Cape Peninsula University of Technology

CAUSES AND EFFECTS OF COST UNDERESTIMATION ON CONSTRUCTION PROJECTS IN SOUTH AFRICA

by

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I, Abiodun Emmanuel Awosina, declare that the contents of this thesis represent my own unaided work, and that the thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

Signed **Date**

DEDICATION

I dedicate this study to the loving memory of my uncle, my great benefactor, Late Abdul Rashied Elujoba, who was instrumental towards my accomplishments in the Republic of South Africa.

ABSTRACT

The South African construction industry is faced with challenges which contribute to unsuccessful project delivery. Cost underestimation have negative contribution to construction projects, the effects and causes of cost underestimation have not been adequately explored with the objective of providing mitigating mechanisms. This study is aimed at investigating factors which contribute to cost underestimation, the prevalence of cost underestimation in relation to causes and effects of cost underestimation, with the final objective to establish mechanisms for efficient mitigation of cost underestimation.

The study review literatures relating to cost estimation, and additional data were collected in form of a structured questionnaire. The questions highlight the following areas; project planning, method and techniques, and tools as factors contributing to cost underestimation; scope changes and risk associated with specialized building works as prevalence of cost underestimation; planning stage, design and material changes risk due to unforeseen factors as causes of cost underestimation; loss of reputation, exposure to risk and financial loss as effects of cost underestimation; and design requirements, effective techniques and planning as cost underestimation mitigation mechanism.

A total of one hundred and forty two (142) emails were sent via the survey website to the selected respondents and seventy four (74) responses were received. A quantitative approach was used and a convenient purposive sampling of respondents was used by handpicking the respondents from the available register of the South African Council for Quantity Surveying Professions (SACQSP) and the general building contractors registered with Construction Industry Development Board (CIBD), construction professionals working in quantity surveying practice and construction firms within and around Cape Town.

Data gathered from the questionnaire were inputted and analysed on the computer using Statistical Package for Social Sciences (SPSS) version 23. The quantitative data gathered were analysed using descriptive statistics. In analysing the research data, the measures of central tendency using mean value were used to analyse the data. Test on reliability of the research instrument were conducted based on Cronbach's alpha coefficient value, the mean value of the internal reliability of the 15 constructs was 0.95. However, each of the constructs had an internal reliability greater than 0.70 which is considered acceptable.

This study revealed that cost underestimation is a significant contributor to unsuccessful project delivery with significant effects on project stakeholders. The findings based on empirical data revealed that design and material changes is the most significant causes of cost underestimation, while risk exposure, financial loss and loss of reputation and credibility of project stakeholder were classified as effects of cost underestimation. Furthermore, design requirement is the most rated mitigating mechanism on cost underestimation with key factors relating to well-preparation of bills of quantities, adequate preparation of project specification and clear scope of work.

The study concluded that cost underestimation does exist on construction projects, and that project stakeholders are mainly responsible. The findings recommended that attention should be focused on the events leading to the production process of cost estimate, from competency, skills and techniques, adequate understanding of scope of work, review of cost-significant building items, risk and avoidance of design and material changes.

ACKNOWLEDGEMENT

I thank God Almighty for granting me the grace to complete this work. I thank both my supervisor, Dr. Ruben Ndihokubwayo and co-supervisor, Dr. Julius Fapohunda for their effort and encouragement towards this study. I also want to thank all the individuals who participated in the survey. Lastly, I wish to thank all my family members, with special thanks to my wife Mrs. Adeola Awosina and my children Oluwole and Vanessa Awosina for their support and prayers.

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DEFINITION OF TERMS

- **Accuracy:** According to Collins English Dictionary (2014), *accuracy* is the correct and precise measurement or representation of the truth, including standard or acceptable value of the quantity.
- **Building trades**: These are *trades and professions* such as carpenters, masons, plasterers and electricians that are concerned with the creation and finishing of buildings (Collins English Dictionary, 2014).
- **Cost control:** According to Project Management Institute (2008:79), *cost control* includes the process of monitoring the performance of cost to detect any variance, ensuring adequate record of cost due to changes, preventing inappropriate changes from being recorded, informing stakeholders of changes and managing the changes as they occur.
- **Cost estimating:** According to Project Management Institute (2008:76), *cost estimating* is the process of developing approximate cost required to complete project activities.
- **Estimator (building):** An *estimator* is an individual that is responsible to quantify the cost of materials, labour, and equipment that is required to complete a construction project (Wikipedia, 2007).
- **Project:** According to Project Management Institute (2008:4), a *project* is a temporary endeavour undertaken to create a unique product of service.
- **Project stakeholders:** According to Project Management Institute (2008:15), *project stakeholders* are individuals who are actively involved in the project and whose interest may be positively or negatively affected due to project execution. Key project stakeholders include owners, funders, project teams, contractors, governments and individual citizens (Project Management Institute, 2008:16).
- **Underestimation:** According to Collins English Dictionary (2014), *underestimation* is an estimate that is too low or less than the true or actual value.

LIST OF ABBREVIATIONS

ASAQS:	Association of South African Quantity Surveyors
BIM:	Building Information Modelling
CAD:	Computer-Aided Design
CURT:	The Construction Users Roundtable
JBCC:	Joint Building Contracts Committee
PPP:	Public Private Partnership
PMI:	Project Management Institute
PwC:	PricewaterhouseCoopers
RIBA:	Royal Institute of British Architects
RICS:	Royal Institution of Chartered Surveyors
SPSS:	Statistical Package for Social Sciences
WBS:	Work Breakdown Structure

CHAPTER ONE

INTRODUCTION

1.1 Background

Cost underestimation, a global characteristic of construction projects (Flyvbjerg, Holm & Buhl, 2002:290), is often attributed to a lack of resources (Cantarelli, Flyvbjerg, Molin & Wee, 2010:12). A project for which the costs are underestimated will experience significant setbacks during execution. Negative consequences will arise due to cost underestimation, so the contracting parties and project stakeholders will therefore be affected, due to setbacks during project execution. Various studies have identified the problems associated with project cost underestimation as including human error, reputation, credibility and low competence of cost professionals (Nijkamp & Ubbels, 1999:17; Flyvbjerg, Holm & Buhl, 2002:290; Doloi, 2013:277). However, insufficient attention has been given to the factors influencing the accuracy of cost estimating processes (Akintoye, 2000:78). Flyvbjerg *et al*. (2002:290) argue that cost underestimation cannot be explained by error alone; it seems to be best explained by strategic misrepresentation. According to Flyvbjerg *et al*. (2002:290), the misrepresentation of cost estimates by infrastructure promoters or estimators, especially on public projects, is systematically and significantly deceptive, and occurs for political and economic reasons.

Ponte (2009:1) indicates that errors during the bidding process, particularly errors relating to cost underestimation which cause delays in contract awards, will eventually result in outright bid rejection or re-bidding of the project. In order to avert cost underestimation, improvement in costing concepts must occur. However, studies by Flyvbjerg *et al.* (2002:290) on transport infrastructure projects across 20 countries on five different continents reveal that there has actually been little to no improvement in the accuracy of cost estimates for 70 years and that cost underestimation still persists in the construction industry. According to Skitmore and Wilcock (1994:141), over the past 20 years, the assumption that tender prices of contractors are based on a 'real cost estimate' of project expenditure has been continuously questioned.

In July 2006, following a series of increases in the estimated cost of road schemes in UK, the Secretary of State for Transport launched an investigation into the Highways Agency's approach to estimating the cost of projects (Nichols, 2007:1). Nichols (2007:22) identifies inconsistencies in the estimating techniques of estimators, as well as a lack of clear definition of purpose, scope and contents during the process of cost estimation. Nichols (2007:51) reveals that there is a need for capacity improvement for the Highways Agency in order to deliver a road programme. According to Nichols (2007:21), reasons that contribute to cost increase are inflation, inaccurate estimating, project definition, risk, time, land, third party cost and preliminaries. Skitmore (1988:17) outlines factors associated with the accuracy of cost estimates: bias and consistency of the estimator, state of the market and location of the project. Nijkamp and Ubbels (1999:17) also highlight three factors leading to cost underestimation in projects: general price rise, incompleteness of estimates, and project changes or extension.

In relating the concept of cost underestimation, which occurs at the early stage, to the concept of cost overrun, which occurs at the later stages of the project; it is important to draw attention to factors such as inaccuracy of cost estimates, cost overruns and cost underestimation. Cantarelli *et al*. (2010:6) consider the inaccuracy of the estimate as the size of cost overruns. Cantarelli *et al*. (2010:6) state that the actual cost of a project is determined at the time of project completion as real accounted cost. Cantarelli *et al*. (2010:6) indicates that cost estimates therefore become more accurate during the process of project execution.

1.2 Challenges in the South African construction industry

According to Statistics SA (2013:4), South African nominal GDP, the GDP evaluated at market rate, stood at R876 billion at the fourth quarter of 2013. The South African construction industry reports an increase in the size of new construction in the public to R137 billion, a significant share of GDP (PricewaterhouseCoopers 2013:6). Seeletse and Ladzani (2012:122) reveal that emerging contractors in South Africa fail to achieve best practice. Hence, project cost estimates prepared by emerging contractors are unreliable. PricewaterhouseCoopers (2013:4) highlights six top risks which create challenges in the South Africa construction industry. All of these factors directly or indirectly impact on the phenomenon of cost underestimation:

(i) *Talent management:* The lack of skilled professionals is a challenge to the construction industry. Stewart (1991:48) identifies skills as an important tool for cost estimation.

(ii) *Labour force and trade unions:* Frequent labour unrest and violence at various project sites are significant factors in the mining sector, but also other industries, and accordingly result in project delays. Thus, unforeseen increases in project costs will emanate from labour unrest.

(iii) *Health, safety and environmental sustainability:* The risk to health and safety of employees will negatively impact on the morale of employees, which will therefore result in loss of production (PricewaterhouseCoopers, 2013:16). Unforeseen losses in production will also contribute to unforeseen cost estimation.

(iv) *Tender risk:* Due to the pressure to increase revenue in the construction industry, there exists a considerable risk of inappropriate pricing. Key controls are required to be implemented on tendering process such as appropriate authorisation, review matrix, operational and territory risk framework, commercial assessment. Stewart (1991:47) identifies information as an important tool for cost estimation.

(v) *Project execution:* The issues of project execution are largely impacted by the complexity of large projects, which requires exceptional skill in project management. Failures in project execution will have negative effects on project profitability (PricewaterhouseCoopers, 2013:16).

(vi) *Scarce resources and cost management:* South Africa has, in the recent past, experienced instances of due prolonged power outages, which translated into lost production. The construction industry is not immune to the effects of these outages, which resulted in increased cost. In addition to power, a shortage of skills has resulted in increases in wages well above the targeted inflation rate of the South African economy. According to PricewaterhouseCoopers (2013:16), a skill shortage results in cost increases and cost inefficiencies such as rework, poor productivity, waste and risk of subsequent claims.

1.3 Problem statement

The construction project cost estimate has been viewed as a mere budgetary allocation, in which accuracy remains uncertain, and this has resulted in a gap between the initial project cost and completion cost being regarded as standard. Unfortunately, insufficient attention has been given to the shortcomings which causes such underestimation, including factors contributing to underestimation, cost-significant work items prone to underestimation, effects of underestimation and the mitigating mechanisms.

1.4 Sub-problems

The research problem emphasised in section 1.3 is broken down into sub-problems as follows:

(i) Competency of contractors and estimators are contributing factors to cost underestimation.
(ii) Unforeseen conditions which impact on final cost result in the inaccuracy of cost estimates.
(iii) Inadequate preparation of the cost estimate itself causes cost underestimation.
(iv) Cost underestimation results in financial loss with obvious damaging effects.
(v) Lack of adequate planning and techniques are factors which evade mitigating mechanisms in the process leading to cost underestimation.

1.5 Research questions

The following research questions emerged from the problem statement:

(i) What are the factors contributing to cost underestimation?
(ii) What is the prevalence of cost underestimation in cost-significant work items?
(iii) What are the causes of cost underestimation in the South African construction industry?
(iv) What are the effects of cost underestimation on project stakeholders?
(v) How can cost underestimation be mitigated?

1.6 Aim of the research

The aim of this research project is to assess the causes and effects of cost underestimation on construction projects within the Cape Town region of South Africa, in order to ascertain mitigating mechanisms.

1.7 Objectives of the research

The objectives of this research are as follows:

(i) to investigate factors that contribute to cost underestimation;
(ii) to evaluate the prevalence of cost underestimation in cost-significant work items;
(iii) to investigate the causes of cost underestimation;
(iv) to identify the effects of cost underestimation on project stakeholders; and
(v) to establish mechanisms for efficient mitigation of cost underestimation.

1.8 Theoretical framework

The theoretical framework for this research will draw from the concept of cost-significant theory. According to Alqahtani and Whyte (2013:53), the ideology of cost-significant items will simplify cost estimation methodology by determining key items that contribute the most to project cost. Cost-significant theory originated from Italian economist Vilfredo Pareto's 80:20 rule: that social wealth is not well-distributed, about 20% of the population own 80% of the society's wealth (Wang, Xing & Lin, 2009:32).

According to Wang *et al.* (2009:32), the application of cost-significant theory to construction cost estimation research found that about 20% of total quantity items make up 80% of total construction cost. The items making up this 20% are referred to as cost-significant items. Mohamed, Mouloud and Mourad (2012:2265) agree, stating that in construction projects, 80% of total cost is contained in 20% of cost items, referred to as cost-significant. In the even that cost-significant items could be easily recognised, estimators are motivated to focus much attention on these specific items, thereby reducing the time taken to estimate cost, as well as providing a more realistic method to analyse and record project cost information (Alqahtani & Whyte, 2013:54). Cost-significant items are those whose values are higher than mean cost, such as the case of a bill of quantities whose value is greater than or equal to the mean item value (Dmaidi, 2003:227; Mohamed *et al.,* 2012:2265).

Alqahtani and Whyte (2013:54) further reveal that most current models of cost estimation mostly focus on cost-significant items; thereby neglecting non-cost-significant items. However, non-cost factors can have a critical impact on the accuracy of cost estimates. These are factors such as project types (residential, commercial, industrial), types of structures (steel, concrete, masonry) and project size (building area, shape, height). According to Dmaidi (2003:226), cost-significant theory introduces simplification to the cost estimating and cost planning process in construction. Resource-significant analysis identifies work packages which are significant in terms of cost and time, by considering labour, plant and materials.

1.9 Conceptual framework

This research project will review causes of underestimation, contributing factors, trade prevalence in underestimation, effects of underestimation and the mitigating factors of underestimation by the contractor's estimator. Costing techniques which guide the preparation of cost estimation will be identified and the causes of underestimation, the factors responsible for cost underestimation and the prevalence of underestimation in building trades will also be reviewed. The effects of underestimation will be explored, as well as mitigating factors and avoidance mechanisms.

Figure 1.1 displays the relationship between the research objectives and the research questions. The conceptual framework indicates the causes of underestimation, which range from errors, inadequacy and lack of cost checks to unforeseen factors and design changes (Nijkamp & Ubbels, 1999:17; Flyvbjerg, Holm & Buhl, 2002:290; Doloi, 2013:277). The basic estimating tools, such as information, skills, method and schedule are linked to the factors contributing to underestimation (Stewart, 1991:48), while the prevalence of underestimation in building trades arises from a lack of forecasting of market conditions, inadequate historical data, specialised building trades and unforeseen site and market conditions (Ashworth & Skitmore, 1983:21). The effects of underestimation include exposure to risk, financial loss, loss of reputation and credibility of estimator, and give rise to claims and dispute (Flyvbjerg *et al*., 2002:290; Mahamid & Dmaidi, 2013:861), while mitigating factors include estimating techniques, identifying requirements, cost planning, cost control and capacity building (Morrison, 1984:61; Skitmore, 1990:2).

The conceptual framework depicts two paths; the first path leads to inaccurate cost estimation while the second path leads to accurate cost estimation. The research will review all variables highlighted in the framework, in order avoid negative effects and to achieve a successful project with accurate cost estimate by avoiding the contributing factors, prevalence and causes of cost underestimation with strict adherence to the mitigating mechanism.

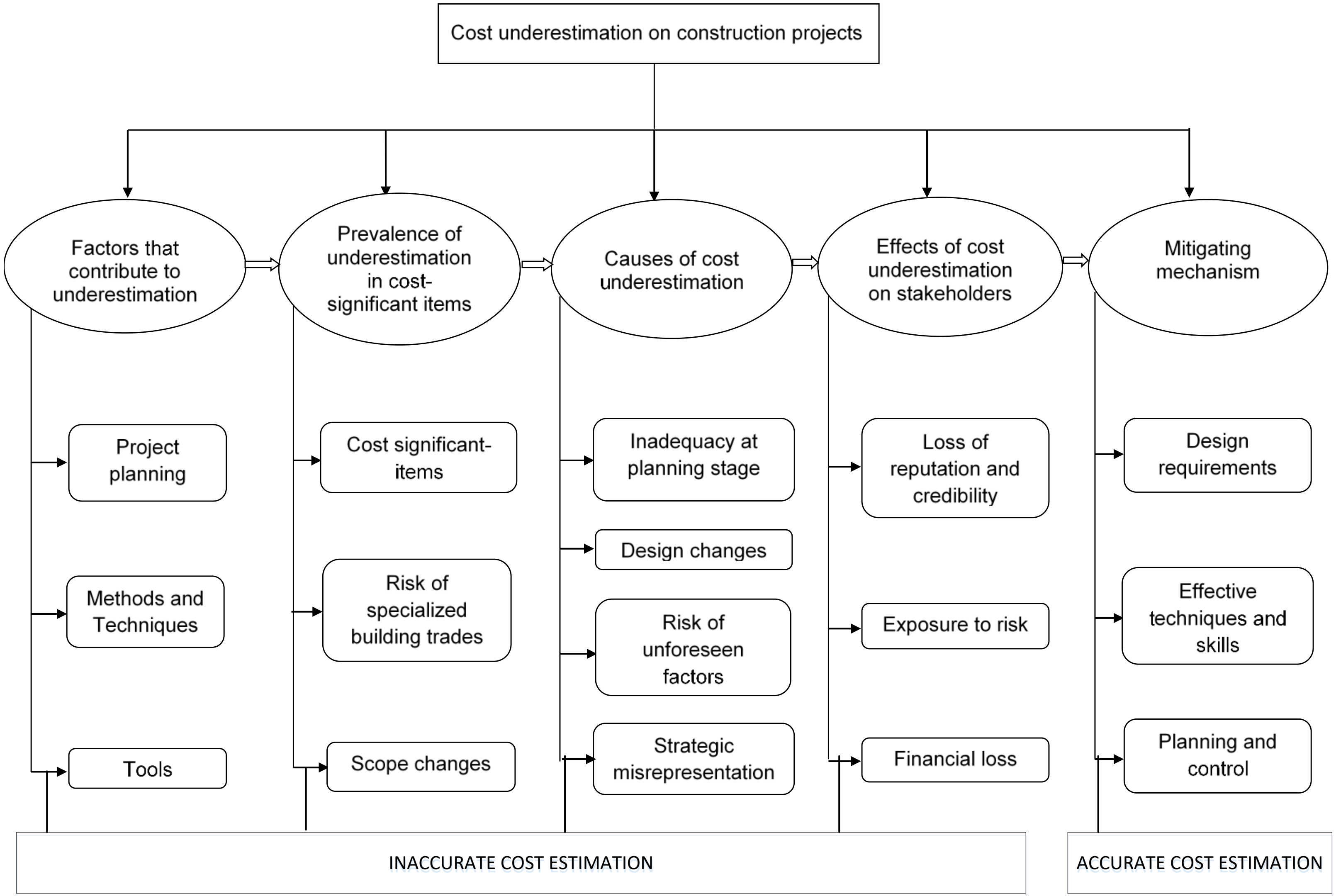

Figure 1.1: Conceptual framework: causes, effects and mitigating mechanisms impacting on underestimation

Source: Own

1.10 Significance

Cost underestimation has effects on the successful delivery of construction project in many areas, which gives rise to cost overrun, claims and dispute. The aim of a project contractor is to achieve delivery and profit while the objective of a project owner is to achieve delivery with "good value for money". With the predominance of cost underestimation on construction projects, these aims and objectives are not achievable.

This research draws attention to the prevalence of cost underestimation in construction projects, which results in financial loss, and the avoidance of dispute relating to additional claims. Upon identifying the factors contributing to the phenomenon of cost underestimation, the research will explore mitigating factors to the problem. These factors will be used as a template for project stakeholders, especially the contractor and estimator, in the construction industry, with the end goal of managing project cost.

1.11 Delimitations

Cost underestimation in construction projects is a global phenomenon. This research will focus on the construction industry within the Cape Town region of South Africa. This research will cover building construction projects ranging from medium to large.

1.12 Limitations

Flyvbjerg *et al*. (2002:5) indicate that previous research has not established whether private projects perform better or worse than those in the public sector. Flyvbjerg *et al*. (2002:30) explain that due to the classified nature of project cost data in the private construction sector, and the need to keep such data from competitors, cost underestimation data are not available to scholars. This research thus may suffer from the limitation of lack of availability of such private sector data.

1.13 Assumptions

In establishing the cost of a project, this research will assume the project cost to be the capital cost including expenses relating to the initial establishment of the facility, such as construction cost excluding the subsequent operational and maintenance cost.

1.14 Ethical statement

The research will adhere to the highest standards in respect of the protection of the dignity, rights and anonymity of entities regarding the dissemination of information, character and confidentially of documentation during the course of this research. This research is intended for academic purposes only.

1.15 Chapter outline

Chapter 1 - Introduction: The chapter presents the background to the research, the ideas and motivation for the research. It highlights the research problem, research questions, research objectives and the aim of the research, including the significance of the research and how the research will be structured, by indicating the research theoretical and conceptual framework. This chapter is concluded by providing the outline of the research project's significance, delimitation, limitations, assumptions and ethical issues.

Chapter 2 - Literature review: The chapter covers the literature on the causes and effects of cost underestimation on construction projects, and classifies the literature into relevant sections of factors contributing to cost underestimation, prevalence of cost underestimation, causes of cost underestimation, effects of cost underestimation and mitigating cost underestimation. Literature from previous research is reviewed with the aim of providing information on the research problem and providing readers with clear ideas of past authors, and input on the research. The chapter concludes with an overview of the main points relating to the literature review by providing the basis for the research project's development.

Chapter 3 – The research design and methodology: The chapter covers the methodological approach, including research strategy, design and analysis of data. The chapter articulates the research variables arising from research questions and research objectives. This chapter concluded with a discussion of the limitations of the data and the scope of the project.

Chapter 4 – The research analysis (results): This chapter presents the data analysis and highlights discussions derived from the analysis. This chapter will articulate the findings on the causes and effects of cost underestimation on construction projects, and suggest mitigating mechanisms. This chapter will be concluded by summarising the main results.

Chapter 5 – Conclusions and recommendations: This chapter presents the summary of all the main points in this research. This chapter draws the results of analysis together with the literature review by discussing anomalies and deviations uncovered during the study. The chapter divides the synthesis of empirical study into the five sub-problems. It further presents a conceptual conclusion on successful project delivery in relation to accurate estimation with particular emphasis on cost-significant items. The chapter discusses the contribution of the study towards possible implementation of policy or practice, which might serve as a guide to project stakeholders in the construction industry. Lastly, the chapter presents the recommendations based on findings and suggests areas that needs further research. It concludes with a summary.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews both past and current literature concerning underestimation in the construction industry. In order to cover the essential and relevant aspects of the research objectives, the literature review is divided into four parts. The first part of the literature review will consider the procedures leading to the preparation of cost estimates of construction projects, with particular emphasis on the estimator's planning, tools, skills and techniques engaged in cost estimation. The second part will review the prevalence of cost underestimation and construction cost-significant work items prone to cost underestimation, as well as risk factors inherent in cost estimation. The third part will review the causes of cost underestimation in construction project and factors which influence inaccuracy in cost estimation. The fourth part will review the effects of cost estimation and mitigating mechanisms.

2.2 Overview of cost underestimation

2.2.1 Cost underestimation in construction industry

A cost estimate is a prediction of expected project cost for a defined scope of work with a degree of assumption, uncertainty and error. Hence, the level of assumption, uncertainty and error can produce cost underestimation (Seeletse & Ladzani, 2012:109). Gunner and Skitmore (1999:268) state that the forecasting of building price is an uncertain business, while an estimator's price is highly subjective. The judgement of the estimator takes as a starting point the base price (cost data) and adjusts for the particular requirements of the new design to be estimated. Nijkamp and Ubbels (1999:1) contend that the study of cost estimates of infrastructure projects is a neglected area. Most studies put emphasis on cost overruns, with little or no attention given to cost underestimation (Kaming, Olomolaiye, Holt & Harris, 1997: 87; MacDonald, 2011:4; Baloyi & Bekker, 2011:53; Mahamid & Dmaidi, 2013:861; Doloi, 2013:177). However, cost overruns and cost underestimation partake of many of the same qualities, though cost overrun occurs towards the completion of a project while cost underestimation occurs at the inception of the project. Hence, it can be posed that cost underestimation will eventually lead to cost overrun. In order to achieve a successful construction project, it is crucial to arrive at a cost estimation that is accurate within certain tolerable limitations.

The process leading to accurate cost estimation is a difficult and challenging one. This is due to the inherent complexity of different projects with regard to gathering of historical data or past experience. Unforeseen factors and unknown risks in construction projects introduce even greater uncertainty to project cost estimates. Akintoye (2000:78) states that important factors which influence cost estimates during tendering process have not received much attention. Hicks (1992:545) as cited by Akintoye (2000:78), in emphasising the importance of cost estimation, contends that "without an accurate cost estimate, nothing short of an act of God can be done to prevent a loss, regardless of management competence, financial strength of the contractor, or know how". Furthermore, Doloi (2013:277) highlights the construction industry's widely-held perception that the competence of the contracting parties is the primary determinant of successful cost performance. However, a wide range of technical, economical, physiological and political factors also come into play, as well as the obvious factor of the competence of the estimators themselves (Flyvbjerg *et al.,* 2002:286).

2.2.1 Factors influencing cost underestimation

Flyvbjerg *et al.* (2002:286) reveals that cost underestimation is common to both first and third world countries, in a wide range of construction projects. This study examined four kinds of explanation relating to cost underestimation:

- Technical: commonly referred to as forecasting error. This error can result from imperfect techniques, incomplete data, honest mistakes, error in future forecasts and inexperience on the part of the forecaster.
- Economic: is explained in terms of both self-interest and public interest. The engineer and construction company have a primary interest in the generation of revenue and profit, which is served by successful completion of the project (self-interest), while public interest provides public officials with incentives to cut cost and save public funds. This explanation would be termed as deceptive as most public regulations forbid misleading information.
- Physiological: touches on the mental state, psyche, and bias inherent in the various project stakeholders, due to the optimistic plans of the promoters concerning the successful outcome of the project. Flyvbjerg *et al.* (2002:288) identify a significant problem with the standard physiological explanation, pointing out that appraisal optimism is likely to influence only inexperienced forecasters.
- Political: Flyvbjerg *et al.* (2002:289) interpret interests and power to political explanation for underestimating cost. The question of deception is further raised in relation to legal, economic and moral reasons. According to Flyvbjerg *et al.* (2002:289), the forecaster or promoter is not likely to admit to researcher or others that they have intentionally fabricated the estimate for a project in order to receive permission to proceed.

Flyvbjerg *et al.* (2002:291) recommend a system of checks and balances in the following areas: transparency, use of performance specifications, formulation of regulatory regimes and involvement of private risk capital. In related studies on the accuracy of cost estimates, Pickrell (1990:61) concludes that cost estimates are highly inaccurate because of errors in forecasting, with actual costs being typically much higher than estimated costs. Skitmore, Stradling and Tuohy (1994:29) deduce that early stage cost estimates are by their very nature imprecise. Nijkamp and Ubbels (1999:1) carried out comparative analysis of cost estimate on infrastructure projects in the Netherlands and Finland, deducing that cost estimates tend to be rather reliable. However, Nijkamp and Ubbels (1999:1) conclude that cost underestimation is vulnerable to inflation, due to delays and extension of time imposed during the preparatory and execution stages of the project, which leads to cost variance caused by market forces.

2.2.1.1 Technical factors

According to Akintoye (2000:77), the tender sum submitted by the contractor combines cost estimate and mark-up. In addition, mark-up is comprised of general allowance for overhead recovery, profit and other indirect cost. Skitmore and Wilcock (1994:148) in their study noted that contractors' estimators price a lump sum amount for complexity of work items based on subjective decisions and experiences. This further indicates that behavioural and environmental factors such as personality, motivation, incentives and habit influence the experientially-based techniques of estimating. A high degree of subjectivity is involved in estimating indirect costs. During tender price submission, senior management typically include a subjective percentage added to the cost estimate. This subjective decision-making is characterised by qualitative data and knowledge that is vague and not easy to quantify (Akintoye, 2000:78). As projects commence, the price rarely remains constant, as various factors necessitate changes in cost during different stages of the project (European Commission, 1998:9).

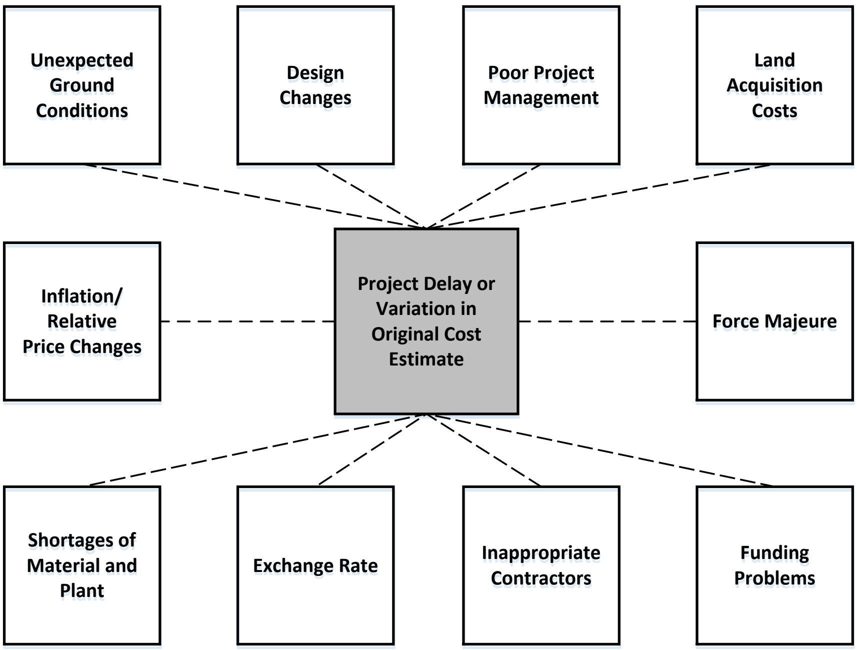

Figure 2.1: Cost-changing factors

Source: European Commission (1998:10)

Figure 2.1 illustrates some factors which change the cost of a project over time. In examining the factors that influence the cost of a project, Doloi (2013:274) puts forward eight factors which critically impact on cost:

- accuracy of project planning and monitoring
- design efficiency
- effectiveness of site management
- communication
- contractor’s efficiency
- project characteristics
- due diligence
- market competition.

Morrison (1984:61) proposes that factors which influence estimates depend upon the nature of the project which is to be estimated. In order to achieve accurate estimate in construction projects, the estimator is required to consider some significant factors which affect the project cost. According to Seeltese and Ladzani (2012:109), the choice of estimate depends on several factors such as: end-use of the estimate, amount of time and money available to prepare the estimate, estimate tools, data available, project definition, and project timing. Stewart (1991:3) relates the outcome of a realistic estimate to greater productivity. Skitmore (1990:2) further argues that accurate estimate generation depends upon variables such as items, quantities, and rates. The accuracy of combination of these variables has a resultant effect on the accuracy of the cost estimate. In essence, it is important to specify the right item and apply the correct quantity at an appropriate rate to arrive at an accurate estimate. Akintoye (2000:86) sums up the factors which relate to accuracy of cost estimating practise as: complexity of project, scale and scope of construction, market conditions, methods of construction, site constraints, client’s financial position, buildability and the location of the project.

2.2.1.2 Economic factors

According to Ponte (2009:3), in arriving at a cost estimate, the project estimator should not only consider the scope of work or design which they are estimating, but also additional information relating to external factors, which are different from the scope of works and design. Estimators use cost data taken from previous projects as benchmarks of cost estimates. According to Morrison (1984:61), cost data selected for estimates are adjusted in order to convert the relevant data from the previous time, location and prevailing market situation to the anticipated time, location and market situation of the new project. Seeletse and Ladzani (2012:111) identify some common cost change concepts as inflation, deflation, escalation, taxation, and currency variation. Ponte (2009:2) proposes several factors to be considered when preparing construction cost estimates: fluctuation of costs, traffic conditions, restrictive work hours or method of work, small quantities of work, separated operations, handwork and inefficient operations, accessibility, geographic location, construction season, and material shortages. In order to achieve accuracy of cost estimates, the following factors must be considered:

- Inflation (price index): According to Ashworth and Skitmore (1983:20), the type of index used for updating the historical cost data has effects on the accuracy of estimate. Inflations of cost have significant effects on the cost of the project, similar to time value of money, and should be adequately considered when calculating cost estimates.
- Economic cycles (market conditions): This is the fluctuation of the economy between periods of expansion (growth) and contraction (recession), changes in the economic situation of a nation. Ashworth and Skitmore (1983:21) point out that market condition is considered to have effects on the accuracy of estimates. Cost professionals make reference to these changes when providing cost advice.

Danto (2013) illustrates, in Figure 2.2, the different economic cycles which have significant effects on the demand and supply in the construction industry, which effectively has effects on the costing of a project.

- Growth: demonstrates increase in demand for construction, competition reduces, profits increase, resources reduce, prices increase and contractors insist on fair conditions.
- Peak: demonstrates demand increase, little competition, high profit margin, long delays in deliveries of resources, resources exceed budget and more construction professionals enter the market.
- Recession: demonstrates weakening of demand, increase in competition, decline in profit margin and reduction of resource costs.
- Trough (narrow depression): demonstrates high competition, profit reduction, low availability, industry fragmentation, good building conditions, and high productivity.

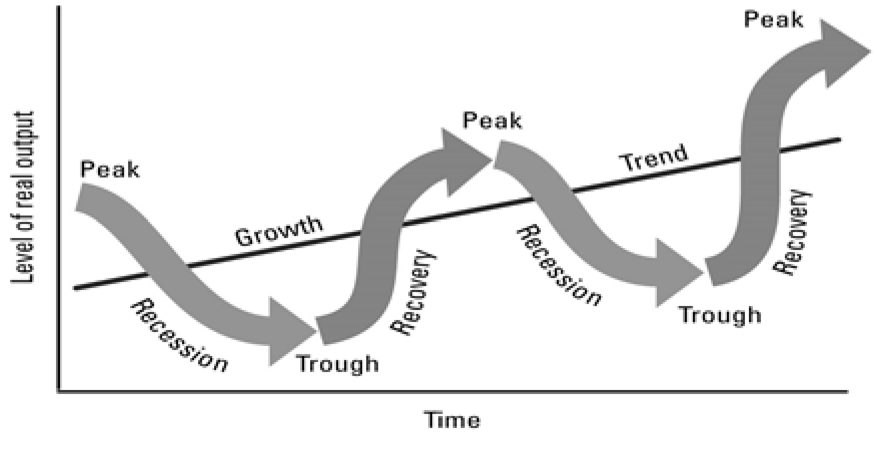

Figure 2.2: Economic cycles
Source: Danto (2013)

2.3 Factors contributing to cost underestimation

2.3.2 Planning for project cost estimate

Project Management Institute (2008:47) proposes the following processes as being core to project planning: scope planning, scope definition, activity definition, activity sequencing, activity duration estimation, schedule development, resource planning, cost estimating, cost budgeting and project planning development.

- Scope planning: the process of developing a written scope statement as the basis for project decisions.
- Scope definition: the process of dividing the project's major deliverables into more manageable components.
- Activity definition: the process of identifying different activities that must be performed in order to achieve project deliverables.
- Activities sequencing: the process of identifying and documenting the interaction of dependent work activities.
- Activity duration estimation: the process of estimating the work periods required to complete each work activity.
- Schedule development: analysing activity sequences, activity durations and resource requirements in order to create the project schedule.
- Resource planning: the process of determining what resources (human, equipment and material) and quantities of resources to be used to execute project activities.
- Cost estimating: develop an approximate estimate of the cost required to achieve project activities.
- Cost budgeting: allocating the work cost estimate to individual work items.
- Project plan development: taking the result of other planning processes and putting them into a consistent and coherent structure for project implementation.

The project cost estimate is prepared at different stages of construction. According to Skitmore (1998:8), the level of information available to the estimator increases as the design progresses. Hendrickson (2000:3) points out that the accuracy level of estimates varies at different stages of project development; estimates prepared at the early stage are less accurate, and estimates prepared at a later stage of project development are more accurate as more information becomes available. According to Flyvbjerg *et al*. (2002:281), cost estimation during successive stages of the project does increase in accuracy, as detailed design information becomes available. The effect of increases in information can be assessed by comparing the accuracy of estimates made at the conceptual design stage to estimates made at the detail design stage. Despite the availability of modern technology and advance methods of computation, realistic estimation still relies heavily on human insight, experience and expertise. The human insight and expertise is referred as the human factor in estimation (Page, 1996:1).

The European Commission (1998:9) reveals the factors that determine the cost of a project as project specification, location, form of procurement and contract, site characteristics, new building or improvement, tax liability, timescale and inflation.

- *Project specification:* This describes the physical attributes of the project to be delivered including functions, objectives, space requirement, appearance, floor space, materials and other related services. The larger and more complex the project specification, the more expensive and challenging the project will be.
- *Location:* The geographical location of a project has effects on the cost of labour and materials to be utilised on the project. Proximity of supplies, climatic or weather conditions, and market conditions all have effects on the cost of the project. Different locations and institutional factors vary within regions and countries, which will obviously affect the project cost.
- *Form of procurement and contract:* The form of procurement, such as negotiated or competitive bidding, used by project promoters will affect the cost. Different forms of contract transfer risk between the project owner and contractor, such as projects designed by employers, present significant design risk for the employer with some cost savings, while projects designed by contractors transfer most design risk to the contractor, with significant cost accrued to the contractor to mitigate such risk. Similarly, the pricing and contracting strategies have effects on the project cost.
- *Site characteristics:* Soil conditions, drainage and access restriction have effects on project cost. The soil condition reflects the amount of excavation, piling and foundation activities to be executed on the project. These site characteristics are factors to be considered in project costing.
- *New building or improvement:* Construction of new buildings will incur more cost than either improvements on existing buildings or refurbishment, because certain items such as land purchase, foundations and service provision are not included when improving an existing building.
- *Tax liabilities:* Some organisations are liable to pay taxes on land purchase and permits, while certain organisations, such as local authority and non-government organisations, are not required to pay such costs. Such levies have effects on the cost of the project.
- *Timescale:* The timescale of the project is determined by the project specifications and complexity. A project can be accelerated if more resources are mobilised. Some projects can take longer due to associated costs involved with re-mobilisation of plant and contractors and non-continuous execution of work, which is related to phasing or interruption. The longer a project takes to implement, the greater the cost.
- *Inflation:* This is the rate at which the general level of prices for goods and services rises, and consequently, purchasing power falls. The general progressive increase in prices of

commodities such as labour, plant and materials is a significant factor to be considered in cost planning for construction projects. The higher the rate of inflation, the higher the cost of labour and materials. The cost of the project is significantly affected by inflation.

2.3.2.1 Definition of works

Seeletse and Ladzani (2012:109) reveal that adequate cost estimates are derived based on the following characteristics:

- a well-defined scope (what are we trying to estimate);
- a cost element structure (how information is organised); and
- historical data.

According to Stewart (1991:33), during the estimation process of a project, some basic questions are asked in order to get started. These questions relate to the project requirement, description, location, and the timing of the work. In the process of preparing the estimate, the following factors are taken into consideration: preparing bill of quantities by defining each item, pricing each item in relation to the work, accessing the general conditions cost, accounting for mark-ups, overhead and profit, factoring in the market conditions, inputting the escalation in relation to rise in labour and material costs, and allowing for contingencies and risks associated with the project.

Stewart (1991:33) further explains the statement of work as a key document which defines what is to be accomplished, for what purpose, and what is to be estimated. According to Stewart (1991:33), the statement of work is the document that answers the following questions:

- *What is it?* Many estimates fail due to the lack of specifying or describing what is to be estimated. The objective, purpose and requirement of work must be spelt out to form the basis of accurate estimates.
- *What does it look like?* In construction projects, a specification is the key factor in describing what is required to be procured. Detail specification takes the form of drawings, sizes, weight, shape, material type and quality. The specification provides comparative descriptions of items and forms the basis for estimates.
- *When is it to be available?* Production rate, production quantity, timing and completion date are important factors to be established before starting to estimate cost. Factors of raw materials, labour availability and timing are key milestones in delivery of products.
- *How is the work structured?* The programme of works details how the work is structured and the tasks assigned to different organisations. The work structure details the sequence of different work elements, including specific performance.
- *Who will do it?* The different organisations or teams assigned to different activities in relation to levels of skills and salary must be known and allocated, with accurate estimates related to specific performance.

- *Where will it be done?* Geographic location of delivery has considerable effects on the estimate. The location has effects on the costs of labour, material and transportation. Estimators should give considerable attention and care to the establishment of cost estimates which take into account the location of the project.

2.3.3 Cost estimating methods and techniques

Royal Institution of Chartered Surveyors (2012:19) highlights three estimating methods comprised of:

- floor area method, such as per square meter;
- functional unit method, such as per-bed space in hospitals, per key in hotels, per house type; and
- elemental method, such as elemental cost estimate indicating different work element.

Cartlidge (2009:38) further categorises cost estimation into interpolation, unit method, superficial method, approximate quantities, builder's quantities, and elemental cost planning.

- *Interpolation:* this technique is used in the early stages such as pre-design, when information relating to design is in short supply (Cartlidge, 2009:39). This technique requires skill and experience in deriving the estimate. A cost analysis of historical data is used by adjustment; either by adding or deducting work elements of a previously completed project, to or from the elements of the new project. Elements of the previous project not incorporated into in the new project are deducted, while elements particular to the new project are added. According to Cartlidge (2009: 39), the process of adjustment continues until all identified differences are reported in the cost estimate.
- *Unit method:* this method is used as a single price rate to determine a functional unit of a building. The unit rate is not flexible to adjust, as it is derived from historical data of other buildings of a similar nature to the new building (Cartlidge, 2009:39). Types of project for which unit method cost estimates are used would be cost per pupils for schools, cost per bed for hospitals, cost per key for hotels, and so forth.
- *Superficial method:* this method is a single rate calculation of the cost per square meter of the building. According to Cartlidge (2009:39), the superficial method should be restricted to the early design stage of the project and this method seems to be the most frequently-used estimating method.
- *Approximate quantities:* According to Cartlidge (2009:41), the approximate quantities method of estimating cost is regarded as the most reliable and accurate method of estimating cost, as it provides sufficient information to work on. The items of work corresponding to the sequence of operations are grouped together, and composite price rates are built up from historical data derived from a similar sequence of operations.

- *Builder's quantities:* This is a method of estimating cost in which quantities are measured and described from the builder's point of view, without a set of prescribed rules (Cartlidge, 2009:41). This method engages a practical approach, reflecting measurement and pricing of work activities in a pragmatic manner, as it unfolds on the site itself.
- *Elemental cost planning:* According to Cartlidge (2009:41), a cost plan is an estimate presented in elemental format, which is based on cost analyses of previous similar projects, while elements of the building are adjusted to suit the new project. In arriving at the elemental estimate of the building, the various sections are taking into consideration, including elements (part of building that performs same function irrespective of construction or specifications) and the components (sub-division of elements) (ASAQS, 1998:3).

Project Management Institute (2008:77) categorises the tools and techniques used for cost estimating into analogous estimating, parametric estimating, bottom-up estimating, and computerised tools.

- *Analogous estimating:* Also called top-down estimating, this technique of estimating uses the actual cost of a similar or pervious project as the basis for estimating. This is used in the early stages of project planning, when a limited amount of information is available. Analogous estimating takes the form of expert judgement, when previous projects are similar in appearance to a new project that requires estimation.
- *Parametric estimating:* This technique of estimating occurs when project parameters (characteristics) in mathematical models are used, such as basing costs on square meters of residential building or per beds of a hospital.
- *Bottom-up estimating:* This technique of estimation is derived from cost of individual work items, summarised up to get the project cost.
- *Computerised tools:* These estimating tools such as project management software and spreadsheets are used in assisting with cost estimating. Such products simplify the use of the techniques mentioned above.

Skitmore and Wilcock (1994:153) reveal that, in a survey conducted on eight building contractors in the United Kingdom, most items were estimated based on previous experience, while a small percentage of specialised items were estimated using the methods prescribed by literature. According to Skitmore and Wilcock (1994:140), there exists much prescriptive literature concerning methods of determining the project price, but the literature contains fewer outlines of the methodology employed by contractors during cost estimation. It is generally recognised that most estimators don't keep formal records of site performance; so contractors' estimators typically base their calculations on prior experience, rather than utilising methods prescribed by the literature. According to Doloi (2013:267), the ability of contractors to use sophisticated methods of estimating at the early stage of a project is crucial to achieving cost success. Cost estimating methods and techniques are considered to be key factors in project cost estimation.

Morrison (1984:61) highlights the different estimating techniques commonly used by quantity surveyors to determine cost estimates, such as the unit method, floor area method, approximate quantities and bill of quantities. According to Seeletse and Ladzani (2012:109), the choice of estimating method depends on several factors such as the end-use of the estimate, amount of time and money available to prepare the estimate, estimating tools and data available, level of project definition, design information available, and the timing or phase of the project. It is important to use suitable estimating methods and techniques that correlate with the cost data information available.

Skitmore and Gilmore (1989:36) explore the difficulties of compatibility that are inherent in transition from one estimating technique to another. Figure 2.3 illustrates different estimating techniques that are appropriate to different design stages. As more information is made available through different stages of work, estimators will need to proceed to different forms of estimating technique. However, this will often entail the reworking of estimates from scratch, due to non-compatibility of different estimating techniques. The more detailed the project information made available, the more sensitive the estimating techniques are (Skitmore & Gilmore, 1989:36).

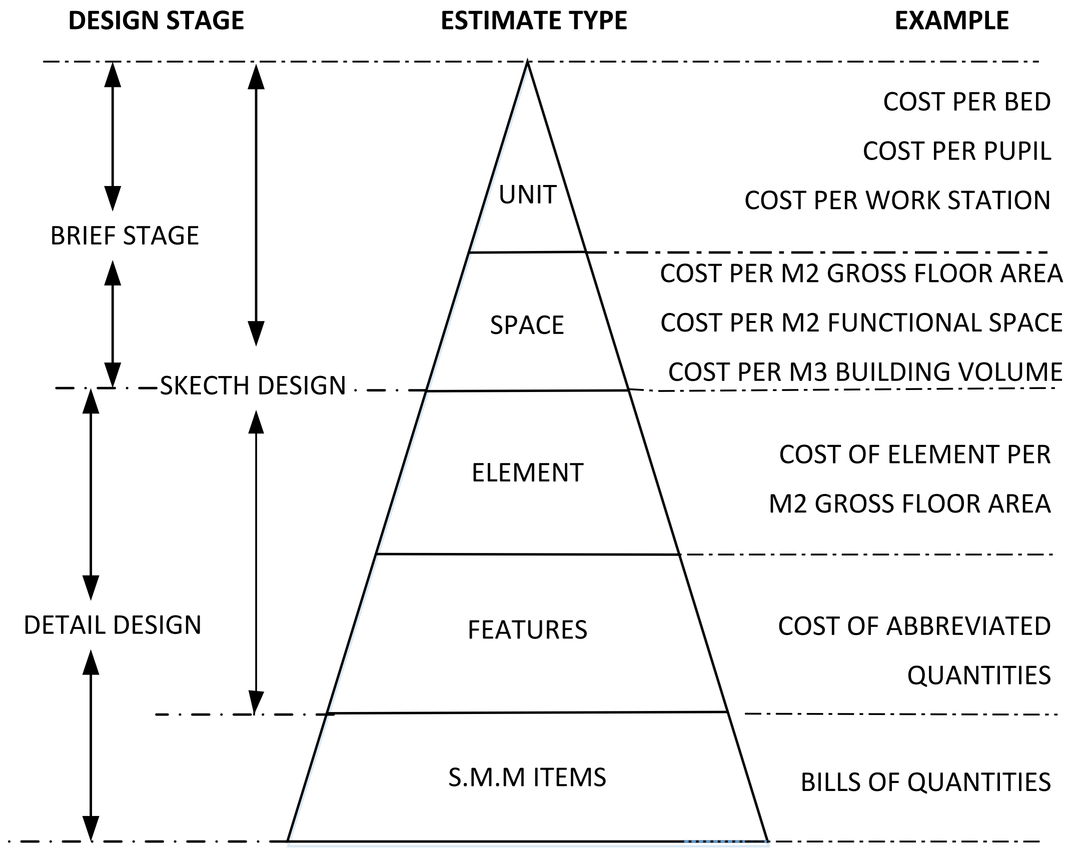

Figure 2.3: Traditional early stage estimating
Source: Skitmore and Gilmore (1989:36)

2.3.3.1 Basic functions of estimates

According to Hendrickson (2000:4), project estimates are classified into three basic categories and these categories serves three basic functions:

- *Design estimate:* The design estimate typically derives from the project owner and the owner's appointed design team. The design estimate covers the project planning stage and design stage and incorporates: screening estimate (order of magnitude estimate), preliminary estimate (conceptual estimate), detail estimate (definitive estimate), and engineer's estimate (based on the completed plans and specifications).
- *Bid estimate:* The bid estimate is prepared and submitted by the contractor to the owner for competitive or negotiated tender. The contractor prepares this estimate based on information gathered from subcontractor quotations, quantity take-offs, labour and materials prices and construction procedures.
- *Control estimate:* The control estimate is used to check cost from time to time. When deviation from the initial project estimate occurs, changes in scope of design and works are monitored by the control estimate. Hence, both project owners and project contractors engage cost control mechanisms during design and construction works, by applying design estimates or bid estimates.

2.3.3.2 Cost estimating procedure

Dell'Isola (2003:6) describes the process leading to the preparation of the cost estimate as consisting of the following phases: establishing the scope and the physical state of the project, preparing an organised work plan for estimate, reviewing the estimate, reconciling and presenting the estimate. According to Project Management Institute (2008:76), the cost estimating process considers three key elements as illustrated in Figure 2.4.

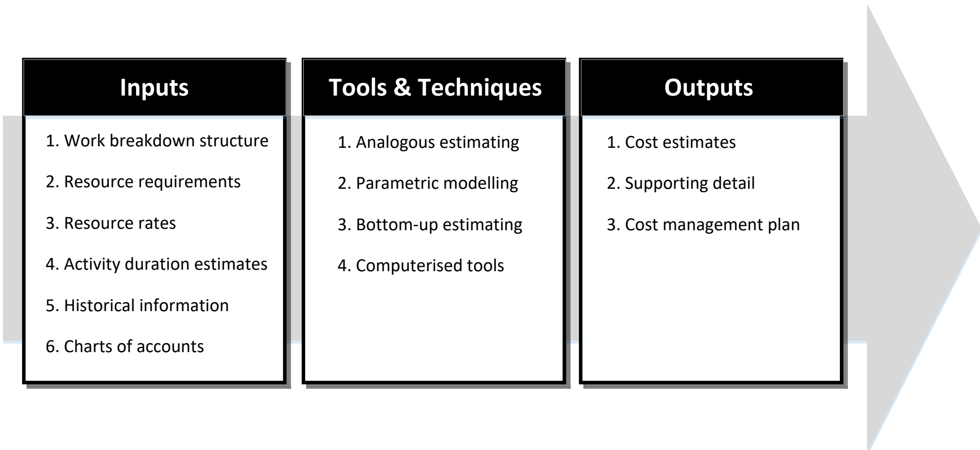

Figure 2.4: Estimate costs: input, tools & techniques and outputs
Source: Project Management Institute (2008:76)

Anderson, Molenaar and Schexnayder (2007:11) arrange cost estimating practise into four basic steps, as listed in Table 2.1, which includes descriptions of the activities which are performed in the various steps. These steps highlight the required information and various tasks accomplished in the process leading to cost estimation on construction project.

Table 2.1: Cost estimation process

Cost estimating steps	Description
Determine estimate basis	Document project type and scope, including: • scope document • drawings that are available (defining percentage of engineering and design completion) • project design parameters • project complexity • unique project location and characteristics • discipline require to prepare the cost estimate
Prepare base estimate	Prepare estimate, including: • documentation of estimate assumption, type of cost data and adjustment to cost data • application of appropriate estimation techniques, parameters and cost data consistency with level of scope definition • coverage of all known project elements • coverage of all known project conditions • checking of key ratios to ensure that estimate are consistent with past experience
Determine risk and set contingency	Identify and quantify area of uncertainty related to: • project known and unknown • potential risk associated with these uncertainties • appropriate level of contingency congruent with the project risks
Review total estimate	Review estimate basis and assumptions, including: • method used to develop estimate parameters (e.g. quantities) and associated costs • completeness of estimate relative to the project scope • application of cost data, including project-specific adjustments • reconciliation of current estimate with the baseline estimate (explain differences) • preparation of an estimation file that compiles information and data used to prepare the project estimate

Source: Anderson *et al.* (2007:11)

2.3.3.3 Collection and storage of cost data

According to Royal Institution of Chartered Surveyors (2012:40), the bill of quantities is one of the best sources of real-time cost data. Bills of quantities can store, analyse and reprocess cost data such as distinct rates, detailed elemental cost analyses, element unit rates, cost per meter square of gross internal floor area, and/or functional unit rates. The main functions of the bill of quantities are to present a coordinated list of components or items; descriptions and quantities, and apply rates in order to prepare project cost. In addition, the bill of quantities provides vital tools of cost management and cost control including pre-tender estimates, post-tender estimates, cost planning, pricing variations, and interim valuations and payment (Royal Institution of Chartered Surveyors, 2012:38).

2.3.3.4 Types of estimates throughout construction stages

Figure 2.5 shows the Royal Institute of Architects established construction work stages, in relation to Royal Institution of Chartered Surveyors order of cost estimate. Each of the different stages of construction requires a suitable technique of estimate, and these estimates are developed into detailed form as the stages of work progress.

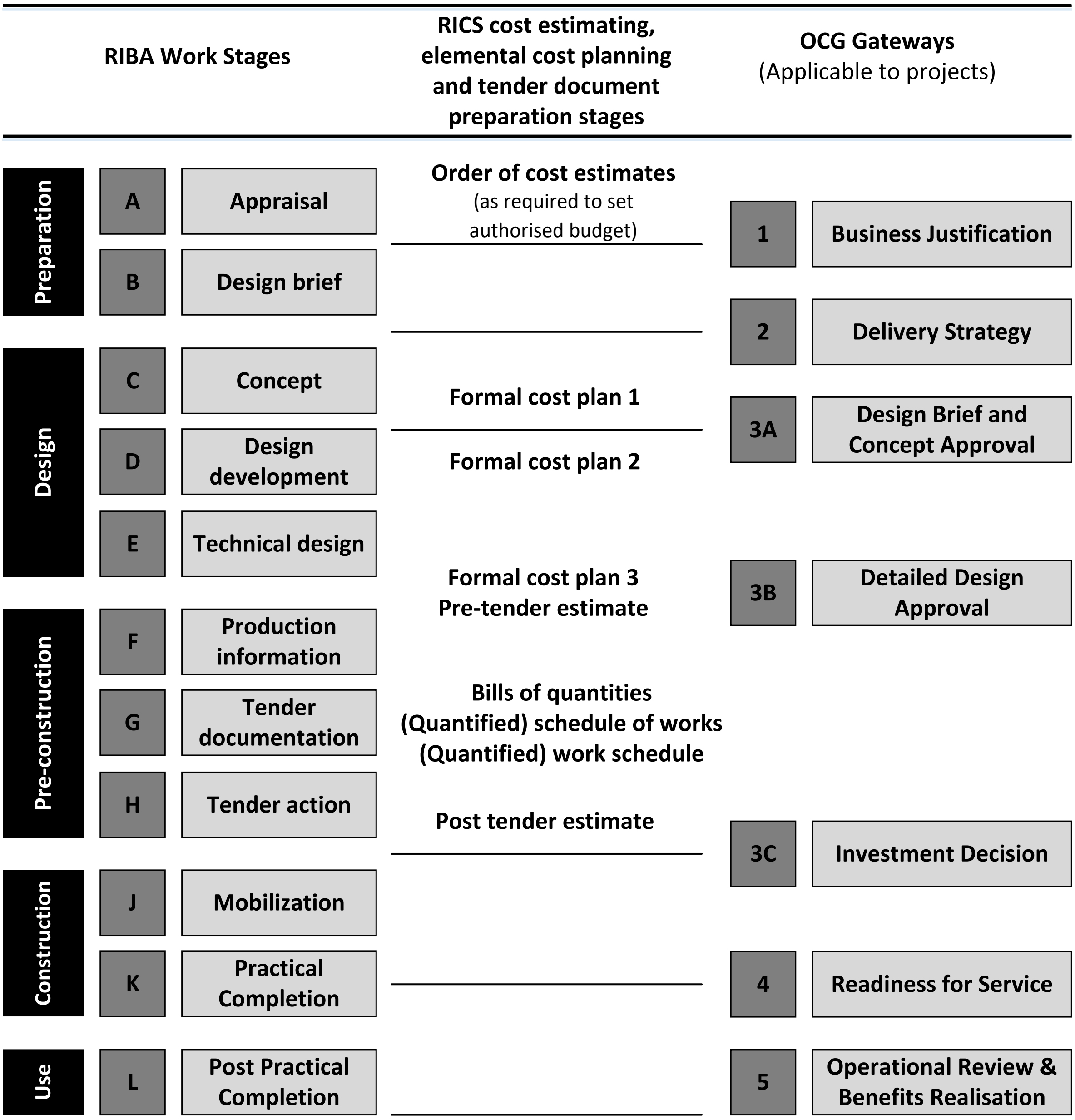

Figure 2.5: Cost estimating, cost planning and tender documentation preparation stages
Source: Royal Institution of Chartered Surveyors (2012:8)

- *Preliminary estimate:* Estimating technique such as the unit method, floor method and approximate quantity method are categorised under preliminary estimate. The preliminary estimate is established during the initial stage, sometimes referred to as the conceptual phase of the project, and assists in deriving feasibility of the project. The clients base their budget decision-making on the preliminary estimate. The estimate is derived from measurement and costs for various elements and components of the construction project. It is sometimes derived using the construction area, shapes, volume, sizes and other similar conceptual estimating techniques.
- *Detailed estimate:* This provides a greater degree of accuracy of cost estimation. It also facilitates competitive tender, comparative evaluation of tender price, contract compilation, measurement and pricing strategy, cost control, progress valuation, payments and compilation of final accounts. A bill of quantities is used to derive a detailed estimate, applying detail design and project information. Stewart (1991:50) identifies the requirements of the detailed estimate as detailed design information, including manufacturing, assembling, testing, and delivery.

Morrison (1984:60) points out that it is possible to establish the performance of a quantity surveyor's degree of certainty on cost estimation when a more detailed estimating technique is used. The accuracy of the cost estimate depends on the technique applied by the cost professional during the production process of the cost estimate. Morrison (1984:61) states that using differing estimating techniques at a particular stage of work will affect the accuracy of the cost estimate; thereby providing a closer analysis at a detailed level.

2.3.3.5 Composition of cost estimate

As project work elements and composition varies from project to project, so the composition of the project cost estimate varies within each of the project parameters. Dell'Isola (2003:3), in Figure 2.6, illustrates the detailed breakdown of the construction cost estimate to include cost of materials, installation, labour, equipment and mark-ups.

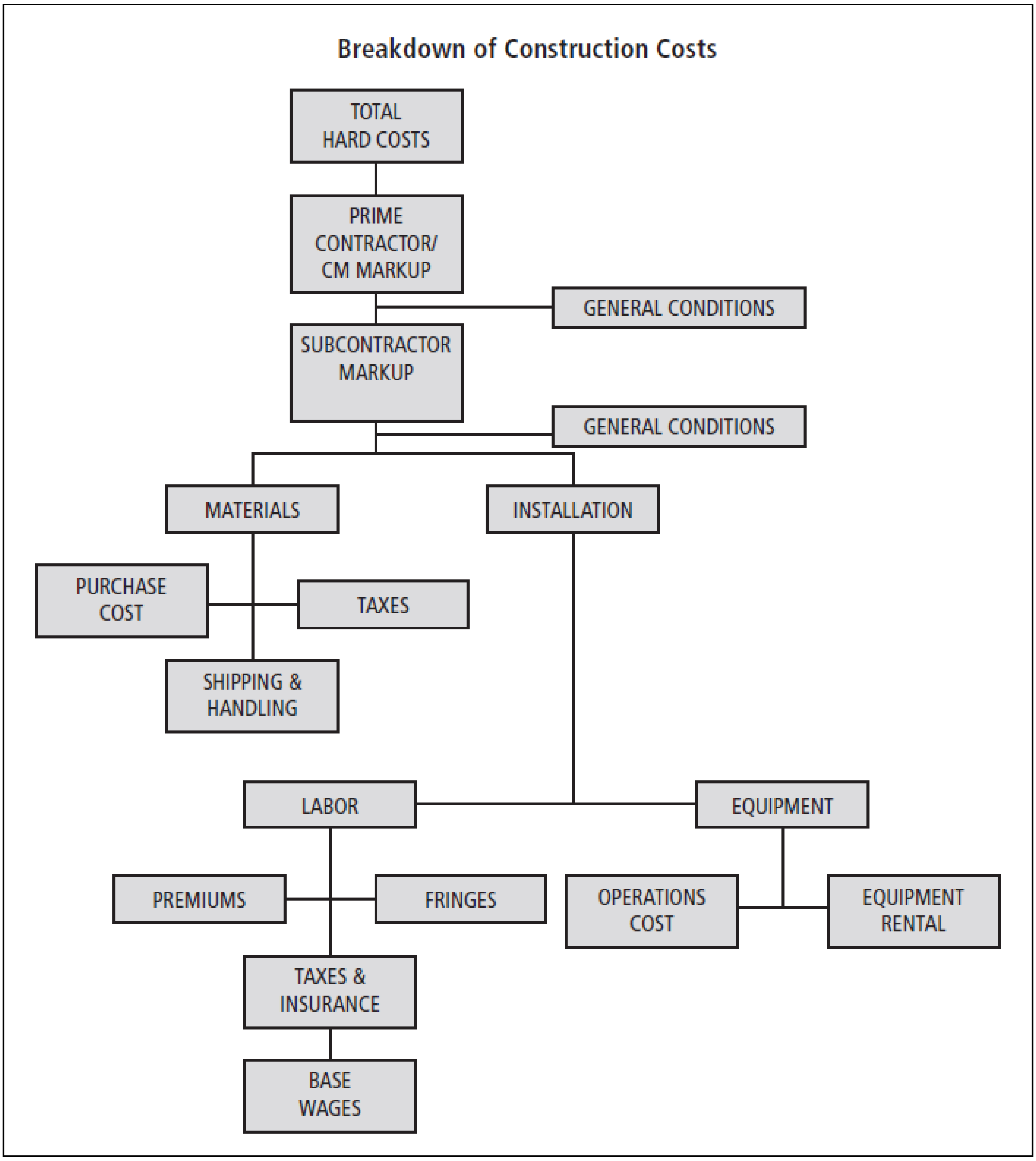

Figure 2.6: Breakdown of construction cost
Source: Dell'Isola (2003:3)

Table 2.2 provides a broad description of major items and disciplines of work that are necessary in the preparation of the cost estimate, and which should be given consideration by estimators in the process of arriving at a project cost estimate.

Table 2.2: Disciplines of work

	Categories	Components	Items
1	Direct cost	Processing equipment	Tower crane, batch plant.
		Site preparation	Clearing, cutting, filling, borrow pit
		Site improvement	Plant site, fencing, site establishment
		Building works and trades	Earthworks, concrete works, masonry, carpentry, steel works, metal works, electrical and IT, plumbing, mechanical, finished works
2	Construction equipment	Rental or purchase	
		Service labour	
		Fuel, lubricant, grease, supplies	
3	Overhead and indirect cost	Indirect labour	Salary indirect, office hourly indirect, field hourly indirect
		Temporary construction facilities	Temporary buildings
		Labour burden and overhead personnel benefits	Retirement and saving plans, insurance plan and medical plans, taxes – payroll, vacation pay
		Small tools and consumables	Construction supplies, small tools, workmen's supplies
		Other indirect cost	Advertisement, bond premium, communications and postage, containers, dues, engineering supplies, expediting, heat, light, water and power, legal, licence and permit, office supplies, safety, travelling, testing and laboratory, data processing, consulting services, trade book, journal, quality assurance, employer education
4	Head office cost	Engineering / design service	
		Construction service	
		Project management	

Source: Page (1996:2).

2.3.4 Tools for cost estimate

A study conducted on emerging South African contractors reveal that inadequacy in cost concepts, scheduling tools, risk management and price estimation is common in costing projects (Seeletse & Ladzani, 2012:106). According to Stewart (1991:48), the basic tools for estimating are as follows:

- *Information:* Every cost estimate should include thorough and complete information concerning the process, product, project and service being estimated. In construction projects, the information takes many forms, including drawings, specifications, historical cost data, labour and workmanship, materials, plant, supervision, establishment, specialist, services, levies and taxes. The higher the amount of project information available, the greater the accuracy of the cost estimate (Skitmore, 1987:327).

- *Method:* There are different methods of estimation. Depending on the timing, stages and degree of accuracy required, a suitable method of estimation should be adequately considered.
- *Schedule:* This is a tool that is required to develop the estimate. Details on the timing of activities and completion dates should be planned into the scheduling tool in order to show the phases of the estimating cycle.
- *Skills:* Different skills are required in the relevant areas relating to the project cost estimate. It is important to acquire the necessary skills, either individual or collective, in order to achieve a viable or accurate estimate.

Skitmore *et al.* (1994:29) argue that the skill of the estimator is a key factor in the practice of forecasting construction price. Skill is relevant to other factors which affect quality of cost estimates, such as information, technique and expertise of forecaster. According to Olatunji (2012:28), estimators are moving beyond the conventional estimating procedure, towards information technology (IT) based estimating procedures such as CAD-enabled or BIM-enabled procedures. As the IT-based solution gains greater currency, estimators need to develop their skills beyond the conventional estimating procedure. The expertise required of forecasters varies across different generic building contracts, such as educational, medical, industrial, retail, offices, housing and other engineering contracts; hence such expertise is perceived to be tightly bounded and is suggestive of a difference in forecasting processes of different types of projects. The expertise of the cost estimator does not necessarily translate well across a wide range of project types (Skitmore *et al*., 1994:38).

2.4 Prevalence of cost underestimation

The South African construction industry does not operate in isolation and it is affected by the global phenomenon of cost underestimation. According to Flybjerg *et al.* (2002:285), cost underestimation spreads across all spectrums and types of construction projects. In 2006, South Africa embarked on the hosting of a major soccer tournament which recorded a high occurrence of cost overruns during the construction of the 2010 World Cup soccer stadiums across the different regions of South Africa. Baloyi and Bekker (2011:53) highlight this in Table 2.3 by comparing the initial cost estimates and final costs of the 2010 World Cup stadia, thus showing the extent of cost underestimation of the initial budgets of the various projects.

Table 2.3: The 2010 FIFA World Cup stadia in South Africa

Stadiums	Regions	Initial budget	Final cost
Soccer City	Johannesburg	R 2.2 billion	R 3.7 billion
Ellis Park	Johannesburg	R 240 million	R 253 million
Moses Mabida	Durban	R 1.6 billion	R 3.1 billion
Mombela	Nelspruit	R 600 million	R 1 billion
Green Point	Cape Town	R 2.9 billion	R 4 billion
Nelson Mandela Bay	Port Elizabeth	R 2.1 billion	Not known
Peter Mokaba	Polokwane	R 1.3 billion	Not known
Royal Bafokeng	Rustenburg	R 360 million	R 483 million
Mangaung	Bloemfontein	R 245 million	R 359 million
Loftus Versfeld	Pretoria	R 122 million	R 131 million

Source: Baloyi and Bekker (2011:53)

2.4.1 Effects of cost-significant items

ASAQS (1998:3) defines elements as any part of building that performs the same function irrespective of its construction or specification. According to Nijkamp and Ubbel (1999:17), key project work elements have effects on the cost estimate. In order to apply the correct quantity and rates, correct elements need to be identified. ASAQS further sub-divides elements into sections such as primary elements, special installation, alterations, external works, training, preliminaries, contractor's fee, contingencies allowance, escalation and value added tax. Table 2.4 presents a summarised breakdown of construction elements.

Royal Institution of Chartered Surveyors (2012:54) relates the degree of the detail of building work to measure to the cost-significant elements in the particular design, where sufficient information is available, the cost-significant items are to be measured in approximate quantities. Vilfredo Pareto's 80:20 rule: the 80% value of the BOQ is contained in approximate 20% of the items, hence the items contained the 20% is termed as cost-significant items (Hamish, 2002). Smith and Jaggar (2007:78) describe some cost-significant elements and their cost effect:

- *Substructure:* In a project where soil condition is severe and pile foundation is required, or adjacent structures require underpinning, substructure will be cost-significant. Foundation type, depth, soil condition and the need for a basement will influence the cost of project. However, in the case of a multi-storey building, the cost of the substructure will be spread over the total number of floors and often represents a small ratio of the total cost.
- *Frame (columns, upper floors):* These are relatively high-cost elements, representing between 10% and 20% of total cost. Frames may not greatly affect cost, but are likely to influence construction time significantly. Non-cost-significant items (design requirements)

such as project size and shape also influence the frame cost. Staircases are classified under frame, but are not likely to be cost-significant as the costs are spread over the floor ratios, especially for multi-storey building, and are also attributed towards fire and evacuation requirements.

Table 2.4: Breakdown of construction elements

Primary elements	**Special elements**	**External works and services**
• Foundations • Ground floor construction • Structural frame • Independent structural components • External envelope • Roofs • Internal divisions • Partitions • Floor finishes • Internal wall finishes • Ceilings and Soffits • Fittings • Electrical installation • Internal plumbing • Fire services • Balustrading	• Piling • Sun control screens, grilles • Raised access floors • Special fire protection • Lifts • Escalators • Air conditioning • Ventilation • Heating • Special electrical installations • Compactors • Access Control • Gondolas • Stoves, kitchen equipment • Specialised equipment • Security systems • Communication systems • Prefabricated cold rooms • Signage, artwork	• Soil drainage • Sub-surface water drainage • Storm water drainage • Water supplies • Fire service • External electrical installations • Connection fees • Demolitions, site clearance • Earthworks • Boundary, screen, retaining walls, etc. • Fencing and gates • Roads, paving, etc. • Covered parking, walkways • Pergolas, canopies, etc. • Minor construction work • Pools • Sports facilities • Garden works
Alteration	Training	Preliminaries
• Alteration	• Training	• Preliminaries
Contractor's fee	Contingencies allowance	Escalation
• Contractor's fee	• Price and detail development • Building contract contingencies	• Pre-tender escalation • Contract escalation

Source: ASAQS (1998:5)

- *Envelope (external walls and windows):* The shape of the building influences this element, and the specification requirement of this element is of great importance and most likely will influence cost. The envelope typically represents between 10% and 20% of total cost.
- *Roof:* On multi-storey buildings, the roof cost is spread over the total cost. Hence, the roof represents a less significant proportion of costs the higher the numbers of floors.
- *External door:* This element is not normally cost-significant, but may be subject to a great deal of quality and design requirements, which may affect total cost.
- *Internal subdivision (internal walls, screens and doors):* This element could represent a low ratio of building cost, depending on the type of building. In an open plan office building, less internal division is required, as most tenants will implement internal office layouts.

Residential buildings will likely have higher cost ratios, since most internal division will be part of the building. Their ratio represents between 5% and 10% of total cost.

- *Finishes (wall, ceiling and floor):* Wall finishes are related to internal subdivision, while ceiling and floor are inclined to quality and design selections. Suspended ceilings and access flooring have higher costs, but their selection provides accessibility for installation and passage of services.
- *Fittings:* These elements include fit-outs such as wardrobes, bathroom, kitchen and built-in fittings and their cost can be influenced by the quality and design, which can be a significant cost item, between 5% and 10% of the total cost.
- *Services:* These elements range between 30% and 40% of the total cost and are important aspects to be considered in construction projects. Building services are mostly mechanical items such as air conditioning, ventilation, heating system and lifts. They are elements which should be carefully designed in relation to capital cost, operating and maintenance cost requirements.
- *External works:* These are not usually cost-significant items in building projects. However, on large construction sites, extensive external works and services will most likely influence and increase the cost ratio of external works on the total cost, thereby making it a cost-significant item.
- *Preliminaries:* These items represent between 8% and 15% of the total cost. Hence they are considered a cost-significant item. Cost of preliminaries is general influenced by factors such as access to site, storage, building height, scaffolding, adjoining property, insurance, supervision, temporary works, plant and equipment requirements and project complexity.

2.4.2 Risk of specialised trade

It is widely acknowledged that risk associated with specialised trades exist on construction projects. In the case of most projects, such risk factors contributes project costs exceeding initial cost estimates, and can be due to several other unforeseen events which arise during the course of project execution. Estimators rely on experience and project information which is available in the pricing of risk based on the nature and complexity of different projects. Contrary to the general perception within the construction industry that large projects are easier to estimate, Skitmore and Cheung (2007:458) argue that large projects are more complex and tend to be difficult to estimate. Hence, from the client’s point of view, the margin of error in both large and small projects will imply that large dollar error is more significant than small dollar error. Skitmore *et al.* (1994:39) also point out that the complexity and degree of building services in construction projects require high emphasis and special attention. Flyvbjerg *et al.* (2002:282) describe cost underestimation by project type and further suggest that the complexity of technology and geology might have effect on cost underestimation.

Babalola and Adesanya (2007:75) state that increased ‘quality of life’, modern technology and the design and construction of specialised services such as telecommunication, are becoming increasingly significant, as building services are making up a greater proportion of building cost and often involve the largest subcontracts. The design of electrical services is becoming more complex and thus creating large cost gaps in the pricing of electrical works. Babalola and Adesanya (2007:76) suggest that the traditional method such as the superficial method of cost per square meter used to estimate mechanical and electrical works are inappropriate and ineffective. Babalola and Adesanya (2007:76) also noted that mechanical and electrical works cost data, published by Building Cost Information Service (BCIS), is inadequate; and a method of collecting appropriate information is required.

Azman and Samad (2011:3) illustrate five broad factors (Table 2.5) which affect project cost: scope quality, information quality, uncertainty level, estimator performance and quality of estimating procedure. Duffey and Dorp (1998:29) identify simulation based-project risk analysis as a possible tool to address unrealistic estimates, which are often associated with traditional methods of cost estimation for large projects.

Duffey and Dorp (1998:29) describe Monte Carlo simulation of activities network as a common tool for cost risk analysis, but stress that some issues relating to practical implementation and methodological approach remain to be addressed. Risk analysis tools and management techniques are not widely used by contractors (Akintoye & MacLeod, 1997:37). Skitmore and Cheung (2007:455) posit that overestimating project cost estimate seems to be a medium of risk reduction for the estimator in order to preserve their reputation with the client. The estimator aims to be ‘on the safe side’ when preparing cost estimates, based on the assumption that clients are more tolerant of overestimation than underestimation. Hence it is assumed that estimators add a suitable amount to their honest estimate to allow for risk factors inherent in cost underestimation.

Table 2.5: Factors affecting project cost

Scope quality	Design scope (shape, size, height, specification and performance
	Design team experience (architect, engineer, etc.)
	Unclear documentation (project brief/drawing)
	Location of project (site and soil conditions and extent of services)
	Type and condition of contract
	Basic of selection (open, selective and direct negotiated)
	Commitment of client to project
Information quality	Cost data (historical and current information)
Uncertainty level	Project complexity and technology level
	Market conditions and sentiments
Estimator performance	Quantity surveyor or estimator experience
	Ability of quantity surveyor to cope with stress (work pressure)
	Communication barriers
	Familiarity of quantity surveyor with the type of project
	Perception of estimating importance
Quality of estimating procedure	Expected level of error in estimate
	Limited time to prepare estimate due to dateline
	Estimating method used in the preparation of estimate
	Application of alternative method by organisation
	Organisation's estimating procedure

Source: Azman and Samad (2011:3)

2.4.3 Scope changes

Buertey (2014:149) identifies the substructure, electrical and IT, mechanical and finishes trades as main work sections which are prone to high scope changes. Table 2.6 highlights the causes, effects and compensation of work sections, which are highly prone to scope changes. The risks associated with specialised building trades have not been broadly highlighted in most research relating to cost underestimation. The unforeseen situations relating to inadequate specifications and incomplete drawings are attributed to the inaccuracy in cost estimation of specialised trade (Al-Hasan, Ross & Kirkham, 2006:1). Al-Hasan *et al.* (2006:9) maintain that the main methods of estimating specialised trade, such as mechanical and electrical work, do not differ from traditional methods of measuring other building trades. However, such traditional methods are inaccurate and rely on the judgment and experience of the estimator. Al-Hasan *et al.* (2006:9) state that previous recorded data derived from site feedbacks are more reliable and provide more accurate cost estimates. Al-Hasan *et al.* (2006:9), however, note that large construction companies have reservations about using site feedback, due to the unstructured nature of such feedback.

Table 2.6: Factors affecting work section prone to scope changes

Work sections prone to changes	Causes	Effects	Detection and compensation
Substructure (foundation)	Changes in substructure works quantities and cost due to variation Incomplete design and lack of technical site survey The sudden eruption of rare ground conditions	Changes in substructure design Changes in associated cost of ground work Varied secondary risk of variations, specifications changes, etc.	Resurvey of ground work Overdesign of substructure work Proper geological survey and ground survey
Electrical and IT installations	Sudden introduction of work elements into the work inflation cost Unavailability of design for services during tendering Use of price cost sum in documentation resulting from late design	New work sections and items introduced into the work Delays in the work and unbudgeted variation Inadequacy of contingencies	Critical examination of quantities and early service design
Mechanical installations (lift, escalators, air-conditioning)	Sudden introduction of work elements into the work inflation cost Incomplete scope definition and late design delivery during tendering Use of price cost sum in documentation resulting from late design	New work sections and items introduced into the work Delays in the work and unbudgeted variation Inadequacy of contingencies	Critical examination of quantities and early service design
Finishes (wall, ceiling, floors)	Changes in specification of finishes Changes in the taste of the client Incomplete definition of specification	Challenged planning and late decision of procurement Project time overrun resulting from late delivery of finishes	Minimisation of client change in taste and certainty in scope definition

Source: Buertey (2014:148)

2.5 Causes of cost underestimation

According to Baloyi and Bekker (2011:60), the most significant contributors to cost overrun in the construction of the 2010 FIFA World Cup stadia in South Africa are increase in material cost, inaccurate estimates, shortages of skilled labour, client's late contract award, project complexity, increases in labour cost, inaccurate quantity take-off, difference between selected bid and consultant's estimate, change order during construction and shortage of manpower.

2.5.1 Inadequacy at planning stage

Nijkamp and Ubbels (1999:17) reveal that price rise, project changes, incompleteness of cost estimation and omission of key elements at the project planning stage are causes of cost underestimation. The production of accurate cost estimates at the early stages of the project remains a challenge for most organisations involved in the development and delivery of infrastructural projects (MacDonald, 2011:8). CURT (2004:4) suggest that the cost and time may exceed forecast if other factors are not properly managed. CURT (2004:4) further suggest shifting bulk analysis, design and decision-making of the project to the inception in order to maximise good opportunity in decision-making processes. Al-Hasan *et al*. (2006:9) identify the causes of inaccurate cost estimates as being: insufficient time for estimating, inadequate specifications, incomplete drawings, quality of project management, lack of historical cost data, and lack of confidence in the structure of site feedback. Some of the other key issues relating to cost underestimation are inadequate cost checks, incompleteness or mistakes by estimators assigned the responsibility of estimating the cost of the construction project.

2.5.2 Strategic misrepresentation

Flyvbjerg *et al.* (2002:290) point out that the majority of researchers concur that most projects are cost-underestimated as a result of misrepresentation such as lying, and that there is no significant evidence to conclude that such underestimation is caused by error. According to Gupta (2009:159), optimism bias and strategic misrepresentation are the main causes of cost underestimation. Gupta (2009:159) describe optimism bias as the tendency to be over-optimistic about the outcome of a project (which includes over-estimating the likelihood of positive event and under-estimating the likelihood of negative event).

Pickrell (1990:66) conducted a study on the accuracy of train ridership projections that were available to decision-makers in the United States of America. This study identified the causes of difference between the forecast and actual performance of the project. The study established the bias of the forecaster, arising due to the economically preferred transit mode that higher ridership is spread over lower capital cost and operating expense. According to Nijkamp and Ubbels (1999:1), decision-makers are faced with hesitation to approve new large infrastructure project due to uncertainty about the cost estimate. Pickrell (1990:66) concur that forecast errors in estimates may have led project decision-makers to choose projects that would have appeared less desirable if accurate forecasts were available. Nijkamp and Ubbels (1999:1) maintain that cost estimates play a major role in decision making, and often provide reliable information about the expected costs for the entire project, as well as help to maintain the budget.

2.5.3 Design changes and material price

Baloyi and Bekker (2011:55) reviewed the causes of cost overrun in three different perspectives:

- clients' action from additional works or changes to work;
- contractors' action of time delays; and

- external factors of material price changes.

From the point of view of most contractors, cost underestimation is a result of inaccuracy of material take-off, increases in material costs and cost increase due to external factors (Kaming, Olomolaiye, Holt & Harris, 1997: 87). Monyane (2013:70) concluded, in a study conducted in the Free State region of South Africa, that inadequate planning and incomplete design at the time of tender are the main causes of cost underestimation. Nijkamp and Ubbels (1999:20) posit price rise, inflation, incompleteness of estimate, project changes and soil as causes of underestimation.

2.5.4 Risk of unforeseen factors

Olupolola, Agnes and Adeniji (2009:228) highlight construction risk as a threat which exposes a project to the possibility of economic or financial loss, physical damage or injury, or delay. Aziz (2013:61) lists high ranking factors which expose projects to risk: lowest bidding procurement method, additional work, bureaucracy in bidding/tendering method, wrong method of cost estimation, funding problems, inaccurate cost estimation, mode of financing and payment for completed work, unexpected ground conditions, inflation, and fluctuation in prices of raw materials. Mahamid and Dmaidi (2013:866) highlight different risk factors relating to construction projects, such as estimating, construction items, project participation and financing factor.

2.5.4.1 Estimating factors

Mahamid and Dmaidi (2013:866) highlight four factors that are significantly related to the process of estimating, such as wrong estimation method, fluctuation of material price, bureaucracy in tendering methods, long periods between design and time of tendering.

- *Wrong estimation method:* Pfleeger, Wu and Lewis (2005:83) reveal that uncertainties are inherent in the selection, application and interpretation of the estimating method, thus affecting the estimation result.
- *Fluctuation of price of materials:* In certain projects, adjustments are allowed for changes in prices of materials, while other projects omit such adjustments, thereby making provisions for built-in cost of inflation in contract prices. Ramus, Birchall and Griffiths (2007:158) explain that fluctuations are normal in market conditions and take the form of such phenomena as changes on duties or taxes on materials, cost of labour, plant and equipment. Other price changes, such as buying in part loads or small quantities, as well as changes in the buying of materials from another supplier with less favourable discounts are not considered in price adjustment provisions.
- *Bureaucracy in tendering method:* According to the Collins English Dictionary (2014), bureaucracy is a system of administration in which action is impeded by unnecessary

official procedures and red tapes. Unnecessarily convoluted tender procedures will cause uncertainty, delay and additional cost on the project.

- *Period between design and tendering:* According to Reeves, Flannery and Palcic (2013:2), the primary objective of project promoters procuring a new infrastructure project is to ensure the delivery on time and within budget. The period between design and tendering, if not adequately managed creates additional risk and burden on project teams, planning and project execution. Reeves *et al.* (2013:8) conducted a study on PPP projects in UK. This study indicates that PPP projects entail longer-term in elements of design, financing and operation of new projects. This longer term leads to complexity and uncertainty of projects. Lengthy procurement periods translate to higher transaction cost (Reeves *et al*., 2013:8).

2.5.4.2 Factors relating to construction items

Mahamid and Dmaidi (2013:866) highlight five factors that are significantly related to construction items, such as contract management, frequent changes in design, duration of contract period, lack of adequate manpower and contractual procedure.

- *Contract management:* Managing a project can be compared to a game of chance; uncertainties at the planning and execution stage of a project are the most overlooked aspects of project management (Oracle, 2009:2). Project risk management is not carried out to eliminate uncertainties, but to understand the possible impact and plan for appropriate action. In contract management, as illustrated in Figure 2.7, risks like the "waterfall effect" are spread across three parties: the project owner, prime contractor and sub-contractors. Understanding the risk involved and managing the risk through mitigation and application of contingencies are vital for project success. Risks, like responsibilities, are shared down the line; the project owner shares some responsibilities with the prime contractor, while the prime contractor shares some responsibilities with the sub-contractor. All these risks and responsibilities are to be adequately managed to deliver the project in accordance with certain specifications, such as cost, time and quality.

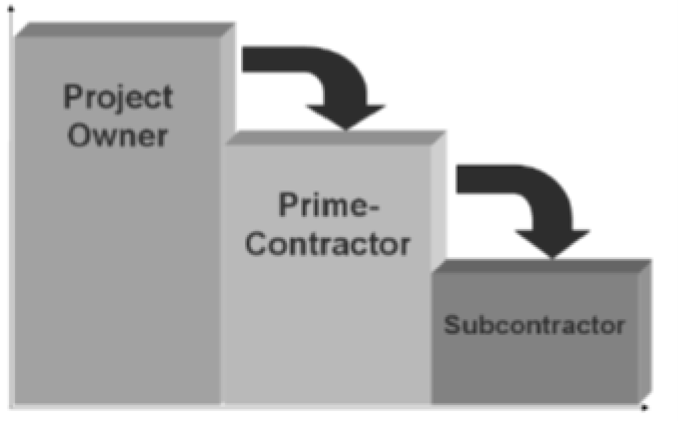

Figure 2.7: Waterfall effects share responsibility for risk amongst different parties

Source: Oracle (2009:3)

- *Changes in design:* According to Anderson *et al.* (2007:61), changes in design could lead to new risks. Design risks will have been previously managed during the planning and design stage of the project but risk identification should be a continuous process during construction, especially once new changes are made to the specifications. As shown in Figure 2.8, all risk management steps are applied continuously in the design process.

Figure 2.8: Risk management focus in the design
Source: Anderson *et al.* (2007:61)

- *Duration of contract period:* A construction contract requires that works be carried out within a specific time period. However, contracts usually list certain circumstances when the contractor is unavoidable delayed and extension of time period is accommodated (Rojas, 2009:373). The project team and contractor are responsible for evaluating the risk related to contract period and extension of time. In the context of South African construction contracts, several factors are responsible for non-completion of project on time. Such circumstances are listed in Table 2.7, with relevant conditions. Two events lead to extension of contract period; without adjustment of contract price and with adjustment of contract price (JBCC, 2014:22).
- *Lack of manpower:* Ofori (2000:3) points out that local construction companies in developing countries lack the required technical and managerial capacity to undertake most foreign-funded projects. The gravity of the shortage of high-level engineering skills in African countries has been recognised for some time. In South Africa, one civil engineer is considered to serve a population of 33,000 at the local government level (Ekolu, Dundu, & Gao, 2014:78).

Table 2.7: Changes to contract period

Changes without adjustment of contract price	Changes with adjustment of contract price
Adverse effect of weather conditions	Failure to give possession of the site to the contractor
Inability to obtain materials and goods	Making good physical loss and repairing damage to the works where contractor is not at risk
Making good physical loss and repairing damage to the works where contractor is at risk	Contract instructions not occasion by default of contractor
Event that neither party could prevent, civil commotion, riot, strike or lockout	Failure of project team to issue construction information timeously
Late supply of a prime cost amount where contractor has taken reasonable steps to avoid delay	Late acceptance by the principal agent of a design undertaken by a selected subcontractor where the contractor's obligations have been met
Default by a nominated subcontractor	Suspension or termination invoked by a nominated or selected subcontractor due to default by the employer
	Insolvency of a nominated subcontractor
	Default by a direct contractor
	Opening up and testing of work and materials and goods where such work is in accordance with the contract documents
	Execution of additional work for which the quantity included in the bills of quantities is not sufficiently accurate
	Late delivery or failure to supply materials and goods for which the employer is responsible
	Suspension of the works from employer's default
	Any other cause beyond the contractor's reasonable control that could not have reasonably been anticipated and provided for

Source: JBCC (2014:22)

- Contractual procedure: According to CIBD (2005:12), choosing the right form of contract is necessary to improve the delivery of the project. The recommended and commonly used forms of contracts in South Africa are FIDIC, GCC 2004, JBCC Series 2000 and NEC3 (CIBD, 2005:2). Various approaches and procedures are associated with different forms of contract and using the right form of contract will minimise risks, liabilities, obligations to the parties and administration procedures associated therewith. CIBD (2005:13) illustrates in Figure 2.9 the logic to be followed in deciding the appropriate form of contract.

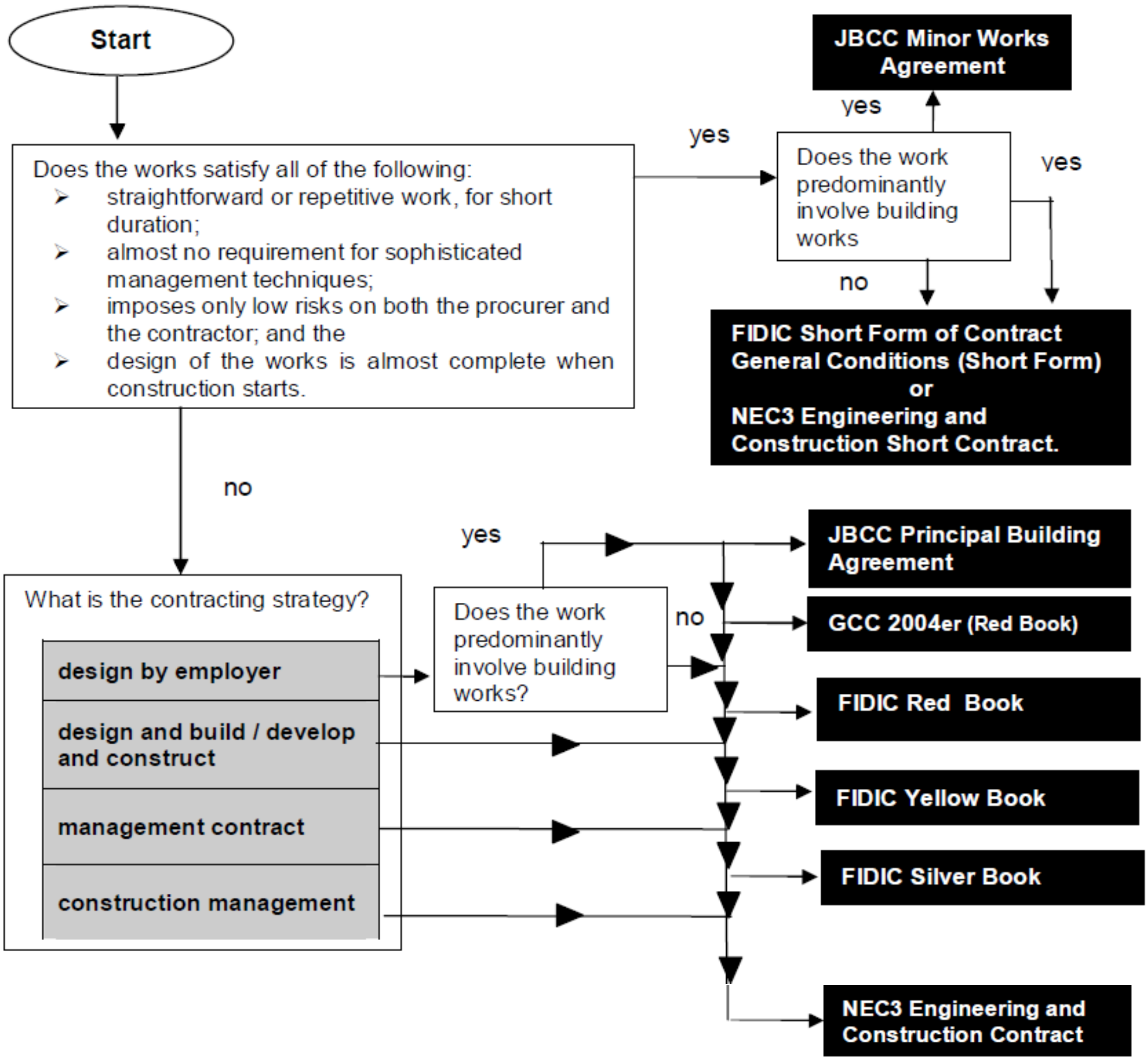

Figure 2.9: Selecting appropriate form of contract

Source: CIBD (2005:13)

CIDB (2005:12) highlights different factors to be considered in selecting the form of contract:

- complexity of the works;
- management capacity and expectations of parties;
- specific contracting and pricing strategies;
- compatibility of contract administrative procedures;
- requirements relating to management of risk, time and cost; and
- ability and capacity of skill resources.

2.5.4.3 Factors relating to project participants

Mahamid and Dmaidi (2013:867) highlight two factors that are significantly related to project participants: poor planning and previous experience of contract. Project Management Institute (2008:31) illustrates in Figure 2.10 the planning processes in project management.

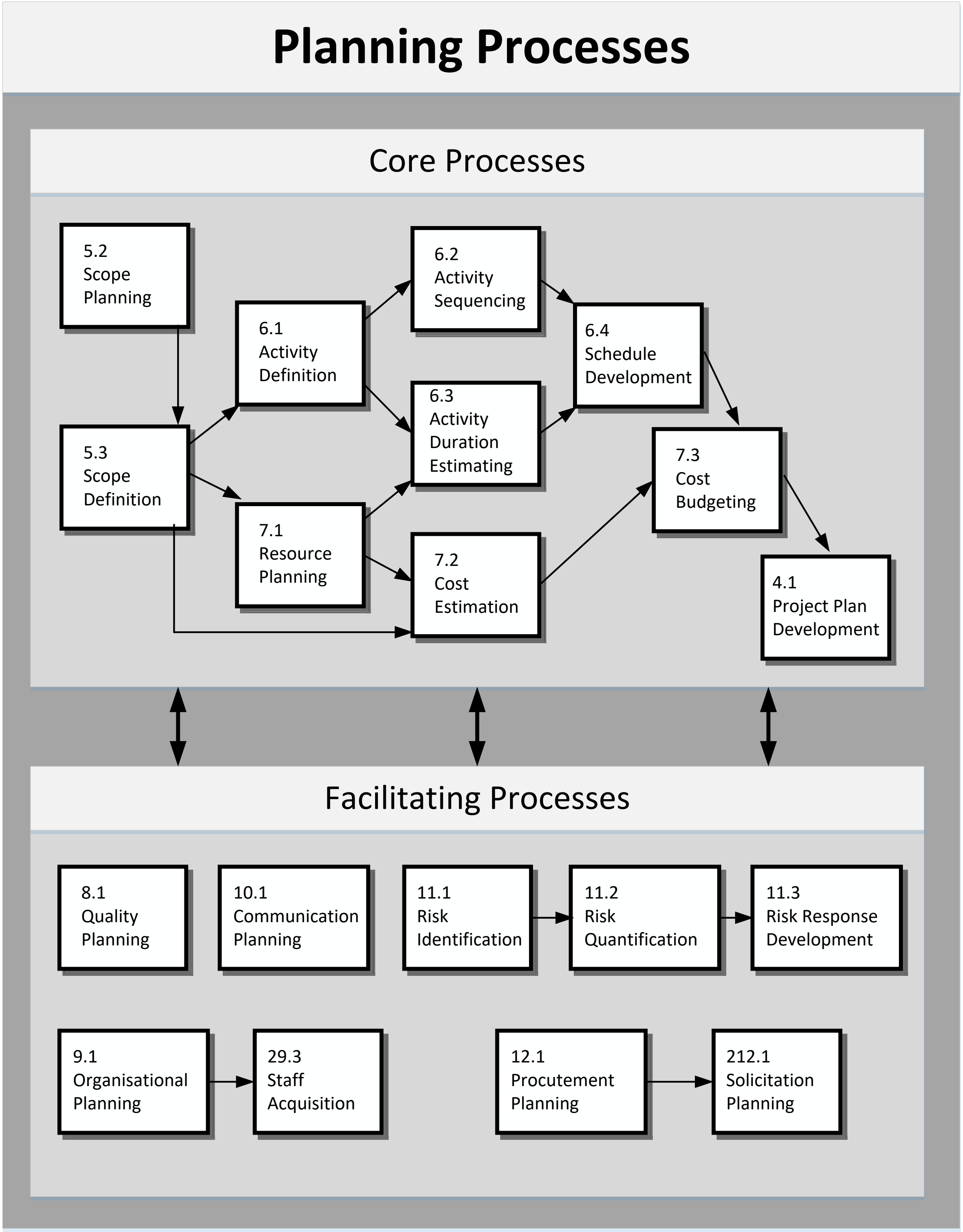

Figure 2.10: Planning processes in project management

Source: Project Management Institute (2008:31)

According to the European Commission (1998:11), poor project management structure will lead to a lack of planning and coordination, poor communication between project teams, failure to identify problems and institute remedies and lack of control over time and cost. The Project management team is the most important element in controlling the cost of the project.

2.5.4.4 Financing factors

Mahamid and Dmaidi (2013:868) highlight three factors that are significantly related to financing such as currency exchange, inflationary pressure and .project financing.

- *Currency exchange:* The exchange rate is of particular interest when services or elements of a project are purchased from another country (European Commission 1998:10). As the “world is a global village”, market and financial transactions are interlinked with major currencies such as the US dollar. The effect of changes in the value of a country’s currency has effects on prices of labour, plant and materials. The strengthening or weakness of a local currency is a significant factor to be considered in project cost.
- *Inflationary pressure:* Inflation is a key factor which has a determinate effect on project cost. The longer the project construction period, the more the expected cost to be allocated for expected inflationary price increase over time (European Commission, 1998:10). Hence, any other factor that gives rise to project delay exposes the project to risk of further inflationary cost increase.
- *Project financing:* Projects are funded through different sources of finance such as government, organisations, private sector and financial institution. According to the European Commission (1998:4), the timing and structure of financial arrangements may impose constraints on design and scheduling of the project. A project with funding not in place or not yet secured may be too risky to make commitments on design and planning.

2.6 Effects of cost underestimation

Gupta (2009:159) explains the similarities between cost underestimation and cost overrun; cost underestimation is the act of assessing (planning) cost of a project lower than the actual cost turned out to be after implementation, while cost overrun is the excess of actual cost over budget. Hence, cost underestimation occurs at the planning stage and cost overrun occurs at or towards the final stage. Cost underestimation leads to a shortfall in project completion cost, with similar effects as project cost overrun. Mukuka, Aigbavboa, and Thwala (2014:114) highlight the consequences encountered by key stakeholders in the construction industry as a result of cost underestimation in respect of the following:

- *The client:* added cost over the budget agreed upon and less return on investment
- *The end user:* additional cost passed onto rental or lease cost or prices

- *The design team and professionals:* inability to deliver value for money, which results in loss of reputation or loss of confidence by client
- *The contractor:* loss of profit and, if the contractor is at fault, it would imply further damages to reputation that could jeopardise the chance of getting additional jobs
- *The industry as a whole:* causes project abandonment and a drop in building activities, bad reputation, and inability to secure finance or securing finance at higher cost due to risk exposure.

2.6.1 Loss of reputation and credibility

MacDonald (2011:3) argues that the credibility, reputation and survival of project stakeholders, especially the forecaster, contractor's estimator and promoters, are put in doubt in the event of cost underestimation. Cheung, Wong and Skitmore (2008:11) states that clients have low tolerance for cost underestimation. In their study on clients' and estimators' tolerance towards estimating error, it is reported that clients are more tolerant of overestimation than underestimation, because cost underestimation induces severe effects. Cheung *et al.* (2008:13) concludes that estimators or quantity surveyors perceive estimating error as something to be eliminated rather than minimised.

2.6.2 Risk exposure

Akintoye and MacLeod (1997:33) confirm that risk elements associated with construction projects have influences on time, cost and quality. These risks associated with construction activities range from environmental, design, logistic, financial, legal, political, to construction and operational risks. Risk not adequately managed is perceived to adversely affect the successful completion of the project and consequently leads to loss on the part of the contractor. The techniques of risk management commonly used by contractors are judgement and experience, sensitivity analysis and risk premium insurance (Akintoye & MacLeod, 1997:36).

According to Mahamid and Dmaidi (2013:861), cost overruns have negative effects on project stakeholders, especially clients, contractors and consultants with adversarial relationships, creating cash flow problems, claims, mistrust, arbitration, litigation, and a general feeling of apprehension towards others involved in the project. Akintoye and MacLeod (1997:35) highlight several ways in which construction risk can be transferred, such as: to subcontractors, through contractual terms, to design teams and consultants, to clients, to insurance providers, and to contractors. Most forms of construction contract transfer the majority of the construction risk to the contractor, hence it is important for the contractor to manage risk in an effective way to avoid consequences such as loss of profit, claims, litigations, injuries, and damages to property. Nijkamp and Ubbels (1999:4) outline types of risk that influence the cost of a project, making it difficult for estimators to derive accurate cost estimates:

- *political risks:* such as changes in transport policy or regulations by the government;
- *financial risks:* such as fluctuations in interest rates and exchange rates, and false expectations about inflation;
- *construction risks:* such as delays, unexpected costs and higher or lower costs;
- *operational risks:* such as damage from accidents and vandalism; and
- *commercial risks:* such as incorrect cost estimates or inaccurate forecasting.

2.6.3 Financial loss

Gunner and Skitmore (1999:269) explain that estimators make errors in such a way that positively biased forecasts thus overestimate the actual price, and negatively biased forecasts thus underestimate the actual price. Akintoye (2000:1) emphasises the negative impact of both overestimated cost and underestimated cost, and noted that while overestimated costs result in higher tender prices and tenders being unacceptable to project owners, therefore causing loss of work to contractors, underestimated costs lead to situations where project contractors incur losses. According to Flyvbjerg *et al*. (2002:290), the strategic misrepresentation which is characteristic of underestimation leads to misallocation of scarce resources, and thus effectively creates loss to those financing the project, and has a negative effect on the end users of the project. Akintoye (2000:1) argues that the loss incurred by contractors due to underestimated project costs has the effect that profitability in the construction industry is significantly lower than in other industries. Hence, project cost that is underestimated will have a negative effect on the contractor's and other stakeholders' profitability, and the causal factors leading to cost underestimation in construction projects has become an important area for project stakeholders to address

2.7 Mitigating cost underestimation

2.7.1 Design requirements

According to Doloi (2013:177), the contractor's adequate understanding of design and site constructability issues enhances the possibility of achieving positive cost performance. The probability of achieving positive project performance in relation to cost is reliant on the contractors' understanding of the project scope at inception, as well as an understanding of how to execute the construction works in accordance with the design. Skitmore (1978:335) argues that the more project information is available, the more accurate the cost estimation. However, the different degrees of basic project information, such as building type, height and location, do not have significant effects on the accuracy of the cost estimate. In addition, Nijkamp and Ubbels (1999:5), share the view that a more detailed plan leads to more detailed cost estimation.

2.7.2 Effective techniques and skills

Al-Hasan *et al*. (2006:9) indicate that in order to derive a more accurate cost estimate, more sophisticated estimating techniques should be developed and used in estimating project cost. Azman and Samad (2011:16) state that continuous training, acquisition of knowledge, skills and improving estimating technique by estimators, perhaps utilising more modern technology, will fine-tune the cost performance of construction projects. Olatunji (2012:38) recommends the utilisation of IT advancement and modern business behaviours, which integrate innovation as a means of improving accuracy in estimating practice. However, using IT-based estimation such as CAD or BIM will not entirely eliminate human subjective judgements and assumptions, such as those involved in the calculation or planning of contingencies, preliminaries, provisional sums and prime cost sums, which generally rely heavily on the judgement and experience of the estimators. Skitmore *et al.* (1994.39) suggest that estimators must exercise great caution when estimating works that are out of their area of expertise or regular activities. Skitmore *et al.* (1994.39) further identifies knowledge and care as essential components of positive estimating.

According to Seeletse and Ladzani (2012:109), the knowledge and experience of the estimator, together with a good performance record, have substantial effects on the validity and reliability of cost estimates. Cheung *et al*. (2008:360) review the advantages of cost overestimation, revealing that, in the view of project facilitators, who comprise part of client organisation, it is better to be on the safe side with cost overestimation rather than risk the uncertainty associated with cost underestimation. However, it is not a legitimate practice to overestimation mitigates the risks of underestimation. Both cost underestimation and cost overestimation are classified as errors in cost estimating, though the conservatives tend to prefer overestimation despite a diversity of opinion in the industry as a whole (Cheung *et al*., 2008:359).

2.7.3 Cost planning and control

Ponte (2009:4) suggests that all aspects of projects be planned at the initial stage of cost estimating to prevent cost underestimation. Ponte (2009:4) further highlights the need to utilise relevant estimating methods suitable for each project and focus on market factors. Skitmore *et al.* (1994:39) suggest that forecasts with cost planning are perceived to be more accurate than forecasts without cost planning. Hence, cost planning is considered a way of mitigating cost underestimation.

Doloi (2013:277) argues that project planning and controlling play a significant role in project cost performance, which is a departure from the standard construction practice of heavy reliance on the competence of contractors. Cheung, *et al*, (2008:8) suggest that the ability to identify cost of sensitive elements is more desirable to the client who provides better focus on cost planning and control. Cost planning and cost controlling are significant tools when properly utilised during the process of construction cost management (Skitmore, *et al*., 1994:39; Project Management Institute, 2008:79).

- *Cost planning:* Is engaged during the planning or conceptual stage and developed during the design development and procurement stage. The cost estimates establish the project cost in the form of cost analysis by identifying different elements or building trades. This cost investigation compares the various building trades as a percentage composition of the overall estimate. The trades with highest percentage costs can be identified and monitored as sensitive elements. The cost plan is updated at various stages of the project, when detailed or new information is made available, in order to update project cost and to reconcile cost with the initial project cost estimate.
- *Cost control:* Is the financial and cost management process used by cost professionals from the inception of the project to the close out and final stage of the project in order to maintain the project estimate as initially determined. The primary aim of project cost control is to guide, protect, report, advise and maintain the financial interest of the project stakeholders, especially the client, project team and contractor, to avoid exposure to negative or unforeseen financial situation.

Flyvbjerg *et al*. (2002:290) point out the need for implementation of checks and balances as basic instruments of accountability, to be developed to ensure less production of deceptive estimate and error. Flyvbjerg *et al*. (2002:290) indicate the four basic instruments of accountability as:

- increased transparency;
- the use of performance specifications;
- explicit formulation of the regulatory regimes that apply to project development and implementation; and
- the involvement of private risk capital, even in public projects.

MacDonald (2011:3) highlights a framework of technical improvement and accuracy of cost estimation as follows:

- a clear and consistence process;
- a comprehensive and rigorous Work Breakdown Structure (WBS), as illustrated in Figure 2.11, covering construction and non-construction cost (this aligns with standard methods of measurement);
- a comprehensive and rigorous cost-build which takes proper account of risk and uncertainty and comprises base estimate, unscheduled items adjustment (to take account of the level of design definition), project risk, uncertainty (where risk is not practically quantifiable), programme risk, inflation (cost estimates are presented at outturn year prices);

- an estimating software system and centralised libraries of cost data aligned with the Work Breakdown Structure; and
- a cost capture system to collect tender rates and actual costs.

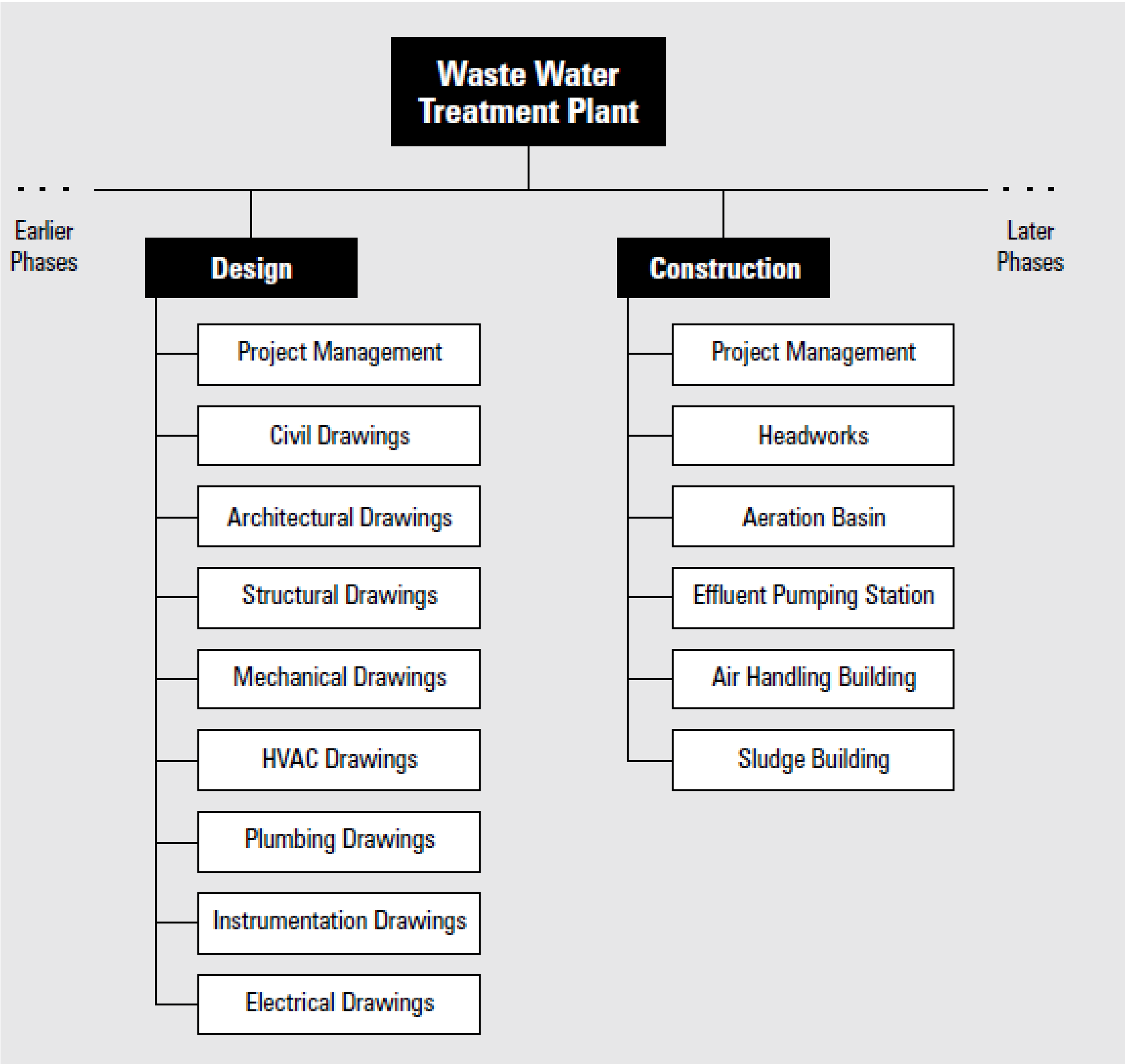

Figure 2.11: Work Breakdown Structure (WBS): design and construction phase
Source: Project Management Institute (2008:55)

Azman and Samad (2011:14) outlined various ways to lessen project cost underestimation by adopting process such as follows:

- putting in place proper design and documentation;
- carrying out effective communication and coordination between engineers;
- receiving sufficient design information from the designer;
- ascertaining clarity on assumptions from designer and client;
- establishing formal feedback for design and estimating activities;
- adopting realistic times for estimating;
- utilising more rigorous estimating techniques;

- incorporating market sentiment and economic conditions into estimate;
- use of tender document as estimate;
- measuring of design and construction risk;
- applying cost planning and cost control during the design stage;
- subdividing large items into small items in order to reduce pricing erro;
- improving methods of selection;
- adjustment and application of cost data; and
- updating costs with new costs and creating a feedback system.

Skitmore *et al.* (1994:29) argue that price forecasts that engage the use of cost planning tend to be more accurate than price forecasts without cost planning. Hence, cost planning is considered a mitigating factor in cost underestimation.

2.8 Chapter summary

This chapter reviews the literature relating to causes and effects of cost underestimation on construction projects. The literature pertaining to factors contributing to cost underestimation, planning factors, and cost estimating methods and tools was also reviewed. From the literature, the definition of statement of works was consistent with adequate methods of estimation, and expertise was perceived as the primary factor which affects accuracy of the cost estimate. The literature mentioning the prevalence of cost underestimation was reviewed in relation to cost-significant items, including specialised building works and scope changes. It was indicated that a high prevalence of cost underestimation existed in the South African context, particularly on recent projects leading to the 2010 World Cup stadia construction. Factors affecting work elements were highlighted in the literature, while cost-significant items such as foundation, finishes and specialised works was attributed to scope changes. The literature drew attention to the causes of cost underestimation by highlighting inadequacy at the planning stage, among other weaknesses, which gives rise to incompleteness and omission in cost estimates. The literature also summarised design and material changes, and other unforeseen factors, which bring about cost underestimation due to client, contractor and other third party actions which are attributed to changes. The literature review discussed the effects of cost underestimation with particular attention paid to loss of reputation and credibility of project stakeholders, including risks that will be passed on to stakeholders and result in financial loss. The literature was unanimous that projects that are underestimated will have a negative effect on profitability and will lead to misallocation of financial resources. The literature on mitigating mechanisms found that design requirements will achieve positive cost performance. It was further widely held that effective techniques and skills will improve inadequacy in cost estimation, while cost planning and control were considered as significant tools to be used in order to serve the financial interests of project stakeholders and achieve accurate cost estimate.

CHAPTER THREE

RESEARCH METHODOLOGY AND DESIGN

3.1 Introduction

In the previous chapter, several authors relevant to the research study were reviewed, in order to gain background knowledge and to address the research problems and objectives. This chapter highlights the methodology and design strategies of the research study, including data collection, sampling, research tools and instruments, and data analysis and processing undertaken in the study. This chapter also discusses anticipated problems, questionnaire design and survey, data collection steps, techniques and the testing of the validity of the study.

3.2 Research design

The research design is a blueprint for the collection and analysis of data with the aim of combining relevance to the design purpose. It also provides the pattern for data collection, measurement and analysis (Kothari, 2004:31; Khan, 2008:70). Mouton (2002:56) metaphorically illustrates, in Figure 3.1, the process of research design as being similar in concept to planning the architectural design of a building (house): in that a focus on the end product of the process will what kind of study is being planned. Kothari (2004:14) argues that the preparation of research design will facilitate efficiency and optimal yield of information.

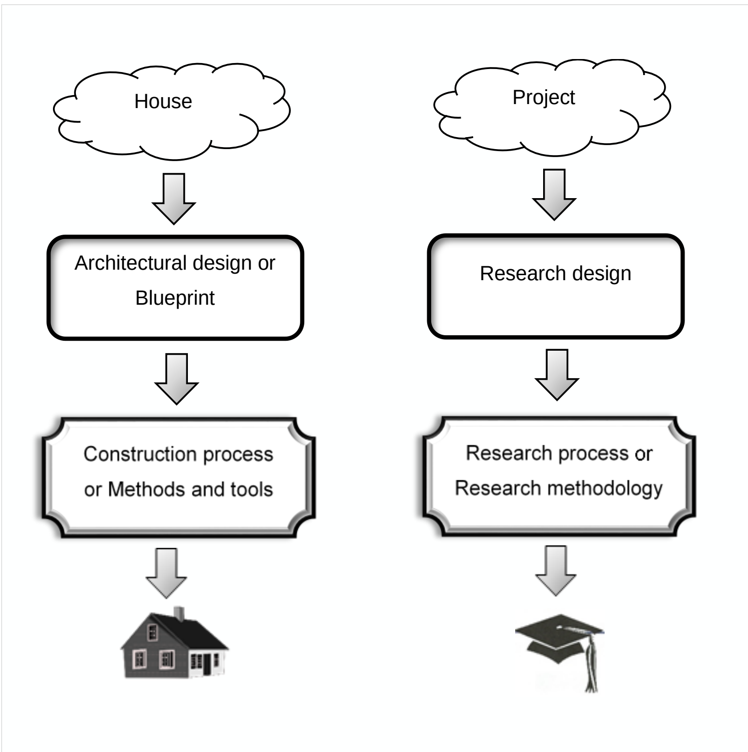

Figure 3.1: Metaphor for research design
Source: Mouton (2002:56)

3.3 Research study

Research design is aimed at addressing different questions such as kind of studies and design types. Mouton (2002:57) demonstrates (Figure 3.2) the major classifications of research study, namely empirical studies and non-empirical studies.

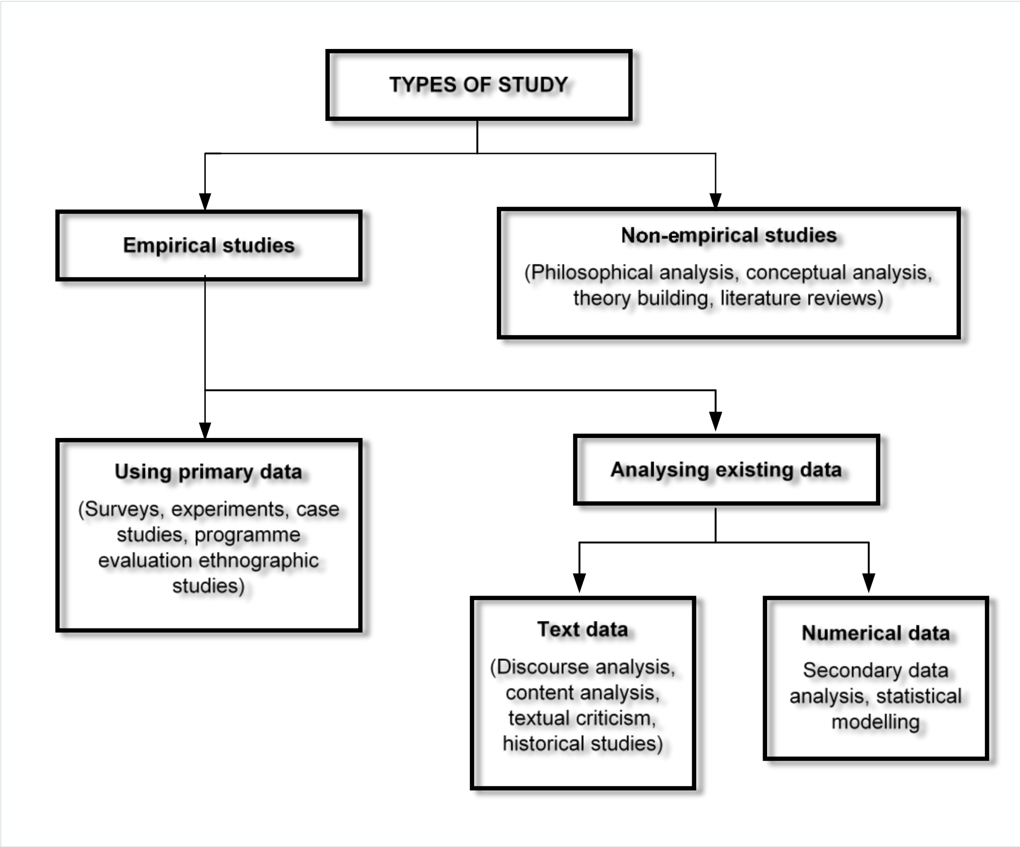

Figure 3.2: Classification of research design

Source: Mouton (2002:57)

Kothari (2004:30) recommends that the study should provide answers to the following:

- What is the study about?
- Why is the study being made?
- Where will the study be carried out?
- What type of data is required?
- Where can the required data be found?
- What periods of time will the study include?
- What will be the sample design?
- What techniques of data collection will be used?
- How will the data be analysed?
- In what style will the report be prepared?

3.3.1 The research logic

The research study will eventually culminate in the writing of a thesis (Mouton, 2002:112), which is the documentation of the researcher's thinking. The decision taken during the process of research is a reconstruction of the logic of the research. Mouton (2002:113) defines logic as the act of advancing and clarifying arguments, reasons and evidence for reaching conclusions. There are two basic types of reasoning which are used when writing theses: deductive and inductive.

3.3.1.1 Deductive reasoning

Deductive reasoning is a logical process of reasoning from one or more statements (theories or premises) to reach a logical conclusion (Collins English Dictionary, 2014). Hatch and Hatch (2006:66) further define deductive reasoning as taking the form of arguments that, if the premises are true, the conclusion must be true. According to Mouton (2002:117), the conclusions in deductive arguments are already implicitly contained in the premises. Mouton further identifies the most common forms of deductive reasoning:

- *Deriving hypotheses:* reasoning from derivation of theory or model
- *Conceptual explication:* meaning of concept clarified through deductive reasoning, based on the source or origin of its constitutive meanings.

3.3.1.2 Inductive reasoning

Inductive reasoning is the argument form in which the premises try to supply firm evidence (not absolute proof) for the truth of the conclusion (Collins English Dictionary, 2014). Hatch and Hatch (2006:66) declare that inductive reasoning is the opposite of deductive reasoning, developing a general conclusion from specific premises. Another important argument form in inductive reasoning is that a conclusion could be false even if all premises are true. Hatch and Hatch (2006:66) indicate three forms of arguments in which conclusions are based on inductive reasoning such as analogy, statistical and cause and effect.

- *Analogy argument:* is based on the argument that two or more concepts are similar, and that what holds true for one is true for the other. The strength of such argument is based on the degree of similarity between the two variables in comparison.
- *Statistical argument:* an argument based on statistical evidence relies on conclusion by numbers or figures. Based on inductive reasoning, it can be proven that statistical results and findings are absolute fact.
- *Cause and effect argument:* this argument establishes that one event is the cause or effect of another. This type of argument is the strongest in view that a premise proves that one event is the result of another and there is no other probable cause.

The research logic is based on inductive reasoning and research findings attained with statistical argument.

3.4 Research methods

According to Kothari (2004:7), all methods (sometimes referred to as techniques) used by researchers during the course of studying the research problem are termed as research methods. Hence, research methods can be further classified into the following groups:

- methods that are connected with the collection of data;
- methods that are connected with the use of statistical techniques, used for establishing relationship between the data and the unknown; and
- methods used to evaluate the accuracy of the result obtained.

Kothari (2004:7) illustrates (Table 3.1) relevant methods used in different fields of research.

Table 3.1: Different fields of research, methods and techniques of data collection

	Types	Methods	Techniques
1.	Library Research	(i) Analysis of historical records	Recording of notes, content analysis, tape and film listening and analysis
		(ii) Analysis of documents	Statistical compilations and manipulations, reference and abstract guides, contents analysis
2.	Field Research	(i) Non-participant direct observation	Observational behaviour scales, use of score card, etc.
		(ii) Participant observation	Interactional recording, possible use of tape recorders, photo graphic techniques
		(iii) Mass observation	Recording mass behaviour, interview using independent observers in public places
		(iv) Mail questionnaire	Identification of social and economic background of respondents
		(v) Opinionnaire	Use of attitude scales, projective techniques, use of sociometric scales
		(vi) Personal interview	Interviewer uses a detailed schedule with open and closed questions
		(vii) Focused interview	Interviewer focuses attention upon a given experience and its effects
		(viii) Group interview	Small group of respondents are interviewed simultaneously
		(ix) Telephone survey	Used as a survey technique for information and for discerning opinion; may also be used as a follow-up questionnaire
		(x) Case study and life history	Cross-sectional collection of data for intensive analysis, longitudinal collection of data of intensive character
3.	Laboratory Research	Small group study of random behaviour, play and role analysis	Use of audio-visual recording devices, use of observers, etc.

Source: Kothari (2004:7)

3.5 Research methodology

According to Mouton (2002:56), research methodology focuses on research process, tools, specific tasks such as data collection and sampling, individual steps and procedures employed in the study. As illustrated by Mouton in Figure 3.1, the blueprint of an architectural design is similar to research design, while the various methods and tools of systematic, methodical and accurate execution of the project are similar to research methodology. Kothari (2002:8) states that the scope of research methodology is wider than that of the research method, and is therefore a way of systematically solving the research problem. In solving the problem, the researcher needs to know the methods/techniques, and also the logic or decision behind the particular method or technique that is selected.

3.6 Research approach

In the conduct of social and human science research, there are two primary approaches, which are the quantitative and qualitative approaches (Kothari, 2002:5), and the practice of combining both quantitative and qualitative is referred to as mixed approach. Creswell (2013:4) states that the mixed research method has come of age as the major approach used in social and human science research, hence to include only quantitative and qualitative methods falls short of approaches being used today. Other research approaches are available and used by scholars, such as exploratory, descriptive, explanatory, basic, applied, classification, comparative, casual, theory-testing, theory-building, action and participatory research, but the quantitative and qualitative research approaches appear to be the two umbrella categories often used by researchers (Pawar, 2004:6). In Table 3.2, Creswell (2013:17) outlines the methods of data collection and analysis of quantitative, qualitative and mixed approaches.

Table 3.2: Quantitative, qualitative and mixed method procedure

Quantitative research	Qualitative research	Mixed method research
Predetermined instrument-based questions	Emerging methods	Both predetermined and emerging methods
Closed-ended questions	Open-ended questions	Both open-ended and closed-ended questions
Performance data, attitude data, observational data, and census data	Interview data, observation data, document data, and audio-visual data	Multiple forms of data drawing on all possibilities
Statistical analysis	Text and image analysis	Statistical and text analysis

Source: Creswell (2013:17)

3.6.1 Quantitative approach

Wiid and Diggines (2009:86) define quantitative research as the collection of data that involves larger or more representative respondent samples and the numerical calculation of results. Quantitative approaches resort to the use of post-positivism for development of knowledge which employ strategies such as experiments and surveys, and collect data on predetermined instruments that yield statistical data (Creswell, 2013:17). Quantitative research is considered to be the classic scientific approach to doing social science research. It involves the generation of data in quantitative form which is subjected to accurate quantitative analysis (Kothari, 2002:5). Golafshani (2003:597) describes quantitative research as a systematic arrangement which reflects the following: the emphasis on facts and causes of behaviour, information in the form of numbers that can be quantified and summarised, the use of mathematical process as the norm for analysing the numerical data, and the final result is typically expressed in statistical terminology. According to Kothari (2002:5), the quantitative approach can be further sub-classified into the following approaches:

- *Inferential approach:* the form of data based on inference character or relationships of population, which can be a survey of a sample of a population, determined by question or observation
- *Experimental approach*: characterised by greater control over the research environment or variables which are manipulated to observe the effect over other variables
- *Simulation approach:* creates an artificial environment within which the relevant information or data can be generated, such as observation of behaviour under controlled conditions.

The research will adopt a quantitative approach in order to gain access to the causes and effects of cost underestimation on construction projects. Such quantitative findings will strengthen the available data, based on assessment of opinion of professionals and stakeholders responsible for cost estimation on construction project.

3.6.2 Qualitative approach

Wiid and Diggines (2009:85) define qualitative research as the collection, analysis, and interpretation of data that cannot be meaningfully quantified, or summarised in the form of numbers. According to Kothari (2002:5), the qualitative approach is concerned with subjective assessment of attitudes, opinions and behaviour. Qualitative research focuses on the process of implementation, by describing rather than quantifying outcomes (Mouton, 2002:161). The qualitative process of research is a function of the researcher’s insight and impression, and does not yield data which can be meaningfully subjected to quantitative analysis. Creswell (2013:17) defines qualitative research as an approach in which the researcher often makes knowledge claims based on constructivist perspectives or advocacy/participatory perspectives or both. The knowledge gained through qualitative investigation is more informative, richer and offers an enhanced understanding when compared with the knowledge gained from quantitative approaches (Tewksbury, 2009:38).

3.7 Data collection

No research study can be undertaken without data, but for data to be useful, observation needs to be organised in a logical pattern in order to achieve logical conclusions (Bhattacharyya, 2006:52). Kothari (2002:17) argues that in real life problems, data at hand are inadequate, and it is necessary to collect appropriate data in the context of cost, time and other available resources at the disposal of the researcher, while taking into consideration the nature of the investigation, objectives and scope of study, and the desired degree of accuracy, as well as the ability and experience of the researcher.

3.7.1 Empirical data collection

The term 'empirical' applies to information based on experience; information gathered through surveys, experimentation and observation is called empirical data. Data is classified into two categories, namely primary and secondary data. In Table 3.3, Bhattacharyya (2006:52) illustrates some distinctions between primary and secondary data. Wiid and Diggines (2009:87) also point out that the two categories of primary and secondary data collection can be used together to complement each other, but the researcher should preferably use one specific method, based on the researcher's own imagination or creativity. For the purpose of this study, primary data were collected through surveys, using questionnaire methods.

Table 3:3: Distinction between primary and secondary data

	Description	Primary data	Secondary data
1.	Source	Original source	Secondary source
2.	Method of data collection	Observation, questionnaire, interview, experimentation, survey, case study	Published data by government agencies, trade journal, books, reports, others various publications
3.	Statistical process	Not done	Done
4.	Originality of data	Original first time collected by user	Data are collected by some other agency
5.	Use of data	Data are compiled for specific purposes	Data are taken from other sources and used for decision-making

Source: Bhattacharyya (2006:52)

3.7.1.1 Primary data

Bhattacharyya (2006:52) describes primary data as data collected personally by the researcher for the study, and such data are original in character. The researcher gains direct access to data through observation or measurement of certain phenomena. Primary sources of data are first-hand accounts of experiments and investigation, original work such as reports, books, periodicals, journals, technical bulletins, conference proceedings, theses and dissertations, and patents (Khan, 2008:112). There are five common methods of collecting primary data: observation, experimentation, questionnaire, interviewing and case study (Bhattacharyya, 2006:53). The research data will be collected in the form of a structured questionnaire. Direct questions will be posed to respondents in the form of closed-ended and open-ended questions (mixed method), while respondents such as contractors, quantity surveyors and other professionals with direct involvement in cost estimation of construction projects will respond based on opinion, experience and their project history. Wiid and Diggines (2009:84) illustrate in Figure 3.3 that primary data can be collected either in quantitative or qualitative ways, which are further sub-divided into distinctive approaches and techniques.

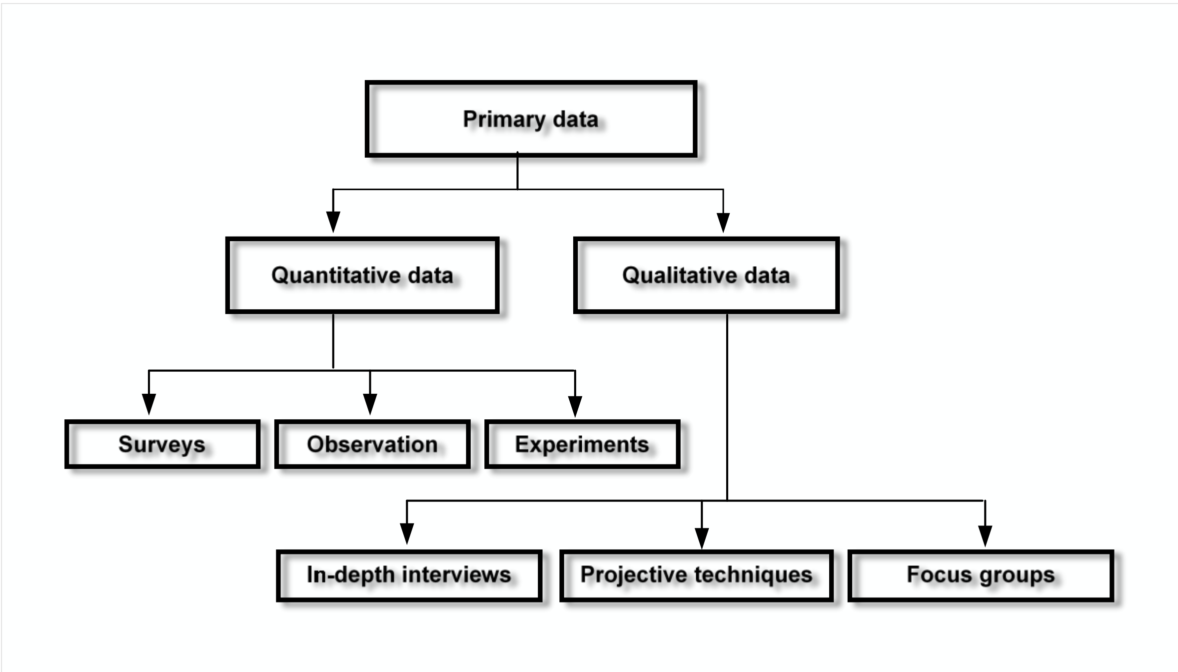

Figure 3.3: Primary data collection techniques
Source: Wiid and Diggines (2009:84)

3.7.1.2 Secondary data

Secondary data for the research is conducted through a comprehensive literature review with an emphasis on cost underestimation and cost overrun in the construction industry. According to Wiid and Diggines (2009:71), secondary data is data which already exists, previously gathered. It is important to note that primary data becomes secondary data once the primary data is used or is passed on to be used by another researcher (Bhattacharyya, 2006:52; Khan, 2008:115). Mouton (2002:71) defines secondary information sources as written sources which discuss, comment, debate and interpret primary sources of information. In the management of secondary data, Mouton (2002:74) describe the management process as organisation, keeping records and keeping track of information gathered through literature review. In order to collect adequate secondary data for use, the researcher determines whether the secondary data throws some perspective on the problem or solves it; hence the researcher gathers secondary data which are relevant to the causes and effects of cost underestimation on construction projects, from sources such as textbooks, periodicals, journals, technical bulletins, conference proceedings, reports, theses and dissertations, and other forms of secondary data.

3.8 Population and sampling

Sampling selection is undertaken due to the practical impossibility of surveying the entire population (Bhattacharyya, 2006:80). Burgess (2001:4) defines a sample as the subset of the population that is chosen, because of the inability to access the entire population due to constraints of time, money and other resources. According to Kothari (2002:14), all the items under consideration in any field of inquiry constitute a population. In designing the sample for the research study, three decisions are considered by the researcher; the type of information and who is likely to have such information (the sample), how many people to be surveyed (sample size), and how the sample will be chosen (sampling), hence the researcher must choose a method of selecting the sample (Kothari, 2002:14). Khan (2008:75) defines sampling as the selection of a part of group or entity from a totality of all members known as a population, while the selected part used to determine the features of the population is referred to as a sample. Burgess (2001:4) indicates that a key issue in selecting the sample relates to the true representation of the population. Sampling is divided into two categories: probability sampling and non-probability sampling (Kothari, 2002:15; Bhattacharyya, 2006:83; Khan, 2008:80). According to Babbie (2007:203), the basic logic of probability sampling occurs in a population where characteristics, attitude, identity, experience and behaviours are identical. Babbie (2007:199) also describes non-probability sampling as the opposite of probability sampling; which has no way of predicting population based on available subjects, purposive or judgmental, snowball or quota sampling.

According to Babbie (2007:204), purposive sampling is a type of non-probability sampling in which the researcher selects the units to be observed based on judgment about which sample will be the most useful or representative. Due to the different range of attributes, behaviours and experience of respondents, the researcher used purposive sampling techniques, based on stakeholders sampling criteria. Palys (2008:698) put forward that stakeholders sampling is useful when evaluating research and policy analysis, by identifying the major stakeholders involved or might be otherwise be affected. The sampling of respondents was used by handpicking the respondents from the available register of the South African Council for

Quantity Surveying Professions (SACQSP) and the general building contractors registered with Construction Industry Development Board (CIBD), construction professionals working in quantity surveying practice and construction firms within and Cape Town its environs. The list and contact details of participant other construction professionals were drawn from the register of Professions and Project Register, which is a comprehensive database of practicing professionals. In addition, the list of building contractors was drawn from the CIBD register of companies which carry out construction activities. The selected samples adequately represent the population of construction project stakeholders, who are directly involved in the planning and control of construction cost estimates.

3.9 Questionnaire

Krosnick and Presser (2010:263) state that "the heart of a survey is its questionnaire". The survey method is the technique of gathering data by posing questions to respondents who are thought to have the desired information. Brace (2008:22) describes the survey method of questionnaire in two categories: interviewer-administered questionnaire and self-completion questionnaire. It is not unusual for interviewer-administered questionnaires to include a section of self-completion survey and a third category of interviewer-supervised self-completion. Bhattacharyya (2002:60) highlights two basic functions of questionnaires: to translate the researcher's objectives into specific questions and motivate the respondent to furnish specific survey information correctly. Questionnaires are divided into two common types: closed-form types and open-end types (Khan, 2008:102). However, both closed-form and open-end types of questionnaire can be used in combination for research surveys. The researcher will administer self-completion questionnaires, which will include sections containing closed-ended questions. Mouton (2002:103) highlights some of the common errors that should be avoided in questionnaire construction:

- no piloting or pretesting;
- ambiguous or vague items which leaves respondent to assume;
- double-barrelled question (combining two or more questions in one);
- items in order or sequence of questions that may affect accuracy and response rate;
- fictitious construction of questions (matters of which respondents have no knowledge);
- leading or influencing questions intended to elicit particular responses;
- negatively phrased questions and poor or confusing questions;
- questions that are too long which lead to negative impact or confusion; and
- sensitive, threatening or private questions that might lead to refusal to participate.

3.9.1 Closed-ended questionnaire

The closed-ended type of questionnaire requires respondents to select short answers from a list of options selected by the researcher (Khan, 2008:102). Closed-ended questions include possible answers which are pre-written by the researcher in different categories for respondents to choose from, whether in the form of multiple choice or scale questions. These types of questions can be used to generate quantitative data for easy analysis. Newing, Eagle, Puri, and Watson (2011:127) describe closed-ended questions, where the respondents choose from one of the several predetermined answers which are in the form of a closed checklist, ranking and rating scale, as follows:

- *Closed checklist:* a form of question with a list of possible answers (yes/or, longer list).
- *Ranking:* the respondents are asked to rank in order of preference or importance.
- *Rating scale:* the respondents are asked to rate an item on a numerical scale such as semantic (alternatives of two opposing terms), a Likert scale (alternative to agree or disagree) and horizontal scale (alternative of two opposing statements or view points).

3.9.2 Open-ended questionnaire

According to Khan (2008: 104), an open-ended type of questionnaire is one in which the respondents are required to respond descriptively. Hence, open-ended questions allow respondents to answer in their own words. The questions do not contain ticks or yes/no options, instead a blank section is provided for the respondent to write in an answer and there are no standard answers to questions. The data analysis is qualitative in nature and more complex and difficult (Khan, 2008:104). Opinions are sought rather than numerical data.

3.9.3 Piloting questionnaire

Before applying the questionnaire method to gather data, a pilot study for testing the questionnaire is usually conducted to reveal any weakness in the questionnaire (Kothari, 2002:17). The researcher sends out a pilot questionnaire for testing ambiguity and to receive feedback and comments on the structure and wording of the questionnaire. Newing *et al.* (2011:142) argues that the importance of formal field piloting of questionnaire cannot be overemphasised; it is almost certain that some questions might not be understood or will be misinterpreted. Hence, by administering the pilot questionnaire to a small group similar to those sampled in the final study, such fine-tuning or correction of questions may be adjusted or redrafted. Burgess (2001:15) suggests the running of a pilot survey on researcher’s subjects, colleagues and friends, with the aim of detecting any flaws in the questioning and making necessary corrections prior to the main survey.

3.9.4 Questionnaire design

The design goal of the questionnaire is to achieve the researcher’s objectives by obtaining valid data from respondents (Azzara, 2010:18). Bhattacharyya (2002:62) maintains that questionnaires can be deployed by personal interview, mail, or telephone, depending on the type of information to be gathered and the type of respondents from whom it is to be obtained.

In any case, should the questionnaire be administered directly or by any other indirect means such as post or email, it is important to explain to the respondents why they should response to the questionnaire (Burgess, 2001:5). The questionnaire for the study was delivered by email with a covering letter, highlighting the importance of the research to the construction industry stakeholders. Wiid and Diggines (2009:120) stress that the overall structure and design of a questionnaire is crafted to draw the attention of respondents with clear and concise instructions, contains questions of moderate length, and arranged in sequence and categories. Burgess (2001:3) agrees that a clear and concise questionnaire helps the researcher elicit a superior response. Azzara (2010:172) maintains that sometimes, there is a need for open-ended questions; the need to ask specific questions which are too varied and not easily structured, particularly useful when the researcher is unsure about the answer. Fowler (1995:177) as cited by Newing *et al.* (2011:127) outlines five ways in which open-ended questions can be used to complement closed-ended questions:

- When the range of answers is too great to cover in a closed list;
- When descriptive answers are required and cannot be expressed in a few words;
- In determining people's knowledge;
- In order to find the reason for a particular viewpoint or behaviour; and
- To learn about a complex situation.

The research used a closed-ended type of question to gather data. Newing *et al.* (2011:135) state that questionnaires are usually divided into different sections on different topics, separating questions into different areas of information:

- Information on respondents' attributes (basic character of respondents);
- Information on knowledge (abstract knowledge, memories and experience);
- Information on behaviour and.
- Information on subjective states (attitudes).

Burgess (2001:5) points out that respondents are likely to commit to answer questionnaires seen as interesting, of value, short, clearly thought through, and well presented. The questionnaire for the study is clearly and neatly put together and divided into different sections. The first section contain questions relating to the personal characteristics of respondents, in order to gather the demographics of the participants for statistical purposes (such as location, name of organisation, company size, current position, length of experience and formal education). The second part relates to research data collection on the causes and effects of cost underestimation, and research aims and objectives. The second part is further divided into sub-sections, grouping the questions in adequate sequence of different factors, issues, components and relevance. According to Kothari (2002:56), the design of the questionnaire depends on the nature of the data which the researcher seeks to gather; for instance qualitative information (exploratory questionnaire) or quantitative information (formal standardised questionnaire).

The questionnaire for the study is formulated to generate statistics for quantitative data. Questions will be drawn into sections with relevance to different research questions and issues. In designing a rating scale, the researcher must specify the numbers of points. Likert scaling, developed in 1932, most often uses five points (Krosnick & Presser, 2010:268). Respondents were required to answer questions in the form of a rating scale. According to Krosnick and Presser (2010:270), in order for rating to be reliable and valid, respondents need to a have clear understanding of the points on the scale. Hence, each point scale was adequately defined on the questionnaire. The questions highlight the following areas or issues: factors contributing to underestimation, trades in which underestimation is common, cause of underestimation, effects of underestimation and the mitigating mechanisms for underestimation. The questionnaire incorporates questions relating to secondary data such as literature gathered on the frequent causes and effects of cost underestimation. The questions are pre-determined, short, simple facts, clear and comprehensible, and not misleading for respondents to answer. The primary advantage of adopting the use of self-administered questionnaires or self-completion surveys is the economical and wider coverage of participants during data collection, as well as removing major sources of potential bias in the response, and making it easier for the respondent to be honest about sensitive subjects in the absence of the researcher (Braces, 2008:29). The survey was open for one month, during this period reminder emails were sent out through the web link: https://www.surveymonkey.com/r/X7S3FW8.

3.10 Data processing and analysis

Many experts differentiate analysis of data from processing of data (Kuma, 2008:113). Data processing involves concentrating, recasting and dealing with data so that they can be amendable for analysis. Research fieldwork ends with the analysis and interpretation of data. Data analysis involves the breaking up of data gathered during the research survey into manageable themes, patterns, trends and relationships (Mouton, 2002:108). According to Burgess (2001:17), preceding events to analysis are the coding, entry and checking of data collected during fieldwork. Analysis of data involves closely-related operations conducted in a manner that will summarise and organise the collected data in order to yield answers to the research questions (Kumar, 2008:113). The data collected in the study is summarised and organised for processing and analysis in operations such as editing, classification, tabulation and data analysis.

3.10.1 Editing

The first step in data processing, examination of the data for errors, omissions and corrections will be made where necessary and possible. This is desirable when there are some inconsistencies in the responses as entered, partial or vague answers in the questionnaire, editing of answers to be consistent with others, omitting one answer in the case of respondents marking two answers in a particular question, etc. The completed and returned questionnaires were retrieved from the online survey through the web link: https://www.surveymonkey.com/r/X7S3FW8. The data collected by the SurveyMonkey website were converted into Microsoft Excel spreadsheet, and minor editing was done in relation to coding to enable SPSS to recognise and classify data. The edited spreadsheet was imported into SPSS software for data analysis.

3.10.2 Classification

Data is arranged and classified into groups on the basis of characteristics, attributes and categories. The symbols use to classify such categories are called codes (Kumar, 2008:117). In practice, editing and coding are frequently done simultaneously. The coding is important in order to carry out subsequent operations of tabulation and analysis. Once the survey data collected through SurveyMonkey were converted and exported in Microsoft Excel for editing, coding of data was done by using alphabets, which are consistent and easily recognised by SPSS.

3.10.3 Tabulation

The coding of data, together with arrangement and classification, allowed the data to be handled, tabulated and displayed in a compact form, by arrangements of columns and rows for comparison, summation, and statistical analysis in SPSS.

3.10.4 Data analysis

3.10.4.1 Inferential and descriptive statistics

Data were entered into, and analysed on, the computer using applicable software programmes such as SPSS or Excel. Asadoorian and Kantarelis (2005:2) define statistics as the science of collecting, organising, analysing and interpreting data in order to make a decision. Statistical methods of research in the broadest sense are classified into two main groups as inferential and descriptive statistics. Inferential statistics uses probabilistic techniques to analyse data or sample information from a specific population in order to improve knowledge about the population (Asadoorian & Kantarelis, 2005:2). A descriptive statistical method was used to analyse the surveys sections containing quantitative data.

3.10.4.2 Quantitative data analysis using descriptive statistics

De Vaus (2014:207) describes the descriptive method of analysing data as functioning by putting responses of the sample in a summarised pattern and presenting them in three broad ways: tabular, graphical and statistical. Descriptive studies describe the characteristics of an individual or group, in order to prepare a profile or to describe interesting phenomena from such an individual or group's point of view (Verma, 2013:29. Descriptive statistics are therefore computed in descriptive studies to describe the nature of data; and can be described in two different measures: measures of central tendency (mean, median and mode) and measures of variability or spread (the range, quartile, absolute deviation and standard deviation).

Chambliss and Schutt (2012:155) describe quantitative data analysis as a statistical technique use to describe and analyse variables in quantitative measures. The statistical analysis package used to capture and analyse data in the research is the Statistical Package for Social Sciences (SPSS). The quantitative data gathered were analysed using descriptive statistics. According to Chambliss and Schutt (2012:155), descriptive statistics is used to describe the distribution of and relationship among variables. Burgess (2001:17) maintains that the measurement level of variables is important, as it determine the type of analysis that can be undertaken. Descriptive statistics measures of central tendency using mean value were use in analysing the research data.

3.10.5 Ethical issues

According to De Vaus (2001:193), in order to address ethical issues in any research design, the researcher needs to attend to matters of confidentiality, privacy, avoidance of harm to participants and informed consent. In the process of collecting data for the research study, issues relating to ethics and codes of conduct will be adequately adhered to with regard to research participants and respondents:

(i) *collecting information:* respondent's information will not be requested or stored as it does not have any relevance on the research

(ii) *seeking consent:* informed consent of respondents will be obtained voluntarily, without any pressure

(iii) *providing incentives:* no incentives or inducement will be awarded in return for research information or data from respondents

(iv) *seeking sensitive information*: no private, confidential or sensitive information will be requested from research respondents

(v) *maintaining confidentiality:* no information collected from respondents will be shared with any third party, other than for the purpose of this research.

3.10.6 Validity and reliability assessment

The significance of the testing or validity of measuring instruments is to ensure replicability or repeatability and to ensure the credibility of the result. Measurement error is considered as a threat to the result which is drawn from the research study (De Vaus, 2001:29). This error occurs when flawed indicators are used. Indicators must meet two fundamental criteria: they must be valid and reliable. Validity determines whether the research truly measures that which it was intended to measure (in other words whether the measurements are accurate), while reliability is the consistency of results over time and accurate representation of the total population of the research study; therefore should the research results be able to be reproduced under the same methodology, then the research instrument is considered reliable (Golafshani, 2003:598).

3.10.6.1 Validity

Lakshmi and Mohideen (2013:2752) consider two essential components of validity as internal and external validity. Internal validity addresses whether the results of the study are legitimate because of the way the samples were selected, data was gathered and analysis performed. External validity explores whether the results are transferable to other populations of interest. In order to address these two essential components, the researcher ensured that both internal and external validity based on the inferences made from the measuring instrument were appropriate, meaningful, and useful (Lakshmi & Mohideen, 2013:2754). A measure is valid if it measures what it is supposed to measure cleanly.

3.10.6.2 Reliability

Reliability is the degree to which measures are free from error and yield consistency. According to Lakshmi and Mohideen (2013:2752), reliability is a common threat to internal validity. They further explain that reliability is often at risk when assessments are taken over time, are carried out by different people and are highly subjective. Lakshmi and Mohideen (2013:2753) list different ways of measuring consistency or homogeneity, the split-half method, the alternate-form method and Cronbach's alpha method:

(i) *split-half method:* measures the degree of internal consistency by checking half the result and comparing it against the other half (it demands equal item representation against the two halves)

(ii) *alternate-form method:* this is used to correlate measures between alternatives which are as equivalent as possible, and it is administered in the same group of subjects, such as the technique of creating a make-up exam because students already know the earlier exams (equivalent/alternative form)

(iii) *Cronbach's coefficient alpha:* according to Lakshmi and Mohideen (2013:2754), the coefficient alpha method is the most common method of attaining consistent reliability. Cronbach's alpha is the average of all possible split-half estimates which measures inter-item reliability or degree to which items measuring variables attain constant results. The coefficient varies from 0 to 1; a value of 0.6 or less is considered unsatisfactory, while values of 0.7 to 0.8 ranges are acceptable. For the purpose of the research study, the internal reliability is tested on scales using Cronbach's coefficient alpha and the cut-off point of 0.6 is unreliable.

3.10.7 Treatment of research objectives and instruments

The schedule in Table 3.4 highlights the treatment of the research objectives in relation to research measuring instruments. The schedule will articulate the research variables arising from research objectives and research questions, and the specific treatments thereof.

Table 3:4: Treatments of research objectives and instruments

	Research objectives	Research questions	Variables	Analysis
1.	To investigate factors that contributes to cost underestimation	What are the factors contributing to cost underestimation?	Project planning factors, methods and techniques factors, tools factors	Mean rankings
2.	To evaluate construction cost-significant work items in which underestimation are prevalence	Why are construction cost-significant work items underestimated?	Cost-significant building work elements, scope changes on building works, risk associated with specialised building works	Mean rankings
3.	To investigate the causes of cost underestimation	What are the causes of cost underestimation in South Africa construction industry?	Planning stage, design and material changes, risk due to unforeseen factors	Mean rankings
4.	To identify the effects of cost underestimation on project stakeholders	What are the effects of cost underestimation on project stakeholders?	Loss of reputation and credibility, risk exposure, financial loss	Mean rankings
5.	To develop mechanisms for mitigating cost underestimation	How can cost underestimation be mitigated?	Design requirements, effective techniques and skills, planning	Mean rankings

3.11 Chapter summary

This chapter presents the methodology and design that was adopted in this research. A qualitative approach was adopted and a convenient purposive sampling of respondents was used by handpicking contractors and quantity surveyors, which adequately represent project stakeholders that participate directly in the cost management of construction activities within Cape Town and its environs. It was indicated that sources of data will be both primary and secondary. Pilot questionnaires were administered through a small group of colleagues working in the construction industry prior to sending the final questionnaires to the respondents. Closed-ended types of questionnaire were formulated to generate statistical data, and a five-point Likert scale was adopted in the questions. The data were analysed in the form of a descriptive statistical method of measures of central tendency using a mean value. Statistical Package for Social Sciences (SPSS) was used to analyse the quantitative data gathered using descriptive statistics. Tests on the reliability of the research instrument were conducted based on Cronbach's alpha coefficient value.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION

4.1 Introduction

In the previous chapter, research methodology and design used for data collection and sampling were discussed. This chapter will present the data analysis; presentation and discussion of findings from the empirical data gathered from the questionnaire. The chapter is divided into sections: the first section presents the participants' biographical information, the other sections present the five research question areas, and subsequently present them in subsections for data analysis, covering factors contributing to cost underestimation, prevalence of cost underestimation, causes of cost underestimation, effects of cost underestimation and strategies for mitigating cost underestimation.

4.2 Piloting the questionnaire

In order to check clarity of the questionnaire, a pilot study was conducted with select professional colleagues in the construction industry, as well as contractors. A total of ten questionnaires were distributed and feedback received was satisfactory in terms of the wording, structure and clarity of questions. No adjustment was made to the questionnaire.

4.3 Survey response rate

The survey was conducted online, with a total of one hundred and forty two (142) emails sent via the online survey website to the selected respondents. The questionnaire was accessed through the web link: https://www.surveymonkey.com/r/X7S3FW8. The selected respondents were mainly construction professionals working in both quantity surveying practices and construction firms within and around Cape Town. Follow-up emails were sent via the website used to distribute the questionnaire, and a total of seventy four (74) responses were received. According to Burgess (2001:4), by explaining the need to respondents why they should answer the questions and persuasive collection of replies can improve response rate. The reminder emails and the online completion option were responsible for the high response rate of fifty two percent (52%). Burgess (2001:4) further put forward that sending out five times as many questionnaires as you want in returning is quite common to achieve twenty percent survey response rate.

4.4 Research participants

The respondents' general information was collected in the first section of the questionnaire. The information relating to gender, the sector of work in the construction industry, years of experience and level of education from the completed questionnaires were analysed.

4.4.1 Respondents' gender

Table 4.1 presents the gender composition of the respondents of the questionnaire. It is shown that the sample was made up of 14.9% females and 85.1% males. While both genders were represented in the survey; the higher percentage of male respondents indicates the norm of higher participation ratio of males in the construction industry.

Table 4.1: Gender of respondents

Respondents' gender	N	Percentage (%)
Female	11	14.9
Male	63	85.1
Total	74	100.0

4.4.2 Respondents' working sector

In Table 4.2, it is shown that respondents work in both private and public sectors. 73% of the respondents work in the private sector, 10.8% work in the public sector, and 16.2% of the respondents work in both private and public sectors. These data suggest that the respondents possess a blend of experience in both private and public sectors.

Table 4.2: Working sector of respondents

Respondents' working sector	N	Percentage (%)
Private	54	73.0
Public	8	10.8
Both	12	16.2
Total	74	100.0

4.4.3 Respondents' years of experience

In Table 4.3, it is shown that over 63% of the respondents are above the middle level cadre, while 36% are below the middle level cadre in the construction industry. These statistics indicate sufficient work experience of the respondents and it also indicates that almost 49% of respondents have over 15 years' experience and thus have adequate experience in the construction industry.

Table 4.3: Years of respondents' experience

Respondents' years of experience	N	Percentage (%)
0 – 5 years	13	17.6
6 – 10 years	14	18.9
11 – 15 years	11	14.9
16 years and above	36	48.6
Total	74	100.0

4.4.4 Respondents' current position

From Table 4.4, it is shown that respondents are spread across a broad cross-section of the construction industry, indicating diverse knowledge and professional background.

Table 4.4: Current company position of respondents

Respondents' current position	N	Percentage (%)
Architect	8	10.8
Director	26	35.1
Engineer	6	8.1
Estimator / Quantity Surveyors	16	21.6
Project Manager	11	14.9
Supervisor	1	1.4
Others	6	8.1
Total	74	100.0

4.4.5 Respondents' formal qualification

Table 4.5 shows that 97% of the respondents acquired a minimum of a bachelors' degree. The respondents' qualification statistics reveal that the majority of respondents have adequate educational qualifications to understand and respond to the questions listed in the survey. This further suggests that the data collected from the survey will possess a substantial degree of relevance, consistent with the best practice which is attainable in the construction industry.

Table 4.5: Respondents' formal qualification

Respondents' formal qualification	N	Percentage (%)
Diploma	1	1.4
BTech degree	5	6.8
BSc degree	9	12.2
BSc Honours	21	28.4
Masters	27	36.5
Doctoral	10	13.5
Others	1	1.4
Total	74	100.0

4.5 Reliability of research instrument

Table 4.6 presents the test of the scale questions with Cronbach's alpha coefficient, using Statistical Package for Social Sciences (SPSS) version 23. In presenting the test on reliability of the research instrument, it is shown in Table 4.6 that the Cronbach's alpha coefficient value for each scale question ranges from 0.71 to 0.95, and the overall Cronbach's alpha coefficient value for the total of 147 questions is 0.95. These values indicate that the reliability of the research instrument is found to be satisfactory. George and Mallery (2003:231) put forward the following rules on degree of reliability: > 0.9 to be excellent, > 0.8 to be good, > 0.7 to be acceptable, > 0.6 to be questionable, > 0.5 to be poor, and < 0.5 to be unacceptable.

Table 4.6: Consistency reliability for scale items

Question number	Research variables	Number of items	Cronbach's alpha coefficient values	Degree of reliability
2.1	Project planning factors	15	0.71	Acceptable
2.2	Methods and techniques factors	15	0.87	Good
2.3	Tools factors	8	0.92	Excellent
3.1	Prevalence of cost underestimation	9	0.75	Acceptable
3.2	Scope changes	9	0.87	Good
3.3	Risk associated with specialised building works	6	0.86	Good
4.1	Planning stage	13	0.88	Good
4.2	Design and material changes	8	0.88	Good
4.3	Risk due to unforeseen factors	12	0.87	Good
5.1	Loss of reputation and credibility	10	0.95	Excellent
5.2	Exposure to risk	7	0.88	Good
5.3	Financial loss	12	0.95	Excellent
6.1	Design requirements	9	0.84	Good
6.2	Effective techniques and skills	7	0.93	Excellent
6.3	Planning	7	0.94	Excellent
Sum	All questions combined	147	0.95	Excellent

4.6 Presentation of findings

In presenting the survey findings, each research question was presented in sections and sub-sections. The findings were presented in tables, using SPSS to generate the mean value and standard deviation for ranking. Accordingly, the five sections of the questionnaire relating to the factors contributing to cost underestimation, prevalence of cost underestimation, causes of cost underestimation, effects of cost underestimation and mitigating cost underestimation including their different sub-sections were presented.

4.6.1 Factors contributing to cost underestimation

4.6.1.1 Project planning factors

Respondents were asked to rate the level of contribution of project planning factors to cost underestimation on construction project; where 1=of no contribution, 2=of little contribution, 3=of average contribution, 4=of high contribution, 5=of very high contribution, and U=Unsure.

Table 4.7 shows that the description of the work items to facilitate pricing had the highest ranking with MV=4.64. The definition of the scope of works to be executed had the second highest ranking with MV=4.62. The selection process of competent professionals had the third highest ranking with MV=4.18. The level of contribution of project planning factors to cost underestimation had AMV=3.86.

Table 4.7: Level of contribution of project planning factors to cost underestimation

Project planning factors	N	Of no contribution (%)	Of little contribution (%)	Of average contribution (%)	Of high contribution (%)	Of very high contribution (%)	Mean Value	S.D	Rank
The description of the work items to facilitate pricing	74	0.0	0.0	4.1	28.4	67.6	4.64	0.56	1
The definition of the scope of works to be executed	74	0.0	0.0	0.0	37.8	62.2	4.62	0.49	2
The selection process of competent professionals	74	0.0	2.7	23.3	33.8	43.2	4.18	0.85	3
The information on soil conditions for foundation design requirements	73	0.0	1.4	13.7	54.8	30.1	4.14	0.69	4
The information on site location for accessibility	74	0.0	2.7	10.8	58.1	28.4	4.12	0.70	5
The understanding of the prevailing economic conditions at the time of planning the project	74	0.0	0.0	33.8	29.7	36.5	4.03	0.84	6
The information on site restrictions for accessibility	74	0.0	1.4	33.8	47.3	17.6	3.81	0.73	7
Having the detail information of subcontractors that will be responsible for other specialised works	74	1.4	2.7	29.7	47.3	18.9	3.80	0.83	8
The coordination of different tasks of the professional team	74	0.0	10.8	23.0	41.9	24.3	3.80	0.94	9
The type of procurement system used to award contract	74	0.0	4.1	29.7	52.7	13.5	3.76	0.74	10
The cost planning technique used for budgeting	74	0.0	5.4	32.4	60.8	1.4	3.58	0.62	11
The type of contract pricing strategy used to determine contract price	74	0.0	10.8	36.5	39.2	13.5	3.55	0.86	12
The planning of work schedule for equipment mobilisation	74	0.0	12.2	36.5	47.3	4.1	3.43	0.76	13
The planning of work schedule for labour usage	74	0.0	4.1	55.4	37.8	2.7	3.39	0.62	14
The planning of work schedule for material procurement	74	0.0	39.2	10.8	47.2	2.7	3.14	0.98	15
Average mean value	3.86								

4.6.1.2 Methods and techniques factors

Respondents were asked to rate the level of contribution of methods and techniques factors to cost underestimation on construction project; where 1=of no contribution, 2=of little contribution, 3=of average contribution, 4=of high contribution, 5=of very high contribution, and U=Unsure. Table 4.8 shows that describing the work items for clarity of information for pricing had the highest ranking with MV=3.97. The use of design estimate at the relevant stage of works as project cost had the second highest ranking with MV=3.82. The use of preliminary estimate at the relevant stage of works as project cost had the third highest ranking with MV=3.78. The level of contribution of methods and techniques factors to cost underestimation had AVM=3.46.

Table 4.8: Level of contribution of methods and techniques factors to cost underestimation

Methods and techniques factors	N	Of no contribution (%)	Of little contribution (%)	Of average contribution (%)	Of high contribution (%)	Of very high contribution (%)	Mean Value	S.D	Rank
Describing the work items for clarity of information for pricing	74	0.0	5.4	10.8	64.9	18.9	3.97	0.72	1
The use of design estimate at the relevant stage of works as project cost	74	1.4	9.5	16.2	51.4	21.6	3.82	0.93	2
The use of preliminary estimate at the relevant stage of works as project cost	74	0.0	13.5	16.2	48.6	21.6	3.78	0.94	3
The gathering of historical cost data for usage during price production	74	1.4	4.1	51.4	17.6	25.7	3.62	0.96	4
The use of floor area method to determine project cost	74	0.0	5.4	50.0	27.0	17.6	3.57	0.85	5
The use of building price index to calculate project cost	74	0.0	6.8	45.9	39.2	8.1	3.49	0.75	6
The use of previous projects to generate new contract price	74	1.4	27.0	10.8	44.6	16.2	3.47	1.10	7
Taking off quantities of individual items of works for price production	74	0.0	28.4	16.2	39.2	16.2	3.43	1.10	8
Gathering input information from other project stakeholder during price production	74	0.0	28.4	10.8	51.4	9.5	3.42	1.01	9
The use of elemental estimate to determine project cost	74	9.5	2.7	45.9	24.3	17.6	3.38	1.11	10
The use of elemental estimate at the relevant stage of works as project cost	74	0.0	13.5	40.5	44.6	1.4	3.34	0.73	11
The use of unit method to determine project cost	74	0.0	16.2	55.4	17.6	10.8	3.23	0.85	12
The use of measuring list as a guide in the process of price production	74	0.0	17.6	45.9	33.8	2.78	3.22	0.76	13
Measuring work items based on the prescribed standard system of measurement	74	10.8	27.0	12.2	31.1	18.9	3.20	1.32	14
Applying rate build-up to calculate cost of work items	74	1.4	41.9	16.2	27.0	13.5	3.09	1.14	15
Average mean value	3.46								

4.6.1.3 Tools factors

Respondents were asked to rate the level of contribution of tools factors to cost underestimation on construction project; where 1=of no contribution, 2=of little contribution, 3=of average contribution, 4=of high contribution, 5=of very high contribution, and U Unsure. Table 4.9 shows that the use of QS software measuring bills production had the highest ranking with MV=3.49. The use of CAD-enabled measuring bills production had the second highest ranking with MV=3.31. The use of project management scheduling tool software had the third highest ranking with MV=3.28. The level of contribution of tools factors to cost underestimation had AMV=3.12.

Table 4.9: Level of contribution of tools factors to cost underestimation

Tools factors	N	Of no contribution (%)	Of little contribution (%)	Of average contribution (%)	Of high contribution (%)	Of very high contribution (%)	Mean Value	S.D	Rank
The use of QS software measuring bills production	74	10.8	27.0	0.0	27.0	35.1	3.49	1.47	1
The use of CAD enable measuring bills production	74	1.4	27.0	25.7	31.1	14.9	3.31	1.07	2
The use of project management scheduling tool software	74	0.0	32.4	25.7	23.0	18.9	3.28	1.12	3
The use of schedule of works as a planning tools	74	0.0	44.6	17.6	28.4	9.5	3.03	1.06	4
The use of manual take-off measuring bills production	74	1.4	21.6	51.4	25.7	0.0	3.01	0.73	5
The use of computer based spreadsheet measuring bills production	74	10.8	36.5	5.4	35.1	12.2	3.01	1.28	6
The use of simulation-based tools for cost risk analysis	69	11.6	2.9	60.9	23.2	1.4	3.0	0.89	7
The use of bills of quantities as price production instruments	73	37.0	1.4	9.6	42.5	9.6	2.86	1.52	8
Average mean value	3.12								

4.6.2 Prevalence of cost underestimation

Respondents were asked to indicate the level of prevalence of cost underestimation in cost-significant building work elements on construction projects; where 1=of no prevalence, 2=of little prevalence, 3=of average prevalence, 4=of high prevalence, 5=of very high prevalence, and U=Unsure. Table 4.10 shows that prevalence of cost underestimation in foundations work element due to unexpected ground conditions, which brings about changes in work quantities for subsequent re-measurement of works had the highest ranking with MV=4.08. Prevalence of cost underestimation in finishes work element due to requirement of quality selection for good aesthetic had the second highest ranking with MV=4.01. Prevalence of cost underestimation in fittings work element due to the influence of quality requirement in order to achieve good workmanship had the third highest with MV=3.85. The level of prevalence of cost underestimation in cost-significant building work elements had AMV=3.17.

Table 4.10: Level of prevalence of cost underestimation in cost-significant building work elements

Prevalence of cost underestimation	N	Of no prevalence (%)	Of little prevalence (%)	Of average prevalence (%)	Of high prevalence (%)	Of very high prevalence (%)	Mean Value	S.D	Rank
Prevalence of cost underestimation in foundations work element due to unexpected ground conditions which brings about changes in work quantities for subsequent re-measurement of works	74	0.0	2.7	29.7	24.3	43.2	4.08	0.91	1
Prevalence of cost underestimation in finishes work element due to requirement of quality selection for good aesthetic	74	0.0	0.0	27.0	44.6	28.4	4.01	0.74	2
Prevalence of cost underestimation in fittings work element due to influence of quality requirement in order to achieve good workmanship	74	1.4	0.0	23.0	63.5	12.2	3.85	0.67	3
Prevalence of cost underestimation in mechanical installation work element due to capital cost requirement of appropriate design in relation to future running cost requirement	74	0.0	1.4	40.5	29.7	28.4	3.85	0.85	4
Prevalence of cost underestimation in external work element due to extensive works on large construction site	74	0.0	4.1	33.8	52.7	9.5	3.68	0.70	5
Prevalence of cost underestimation in plumbing work element due to the need to re-measure work after execution for accuracy of cost	74	0.0	1.4	44.6	43.2	10.8	3.64	0.69	6
Prevalence of cost underestimation in electrical installation work element due to requirement of specialisation in area of work	74	0.0	0.0	55.4	27.0	17.6	3.62	0.77	7
Prevalence of cost underestimation in external envelope work element due to influence of building shape on the cost	74	1.4	10.8	27.0	54.1	6.8	3.54	0.83	8
Prevalence of cost underestimation in structural frame work element due to substantial time of construction which is required to execute the work	74	0.0	14.9	55.4	27.0	2.7	3.18	0.70	9
Average mean value	3.71								

4.6.2.1 Scope changes

Respondents were asked to indicate the level of prevalence of scope changes on building work elements on construction projects; where 1=of no prevalence, 2=of little prevalence, 3=of average prevalence, 4=of high prevalence, 5=of very high prevalence, and U=Unsure. Table 4.11 shown that the prevalence of scope changes on foundations work element had the highest ranking with MV=4.11. Prevalence of scope changes on fitting work element had the second highest ranking with MV=3.85. Prevalence of scope changes on electrical installation work element had the third highest ranking with MV=3.81. The level of prevalence of scope changes on building work elements had AMV=3.69.

Table 4.11: Level of prevalence of scope changes on building work elements

Scope changes	N	Of no prevalence (%)	Of little prevalence (%)	Of average prevalence (%)	Of high prevalence (%)	Of very high prevalence (%)	Mean Value	S.D	Rank
Prevalence of scope changes on foundations work element	74	0.0	1.4	12.2	60.8	25.7	4.11	0.65	1
Prevalence of scope changes on fitting work element	74	0.0	4.1	31.1	40.5	24.3	3.85	0.83	2
Prevalence of scope changes on electrical installation work element	74	0.0	1.4	31.1	52.7	14.9	3.81	0.69	3
Prevalence of scope changes on finishes work element	74	0.0	0.0	41.9	36.5	21.6	3.80	0.77	4
Prevalence of scope changes on mechanical installation work element	74	0.0	1.4	50.0	18.9	29.7	3.77	0.90	5
Prevalence of scope changes on external envelope work element	74	0.0	10.8	29.7	48.6	10.8	3.59	0.82	6
Prevalence of scope changes on structural frame work element	74	0.0	2.7	60.8	18.9	17.6	3.51	0.81	7
Prevalence of scope changes on external work element	74	0.0	4.1	55.4	33.8	6.8	3.43	0.68	8
Prevalence of scope changes on plumbing work element	74	0.0	0.0	71.6	17.6	10.8	3.39	0.67	9
Average mean value	3.69								

4.6.2.2 Risk associated with specialised building works

Respondents were asked to indicate the level of prevalence of risk associated with cost underestimation in specialised building works on construction projects; where 1=of no prevalence, 2=of little prevalence, 3=of average prevalence, 4=of high prevalence, 5=of very high prevalence, and U=Unsure. Table 4.12 shows that prevalence of risk associated with cost underestimation in security systems works due to specialised skill required for work execution had the highest ranking with MV=3.61. Prevalence of risk associated with cost underestimation in access control works due to specialised skill required for work execution had the second highest ranking, with MV=3.58. Prevalence of risk associated with cost underestimation in demolition works due to factors of health and safety of the general public, including adjoining, had the third highest ranking with MV=3.45. The prevalence of risk associated with specialised works on cost underestimation had AMV=3.42.

Table 4.12: Prevalence of risk associated with specialised works on cost underestimation

Risk associated with specialised building works	N	Of no prevalence (%)	Of little prevalence (%)	Of average prevalence (%)	Of high prevalence (%)	Of very high prevalence (%)	Mean Value	S.D	Rank
Prevalence of risk associated with cost underestimation in security systems works due to specialised skill required for work execution	74	0.0	10.8	25.7	55.4	8.1	3.61	0.79	1
Prevalence of risk associated with cost underestimation in access control works due to specialised skill required for work execution	74	0.0	2.7	43.2	47.3	6.8	3.58	0.66	2
Prevalence of risk associated with cost underestimation in demolition works due to factors of health and safety of the general public including adjoining properties	74	1.5	5.4	50.0	33.8	9.5	3.45	0.79	3
Prevalence of risk associated with cost underestimation in lifts works due to maintenance factors in relation to occupational health and safety regulations	74	0.0	18.9	44.6	10.8	25.7	3.43	1.07	4
Prevalence of risk associated with cost underestimation in piling works due to factors of health and safety of workers	59	1.7	39.0	16.9	6.8	35.6	3.36	1.36	5
Prevalence of risk associated with cost underestimation in escalators works due to maintenance factors in relation to occupational health and safety regulations	74	0.0	41.9	20.3	20.3	17.6	3.14	1.15	6
Average mean value	3.42								

4.6.3 Causes of cost underestimation

4.6.3.1 Planning stage

Respondents were asked to rate the causes of cost underestimation at planning stage of construction project; where 1=never, 2=seldom, 3=sometimes, 4=often, 5=always, and U=Unsure. Table 4.13 shows that insufficient time for cost estimating at planning stage had the highest ranking with MV=3.90. Poor project planning by professional team at planning stage had the second highest ranking with MV=3.88. Mistakes on the part of estimator at planning stage had the third highest ranking with MV=3.86. The causes of cost underestimation at planning staged had AMV=3.59.

Table 4.13: Causes of cost underestimation at planning stage

Planning stage	N	Never (%)	Seldom (%)	Sometimes (%)	Often (%)	Always (%)	Mean Value	S.D	Rank
Insufficient time for cost estimating at planning stage	72	1.4	9.7	4.2	66.7	18.1	3.90	0.85	1
Poor project planning by professional team at planning stage	74	0.0	2.7	35.1	33.8	28.4	3.88	0.85	2
Mistakes on the part of estimator at planning stage	74	0.0	16.2	23.0	18.9	41.9	3.86	1.13	3
Inadequate project specifications at planning stage	74	0.0	2.7	29.7	50.0	17.6	3.82	0.74	4
Poor estimating technique used by contractor	74	0.0	0.0	29.7	60.8	9.5	3.80	0.59	5
Lack of use of historical cost data at planning stage	74	0.0	2.7	28.4	62.2	6.8	3.72	0.62	6
Cost underestimated as a result of bias during planning	74	0.0	5.4	33.8	44.6	16.2	3.72	0.80	7
Inadequate project funding by the project owner	74	1.4	1.4	39.2	44.6	13.5	3.68	0.77	8
Scarcity of competent skills in the construction industry	69	2.9	13.0	7.2	76.8	0.0	3.58	0.83	9
Omission of cost-significant work items during planning	67	0.0	3.0	52.2	37.3	7.5	3.49	0.68	10
Inadequate use of building price index at planning stage	74	0.0	4.1	55.4	33.8	6.8	3.43	0.68	11
Incompleteness of cost estimate at planning stage	74	0.0	10.8	56.8	23.0	9.5	3.31	0.79	12
Cost underestimated as a result of lying during planning	72	0.0	73.6	5.6	12.5	8.3	2.56	1.00	13
Average mean value	3.59								

4.6.3.2 Design and material changes

Respondents were asked to rate design and material changes as causes of cost underestimation on construction project; where 1=never, 2=seldom, 3=sometimes, 4=often, 5=always, and U=Unsure. Table 4.14 shows that changes of design initiated by project owner had the highest ranking with MV=4.08. Additional works initiated by project owner had the second highest ranking with MV=4.01. Time delay caused by the contractor had the third highest ranking with MV=3.77. The design and material changes as causes of cost underestimation had AMV=3.66.

Table 4.14: Design and material changes as causes of cost underestimation

Design and material changes	N	Never (%)	Seldom (%)	Sometimes (%)	Often (%)	Always (%)	Mean Value	S.D	Rank
Changes of design initiated by project owner	74	0.0	0.0	21.6	48.6	29.7	4.08	0.71	1
Additional works initiated by project owner	74	0.0	0.0	18.9	60.8	20.3	4.01	0.63	2
Time delay caused by the contractor	74	0.0	0.0	33.8	55.4	10.8	3.77	0.63	3
Time delay in the procurement of materials	74	0.0	9.5	25.7	55.4	9.5	3.65	0.78	4
Time delay as a result of unforeseen event	74	0.0	2.7	56.8	23.0	17.6	3.55	0.81	5
Time delay caused by the project owner	74	1.4	18.9	20.3	44.6	14.9	3.53	1.01	6
Material price changes due to escalation	74	0.0	10.8	50.0	20.3	18.9	3.47	0.92	7
External factors beyond the control of project stakeholders	74	0.0	12.2	56.8	21.6	9.5	3.28	0.80	8
Average mean value	3.66								

4.6.3.3 Risk due to unforeseen factors

Respondents were asked to rate the risk due to unforeseen factors as causes of cost underestimation on construction project; where 1=never, 2=seldom, 3=sometimes, 4=often, 5=always, and U=Unsure. Table 4.15 shows that the risk of lowest bidding procurement for work execution had the highest ranking with MV=4.01. Risk of poor project planning by the professional team had the second highest ranking with MV=3.82. Risk of project complexity for adequate work execution had the third highest ranking with MV=3.62. The risk due to unforeseen factors as causes of cost underestimation had AMV=3.34.

Table 4.15: Risk due to unforeseen factors as causes of cost underestimation

Risk due to unforeseen factors	N	Never (%)	Seldom (%)	Sometimes (%)	Often (%)	Always (%)	Mean Value	S.D	Rank
Risk of lowest bidding procurement for work execution	70	0.0	0.0	15.7	67.1	17.1	4.01	0.57	1
Risk of poor project planning by the professional team	73	0.0	4.1	38.4	28.8	28.8	3.82	0.90	2
Risk of project complexity for adequate work execution	74	1.4	4.1	39.2	41.9	13.5	3.62	0.82	3
Risk of unexpected ground conditions during construction	74	0.0	2.7	48.6	35.1	13.5	3.59	0.75	4
Risk of delay to completion of works	74	0.0	0.0	64.9	17.6	17.6	3.53	0.78	5
Risk of economic conditions on project cost	74	0.0	0.0	55.4	43.2	1.4	3.46	0.52	6
Risk of financial loss to the project stakeholders	55	0.0	3.6	69.1	14.5	12.7	3.36	0.75	7
Risk of project funding by the project owner	74	0.0	9.5	62.2	10.8	17.6	3.36	0.88	8
Risk of shortage of skills in the construction industry	74	0.0	28.4	48.6	16.2	6.8	3.01	0.85	9
Risk of modern technology to be utilised on the project	74	0.0	37.8	32.4	28.4	1.4	2.93	0.84	10
Risk of physical damages to construction works	74	1.4	39.2	35.1	17.6	6.8	2.89	0.94	11
Risk of injury to life of personnel on construction site	74	4.1	59.5	18.9	16.2	1.4	2.51	0.86	12
Average mean value	3.34								

4.6.4 Effects of cost underestimation

4.6.4.1 Loss of reputation and credibility

Respondents were asked to rate the effects of cost underestimation on loss of reputation and credibility of project stakeholders; where 1=insignificant, 2=little significant, 3=fairly significant, 4=significant, 5=very significant, and U=Unsure. Table 4.16 shows that loss of reputation and credibility for the contractor to be awarded another project for execution had the highest ranking with MV=3.42. Loss of reputation and credibility for the quantity surveyor to get commission to manage another project had the second highest ranking with MV=3.40. Loss of reputation and credibility for the project owner to implement new project had the third highest ranking with MV=3.39. The effects of cost underestimation on reputation and credibility of stakeholders had AMV=3.14.

Table 4.16: Effects of cost underestimation on reputation and credibility of stakeholders

Loss of reputation and credibility	N	Insignificant (%)	Little significant (%)	Fairly significant (%)	Significant (%)	Very significant (%)	Mean Value	S.D	Rank
For the contractor to be awarded another project for execution	74	1.4	35.1	10.8	25.7	27.0	3.42	1.26	1
For the quantity surveyor to get commission to manage another project	73	1.4	35.6	1.4	45.2	16.4	3.40	1.17	2
For the project owner to implement new project	74	4.1	9.5	44.6	27.0	14.9	3.39	0.99	3
For the project manager to get commissioned to manage another project	74	0.0	35.1	13.5	45.9	5.4	3.22	0.99	4
For the financing institution to finance another project	74	4.1	25.7	27.0	37.8	5.4	3.15	1.00	5
For the architect to get commissioned to manage another project	74	1.4	36.5	17.6	43.2	1.4	3.07	0.95	6
For the civil engineer to get commissioned to manage another project	74	1.4	41.9	12.2	43.2	1.4	3.01	0.98	7
For the mechanical engineer to get commissioned to manage another project	74	1.4	51.4	1.4	37.8	8.1	3.00	1.13	8
For the electrical engineer to get commissioned to manage another project	74	1.4	51.4	2.7	43.2	1.4	2.92	1.03	9
For the structural engineer to get commissioned to manage another project	74	1.4	52.7	2.7	41.9	1.4	2.89	1.02	10
Average mean value	3.14								

4.6.4.2 Exposure to risk

Respondents were asked to rate the significance of risk exposure as effects of cost underestimation on construction projects; where 1=insignificant, 2=little significant, 3 fairly significant, 4=significant, 5=very significant, and U Unsure. Table 4.17 shows that risk of bankruptcy as a result of shortage of funds had the highest ranking with MV=3.78. Risk of delay to completion as a result of cash flow problems had the second highest ranking with MV=3.78. Risk of increase in claims due to increase in contract price had the third highest ranking with MV=3.73. The risk exposure on construction projects due to effects of cost underestimation had AMV=3.57.

Table 4.17: Risk exposure on construction projects due to effects of cost underestimation

Exposure to risk	N	Insignificant (%)	Little significant (%)	Fairly significant (%)	Significant (%)	Very significant (%)	Mean Value	S.D	Rank
Risk of bankruptcy as a result of shortage of funds	74	0	10.8	8.1	73.0	8.1	3.78	0.74	1
Risk of delay to completion as a result of cash flow problems	74	0	0	47.3	27.0	25.7	3.78	0.83	2
Risk of increase in claims due to increase in contract price	74	0	0	39.2	48.6	12.2	3.73	0.66	3
Risk of project abandonment as a result of shortage of funds	74	0	0	45.9	41.9	12.2	3.66	0.68	4
Risk of litigation as a result of claims for additional payment	74	0	10.8	44.6	35.1	9.5	3.43	0.81	5
Risk of poor quality of work as a result of shortage of funds	74	0	33.8	21.6	20.3	24.3	3.35	1.18	6
Risk of physical damages due to poor workmanship	74	0	2.7	70.3	23.0	4.1	3.28	0.58	7
Average mean value	3.57								

4.6.4.3 Financial loss

Respondents were asked to rate the significance of financial loss due to effects of cost underestimation on construction projects; where 1=insignificant, 2=little significant, 3=fairly significant, 4=significant, 5=very significant, and U=Unsure. Table 4.18 shows that loss of profit to contractor had the highest ranking with MV=3.88. Loss of resource of project owner had the second highest ranking with MV=3.80. Loss of income to financing institution had the third highest ranking with MV=3.55. The financial loss on construction project due to effects of cost underestimation had AMV=3.25.

Table 4.18: Financial loss on construction project due to effects of cost underestimation

Financial loss	N	Insignificant (%)	Little significant (%)	Fairly significant (%)	Significant (%)	Very significant (%)	Mean Value	S.D	Rank
Loss of profit to contractor	74	0.0	0.0	51.4	9.5	39.2	3.88	0.95	1
Loss of resource of project owner	74	0.0	0.0	47.3	25.7	27.0	3.80	0.84	2
Loss of income to financing institution	74	0.0	28.4	20.3	18.9	32.4	3.55	1.21	3
Negative effect on project end user	74	0.0	37.8	10.8	28.4	23.0	3.36	1.21	4
Misallocation of financial resource	73	0.0	37.0	13.7	39.7	9.6	3.22	1.05	5
Loss of income to mechanical engineer	74	0.0	45.9	12.2	28.4	13.5	3.09	1.13	6
Loss of income to quantity surveyor	74	0.0	45.9	12.2	31.1	10.8	3.07	1.10	7
Loss of income to structural engineer	74	0.0	45.9	13.5	28.4	12.2	3.07	1.11	8
Loss of income to electrical engineer	74	0.0	47.3	12.2	28.4	12.2	3.05	1.12	9
Loss of income to civil engineer	74	0.0	45.9	20.3	20.3	13.5	3.01	1.10	10
Loss of income to architect	74	0.0	45.9	18.8	24.3	10.8	3.00	1.07	11
Loss of work in construction industry	74	10.8	25.7	27.0	29.7	6.8	2.98	1.12	12
Average mean value	3.25								

4.6.5 Mitigating cost underestimation

4.6.5.1 Design requirements

Respondents were asked to rate the importance of the design requirements as mitigating mechanisms on cost underestimation; where 1=not important, 2=slightly important, 3=fairly important, 4=important, 5=very important, and U=Unsure. Table 4.19 shows that the production of well-prepared bills of quantities had the highest ranking with MV=4.89. The provision of clear scope of work had the second highest ranking with MV=4.80. Loss of income to financing institution had the third highest ranking with MV=4.64. The design requirements as mitigating mechanisms on cost underestimation had AMV=4.55.

Table 4.19: Design requirements as mitigating mechanisms on cost underestimation

Design requirements	N	Not important (%)	Slightly important (%)	Fairly important (%)	Important (%)	Very important (%)	Mean Value	S.D	Rank
The production of well-prepared bills of quantities	74	0.0	0.0	0.0	10.8	89.2	4.89	0.31	1
The issuance of adequate project specification	74	0.0	0.0	6.8	6.8	86.5	4.80	0.54	2
The provision of clear scope of work	74	0.0	0.0	0.0	36.5	63.5	4.64	0.48	3
The usage of appropriate conditions of contract	74	0.0	1.4	2.7	31.1	64.9	4.59	0.61	4
The issuance of adequate information of site location	74	0.0	1.4	12.2	14.9	71.6	4.57	0.76	5
The issuance of complete construction drawing	74	0.0	0.0	0.0	44.6	55.4	4.55	0.50	6
The issuance of adequate information on soil condition	74	0.0	2.7	9.5	17.6	70.3	4.55	0.77	7
The provision of detailed tender requirement	74	0.0	1.4	8.1	28.4	62.2	4.51	0.70	8
The avoidance of design changes during execution of works	74	0.0	0.0	50.0	8.1	41.9	3.92	0.96	9
Average mean value	4.55								

4.6.5.2 Effective techniques and skills

Respondents were asked to rate the importance of effective techniques and skills as mitigating mechanisms on cost underestimation; where 1=not important, 2=slightly important, 3=fairly important, 4=important, 5=very important, and U=Unsure. Table 4.20 shows that estimating the works within area of professional expertise had the highest ranking with MV=4.14. Making allowance for contingencies based on requirements had the second highest ranking with MV=3.96. Making allowance for contingencies based on experience had the third highest ranking with MV=3.91. The effective techniques and skills as mitigating mechanisms on cost underestimation had AMV=3.67.

Table 4.20: Effective techniques and skills as mitigating mechanisms on cost underestimation

Effective techniques and skills	N	Not important (%)	Slightly important (%)	Fairly important (%)	Important (%)	Very important (%)	Mean Value	S.D	Rank
Estimating the works within area of professional expertise	74	0	0	27.0	32.4	40.5	4.14	0.81	1
Making allowance for contingencies based on requirements	74	0	0	32.4	39.2	28.4	3.96	0.78	2
Making allowance for contingencies based on experience	74	0	0	41.9	25.7	32.4	3.91	0.86	3
The process of exercising continuous skill development	74	0	32.4	2.7	33.8	31.1	3.64	1.23	4
The practice of IT based estimating technique	69	0	25.7	18.8	34.8	18.8	3.45	1.09	5
The usage of modern technology to implement project	69	0	29.0	21.7	24.6	24.6	3.45	1.15	6
The facilitation of on-job training to acquire skills in costing	69	10.1	29.0	17.4	21.7	21.7	3.16	1.33	7
Average mean value	3.67								

4.6.5.3 Planning

Respondents were asked to rate the importance of the planning as mitigating mechanisms on cost underestimation; where 1=not important, 2=slightly important, 3=fairly important, 4=important, 5=very important, and U=Unsure. Table 4.21 shows that preparing cost plan during successive stages of work had the highest ranking with MV=4.45. The planning of project scope of work had the second highest ranking with MV=4.43. Planning the procurement requirements for the project had the third highest ranking with MV=4.32. Planning as mitigating mechanisms on cost underestimation had AMV=4.22.

Table 4.21: Planning as mitigating mechanisms on cost underestimation

Planning	N	Not important (%)	Slightly important (%)	Fairly important (%)	Important (%)	Very important (%)	Mean Value	S.D	Rank
Preparing cost plan during successive stages of work	74	0.0	0.0	6.8	41.9	51.4	4.45	0.62	1
The planning of project scope of work	74	0.0	0.0	0.0	56.8	43.2	4.43	0.49	2
Planning the procurement requirements for the project	74	0.0	0.0	10.8	45.9	43.2	4.32	0.66	3
Planning the work schedule for construction activities	74	0.0	2.7	13.5	39.2	44.6	4.26	0.79	4
Planning the resource schedule for construction activities	74	0.0	2.7	13.5	51.4	32.4	4.14	0.74	5
Planning for unforeseen risk in construction works	74	0.0	0.0	40.5	20.3	39.2	3.99	0.89	6
Taking out adequate risk cover to mitigate negative effect	74	0.0	1.4	39.2	21.6	37.8	3.96	0.91	7
Average mean value	4.22								

4.7 Discussion of findings

The findings of this survey were discussed in relation to the perspective of secondary data. Hence, this section will discuss the trend of the survey findings together with relevant literature, and in relation to the research questions; the factors that contribute to cost underestimation, the prevalence of cost underestimation in cost-significant work items, the causes of cost underestimation, and the effects of cost underestimation, and how cost underestimation can be mitigated.

4.7.1 Factors contributing to cost underestimation

Table 4.22 displays the ranking of average mean values of subsets of factors contributing to cost underestimation; ranges where 1.00-1.80=strongly disagree, 1.81-2.60=disagree, 2.61-3.40=neutral, 3.41-4.20=agree, 4.21-5.00=strongly agree.

Level of contribution of project planning factors to cost underestimation had AMV=3.86. The survey rated some of the key factors relating to project planning as follows. The description of the work items to facilitate pricing with MV=4.64. CIBD (2010:2) define bills of quantities as a document for tendering, usually prepared in standard form, comprising both a descriptive list of quantities of works and a description of the materials, workmanship and other matters required for construction works. Describing works items provides adequate information for the estimator to accurately and confidently price the works (CIBD, 2010:2). According to Project Management Institute (2008:52), where the scope of a project is poorly defined, the final cost of the project is expected to be high. The survey further reveals the definition of the scope of works to be executed as a factor relating to project planning with MV=4.62. Project Management Institute (2008:78) maintains that the definition of scope of work with reference to work breakdown structure (WBS) is a required supporting detail for cost estimates. Further close relationships can be posited between describing work items and defining scope of work; work activity description normally describes the scope of work activity to be executed (Project Management Institute, 2008:159). Another factor highlighted in the survey is the selection process of competent professionals with MV=4.18. It is important to note that selection of professionals is a key component of the project initiation and planning stage of construction projects. According to Cunningham (2013:7), the choice of the architect as lead designer is a key decision on any project and will reflect the client's priorities, particularly those related to cost and quality. However, architects are naturally reluctant to drop quality to reduce cost. Hence, Project Management Institute (2008:41) suggests that the selection of construction cost professionals will contribute significantly to the cost objective of the project.

Level of contribution of methods and techniques factors to cost underestimation had AVM=3.46. The survey rated some of the key factors relating to methods and techniques as follows. Describing the work items for clarity of information for pricing is another factor which contributes to cost underestimation, with MV=3.97, while the use of design estimates at the relevant stage of works as project cost had MV=3.82. According to Hendrickson (2000:4), the design estimate reflects the progress of design on successive stages of construction projects; preliminary estimates are derived from the layout or conceptual design, which succeeds into detail estimate derived on a well-defined scope of work. The engineer's estimate is derived on the basis of described items and quantities of work. The use of preliminary estimates at the relevant stage of works as project cost was rated as a factor which contributes to cost underestimation, with MV=3.78.

Level of contribution of tools factors to cost underestimation had AVM=3.12. The study reveals the contribution as follows. The use of QS software measuring bills production, with MV=3.49, the use of CAD enable measuring bills production, MV=3.31, and the use of project management scheduling tool software. The modern advancements and use of technology drawing measuring software offers the advantage to impact the way bills of quantities are prepared, which has the potential to automate measurement and facilitate accurate cost estimates (Olatunji, Sher & Gu, 2010:68).

From the survey, as shown in Table 4.22, the finding with AMV=3.86 agree that project planning factors contributes to cost underestimation on construction projects. The finding is in line with previous research work stated in the literature on planning as contributing factor to cost underestimation.

Table 4.22: Factors contributing to cost underestimation

Factors contributing to cost underestimation	Average Mean Value	Rank
Contribution of project planning factors to cost underestimation	3.86	1
Contribution of methods and techniques factors to cost underestimation	3.46	2
Contribution of tools factors to cost underestimation	3.12	3

4.7.2 Prevalence of cost underestimation

Table 4.23 displays the ranking of average mean values of subsets of prevalence of cost underestimation; ranges where 1.00-1.80=strongly disagree, 1.81-2.60=disagree, 2.61-3.40=neutral, 3.41-4.20=agree, 4.21-5.00=strongly agree.

The prevalence of cost underestimation in cost-significant building work elements had a rating of AMV=3.71. The study reveals that prevalence of cost underestimation in the foundations work element due to unexpected ground conditions which brings about changes in work quantities for subsequent re-measurement of works had a rating of MV=4.08. Prevalence of cost underestimation in finishes work element due to requirement of quality selection for good aesthetic showed the third highest prevalence of cost underestimation, with MV=4.01. According to Buertey (2014:149), finishes scope changes are attributed to changes in the taste of the owner during the construction process. The prevalence of scope changes on fitting work element had a rating of MV=3.85. Smith and Jaggar (2007:78) describe fittings as cost-significant items which the design team needs to consider in terms of capital cost, life cycle and the value consequences of any decision.

The prevalence of scope changes on building work elements had a rating of AMV=3.69. The survey ranking indicates that prevalence of scope changes on foundations work element had a rating of MV=4.11. Buertey (2014:149) nominates substructure work, essential building services and finishes as the work items which are prone to scope changes. The substructure work of buildings is work items taking place below the ground, mainly foundation work with uncertain quantities, due to unexpected ground conditions. These work items are subjected to re-measurement in order to verify the actual quantities and extent of work done. Prevalence of cost underestimation in the fittings work element due to influence of quality requirement in order to achieve good workmanship had a rating of MV=3.85, and prevalence of scope changes on electrical installation work element had MV=3.8. Babalola and Adesanya (2007:75) reveal that, due to increased quality and standard of living, the design of electrical services has been more complex and therefore created cost management disparity in the pricing of electrical works.

The prevalence of risk associated with specialised works on cost underestimation had a rating of AMV=3.42. The survey findings indicate prevalence of risk associated with cost underestimation in security systems works due to specialised skill required for work execution had a rating of MV=3.61, while prevalence of risk associated with cost underestimation in access control works due to specialised skill required for work execution had MV=3.58. Buertey (2014:149) classifies electrical and IT specialised work as a significant category of works associated with project risk and yielding to scope changes. Prevalence of risk associated with cost underestimation in demolition works due to factors of health and safety of the general public including adjoining properties had a rating MV=3.45.

From the survey, as shown in Table 4.23, the finding with AMW=3.71 agree that cost-significant building work elements has prevalence on cost underestimation on construction projects. The finding is in line with previous research work stated in the literature on cost-significant items and their prevalence on cost underestimation.

Table 4.23: Prevalence of cost underestimation

Prevalence of cost underestimation	Average Mean Value	Rank
Prevalence of cost underestimation in cost-significant building work elements	3.71	1
Prevalence of scope changes on building work elements	3.69	2
Prevalence of risk associated with specialised works on cost underestimation	3.42	3

4.7.3 Causes of cost underestimation

Table 4.24 displays the ranking of average mean values of subsets of causes of cost underestimation; ranges where 1.00-1.80=strongly disagree, 1.81-2.60=disagree, 2.61-3.40=neutral, 3.41-4.20=agree, 4.21-5.00=strongly agree.

Design and material changes as causes of cost underestimation had a rating of AMV=3.66. The findings reveal that changes of design initiated by project owners had a rating of MV=4.08, while additional works initiated by project owner had MV=4.01. Zainudeen, Kumari, and Seneviratne (2010:2) argue that design changes make a significant contribution to cost overruns, with negative impacts on contractors' cash flow. They further maintain that design changes are inevitable in construction; hence most construction projects have failed to keep within estimated cost. Time delay caused by the contractor had a rating of MV=3.45.

The causes of cost underestimation at planning stage was rated AMV=3.59. The study indicates that insufficient time for cost estimating at the planning stage occurs, with a rating for this variable of MV=3.90. Al-Hasan *et al*. (2006:8) reveal that insufficient time for cost estimation is a major factor leading to inaccuracy of cost estimates. Cost estimation of projects at the planning stage is affected by lack of availability of time to produce a detailed design. The job of producing the cost estimate itself can be expensive and requires a great deal of time (Flouris & Lock, 2016:88). Poor project planning by professional team at planning stage was rated MV=3.88. Poor planning will not allow appropriate project execution and control, hence poor planning results in poor execution (Globerson & Zwikael, 2002:58). Mistakes on the part of estimators at planning stage had a rating of MV=3.86. According to Taylor (2008:85), one of the biggest mistakes in cost estimation is to forget lessons learnt in previous projects in relation to historical cost data. Flyvbjerg *et al.* (2002:290) attribute honest mistakes on the part of estimators as responsible for forecasting error.

The risk due to unforeseen factors as causes of cost underestimation had AMV=3.34. The survey indicates that risk of lowest bidding procurement for work had a rating of MV=4.01. According to Khan and Khan (2015:136), the common practice of awarding contracts to the lowest bidder was designed to ensure low public expenditure for completing a project, and this practise has legal precedents and is intended to avoid fraud and corruption. However, certain adversarial relationships have emerged due to the rise of claims and disputes as a result of contractors' loss of profit and increasing cost of the projects. Risk of poor project planning by the professional team had a rating of MV=3.82, while risk of project complexity for adequate work execution had MV=3.62. Akintoye and MacLeod (1997:33) outline the risk of evaluating the complexity associated with programming, scheduling of labour and plant as views expressed by contractors as risk element in relation to project objectives.

From the survey, as shown in Table 4.24, the finding AMV=3.66 agree that design and material changes are causes of cost underestimation on construction projects. The finding is in line with previous research work stated in the literature on design and material changes as causes of cost underestimation.

Table 4.24: Causes of cost underestimation

Causes of cost underestimation	Average Mean Value	Rank
Design and material changes as causes of cost underestimation	3.66	1
Causes of cost underestimation at planning stage	3.59	2
Risk due to unforeseen factors as causes of cost underestimation	3.34	3

4.7.4 Effects of cost underestimation

Table 4.25 displays the ranking of average mean values of subsets of effects of cost underestimation; ranges where 1.00-1.80=strongly disagree, 1.81-2.60=disagree, 2.61-3.40=neutral, 3.41-4.20=agree, 4.21-5.00=strongly agree.

Risk exposure on construction projects due to effects of cost underestimation had a rating of AMV=3.57. The study indicates risk of bankruptcy as a result of shortage of funds was rated MV=3.78. Risk of delay to completion as a result of cash flow problems had MV=3.78, while risk of increase in claims due to increase in contract price was rated MV=3.73. Akintoye and MacLeod (1997:33) reveal that contractors perceive project risk as adverse possibility which affects successful completion of project in terms of cost, time and quality.

Financial loss on construction projects due to effects of cost underestimation had AMV=3.25. The risk of loss of profit to contractors was rated MV=3.88. Babalola and Adesanya (2007:76) argue that an underestimated cost would lead to situations where contractors incur losses on the contract. Loss of resources of project owners was rated MV=3.80, and loss of income to financing institutions had MV=3.55. Flyvbjerg *et al.* (2002:290) argue that misrepresentation of project costs will lead to misallocation of resources, which will produce losses to those financing the project.

Loss of reputation and credibility of project stakeholders had AMV=3.14. For the contractor to be awarded another project for execution had the sixth highest ranking, with MV=3.42. For the quantity surveyor to get commission to manage another project had MV=3.40. For the project owner to implement new project had MV=3.39. Mukuka *et al.* (2014:114) sum up the effects of cost underestimation on project stakeholders as ranging from financial loss, tarnished reputation, and project abandonment to a drop in building activities in the construction industry. Furthermore, Zainudeen, Kumari and Seneviratne (2010:4) maintain that cost underestimation brings about project abandonment, bad reputation and inability to secure project finance.

From the survey, as shown in Table 4.25, the finding with AMV=3.57 agree that risk exposure on construction projects is the most significant effect of cost underestimation. The finding is in line with previous research work stated in the literature on risk exposure on construction projects as effects of cost underestimation.

Table 4.25: Effects of cost underestimation

Effects of cost underestimation	Average Mean Value	Rank
Risk exposure on construction projects as effects of cost underestimation	3.57	1
Financial loss on construction project as effects of cost underestimation	3.25	2
Loss of reputation and credibility of project stakeholders	3.14	3

4.7.5 Mitigating cost underestimation

Table 4.26 displays the ranking of average mean values of subsets of mitigating mechanisms of cost underestimation; ranges where 1.00-1.80=strongly disagree, 1.81-2.60=disagree, 2.61-3.40=neutral, 3.41-4.20=agree, 4.21-5.00=strongly agree.

Design requirements as mitigating mechanisms on cost underestimation was rated AMV=4.55. The production of well-prepared bills of quantities had MV=4.89. Davis and Baccarini (2004:5) argue that the use of bills of quantities during tender stage reduces the cost of tendering by contractors and results in savings on the cost of the project. They further reveal that without bills of quantities, the tenderer is exposed to the risk of underestimating the project cost, thereby making it difficult to complete the works or encouraging the cutting of corners in an attempt to recover the consequent loss. The issuance of adequate project specifications had the second highest ranking, with MV=4.80, while the provision of clear scope of work had the third highest ranking, with MV=4.64. The European Commission (1998:7) states that once a project's scope and specification has been clearly defined, then a fixed contract sum may be used, thereby passing the risk of completion cost to the contractor.

Planning as mitigating mechanisms on cost underestimation had a rating of AMV=4.22. Preparing cost plan during successive stages of work was rated MV=4.45. Skitmore *et al.* (1994:30) argue for the importance of the cost plan as planning technique that provides designers with continuous cost evaluation feedback during successive stages of design, thereby guiding them toward accurate cost estimates. The planning of the project's scope of work had a rating of MV=4.43, and planning the procurement requirements for the project had the sixth highest ranking, MV=4.32. CIBD (2010:1) maintains that uniformity of procurement documents such as conditions of tender, conditions of contract, specifications and methods of measurement and payment will permit contractors to accurately price the project risk for which they are to assume responsibility.

Effective techniques and skills as mitigating mechanisms on cost underestimation had AMV=3.67. Estimating the works within the area of professional expertise had MV=4.14.

Expertise cannot be generalised across different generic contract types (Skitmore *et al.,* 1994:30). Making allowance for contingencies based on requirements had MV=3.96, while making allowance for contingencies based on experience had MV=3.91. According to Buertey (2014:144), over the years, the risk identification process for estimating the cost of contingencies is inclined toward systemic risk "known-unknowns" while the specific risk "unknown-unknowns" have been neglected.

From the survey, as shown in Table 4.26, the finding with AMV=4.55 strongly agree that achieving design requirements is the most effective mechanism in mitigating cost underestimation on construction projects. The finding is in line with previous research work stated in the literature on design requirements as mitigating mechanisms on cost underestimation.

Table 4.26: Mitigating mechanisms on cost underestimation

Mitigating mechanisms on cost underestimation	Average Mean Value	Rank
Design requirements as mitigating mechanisms on cost underestimation	4.55	1
Planning as mitigating mechanisms on cost underestimation	4.22	2
Effective techniques and skills as mitigating mechanisms on cost underestimation	3.67	3

4.8 Chapter summary

This chapter was comprised of the presentation and analysis of the empirical data gathering exercise. It explained the process followed in gathering the data and results presentation. The empirical data was gathered through online surveys. A structured questionnaire was posted on the web with email request for survey, a follow-up email was sent to respondents and this accounted for the high response rate of 52%. The respondents' gender reflects the construction industry's male dominance, though 14.9% of female participant also reflected participation of both genders in the survey. The survey was carried out within public and private sectors, with participation of highly educated respondents, with significant years of experience in different areas of specialisation in the construction industry. The chapter has shown acceptable reliability of research instruments used to gather the data. The chapter also presented the findings of the survey, and further discussed the findings of the five research areas put forward.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The study set out to explore the shortcomings which emanate from causes and effects of cost underestimation, with the view to establishing factors that contribute to underestimation, and proffer mitigating mechanisms to address these factors. This chapter will present the summary and research salient points; it will review the various aspects of the study, the research objectives and achievements, contribution to the existing body of knowledge and possible implication of the study. It will highlight research limitations, issue recommendations and provide directions, and specify possible areas of further study before concluding with a summary.

5.2 Synthesis of empirical study

In the setting of the research objectives; the research sub-problems were formulated with a direct link to the research objectives. The study further derived research questions and resolved to attempt to answer them. The research problem highlighted the global phenomenon of cost underestimation on construction projects, which was subdivided into the different sub-problem areas. The sub-problems highlighted specific gaps within the construction industry, and the research questions were used as tools to derive the empirical data, the results from the data analysis confirmed that the research objectives were accomplished in relation to the following deductions:

- *Sub problem 1* indicated that competency of contractors and estimators are contributing factors to cost underestimation. The research investigated factors that contribute to cost underestimation based on empirical study of three major factors; the level of contribution of project planning factors to cost underestimation, methods and techniques factors to cost underestimation, and tools factors to cost underestimation on construction projects. The first research objective was to investigate factors that contribute to cost underestimation. From the empirical data gathered, the findings agree with AMV: 3.86, that project planning factors contribute to cost underestimation, in the following order: description of the work items to facilitate pricing (4.64; strongly agree), definition of the scope of works to be executed (4.62; strongly agree), selection process of competent professionals (4.18; agree), information on soil conditions for foundation design requirements (4.14; agree), information on site location for accessibility (4.12; agree), understanding of the prevailing economic conditions at the time of planning the project (4.03; agree). The study deduced that these factors significantly influence cost estimate on construction projects, and thus contribute to cost underestimation.

- *Sub problem 2* pointed out that unforeseen condition of construction works of cost-significant items result in the inaccuracy of cost estimate. The research investigated cost-significant work items based on empirical study of three variables: prevalence of cost underestimation in cost-significant building work elements, prevalence of scope changes on building work elements, and risk exposure on construction projects due to effects of cost underestimation. The second research objective was to evaluate the prevalence of cost underestimation in cost-significant work items. From the empirical data gathered, the findings agree with AMV: 3.71, on the prevalence of cost underestimation in cost-significant building work elements in the following order: foundations work element due to unexpected ground conditions which brings about changes in work quantities for subsequent re-measurement of works (4.08; agree), finishes work element due to requirement of quality selection for good aesthetic (4.01; agree), fittings work element due to influence of quality requirement in order to achieve good workmanship (3.85; agree), mechanical installation work element due to capital cost requirement of appropriate design in relation to future running cost requirement (3.85; agree), external work element due to extensive works on large construction site (3.68; agree), and plumbing work element due to the need to re-measure work after execution for accuracy of cost (3.64; agree). These cost-significant work elements exhibit the prevalence of cost underestimation, and according to the empirical data, most respondents rated each cost-significant item based on different conditions in relation to works execution.
- *Sub problem 3* suggested that inadequate preparation of cost estimates is a factor which causes cost underestimation. The research investigated the causes of cost underestimation based on empirical study of three variables; causes of cost underestimation at the planning stage, design and material changes as causes of cost underestimation, and risk due to unforeseen factors as causes of cost underestimation. The third research objective was to investigate the causes of cost underestimation. From the empirical data gathered, the findings agree with AMV: 3.66, that design and material changes are causes of cost underestimation, in the following order: changes of design initiated by project owner (4.08; agree), additional works initiated by project owner (4.01; agree), time delay caused by the contractor (3.77; agree), time delay in the procurement of materials (3.65; agree), time delay as a result of unforeseen event (3.55; agree), time delay caused by the project owner (3.53; agree). From the survey findings, the ranked factors are the causes of cost underestimation on construction projects, factors related to design and material changes and unforeseen delays.
- *Sub problem 4* indicated that cost underestimation results in financial loss. The research identified the effects of cost underestimation on construction projects based on empirical study of three variables; the effects of cost underestimation on loss of reputation and credibility of project stakeholders, risk exposure as effects of cost underestimation, and financial loss due to effects of cost underestimation. The fourth research objective was to

identify the effects of cost underestimation on project stakeholders. From the empirical data gathered, the findings agree with AMV: 3.57, risk exposure on construction projects, and effects of cost underestimation in the following order: risk of bankruptcy as a result of shortage of funds (3.78; agree), risk of delay to completion as a result of cash flow problems (3.78; agree), risk of increase in claims due to increase in contract price (3.73; agree), risk of project abandonment as a result of shortage of funds (3.66; agree), risk of litigation as a result of claims for additional payment (3.43; agree), risk of poor quality of work as a result of shortage of funds (3.35; neutral). From the empirical findings, it was deduced that risk exposure has significant effects of cost underestimation on project stakeholders. Further to financial risk exposure, cost underestimation would lead to additional damaging effects on various aspects of the construction project.

- *Sub problem 5* indicated that lack of adequate planning and techniques are factors which evade mitigating mechanisms in the process leading to cost underestimation. In order to proffer mitigation mechanisms, the research highlighted mechanisms for mitigating cost underestimation based on empirical study of three variables; design requirements as mitigating mechanisms on cost underestimation, effective techniques and skills as mitigating mechanisms on cost underestimation, and planning as mitigating mechanisms on cost underestimation. The fifth research objective was to develop mechanisms for mitigating cost underestimation. From the empirical data gathered, the findings strongly agree with AMV: 4.55, put design requirements as mitigating mechanisms on cost underestimation, in the following order: production of well-prepared bills of quantities (4.89; strongly agree), issuance of adequate project specification (4.80; strongly agree), provision of clear scope of work (4.64; strongly agree), usage of appropriate conditions of contract (4.59; strongly agree), issuance of adequate information of site location (4.57; strongly agree), issuance of complete construction drawing (4.55; strongly agree). The survey deduced that achieving design requirements is the most effective mechanism for mitigating cost underestimation on construction projects. According to the empirical data and synthesis of fourth and fifth objectives, in order to resolve the research problem, one must close the gap between the initial project cost and completion cost. It was conclusive that design is a significant factor which leads to cost underestimation, and if design requirements are adequately planned, negative effects of cost underestimation can be mitigated on construction projects.

5.3 Limitations of the study

The study evaluated the perspective of project stakeholders directly involved in the cost estimation of construction projects. In this research, the opinions of project end-users and clients were not surveyed with regard to the causes and effects of cost underestimation; this was not considered in this research due to the expertise and knowledge required to be demonstrated in the survey. However, the findings adequately covered the effects of cost underestimation on both project end-users and clients.

5.4 Operational framework

The study revealed that cost underestimation does exist on construction projects, and that project stakeholders are responsible for cost underestimation. The research findings will influence the existing concept of cost-significant theory which was attributed to the research problem; the concept of cost-significant theory depicted simplicity to cost estimation methodology, by determining key items that contribute most significantly to project cost estimation. Vilfredo Pareto's 80:20 rule suggests a simple rule to handle the concept of cost-significant work items; eighty percent of total cost is contained in twenty percent of cost items (Mohamed *et al*., 2012:2265).

Figure 5.1 outlines an operational framework to achieve successful project delivery in relation to accurate cost estimation. The survey findings highlighted a path of accurate cost estimation through the implementation of mitigating mechanisms on cost underestimation, with the importance of design requirements, techniques and skills and adequate planning in order to achieve successful delivery, accurate cost estimates and cost saving on construction projects. The negative effects of inaccurate cost estimation, with factors that contribute to cost underestimation, prevalence of underestimation and the causes of cost underestimation are mostly associated with synthetic events depicted by the path of inaccurate cost estimation in Figure 5.1 and thus lead to the loss of reputation, exposure to risk and financial loss on project stakeholders, which could be avoided if adequate attention is given to mitigating mechanisms. Based on this operational framework, the research objectives can be satisfactorily achieved with positive effects of construction projects by implementing the research findings through the operational framework of mitigating mechanisms, with particular focus on cost-significant work items (which account for 80% of the project cost) by adhering to design requirements, appropriate techniques and skills and formulating adequate planning on the process leading to cost estimation.

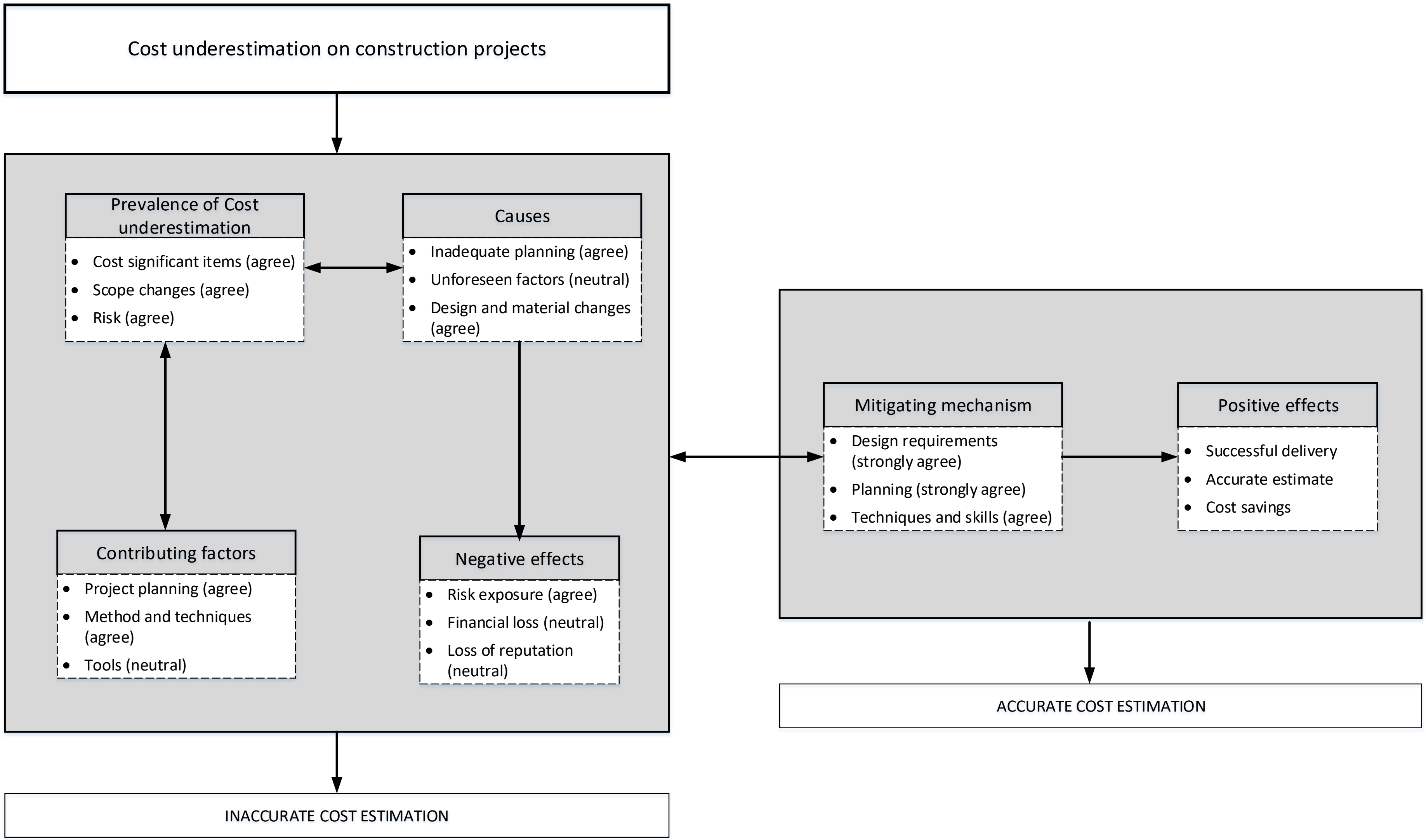

Figure 5.1: Operational framework to achieve successful delivery and accurate estimate

Source: Own

5.5 Contribution to the body of knowledge

The knowledge gap in the area of cost underestimation in construction projects was observed. The research was based on the qualitative approach to acquiring knowledge on the causes and effects of cost underestimation on construction projects. This knowledge was gathered through survey and analysis of opinions of construction professionals and stakeholders responsible for cost estimation on construction projects. The research findings will hopefully influence the existing practice away from the concept of cost-significant theory, which is connected to the research problem; the theory ascribed about 20% of total quantity items to make up 80% of construction total cost. The findings highlight items which are cost significant and draw the attention of project stakeholders to the prevalence of cost underestimation in such items, and the need to identify negative conditions which bring about changes from the initial design, in order to achieve accurate cost estimates.

The researcher went on to assess the prevalence of cost underestimation in cost-significant items, including scope changes and risks associated with building works. The findings contributed to the existing gap of mitigating mechanisms on cost underestimation, through adherence to design requirements, adequate planning, and utilisation of appropriate techniques and skills. The current findings may serve as a policy guide in the construction sector, in the process of cost management and improving cost performance on construction projects. The conceptual theory indicated in Figure 5.16 will further contribute to knowledge and close existing gaps in the mitigation of cost underestimation by demonstrating the path to achieving accurate estimates and successful project delivery by implementing design requirements, avoiding scope changes and identifying, planning, managing and mitigating negative risk associated with cost-significant items.

5.6 Recommendations based on findings

In an effort to achieve accurate cost estimates, the research focused on the causes of cost underestimation with a view to providing mitigating mechanisms in order to avoid negative effects and consequence. The study recommends that contractors and cost professionals should exert adequate attention towards the events leading to the production process of cost estimates; from competency, skills and techniques, the definition and understanding of the bills of quantities, reviewing the cost implication of cost-significant items, risks and scope changes, and planning to avoid design and material changes.

Based on these recommendations, the construction industry is advised to conduct training and seminars to sensitise and expose building contractors and cost professionals regarding improving the accuracy of cost estimate. In order to achieve successful delivery, accurate estimate, cost saving and “good value for money” in the construction industry, the project stakeholders should implement the operational framework in Figure 5.1, hence inaccurate cost estimation can be averted on construction projects in South Africa

5.7 Areas for further research

The research study was limited to causes and effects of cost underestimation from the perspectives of respondents. In addition, the operational framework in Figure 5.1 highlights both the negative effects and the positive effects of cost underestimation, however the research findings was limited to negative effects. Further study should focus on the following:

- The effects of mitigating mechanism on inaccurate cost estimation;
- The opinion of project end-users and clients on causes and effects of cost underestimation, as different and independent perspectives from the view of contractors and construction cost professionals;
- Improving cost performance during construction projects to avoid cost overrun; and
- Improving accuracy of cost estimates at the planning stage to avoid cost underestimation.

5.8 Concluding summary

The research objectives emanated from the problem associated with gaps between the initial project cost and completion cost, which result in cost underestimation. The study further concluded that cost underestimation does exist on construction projects, and that project stakeholders are mainly responsible for cost underestimation. From the findings, the causes of cost underestimation are mostly associated with man-made events, and thus lead to negative effects on project stakeholders, especially their scarce financial resources, which could be avoided if adequate attention were given to the surveyed mitigating mechanism.

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APPENDIX A - E-MAIL REQUESTING PARTICIPATION IN THE QUESTIONNAIRE

Cape Peninsula University of Technology

Cape Peninsula University of Technology

Department of Construction Management

1st June 2016

Dear Sir / Madam,

RE: PARTICIPATION IN A SURVEY

We kindly request you to participate in a survey by completing the enclosed questionnaire. The questionnaire is purely for **academic purpose** towards the degree of masters of technology in construction management. The study is focused on the issues of causes and effects of cost underestimation by contractors and estimators on construction projects and will help to contribute to the body of knowledge in the area of construction cost management.

The survey is distributed to obtain information from project stakeholders which participate directly in the cost estimation of construction activities within the Cape Town region of South Africa, the quantity surveyors registered with the South African Council for Quantity Surveying Professions (SACQSP) and the general building contractors registered with Construction Industry Development Board (CIBD).

Please read the instructions carefully and complete the questions. It will be appreciated if the completed questions could be returned on or before **14 June 2016.** Your response is of high importance, participants' information will be kept strictly confidential and will not be used for any other purpose other than research / academic purposes.

PLEASE RETURN THE COMPLETED QUESTIONNAIRE TO:

Abiodun Emmanuel Awosina

Email: abiodunawosina@nispdsl.co.za or city_ren2002@hotmail.com

Fax: 086 652 0408; Tel: 0734880006

Thank you for your cooperation.

APPENDIX B - QUESTIONNAIRE

SECTION A: GENERAL INFORMATION

1.1 Please indicate your gender:

☐ Male ☐ Female

1.2 Please indicate the sector that you company belongs to in the construction industry:

☐ Private ☐ Public ☐ Both

1.3 Please indicate your year of experience in the construction industry:

☐ 0 - 5 years ☐ 6 - 10 years ☐ 11 - 15 years

☐ 16 years and above

1.4 Please indicate your current position in your company:

☐ Site Agent ☐ Supervisor ☐ Project Manager

☐ Estimator / QS ☐ Engineer ☐ Architect

☐ Director others __________

1.5 Please indicate your level of formal education:

☐ Matric ☐ Diploma ☐ BSc degree ☐ BTech

☐ BSc honors ☐ Masters ☐ Doctoral

☐ others __________

SECTION B: FACTORS CONTRIBUTING TO COST UNDERESTIMATION

2. Kindly rate the level of contribution of the following **'factors to cost underestimation'** on construction project; where 1 = of no contribution, 2 = of little contribution, 3 = of average contribution,
4 = of high contribution, 5 = of very high contribution, and U = Unsure.

Please tick one box in each row.

2.1	**Project planning**	**1**	**2**	**3**	**4**	**5**	**U**
1	The definition of the scope of works to be executed	1	2	3	4	5	U
2	The description of the work items to facilitate pricing	1	2	3	4	5	U
3	The information on site location for accessibility	1	2	3	4	5	U
4	The information on soil conditions for foundation design requirements	1	2	3	4	5	U
5	The selection process of competent professionals	1	2	3	4	5	U
6	The type of contract pricing strategy used to determine contract price	1	2	3	4	5	U
7	The type of procurement system used to award contract	1	2	3	4	5	U
8	The understanding of the prevailing economic conditions at the time of planning the project	1	2	3	4	5	U
9	The cost planning technique used for budgeting	1	2	3	4	5	U
10	The information on site restrictions for accessibility	1	2	3	4	5	U
11	The planning of work schedule for labour usage	1	2	3	4	5	U
12	The planning of work schedule for equipment mobilization	1	2	3	4	5	U
13	The planning of work schedule for material procurement	1	2	3	4	5	U
14	The coordination of different tasks of the professional team	1	2	3	4	5	U
15	Having the detail information of subcontractors that will be responsible for other specialized works	1	2	3	4	5	U
2.2	**Methods and Techniques**	**1**	**2**	**3**	**4**	**5**	**U**
1	The use of floor area method to determine project cost	1	2	3	4	5	U
2	The use of unit method to determine project cost	1	2	3	4	5	U
3	The use of elemental estimate to determine project cost	1	2	3	4	5	U
4	The gathering of historical cost data for usage during price production	1	2	3	4	5	U
5	The use of measuring list as a guide in the process of price production	1	2	3	4	5	U
6	Gathering input information from other project stakeholder during price production	1	2	3	4	5	U
7	Taking off quantities of individual items of works for price production	1	2	3	4	5	U
8	Describing the work items for clarity of information for pricing	1	2	3	4	5	U
9	Measuring work items based on the prescribed standard system of measurement	1	2	3	4	5	U
10	The use of previous projects to generate new contract price	1	2	3	4	5	U
11	The use of building price index to calculate project cost	1	2	3	4	5	U
12	Applying rate build-up to calculate cost of work items	1	2	3	4	5	U
13	The use of preliminary estimate at the relevant stage of works as project cost	1	2	3	4	5	U

		1	2	3	4	5	U
14	The use of elemental estimate at the relevant stage of works as project cost	1	2	3	4	5	U
15	The use of design estimate at the relevant stage of works as project cost	1	2	3	4	5	U
2.3	**Tools**	**1**	**2**	**3**	**4**	**5**	**U**
1	The use of CAD enable measuring bills production	1	2	3	4	5	U
2	The use of manual take-off measuring bills production	1	2	3	4	5	U
3	The use of QS software measuring bills production	1	2	3	4	5	U
4	The use of computer based spreadsheet measuring bills production	1	2	3	4	5	U
5	The use of project management scheduling tool software	1	2	3	4	5	U
6	The use of schedule of works as a planning tools	1	2	3	4	5	U
7	The use of bills of quantities as price production instruments	1	2	3	4	5	U
8	The use of stimulation base tools for cost risk analysis	1	2	3	4	5	U

SECTION C: PREVALENCE OF COST UNDERESTIMATION

3. Please indicate the level of **'prevalence of cost underestimation'** on construction projects; where
1 = of no prevalence, 2 = of little prevalence, 3 = of average prevalence, 4 = of high prevalence,
5 = of very high prevalence, and U = Unsure.

Please tick one box in each line.

3.1	Prevalence of cost underestimation	1	2	3	4	5	U
1	Prevalence of cost underestimation in foundations work element due to unexpected ground conditions which brings about changes in work quantities for subsequent re-measurement of works	1	2	3	4	5	U
2	Prevalence of cost underestimation in structural frame work element due to substantial time of construction which is required to execute the work	1	2	3	4	5	U
3	Prevalence of cost underestimation in external envelope work element due to influence of building shape on the cost	1	2	3	4	5	U
4	Prevalence of cost underestimation in fittings work element due to influence of quality requirement in order to achieve good workmanship	1	2	3	4	5	U
5	Prevalence of cost underestimation in electrical installation work element due to requirement of specialization in area of work	1	2	3	4	5	U
6	Prevalence of cost underestimation in plumbing work element due to the need to re-measure work after execution for accuracy of cost	1	2	3	4	5	U
7	Prevalence of cost underestimation in finishes work element due to requirement of quality selection for good aesthetic	1	2	3	4	5	U
8	Prevalence of cost underestimation in mechanical installation work element due to capital cost requirement of appropriate design in relation to future running cost requirement	1	2	3	4	5	U
9	Prevalence of cost underestimation in external work element due to extensive works on large construction site	1	2	3	4	5	U

3.2	Scope changes	1	2	3	4	5	U
1	Prevalence of scope changes on foundations work element	1	2	3	4	5	U
2	Prevalence of scope changes on structural frame work element	1	2	3	4	5	U
3	Prevalence of scope changes on external envelope work element	1	2	3	4	5	U
4	Prevalence of scope changes on fitting work element	1	2	3	4	5	U
5	Prevalence of scope changes on electrical installation work element	1	2	3	4	5	U
6	Prevalence of scope changes on plumbing work element	1	2	3	4	5	U
7	Prevalence of scope changes on finishes work element	1	2	3	4	5	U
8	Prevalence of scope changes on mechanical installation work element	1	2	3	4	5	U
9	Prevalence of scope changes on external work element	1	2	3	4	5	U
3.3	**Risk associated with specialized building works**	**1**	**2**	**3**	**4**	**5**	**U**
1	Prevalence of risk associated with cost underestimation in piling works due to factors of health and safety of workers	1	2	3	4	5	U
2	Prevalence of risk associated with cost underestimation in demolition works due to factors of health and safety of the general public including adjoining properties	1	2	3	4	5	U
3	Prevalence of risk associated with cost underestimation in lifts works due to maintenance factors in relation to occupational health and safety regulations	1	2	3	4	5	U
4	Prevalence of risk associated with cost underestimation in escalators works due to maintenance factors in relation to occupational health and safety regulations	1	2	3	4	5	U
5	Prevalence of risk associated with cost underestimation in access control works due to specialized skill required for work execution	1	2	3	4	5	U
6	Prevalence of risk associated with cost underestimation in security systems works due to specialized skill required for work execution	1	2	3	4	5	U

SECTION D: CAUSES OF COST UNDERESTIMATION

4. Kindly rate the **'causes of cost underestimation'** on construction project; where 1 = never, 2 = seldom, 3 = sometimes, 4 = often, 5 = always, and U = Unsure.

Please tick one box in each row.

4.1	Planning stage	1	2	3	4	5	U
1	Insufficient time for cost estimating at planning stage	1	2	3	4	5	U
2	Lack of use of historical cost data at planning stage	1	2	3	4	5	U
3	Inadequate use of building price index at planning stage	1	2	3	4	5	U
4	Mistakes on the part of estimator at planning stage	1	2	3	4	5	U
5	Poor project planning by professional team at planning stage	1	2	3	4	5	U
6	Poor estimating technique used by contractor	1	2	3	4	5	U
7	Scarcity of competent skills in the construction industry	1	2	3	4	5	U
8	Inadequate project funding by the project owner	1	2	3	4	5	U
9	Inadequate project specifications at planning stage	1	2	3	4	5	U

10	Incompleteness of cost estimate at planning stage	1	2	3	4	5	U
11	Cost underestimated as a result of bias during planning	1	2	3	4	5	U
12	Cost underestimated as a result of lying during planning	1	2	3	4	5	U
13	Omission of cost-significant work items during planning	1	2	3	4	5	U
4.2	**Design and material changes**	**1**	**2**	**3**	**4**	**5**	**U**
1	Additional works initiated by project owner	1	2	3	4	5	U
2	Changes of design initiated by project owner	1	2	3	4	5	U
3	Time delay in the procurement of materials	1	2	3	4	5	U
4	Time delay as a result of unforeseen event	1	2	3	4	5	U
5	Time delay caused by the contractor	1	2	3	4	5	U
6	Time delay caused by the project owner	1	2	3	4	5	U
7	External factors beyond the control of project stakeholders	1	2	3	4	5	U
8	Material price changes due to escalation	1	2	3	4	5	U
4.3	**Risk due to unforeseen factors**	**1**	**2**	**3**	**4**	**5**	**U**
1	Risk of financial loss to the project stakeholders	1	2	3	4	5	U
2	Risk of physical damages to construction works	1	2	3	4	5	U
3	Risk of injury to life of personnel on construction site	1	2	3	4	5	U
4	Risk of delay to completion of works	1	2	3	4	5	U
5	Risk of lowest bidding procurement for work execution	1	2	3	4	5	U
6	Risk of project funding by the project owner	1	2	3	4	5	U
7	Risk of unexpected ground conditions during construction	1	2	3	4	5	U
8	Risk of economic conditions on project cost	1	2	3	4	5	U
9	Risk of shortage of skills in the construction industry	1	2	3	4	5	U
10	Risk of modern technology to be utilized on the project	1	2	3	4	5	U
11	Risk of project complexity for adequate work execution	1	2	3	4	5	U
12	Risk of poor project planning by the professional team	1	2	3	4	5	U

SECTION E: EFFECTS OF COST UNDERESTIMATION

5. Kindly rate the significance of the **'effects of cost underestimation'** on project stakeholders; where 1 = insignificant, 2 = little significant, 3 = fairly significant, 4 = significant, 5 = very significant, and U = Unsure.

Please tick one box in each line.

5.1	**Loss of reputation and credibility**	**1**	**2**	**3**	**4**	**5**	**U**
1	For the project owner to implement new project	1	2	3	4	5	U
2	For the project manager to get commissioned to manage another project	1	2	3	4	5	U
3	For the architect to get commissioned to manage another project	1	2	3	4	5	U
4	For the quantity surveyor to get commission to manage another project	1	2	3	4	5	U
5	For the structural engineer to get commissioned to manage another project	1	2	3	4	5	U
6	For the mechanical engineer to get commissioned to manage another project	1	2	3	4	5	U
7	For the electrical engineer to get commissioned to manage another project	1	2	3	4	5	U

8	For the civil engineer to get commissioned to manage another project	1	2	3	4	5	U
9	For the contractor to be awarded another project for execution	1	2	3	4	5	U
10	For the financing institution to finance another project						
5.2	**Exposure to risk**	**1**	**2**	**3**	**4**	**5**	**U**
1	Risk of litigation as a result of claims for additional payment	1	2	3	4	5	U
2	Risk of poor quality of work as a result of shortage of funds	1	2	3	4	5	U
3	Risk of delay to completion as a result of cash flow problems	1	2	3	4	5	U
4	Risk of project abandonment as a result of shortage of funds	1	2	3	4	5	U
5	Risk of bankruptcy as a result of shortage of funds	1	2	3	4	5	U
6	Risk of increase in claims due to increase in contract price	1	2	3	4	5	U
7	Risk of physical damages due to poor workmanship	1	2	3	4	5	U
5.3	**Financial loss**	**1**	**2**	**3**	**4**	**5**	**U**
1	Loss of profit to contractor	1	2	3	4	5	U
2	Loss of resource of project owner	1	2	3	4	5	U
3	Loss of income to quantity surveyor	1	2	3	4	5	U
4	Loss of income to architect	1	2	3	4	5	U
5	Loss of income to structural engineer	1	2	3	4	5	U
6	Loss of income to mechanical engineer	1	2	3	4	5	U
7	Loss of income to electrical engineer	1	2	3	4	5	U
8	Loss of income to civil engineer	1	2	3	4	5	U
9	Loss of income to financing institution	1	2	3	4	5	U
10	Negative effect on project end user	1	2	3	4	5	U
11	Misallocation of financial resource						
12	Loss of work in construction industry	1	2	3	4	5	U

SECTION F: MITIGATING COST UNDERESTIMATION.

6. Kindly rate the importance of the following **'mitigating mechanisms'** on cost underestimation;
where 1 = not important, 2 = slightly important, 3 = fairly important, 4 = important, 5 = very important,
and U = Unsure.

Please tick one box in each line.

6.1	**Design requirements**	**1**	**2**	**3**	**4**	**5**	**U**
1	The provision of clear scope of work	1	2	3	4	5	U
2	The issuance of complete construction drawing	1	2	3	4	5	U
3	The provision of detailed tender requirement	1	2	3	4	5	U
4	The usage of appropriate conditions of contract	1	2	3	4	5	U
5	The production of well-prepared bills of quantities	1	2	3	4	5	U
6	The issuance of adequate project specification	1	2	3	4	5	U
7	The issuance of adequate information of site location	1	2	3	4	5	U
8	The issuance of adequate information on soil condition	1	2	3	4	5	U
9	The avoidance of design changes during execution of works	1	2	3	4	5	U
6.2	**Effective techniques and skills**	**1**	**2**	**3**	**4**	**5**	**U**

1	The practice of IT based estimating technique	1	2	3	4	5	U
2	The usage of modern technology to implement project	1	2	3	4	5	U
3	Making allowance for contingencies based on experience	1	2	3	4	5	U
4	Making allowance for contingencies based on requirements	1	2	3	4	5	U
5	Estimating the works within area of professional expertise	1	2	3	4	5	U
6	The facilitation of on-job training to acquire skills in costing						
7	The process of exercising continuous skill development	1	2	3	4	5	U
6.3	**Planning**	**1**	**2**	**3**	**4**	**5**	**U**
1	The planning of project scope of work	1	2	3	4	5	U
2	Preparing cost plan during successive stages of work	1	2	3	4	5	U
3	Planning the procurement requirements for the project	1	2	3	4	5	U
4	Planning the work schedule for construction activities	1	2	3	4	5	U
5	Planning the resource schedule for construction activities	1	2	3	4	5	U
6	Taking out adequate risk cover to mitigate negative effect	1	2	3	4	5	U
7	Planning for unforeseen risk in construction works	1	2	3	4	5	U

Thank you for participating in this survey.