of planning required.

Most stakeholders are selfish when looking at a new concept. The usual question is what is in it for them, rather than what the value will client obtain from such a new method. Everyone look at the resources they will require and how much that will cost them without even thinking about the client providing them with work Kim & Park (2006). I can safely say most designers will see this as extra work for them and will somehow try to add extra cost to the client. Designers would like to do as less as possible in developing designs as most of the revisions are their responsibility, hence would complain about more work without being compensated for extra effort (Kim & park 2006).

Perhaps the concept must commence with the universities adding such a concept as part of their curriculum. Education plays a major role in driving innovation. Lack of support by top management will not assist with the implementation of this concept. Additionally, the political support for this concept is key, without it the concept will not even get off the ground (sarhan and Fox 2013; Tam et al., 2011). There are so many innovations already, which not even have off the ground by the private sector, let alone the public sector. If we have to mention programs such as BIM, which indicates immense benefits to the construction industry, but the implementation is still very low if not at all. We are yet to find a complete BIM project in South Africa currently. The construction industry is very slow in adapting to new innovative ways (Oviedo-Haito et al., 2013), (Sarhan and Fox 2013), (Tam et al., 2011).

The culture of the construction industry kills the future of this sector due to leaders who are not ready to accept change. The industry is full of gatekeepers, hence the slow progress made by the sector. Mossman (2009), Jorgensen & Emmitt (2009), Bashir et al (2010). Again, players who do not even possess the applicable qualification of the industry, and this are the people driving the industry with political agendas of ensuring the industry is ungovernable dominate the construction industry in South Africa.

Finding from the studies of Eswaramoorthi et al. (2011), Jasti & Kodali (2016), Mane and Jayadeva (2015), Mossman (2009), Olatunji (2008), Osaily (2010), Zainul (2009) agrees with the finding of barriers like due to pressure experienced by some contractors to complete the project this might prove to be time consuming if it had to be tried during a live project. Chances of people reverting to old ways is easy as most are lazy to try new ways (Tam et al., 2011). Long term benefits by top managers I hard to sell, unless the benefits can be realized early they are not interested. It will take a long time before such methods can be adopted due to legislation by the public sector. The public sector seldom make changes to how they execute projects, and political interference normally dictate terms (Kim & Park 2006).

The concept seems to be showing long-term benefits, but the time factor might not be favourable for all stakeholders to come on board. However, clients have to start forcing professionals to implement then adoption will be quicker. Educating the client is key. Usually if clients are happy with certain concepts, they tend to demand such practices from professionals and that is the way to start agrees with the findings of (Gao & Pheng 2014; Mossman 2009). Successful projects that have implemented the concept might assist with creation of awareness for educating the industry. The industry is not always receptive to new methods, and this is because most experienced professionals do not want to learn new methods, so they shoot any innovation and make excuses why it would not work similar to findings of (Sarhan 2018).

6.3 DISCUSSION OF THE QUANTITATIVE FINDINGS

The quantitative strand of the study identified first the causes of poor cost performance in the various life cycle of the project. Causes were identified from design stage, construction, and finally completion stage of the project to illustrate a comprehensive picture of cost management of construction projects in South Africa. Ignoring Items with abnormal rates during tender evaluation, especially items with provisional quantities, lack of coordination by professionals in design stage, inadequate project preparation planning are the first three causes rated high by the responders of the electronic survey (Cantarelli et al., 2010; Mukuka et al., 2014). These findings are similar to the findings identified in the qualitative strand of this study. The causes identified in the design stage indicate that there is fragmentation experienced during design development, as most stakeholders are concerned with the responsibilities assigned to them by the client rather than collaborative costing and value proposition for the client (Mossman 2009; Ballard 2009). There was a significant difference in the responses provided by respondents in terms of years of experience. Respondents with high number of years' experience indicates a high-ranking procurement related factors. The respondents identified the following factors in the construction stage of the projects; poor management of the project by the contractor, contractual claims, such as extension of time with cost, the contractor's unstable financial capacity, monthly payment difficulties from the client, delays in issuing information to the contractor during construction (Ali & Kamaruzzan 2010; Ameh et al 2010; Azhar et al 2008; Le-Hoai 2008; Eshofonie 2008). There is no significant difference in opinions of the causes of poor cost performance in the construction stage between respondents that belong to the private sector and those that belong to the public sector. In this instance, it shows that a reasonable skill is lacking from the side of the contractor. Shortage of skills is a huge issue in South Africa, as during the 2010 World cup stadia construction extensive usage of foreign workers was utilised. This finding was identified, as a barrier to lean implementation due to such skills may not stay longer in the country when the economy declines.

Causes of poor cost performance in the completion stage of construction revealed the following factors: Variation orders given to the contractor but not communicated to the QS, Late contract instructions after practical completion, Extra work (Ramabodu & Verster 2010, Monyane & Okumbe 2012, Mukuka et al 2014). Therefore, the results are not significant. This, by implication, means that the opinions of the private and the public sector respondents do not differ significantly. Shortcomings of current cost management practices were rated from the mean scores of 3.34 and 3.80. The results suggest that respondents consider all the identified shortcomings as important as Hanid et al (2010) reports, and require new innovative to improve the current cost management of projects in South Africa.

Furthermore, the study elicits response from the electronic survey for causes of poor time performance in construction projects. Timely completion of projects reduces cost increases that could be realized by projects exceeding their duration and thereby attracting cost due to extension of time claims by the contractor. Such causes are - poor site management and supervision by the contractor, low productivity of the labourers, poor communication and coordination by the contractor with other parties, Improper construction methods implemented by the contractor (Doloi et al 2012; Gardezi et al., 2014; Aziz, 2013; Baloyi and Bekker 2011; Nkobane, 2012; Oshugande 2016). The results reveal that there is no statistically significant difference in respondents' opinions of all the causes of poor time performance across the five categories of years of experience. This is excarbated by the respondents all transferring the blame to the contractor. It is not unusual in construction industry for such blame shifting as the industry is prone to such behaviour. Lastly 85% of the respondents agreed that innovative ways are needed in construction to improve the current project management especially the cost management aspect. In addition, 90% of respondents agree that collaborative contracts are vital for the performance improvements of the sector.

CHAPTER 7
MODEL DEVELOPMENT AND VALIDATION

7.1 INTRODUCTION

The previous chapter presented an analysis of the findings of the study. This chapter advances development of a framework that can assist to improve the cost efficiency of public sector projects. The lean construction cost management model (LCCMM) reflects several stages of project delivery, for easier interpretation, understanding and use by the professional team members executing projects in South Africa. The structured of the chapter is as follows:

- The aim of the LCCMM,
- An overview of the conceptual model,
- The model design and development, and
- The LCCMM validation process.

The chapter also presents a road map to guide implementation of the proposed model, and subsequent evaluation of the model. This chapter achieves objectives 4 and 5 of the study.

7.2 THE AIM OF THE LEAN CONSTRUCTION COST MANAGEMENT MODEL (LCCMM)

The motivation for developing a model is to evaluate how the current system is performing in relation to how that system should actually work (Browning et al., 2006). The main aim of developing a LCCMM for the South African construction industry is to enhance current traditional cost management practices, to improve such processes, with the intention of achieving improved project performance with emphasis on cost-efficiency. The model aims to enhance the pre-design, detailed design, and transfer such practices to ultimately the construction of the asset, and to produce ***lean construction cost management model***, because of the presence of lean tools in the system.

The findings of the study have identified constraints in the current project cost management systems, and the lean construction informed model attempts to make an improvement in public sector construction infrastructure projects in South Africa. The study follows the proposition that *the entire activities of designing and constructing a project have direct and indirect project cost improvement implications*. A LCCMM is required, as the current traditional method of managing projects is still fragmented, and the design and the construction of projects are separate activities, as the system follows the appointed leader's direction on how best the project should be executed. This study has evaluated the performance of current project management practices in South Africa, and it proposes a lean construction informed model to ameliorate the poor performance recorded on construction infrastructure projects, based on empirical data. The study thus far has observed the need to approach and manage public infrastructure projects differently. The importance of adopting a lean construction philosophy is evident from the case studies, the semi-structured interviews, and the questionnaire data presented in chapter four and five.

7.3 THE MODEL DEVELOPMENT PROCESS

According to Fellows and Liu (2008), models/frameworks can be used to investigate or to predict a phenomenon. Mihram (1972) recognised five distinct stages of framework expansion and validation (see Figure 7.1). Fellows and Liu (2008) assert that the objectives of either a framework or a model must be outlined, to ascertain whether the framework or the model is good enough for its intended users. In addition, there is a need to highlight existing differences between verification of a framework and validation as a mode of evaluation (Hvala et al., 2005). Figure 7.1 thus indicates the need to verify and validate models before inferences are made. The development of the framework for this study has followed the steps outlined in Figure 7.1.

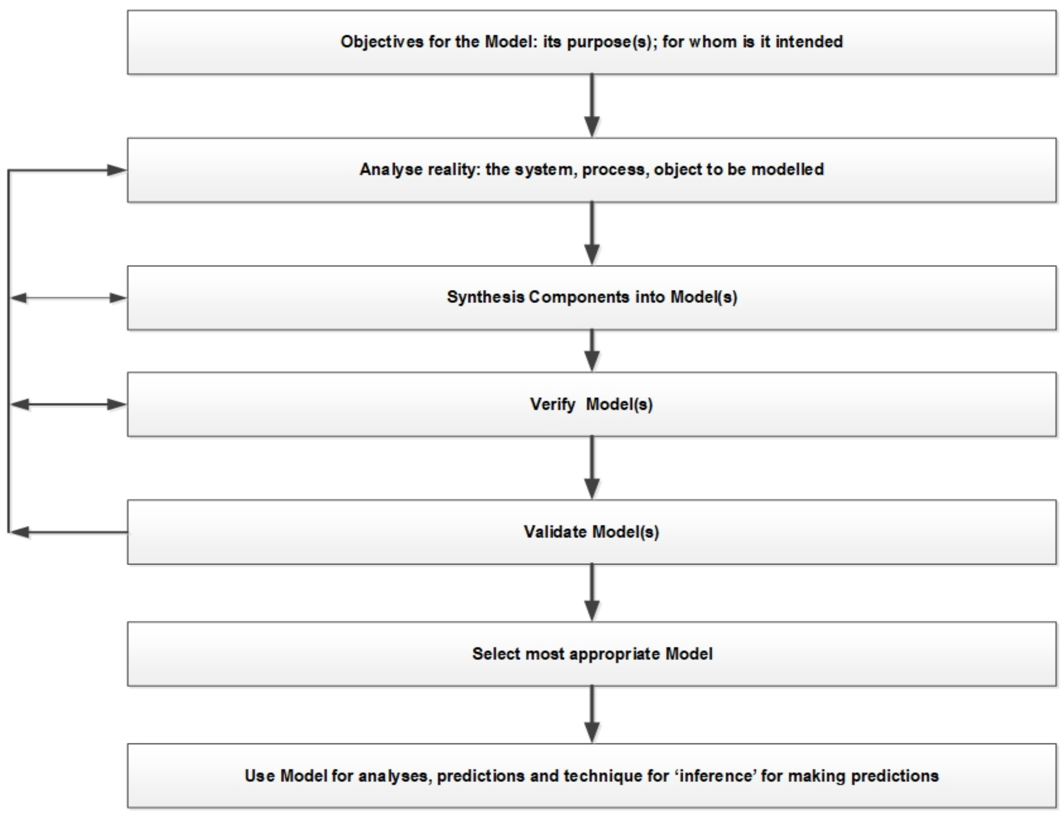
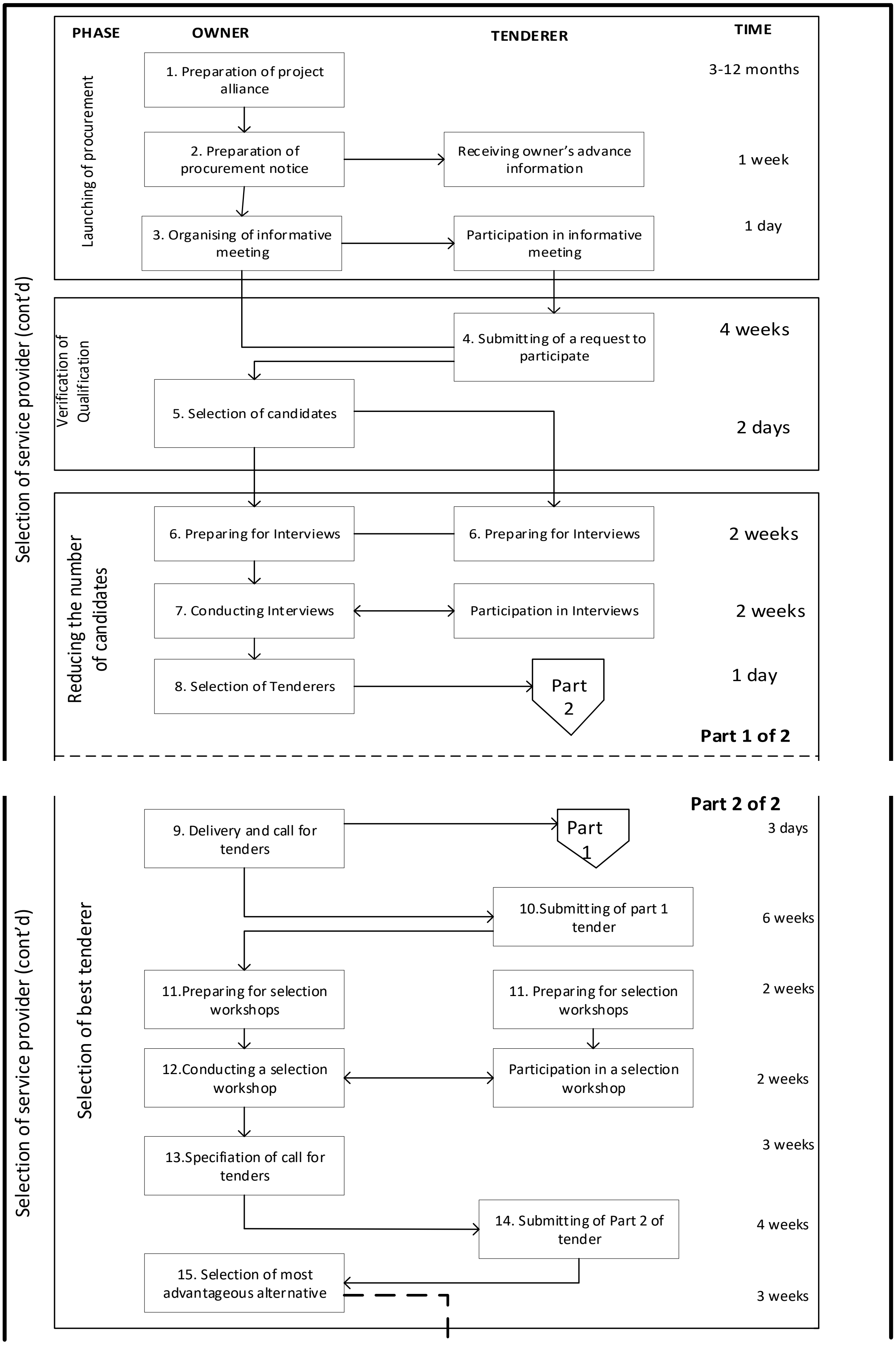


Figure 7.1: The model process (Developed by Mihram 1972)

7.3.1 The framework development for this study

The lean construction cost management model was developed through a mixed methods-based research design, discussed in previous chapters of this study. This framework draws insights from the literature and the primary data. Upon identifying lean opportunities from current cost management in South Africa through “5 why’s” and semi-structured interviews to understand the status quo of executing projects a model was then proposed, drawing on known lean tools. The said authors developed a model following the steps of Ballard (2009) implementing TVD, with the expectation that a process developed by the model would change the traditional method of project delivery. The model development process for this study attains value proposition by outlining the agreement of scope, with all the incentives agreed upon with the project participants upfront. The findings of this study highlight excessive discounts by professionals as a major contributor to poor project performance, which limits the professionals from fully collaborating to offer continuous improvement. To eliminate this factor, this study proposes establishment of alliance partners for procurement of professionals (Merikallio 2014). Appointment of consultants can be done by establishing alliance partners and selecting the number of partners required in each contract. Figure 7.2 below clearly illustrates how project alliance partner selection will be conducted. The procurement method below will offer an opportunity for professionals to be fully compensated for their efforts and to commit to integrated project delivery, unlike the current system, which procures professionals based on the lowest tender received, where excessive discounts are offered just to keep busy.


Selection of service provider (cont'd)
PHASE
OWNER
TENDERER
TIME
Launching of procurement
1. Preparation of project alliance
3-12 months
2. Preparation of procurement notice
Receiving owner's advance information
1 week
3. Organising of informative meeting
Participation in informative meeting
1 day
Verification of Qualification
4. Submitting of a request to participate
4 weeks
5. Selection of candidates
2 days
Reducing the number of candidates
6. Preparing for Interviews
6. Preparing for Interviews
2 weeks
7. Conducting Interviews
Participation in Interviews
2 weeks
8. Selection of Tenderers
Part 2
1 day
Part 1 of 2
Selection of service provider (cont'd)
Selection of best tenderer
Part 2 of 2
9. Delivery and call for tenders
Part 1
3 days
10.Submitting of part 1 tender
6 weeks
11.Preparing for selection workshops
11. Preparing for selection workshops
2 weeks
12.Conducting a selection workshop
Participation in a selection workshop
2 weeks
13.Specifiation of call for tenders
3 weeks
14. Submitting of Part 2 of tender
4 weeks
15. Selection of most advantageous alternative
3 weeks

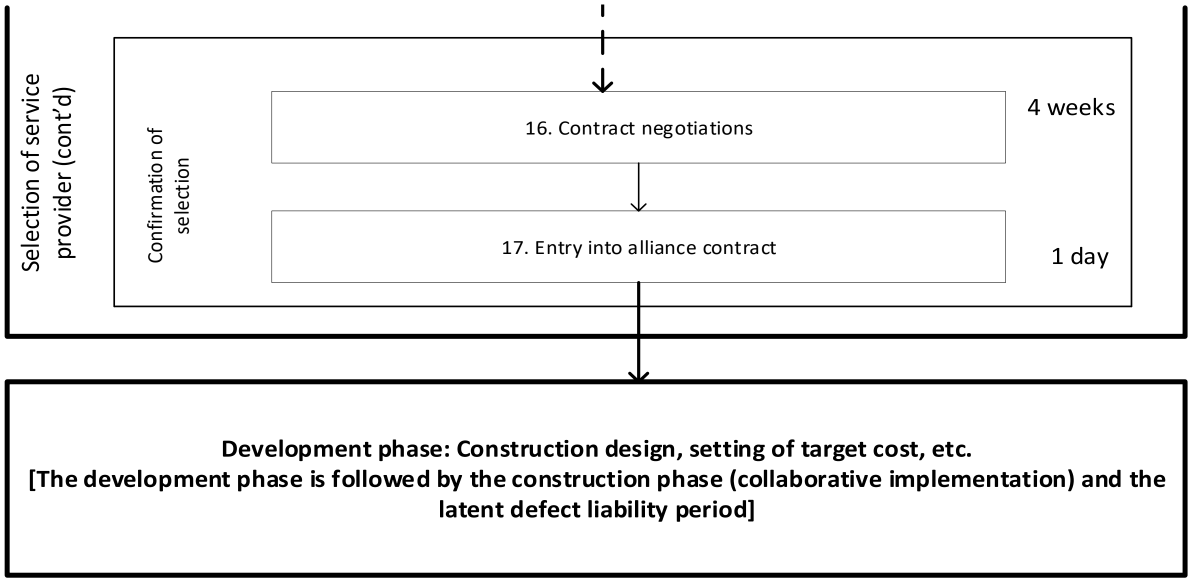


Figure 7.2: Proposed procurement for professionals (Source: Adapted from (Lahdenperä, 2009)

Different weights are assigned to a set of criteria, for assisting in decision-making and for appointing suitable professionals. Table 7.1 below provides an example of weights assigned to the set of criteria used to judge the professionals on their submissions for expressions of interest in taking part in the projects advertised.

Table 7.1: Selection criteria example

Evaluation criteria		Weight			
		Stage 2		Stage 3	
		Total	**Subtotal**	**Total**	**Subtotal**
A	**Capability**	**100%**		**75%**	
A1	**Project implementation plan and organisation**	**60%**		**10%**	
	A1.1 Project implementation plan and organisation		25%		10%
A2	**Track record**			**10%**	
	A2.1 Track record in key result areas		25%		10%
	A2.2 Learning from mistakes		10%		No evaluation
A3	**Value for money**	**40%**		**30%**	
	A3.1 Setting the target outturn cost		25%		15%
	A3.2 The budget critique		15%		15%
A4	**Alliance ability and leadership**	**0%**		**25%**	
	A5.1 Alliance understanding and demonstrated leadership capabilities		No evaluation		25%
B	**Price**			**25%**	
B1	**Fee%**		No evaluation		25%
	A + B (total)	**100%**		**100%**	

(Source: Merikallio 2014:15)

The contribution of the lean construction cost management model will be able to succeed when combined with the procurement system that enables collaboration as required by the public finance management act for the public sector projects. This study then contributes the second achievement by the proposed lean construction cost management model. Figure 7.3 depicts a lean construction cost management model developed for this study. The following steps are followed to develop the LCCMM: the development of this model combines steps of Ballard (2009) and that of (Seed, 2015):

Team forming and team initiation

Some lean/IPD teams do not regularly work together in every project, hence the need to examine any historical management of infrastructure being used by all involved teams (Seed, 2015). It is vital to form a team to understand the boundaries of the project, and it is more than a traditional project kick off. This process happens over time and continuous and not a single even or meeting. This is because should new team members join then, the process of project team formation will continue to bring new members up to date with the development of the project. The team forming and team initiation is achieved by making all involved of the new behaviours, tools and transformational change required for the effort. Kick off meetings will set the stage for new learning. The critical issue at this stage is that it is quiet easy for the original members to forget that they have adopted new behaviours; hence, continuous learning is crucial for a success of the project. Topics to be included in the kick-off meeting comprise of condition of satisfaction, design vision, team structure and team culture (Seed, 2015). Teams can break into smaller work groups to advance the concepts, and then report to the broader team about developing objectives, action plans, identification of roadblocks or needs, etc. (Seed, 2015). Condition of satisfaction have to be developed in such a way that it will leave all participants satisfied with the outcome of the project. The conditions normally comprise of cost, schedule, community, environment, business objectives, relationship, and profit-based goals.

Early stakeholders Involvement

A significant benefit has been indicated by collaborative projects when sub-contractors are and specialist sub- contractors and contractors are invited to assist during the design phase (Seed, 2015). Bringing partners early have several benefits, the most significant among them are a cost savings and the elimination of waste (Seed, 2015). Better constructability, identification of more material and product selection, and provision of a more complete design, is input that could be provided by the contractors and sub-contractors. Moreover, bringing trade partners early also decrease the risk of having to reconfigure the designs or work that could have been prevented. The project becomes more complex the more it develops (Seed, 2015). To integrate partners early, a request for proposal that defines early stakeholder participation is developed. Then partners are chosen through a collaborative interview process structured more like a work session than a formal interview. Time should be spent on defining the desired attribute of the parameters so that those performing the selection understand the parameters. The structure of the engagement should be in a way that compensate the partners for contributing to the design assist and pre-construction phases, and have the opportunity to continue into the build portion and/or compete to become full project partners.

Multi-party agreement

Prevalent issues of traditional contracting have been identified by (Matthews and Howell, 2005). Such issues comprise of i) the lack of field input does not allow good ideas to be shared early in the project, ii) cooperation and integration are discouraged, iii) subcontractors are not responsible for each other's work, which does not encourage collaboration, and iv) there is a focus on maximizing individual profit. While, multiparty agreement enables mutual respect, and benefit, and growing rapidly and embraced by many companies. There are legal restrictions with the public sector projects executed in South Africa, however, design-build contracts can be structured as a relational contract by addition of clauses that encourage IPD philosophy. Addendums can be added and designed to include characteristics of integrated projects specifying details to be followed by the project team (Kim et al., 2016).

Shared risk and reward business deal

The business deal referred to under the shared risk and reward is unique in the lean/IPD environment. The deal attempts to align all project participants to shared project goal, called condition of satisfaction (CoS) (Cheng and Johnson, 2016, Walker and Lloyd-Walker, 2016). Silos of the past has generated waste, thus the intent of CoS is to prepare the entire team to avoid practising previous contract forms. The impetus is to have a unified team instead of individual piecework to optimize the complete value stream. Moreover, contractors often face challenges with the decision to choose between supporting a project's success or their company's success. Hence, sharing risk and reward should be a team effort to eliminate self-interests by multipartite involved in a project. Team collaboration is an absolute must because "if one wins, all win, and if one fails, all fail" (Pishdad-Bozorgi and Beliveau, 2016b). Similarly the business deal ensures that the project partners establish a profit pool or incentive compensation model for all to share based on the agreed condition of satisfaction achievements (Rached et al., 2014, Seed, 2015). Although encouragement of employing an IPD contract cannot be stressed enough, a design-build contract done right is considered IPD-like, and can achieve similar results (Seed, 2015). A top down buy-in from each organisation makes adoption easy. The team establishes four buckets of cost: owner direct cost not at risk to the team, total projects hard and soft costs including home office overheads, an appropriate project management team contingency, aggregated team profit. The last three buckets combine to become the current working estimate (CWE) (Seed, 2015). A project investment threshold is then set by the client/owner, from which the team creates a target cost and can use the TVD to meet the target (Ballard, 2009). The team collaborates to discover the detailed project requirements and meet this target through innovation outlined later in the model.

Cost forecasting in early project phases

Early in the business plan development and validation of a project, it is vital to carefully monitor financial resources and apply them prudently (Seed, 2015). As work progresses, particularly in its early stages, individuals typically proceed independently toward their own interpretation of the project goals (Seed, 2015, Ballard, 2009). Teams should establish a method of tracking expenditures of all participants. Actual labour rate projections for each member and /or individual effort should be predicted in advance and measured to track performance. Frequent meetings with monthly invoice reconciliation must be scheduled, with all financial information available in one area for everyone to examine. In addition, designate one point of invoice collation each month. Displaying of financial and other information in a room for all collaborators to view and match with occasional delivery milestones (Ballard, 2009). Showing value created through Plan-Do-Check-Adjust (PDCA). Emphasis on whether the project is ahead of schedule or behind, no news not necessarily good news. Scheduling of monthly budget cluster discussions. The public presentation of updates assist to drive accountability and monitoring of the plan (Seed, 2015; Ballard, 2007).

Conceptual and continuous estimating

A collaborative project environment' intention is to implore and share input from numerous stakeholders across the delivery supply chain. The value of this interaction and facilitation of true value-based decisions, participants must have conversations about solution Set Based Design concepts that lead to the need to comprehend the cost impact of such decisions (Seed, 2015; Ballard, 2007). The impacts of these cost necessitates Conceptual Estimating, a rare, high value skill that is dissimilar to other more prevalent estimating skills. The skill is specifically vital in the collaborative environment (Seed, 2015; Ballard, 2007). Cost information in this stage is informed by well-grounded time and schedule assumptions critical to determining which asset solutions can be provided to stakeholders within the given time and financial constraints (Seed, 2015; Thomsen et al., 2009). Conceptual estimating necessitates the constant re-evaluation of a project's value proposition, established from the commencement and updated regularly throughout the process.

Tow skill sets are key elements of conceptual and continuous estimating: one "soft" involving necessary interpersonal skills, and other "mechanical" having actual experience and knowledge (Seed, 2015; Thomsen et al., 2009). It is vital to note how these necessary skills differ from those of traditional estimator.

Mechanical

From the outset of a collaborative project, the team should develop a detailed cost projection of the "want". When possible, benchmark what is feasible based upon historical experience (Seed, 2015). This balances against what the owner can expend by way of the business case, and a target is the established. Often the overall target is broken down into systems or components and distributed amongst several cluster groups to employ as a guide for further development, and to arm them with tools to inform their design decisions (Seed, 2015). Up to date data and benchmarking must be incorporated into a format, to ensure comprehension of the costs and target in the context of the whole project by all participants (Seed, 2015). Cost data should be pushed into A3, BIM, CBA, and other decision-making tools. All participants must have rich comprehension of the project's requirements without the need for a sketch. Estimators who have problems imparting information should be pressed to explain. Continuous estimating is not about re-estimating the whole project on a particular frequency, however is about continual reporting of variations since the last report in an easily consumed format, as the design coagulates (Seed, 2015).

Soft

The importance of communication in a collaborative project environment is crucial. Listening attentively is vital to comprehend the 'wants' and 'needs' of the owner and the intent of the designer (Seed, 2015, Ballard, 2007). A comprehension of the level of detail, value proposition, or level of accuracy is critical, and the confidence to share opinions is valuable (Seed, 2015, Ballard, 2009). This processes' success demands the owner to share historical knowledge with the team, as many products or processes are unique and have little industry comparative cost data, but owners should still share this information with builders to better inform set based designs (Seed, 2015, Ballard, 2009).

Setting the overall systems and targets

At this stage most of the work has brought about rich data for decision making by the project team and the owner/ client. Then the project team determine the market cost, which is identified through a comprehensive collective benchmarking (Namadi et al., 2017). The project team extensively provide the feasibility study to reveal the estimated maximum price for the project.

Develop design and detailed engineering

Based on the product design, detailed engineering will be done to manufacture and deliver the components and material. This stage involves logistic concepts to minimize the inventory and reduce lead-time. In view of Ballard (2008) this step is to cultivate the process design and product design together based on the conceptual design.

Design innovation / Work structuring

According to Seed (2015), work structuring can be described as a path taken from chaotic work to optimized work. Work structuring involves implementing a number of strategies and tools, inclusive of defining standard processes, working to optimize the said processes, and seeking one piece flow, while using tools such as mistake-proofing and built in quality (Seed, 2015; Ballard, 2009). Moreover, work structuring often begins with an effort to standardize repetitive work, whilst it is noteworthy that non-repetitive work is ripe for improvement as well. In non-repetitive work, individuals seek hidden opportunities to optimize and strengthen connections and hand off of work. Companies should always seek the new standard by elevating the baseline through innovation. Emergence of the new innovation, moves the baseline in concert to become the new better practice that is spread through the company as the updated standard (Seed, 2015; Ballard, 2009). The cycle can repeat perpetually and is the basis for continuous improvement. Mistake proofing can be a powerful tool in work structuring.

Design to targets

According to Namadi et al. (2017), designs are then produced to meet the detail estimate rather than creating a detail estimate around a preliminary design. The most significant fact is that the customer is not the only client to the project as the whole information is prematurely shared and the core function teams manage the costs with the inclusion of the supply chain during the product design.

Collaborative budget management

Traditional project teams normally hold sufficient budget management skills; however, such skills are purely focusing on the individual participants instead of the whole project team. In South Africa, traditionally the project team assign cost management duties to the chief Quantity Surveyor (QSs). Namadi et al. (2017) further reiterate that this practice of assigning cost management mainly to the chief QS accounts for much of the cost overruns that is prevalent in the construction industry due to its lack of collaborative approach to costing. A collaborative budget management process is essential for an accurately tracking and projecting a project’s cost to complete (Seed, 2015). If this process is not properly managed by the various parties in the industry, often leads to unplanned project cost overruns (Seed, 2015). A collaborative budget management process that is proactive creates a reliable barometer for participants to monitor profits and outcomes throughout the duration of the project Seed (2015), moreover, promotes a cost to complete awareness, and engenders a shared comprehension of current working estimate. The budget management process should discuss encouragement of owning the budget components as well a challenge participants and transaction details. The budget management process should not only focus on actual cost, but should reach a determination as to why actual cost differs from the original estimate (Seed, 2015). A solid handoff between managing the cost during development to handling the construction cost details and forecasting meaning a solid handoff from cost forecasting during early project phases to collaborative budget management. Should errors be identified, the project team should stop and make adjustments via a root cause analysis (Seed, 2015). In the context of lean/IPD, a promise is a commitment and an agreement.

Reliable promises

Traditionally construction projects comprise of multi-party organizations contracted independently for a short term to one general managing firm. Each company typically comes to the project with independent and mutually exclusive goals, definitions, assumptions and generalities (Seed, 2015). These differences can lead to misunderstandings, incorrect work, rework, poor coordination, and overproduction and missed deadlines. Lean/IPD projects focus on cultivating interactions and dialogues to develop communication, consequently reducing failures through reliable promising (Seed, 2015). The model development is illustrated explicitly in Figure 7.3.

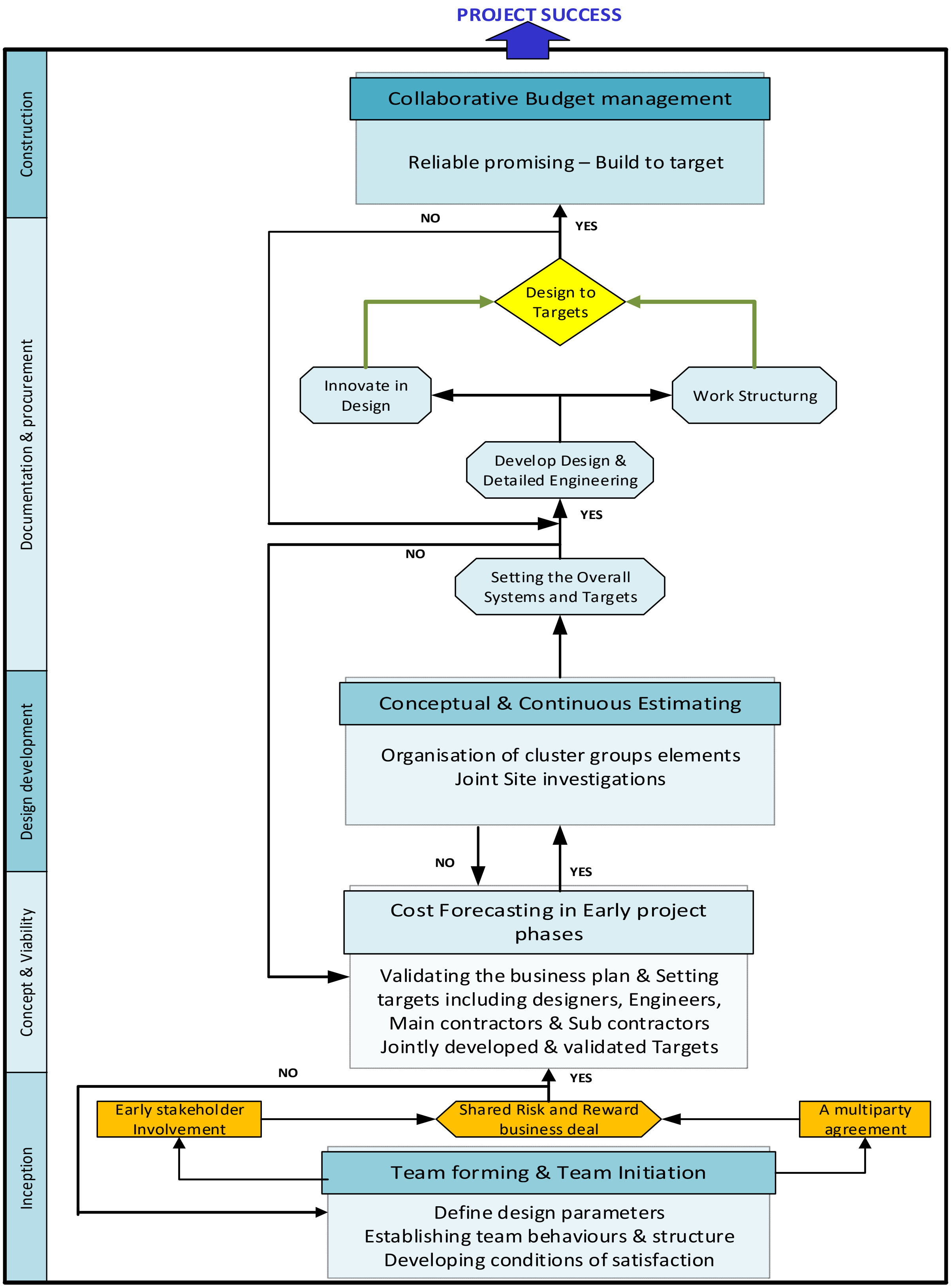


Figure 7.3: The first draft of the lean construction collaborative cost management framework

7.3.2 Transformation of the current system

Operationalisation of the lean construction cost management model consists of seven of the perceived components of lean construction practices and the expected outcomes. The study identified features of South Africa's national Department of Public Works that clash with the principles of lean construction. For instance, the NDPW uses only one design-bid-build type of procurement for all their projects. This type of procurement poses the following challenges:

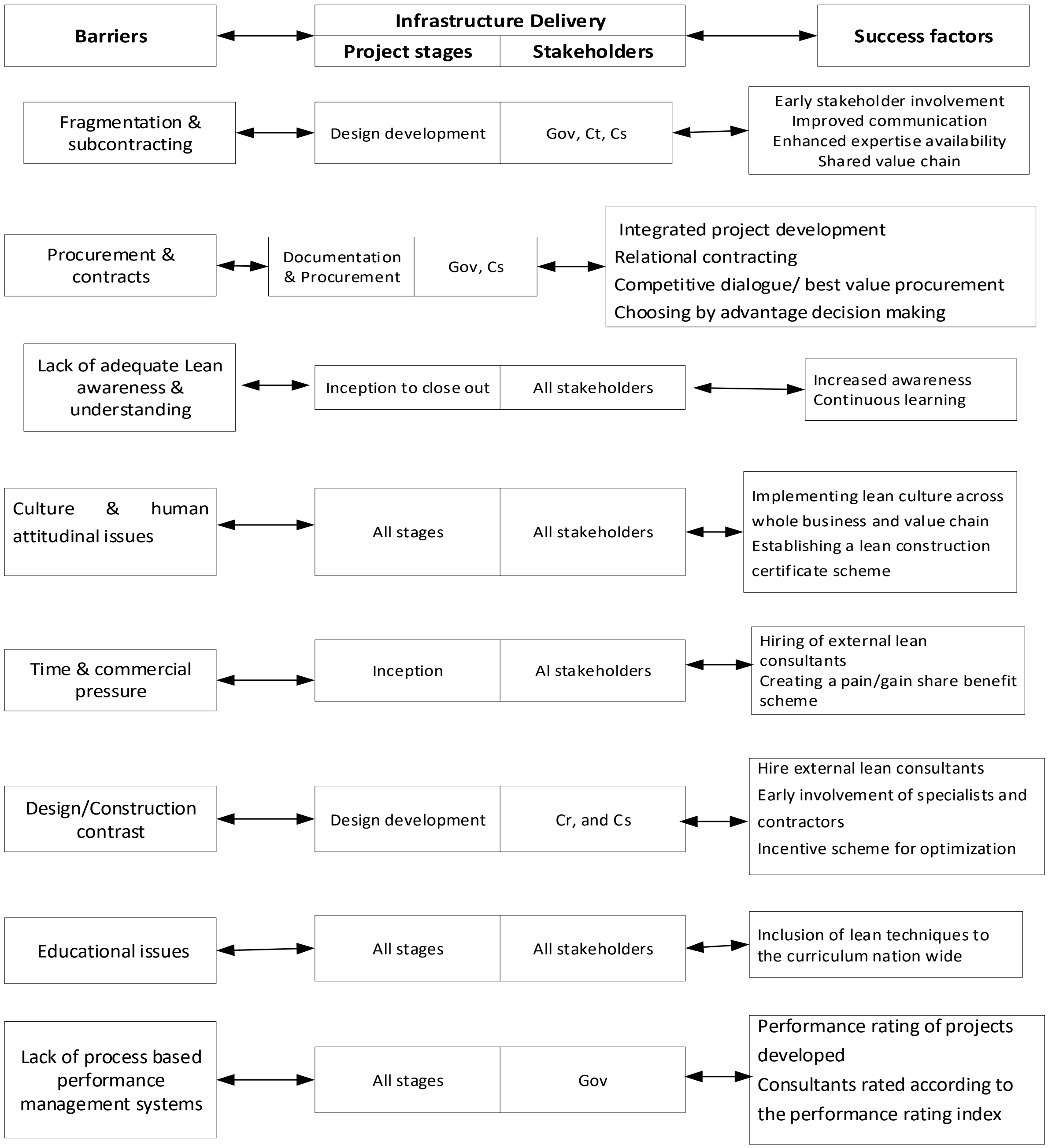
- It uses qualifications-based selection;
- It does not encourage owner/architect/engineer/contractor teams;
- It does not support early contractor involvement;
- There is no flexibility for inclusion of building information modelling;
- There are no negotiated contract terms;
- It does not fully support shared performance incentives; and
- There is no upfront risk allocation.

Successful transformation from the conventional system to the lean-led system involves changes in the culture, the process, and the relationships between stakeholders. These include changes in values and human behaviour, in process and function, in coordination and control, and in the power within the organisation (Smit et al., 2011). The process of transformation requires engagement of stakeholders. Thus, this study started with VSM of the current state of delivery of construction projects and their performance outcomes, and it then provided VSM of an improved performance state, from identified opportunities for lean implementation exploitation. There is no doubt that some form of change in legislation is required in order to allow exploitation of lean opportunities from the current system of project delivery. However, statutory changes alone are not enough; addressing institutional factors through education is critical for full implementation of lean construction in South Africa. With the rising perception among the public that the procurement system is open to abuse, more needs to be done to protect public confidence that the contracting process is fair and open. Trying new methods is a complex task, on its own, and thus implementation of lean construction principles in South Africa will require a roadmap to assist in navigating the complexity of the process. Other than the barrier posed by legislation to adoption of lean, people's attitude towards change is an even greater challenge to overcome.

Lean is a philosophy. Therefore, all that is required is to infuse it in your daily life, and half the battle is won. If lean is treated as a task-oriented approach, it will never be understood, and the objectives will not be achieved. The South African construction industry needs to achieve small victories in lean in order to build capacity and create awareness for industry-wide adoption.

Transformation to lean will not be free from challenges at the beginning of the journey. Thus, this study has identified the barriers to lean construction, based on the findings in chapter 4 and 5.

However, besides identifying barriers to adoption of lean, there are also critical success factors to exploit in order to counter the barriers. Figure 7.4 below illustrates this achievement for this study.



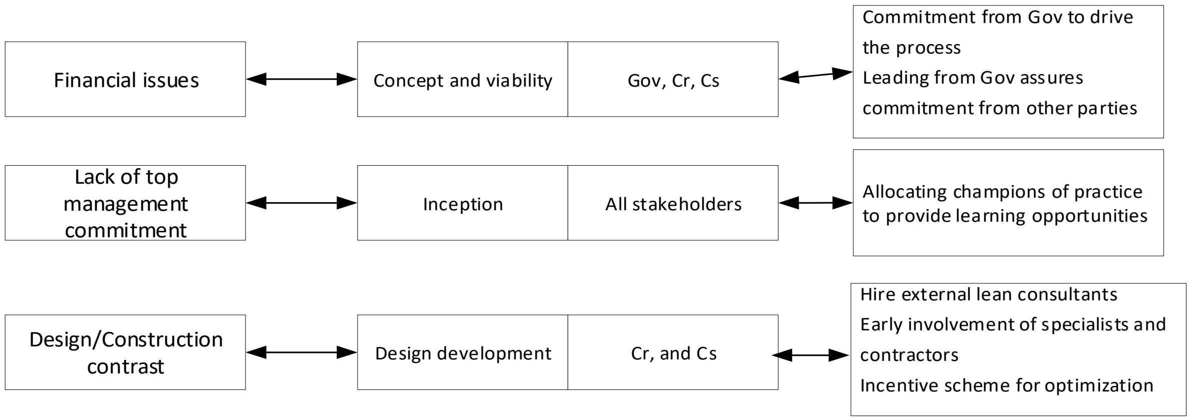


Figure 7.4: Linking the barriers with the critical success factors of lean in the infrastructure delivery life cycle (Figure by Author 2018)

Key: Gov = government, Cr = contractor, Cs = consultant

Achieving the success factors identified in Figure 7.4 above is made possible through collaboration, coordination, and communication, recognised as the 3Cs. These three connecting techniques are essential to achieve success and entrench integrated project delivery (IPD) concepts as inherent in lean construction (Forbes & Ahmed 2011). Similarly, Smit et al. (2011) recognise certain values, namely communication, participation and involvement, facilitation and support, negotiation, and rewards, as strategies to overcome resistance to change in a sociotechnical system. Therefore, effective construction demands commitment of stakeholders to cultural and system changes, an integrated environment system with normal work processes, and close cooperation between and collaboration with all stakeholders, which starts as early as possible and is as visible as possible throughout the building's life cycle. The 3Cs are explained below:

- **Collaboration:** This technique requires collaboration with stakeholders, by adopting an integrated project delivery (IPD) approach. Early appointment and involvement of all stakeholders from the project conception stage and seeking relevant opinions of the experts regarding what works in the critical stages (planning, design, and execution) helps to straighten the fragmented lean construction value chain, and it limits the effect of associated barriers, in order to achieve project objectives. Collaboration allows project participants to change their traditional approach, by making the project's overall success the crucial objective, which leads to a sustainable industry. Viewing projects as a joint initiative, by aligning rewards with project-wide optimisation, motivates project team members to take ownership of the project's success, for improved performance (Luisi and Houshmand, 2010). Team orientation and trust are essential for mobilising creativity and for ensuring cultural transformation, because of the process of emergence – the whole is more than the sum of its parts. Cultural transformation involves using system principles of openness, purposefulness, multidimensionality, emergent property, system dimensions, membership, decision systems, measurement systems, organisational processes, throughput processes, and system methodology. System transformation is possible due to the influence that the relatedness of the parts of a system has on the behaviour of the parts (Forbes & Ahmed 2011; Luisi & Houshmand 2009).

- **Coordination:** Leadership as an innovative platform is desirable for organisation of the stakeholders involved, for a successful transformation process, as is the ability to create a framework that will guide operationalisation of various tasks in an orderly manner among the various segments of the project team (Lichtig 2006). Standardisation of activities, by implementing standard procedures, is often the means to reduce variability in both conversion and flow processes. Coordination increases predictability of the work process. The processes (tasks) must be properly defined and must be assigned to competent organisations (role players), to enhance proper value streaming – early appointment of lean consultants makes all the difference. Forbes and Ahmed (2010) and Lichtig (2006) state that impeccable coordination leads to workflow predictability, it reduces project fragmentation, and it serves as a catalyst for project success.
- **Communication:** Engagement and appropriate communication serve as a lubricant for collaboration and coordination. Effective and efficient communication is a feature of successful collaboration and coordination for a project-based industry (Lichtig 2006). Acceptable and unfiltered communication generates value, and it ensures that the stakeholders have the right success factors and benefits. Efficient communication increases transparency and work variability, and it reduces rework. It also enables the goals of infrastructure projects to be appropriately aligned with stakeholders' needs, and it thus enables acceptability (Forbes & Ahmed 2010).

These three principles enable proper interrelationships within the niches of innovation, and they enhance the production of creative ideas throughout the infrastructure life cycle, as well as a smooth transition to an LCCMM. They break the system and cultural barriers, by working with stakeholders in an efficient and effective manner, which is necessary for transformation. The concept of lean construction sustains continuous improvement throughout the project life cycle, in pursuance of stakeholder satisfaction, and it creates a more effective and efficient industry ((Suresh et al., 2012)). The effectiveness of these principles is continually being improved, through continuous learning and improvement. The development of this study's lean construction cost management model required validation from the lean experts, to ascertain that the model has lean-infused principles embedded in it.

7.3.3 Validation of the framework of this study

The validation process of the lean construction cost management model was conducted in two phases, using the following data-collection methods:

- Initial validation phase – semi-structured interviews; and
- Final validation phase – focus group interviews.

Different participant selection criteria were employed in selecting the participants, as the data collected was for different purposes.

7.3.4 Initial validation phase

The initial validation phase concentrated on lean enablers and the relationships of all project participants and the appropriateness of their components, towards ensuring that the model can be easily understood and used by the intended users, namely professional teams and constructors. For the initial validation phase, 10 participants were purposively selected and contacted by email based on their knowledge of lean construction, their involvement in lean construction projects, and their having at least 10 to 20 years of work experience in lean construction. However, only five responded and willing to participate. The researcher viewed this as vital to obtain adequate information, which is critical to refine the framework as appropriate and to develop an operational framework before final validation.

The responses of all the participants that participated in the interviews were used to refine the second draft of the framework. The results from the validation are presented in the following sections.

7.3.5 Responses of the initial validation phase

The interview respondents had a balanced positive response towards the model being easily adaptable enough and covering vital issues for the operationalisation of the lean construction concept in South Africa. Although three of the four respondents generally agreed that the model is consistent with current best lean practice, a suggestion from E_1 was given for improving the appointment of contractors, namely to include best-value procurement. The model was also commended by E_1 for bringing vital expertise early, to improve the economic aspects of risky projects. A recommendation from two of the experts, E_1 and E_4, was to bring all project parties simultaneously also through construction management at risk contract, instead of engaging with professional consultants prior to appointing the contractors. E_4 commended the model for having a comprehensive outline and simplicity for adoption such as the simple framework or lean implementation. However, he stated that a top down approach will be more simplistic to follow that a bottom up approach as drawn by the autthor. E_2 and E_3 and E_5 were generally satisfied with the model, but they also suggested top down approach for a much simpler version, for ease of comprehension.

The experts further provided positive feedback for enacting the goals of lean/IPD, for improved performance of projects. Responses from E_2 and E_3 stated that forms of contract such as NEC3 could be utilised, especially for public infrastructure projects, to suit the uniqueness of the lean/IPD setting. However, this was seen as a challenge, as the public sector has been known not to prefer such forms of contract except for state-owner enterprises, which normally deal with international contractors and specialists. E_1 recommended whole-value delivery from design through to construction as valuable to the construction industry. The reason for such a recommendation from E_1 was specifically "steering continues in construction, which produces the constructed asset the client needs to accomplish their purposes". Similarly, E_4 had specific recommendations to foster IPD in the model, for better operationalisation, namely:

"Before continuing with sharing risk and reward

- *Owner, architect, and CM/GC sign a relational contract;*
- *Validation study is executed;*
- *Go/no-go decision;*
- *Use CBA process to hire trade partners;*
- *Trade partners are hired and join team;*
- *Train everyone.*

The respondents were asked to provide suggestions for improving the model, and E_1 had this to say:

> *"Generate multiple alternative designs at each level, overall project concept, individual systems (structural, mechanical, electrical, etc.), and components. This practice is called 'set-based design', after Toyota's 'set-based engineering'. To avoid extending the design phase beyond the last responsible moment – where it threatens to extend the project – agree early on an acceptable, if not optimum, alternative to serve as a fall back.*

The responses obtained from the initial validation exercise revealed that the LCCMM requires some improvements to represent simplicity. The respondents expressed that the model is a representation of lean practices that could engender improvement. The following points were suggested for refinement of the framework, so that it can be used fully for better implementation:

- Clearly illustrating the model as a top down approach,
- Rectifying design parameters to add based on estimating cost,
- Amend develop design and detailed engineering to develop production process and engineering designs similar to LPD framework
- Amend design to target decision triangle to a rectangular shape like shared risk and reward and add target to read targets cost

- Finally amend reliable promising with build to target cost

Based on the interview responses and feedback and recommendations from the initial validation phase, the researcher continued to develop the model according to the suggestions made by the lean construction experts, as shown in Figure 7.5. In this version of the model, proper reflection was done, to reflect the steps for each process stage.

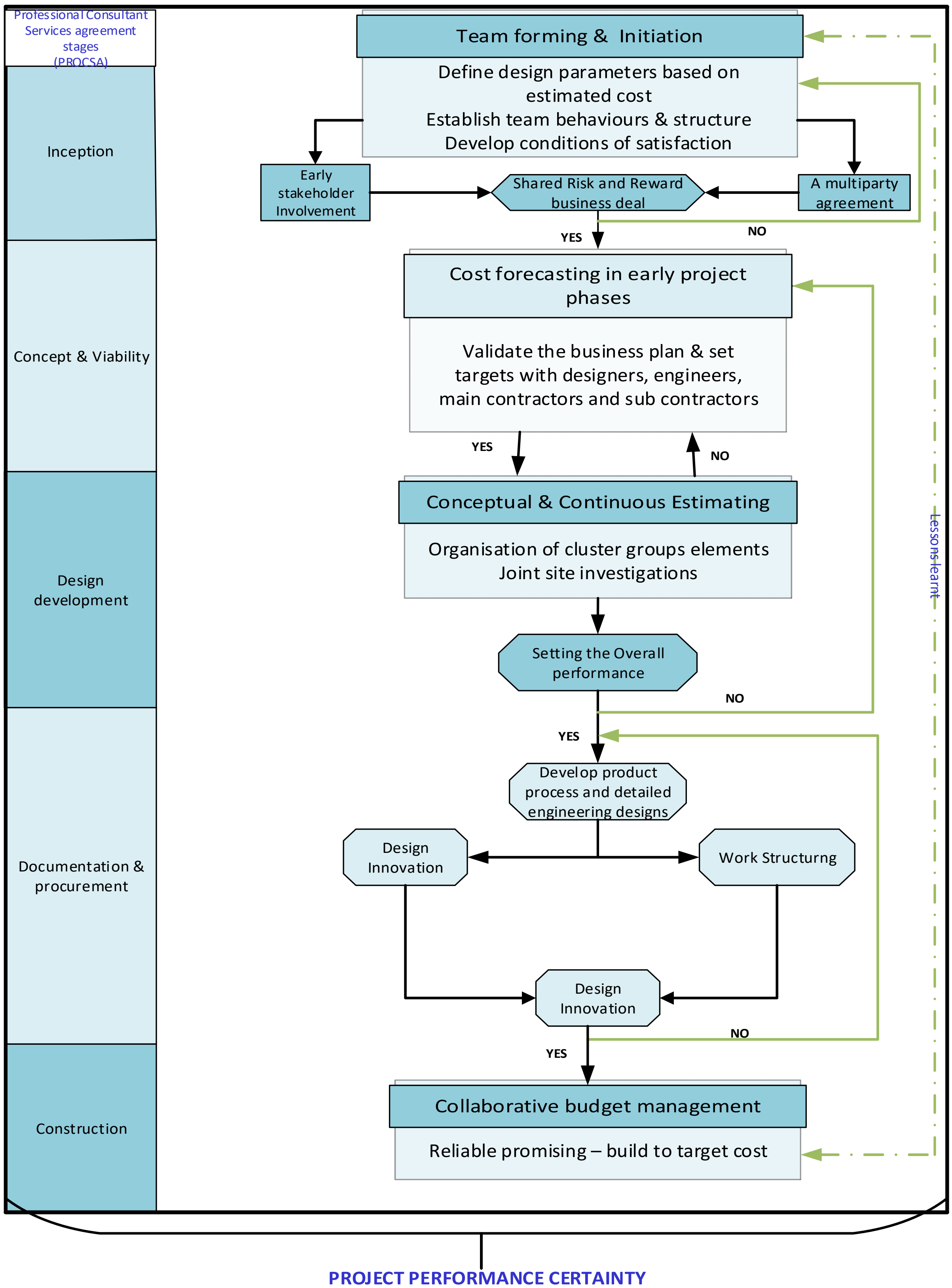


Figure 7.5: Cost Management logic model using lean tools

The revised model is to enhance the cost management of the entire life cycle of public sector infrastructure projects in South Africa. Waste in the existing project delivery has been identified through a vignette in chapter 4 on how the professionals in South Africa carry out activities until the construction stage of the project.

7.3.6 Final validation phase

Stage 2 is the final validation phase. This stage focuses on

- Establishing the usability of the LCMM and guidelines for practical application in a South African context, and
- Establishing that the developing model will support the professional participants of the South African construction industry to achieve effective project management and performance in infrastructure project delivery.

The researcher conducted focus group interviews with the professionals working for the client, namely the Free State Department of Public Works. The focus group discussion was done to gain insight directly from individuals who will contribute garner support for implementation. Table 7.2 below presents a profile of the focus group interview respondents from the Free State Department of Public Works.

Table 7.2: Demographics of the final validation sample

Contacted experts	Consenting experts	Industry	Area of expertise / job role	Location	Code
10	6	Public sector	Senior construction project manager	Bloemfontein, South Africa	I_1
		Public sector	Senior construction project manager	Bloemfontein, South Africa	I_2
		Public sector	Chief quantity surveyor	Bloemfontein, South Africa	I_3
		Public sector	Architect	Bloemfontein, South Africa	I_4
		Public sector	Architect	Bloemfontein, South Africa	I_5
		Public sector	Quantity surveyor	Bloemfontein, South Africa	I_6

7.3.7 Responses of the focus group interviews

The focus group interview participants agreed that the LCCMM is sufficiently robust, and that it is vital for operationalisation of the lean concept in the South African construction industry, especially the public sector. There was consensus from the participants that the framework is different from current project management practices in the public sector sphere of infrastructure projects. All the participants agreed that the framework has demonstrated innovative features, which promise to transform current industry practices and provide the industry with useful tools necessary for raising awareness and understanding of lean implementation and its associated benefits for the wider construction industry. However, concerns were raised that the public sector is slow to adopt innovative methods, due to a lack of political buy-in among senior management. All the participants mentioned that the model, although promising, requires political support for it to be considered for adoption. Furthermore, all the participants stated that implementation of the model should engender increased stakeholder awareness and action bias, new ways of thinking, new leadership attitudes, new skills, and a new industry culture of continuous improvement.

Feedback on the appropriateness of the LCCMM as an emerging concept in the construction industry was positive from all the participants. Some of the participants found the concept of lean very interesting, as before engagement with the participants, they received a presentation on what lean is and how it evolved in the construction industry, the benefits of lean and challenges with its implementation, and cases on its achievements. All the participants were content to understand that lean is a philosophy, more than it being about use of tools. Emphasis was placed on the attitude towards continuous improvement of the individuals first, to realise how much is really required to adopt a new way of thinking. However, some comments were made that the framework might look easy as explained now, but that actual implementation of the model might pose a challenge if mentoring is not received from an expert, to assist with navigating through the steps outlined. All the participants were pleased that the model provides some kind of steps to follow, as most models are complex and not easily understood before the developer further explains the process to be followed.

I_3 made a comment that intensive training will be required for other stakeholders to come on board with the new concept. In fact, I_3 mentioned that professional bodies should take a leadership role in engaging the wider construction industry for training and initiation of dialogue about the concept of lean. Leadership is necessary to create robust collaboration between various stakeholders. Successful application of any innovative ideas could depend on leadership influencing their uptake and managing contingencies. The final version of the lean construction cost management model for South African public sector infrastructure projects proposed in this study is presented in Figure 7.7 below.

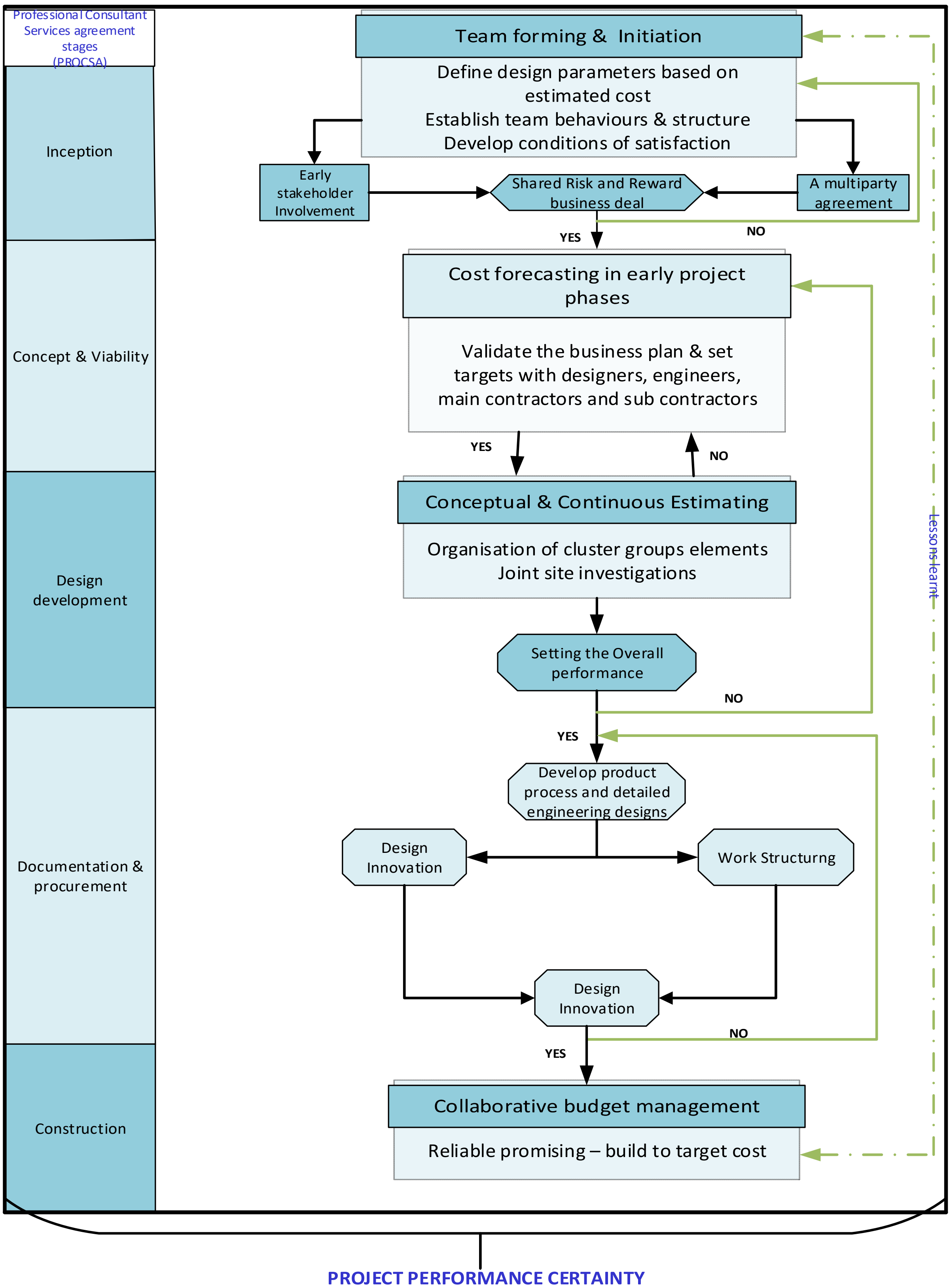


Figure 7.5: A lean-led project management framework for South African public sector projects

7.4 CHAPTER SUMMARY

This chapter focused on the development and validation of the lean construction cost management model. The initial validation outlined refinement necessary to improve the model, to enable robustness. For better implementation of the model, experts provided feedback to refine the model, in order to mirror reality. Initial validation used lean experts from around the world, due to the fact that lean construction is a new approach in South Africa. The final validation was undertaken with the client's professional team in the employ of the public sector, through focus group interviews. From the feedback obtained from the focus group, it is clear that the professional team in the employ of the public sector has embraced lean thinking as a better strategy to shift the construction industry to a new paradigm. The validations from both stages indicate that the LCCMM creates the opportunity for effective collaboration between actors within a project, as well as for improvement of project performance outcomes. The following chapter of this thesis concludes the report and offers recommendations.

CHAPTER 8
CONCLUSIONS AND RECOMMENDATIONS

8.1 INTRODUCTION

The aim of this research is to establish how to eradicate the poor cost performance recorded in infrastructure projects in South Africa, using known lean practices. The focus is on infrastructure projects in South Africa. Previous chapters have presented the empirical findings, while this chapter summarises how the aim of the research has been achieved through the outlined objectives. The chapter makes relevant recommendations for future research and policy. The chapter is structured as follows: research conclusions, concluding remarks on the research objectives, contributions to knowledge, limitations of the research, and recommendations for further research.

8.2 GENERAL CONCLUSIONS

Studies related to project performance engage the minds of scholars in various locations. Existing research suggests that traditional project cost management practices do not eliminate poor performance in construction. In particular, the report study in this thesis has been able to establish how lean tools will tackle cost- and time-related problems in the delivery of public sector projects. The data presented in previous chapters of the thesis suggest that

- Current project management practices in South African infrastructure projects are producing poor performance related to cost and time,
- Poor performance on South African infrastructure projects can be attributed to fragmentation, excessive fee discounts by construction professionals, long internal processes by the public sector due to red tape, poor supervision of the construction site, leading to major delays in project completion, excessive change orders, leading to major cost overruns, and poor planning of projects by project managers, leading to poor communication of professionals,
- Integrated project delivery, and design-build form of contract is an enabler of lean that can offer a different approach, and it demands real collaboration, where the design is steered to the target cost, instead of the cost following the design, and where best value procurement is used as a procurement option to increase early contractor involvement opportunities,
- Existing project management practices are failing to deliver the expected performance outcomes, especially in infrastructure projects by the public sector,
- Design and costing activities are treated as separate stages, which contributes to a more fragmented approach to managing projects, rather than encouraging collaboration,
- Excessive fee discounts discourage construction professionals from enhancing project value,

- The improved lean construction cost management model can be considered an alternative modern approach to implementing lean among professionals in the construction industry, and the model is more proactive to dynamic situations,
- The LCCMM is deemed appropriate for South African infrastructure projects, especially in the public sector sphere, and
- Based on the validation results, the proposed LCCMM is capable of assisting professional teams to achieve improved project management performance of infrastructure projects in South Africa especially in cost certainty.

8.3 CONCLUDING REMARKS ON THE RESEARCH OBJECTIVES

The aim of the study is to establish how to eradicate the poor cost performance recorded in infrastructure projects in South Africa, using known lean practices. The objectives of the study to achieve the aim include:

- To identify and evaluate the outcomes of current project management practices used in South African infrastructure projects,
- To establish the causes of poor performance on South African infrastructure projects in terms of cost and time parameters.
- To establish and describe how lean construction practices will make a difference in South African infrastructure projects,
- To identify the enablers for adoption of lean in South African infrastructure projects, and
- To develop a framework for using lean construction practices in South African infrastructure projects.

The achievement of each objective is shown in the following sections.

8.3.1 The outcomes of current project management practices

Through the case studies, it was clear that current project management practices lead to poor performance of infrastructure projects in South Africa. Project case 1 showed a cost overrun of R185 million, which amounts to 40% of the original contract value. Many changes were made to the original scope of the project, and, similarly, the project was completed 17 months later than the original scheduled date of completion. Extension of time also contributed to the cost overruns incurred by the project. The procurement process of the public sector contributed to longer delays, which later opened the project up to cost escalation adjustments. So the project inherited overruns before it commenced. Most of the construction professionals seemed to put the blame on the contractor as the leading cause of poor performance. There were disruptions caused by a community strike as well, and that contributed to delays to the project. Project case 2 was no different from project case 1, in terms of excessive delays and major cost overruns recorded in the project. Overruns related to cost amounted to R42 million, and the project was delayed by approximately 12 months after the original scheduled completion date. A long procurement process also contributed to delays, and there was escalation of costs before construction started. It was notable that the contractor was awarded the project in November 2011, but the site handover was only done in May 2012. This indicates a delay, which would contribute to cost overruns and time overruns to the project. Overall, the project had a total of 2,555 days of slippage from the original date scheduled for the project to be completed. Project case 3 had similar outcomes of cost and time overruns, although the project was live at the time of evaluation. The project has not been completed as yet, but the cost and time overruns are considerable. This shows poor project performance, and the image of the construction industry is damaged by such poor recorded performance. It is evident that poor performance is the status quo for public sector projects, and this requires innovative ways to eliminate this occurrence. Project case 4 fared no differently from the rest of the projects. The project also showed excessive cost overruns and major delays to the completion of the project. Project case 5 likewise showed poor performance. The project showed the worst performance, as the original contract was terminated with the original contractor appointed for the project, a replacement was sought, and a new procurement process was followed to appoint a new contractor to complete the project.

8.3.2 The causes of poor performance on infrastructure projects

The reasons why projects are performing poorly can be attributed to various factors, some of which have to do with the public sector as a client. Some of the construction professionals blamed the contractor, singling out incompetence. Use of the lowest price tender has also been blamed for the poor performance of public sector projects. The current design-bid-build system is to blame, as pointed out by the professionals, in that it does not offer flexibility in dynamic situations. In other cases, the client is blamed for inexperience of the type of projects procured and lack of proper monitoring of the activities of the projects. Overdesign by architects to inflate fees due to excessive fee discounts offered, just to break even and survive, has a lot to do with the quality of work produced by the professionals executing projects on behalf of public sector clients.

Sometimes the use of technologies just to modernise the building contributes to poor performance. In this case, the public sector will be convinced to use a certain type of technology, which the manufacturer is the only one that can fix it if it breaks adding extra cost of repairs. This creates extra costs. These technologies are not properly planned for implementation. The main reason why projects are performing so poorly is clearly the slow process on the side of the public sector to arrive at the point of appointing the contractor to commence with construction. All the respondents complained about the long bureaucratic process before a decision can be taken for approval to pass on to the next stage. In addition, every approval stage has a committee that has to call a meeting before such a decision and/or approval is granted for the process to continue to the next step in the project execution plan. The project execution plan has 21 steps in order for a project to commence for approval to commence with needs analysis, and then proceeding to all the other steps until practical completion of the construction work.

8.3.3 How lean construction could change current practice

The greatest requirement to start lean project delivery is to change the culture, before contracts are changed. This objective requires that construction professionals have a change of thinking from the conventional way of thinking to lean thinking. This objective was achieved by first getting the professionals to acknowledge that poor performance realised by infrastructure projects constitutes a non-value-adding activity, and that this is waste to the client and all the project partners. All the respondents agreed that poor performance recorded in projects is wasteful and that it does not add value to the project and all the stakeholders involved in the project. Secondly, the long bureaucratic process requires lean thinking principles to evaluate which of the steps in the project execution plan are not adding value to the entire process. The professionals had to realise that continuous improvement is also a concept of lean thinking. They were asked why they would not use a pull system when the process is taking a long time, by requesting feedback from wherever the process is not moving, so that it can help to eliminate non-value-adding activities and probably speed up the process. Most of them accepted that the process takes that long, so they would rather wait for whoever is holding up the process, until they pass things along to the next step. This was deemed part of the process, and it was deemed that it has to be accepted as necessary, and that it forms part of the steps in the project execution plan.

Thirdly, since most projects exhibit a fragmented approach to designing and costing activities, the respondents were asked to explain how the design plays a role in cost management of the projects. The architect respondents disagreed with the notion that the design plays a role in contributing to cost implications for the project, while all the other professionals agreed that the design has a major role to play in connecting the design and costing activities of the project. Lean connects these two activities as lean design and lean assembly, and this is not evident in the current projects, which have recorded poor performance. Some of the respondents said that it happens very rarely that the design contributes to the cost performance of a project.

However, a different view emerged after respondents were asked about steering the design to an acceptable cost, rather than the cost following the design. A light bulb lit up after this question was asked. All of the respondents said that they had never thought of it like that. Some agreed that this will be a new concept, and that it sounds exciting if this is how the principle of lean works. This question was to introduce lean tools such as TVD and lean /IPD to the professionals, and to get them to understand that continuous improvement is possible if one shifts to a new way of thinking, rather than following the old way of reacting to changes. Some professionals acknowledged that the concept of reverse logistics could assist with situations of overdesign by architects, leading to higher fees being claimed from the client. This issue is due to the fact that the higher the cost of the project, the higher the fees of the professionals. This practice is what contributed to the client asking all professionals to bid for appointments to the projects, as opposed to a prior practice, where a database of professionals was kept and professionals were selected on a rotation basis. To embed lean thinking among professionals is a huge task. In this regard, one of the professionals said *"is happening quite frequently that architects act arrogantly when questioned on design decisions, producing non-value-adding to the projects, especially that they undermine the public sector as a project owner"*. With such behaviour by professionals, it will be difficult to 'sell' lean, especially when it comes to profits. However, the public sector now issues a mora letter to any architect who is not acting professionally and not cooperating with other professionals. Some professionals confused steering the design to an acceptable cost as a unit cost derived from previous projects to estimate the cost of appointing professionals, as professionals are appointed based on the contract value to calculate their fees provided by the fee scale of their respective professional body.

8.3.4 Lean enablers for improved project performance

The findings of this study reveal long internal processes by the public sector as one of the contributing factors to poor performance of projects. This study has demonstrated project alliance partnering procurement as the best alternative to ameliorate such counterproductive practice by professional design and costing teams. A 17-step procurement process was proposed in chapter 7 of this study (see Figure 7.1).

This study identified a lean enabler for procurement of contractors, namely competitive dialogue. This procurement process includes five stages, from pre-qualification of contractors through to awarding one contractor for the project. Best-value procurement from the contractor is elicited through a detailed questionnaire for contractors to answer. The questionnaire is used as a tool to evaluate bidders in five set criteria for the project. The set criteria are demonstrated management competence, safety, labour law compliance, financial condition, and relevant experience. Scores achieved on the questionnaire are divided into bid price, to determine the lowest bid cost per evaluation point. Award is made to the bidder with the lowest cost per point. To encourage collaboration and build trust among project participants, incentives are employed as a motivator for joint responsibility of project performance, to avoid the culture of blame. This way the responsibility of project performance depends on everyone working towards one goal. These incentives should be utilised in the pre-construction and construction phases.

Further lean enablers include fostering collaboration, by employing a contract that encourages such a practice. Elements of lean/IPD were identified and were deemed necessary for accomplishment of real collaboration in successful execution of projects. Lean and IPD complement each other as critical success factors for project performance improvement. This is achievable also by early involvement of versatile experts, as it improves the economic aspects of risky projects.

When targets are achieved, percentage-scale payouts are made at agreed intervals. Lookahead schedules are created from the master plan, and six-week plans are also drawn from the master plan schedules. Furthermore, weekly schedules are measured to check for progress, with scenarios of what should be done, what can be done, and what will be done.

8.3.5 Contributions to knowledge - a framework for using lean construction practices in South African infrastructure projects

Objective 5 was the last objective, and it required development of a model for infusing lean construction in the cost management practice in South African infrastructure projects, especially in the public sector. Chapter 7 of this thesis depicted the steps followed to develop and validate the model. The model is structured in such a way as to guide the users involved in planning and execution of infrastructure projects. It has steps to follow collaborative project cost management, with the aid of lean thinking concepts. The stages of the Professional Consultants Services Agreement (PROCSA) for executing projects are appropriately outlined in the model, to encourage collaboration among project participants.

The developed model also highlights challenges of contractor appointment as faced by the public sector currently. The traditional system employs the points system, which ultimately allows the lowest tender to be appointed for the project. Several authors have blamed the lowest tender method for contributing to poor performance. As such, this study proposes a different method of procurement of contractors. The lean construction cost management model illustrates a lean/IPD elements to collaborate on the cost management to provide value for the client/owner and demands accountability from project team members undertaking public sector projects.

A validation process was used to improve the model, first by lean experts, through interviews to ascertain that the framework includes lean principles in its approach and that value will be provided. Secondly, focus group interviews were conducted with the client's professional teams, to validate the framework further for suitability for implementation with public sector clients. Based on the above findings and results, objective 5 of the study has been achieved.

8.3.6 Recommendations for policy and practice

Insights from the research produce recommendations that have implications for policy and practice. The focus is on improvement, uptake and implementation of the lean construction concepts in infrastructure delivery. **The following arguments are made for practice**:

(1) The LCCMM needs visionary leaders to stimulate its principle of continuous improvement. Integrated project delivery is key to deliver the kind of value required for lean-led project management infrastructure.

(2) Industry leaders and decision-makers in the public sector require development of skills in understanding the concept of lean, to engender the delivery practices advocated through the LCCMM, so that such an ethos can permeate the system.

(3) The developed IPD elements and lean enablers in current project management practices will assist project teams to gain a more comprehensive view of the impact of lean construction tools when employed to improve performance.

(4) The industry and public sector clients should develop a high level of commitment to the required knowledge and skills, including understanding of the basic concepts for successful operationalisation of lean construction practice.

(5) There is a need to build momentum for more industry practitioners to learn and take note of the small victories gained from the piloted lean projects. Proper records of case studies need to be kept, to share challenges and benefits through workshops and seminars.

The following arguments are made for policy

(6) The LCCMM advocates for change in procurement policy, to allow for flexibility and to foster collaborative work in construction.

(7) Lean certification training needs to be introduced, in order to learn from lean best practice from other international lean construction institutes.

8.3.7 Limitations of the research

Each research project has limitations, because of it having a predefined duration and limited resources. This is also the case in this research. The limitations of this research include the following:

- The fact that the study is limited to South African public sector construction projects. The results may thus not be statistically generalizable, but they are analytically generalizable.
- The applicability of the model should be treated with caution. Although the model was validated in the study, its robustness in practice is still unknown.

- The fact that only public sector projects were the focus of the study requires cautious future application of the model to private development projects.
- Certain constraints were experienced in fully gathering more rich data due to the confidentiality of some public sector documents.
- There are lean construction projects being undertaken in South Africa, however, due to confidentiality such data could not be collected and the author would have liked to showcase such experiences to document the depth lean can contribute to the construction industry

8.4 CHAPTER SUMMARY

This study explored the outcomes produced by current project management practices in South Africa, to understand the reasons for poor project performance. Through realisation of the aim and objectives of the study, the chapter shows how lean construction can contribute to project performance improvement, as opposed to procuring projects in the traditional way of project delivery, which lacks continuous improvement within the context of the public sector environment. The lean construction cost management model previously mentioned in this chapter will assist the construction industry in following a standardised approach of executing projects differently, with the aim of providing value to project owners and demanding accountability from project teams. The model is expected to make measurable improvement in the context of the public sector environment.

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APPENDICES

APPENDIX A: LETTER OF INVITATION FOR INTERVIEW

Dear Sir/Madam,

LETTER OF INVITATION

I humbly write to invite your organisation to seek your consent to be a part of this on-going research. I am currently a PhD research student in the department of Quantity Surveying, Nelson Mandela University, conducting a research: **Lean-led evaluation of Infrastructure Development Improvement Programme in South Africa.** The aim of this research is to develop a conceptual system approach to assist the client departments and the construction industry to achieve improved and effective time and cost management and performances.

I am inviting you to kindly participate in this research. Given your level of involvement in the public construction project delivery and knowledge in the project management practice on such projects, I believe your contribution would be of significant value to the research. Your participation would only involve responses to a 30-45-minute interviews and /or a focus group participation if situation arises, whichever you indicate most suitable for you.

Please let me know if this is of interest to you, through the above contact details. In which case, I will then send additional information on the participation procedure, including, respondent Consent Form and an Information Sheet. I would also like to emphasise and guarantee you that, the contents of your completed response to the participation will be kept strictly confidential and anonymous and would only be used for the purpose of this academic research.
If you have any queries or require more information, kindly reach me on the above address or contact. Should you wish to clarify on the authenticity of this research or more about the context on the study, you could also contact Prof Gerrit Crafford and Prof Emuze who are currently supervising this research work.
I look forward to hearing from you.

Yours Faithfully,

APPENDIX B: CONSENT FORM TO PARTICIPATE IN RESEARCH

NELSON MANDELA UNIVERSITY
CONSENT TO PARTICIPATE IN RESEARCH

You are invited to take part in a study conducted by **Godfrey Monyane, Prof Gerrit Crafford**, and **Prof Fidelis Emuze** from the Department of **Quantity Surveying** at the Nelson Mandela University. You were approached as a possible participant because of your experience and expertise of public Infrastructure project delivery.

1. PURPOSE OF THE STUDY

The study is about development of a guideline approach to improve the current project management practice to improve the time and cost parameters with the aid of lean construction principles.

2. WHAT WILL BE ASKED OF ME?

If you agree to take part in this study, you will be asked to take part on a one-on-one interview of about 30-45 minutes about your experience of current project management practices in the public sector especially the outcomes achieved in terms of performance of public projects. Due to time constraints, it may be possible to conduct such interview in a focus group mode if all participants are comfortable with engagement and hear what others perceive. The interviews will be conducted at your convenience and a venue suitable to you will be communicated as soon as you provide consent. Questions may be sent to you prior to the interview so that you can familiarise yourself with the questions to be asked.

3. POSSIBLE RISKS AND DISCOMFORTS

Some questions you may be in a particular manner, which might make you feel that, you are revealing confidential information and please inform us so we can understand the sensitivity of the question to be considered for revision

4. POSSIBLE BENEFITS TO PARTICIPANTS AND/OR TO THE SOCIETY

The current project management practices are facing a challenge in terms of achieving time and cost success parameters. This is displaying a bad image to the construction industry; hence, this study is attempting to develop a guideline approach to eliminate all the wasteful activities in the current practices with the aid of lean construction principles. The construction industry at large will benefit from this study as if implemented there will be a structured way of delivering projects in an efficient and effective manner in the future. The public sector owes its tax paying citizens to improve the current state of infrastructure in the country.

5. PAYMENT FOR PARTICIPATION

You understand that your participation in this study is strictly voluntary and that no remuneration will be offered to me for taking part in the interview sessions and or focus group discussions.

6. PROTECTION OF YOUR INFORMATION, CONFIDENTIALITY AND IDENTITY

Any information you share with me during this study and that could possibly identify you as a participant will be protected. This will be done by only using coding to refer to you as participant A, A1, B, B1, etc, to protect the identity of the respondents of the interview sessions. The interview sessions will be recorded for the researcher to transcribe to enable an easy analysis of what the results of the sessions. The information will be stored safely by the researcher for five years for auditing purposes and only the researchers will have access to such an information and the University during an auditing process. The final report will also not reveal any names of anyone that took part part in the interview and or focus group discussions.

The information collected for this study will be used for future publications in peer-reviwed Journal articles and conference proceedings, and or book publishing.

The participants will have the opportunity to review/edit the tapes, and PhD supervisors will aslo have access to these recordings, as they will be used for educational purposes, and they will be erased after five years.

The results of interview sessions and or focus group discussions will be published as the results of the study on peer reviewed Journal and conference proceedings, and the identity of the respondents will be strictly confidentiality and/or anonymity will be maintained in the publication

7. PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you agree to take part in this study, you may withdraw at any time without any consequence. You may also refuse to answer any questions you don't want to answer and still remain in the study. The researcher may withdraw you from this study if there is a believe that you are intentionally providing false information and that you are not honest in the manner you are answering questions.

8. RESEARCHERS' CONTACT INFORMATION

If you have any questions or concerns about this study, please feel free to contact Thabiso Godfrey Monyane at +2751 507 3915*, or 073 341 2646* and/or the supervisor *Prof Fidelis Emuze* at 051- 507 3915, or Prof Gerrit Crafford at 041- 504 2153.

9. RIGHTS OF RESEARCH PARTICIPANTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study.

DECLARATION OF CONSENT BY THE PARTICIPANT

As the participant I confirm that:

- I have read the above information and it is written in a language that I am comfortable with.
- I have had a chance to ask questions and all my questions have been answered.
- All issues related to privacy, and the confidentiality and use of the information I provide, have been explained.

By signing below, I ________________________________ *(name of participant)* agree to take part in this research study, as conducted by ____ *(name of principal investigator).*

____ ______________________

Signature of Participant **Date**

DECLARATION BY THE PRINCIPAL INVESTIGATOR

As the **principal investigator,** I hereby declare that the information contained in this document has been thoroughly explained to the participant. I also declare that the participant has been encouraged (and has been given ample time) to ask any questions. In addition, I would like to select the following option:

	The conversation with the participant was conducted in a language in which the participant is fluent.

	The conversation with the participant was conducted with the assistance of a translator (who has signed a non-disclosure agreement), and this "Consent Form" is available to the participant in a language in which the participant is fluent.

Signature of Principal Investigator **Date**

Faculty of Engineering, the Built Environment and Information Technology

Self-Assessment Research Ethics Checklist

The checklist should be completed by the researcher (PI) in consultation with supervisor/promotor (PRP) and attached to the research proposal. Please note that retrospective approval for studies is not possible.

Principle Investigator (PI):	Mr Thabiso Godfrey Monyane
Department of PI:	Quantity Surveying
Title of Research Project:	**Evaluation Of Infrastructure Delivery Improvement Programme: Towards A Target Value Design Of Construction Projects**
Registered Degree:	PhD Construction Economics
Staff or Student Number:	215222059
Primary Responsible Person (PRP):	Prof Gerrit Crafford

1. Familiarity with ethical codes of conduct	
a)	I have familiarised myself with the Research Ethics and Code of Conduct Policies for Researchers at Nelson Mandela University
Yes	Yes
No	*If no, do so before proceeding*

b)	I have familiarised myself with the professional code(s) of ethics and/or guidelines for ethically responsible research relevant to my field of study
Yes	*If yes, please specify the professional code(s) of ethics and/or guidelines which were consulted*
No	*If no, do so before proceeding*

The level of risk involved in your proposed research is measured as follows:

No risk	No approval is necessary
Negligible to Low risk	Faculty level ethics approval is necessary
Medium to High risk	Institutional level ethics approval is necessary

Please answer the questions below. Select one or more of the options that in your opinion might be applicable to your investigation

2. Does the proposed research intentionally involve the collection of data on people in the following categories?	
No	NMMU staff/students
No	Persons that are in a dependency relationship with the Principal Investigator (PI) and/or Primary Responsible Person (PRP)
No	Children under the age of 18
No	Handicapped (e.g. mentally or physically) persons

No	Socially and/or economically disadvantaged persons
No	Persons of diminished physical and/or mental and/or educational capacity (e.g. traumatised)
No	Persons who are not competent to give participation consent (e.g. due to language challenges)
Yes	None of the above

3. Are you administering any process and/or treatment that	
No	Involves participants undergoing psychological, physiological or medical testing or treatment.
No	Involves the collection and use of human biological samples (e.g. skin, blood, urine, saliva, hair, bones, tumour and other biopsy specimens) or their exhaled breath.
No	Could be hazardous to the physical health (e.g. possibly results in illness, injury, pain) of the participants and/or researcher.
No	Could be hazardous to the psychological well-being (e.g. possibly results in feelings of worthlessness, guilt, anger, fear) of the participants and/or researcher.
No	Could be hazardous to the legal well-being (e.g. possibly results in the discovery and prosecution of criminal activity) of the participants and/or researcher.
No	Could result in the participant learning about a genetic possibility of developing an untreatable disease.
No	Could be hazardous to the economic well-being (e.g. possibly results in the imposition of direct and/or indirect financial commitments on participants) and/or result in discomfort associated with the economic well-being of the participants and/or researcher.
No	Collects any articles/documents of property, personal or cultural from participants.
No	May result in a traumatic experience for the participants and/or researcher.
No	May result in the disclosure of sensitive and/or embarrassing information about the participants and/or researcher.
No	Involves covert observation of behaviour that is not normally in the public domain.
No	Could result in the participants feeling humiliated, manipulated and/or in other ways treated disrespectfully and/or unjustly.
No	Could result in discomfort associated to the physical health (e.g. the act of measuring blood pressure, minor side effects of taking medication) of the participants and/or researcher.
No	Could result in discomfort associated with the psychological well-being (e.g. feelings of anxiety due to being interviewed) of the participants and/or researcher.
No	Could result in the identification and/or re-identification of a participant from a resulting report.
No	Could result in risks to non-participants (e.g. distress to relatives upon discovering that a participant suffers from a serious genetic disorder, infectious disease risks to a community, social/economic discrimination of subgroup populations).
Yes	Is expected to result in the only foreseeable discomfort being that of inconvenience (e.g. time and effort required by participants to complete questionnaire/form, participate in a street survey).
Yes	Is expected to result in no foreseeable risk, harm or discomfort to the mental and/or physical well-being of the participants.

4. Are you administering a questionnaire / survey / interview / focus group that	
No	Collects sensitive data from the participants (e.g. personal data that is not normally in the public domain).
No	Does not guarantee the anonymity of the participant.
No	Does not guarantee the confidentiality of data collected from the participants.
Yes	None of the above.

5. Are you intending to access participant data from an existing stored repository (e.g. school, institutional or university records) that	
Yes	Requires access to participant information (in individually identifiable or re-identifiable form) as part of an existing published or unpublished source or database?
Yes	Requires access to participant information (in non-identifiable form, e.g. summarised form) as part of an existing published or unpublished source or database?
No	None of the above.

6. Do you intend publishing the findings of your study in a publication that

No	Requires evidence of human ethics approval/acknowledgement?
Yes	Requires no evidence of human ethics approval/acknowledgement?

7. Is this study	
No	An international/cross border study?
Yes	A local (e.g. regional, national) study?

Your proposed study's risk is summarised below:

No risk	No approval is necessary
Negligible to Low risk	Faculty level ethics approval is necessary
Medium to High risk	Institutional level ethics approval is necessary

Principle Investigator (PI) Signature **Date: 28/08/2017**

Primary Responsible Person (PRP) Signature **Date**

Research Ethics Process in the EBEIT Faculty

Role-players in the process:

- **Faculty Ethics Committee Chairperson** – Prof Gerrit Crafford (Gerrit.Crafford@mandela.ac.za)
- **School Ethics Representatives**
  - Built Environment: Prof Gerrit Crafford (Gerrit.Crafford@mandela.ac.za)
  - Engineering: Dr Karl Van der Merwe (Karl.vanderMerwe@mandela.ac.za)
  - Information Technology: Mr Rudi Harmse (Rudi.Harmse@mandela.ac.za)
- **Institutional Ethics Committee Officer**: Ms Ursula Spies (Ursula.Spies@mandela.ac.za)
- **Institutional Ethics Committee Administrative Manager**: Mr Imtiaz Khan (Imtiaz.Khan@mandela.ac.za)
- **PI**: Principal investigator (Normally the Student)
- **PRP**: Primary Responsible Person (Normally the Supervisor)

Step 1	All research proposals/protocols and treatises/dissertations/theses should include a section on ethical consideration (Nelson Mandela University Policy 404.02)		
Step 2	Use the EBEIT Faculty self-evaluation checklist to assess the level of risk of potential harm that is involved in your proposed research. The level of risk will determine the next step. ***Include the completed self-evaluation checklist in the appendix section of your proposal.***		
	No risk	**Negligible to Low risk**	**Medium to High risk**
Step 3	No approval is necessary.	***Faculty level ethics approval is necessary.*** Following your proposal acceptance, submit the ethics application form and supporting documentation to the Faculty Ethics Committee Chairperson. If assistance is needed to complete the application form, please ask your School Ethics Representative for assistance.	***Institutional level ethics approval is necessary.*** Following your proposal acceptance, submit the ethics application form and supporting documentation to the Faculty Ethics Committee Chairperson. If assistance is needed to complete the application form, please ask your School Ethics Representative for assistance.

Step 4		The application is assigned a unique number by the Faculty Ethics Committee Chairperson.	The application is assigned a unique number by the Faculty Ethics Committee Chairperson.
Step 5		The Faculty Ethics Committee reviews the application during ad-hoc meetings (meetings organised as applications are submitted) and decides if the application is ***approved or should be re-submitted.***	The Faculty Ethics Committee Chairperson submits the application form and supporting documentation to the Institutional Ethics Committee Administrative Manager for inclusion in the monthly Institutional Ethics Committee meeting agenda (Please consult agenda closing dates on website).
Step 6		If the ***application should be re-submitted***, the amendments must be made to the application and submitted to the Faculty Ethics Committee Chairperson. The process will restart at step 5. ***If accepted***, the Faculty Ethics Committee Chairperson will issue an Ethics Clearance Certificate for the project ***(Valid for 3 years)***.	At least 4 other (Not EBEIT member) Institutional Ethics Committee Members are requested to review the application form and supporting documentation.
Step 7			The application form and supporting documentation serve at the Institutional Ethics Committee meeting where reviewers comment on the submissions. The application is either ***approved / provisionally approved or should be re-submitted.*** (If ***approved*** the Institutional Ethics Committee Officer will issue an Ethics Clearance Certificate - ***Valid for 3 years***).
Step 8			If the application is ***provisionally approved or should be re-submitted*** the Institutional Ethics Committee Officer compiles the feedback provided at the Institutional Ethics Committee meeting and forwards it to the PI and PRP (Applicants). The PI and PRP should liaise with the designated Institutional Ethics Committee Member (name will be on the feedback form) to incorporate the feedback into the application.
Step 9			If ***provisionally approved***, amendments should be made to the application and submitted (***within 3 months of receiving feedback***) to the designated Institutional Ethics Committee Member. If the amendments are accepted by the designated Institutional Ethics Committee Member, the Institutional Ethics Committee Officer will be asked to issue an Ethics Clearance Certificate for the project ***(Valid for 3 years).*** If the ***application should be re-submitted***, the amendments must be made to the application and submitted to the Institutional Ethics Committee Officer. The process will restart at step 6.

APPENDIX C: SEMI-STRUCTURED INTERVIEW PROTOCOL

IN-DEPTH SEMI-STRUCTURED EXPERT INTERVIEW QUESTIONS

SECTION A: INTERVIEWEE'S BACKGROUND INFORMATION

INTERVIEW PROTOCOL

This interview is aimed at identifying the procurement process of appointing stakeholders needed for an Infrastructure project through to project hand over. The findings will direct the development of requirements of a guideline to enhance the project delivery system in the construction industry. Thank you for agreeing to participate in this study.

General Information on the Interviewee

Designation:

Job Description:

Years of Employment /Appointment:

Qualification:

Date of Interview:

Contact Details:

SECTION B: INTERVIEW

(*Theme 1*) – Outcomes of current project management practices

1. How would you rate projects performance regarding conventional/traditional cost management practices?
2. What are the frequent outcomes of projects executed with conventional/traditional cost management practices?
3. Why are the existing cost management practices performing poorly in projects?
4. What are the direct causes for worrisome cost performance in projects?
5. What are the indirect causes for worrisome cost performance in projects?
6. Would you agree that poor time and cost performance is a waste (non-value adding activity) to clients, contractors, and the entire project team? If YES, please discuss other activities that contribute to cost problems while not adding value to the progress of work.
7. What is the role of design regarding worrisome cost performance in projects?
8. How do design influence project cost and to what extent can cost influence design? Please explain how active steering of design to an acceptable project cost rather than the cost reflecting the design would impact on overall project performance?
9. How should project parties use flexibility to tackle costing matters in construction?
10.

Any other comments?

SECTION C: INTERVIEW

(*Theme 2*) – Poor performance of projects in terms of time and cost

11. Do you think projects undertaken are performing well or performing poorly?
12. What do you think is the cause for such a performance in projects?
13. Would you agree that such poor performance can be regarded as waste?
14. Do you think the current construction cost management system allows active steering of the design to an acceptable overall project cost rather than the cost reflecting the design?
15. Do you think a more flexible and a responsive approach to budgeting in construction cost management are needed to enhance construction project management?
16. Do you think that eliminating waste (as advocated in lean production) is sufficiently accounted for in the current approaches to construction cost management?
17. Do you think the situation that this waste is not acknowledged, results in failure to the current construction cost management approaches/system?

Any other comments?

IN-DEPTH UNSTRUCTURED EXPERT INTERVIEW QUESTIONS

SECTION A: INTERVIEWEE'S BACKGROUND INFORMATION

INTERVIEW PROTOCOL

This interview is aimed at identifying the procurement process of appointing stakeholders needed for an Infrastructure project through to project hand over. The findings will direct the development of requirements of a guideline to enhance the project delivery system in the construction industry. Please feel free to state any important point(s), as you think is appropriate, without limiting to the questions stated here. Thank you for agreeing to participate in this study.

General Information on the Interviewee

Designation:

Job Description:

Years of Employment /Appointment:

Qualification / Background:

Date of Interview:

Contact Details:

SECTION B: INTERVIEW

Procurement information on the Interviewee experience

18. Please explain the process of starting a project from inception to completion? (Please discuss: type of procurement, types of contract, appointment of professional team, appointment of contractor, and subcontractors.)
19. What are the challenges experienced in a typical procurement process?
    (Please discuss challenges related to timelines, co-operation, conflicts, capacity, tender guidelines, etc.).
20. What do you recommend as a solution to overcome these challenges?
21. How is current contracting forms (for example the JBCC) responsive to the mentioned challenges?
22. What is the likelihood of applying relational contracting as a solution to resolving the identified challenges?
    Any other comments?

Thank you

Lean Drivers	**1-5**
Waste elimination	
Meeting customer expectation and requirement	
Continuous improvement	
Efficiency improvement	
Process control	
Flexibility	
People and resource utilisation	
Optimisation	
Increasing competitive advantage	
Business pressure	
Government policy and regulation	
Cost savings	

Barriers of Lean implementation	**1-5**
Lack of management commitment	
Long implementation period	
Lack of proper training	
Lack of adequate skills and knowledge	
Lack of application of the fundamental techniques	
Gaps in standards and approaches	
Fragmented nature of industry	
Cultural barriers	
Lack of implementation understanding & concepts	
Resistance to change	
Government bureaucracy and instability	
Long lists of supply chain and lack of trust	

APPENDIX D: QUESTIONNAIRE COVER LETTER

To Whom It May Concern

Dear Sir /Madam,

Re: Questionnaire on factors that affect project performance

I am undertaking a PhD in Construction Economics at the Nelson Mandela University. I would like your assistance to complete the qualification.

The construction industry is a complex industry that requires rigorous systems to deliver projects in efficient and effective manner. The overall research aim of the study is to propose ways to improve the performance of projects in terms of cost and time through the use of lean construction concepts and tools. Lean construction delivers projects with maximum value and minimum waste.

The objective of this survey is to identify the industry's understanding of project's delivery approach and outcomes that would influence the adoption of new approaches in construction.

The questionnaire consists of 3 main sections, which include:

- Section (A): Is structured to investigate the general information about respondent's experience in the construction Industry.
- Section (B): Is structured to identify the factors affecting the overall performance of the project in current practice.
- Section (C): Is structured to proffer and understanding of the current cost management approaches in planning and controlling costs and identify the shortcomings.
- Section (D): Is structured to identify the factors affecting the overall performance of the project in current practice.

The survey will take about 10 to 15 minutes to complete. I would very much appreciate it if you could participate in this survey and complete it at your earliest convenience before 6 April 2018.

Finally, I would like to thank you for your valuable time and co-operation. Your information will be kept strictly confidential and will not be disclosed to a third party, as this is purely for academic purpose.

Names: Thabiso Godfrey Monyane – 073 341 2646

Email: tmonyane@cut.ac.za or tgmonyane01@gmail.com

APPENDIX E: QUESTIONNAIRE INSTRUMENT

Section A: Personal Information

Please indicate your response by making an X in the block provided. e.g X

1. Please indicate the sector that your organisation belongs among the under listed?

Private	
Public	
Others:	

2. Please indicate how long your organisation has being in existence?

0-5 years		15 - 20	
5-10 years		> 20	
10-15 years			

3. Please indicate the approximate number of employees in your organisation?

1 - 20		101 - 200	
21 - 50		> 200	
50 - 100			

4. Please indicate your current position in the organisation?

Engineer		Director	
Quantity Surveyor			
Construction / Project manager			
Architect		Other	

5. Please indicate the length of your experience in the construction industry?

1-5 years	
5-10 years	
> 10 years	

6. Please indicate the highest formal qualification you have obtained?

Matric certificate		Doctorate	
Diploma		Other:	
Bachelors			
Masters			

Section B: Factors that affect COST performance
On a scale of 1 (Strongly disagree) to 5 (Strongly agree), please indicate the extent to which each of the mentioned causes apply at the design phase in public sector in South Africa (**please note the 'unsure' option**)?

1. Design Phase

Factors that affect performance	Unsure	Strongly disagree…………………………..Strongly agree				
		1	2	3	4	5
Lack of co-ordination at design phase						
Incomplete design at time of tender						
Technical omissions at design stage						
Ignoring items with abnormal rates during tender evaluation, especially items with provisional quantities						
Limited knowledge of project location						
Lack of experience of project type						
Inadequate project preparation, planning						
Poor technical inputs from consultants						
Procurement related procurement related factors such as delay to appoint a contractor						
Difference between actual geological conditions and the original survey						

2. Construction Phase

Factors that affect performance	Unsure	Strongly disagree………………………Strongly agree				
		1	2	3	4	5
Unpredictable weather conditions						
Rework due to errors during construction						
Fluctuations in the cost of building materials						
Change order from owner						
Lack of cost planning / monitoring during pre-and-post contract stage						
Site / poor soil conditions						
Re-measurement of provisional works						
Community Interference and employment of local labour						
Logistics due to site conditions and location						
Delays in issuing information to the contractor during construction stage						
Contractual claims, such as, extension of time with cost claims						
Revision to standard drawings during construction stage						
Delays in costing variations and additional works						
Labour cost increased due to scarcity in remote areas						
Lack of experience of local regulations						
Labour unrest						
Monthly payments difficulties from client						
Poor management of the project by the contractor						

New information on existing site conditions						
Changes to safe work procedures						
Contractor's unstable financial background						

3. Completion Phase

Cause	**Unsure**	**Strongly disagree……………………….strongly agree**				
		1	**2**	**3**	**4**	**5**
Extra work						
Late contract instruction after practical completion						
Delay in resolving disputes						
Variation orders not communicated to the QS						
Delay in final account agreements						
Works suspended due to safety reasons						

Section C: Shortcomings of current cost management practices

On a scale of 1 (Strongly disagree) to 5 (Strongly agree), please indicate the extent to which each of the mentioned shortcomings of current cost management practice apply in the public sector in South Africa (**please note the 'unsure' option**)?

Factors Impacting the project Performance	**Unsure**	**Strongly disagree……………………..Strongly agree**				
		1	**2**	**3**	**4**	**5**
Poor Estimation						
Failure to support improvements opportunities						
Costs are the outcome of the design rather than costs steering design						
Negative influence on behavior						
Relative neglect of value consideration						
Costs being an Individual task rather than collaborative						
Budget constraints treated as a limitation						

Section D: Factors that affect time performance

On a scale of 1 (Strongly disagree) to 5 (Strongly agree), please indicate the extent to which each of the mentioned factors affect time performance of projects in the public sector in South Africa (**please note the 'unsure' option**)?

Factors Impacting the project Performance	**Unsure**	**Strongly disagree……………………. Strongly agree**				
		1	**2**	**3**	**4**	**5**
Change orders by owner						
Rework due to errors during construction,						
Poor site management and supervision by contractor						
Poor communication and coordination by contractor with other parties,						
Ineffective planning and scheduling of tasks by contractor						
Improper construction methods implemented by contractor						
Poor qualification of the contractor's technical staff,						
Mistakes and discrepancies in design documents,						

Non-use of advanced engineering design software and tools						
Limited details in drawings,						
Complexity of project 's design,						
Delay in material delivery						
Changes in material types and specifications during construction						
Damage of sorted material while they are needed urgently,						
Lack of skilled workforce						
Low productivity of labours						
Site uncertainties						

With a Yes, No or Unsure, please indicate if design and cost methods need innovative methods and tools to improve the performance of construction projects?

Yes ☐ No ☐ Unsure ☐

With a Yes, No or Unsure, please indicate if contracts that encourages more collaboration and eliminate problems between professionals and the contractor and subcontractors may improve the performance of public projects?

Yes ☐ No ☐ Unsure ☐

OPTIONAL: Please record your details below to facilitate contacting you, in the event that a query should arise. **Please note that your information will be treated in the strictest confidence.**

Organisation Name: ____________________

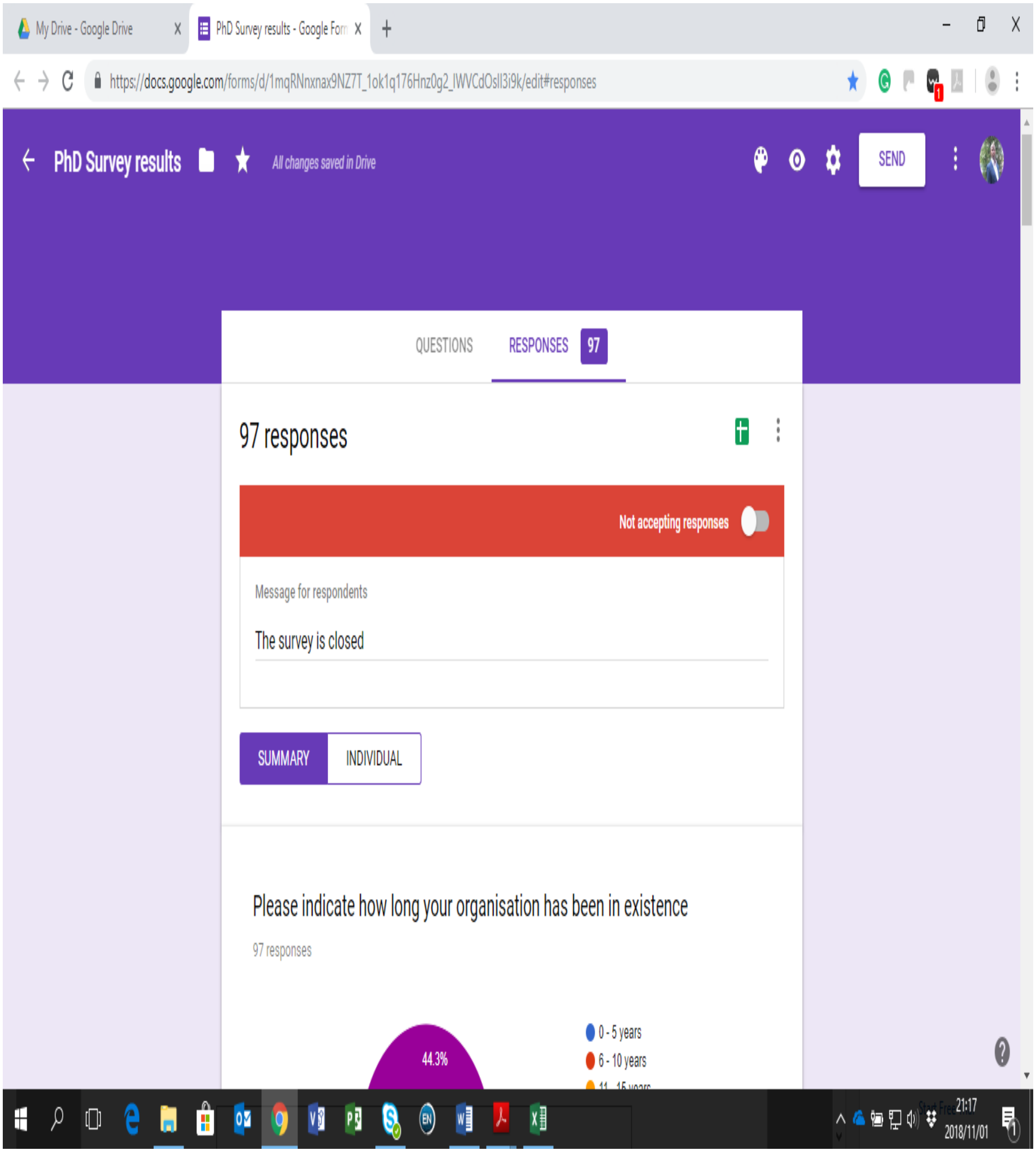
Contact Person: ____________________

Tel: ____________________

E-mail:____________________

Thank you for your contribution to this research project.

APPENDIX F: NUMBER OF RESPONSES RECEIVED FROM GOOGLE FORMS



APPENDIX G: LETTER OF PERMISSION FROM NDPW GRANTING ACCESS TO DATA

public works
Department:
Public Works
REPUBLIC OF SOUTH AFRICA

Private Bag X65, PRETORIA, 0001 Int Code: +27 12 Tel: 406 1300 Fax: 321 3898
E-mail: Solly.Mwenze@dpw.gov.za website: www.publicworks.gov.za

Attention: Mr GT Monyane
House 26899 Vistapark
Ehrlichpark
Bloemfontein
9312

Dear Mr. GT Monyane

REQUEST FOR PERMISSION TO CONDUCT A RESEARCH WITHIN NDPW ON THE TOPIC "A LEAN LED EVALUATION OF INFRASTRUCTURE DELIVERY IMPROVEMENT PROGRAMME IN SOUHT AFRICA".

1. Your request dated 28/08/2017 pertaining to the above mentioned matter is hereby acknowledged.

2. The Department has decided to grant you permission to conduct a research study on the topic" A lean led evaluation of the infrastructure delivery improvement programme in South Africa".

3. You are hereby requested to submit the outcome of your approved research to the Department, through the Director: Human Resources Development for future references and service delivery improvement strategies to be sourced from your findings and recommendations.

4. The Department wishes you everything of the best in your academic and career developments.

Yours Sincerely

Advocate: Sam Vukela

Acting Director General

Date: 09/10/2017