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A DECISION SUPPORT FRAMEWORK FOR GRADING OF CIVIL ENGINEERING CONTRACTORS AND EVALUATION OF INFRASTRUCTURE PROJECT PERFORMANCE

PROGRAMME: DOCTOR OF PHILOSOPHY: CIVIL ENGINEERING

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JULY 2024

DECLARATION

I declare that this research is my unaided work. It is being submitted to the University of Witwatersrand, Johannesburg for the degree of Doctor of Philosophy in Civil Engineering. It has not been submitted before for any degree or examination to any other University.



10th day of July 2024

Salome Chiloane-Nwabueze

Date

ABSTRACT

The construction sector plays a key role in the economic development of a country. The management of this sector is thus crucial in maximising the performance of the sector and the economy. The South African construction sector performance has some level of inefficiencies that could be improved to enhance the sector's performance outputs. Therefore, the study aimed to develop a framework for grading civil engineering contractors and the evaluation of project performance. To achieve this, the study reviewed the literature on relevant key concepts and CIDB processes and systems. The government of South Africa has mandated the registration and grading of contractors to the Construction Industry Development Board (CIDB).

The CIDB grade is a license for trading with the government. It certifies contractors who are graded as capable of delivering projects up to a pre-determined contract value in each class of work. Currently, the grading system is based on two key determinants, which are the contractor's track record (i.e., completed projects) and available capital. Presently, a contractor grade does not denote the contractors' capabilities. However, contractor grading and performance evaluation should be a multi-criteria decision-making process. A questionnaire was developed and distributed to the key participants in the industry to establish whether there is a need for enhancing the current registration, grading, and performance evaluation of contractors in the construction sector and to establish relevant criteria.

Of the 149 respondents, the results of the study have revealed that most of the respondents (88.6%) agree that enhancing the current construction sector entry requirements could assist in improving contractors' capabilities. Moreover, 90.6% of the respondents have indicated that enhancing the current construction sector entry requirements will assist in improving the performance outputs of the construction sector.

A multicriteria decision-making methodology using the Analytical Hierarchy Process (AHP) based on seven main criteria with seventeen sub-criteria was carried out for

grading of contractors and performance evaluation of contractors. Thereafter, using the results obtained from the AHP, an enhanced framework was developed for registering, grading, and evaluating the performance of contractors. Relevant scenarios and CIDB grading scenarios were applied to test and validate the developed framework.

The construction sector entry requirements have been proposed by the study based on the literature reviewed and results of the state of practice survey to improve the sector performance. One way of improving the sector's performance is through entry regulation. Organisations and some countries worldwide have some form of entry regulation to manage the construction sector. To minimise business failure and poor performance, new entrants need to have at least a recognised technical qualification in the aspiring field of work. This will ensure that new entrants have the relevant knowledge of the field in which they aspire to enter. Having entry regulations and improved grading and performance evaluation systems may assist in improving the sector's performance. Proposals on the enhancements that may be considered by the CIDB are made which may assist in improving the industry's performance.

Keywords: Construction Sector, Grading System, Multi-criteria Decision Making, Analytical Hierarchy Process, Construction Industry Development Board.

DEDICATION

I dedicate this report to my husband and me. Our love, children, and your understanding, support, and patience have kept us through thick and thin and greatly motivated me. May the Almighty God continue to be with us and our families. I further dedicate this report to my parents for impacting a good academic foundation for me. To my beloved children (Koketso, Kgotso, ThatoyaModimo, and Emmanuel Jr) who have always understood and had patience with me throughout my studies, may the blessings of the Almighty God, the God of Abraham, Isaac, and Jacob be showered upon you and our future generations.

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NOTATION

A	a matrix of comparisons
ajk	elements of matrix A, for j, k= 1,2……..,n.
CI	consistency index
CR	consistency ratio
D	project priority matrix
E	overall project priority matrix
Pm	priority vector for main criteria
Ps	priority vector for sub-criteria
RI	random index
S	project priority vector for each criterion
V	overall project priority vector
X	column vector
λ_{max}	maximum eigen value
∞	incomplete or abandon projects

LIST OF ACRONYMYS

AEC	Architecture, Engineering and Construction
AHP	Analytical Hierarchy Process
AVE	Average Variance Extracted
B-BBEE	Broad –Based Black Economic Empowerment
BIM	Building Information Modelling
BNG	Breaking New Ground
BOQ	Bills of Quantities
CCD	Contractor Continuous Development
CCDP	Contractor Continuous Development Points
CE	Civil Engineering
CFA	Confirmatory Factor Analysis
CI	Consistency Index
CID	Construction Industry Development
CIDB	Construction Industry Development Board
CSR	Corporate Social Responsibility
CTQS	Composite Target Quality Score
COGTA	Co-operative Governance and Traditional Affairs
COPRAS-G	Complex Proportional Assessment with Grey Values
CR	Consistency Ratio
DCF	Discounted Cash Flow
DOD	Degree of Delay
DPWH	Department of Public Works and Housing
DSS	Decision Support System
EB	Electrical Works
EPA	Environment Protection Agency (USA)
EC	European Commission
ELECTRE	Elimination Et Choice Translating Reality
G	Grade
GB	General Building
GDP	Gross Domestic Product
GEAR	Growth, Employment and Redistribution
GFI	Global Fit Index
GoF	Global Goodness-of-Fit
HKHA	Hong Kong Housing Authority
HOLT	High Optimum Legitimate Tender Technique
H&S	Health and Safety
ICT	Information Communication and Technology
IDP	Integrated Development Plan
ISO	International Standardization for Organisation
ITT	Invitation to Tender
LBO	Leveraged Buy Out

MCA	Multi Criteria Analysis
MCDM	Multi Criteria Decision Making
ME	Mechanical Engineering
MFMA	Municipal Finance Management Act
NDP	National Development Plan
NFI	Normed Fit Index
NGP	National Growth Plan
NPC	National Planning Commission
NQF	National Qualification Framework
NW DPWR	North West Department of Public Works and Roads
OHS	Occupational Health and Safety
OHSAS	Occupational Health and Safety Assessment Series
OR	Operations Research
PASS	Performance Assessment Scoring System
P&E	Plant and Equipment
PERT	Programme Evaluation and Review Technique
PHP	Philippine Peso
PQC	Prequalification Criteria
PROMETHE	Preference Ranking and Organisation Method for Enrichment Evaluation
R	South African Rand
RDP	Reconstruction and Development Programme
RET	Request for Tender
ROC	Register of Contractors
ROP	Register of Projects
RSA	Republic of South Africa
RM	Malaysian Rinngit
SACPCMP	South African Council for Project and Construction Management
SAICE	South African Institution of Civil Engineering
SANRAL	South African National Roads Agency
SEM	Structured Equation Modelling
SICW	Safety Induction for Construction Workers
SKK	Certificate of Skills Competency
SPSS	Statistical Package for Social Scientist
SO	Single Objective
SRMR	Standardised Root Mean Residual
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution
UAE	United Arab Emirates
UK	United Kingdom
UN	United Nations
USA	United States of America
US$	United States of America Dollar
USAID	United States Agency for International Development
VAT	Value Added Tax
WSM	Weighted Sum Model

CHAPTER 1 INTRODUCTION

1.1 INTRODUCTION

Economic development can be measured by the physical development of infrastructure such as bridges, roads, and buildings, and job creation (Alzahran & Emsley, 2013) which are mainly offered by the civil engineering and general building construction sectors. According to Thwala (2005), investment in infrastructure has a huge potential to redress the high employment and poverty levels in South Africa. The aim of all parties, including client, contractor, consultants, suppliers, and end users involved in a construction project in either the public or private sector is to complete the project on schedule, within the planned budget, with the highest quality, and in the safest manner (Abiodun *et al.* 2017).

However, this is not always the case, as at times contracts are awarded to contractors who are unable to deliver the project outputs. For the economy to grow rapidly, the project performance of contractors undertaking infrastructure projects needs to match the grading level, especially in the public sector, where the infrastructure is constructed for public use.

The Construction Industry Development Board (2011) indicates that the failure rate of infrastructure projects in South Africa has greatly increased. Factors such as time, cost, quality, and client satisfaction are some of the indicators that are used to measure performance in a project environment (Cheung *et al.* 2004). Unfortunately, most contractors in government infrastructure projects fall short when assessed against these indicators (Mohlala, 2015). In a survey undertaken by the Construction Industry Development Board (2011), around 12% of the South African infrastructure projects surveyed had levels of defects that are regarded as inappropriate. It is estimated that this translates into a cost of around US $250 million per year (CIDB, 2011).

As stated by Dithebe et al. (2022), the South African construction industry experiences many other failures, including failure to complete projects within the agreed schedule and period and against the required quality standards. Contractors responsible for the failures are later required to rectify work done, which in turn increases the cost of the project, resulting in cost and time overruns.

The Construction Industry Development Board (CIDB) was established by an act of parliament of the Republic of South Africa (RSA). This is the Construction Industry Development Board Act No. 38 of 2000 which founded the regulatory body (CIDB) for the construction industry of South Africa. According to the Act, the objectives of the CIDB are not only to grow the South African economy through the construction industry but also to develop improved industry performance and best practices.

One way of improving industry performance and best practices in the construction sector is to ensure that the process for grading contractors is efficient, effective, and in line with international leading practices. Presently, the South African CIDB has nine grading levels: contractors are upgraded to the next higher grading level based solely on financial capabilities and evidence of completed projects.

Contractors are also classified according to the work they can carry out (Appendix A). This study focuses on the Civil Engineering (CE) category. There are presently no technical entry requirements: the current requirements for registering as a Grade 1 are a registered company, business account, tax clearance certificate, and R450 registration fee (CIDB, 2023). The registration from Grades 2-9 is based on the financial capabilities and evidence of completed projects conducted by the contractor during the application process. The grading system of the CIDB needs to be robust as contractors are awarded projects based on the grade that contractors hold.

The CIDB Act No 38 of 2000 established the CIDB to implement an integrated strategy for the reconstruction, growth, and development of the construction industry. The CIDB Regulations, adopted in 2004, provide a framework for grading contractors in terms of their capabilities and the volume/nature of the projects they can undertake. Initially, the grade of a contractor was based on two methods, one based on the track record and the other on the available capital. The latter method meant that a contractor could achieve a high grade provided it had available capital, regardless of its track record. This led to the amendment of the CIDB regulations in 2013 to provide for a ranking framework based on both the track record and available capital.

It is posited herein that relevant key criteria need to be considered for grading contractors who roll out infrastructure projects to decrease the failure rate of infrastructure projects in South Africa. A study conducted by the CIDB (2016) on contractor progression has shown that there is a strong correlation between contractors having construction-related training or qualifications and the contractor's survival and progression. The grading of contractors using a more extensive set of relevant key criteria may assist in improving the client's confidence in the quality of the contractor who will roll out the infrastructure project and enhance the performance of the construction industry.

According to Hanson *et al.* (2003), contractor project performance in South Africa is affected by poor workmanship because of contractor incompetence. In South Africa, construction projects still experience non-conformance to quality requirements as well as cost and schedule overruns to the detriment of clients. For project success to be attained, conformance to these parameters is the minimum expectation in the face of other considerations related to client satisfaction (Emuze & Mlwa, 2015). The increase in the failure rate of South African infrastructure projects indicates that the CIDB grading system needs to be improved as noted by Ratshisusu (2014). Moreover, the increase in the failure rate of infrastructure projects calls for an improved contractor project performance evaluation framework to support decision-makers in the infrastructure project management decision-making process.

It is important to understand that spending money on public infrastructure is synonymous with spending money on people themselves (Arif, 2013). Therefore, decision-makers are required to think innovatively and develop inventive and improved ways of grading contractors and monitoring and evaluating infrastructure project performance. This creates a need for systematic processes, decision support frameworks, and procedures in place that would enable better decision-making (Mihai *et al.* 2000).

Presently, the South African construction and civil engineering sector does not have a minimum requirement for contractors who wish to enter the construction industry. Anyone with or without technical knowledge, with little or no schooling can register a construction firm. It is posited herein that the development of a minimum entry requirement for

registering a construction firm can also assist in improving the status quo of the construction sector in South Africa.

Having such requirements would likely increase the success rate of Grade 1 contractors and would also make it easier for companies seeking to develop enterprises to select entities with potential (CIDB, 2016). Any minimum criteria for registration would, however, need to consider the currently registered Grade 1 contractors. According to CIDB (2016), 91% of the current registered Grade 1 contractors are black-owned, 32% are women-owned and 26% are youth-owned. The high representation of historically disadvantaged individuals, women, and youth amongst Grade 1 contractors highlights the importance of this category as a route in the transformation of the construction industry (CIDB, 2016).

This research was carried out to address the aforementioned need by developing a decision support framework that integrates multiple decision criteria and guides decision-makers on registering, grading, and evaluating contractors' performance. The study has proposed minimum entry requirements for new contractors who intend to register a construction civil engineering firm. Moreover, a framework for grading and evaluating the performance of contractors was developed. Proposals on the enhancements that may be considered by the CIDB were also made which may assist in improving the industry performance.

1.2 PROBLEM STATEMENT

According to Ngai *et al.* (2002), the construction industry is an integral part of the nation's infrastructure development and is an essential part of the economic backbone in many countries, often contributing 7-10% of the Gross Domestic Product. The industry is often criticised for inefficiencies in outcomes such as time and cost overruns, low productivity, poor quality, and inadequate customer satisfaction (Chan *et al.* 2003). It is, therefore, important to have changes in attitudes and procedures to enhance the chances of success in construction projects (Dubois & Gadde, 2002).

The increase in the failure of infrastructure projects, as indicated by the Construction Industry Development Board (2011), raises a great concern about the way the construction sector operates. Rodriguez *et al.* (2005) indicate that the construction sector is estimated globally to be worth US$3,200 billion per year and US$250 billion is spent annually on infrastructure in the developing world alone. Maseko (2017) notes that the construction of infrastructure projects is mostly characterised by high levels of unethical practices and poor performance, and this has impaired the image of the industry. Moreover, the delivery of good quality infrastructure projects in some emerging economies is continuously disrupted because of poor performance outputs.

Zulu and Chileshe (2010) found that contractor performance in Zambia is below expectation and most projects are delayed or do not reach the completion stage. The South African construction industry is no different because most projects are delayed or do not reach the completion stage as noted by Mohlala (2015). The failure of infrastructure projects in South Africa, therefore, suggests that the current decision support systems which are in place are not adequate. Many contractors lack the necessary business, technical and project management skills, qualifications, knowledge, and experience necessary to meet the objectives of public sector projects (Cheung *et al.*2004). As a result, most government infrastructure projects in South Africa are delayed and experience cost overruns whilst other projects remain incomplete (Mohlala, 2015).

Thus, this calls for an improved framework for registering, grading, and evaluation of project performance of contractors. However, this needs to be complemented by a clear governance framework with strict monitoring and evaluation of projects. The development of a prototype decision support framework that integrates multiple decision criteria, and guides decision makers in registering, grading of contractors and evaluation of performance may enhance the sector's performance. Such an approach may also assist government and municipal officials to confidently manage and evaluate projects.

According to Ratshisusu (2014), the grading system of the CIDB has some deficiencies. Firstly, the grading does not provide enough information to clients on the capacity and

ability of firms to undertake construction works. It could assist clients if the grade of the contractors matched the capacity and ability of the contractor concerned to undertake a construction project at a given point in time, which information can be made available by the CIDB. For instance, the CIDB grade 9, which is the highest grading a contractor can attain, has more than 50 firms that can potentially qualify to undertake large infrastructure projects, but only the top firms can deliver such projects. The number of firms in the CIDB grade 9 category gives a false impression that there is a high number of large construction firms, whereas competition for large infrastructure firms occurs only between the top firms (Ratshisusu, 2014).

The study has developed a framework for grading and evaluating the performance of contractors in the construction sector. Proposals on the minimum entry requirements have also been made. The problem at hand is to have a robust framework to register, grade, and evaluate the project performance of contractors to improve the performance of the South African construction sector. It is envisaged herein that a robust contractor registration and grading framework could assist in improving the performance of the construction sector and reflect the true capabilities of contractors.

This study has developed a robust framework that considers relevant criteria for grading and evaluation of the project performance of contractors using the Analytical Hierarchy Process (AHP). Minimum entry requirements for contractors who wish to register a construction firm to manage the sector and improve its performance have been proposed. Moreover, proposals are made for the enhancement of the current systems to ensure optimal use.

1.3 AIMS AND OBJECTIVES

1.3.1 Aim of the study

The study aims to develop a decision support framework that integrates multi-criteria decision parameters, and guides decision makers on registration, grading, and evaluation of civil engineering project performance of contractors. The framework will be flexible

enough to customise it for use in similar engineering disciplines. The focus of the framework is to provide a decision support framework whose output can be utilised for:

i. Registering new contractors who intend to register a civil engineering construction firm;
ii. Grading civil engineering contractors who are applying to be upgraded from one grade to the next grade;
iii. Monitoring and evaluating the project performance of contractors;
iv. Identifying gaps in civil engineering contractors' developmental needs;
v. Determining the support that may be provided to contractors to improve project performance;
vi. Evaluating and comparing project performance of local, provincial, and national contractors based on a common framework.

1.3.2 Objectives of the study

The objectives of the study are to:

i. Propose requirements for registering new contractors who intend to register a civil engineering firm;
ii. Develop a framework for grading civil engineering contractors who are applying to be graded from one grade to the next grade;
iii. Develop a framework for monitoring and evaluating project performance of contractors;
iv. Develop an enhanced framework to register, grade and evaluate the project performance of contractors;
v. Make recommendations that may be adopted by the South African Construction Industry Development Board and other relevant government departments.

1.4 RESEARCH QUESTIONS, MODEL AND HYPOTHESIS STATEMENTS

To achieve the objectives of the study, the research questions for the study were as follows:

i. What are the proposed requirements that could be used to register new contractors who intend to register a civil engineering firm?
ii. Which framework could be adopted for grading civil engineering contractors who are applying to be graded from one grade to the next grade?
iii. Can the adopted framework be utilised to monitor and evaluate the project performance of contractors?
iv. How can an enhanced framework that will be used to register, grade, and evaluate the project performance of contractors be developed?
v. What are other considerations that may be proposed to the South African Development Industry Board?

The research model indicated in Figure 1.1 was developed based on the literature review and the findings of the state of practice survey.

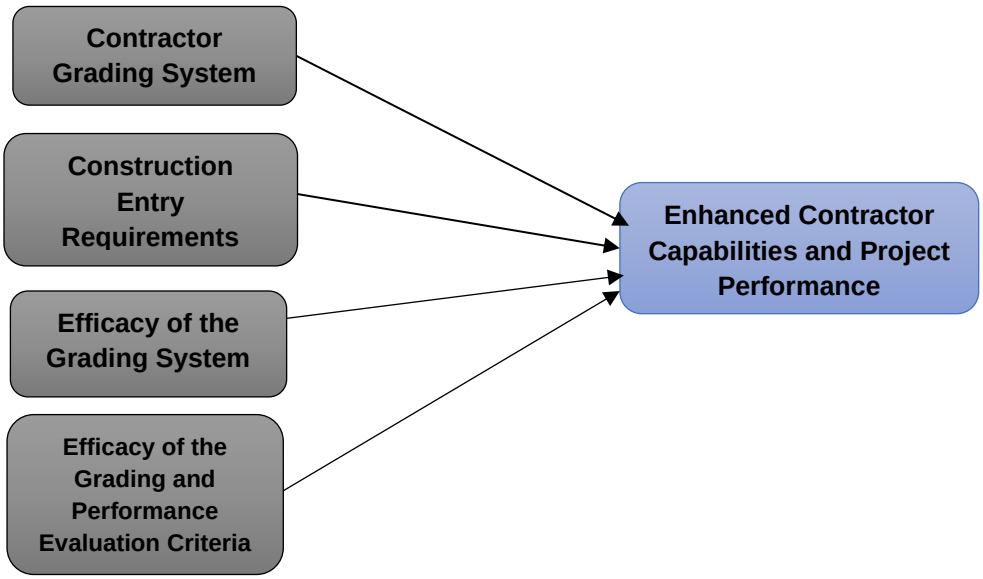


Figure 1.1 The research model

The model shows that the contractor grading system, construction entry requirements, efficacy of the grading system, and efficacy of the grading and performance evaluation criteria may lead to enhanced contractor capabilities and project performance, which is the outcome variable.

1.4.1 Hypotheses

1.4.1 Hypotheses

Based on the conceptual model of the study illustrated in Figure 1.1, the following hypotheses were formulated.

H_1: Contractor Grading System has a positive relationship with Enhanced Contractor Capabilities and Project Performance

H_2: Contractor Grading System has a positive relationship with Construction Entry Requirements

H_3: Contractor Grading System has a positive relationship with Efficacy of the Grading System

H_4: Contractor Grading System has a positive relationship with Efficacy of the Grading Criteria

H_5: Construction Entry Requirements have a positive relationship with Enhanced Contractor Capabilities and Project Performance

H_6: *Efficacy of the Grading System has a positive relationship with Enhanced Contractor Capabilities and Project Performance*

H_7: Efficacy of the Grading and Performance Evaluation Criteria has a positive relationship with Enhanced Contractor Capabilities and Project Performance

1.4.2 Significance of the study

In South Africa, the failure rate of infrastructure projects has greatly increased as noted by CIDB (2011). The increase in the failure rate of infrastructure projects, as cited by the Construction Industry Development Board (2011), raises great concern about how the

construction sector operates. The proposal of minimum entry requirements for the construction sector will assist in controlling the inflow of contractor registration. This will only allow individuals with technical knowledge and relevant experience to operate in the sector. Regulation of construction sector entry may assist in decreasing failure rates of projects and improve the performance of the sector. This practice will also bring forth control measures for the industry's new entrants and decrease the business dropout rate of Grade 1 contractors.

A robust framework of grading and performance evaluation of contractors is important. Contractor and performance evaluation of contractors requires a multi-criteria decision-making approach and, as such, relevant technical and non-technical criteria of contractors should be considered. This will increase the client's confidence in the contractor's capability, and it may also improve the performance of the sector. The importance of a robust framework for registering, grading, and performance evaluation of contractors in the construction sector cannot be emphasised enough.

The study has also made proposals that could be considered by the CIDB on linking some of the available systems which are the Register of Contractors and Register of Projects. This will assist in establishing the contractor's development needs so that clients can identify the contractor's key development areas and how to target contractors for interventions when planning projects. Moreover, this will also enable clients to identify contractors who are failing to execute projects within the specified time, quality, and budgetary requirements. The requirements for contractor grading progressions have also been proposed, based on the contractor grading criteria.

1.5 STRUCTURE OF THE REPORT

Chapter 1: Introduction

This chapter provides an overall context and motivation that derives the concept of this research in terms of key challenges faced by the South African construction sector. Thus, the focus is on improving the grading system of contractors, as well as introducing entry requirements and project performance evaluation framework in the construction sector to

assist in improving the sector's performance. Considering the context, it describes the problem statement, aims, and objectives of the research, as well as the significance of the study, novelty, and contributions.

Chapter 2: Literature review

Chapter 2 reviews the literature on project performance, the role of the Construction Industry Development Board, regulation of business entry, contractor grading, the performance of the construction sector, and other related concepts. The aim was to establish the basis for this research and identify requirements to be addressed by this research. It also reviews prior studies and existing frameworks to provide gap analysis to assist in establishing relevant criteria for consideration in the registration, grading, and performance evaluation of contractors.

Chapter 3: Current contractor registration processes and grading criteria

This chapter focuses on the contractor registration and grading processes that are currently in place at the South African Construction Industry Development Board. This chapter focuses on the Construction Industry Development Board processes and systems and construction sector procurement, as well as the legislative framework governing the industry in South Africa.

Chapter 4: Research Methodology

Chapter 4 describes the methodology for the study which has adopted a quantitative approach (questionnaires). It further describes the multi-criteria decision-making framework, which was adopted using the Analytical Hierarchy Process (AHP). The aim is to enhance the current contractor grading and performance evaluation framework to improve robustness. The AHP is one of the multiple decision-making methods that model decision-making processes mathematically and are used to solve complex problems.

Chapter 5: State of Practice Survey

In Chapter 5, responses from the questionnaire were analysed using the Structural Equation Modelling Approach and Statistical Package for Social Scientists (SPSS)

software. SPSS is a programme used for statistical analysis. The responses formed a basis to be used in the determination of the relevant criteria.

Chapter 6: Multi-criteria analysis for contractor grading

This chapter describes a step-by-step approach to the application of the AHP model for decision making in the process of determining contractor grading and project performance criteria. A Microsoft Excel spreadsheet-based programme was used in the application of the AHP. The results from the developed AHP Microsoft Excel spreadsheet-based programme are elaborated. The results of the AHP have been utilised to develop the framework for registering, grading, and evaluating performance of contractors.

Chapter 7: The development of a framework to register, grade, and evaluate project performance of contractors.

This chapter provides the developed framework for registering, grading, and evaluating contractors. The AHP results in Chapters 6 and Chapter 7 were utilised for the development of the framework. In this chapter, the contractor grading and project performance framework has been developed. The framework is aimed at guiding the grade in which contractors may be placed and evaluating the contractors' project performance. Other key proposals for development based on the available CIDB systems are also indicated.

Chapter 8: Development of entry requirements for the construction sector

This chapter focuses on proposing the requirements for the regulation of new entrants into the construction sector and the minimum requirements for consideration to the next grade. The focus of the study is to develop requirements for the Civil Engineering (CE) category. The aim is to enhance the current contractor registration and grading framework to improve the robustness of the framework.

Chapter 9: Discussion of findings

This Chapter discusses the key results obtained in chapters five, six, seven, and eight. This chapter aims to discuss key findings from the results of these chapters and compare the most important findings with those from the literature. It therefore positions the

findings of this study within the international body of knowledge as represented in the literature review.

Chapter 10: Conclusions and recommendations

This chapter provides concluding remarks and recommendations. The study focused on developing a decision support framework using the Analytical Hierarchy Process for grading and evaluating the project performance of civil engineering contractors. This was done by conducting a state of practice survey. Thereafter Analytical Hierarchy Process was utilised for grading and evaluating the performance of contractors. The results of the AHP have thus played a key role in developing the enhanced framework for grading contractors and evaluating their performance.

Proposals were also made on the construction sector entry, grading, and performance evaluation requirements. Moreover, a brief review was conducted on the current systems that are in place at the South African Construction Industry Development Board to make proposals that may be put in place to assist in the evaluation of infrastructure project performance. Key recommendations have also been described in the chapter.

1.6 CHAPTER SUMMARY

This Chapter provides an overview of the research study, and it further outlines the problem statement that is facing the South African construction sector. The aim and objectives of the study have been indicated followed by the study research questions, model, and hypotheses. Moreover, the chapters of the study have been briefly summarised to provide a view of all chapter contents.

CHAPTER 2 LITERATURE REVIEW

2.1 INTRODUCTION

The main aim of this research is to develop a decision support framework, which is intended to enhance the Construction Industry Development Board's processes used to register new civil engineering contractors and to grade contractors. This chapter presents the findings of a comprehensive literature survey and review of fundamental concepts and contemporary issues involved in contractor grading, project monitoring and evaluation, and entry-level requirements of civil engineering firms. In addition, it provides an account of the previously conducted studies and existing decision-support tools and frameworks. The success rates of civil engineering projects focusing on South African and global trends have also been highlighted.

2.2 OVERVIEW OF THE CONSTRUCTION SECTOR

The construction industry in both developed and developing countries may be viewed as that sector of the economy which, through planning, design, construction, maintenance and repair, and operation, transforms various resources into constructed facilities. The types of public and private facilities produced range from residential and non-residential buildings to heavy construction, and these physical facilities play a critical and highly visible role in the process of development (Kheni *et al.* 2008). Ibironke (2004) and Shittu and Shehu (2010) state that the construction industry plays a key role in satisfying a wide range of physical, economic, and social needs and contributes significantly to the fulfillment of various major national goals.

Sarvari *et al.* (2021) note that the infrastructure construction sector takes a significant portion of the gross domestic product of each country, and its success can result in the long-term economic and social development of lives in general. The construction business environment is very complex because it involves multiple resources, and it requires the overall collaboration of project participants in all stages of the project life cycle (Dinesh, 2016; Müller & Turner, 2007; Lim & Mohamed, 1999). In recent years, the success and performance of infrastructure construction projects are measured through

multiple indicators such as cost, schedule, safety, quality, sustainability, and stakeholder management (PMBOK, 2017). The level to which these project goals are achieved controls the overall success of infrastructure projects in budget-constrained environments (Mathar *et al.*2020; Kovacic & Müller, 2014;). In contrast, the successful completion of different infrastructure projects in low- and middle-income countries is greatly affected by various risk factors, including project teams, financial resources, and the technical expertise of different stakeholders (Liu *et al.* 2018; Davis, 2014; Locatelli *et al.* 2014; Yong & Mustaffa, 2013).

It is posited herein that to improve the state of the construction sector and the grading system, relevant technical and non-technical criteria need to be considered for grading contractors to decrease the failure rate of infrastructure projects in South Africa. A study conducted by CIDB (2016) on contractor progression has shown that there is a strong correlation between the contractor having construction-related training or qualifications and the contractor's survival and progression.

Mohlala (2015) studied the relationship between the project performance of emerging contractors in the South African government infrastructure projects and their experience and technical qualifications and found that contractors with technical qualifications and experience generally perform better than those without technical backgrounds. The study also found that where there is no technical background, the level of education also affects the level of project performance. The grading of contractors using key criteria may improve the client's confidence in the quality of the contractor who will roll out the infrastructure project and may enhance the performance of the construction industry.

According to Hanson *et al.* (2003), contractor project performance in South Africa is affected by poor workmanship as a result of contractor incompetence. This affects the contractor's track record or reputation and, therefore, the eligibility for future contracts. Operational skills which include project management and business skills such as planning and financial accounting are crucial for the success of any business (Thwala & Mvubu 2008). Mofokeng (2012) also found that small and medium construction companies lack business and managerial experience.

Previous literature (Fredland & Morris, 1976; Yusoff, 1995; Jo & Lee, 1996; Lin, 1998; Jaafar & Abdul-Aziz, 2005) has shown that managerial expertise and experience are vital for the success of any enterprise and have a significantly positive relationship to the performance of the enterprise. According to Croswell and McCutcheon (2001), some of the difficulties facing emerging contractors in the construction sector include a lack of entrepreneurial, managerial, technical, and administrative expertise. These skills and expertise are vital for emerging contractors' performance through the life cycle of a project and from one project to the next.

The acquisition of competence is, thus, an ongoing process, especially in project-based enterprises (i.e., construction companies) since each project is inherently unique. Thus, emphasis should also be put on continuous learning from one project to the next to improve competence in infrastructure projects (Croswell & McCutcheon, 2001). The increase in the failure rate of South African infrastructure projects indicates a need to identify what can be done to improve the sector's performance which is the mandate of the Construction Industry Development Board.

2.3 CONTRACTOR PERFORMANCE

One of the most important players in the construction process is the contractor (Sweis *et al.* 2014). According to Xiao and Proverbs (2003), contractors convert designs and drawings into reality. Ejaz *et al.* (2013) claim that construction is considered one of the industries on which national prosperity depends. Many studies have investigated the project performance factors that impact contractor performance in developing countries (Mohlala, 2015; Zulu and Chileshe, 2008; Hanson *et al.* 2003). A shortage of manpower skills, poor supervision and site management, unsuitable leadership, and equipment failure have all contributed to construction delays in the United Arab Emirates (Faridi and El Sayegh, 2006).

Furthermore, contractor performance and reputation is found to be one of the factors affecting customer satisfaction (Gharakhani *et al.* 2013). Aklnci and Fischer (1998) argue

that cost overruns create a significant financial risk for both contractors and owners. Economic growth and the competitive nature of the construction market have forced contractors to reduce their markups to stay competitive (Grogan, 1995).

Zulu and Chileshe (2008) investigated contractor performance in Zambia and found it below expectations, arguing that nothing can be learned from local ongoing projects that have not been completed or have been delayed. They concluded that contractors' poor performance has huge implications on competitiveness. Enshassi *et al.* (2009) found that the construction industry is complex, as it includes large numbers of parties as owners (or clients), contractors, consultants, stakeholders, and regulators.

In a study conducted in Palestine, UNRWA (2006) found that local construction projects suffered from poor performance, especially poor contractor performance for many reasons, such as the unavailability of materials, excessive amendments to designs and drawings, poor coordination among respondents, ineffective monitoring and feedback, and a lack of leadership skills. Hanson *et al.* (2003) studied the client dissatisfaction factors in South Africa's building industry and found poor workmanship and contractor incompetence to be the main factors affecting project performance, and thus contractor performance.

According to Mohlala (2015), in South Africa, the CIDB has set up guidelines for reporting contractor performance. The contractor performance report should include records of contractors' breach of contract thus resulting in either termination and/or cancellation of a contract (CIDB, 2013). These efforts by the CIDB indicate that importance is placed on client satisfaction which is a measure of project performance. Client satisfaction can also be used to indicate the performance of the contractor in relation to time, cost, and quality.

Presently, the South African construction and civil engineering sector does not have a minimum requirement for contractors who wish to enter the construction industry. Anyone with or without technical knowledge, with little or no schooling can register a construction firm. The lack of systems in place to manage new entrants in the sector may be one of the key factors that constitute the increase in failure rates of contractor performance. It is

thus important for the study to investigate the success rate of civil engineering infrastructure projects to assess the performance of the sector.

2.4 SUCCESS AND FAILURE RATE OF CIVIL ENGINEERING INFRASTRUCTURE PROJECTS

According to Belay *et al.* (2022), construction projects are complex and require the collaborative effort of each construction team across the project life cycle. Thus, the successful completion of these infrastructure construction projects could be a detrimental factor in ensuring client satisfaction and profit for construction organisations. Ensuring success in the competitive business environment is dependent upon a combination of multiple factors, including internal project-related factors, external factors directly and indirectly affecting construction projects, and the key stakeholders involved in those projects.

The success factors of companies differ from industry to industry, and even from project to project, taking into account the difference in construction policies and regulations, contract agreements, project budgets, and other critical factors (Belay *et al.* 2021). Kog and Loh (2012) have identified 10 critical success factors from a total of pre-identified success-related factors in Singapore. The pre-identified factors were initially grouped under four categories, namely, project characteristics, contractual arrangements, project participants, and interactive processes. Tabish and Jha (2011) in India summarised 36 critical factors based on public infrastructure projects. Similarly, in China, the top-ranking success-related factors in public infrastructures are the clarity of information disclosure, timely responses to public inquiries, necessary avenues and equipment, diversity in the ways of disclosing information, and results presentation (Liu *et al.* 2018).

A study by Shen *et al.* (2017) in Thailand's public green building industry reveals that all key project teams and stakeholders are responsible for the successful completion of infrastructure projects and should regularly enhance their overall technical and management capacity to make sure that affordable and sustainable products are met, thereby making green buildings more affordable and pleasing to the public. Furthermore, Tripathi and Jha (2017) reported success criteria in India's construction market using a

multi-criteria structural equation modelling approach. The findings proved that the top management team of construction organisations plays a valuable role in ensuring the success of infrastructure and helps to get a better and more valuable lesson to innovations and strategies to improve the performance of construction projects.

According to Murwira and Bekker (2017), construction projects worldwide often suffer from poor performance in terms of time delays, cost overruns, and quality defects. Pheng and Chuan (2006) stated that, traditionally, the successful delivery of a construction project hinges on the performance of the project manager, who must consider delivery time, budgeted cost, and expected quality. However, with the delivery of projects being predominantly a team effort, the allocation of accountability for project performance to one individual might not achieve the desired results.

Various studies investigated and analysed factors causing poor performance on construction-related projects (summarised in Table 2.1). Many of these studies focused on identifying the major causes of time and schedule overruns, challenges facing contractors, as well as quality management in various construction projects. Table 2.1 provides a summary of some of the common causes for the poor performance of construction-related projects as per the categories identified.

Table 2.1 Summary of typical factors causing the poor performance of construction-related projects critical performance factors

Critical performance factors	Authors
Owner related factors	
Delayed monthly payments for completed work	Assaf & Al-Hejji (2006); Frimpong, Oluwoye & Crawford (2003); Fugar & Agyakwah-Baah (2010); Mansfield, Ugwu & Doran (1994); Odeh & Battaineh (2002); Sambasivan & Soon (2007); Sweis, Sweis, Hammad & Shboul (2008).
Owner's cash-flow problems	Al-Momani (2000); Assaf & Al-Hejji (2006); Kaliba, Muya & Mumba (2009); Koushki, Al-Rashid & Kartam (2005); Monyane & Okumbe (2012); Sweis *et al.*(2008).
Scope changes from owner	Al-Momani (2000); Assaf & Al-Hejji (2006); Kaliba et al.(2009); Koushki *et al.*(2005: 294); Monyane & Okumbe (2012); Sweis *et al.*(2008).
Delays in decision-making	Chan & Kumaraswamy (1997); Monyane & Okumbe (2012).

Critical performance factors	Authors
Contractor related factors	
Inadequate and poor planning	Assaf & Al-Hejji (2006); Dlungwana, Nxumalo, Van Huysteen, Rwelamila & Noyana (2002); Sambasivan & Soon (2007); Sweis *et al.*(2008)
Contractor's financial difficulties	Aibinu & Odeyinka (2006); Frimpong *et al.*(2003); Sweis *et al.*(2008).
Shortage of skilled labour	Baloyi & Bekker (2011); Dlungwana *et al.*(2002); Sweis *et al.*(2008); Thwala & Phaladi (2009).
Poor site management and supervision	Assaf & Al-Hejji (2006); Chan & Kumaraswamy (1997); Kaliba *et al.*(2009); Sambasivan & Soon (2007).
Underestimation of project cost	Dlakwa & Culpin (1990); Fugar & Agyakwah-Baah (2010); Mansfield *et al.*(1994); Thwala & Phaladi (2009).
Lack of experience in executing projects	Koushki (2005); Muhwezi, Acai & Otim (2014); Nguyen & Chileshe (2015); Sambasivan & Soon (2007); Thwala & Phaladi (2009).
Increase in material cost	Baloyi & Bekker (2011); Dlakwa & Culpin (1990: 239); Koushki *et al.*(2005); Mansfield *et al.*(1994)
Consultant-related factors	
Poor design capacity and design changes	Al-Momani (200); Baloyi & Bekker (2011); Jackson (2002); Nguyen & Chileshe (2015); Muhwezi *et al.*(2014).
Incomplete designs by architect and engineering disciplines	Aibinu & Odeyinka (2006); Baloyi & Bekker (2011); KPMG International (2013); Muhwezi *et al.*(2014).
Architect's incomplete drawing: design error made by the designers	Aibinu & Odeyinka (2006) Muhwezi *et al.*(2014); Tumi, Omran & Pakir (2009).

Source: Murwira and Bekker (2017)

Murwira and Bekker (2017) revealed that clients', contractors', and consultants' viewpoints differ in the factors they identified as causing construction project failure. The identified viewpoints of clients, contractors, and consultants are as follows:

Clients' viewpoints

The top five causes of construction project failure identified by the clients' representatives were as follows (Murwira & Bekker, 2017):

- Contractor's cash-flow constraints;
- Underestimation of project cost;
- Lack of experience in executing projects;

- Corruption and bribery during the bidding and contract award phase; and
- Incomplete designs by engineering disciplines.

Contractors' viewpoints

The contractors' perceived top five major causes of construction project failure are as follows:

- Underestimation of project cost;
- Poor site management and supervision;
- Lack of experience in executing projects;
- Contractor's cash-flow constraints; and
- Corruption and bribery during the bidding and contract award phase.

Consultants' viewpoints

The top five causes of construction project failure identified by the consultants are as follows:

- Lack of experience in executing projects;
- Contractor's cash-flow constraints;
- Underestimation of project cost;
- Poor site management and supervision; and
- Awarding of contracts primarily on price. Notably, consultants did not rank any consultant-related factors in the top five.

The Overall top five viewpoints of the clients, contractor and consultant are as follows:

- Owner and contractors ranked underestimation of project cost by the contractor as a major cause of construction project failure;
- Owner and consultants ranked contractors' lack of experience in executing projects as another major cause of construction project failure;
- Owner and consultants ranked contractors' cash-flow constraints as another major cause of construction project failure;
- According to owners and contractors, corruption and bribery during the bidding and contract award phase by the owner are among the major causes of construction projects' failure;

- Based on their viewpoints, contractors claimed that poor project conceptualisation and design are major causes of project failure.

<u>All three parties agree that the following causes are the least important:</u>

- Inclement weather;
- Late or delayed contract award by owner;
- Inadequate contingency allowance by the contractor;
- Owner-initiated changes;
- Complexity of building design.

All the major stakeholders agreed that seven out of the top ten causes of construction project failure are linked to contractor-related factors. The top ten factors causing failure in construction projects are: Underestimation of project cost; Lack of experience in executing projects; Contractor's cash flow constraints; Corruption and bribery during the bidding and contract award phase; Poor site management and supervision; Awarding of contracts primarily on price; Underestimation of time for completion by contractor; Shortage of skilled labour; Incomplete designs by engineering disciplines; and Late payment of subcontractors for completed works by contractor. The role of the contractor in the implementation of a construction project is important, and as such, emphasis should be placed on ensuring that competent contractors operate within the sector to minimise project failure (Murwira & Bekker, 2017).

In a study conducted by Abdul-Rahman *et al.* (2009) addressing matters pertaining to financially related delays in construction projects, it was found that poor cashflow management is the most important factor that leads to a project's delay followed by late payments, inadequate financial resources, and volatility in financial markets. Yang and Wei (2010) found thirty-five delay project factors. Fifteen factors were related to the planning phase, whilst twenty causes were related to the design phase. Using the importance-frequency matrix, they concluded that change in owner requirements is the predominant cause of project delay.

Soliman (2010) recognised twenty-nine causes of delay in construction projects in Kuwait and then characterised them into six groups. The causes were graded based on the

Relative Importance Index (RII). He demonstrated that financial and design problems are the main factors behind project delays. Hasseb *et al.* (2011) scrutinised the dynamics behind the delay of construction projects in Pakistan and found that client factors are the key sources of delay. Understanding the causes of delays in the construction sector is important for the study because it will assist in determining grading criteria.

Doli *et al.* (2012) explored the delay causes of construction projects in India. Using a selected set of forty-five attributes, this study identified the key factors affecting delay in the Indian construction industry and then established the relationship between the critical attributes for developing prediction models for measuring the impacts of these factors on delay. A questionnaire and personal interviews formed the foundation of this research. Factor analysis and regression modeling were employed to study the implications of the delay factors. From the factor analysis, the major critical factors of construction delay were identified as a lack of commitment, inefficient site management, poor site coordination, improper planning, a lack of clarity in project scope, a lack of communication, and substandard contracts. The regression model specified slow owner decision-making process, poor labour productivity, architects' reluctance to change, and rework due to mistakes in construction are the reasons that significantly affect the overall delay of the project.

Ezeldin and Abdel-Ghany (2013) found that there are five main reasons for project delays which are attributed to construction, managerial, political, financial, and technical factors. Rahsid *et al.* (2013) identified the causes of delay using structured questionnaires distributed among construction firms. To determine the main causes, several statistical instruments were utilised which include reliability test, factor analysis, and regression. Their conclusions indicate that the existing problems are associated with contractor, client, consultant, material, and equipment factors.

2.4.1 Global context

According to Ngai *et al.* (2000), the construction industry is an integral part of the nation’s infrastructure development and is an essential part of the economic backbone in many

countries, often contributing 7-10% of the Gross Domestic Product. The industry is often criticised for inefficiencies in outcomes such as time and cost overruns, low productivity, poor quality and inadequate customer satisfaction (Chan *et al.* 2003). It is, therefore, important to have changes in attitudes and procedures to enhance the chances of success in construction projects (Dubois & Gadde, 2002).

The New Zealand Ministry for the Environment (2010) stated that the effective implementation of planning and urban infrastructure outcomes relies on being able to access a full range of appropriate tools and assess which is best for the job in specific circumstances. The full range of tools covers a spectrum, including the use of plans to implement national objectives and standards, the provision of information, and the use of incentives and regulatory tools.

The use, flexibility and effectiveness of tools should complement the broader planning system, allowing the achievement of broader objectives, such as economic growth, integrated urban and infrastructure development, value for money from investment, and well-designed urban environments that create value. Three potential barriers to effective implementation have been identified, namely, inconsistent plan structure and format, cost and time associated with preparing and changing plans, and potential problems with tools in practice (Ministry for the Environment, 2010).

In the United Kingdom, the construction industry had a significantly poor record with respect to the completion of projects on time (Soliman, 2010). In Canada, over 70% of high-rise buildings experienced time over-run. In developing countries, the problem may be worse. In Saudi Arabia, the percentage of delayed projects varied from 35% to 84% of the original duration. Delays in the completion of projects have many negative consequences during and after project completion. Delays cause cost and time overruns in addition to adversarial relationships among construction shareholders, arbitration, and cash flow problems (Soliman, 2010).

Literature gives a plethora of support to the studies conducted by Luwaga (2009), McCutcheon and Croswell (2005), Egbeonu (2004), and Mintzberg (1994), as cited by Quainoo and Akyen (2003) on barriers to effective implementation of the infrastructure

projects in various sectors across the municipalities or organisations. The public sectors globally have endured the malpractices emanating from unscrupulous conduct and a lack of adherence to regulatory tools from people who wield power in these organisations.

According to McCutcheon and Marshall, as cited by Quainoo and Akyen (2003), the negative factors below are evident in most failed infrastructure programmes undertaken both in South Africa and elsewhere:

- Ill-defined scope;
- Poor management;
- Poor planning;
- Breakdown in communication between engineering and construction;
- Unrealistic scope, schedules and budgets;
- Many changes at various stages of progress; and
- Lack of good project control.

For civil engineering projects or any other infrastructure projects to be executed efficiently and effectively, a contractor needs to have most of these criteria of project management competency as described above. The possession of this project management competency will enable contractors to execute projects without the struggle of managing project cost, budget, and quality. South Africa is no different to the global trends in implementing infrastructure projects as noted by Mohlala (2015).

2.4.2 South African context

According to Dlungwana *et al.* (2000), the government of South Africa is the most significant construction client, contributing between 40% and 50% of the entire domestic construction expenditure. Ramokolo and Smallwood (2008) stated that South Africa aims to invest 5.1% of South Africa's Gross Domestic Product (GDP) in construction. To address infrastructure backlogs across the country, the South African government is committed to investing in infrastructure development to achieve economic growth and

address the backlog. It is however unfortunate that approximately 60% of the projects being implemented by the North West Department of Public Works and Roads (NW DPWR) are not completed on time and on budget, often resulting in service delivery protests by local communities (Murwira & Bekker, 2017).

Murwira and Bekker (2017) uncovered some of the problems experienced in the delivery of building infrastructure projects by the North-West Department of Public Works and Roads (NW DPWR). A preliminary internal evaluation and analysis of project performances and operational deficiencies in the NW DPWR was done. It was evident that there were various challenges facing the NW DPWR in delivering building and infrastructure projects, including the termination of contractors for poor performance, cost, and schedule overruns on projects. This is unfortunately mostly the case with the delivery of South African infrastructure projects (Mohlala, 2015).

In South Africa, the implementation of infrastructure projects is highly impacted by capacity constraints. To curb the malpractices and uphold the standards, South Africa, like other countries, has adopted Integrated Development Planning (IDP) as a method to plan future development in municipalities. The purpose of an IDP is to foster more appropriate service delivery by providing the framework for economic and social development within the municipality (Makgetla & Seidman, 2007).

The Municipal Finance Management Act (Act No.56 of 2003) requires municipalities to “take reasonable steps to ensure that the resources of the municipality are used effectively, efficiently and economically”. According to Quainoo and Akyen (2003), several large-scale infrastructure programmes were implemented in South Africa after 1994 when an all-inclusive government was formed. The overriding goal was to improve the living conditions of the poor by generating employment opportunities and providing access to basic infrastructure and employable skills. However, performance was mixed and, in many instances, projects either failed to achieve the intended objectives (Holicki & Tladinyane, 2000) or to reach the targeted beneficiaries, which also includes the delivery of civil engineering projects.

To conclude, both past and present infrastructure projects undertaken have, in general, failed to alleviate the socio-economic problems in South Africa. The outbreak of project implementation failures within South Africa, resulting from poor or a lack of institutional capacity development and knowledge management, was manifested by the collapse of apprenticeship culture, as well as the loss of skills to foreign companies (Makgetla & Seidman, 2007).

According to Quainoo and Akyen (2003), the underlying root causes for the poor performance of large-scale projects/programmes implemented so far are that the technical objectives (specification and quality) are equally as important as the socio-economic goals, however, poor quality of work is widespread amongst emerging contractors. The immediate questions are: Do they have the requisite skills and track record to perform? Does the non-performance stem from project nature or a lack of skills and technical know-how?

To worsen the situation, the contractor grading system does not take the contractor development process into account. For example, in Malaysia, contractors are required to earn Contractor Continuous Development points in order to progress from one grade to the next grade. Also, contractors are required to have a minimum certificate/diploma or degree in construction-related courses to register a construction firm (CIDB Malaysia, 2016). This practice may assist in the improvement of the implementation of infrastructure as the contractor would have knowledge and interest in the industry prior to entry.

Although several forms of contracts for the delivery of public infrastructure exist in South Africa, the most used is based on the three-party system, namely legal agreement between the client (who is the employer), the consultant (clients representative), and the contractor (Dison, 2005). The triangular system requires that the client pays, the consultant plans and designs, while the contractor constructs the intended infrastructure. This triangular system is noted to be inadequate by Dison (2005) in enabling the successful implementation of small-contractor development programmes to alleviate unemployment and develop capacity within the construction industry.

It is on this basis that a multi-criteria decision framework for contractor registration and grading needs to be developed to enhance the current project and contractor management processes in place to better manage contractors and improve construction contractors' performance outputs. The introduction of the multi-criteria decision system on contractor registration and grading may assist in improving the state of the implementation of infrastructure projects in South Africa. The importance of understanding business entry regulations in various countries within the construction sector cannot be emphasised enough for the study. This will assist in understanding the merits and demerits of regulation of entry in the construction sector.

2.5 REGULATION OF BUSINESS ENTRY

Greve (2014) indicates that the lack of barriers to entry into the construction industry makes it difficult for client companies to select high-potential contracting entities. The easy access to CIDB grading further makes it easy for entrants with a lack of basic skills to gain credibility in the industry. Of the 94 792 contractors registered with the South African CIDB in grades 1 to 9, 84 770 were active level 1 registered contractors in the civil engineering and the general building division (Greve, 2014). The total number of applications received at the end of June 2022 was 77 459 applications, which is a decline of 1.48% from previous year. About 7% of these registrations are at Grade 1, indicating that potential entrepreneurs are drawn to the industry, however, many of the registered contractors lack skills and experience (CIDB, 2022b).

The Construction Industry Development Board (2016) concurs with Greve (2014) that having minimum entry requirements would likely increase the success rate of Grade 1 contractors and would also make it easier for companies seeking to develop enterprises to select entities with potential. According to the CIDB (2016), 91% of the current registered Grade 1 contractors are black-owned, 32% are women-owned and 26% are youth-owned.

The high representation of historically disadvantaged individuals, women and youth amongst Grade 1 contractors highlights the importance of this category as a route in the

transformation of the construction industry (CIDB, 2016). Any minimum criteria for the registration would need to consider the current status quo of the registered Grade 1 contractors.

A study conducted by Klapper *et al.* (2004) has found that entry regulations hamper entry, especially in industries that naturally should have high entry. In a study conducted by Forth (2019) on the impact of entry regulations on business growth in Spain, it was found that higher entry requirements can hamper the creation of new firms, thereby muting the dynamism of the market with attendant consequences for business competitiveness and growth. They found that naturally "high entry industries grow less, have lower profitability and account for a lower share of the economy in countries with onerous regulations on entry". Also, value added per employee in naturally "high entry" industries grows more slowly in countries with onerous regulations on entry.

This suggests entry regulations are neither benign nor welfare-improving. Klapper *et al.* (2004) also found that there is less entry into labour-intensive industries in countries with labour regulations that restrict the ability to fire workers. They do not imply that all regulations inhibit entry. Regulations that enhance the enforcement of intellectual property rights or those that lead to a better-developed financial sector do lead to greater entry in industries that do more research and development or industries that need more external finance. Finally, other aspects of the environment also matter, for instance, the general availability of skilled labour enhances entry into industries that require skilled labour.

In a study conducted by Djankov *et al.* (2000) on the regulation of business entry in 75 countries, it was found that the official costs of entry are extremely high in most countries. Countries with heavier regulation of entry were found to have higher corruption and larger unofficial economies but not better quality of public or private goods. Countries with more democratic and limited government influence have fewer entry regulations. The findings by Djankov *et al.* (2000) and Klapper *et al.* (2004) are important for the study, and they need to be taken into consideration given that South Africa is a democratic country, and

the development of the framework for regulations of new entrants should not hamper entry to the industry but rather manage the sector's performance inefficiencies.

Djankov *et al.* (2000) indicate that there are two theories of regulation of entry; the helping hand theory which predicts that stricter regulation of entry, as measured by a higher number of procedures should be associated with socially superior outcomes. The grabbing-hand view sees the government as less benign and regulation as socially inefficient.

According to Forth (2019), the creation of new businesses is a key part of the process of creative destruction that is argued to be a key ingredient in spurring economic growth. Creative destruction is described by Vitasek (2022) as the old way of doing things is constantly getting destroyed or supplanted as it is replaced by a newer, better alternative. Forth (2019) indicates that young firms are not only seen to have an important role in bringing innovations to the market and in aiding the diffusion of new technologies, but also in raising the competitive pressure on incumbents. This provides incentives for incumbent firms to raise their efficiency, as well as aiding the reallocation of resources from lower to higher productivity businesses, all of which give a further stimulus to productivity and economic growth.

Although the positive contribution of entrepreneurship to business dynamics and growth is widely recognised (Syverson, 2011 cited by Forth, 2019, Audretsch *et al.* 2006), most countries place some restrictions on those wishing to register a new firm. In some cases, this may simply involve a requirement to register with the national tax office. In others, the entrepreneur may have to give notification to the local municipal authorities, obtain an official identification number for the business or even obtain a licence to operate. Many countries require those wishing to establish a limited liability company to undertake additional steps, including the deposit of a minimum amount of paid-up capital.

A certain amount of regulation or bureaucracy may be justified based on public interest, particularly where there is a risk of market failure (Pigou, 1938). It may be possible to correct market failures using private market solutions, government-imposed solutions, or voluntary collective actions (Boyle & Clarine, 2023).

For instance, governments may seek to screen new entrants to protect consumers from low-quality goods or services or to protect third parties from negative externalities such as pollution. Registration and screening can also provide protection for creditors and generate information to aid aspects of public administration – notably tax collection.

However, there is a growing recognition that high entry barriers may also have economic costs, reducing the rate at which new firms enter the marketplace and thus muting the disciplinary effects of competition on economic growth. This study views the international practices on regulation of new entrants in the construction sector given that the focus of the study is on the construction industry.

2.6 INTERNATIONAL PRACTICES ON REGULATIONS OF NEW ENTRANTS AND CONTRACTOR GRADING IN THE CONSTRUCTION SECTOR

The World Bank has minimum requirements for the registration of contractors in line with the grade in which contractors intend to register (World Bank, 2018). For instance, at an entry-level, a trade test certificate is required for building construction works and maintenance. The trade certificate is required as an entry requirement for all disciplines. As the grades progress, the minimum requirement increases in terms of academic qualifications, number of key staff and key staff relevant experience, as well as the number of completed projects by the company/key staff. Table 2.2 is an extract of the World Bank's minimum requirements for contractor registration.

Table 2.2 World Bank minimum requirements for registration of works for contractors

Code 03: Civil Engineering Works; Sub code 06- water supplies, sanitation reticulation, and irrigation works								
Grade	Ceiling	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staff's relevant experience	Number of successfully completed projects by the company or key staff
OC	P5,000,000.00	None	None	Bank account	Certificate in Civil/Water Engineering	1	None	None
A	P10,000,000.00	None	None	Bank account	Certificate in Civil/Water Engineering	1	2 years	2 projects of similar nature from grade OC

Code 03: Civil Engineering Works; Sub code 06- water supplies, sanitation reticulation, and irrigation works								
Grade	Ceiling	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staff's relevant experience	Number of successfully completed projects by the company or key staff
				Office space				
B	P20,000,000.00	Tipper truck/ Water bowser	1 of them	Bank account	Diploma in Civil/Water Engineering AND	1	3 years	2 projects of similar nature from grade A
				Office space	Certificate in Civil/Water Engineering	1	2 years	
		Loader/Grader	1					
		Light Delivery Vehicle	1					
C	P60,000,000.00	Tipper truck/ Water bowser	1 of them	Bank account	Degree in Civil/Water Engineering AND	1	2 years	2 projects of similar nature
		Compactor	1	Office space	Diploma in Civil/Water Engineering	1	2 years	
		Loader/Grader	1					
		Truck flat	1					
		Light delivery vehicle	1					
D	P120,000,000.00	Tipper truck	2	Bank account	Degree in Civil/Water Engineering AND	1	4 years	2 projects of similar nature from grade C
		Compactor	1	Office space	Degree in Quantity Surveying or equivalent AND	1	2 years	
		Loader/Grader	1 of them		Diploma in Civil/Water Engineering	1	2 years	
		Truck flat	1					
		Light delivery vehicle	1					
		Water bowser	1					
		Excavator	1					
E	Unlimited	Tipper truck	2	Bank account	Degree in Civil/Water Engineering AND	1	4 years	2 projects of similar nature from grade D
		Compactor	1	Office space	Degree in Quantity Surveying or equivalent AND	1	4 years	

Code 03: Civil Engineering Works; Sub code 06- water supplies, sanitation reticulation, and irrigation works								
Grade	Ceiling	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staff's relevant experience	Number of successfully completed projects by the company or key staff
		Loader	1		Diploma in Civil/Water Engineering	1	2 years	
		Truck flat	1					
		Light delivery vehicle	1					
		Water bowser	1					
		Excavator	1					
		Grader	1					
		Steel roller	1					
		Crane truck	1					

Source: World Bank (2018)

The ceiling amounts are in Philippine Peso (PHP). The following factor was used to calculate the PHP equivalent of the USD (United States Dollar):

1 PHP = 0,01960 USD (TransferWise, 2020).

It should be noted that the exchange rate between the PHP and the USD that was used was for the 25th of February 2020 only and is subject to change. Table 2.2 indicates the minimum entry requirements per grade for contractors who wish to do works for the World Bank.

In Malaysia and Mauritius, there are also minimum requirements of entry for contractors who wish to enter the construction sector. The requirements for Malaysia are depicted in Table 2.3.

Table 2.3 Malaysian CIDB grades, financial capacity, and minimum requirements of technical person

Grade	Financial Capacity	Minimum requirements of technical person
G1	RM 5,000 to 10,000	A technical certificate holder related to the construction field and recognised by Malaysian Government/CIDB
G2	RM 25,000	A technical certificate holder related to the construction field and recognised by Malaysian Government/CIDB
G3	RM 50,000	A technical certificate holder related to the construction field and recognised by Malaysian Government/CIDB

Grade	Financial Capacity	Minimum requirements of technical person
G4	RM 150, 000	A diploma holder related to the construction field and recognised by Malaysian Government/CIDB
G5	RM 250, 000	A diploma holder (minimum 5 years' experience or a degree holder with minimum 1-year experience) related to the construction field and recognised by Malaysian Government/CIDB
G6	RM 500, 000	A degree holder and a diploma holder (at least one with minimum 3 years' experience) related to the construction field and recognised by Malaysian Government/CIDB
G7	RM 750, 000	2-degree holders (at least one with 5 years' experience or a degree holder and a diploma holder: both with minimum 5 years' experience) related to the construction field and recognised by Malaysian Government/CIDB

Source: CIDB Malaysia (2016)

New contractors who are not registered with the Malaysian CIDB are required to fulfil the registration criteria and requirements. The registration period is one year, and the contractor must fulfil the following requirements:

- Attend and pass the Contractor Integrity and Code of Ethics Course
- Accumulate the minimum Contractor Continuous Points (CCD)
- Attend and pass the Business Management Course (for grades G1 to G3 without a technical certificate).

A contractor is registered by the grade, category, and specialisation they qualify for. Generally, category and specialisation are approved in accordance with the applicant's qualification (CIDB Malaysia, 2016).

In Malaysia, contractors are also required to get continuous training to acquire Contractor Continuous Development (CCD) Points and to stay abreast with development in the construction sector. The points required for different grades and renewal periods are shown in Table 2.4:

Table 2.4 Required Contractors' Continuous Development Points for the renewal of the application

Grade	Renewal Period		
	1 Year (Minimum points)	2 Years (Minimum points)	3 Years (Minimum points)
G1 and G2	10	20	30
G3 and G4	20	40	60
G5 and G6	30	60	90
G7	40	80	120

Source: CIDB Malaysia (2016)

The CCD points are required for approval of a renewal application to extend the registration certificate. Only CCD points obtained by the company owner, director full-time employee, or a certificate held by the company are considered. Moreover, an application for a grade upgrade or downgrade can be made by contractors (CIDB Malaysia, 2016).

The United States of America (USA) also has requirements that are in place for contractors, and they differ from state to state. According to Heaslip (2022), general contractor licensing requirements vary by state, but many states' standards include showing industry experience, financial stability, and specialised training. A general contractor license is required for anyone who has a prime construction project. This license may be necessary depending on the value of the project and whether the project is residential or commercial. A contractor license enables contractors to apply for general contracts above $500. A contractor license is also needed if contractors want to start a construction business, hire subcontractors, or advertise services.

In Arizona State, contractors are required to get a pass mark of at least 70% in the chosen classification and complete a specific trade examination unless eligible for a waiver. Passing a trade examination is one of the requirements necessary to be approved for a contractor's license. A trade examination helps to assess whether an applicant has the knowledge required to perform the type of work authorised by a license. However, the Registrar may decide to waive the trade exam requirement under specific circumstances. The Registrar may decide a trade examination is not required where the qualifying party has been the qualifying party within the preceding five years for a license in good standing

in the same classification in this state, or a classification the Registrar deems comparable in another state (Crawford, 2022).

Alabama State also requires that general contractors must have a state license in Alabama to work on any construction, alteration, maintenance, repair, or demolition project that costs more than $50,000. A license is also required on residential projects over $10 000 or swimming pools over $5 000. Alabama requires three references as part of the license application, as well as financial statements prepared by a certified accountant and proof of company registration. The license is awarded by the Licensing Board for General Contractors. Applicants must pass a trade examination, and a business and law examination. They also need to document their work experience, and show proof of general liability insurance (Crawford, 2022).

In Georgia, a contractor license is required for work on projects valued at $2,500 or higher. The state takes a tiered approach for licenses based on the project value. Contractors are also required to meet the minimum insurance requirements, as well as education or work experience requirements:

- A diploma or transcript in engineering, architecture, project management, or building construction;
- A diploma or transcript showing college-level coursework and work experience;
- At least four years of work experience in construction, of which two were working for a general contractor (Crawford, 2022);

Contractors' general liability insurance can cover expenses if contractors are held responsible for anyone who is injured during a project, excluding employees, or if there is damage to any property (Crawford, 2022).

In the United Kingdom (UK), any person or company is legally allowed to undertake construction work without having to demonstrate a minimum level of competence. The Federation of Master Builders (2022) indicates that this means that the UK's construction industry is not as safe, professional, or productive as it might otherwise be.

The Japanese construction sector also requires a construction license to carry on a construction business, regardless of public or private works. However, a company that only carries out minor work is not required to register the construction license. Minor works mean general building works for less than 15 million yen or wooden house construction with a total floor area of less than 150 m^2 as well as other types of works less than 5 million yen (Japan Ministry of Land, Infrastructure, Transport and Tourism, 2022).

Similar to the South African CIDB, the Mauritius Construction Industry Development Board was developed under Section (19) of the Construction Industry Development Board Act which stipulates that "No person shall offer his services as a Consultant or Contractor unless he is registered under the Construction Industry Development Board Act" (CIDB Mauritius CIDB, 2022). There are six Classes of Works under which a Contractor can be registered, namely, Building Construction Works, Civil Engineering Construction Works, Mechanical, Electrical and Plumbing Works (MEP Works), Mechanical Works, Electrical Works, and Specific Works. Contractors are also classified into four (4) grades from large to small. Each grade allows a Contractor to undertake construction up to a contract value. A Contractor is not allowed to undertake construction works above his grade limit (Mauritius CIDB, 2022).

Unlike the South African CIDB, the Mauritius CIDB requires entry contractors to have conducted projects in the construction sector worth 800 000 Mauritian Rupee (MUR). Thus, the criteria for registration of contractors are in line with the construction project value carried out. The grading criteria consider the highest value of projects done as well as the annual turnover for construction works. Similarly, contractors are required to demonstrate the two highest values of projects conducted as well as average annual turnover when applying for an upgrade (Mauritius CIDB, 2022).

In South Africa, the Construction Industry and Development Board (CIDB) stipulates that all contractors who intend to bid for or participate in tenders in the South African public sector need to be registered with the CIDB (CIDB, 2011a). There are no technical requirements that new business entrants need to adhere to be registered with the CIDB,

whilst progressing to higher grades only requires contractors to be financially viable and complete projects.

From the above international practices on construction sector entry and grading requirements, it is noted that most countries in the world have some form of entry requirements and technical and non-technical criteria which are used to allow contractors to operate in the construction sector. These requirements are put in place to ensure that competent contractors operate in the sector. This assists in safeguarding the sector and in ensuring the quality of performance outputs which is a cause for concern in South Africa, as indicated by the CIDB that around 12% of projects surveyed had levels of defects which are regarded as inappropriate (CIDB, 2011). This thus necessitates the review of decision parameters influencing project performance.

2.7 DECISION PARAMETERS INFLUENCING PROJECT PERFORMANCE

According to Hanson *et al.* (2003), contractor project performance in South Africa is affected by poor workmanship and contractor incompetence. Gharakhani *et al.* (2013) found that reputation affects client satisfaction and, therefore, contractor performance is affected. Cheung *et al.* (2004) indicate that factors such as time, cost, quality, and client satisfaction are some of the indicators that are used to measure performance in a project environment. Unfortunately, most contractors in government infrastructure projects fall short when assessed against these indicators (Mohlala, 2015). Zulu and Chileshe (2008) found that contractor performance in Zambia is below expectation and most projects are delayed or do not reach the completion stage. Mohlala (2015) indicates that the South African construction industry is no exception.

Neely (1998) defines performance measurement as a systematic process of assessing and quantifying past behaviours and activities. Project performance measurement is essential to determine whether or not project goals have been met for both the client and the contractor. A study conducted by Cheung *et al.* (2004) found that there are seven main key performance indicators notably, time, cost, quality, client satisfaction, client

changes, business performance, and health and safety. According to the CIDB, project performance can be measured against the following project parameters (CIDB, 2013):

- Time management;
- Cost management;
- Quality management;
- Health and safety management;
- Site management; and
- Sub-contractor management.

Thus, project performance can be defined as the actions taken through the life cycle of a project to meet pre-determined goals. These goals may be one of the seven key performance indicators identified by the CIDB (2013), those proposed by Cheung *et al.* (2004) or a combination thereof.

According to Xiao and Proverbs (2003), the improvement of project performance, which leads to improved contractor performance, can result in increased client satisfaction, better reputation, and improved competitiveness. Many authors attribute project performance to the contractor's competence (Faridi & El-Sayegh, 2006; Iyer & Jha, 2005; Hanson *et al.* 2003). It is, therefore, important that performance indicators and project goals are clearly defined and understood by all stakeholders (the client, the engineer, the contractor, and the user) at the beginning of the project.

Thus, the appointment of competent contractors and engineers is crucial for the success of a project. Factors related to project performance are discussed below in order to establish parameters which can be used to assist municipal and government decision makers in monitoring and evaluating project progress:

2.7.1 Contractor competencies

Sweis *et al.* (2014) conducted a study on contractor performance at an international level in order to determine the most critical contractor performance factors in public infrastructure projects according to the perspectives of contractors, clients and engineers. The study found the following responses:

Clients' perspective

- Contractors' financial difficulties
- Unacceptable construction techniques by contractors
- Clients' financial difficulties

Engineers (consultants) perspective

- Shortage of manpower or skilled labour
- Poor planning and scheduling of projects
- Contractors' financial difficulties

Contractors' perspective

- Changes in instructions by clients
- Contractors' financial difficulties
- Clients' financial difficulties

From the above findings, it is observed that the factors affecting contractor performance are related to the contractor's inability to perform the work due to shortages of skilled labour, poor planning, and unacceptable construction techniques. The studies also show that a contractor's lack of financial resources is also a predominant factor with regard to contractor performance. It should be noted that due to the uniqueness of projects, it is difficult to generalise these factors. These findings do, however, form a basis for the need to assess whether contractors who are not delivering on services are due to a lack of adequate financial resources in South Africa.

Competence can be defined as the ability or potential to perform a particular task or job effectively (Rozewski & Malachowski, 2009) or the capacity to perform a given activity (Guillaume *et al.* 2014) to achieve a predetermined goal to a particular standard (Peters & Zelewski, 2007). This involves the application of knowledge and skills and is likely to vary from one organisation or contractor to the next (Guillaume *et al.*2014). It is evident that competence should involve not only the ability to perform a given task but the application of the necessary skills and knowledge, which are acquired before the given task.

This is an indication that there may be a need to assess the level of contractor competence before awarding every contract, as it may affect the performance during the construction phase of the project. Literature (CIDB, 2016; Mohlala, 2015) has shown that most contractors in the South African public sector lack these skills. As indicated above, contractor performance in South Africa is affected by poor workmanship and contractor incompetence (Hanson *et al.* 2003). This affects the contractors' track record or reputation and, therefore, the eligibility for future contracts as indicated by Gharakhani *et al.* (2013). Operational skills which include project management and business skills such as planning and financial accounting are crucial for the success of any business (Thwala & Mvubu, 2008).

2.7.1.1 Training and skills development

Adams (1995) identified a lack of skilled labour as one of the major causes of emerging contractor failure in the construction industry. Training, either on-the-job or through tertiary education, develops skills which result in the development of competencies. Skills development can also occur through experience and the application of acquired knowledge (Edum-Fotwe & McCaffer, 2000).

The CIDB allocated R50 000 in the 2012/2013 financial year for the training of 512 contractors. The areas in which the contractors were trained were:

- Occupational health and safety;
- Construction management;

- Contract management;
- Pricing and tendering; and
- Financial management (CIDB, 2013).

Parkin *et al.* (2009) stated that a motivated unskilled worker may not have the required ability to perform well and improve construction productivity. While Kazaz *et al.* (2008) have noted that despite such motivation, there is a need for competent management to ensure that the worker gets the necessary skills to enhance construction productivity. In a study conducted by Hanafi *et al.* (2010), it was found that the competency of site supervisors is an important contributing factor influencing labour productivity in installing on-site prefabricated components.

This implies that skills acquisition is vital for capacity building and productivity improvement. Relevant skills are needed not only in labour management and organisation, but also in the inspection and approval of completed work. They are also required in the organisation and coordination of work, and supervision of main and sub-contractors' work if improvement in workers' productivity must be realised (Orando, 2013). Therefore, skills development, in addition to motivation, is vital regarding capacity and work productivity in the construction sector (Orando, 2018).

Literature (Erasmus *et al.* 2016; Schenk, 2016) notes that a worker's educational background, attitude towards own skills development, the organisation where one works, the work environment, and the nature of construction work tasks play a major role in enhancing an employees' skills development for improved productivity.

2.7.1.2 Technical qualifications and experience

In a study conducted by CIDB (2016a) on contractor progression, there is a strong correlation between the contractor's having construction-related training or qualifications and the contractor's survival and progression. Mohlala (2015) conducted a study on the relationship between the project performance of emerging contractors in government

infrastructure projects in South Africa. The findings of the study revealed that the degree of delay in project completion was higher for contractors who did not have technical qualifications as compared to contractors who had technical qualifications. This indicates the importance of having a technical qualification when operating in the construction sector.

A study conducted by Orando and Isabirye (2018) on construction workers' skills development has shown that a good technical educational background in construction and a worker-skill attitude is very important for work productivity improvement. The study has further stated that construction workers ought to acquire basic education to be productive in the construction industry.

An example cited was a mason tasked with the construction of a gravel road who builds simple structures like retaining walls or culverts on a small scale. Such a mason performs a job where technical demands are moderate. Another job may require a mason to work on the construction of a large and complex power station where reading complex drawings and finishing work to the required standards are needed. This kind of project will demand literacy and technical skills, including reading, as part of communication skills (Orando, 2013).

Construction project managers also need a blend of project management knowledge, technical knowledge, and experience in the field, to contribute to successful project management. The correct knowledge set will contribute to effective communication and trust in a project. These organisational elements are crucial for efficient and successful project management (Burger *et al.* 2015).

2.7.1.3 Project management competence

Project management competence can be defined as the execution of a project in an effective manner that involves the knowledge of the project environment, the application of project management and leadership skills, and personal growth to achieve preset goals (Suikki *et al.* 2006).

According to Edum-Fotwe and McCaffer (2000), project management competency can be achieved through a combination of acquired knowledge through training, and the application of skills and knowledge. Edum-Fotwe and McCaffer (2000) further state that the skills that are required of a construction project manager involve:

- Project, technical and team leadership;
- Communication (writing, oral, and listening);
- Negotiation; and
- Problem-solving (problem definition and decision-making).

According to Burger and Zulch (2018), a successful project needs to be completed within time, cost, and quality and according to the agreed-upon scope. However, some organisations fail to realise that having staff, time and money is not enough to ensure success. Some important factors to accomplish this are effective project planning, management, and control (Chordas, 2008; Kerzner, 2013).

Having project management tools and techniques is important for planning. Planning is important to manage a project within time, cost, and quality parameters. By implication, integrated knowledge is required to understand, and an ability to apply and evaluate the key terms, concepts, facts, principles, rules, and theories of project management to other fields, disciplines, or practices (e.g., engineering) in the construction industry (Longman & Mullings, 2005; Kerzner, 2013). Project management is regulated by professional bodies, one of which is the Project Management Institute (PMI). The PMI has published a knowledge guide known as the PMBOK guide stipulating the key terms, concepts, facts, principles, and rules of project management areas.

The nine generic project management areas include integration, scope, time, cost, quality, human resources, communication, risk, and procurement. In addition to the nine PMBOK knowledge areas that are generic, the PMI has identified four additional areas known as the *Construction Extension to the PMBOK* that are industry-specific, namely,

safety management, environmental management, claims management, and financial management (PMI, 2015; Burger *et al.* 2015). The purpose of the Construction Extension is to improve the efficiency and effectiveness of the management of construction projects.

2.7.2 Project delays

Project delays or timely completion of projects can be used as another indicator of contractors' project performance. It should be noted that not all delays reflect a contractor's incompetence, a lack of project management skills, or poor performance. It is therefore important to investigate the different causes of construction delays to determine the causes. Delays are classified into two categories, excusable and non-excusable delays (Alkass *et al.* 1996). Excusable delays include unforeseen events and those that are not linked to the contractors' actions or inactions and are beyond the contractors' control (Alkass *et al.* 1996). Contractors may not be penalised for such delays and would, therefore, be entitled to an extension of time.

However, not all excusable delays warrant compensation. Project delays that are attributed to the clients' actions, inactions, and negligence are classified as excusable compensable delays (Alkass *et al.* 1996). Excusable non-compensable delays are due to events that the client or the contractor are not responsible for, such as unprovoked strikes and natural events. The second category of project delays is non-excusable delays, which result from the contractors' actions, inactions, and negligence. The contractor is not entitled to any compensation for such delays and may suffer penalties (Alkass *et al.* 1996).

The causes of project delays that are attributed to the contractors' actions or lack thereof can then be used to determine the solutions that can be used to limit such delays and, as a result, improve contractor performance. Project delays that are attributed to government organisations (the client) and the built-environment professionals (internal engineers, consultants, and client agents) should also be noted.

A study done by Faridi and El-Sayegh (2006) in the United Arab Emirates (UAE) shows that a shortage of skilled labour, poor supervision and site management, inadequate leadership, and equipment failure have contributed to delays in construction projects. Alkass *et al.* (1996) attribute delays to strikes, project rework, poor organisation, material and equipment shortage or failure, change of scope, natural events, contractors' failure to provide sufficient manpower, and denial of access to the site by the client after site handover has been carried out.

Faridi and El-Sayegh (2006) found that the most prevalent causes of project delays as ranked by consultants and contractors in the UAE are inadequate early planning of projects, preparation, and approval of drawings, poor supervision and site management, and shortage of manpower. The lowest-ranking causes from the same study were found to be shortage or delays in delivery of materials, poor leadership of the construction manager or project manager, incomplete drawings, specifications, or documents, and productivity of manpower.

Similar studies were done by Assaf *et al.* (1995), and Mezher and Tawil (1998) in Saudi Arabia and Lebanon, respectively. Assaf *et al.* (1995) found that the top-ranking causes of project delays are preparation and approval of drawings, financing by contractors during construction, and shortage of manpower, while the lowest-ranking one was productivity of manpower.

According to Mezher and Tawil (1998), the most common causes of project delays include poor leadership by the construction or project manager, and the preparation and approval of drawings. The study also found that the lowest-ranking cause of delays is the shortage of manpower. Assaf *et al.* (1995) further stated that project delays in the construction industry are closely related to the availability and productivity of manpower which are linked to skills and competencies of contractors. Skills and competencies in the construction industry place contractors in a better position to get work and, as a result, experience. Contractor performance in South Africa is linked to skills, competencies, and experience.

Project delays can lead to cost overruns (Sambasivan & Yau, 2007), low productivity, contract termination (Arditi & Pattanakitchamroon, 2006) and hinder business development for the contractor (Benson, 2006). According to Arditi *et al.* (1985) and Lo *et al.* (2006) project delays can lead to slow economic growth. According to Adnan *et al.* (2012), the construction industry plays a major role in infrastructure development and, therefore, the growth of the economy.

2.8 PROJECT PERFORMANCE CRITERIA

According to Morote and Ruz-Vila (2012), the following key criteria should be considered for contractor prequalification and or grading.

- Technical capacity
- Experience
- Plant and equipment
- Management capability
- Financial stability
- Past performance
- Past relationship
- Reputation and,
- Health and safety

2.8.1 Technical capacity

The contractor must demonstrate that it has the technical capacity to perform the activities of the specific project for which they are seeking prequalification. In the context of contractor grading, a contractor must demonstrate technical capability for the grade to which the contractor seeks application. Adams (1995) identified a lack of skilled labour as one of the major causes of emerging contractor failure in the construction industry.

Training, either on the job or through tertiary education, develops skills which result in the development of competencies. Skills development can also occur through experience and the application of the acquired experience and knowledge (Edum-Fotwe & McCaffer,

2000). Moreover, training is a necessity in the construction industry: a lack of which, may result in skills shortage, shortage of labour and poor-quality outputs (Gann & Senker, 1998). The lack of skilled labour results in competition for labour within the industry and, as a result, causes high labour prices for the contractor. Increased expenses such as high wages can lead to business failure.

The study by Sweis *et al.* (2014) found that clients and engineers attribute contractors' poor performance to a lack or shortage of technical professionals within their organisations. According to a study conducted in Germany, a combination of vocational training and formal qualifications is a great strength of the German construction labour force (Richter, 1998). It was also found that Germany has a high number of technically qualified construction workers even up to the master's level. According to Richter (1998), this is the support system and essential factor for entrepreneurship and self-employment in the German construction industry.

The lack of technically qualified contractors was found to be the primary cause of low productivity in the United Kingdom (UK) construction industry (Praise & Steedman, 1986; Clarke & Wall, 1996).

Croswell and McCutcheon (2001) have also identified the lack of technical expertise as a contributory factor to the poor performance of emerging contractors in South Africa. Mohlala (2015) studied the relationship between the project performance of emerging contractors in South African government infrastructure projects and their experience and technical qualifications and found that contractors with technical qualifications and experience generally perform better than those without technical background. The study also found that where there is no technical background, the level of education also affects the level of project performance. The grading of contractors using a set of key relevant criteria may improve the client's confidence in the quality of the contractor who will roll out the infrastructure project and may enhance the performance of the construction industry.

These studies highlight the importance of technical qualifications and experience in the construction industry. To ensure sustainability, institutions and construction companies

should pass on their skills, knowledge, and experience through the training of incoming members in the industry (Richter, 1998). This can be achieved by collaboration between the government (public sector) and the private sector.

2.8.2 Experience

The contractor must demonstrate its participation in other previous projects, especially if they are like the project that will be executed. According to Sweis *et al.* (2014), some of the factors that affect contractor performance in the construction sector are poor project planning and scheduling by contractors. These are fundamental project management skills which are essential for the successful implementation of every project.

In a study conducted by Burger and Zulch (2018), it was found that experience in industry is essential to contribute to effective project management. However, experience on its own, without knowledge, will not sufficiently contribute to effective project management. Thus, the knowledge which is expected from project managers can be grouped into technical knowledge (construction science, finance and cost, construction processes, and design processes within the built environment), and knowledge through industry experience and project management knowledge theory (the nine generic project management areas include integration management, scope management, time management, cost management, quality management, human resources management, communication management, risk management, and procurement management; the four construction-specific project management areas include safety management, environmental management, claims management, and financial management).

The research results showed that knowledge is fundamental to the development of effective construction project management to produce successful projects. The study recommended that National Qualification Framework (NQF) Level 6 and NQF Level 7 should be used in combination with knowledge gained through industry experience to assist construction project managers in developing their knowledge sets, and through improved levels of knowledge, ensuring the successful execution of projects (Burger &

Zulch, 2018). The NQF Level 6 is equivalent to a diploma or advanced certificate and NQF Level 7 is equivalent to an advanced diploma or bachelor's degree.

2.8.3 Management capability

Management plays a key role in the success of a business. The contractor must demonstrate that they are capable of planning, organising, and controlling a project. This criterion is critical as it also considers the number of managerial staff with relevant business-related qualifications and skills. Mofokeng (2012) found that small and medium construction companies lack business and managerial experience. Project management capabilities include management capabilities regarding research and development, health and safety, schedule, cost, quality, knowledge, risk, supply chain, and human resources (Sueliman & Alfaraidy, 2019).

Previous literature (Fredland & Morris, 1976; Jo & Lee, 1996;) has shown that managerial expertise and experience are vital for the success of any enterprise and have a significantly positive relationship to the performance of the enterprise. The acquisition of experience is, thus, an on-going process, especially in project-based enterprises since each project is inherently unique. Thus, emphasis should also be put on continuous learning from one project to the next to improve contractor experience in government infrastructure projects.

2.8.4 Financial status

The client must reach an informed opinion regarding the overall financial position and capability of the contractor. In a study conducted by Sweis *et al.* (2014) on contractor performance at an international level to determine the most critical contractor performance factors in public infrastructure projects according to the perspectives of contractors, clients, and engineers, it was found that contractors' financial difficulties were one of the key concerns from clients and engineers as well as contractors.

According to Pearson (2018), the construction business is riskier than any other average business. This necessitates a special focus on financial management for the construction

business. Financial management is the use of a company's financial resources. This includes the use of cash and other assets, such as equipment. Many everyday decisions affect a company's financial future.

For example, Pearson (2018) states that the decision to bid on a large project can have a great impact on the finances of a company. In construction, the need to improve is clear because clients need better value from their projects, and contractors need reasonable profits to ensure their long-term future (Egan, 1998). Improved contractor performance leads to improved client satisfaction, reputation, and competitiveness (Xiao & Proverbs, 2003).

According to Gibb *et al.* (2005), different contractors could not finish their projects without enough financial support. A study conducted by Ling *et al.* (2011) has shown that cost overrun, and financial constraints were the main factors that affected road construction projects in Singapore. Harris and McCaffer (2013) state that contractors' financial capacity is the resource to smooth the progress of implementation of the construction work on site. It is made up of money at hand, bank credit, overdraft, credit purchases, work-in-progress, and invoiced amount.

Akali and Sakaja (2018) indicate that financial capacity also includes the resources needed to run the daily business of the construction firm. The management of financial capacity includes planning, sourcing, and controlling the use of financial capacity during construction. The sufficiency of financial capacity always depends on the correct composition and correct financing during construction.

Nwude (2010) observed that it requires a determined positive effort by the contractor as mismanagement can weaken productivity and profit levels. Management of financial capacity is very critical. To ensure that the level of financial capacity is maintained and that there is sufficient provision of funds to finance current assets to facilitate projects to be project completion within cost and time, there is a need to establish the optimum level of financial capacity needs of a project. Furthermore, there is a need for continuous

checking and monitoring of the quantum of individual parts that comprise the financial capacity to ensure that the requirements are not exceeded (Akali & Sakaja, 2018).

2.8.5 Past performance, relationships, and reputation

Considering the past performance of each contractor, the client's project manager will have a higher or lower degree of confidence in the possible contractors regarding the quality, time, and cost control requirements. Factors such as time, cost, quality, and client satisfaction are some of the indicators that are used to measure performance in a project environment (Cheung *et al.* 2004).

The client must collect and analyse information about the contractor's past relationship with other entities which participate in the construction activities (Morote & Ruz-Vila, 2012). Morote and Ruz-Vila (2012) further indicate that the project manager must have an overall estimation or opinion about how good a contractor is. One way of assessing reputation could be through referral letters from the previous and current contractors' clients.

According to El-sokhn and Othman (2014), the construction process appears to be an ordered, linear phenomenon that can be organised, planned, and managed easily. The high rate of failures that occur in the construction projects to be completed on budget and schedule clarifies that the nature of the construction process is not as ordered and predictable as it may appear. The construction process is a complex, nonlinear, and dynamic phenomenon that may exist on the edge of chaos sometimes. Therefore, construction projects are rich in plan failure, delays, and cost overruns more than in successes (Bertelsen, 2002).

The construction industry is known for its chronic problems of fragmentation, low productivity, time and cost overruns; poor safety, inferior working conditions, and insufficient quality which ultimately lead to project failure and poor construction image. Some practitioners refer to a project to be successful if it satisfies the three legs of the triple constraint of "specification, cost, and time". However, this definition does not fully

embrace the factors of project success/failure. For instance, the Sydney Opera House in Australia is one of the most recognisable images of the modern world, although it cost about sixteen times as much to build, and it took four times as long to complete. Nowadays, the opera house has enormous value and is the icon of Australia, and it is considered an architectural accomplishment (Camilleri, 2011).

El-sokhn and Othman (2014) further state that from the project management perspective, success means the delivery of the project within the deadlines, and budgets, and its functionality fulfils the mission and the planned objectives and meets the required expectation of the stakeholders. The project is assumed to be a failure when the completion time exceeds the due date, when there is an occurrence of budget overruns, and when the outcomes do not satisfy the company's performance criteria or the stakeholder's expectations.

2.8.6 Occupational health and safety

Adinyira *et al.* (2020) and Schmidt *et al.* (2019) state that the construction sector remains one of the key generators of adverse environmental impacts and is among one of the highest contributors of work-related accidents, resulting in injuries, fatalities, and illnesses. In the United States of America (USA), the construction sector accounted for over 800 worker-related deaths in 2019 (Bureau of Labour Statistics, 2020). Moreover, the United Kingdom's construction sector recorded the highest number of fatal injuries in the 2020/21 financial year in comparison to previous years (Health, Safety and Executive, 2021 cited by Adinyira, 2020). Similarly, India's construction sector also contributes 16.4% of fatal occupational accidents (Kanchana *et al.* 2015).

Moreover, the construction sector accounts for significant consumption of natural resources and energy. Estimates indicate that buildings and construction together account for 36% of final energy use, 16% of natural water, 39% of CO_2 emissions, 40% of the waste produced, and 50% of all raw materials extracted (Gupta & Deshmukh, 2016; UN Environment and International Energy, 2017). With the volume of construction output projected to grow by more than 85% globally by 2030 (Global Construction Perspectives

and Oxford Economics (2015), the impact of construction operations on the environment and workers' safety and health would be far-reaching if nothing were to be done about it.

The socio-economic impacts arising from these negative environmental impacts, injuries, illnesses, and fatalities (Health and Safety Executive, 2018; Workplace Safety and Health Institute, 2013) have triggered several efforts to address the poor status of Safety, Health, and the Environmental management in construction (Asah-Kissiedu, 2021). One of the prominent initiatives to address the Safety, Health, and Environment (SHE) situation in construction is the implementation of management systems, particularly environmental management systems (EMSs) and safety and health management systems (SHMSs) in construction to manage SHE risks with maximum effectiveness and minimum bureaucracy (Sze *et al.* 2019). This could be beneficial in reducing the number of fatalities, injuries, illnesses, and potentially negative environmental impacts, leading to better SHE performance outcomes within the construction sector.

In South Africa, Construction OH&S has long been the focus of attention of many industry stakeholders and role players, and while it is acknowledged that many industry associations and professional societies, contracting organisations, and others have made significant efforts to improve H&S within the construction industry, the overall construction H&S is not improving significantly. Notably, construction continues to contribute a disproportionate number of fatalities and injuries, and there continues to be a high level of non-compliance with the H&S Regulations in South Africa. Improving OH&S in the construction industry therefore remains a priority - including being a priority for the CIDB (Enslin, 2013).

The aim is to encourage contractors to establish and maintain effective systems to manage the risks of occupational health and safety (OH&S) of employees arising from the nature of the work. Minor injury to fatality or permanent disablement cases due to accidents at the construction sites is one of the highest in the construction sector as compared to the other sectors (Shrestha, 2021). Globally, the construction industry has a poor health and safety (OH&S) record and South Africa is no exception. In South Africa,

the Occupational Health and Safety Act No 85 of 1993 and the General Safety and Administration Regulations govern issues pertaining to safety in the construction sector. Further details on the OH&S legislation and regulations are provided in Chapter 3.

2.8.7 Plant and equipment

The World Bank (2018) considers plant and equipment as important criteria for grading contractors. Plant and equipment are also good indicators of a company's financial stability. Alkass *et al.* (1996) have attributed some of the construction delays to plant and equipment. It is therefore important that plant and equipment be considered when grading contractors as they are critical in construction activities.

Zakeri *et al.* (1996) investigated the lack of proper tools and equipment and its effect on the productivity of construction workers. Similarly, Haslam *et al.* (2005) mentioned that there is a direct relationship between using equipment and its connection to several construction accidents. Gibb *et al.* (2005) pointed out that it is essential to use better construction facilities. It has been estimated that 36% of the whole construction project cost refers to equipment costs (Yeo & Ning, 2006).

In Iran, managing and owning plants and equipment in the construction industry was beneficial for different aspects of a construction project and had significant positive effects on decreasing the time and cost of the projects and increasing the quality of the project. It should further be noted that construction plant and equipment need adequate knowledge and expertise and a lack of knowledge can affect performance in construction projects negatively (Yeo & Ning, 2006). It will thus be important for contractors to have ownership of key plants and equipment in their field of operation to be more efficient and effective in delivering construction projects.

2.9 SUMMARY OF KEY CRITERIA IN THE CONSTRUCTION SECTOR

The summary of key criteria for consideration by various authors when grading and evaluating the performance of contractors in the construction sector can be tabulated as follows:

Table 2.5 Summary of key criteria in the construction sector

Critical criteria in contractor performance	Authors
Technical Capacity	Burger *et al.*(2015), Hanson *et al.*(2003), Orando (2013), Iyer and Jha (2005), Faridi & El-Sayegh (2006), Sweis *et al.*(2014), World Bank (2018), Edum-fotwe & McCaffer (2000), Adams (1995), Kazaz *et al.*(2008), Hanafi *et al.*(2010), Orando (2018), Erasmus *et al.*(2016), Schenk (2016), Praise & Steedman (1986), Clark & Wall (1996), Morote & Ruz-Villa (2012), Mohlala (2015), Orando & Isabirye (2018), CIDB (2016a), Gann & Senker (1998), Longman & Mullings (2005), Kerzner (2013), Richter (1998), Crosswell & McCutcheon (2001), Assaf *et al.*(1995), Baloyi & Bekker (2011); Dlungwana *et al.*(2002); Sweis *et al.*(2008); Thwala & Phaladi (2009).
Experience	Morote & Ruz-villa (2012), Sweis *et al.*(2014), Mohlala (2015), Orando & Isabirye (2018), Assaf *et al.*(1995), Adams (1995), Edumfotwe & McCaffer (2000), Orando (2013), Faridi & El-Sayegh (2006), Gann & Senker (1998), Richter (1998), Crosswell & McCutcheon (2001), Burger and Zulch (2018), Assaf & Al-Hejji (2006), Chan & Kumaraswamy (1997), Kaliba *et al.*(2009), Sambasivan & Soon (2007), Koushki (2005), Muhwezi, Acai & Otim (2014), Nguyen & Chileshe (2015), Sambasivan & Soon (2007), Thwala & Phaladi (2009).
Financial Stability	Sweis *et al.*(2014), CIDB (2013), Burger *et al.*(2015), PMI (2015), Assaf *et al.*(1995), Morote & Ruz-villa (2012), Burger and Zulch (2018), Pearson (2018), El-Sokhn & Othman (2014), Bertelsen (2002), Camillen (2011), Al-Momani (2000), Assaf & Al-Hejji (2006), Kaliba, Muya & Mumba (2009), Koushki, Al-Rashid & Kartam (2005), Monyane & Okumbe (2012), Sweis *et al.*(2008), Aibinu & Odeyinka (2006), Frimpong *et al.*(2003). Ling *et al.*(2011), Akali & Sakaja (2018), Harris and McCaffer (2013), Gibb *et al.*(2005), Nwude (2010).
Past Performance	Cheung *et al.*(2004), Gharakhani (2013), Mohlala (2015), CIDB (2013), Xiao & Proverbs (2003), Burger and Zulch (2018), Morote & Ruz-villa (2012), Gann & Senker (1998), Cheung *et*

Critical criteria in contractor performance	Authors
	*al.(*2004), Suelima & Alfaraidy (2019), Al-Momani (2000), Assaf & Al-Hejji (2006), Kaliba *et al.*(2009), Koushki *et al.*(2005: 294), Monyane & Okumbe (2012), Sweis *et al.*(2008), Dlakwa & Culpin (1990), Fugar & Agyakwah-Baah (2010); Mansfield *et al.*(1994); Thwala & Phaladi, (2009), Baloyi & Bekker (2011), Dlakwa & Culpin (1990: 239), Koushki *et al.*(2005); Mansfield *et al.*(1994) El-Sokhn & Othman (2014), Bertelsen (2002), Camillen (2011).
Occupational Health and Safety	Cheung *et al.*(2004), CIDB (2013), Burger *et al.*(2015), PMI (2015), Morote & Ruz-villa (2012), Adingva *et al.*(2020), Suelima & Alfaraidy (2019), Schmid*t et al.*(2019), Bureau of Labour Statistics (2020), Asah-Kissiedu (2021), Sze *et al.*(2019), Enslin (2013), Shresta (2021), Health and Safety Executive (2021), Kanchana *et al.*(2015), Gupta & Deshmukh (2016), Global Construction Perspective (2015), UN Environment and International Energy (2017)
Management Capability	Thwala & Mvubu (2008), CIDB (2013), Burger *et al.*(2015), Chordas (2008); Kerzner (2013), Faridi and El-sayegh (2006), Assaf *et al.*(1995), Morote & Ruz-villa (2012), Mofokeng (2012), Suelima & Alfaraidy (2019), Fredland & Morris (1976), Jo & Lee (1996), Chan & Kumaraswamy (1997); Monyane & Okumbe (2012)
Plant and Equipment	World Bank (2018), Faridi and El-Sayegh (2006), Alkas *et al.*(1995), Morote & Ruz-villa (2012), Haslam *et al.*(2005), Pearson (2018), Alkass *et al.*(1996), Zakeri *et al.*(1996), Gibb *et al.*(2005), Yeo & Ying (2006)

The importance of these criteria cannot be emphasised enough in project performance.

2.10 THE EFFECTS OF CORRUPTION IN THE CONSTRUCTION SECTOR

Amundsen (2000) distinguished between political and bureaucratic corruption, ‘individual’ and ‘collective’ forms of corruption, and corruption as a mechanism of either ‘upward extraction’ or ‘downward redistribution’. The main forms of corruption identified are

bribery, embezzlement, fraud, and extortion. These concepts are partly overlapping and at times interchangeable with other concepts.

According to Gordon and Miyake (2001), as cited by Adnan *et al.* (2012), it is not always easy to define exactly what constitutes bribery and other corrupt practices, but identified facilitation payment, gifts and hospitality, conflict of interest and the use of intermediaries as falling within these practices. Shakantu (2006) as cited by Adnan *et al.* (2012) defines corruption as the 'offering, giving, receiving or soliciting of anything of value to influence the action of an official in the procurement or selection process or in contract execution'. Bribery is therefore at the core of what is commonly viewed as an unacceptable, corrupt practice. Amundsen (2000) listed the synonyms for 'bribery', such as kickbacks, gratuities, baksheesh, sweeteners, pay-offs, speed, grease money, and regarded fraud as an economic crime that involves some kind of trickery, swindling or deceit and has a broader legal and popular term that covers more than bribery.

Adnan *et al.* (2012) is of the view that bribery inhibits economic development and distorts competition. In addition, it disrupts distribution channels, destroys incentives to compete in quality and prices, undermines market efficiency and predictability, and ultimately denies many people the right to a minimum standard of living. The construction industry plays an important role in the economic contribution to the development of the country. To obtain optimal benefits from the industry and ensure the smooth functioning of the industry itself, good ethical practices are vital. Despite the innovations and advanced technology that have taken place in the industry, good ethical practices by the players in the industry are crucial for its growth. Professional institutions and government agencies play a crucial role in minimising ethical lapses in the construction industry (Adnan *et al.* 2012).

According to Transparency International (2005), the construction industry is highly fraudulent globally and provides a favourable environment for improper ethical conduct. These unethical issues can occur at any stage of the project cycle; during planning and design, pre-qualification and tendering process, and project implementation, operation,

and maintenance (Adnan *et al.* 2012). The effects of unethical practices have lasting impact detrimental to construction and engineering companies such as wasted tender expenses, tendering uncertainty, increased project costs, economic damage, blackmail, criminal prosecutions, fines, blacklisting and reputational risk. Adnan *et al.* (2012) argue that contractors may not be the only stakeholders who are responsible for unethical conduct in the construction industry and, although often forgotten and not reported, clients and technical consultants may be a contributory factor. Government officials are perceived to be actively involved in corruption in the form of accepting bribes and tender manipulation (Bowen *et al* .2012).

Corruption in construction projects can result in several issues such as cost overruns and time delays (Abdul-Rahman *et al.* 2008), and the consequences may include economic, financial, and reputational damage for the contractor (Adnan *et al* .2012). Corruption can result in up to 25% of cost overruns in the public sector (Transparency International, 2005). It has undesirable impacts on the achievement of South Africa's sustainable development (Pillay, 2004).

A survey conducted by Bowen *et al.* (2007) on the opinion of South African architects, quantity surveyors, engineers, and contractors regarding ethical behaviour within the construction industry reveals that South African contractors seem to possess a reputation for unethical conduct. The range of problems encountered includes collusion, bribery, negligence, fraud, dishonesty, and unfair practices. While bribery in the form of payments and gifts is prevalent, fraud does not appear to be a serious problem. Most construction professionals believe that the industry suffers from unfair tendering practices, as well as over-claiming and/or withholding payment for service delivery. Negligence arises mainly from poor documentation and poor workmanship. The Organisation for Economic Co-operation and Development's bribery codes could be used to counter unethical behaviour in the construction industry (Bowen *et al.* 2007).

Studies show that fraud in construction businesses is widespread with the manufacturing, construction, and engineering sectors as those highly involved in fraudulent activities (Fraud Survey, 2009). There are many reasons why professionals are involved in

unethical practices. This may be due to insufficient legislative enforcement, fierce competition, the economic downturn, insufficient ethical education from schools and professional institutions, cultural changes, and the high complexity of construction works.

The South African construction and engineering sectors are no exception. Even though there are guidelines and Acts of Parliament to guide the procurement process, ethical issues still arise in projects, leading to lower project quality outcomes. In South Africa, several high-profile public sector projects are muddied by problems that range from incomplete projects to poor quality projects because of the appointment of incompetent contractors (Fraud Survey, 2009).

Various studies (Vee & Skitmore, 2003; Ratshisusu, 2014; Sohail & Cavill, 2008; Bowen, *et al.* 2012) have shown that most unethical behaviour in the construction industry takes the form of unfair conduct, negligence, conflict of interest, collusive tendering, fraud, and bribery. Furthermore, in terms of professional conduct, it has been identified that most professionals believe that obligations to the client and the public are of equal importance (Vee & Skitmore, 2003; Fan *et al.*2001;). To assist in minimising corruption, the application of decision support frameworks can be utilised.

2.11 DECISION SUPPORT FRAMEWORKS

Decision support frameworks are tools that help users in a problem-solving environment to improve their productivity and decision-making ability (Molenaar & Songer, 2001). Decision support systems include a diverse set of techniques and applications such as artificial intelligence and expert systems, database queries, and group conference decision support systems (Loughlin *et al.*1995; McIntyre & Parfitt, 1998). The traditional description of a decision support system is “a computational or computerised environment for assisting human decision-making” (Kroenke & Hatch, 1993; Molenaar & Songer, 2001).

According to Molenaar and Songer (2001) and Loughlin *et al.* (1995), decision support frameworks do not provide the decision maker with a direct solution but help the user add

value to the system output to reach a decision. McIntyre and Parfitt (1998) indicate that a decision support system involves four basic interrelated elements:

- Human input,
- Data describing the problem,
- Procedures for operating the system, and
- Computerized system

Decision support systems are critical for the study as the premise of the study lies in the development of decision support systems for grading contractors, regulation of new entrants in the construction sector (focusing on civil engineering), and monitoring and evaluating infrastructure project performance. Decision-making is one of the most important activities for human beings. Complex decision-making problems are full of uncertainty and ambiguities. A large amount of data is needed, and several strategies must be applied at the same time to make a good decision (Chen *et al.* 1999).

With specific domain knowledge and external information as a background, the task of decision-making is to get an optimal or nearly optimal solution from input information using solution strategies. Generally, there are three ways to decide a complex environment:

- By building an accurate mathematical model.
- By seeking human experts' advice.
- By building a decision support system or an expert system.

Among these options, building an accurate mathematical model to describe the complex environment is a good way. However, accurate mathematical models do not always exist, nor can they be derived for all complex environments because the domain may not be thoroughly understood. The first method is then limited and when it fails, an alternative for making a good decision is to seek human experts' help. However, the cost of consulting an expert may be high, and there may be no human experts available when the decision must be made. Decision support systems have been widely used in domains for which the first two methods are not suitable (Chen *et al.* 1999).

The database and the model base in a decision support system can grow incrementally and can be updated dynamically so that the performance of a decision support system will become better and better as it develops. Also, a decision support system can improve personal efficiency, expedite problem-solving, facilitate interpersonal communication, promote learning or training, and increase organisational control. Successful decision support systems have been widely applied to many fields such as manufacturing, engineering, economics, business, and others (Chen *et al.*1999). It is thus important to review decision support systems in civil engineering construction management to determine which one would apply to the study.

2.11.1 Decision support framework in civil engineering construction management

The construction industry provides an excellent opportunity for the utilisation of decision support systems due to the highly unstable environment of construction projects and the need for increased effectiveness in such a situation (Hastak & Vanegas, 1993). Arif (2013) has indicated that several researchers have attempted to build mathematical models to optimise the management and maintenance of infrastructure. These models can be classified into single-objective models, multi-objective models, and cost/finance-based models.

Savic (2002) indicates that many real-world decision-making problems need to achieve several objectives which are to minimise risks, maximise reliability, minimise deviations from desired levels, and minimise cost. The main goal of single-objective (SO) optimisation is to find the “best” solution, which corresponds to the minimum or maximum value of a single objective function that lumps all different objectives into one. This type of optimisation is useful as a tool that should provide decision-makers with insights into the nature of the problem, but usually cannot provide a set of alternative solutions that trade different objectives against each other.

On the contrary, in a multi-objective optimisation with conflicting objectives, there is no single optimal solution. The interaction among different objectives gives rise to a set of

compromised solutions, largely known as the trade-off, non-dominated, non-inferior or Pareto-optimal solutions. According to Cohon (1978), as cited by Savic (2002), the consideration of many objectives in the design or planning stages provides three major improvements to the procedure that directly supports the decision-making process:

- A wider range of alternatives is usually identified when a multi-objective methodology is employed.
- Consideration of multiple objectives promotes more appropriate roles for the participants in the planning and decision-making processes, i.e., "*analyst*" or "*modeller*"– who generates alternative solutions, and "*decision maker*" - who uses the solutions generated by the analyst to make informed decisions.
- Models of a problem will be more realistic if many objectives are considered.

Single-objective optimisation identifies a single optimal alternative; however, it can be used within the multi-objective framework. This does not involve aggregating different objectives into a single objective function, but, for example, entails setting all except one of them as constraints in the optimisation process. Those objectives expressed as constraints are assigned different levels of attainment of their respective objective functions (minimum reliability levels) and several runs are performed to obtain solutions corresponding to different satisfaction of constraints.

2.11.2 Multi-criteria analysis

Multicriteria analysis (MCA) is a flexible and multidisciplinary tool that ranks or scores a finite number of options based on a set of evaluation criteria (Wilson *et al.* 2004; Malczewski, 1997; Saaty, 1994; Nijkamp *et al.* 1990; Keeney & Raiffa, 1976;). It can solve civil engineering decision problems which are typically guided by multiple objectives, and are complex and dynamic (Hamouda *et al.* 2009, Hajkowicz & Higgins, 2008; Gough & Ward, 1996). Due to its flexibility, MCA has been used to solve civil engineering problems in industrialised, rural, developed, or developing contexts (Chen *et al.* 2006; Riesgo & Gomez-Limon, 2006; Mohanty, 1992). Specifically, it is considered an appropriate

assessment method for projects that aim to improve basic needs in developing countries (Garfí *et al.* 2011; Garfí *et al.* 2009; Cherni *et al.* 2007; Mohanty, 1992;).

MCA can consider multiple social, environmental, and economic criteria that may have different units (Hajkowicz & Collins, 2007) and could include qualitative and/or quantitative aspects of the problem in the decision-making process (Wilson *et al.* 2004). The outcomes are often highly intangible and may include items such as biodiversity, recreation, scenery, and human health. These characteristics of civil engineering planning decisions make MCA an attractive approach (Hajkowicz & Higgins, 2008).

The selection of criteria to evaluate alternatives is the key decision in MCA as it is essential to effective assessment. In all these projects, general criteria including socioeconomic, environmental, and basic technological objectives must be considered. MCA has been applied in different case studies concerning civil engineering projects (Garfí *et al.* 2011; McConville *et.al.* 2010; Paneque Salgado *et al.* 2009; Flores *et al.* 2007; Moura *et al.* 2007; Chen *et al.* 2006; Riesgo & Gomez-Limo, 2006; Tiwari *et al.* 1999; Al-Kloub *et al.* 1997; Gough & Ward, 1996;).

According to Garfi *et al.* (2009), the use of MCA in developing countries has the following advantages:

- It can be adapted to each problem and multiple criteria can be included in the analysis.
- It can work with mixed data and the analysis need not be data intensive. Both qualitative and quantitative information can be incorporated, which is crucial when accurate data are not available, as in the case of developing countries.
- Multiple experts, interest groups, and stakeholders can be directly involved, and the analysis is transparent to participants.
- It includes mechanisms for feedback on the consistency of judgments.

Generally, MCA considers five common phases: (i) a given set of objectives; (ii) a set of alternatives; (iii) a set of criteria, which are used for comparing the alternatives; (iv)

calculating the relative weight of each criterion; (v) evaluating alternatives by a set of indicators to assess each criterion of each alternative. To finally obtain a global score for the solutions it estimates how well they satisfy the criteria (CIFOR, 1999). Objectives must reflect all the concerns that are relevant to the decision problem; they must be achieved by the implementation of the alternatives. The identification and selection of a set of criteria for comparing alternatives result from the specification of a comprehensive set of objectives (Rogers & Bruen, 1998).

The criteria are the standards or rules that are used to rank the alternatives according to their desirability and describe the degree of achievement of objectives. The criteria list will be site-specific and will reflect the concerns and preferences of the decision-maker and stakeholders. Some criteria may have such importance that they have to be singled out. This is the case for veto criteria determined by a veto threshold that sometimes can be imposed by the regulation (EC, 2005; Rogers & Bruen, 1998;). Criteria relative weights can be calculated in various ways, including pairwise comparisons. The MCA can be considered a good decision support tool that can be used for developing a decision support framework for contractor grading and minimum civil engineering entry requirements.

2.11.3 Multi-criteria decision making for contractor registration and grading

Multi-criteria decision-making (MCDM) is adopted in the study to achieve a holistic contractor grading and registration process. MCDM deals with structuring and solving decision and planning problems comprising multiple criteria. It involves assessing various criteria and evaluating alternatives based on each criterion. MCDM problems have been studied under the general classification of operations research (OR) problems, which deal with decision-making in the presence of several often-conflicting criteria (Bhushan & Rai, 2004).

Some common methods of MCDM are the analytic hierarchy process (AHP), elimination et choix traduisant la realitè (ELECTRE), preference ranking and organisation method for enrichment evaluation (PROMETHEE), Complex proportional assessment (COPRAS)

method and technique for order preference by similarity to ideal solution (TOPSIS). The analytical hierarchy process AHP (Saaty, 1980) is used for this study because it is widely used and versatile, easy to use, can be used with limited data, and provides for mitigation of its shortfall. The MCDM methods are briefly described.

2.10.3.1. Analytical Hierarchy Process

The analytic hierarchy process (AHP), proposed by Thomas L. Saaty in 1971, is a multiple-criteria decision-making method applied to overcome problems that are under uncertain conditions or need to take several evaluation criteria into account for decision-making. It aims to provide the decision maker with a precise reference for adequately making decision and reducing the risk of making a wrong decision by decomposing the decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be evaluated independently. The elements of the hierarchy can relate to any aspect of the decision problem such as tangible or intangible, carefully measured or roughly estimated, well- or poorly understood; that is, anything at all that applies to the decision at hand (Zolfani *et al.* 2012).

It has been well utilised in several fields (Saaty, 1980) that require the choosing of alternatives and the weight exploration of evaluation. In the past, 13 major conditions have been discovered to well fit the utilisation of AHP such as setting priorities, generating a set of alternatives, choosing the best policy alternative, determining requirements, allocating resources, predicting outcomes, measuring performance, designing systems, ensuring system stability, optimisation, planning, resolving conflict, and risk assessment (Saaty,1980).

Besides, recent conditions encompass the reduction of the influence of global climate change (Berrittella *et al.*2007) to quantify the quality of software systems (McCaffrey, 2005), and to choose staff (Grandzol, 2005), and so on. Some of the applications of the AHP method are listed in Table 2.6:

Table 2.6 Other applications of AHP

Reference	Considered problem
Amiri *et al.*2010	Evaluating ICT business alternatives
Gungor *et al.*2009	Personnel selection problem
Gumus, 2009	Forest road evaluation form
Chen and Wang, 2010	Information service industry
Sun *et al.*2010	Assessment of sustainability
Kim, 2009	Surface of Spatial Urban Growth
Martinez *et al.*2010	Optimal emplacement in buildings
Medineckiene *et al.*2010	Sustainable construction
Podvezko, 2009	Application of AHP technique
Podvezko et al, 2010	Evaluation of contracts
Maskeliunaite *et al.*2009	Quality of Passenger Transportation
Sivilevicius and Maskeliunaite, 2010	Quality of transportation

The AHP calculation adopts a ratio scale or developing pair-wise comparison matrix. It typically can be categorised into 5 sub-scales based on different levels of importance: equal importance, somewhat more important, more important, much more important, and very much more important. There are still 4 sub-scales with each level of importance. Therefore, there is a total of nine sub-scales, the ratio values from 1 to 9. The application of AHP is important for this study, as it will be used to weight the criteria for contractor grading and criteria for project performance.

Unlike multi-criteria decision-making algorithms (TOPSIS, ELECTRE, PROMETHE); AHP aims to combine qualitative and quantitative factors and arrive at a single judgment (Alsamaray, 2017). Advantages of the AHP method include the use of hierarchical and ratio scales, comparisons of intuitive, qualitative, quantitative, and rational factors, comparison of both criteria and alternatives according to criteria, and solving decision problems that have objective and subjective criteria (Bhutta & Huq, 2002).

2.10.3.2. COPRAS-G

To evaluate the overall efficiency of a project, it is necessary to identify selection criteria, assess information relating to these criteria, and develop methods for evaluating the criteria to meet the participants' needs. Decision analysis is concerned with the situation in which a decision-maker must choose among several alternatives by considering a

particular set of criteria. For this reason, the Complex Proportional Assessment (COPRAS) method (Zavadskas & Kaklauskas, 1996) can be applied. This method was applied to the solution of various problems in construction (Kaklauskas *et al.* 2010; Zavadskas *et al.* 2010). Most alternatives under development deal with the future and the values of criteria cannot be expressed exactly.

These multi-criteria decision-making problems must be determined not with the exact criteria values, but with fuzzy values or with values within defined intervals. Zavadskas *et al.* (2008) presented the main ideas of the complex proportional assessment method with grey interval numbers (COPRAS-G) method. The idea of COPRAS-G method with criterion values expressed in intervals is based on the real conditions of decision-making and applications of the grey systems theory (Deng, 1982; Deng, 1988). The COPRAS-G method uses a stepwise ranking and evaluating procedure of the alternatives in terms of significance and utility degree. The recent developments of decision-making models based on COPRAS methods are listed below:

- Bindu Madhuri *et al.* (2010) presented a model for the selection of alternatives based on COPRAS-G and AHP methods.
- Uzsilaityte and Martinaitis (2010) investigated and compared different alternatives for the renovation of buildings considering energy, economic, and environmental criteria while evaluating the impact of renovation measures during their life cycle.
- Chatterjee *et al.* (2011) presented a materials selection model based on COPRAS and EVAMIX methods.
- Zavadskas *et al.* (2011) presented an assessment of the indoor environment.
- Podvezko (2011) presented a comparative analysis of MCDM methods (SAW and COPRAS).

2.10.3.3. ELECTRE

Along with its many iterations, this is an outranking method based on concordance analysis (Velasquez & Hester, 2013). Its major advantage is that it considers uncertainty and vagueness. One disadvantage is that its process and outcomes can be hard to explain in layman's terms. Furthermore, due to the way preferences are incorporated, the

lowest performances under certain criteria are not displayed. The outranking method causes the strengths and weaknesses of the alternatives not to be directly identified, nor results and impacts to be verified (Konidari & Mavrakis, 2007).

The disadvantages in the process and outcome when using the elimination and choice translating reality (ELECTRE) could not be ignored for this study. Thus, the analytical hierarchy process AHP (Saaty, 1980) method is used for this study due to its flexibility and ability to consider both the qualitative and quantitative criteria, as well as objective and subjective criteria.

2.10.3.4. PROMETHEE

PROMETHEE is similar to ELECTRE in that it has many iterations and is an outranking method (Velasquez & Hester, 2013). It measures the degree of dominion of one alternative over all others based on pairwise comparisons, and the results are usually represented in an evaluation matrix that displays the ranking of alternatives (Cunha *et al.* 2019). PROMETHEE measures the intensity of preferences and uses pairwise comparisons to comprehensively analyse the outranking relationship amongst alternatives (Rocco *et al.* 2016). Although the method is easy to use, the disadvantage of this method according to Velasquez and Hester (2013) is that it does not provide a clear method by which to assign weights.

2.10.3.5. TOPSIS

This is an approach to identify an alternative that is closest to the ideal solution and farthest from the negative ideal solution in a multi-dimensional computing space (Qin *et al.*2008). The ideal solution is given by the best criteria values for all alternatives, while the anti-ideal solution is given by the worst criteria values for all alternatives (Cunha *et al.*2019). Although TOPSIS is a simple process, its disadvantage according to Velasquez and Hester (2013) is its use of the Euclidean Distance which does not consider the correlation of attributes, thus it is difficult to weigh attributes and keep consistency of judgments. Inconsistencies arise when performing many pairwise comparisons and the AHP makes provision for checking such inconsistencies.

2.12 CHAPTER SUMMARY

This chapter has reviewed the literature on contractor performance, the success rate of civil engineering infrastructure projects, regulation of business entry, project performance criteria, decision support frameworks, effects of corruption in the construction sector as well as international practices on contractor grading. This was done to understand factors that are affecting the performance of contractors and look at how other countries and organisations grade contractors. The key lesson learned from the literature is that countries like Malaysia, the USA, Japan, Germany, Australia, and the World Bank have regulations for entry into the construction sector. Also, technical, and non-technical criteria are considered for entry into the construction sector and progression through the grades.

The CIDB is empowered to regulate the construction sector and to promote the growth and development of the sector. Literature has noted that the South African CIDB needs to improve on its grading system. Moreover, it is noted that the grading system does not provide a true reflection of contractors' capabilities which is misleading. This indicates that there is a need to improve the current grading system in South Africa. The study addresses this gap by developing an enhanced contractor grading and performance evaluation framework.

Generally, project performance outputs in South Africa are very poor in infrastructure projects. It has been observed in the literature that this is prevalent in developing countries. In South Africa, this is so as contracts are awarded to contractors who have limited technical capabilities and yet have progressed through the grades due to adequate financial capability and the number of projects completed. It is important to also consider other relevant criteria for grade progressions to ensure that grades are a true reflection of a contractor's ability to execute work.

Moreover, the success rate of civil engineering projects is not good in South Africa due to a limited or shortage of technically proficient contractors. The introduction of multi-criteria requirements for contractors' registration and grading may assist in improving the

status quo of contractor project performance. This will enable clients to identify relevant contractor development needs.

Literature indicates that contractors with technical qualifications and experience are less likely to perform poorly and fail as contractors. Other key criteria for contractor grading are past performance, relationship and reputation, financial stability, management capability, plant and equipment, as well as occupational health and safety. It is thus crucial to consider all relevant criteria when grading contractors to ensure that the grade of contractors matches their capabilities.

It is also noted that corruption plays a role in the performance outputs of the construction sector. To assist in minimising corruption, a multi-criteria decision-making process can be utilised. Multicriteria analysis is a flexible and multi-disciplinary tool that ranks or scores a finite number of options based on a set of evaluation criteria. It is posited herein that contractor registration, grading and performance evaluation is a multi-criteria decision-making process. The study made use of the multi-criteria decision-making framework (Analytical Hierarchy Process) to develop the weightings for contractor grades and performance evaluation.

CHAPTER 3 CIDB PROCESSES, CONSTRUCTION, PROCUREMENT, AND LEGISLATIVE FRAMEWORK

3.1 INTRODUCTION

As discussed earlier, the purpose of this research is to develop a decision support framework for registering, grading, and evaluating the performance of contractors to improve the project performance of the construction sector. The purpose of the framework is to assist decision-makers in registering new entrants in the construction sector and grade contractors who wish to progress to a higher grade. This framework can be adopted by both the public and the private sector. This chapter focuses on the Construction Industry Development Board processes and systems, construction sector procurement as well the legislative framework governing the industry in South Africa.

3.2 THE CONSTRUCTION INDUSTRY DEVELOPMENT BOARD

The Construction Industry Development Board (CIDB) draws its mandate from the CIDB Act (No 38 of 2000). According to the CIDB Act (No 38 of 2000), the mandate of the CIDB is to implement an integrated strategy for the reconstruction, growth, and development of the construction industry and to provide for matters connected therewith. The Construction Industry Development Board (CIDB) stipulates that all contractors who intend to bid for or participate in tenders in the South African public sector need to be registered with the CIDB (CIDB, 2011a). Thus, the CIDB is empowered to regulate the construction sector to promote the growth and development of the sector. There are regulatory requirements that firms must adhere to, particularly concerning the register of contractors, which the CIDB keeps and uses to grade firms according to their capacity to carry out construction work.

The construction industry is fundamental to society, the economy, and the environment. Construction shapes daily lives for humanity in unique ways. The built environment influences the quality of life for nearly the entire population of the world, therefore the materials used in construction have major impacts on the health and well-being of end users. The industry accounts for almost 6% of the global GDP according to the World

Economic Forum (2016). Furthermore, construction has considerable interaction with numerous other sectors, therefore, for countries to enjoy inclusive and sustainable growth, modern and efficient infrastructure is essential. The construction industry is the single largest global consumer of resources and raw materials: value therefore lies in improving the quality of construction and the quality of materials used in contributing to a healthier environment, increasing its sustainability, and reducing its cost.

A study conducted by the Construction Industry Development Board (2011) in South Africa indicated that around 12% of projects surveyed had levels of defects that are regarded as inappropriate. It is estimated that this translates into a cost of around US$250 million per year. The results of the recent study have not been released by the CIDB and it is expected that the status quo may be worse due to the invasion of construction mafias in South Africa since 2014 (Mashego, 2023). Construction mafias are a group of business forums that invade construction sites and demand payment from the companies working on those sites. Unfortunately, this negatively affects progress as construction may be delayed or halted (Mashego, 2023). However, the selection of poor contractors in South Africa to implement infrastructure projects could be because of the inefficient grading system of the Construction Industry Development Board (CIDB).

Ratshisusu (2014) argued that the CIDB grading of contractors is a necessary tool to ensure that firms in the sector meet certain minimum requirements to undertake projects. This is however not the case as the CIDB grading system has deficiencies. According to Ratshisusu (2014), the grading does not provide sufficient information to clients on the capacity and ability of firms to undertake construction works. It could assist clients if the grade of the contractors matched the capacity and ability of the contractor concerned to undertake a construction project at a given point in time, and which information can be made available by the CIDB.

Ratshisusu (2014) further suggested that the thresholds must be revised to be based on the allowable annual turnover thresholds to ensure that contractors do not take work beyond their capacity to perform. As per the current formulation, the thresholds do not provide a limit on the number of projects a firm can take within a grade, that is, a firm may

simultaneously take multiple projects of equal value but cannot deliver on all. It is on this basis that the research is conducted to develop a decision support system for contractor grading which will consider all relevant contractor grading criteria.

The grading system of the CIDB needs to be robust as contractors are awarded projects based on the grade which contractors hold. The CIDB Regulations, adopted in 2004, provide a framework for grading contractors in terms of their capabilities and the volume/nature of the projects they can undertake.

Initially, the grade of a contractor was based on two methods, one based on the track record and the other on the available capital. The latter method meant that a contractor could achieve a high grading provided it had available capital, regardless of its track record. This led to the amendment of the CIDB regulations in 2013 to provide for a ranking framework based on both the track record and available capital.

Key relevant technical and non-technical criteria need to play a critical role in the grading of contractors who roll out infrastructure projects to decrease the failure rate of infrastructure projects in South Africa. In a study conducted by CIDB (2016) on contractor progression, there is a strong correlation between the contractor having construction-related training or qualifications and the contractor's survival and progression. The grading of contractors using robust set of technical criteria may improve the client's confidence in the quality of the contractor who will roll out the infrastructure project and enhance the performance of the construction industry.

3.3 THE CIDB PROCESSES AND SYSTEMS

According to the CIDB (2020), construction plays a vital role in South Africa's economic and social development and serves as a large-scale employer. It provides the physical infrastructure that makes up the backbone of the country's economic activity. Thus, the role of the CIDB is to facilitate and promote the improved contribution of the construction industry to the South African economy and society. Thus, the CIDB promotes:

- Uniformity in construction procurement;

- Efficient and effective infrastructure delivery;
- Construction industry performance improvement;
- Industry transformation and skills development.

To fulfil its mandate, the CIDB has put grading registration and processes in place to assist in managing construction sector contractors. According to section 4 of the CIDB Act, the objectives of the CIDB are to (SA, 2000):

- *promote the contribution of the construction industry in meeting national construction demand and in advancing— national, social, and economic development objectives; industry performance, efficiency, and competitiveness; and improved value to clients;*
- *provide strategic leadership to construction industry stakeholders to stimulate sustainable growth, reform, and improvement of the construction sector;*
- *determine and establish best practice that promotes— improved industry stability; improved industry performance, efficiency, and effectiveness; procurement and delivery management reform; o improved public sector delivery management; national social and economic objectives, including—*
    - *growth of the emerging sector;*
    - *labour absorption in the construction industry;*
    - *improved labour relations;*
    - *positive safety, health, and environmental outcomes; and*
    - *human resource development in the construction industry;*
- *promote best practice through the development and implementation of appropriate programmed and measures aimed at best practice and improved performance of public and private sector clients, contractors, and other participants in the construction delivery process;*
- *promote uniform application of policy regarding the construction industry throughout all spheres of government;*
- *promote, establish, or endorse uniform standards; and ethical standards, that regulate the actions, practices and procedures of parties engaged in construction contracts;*

- *promote sustainable growth of the construction industry and the participation of the emerging sector therein;*
- *promote appropriate research on any matter related to the construction industry and its development;*
- *implement policy on construction industry development;*
- *advise the Minister on policy and programme which impact on construction industry growth and development; and*
- *promote any other related objective.*

The CIDB, therefore, not only seeks to grow the South African economy through the construction industry but also seeks to develop improved industry performance and best practices.

One way of improving industry performance and best practices in the construction sector is to ensure that the process for grading contractors is efficient and effective, and is benchmarked with international practices and norms. Presently, the CIDB has nine grading levels, and contractors are upgraded to the next higher grading level based on the financial capabilities and evidence of completed projects. Table 3.1 shows the nine different grades in which contractors can be registered along with the corresponding contract value.

Table 3.1 Contractor registration grades and contract value

Grade	Tender value less than or equal to (R)
1	500 000
2	1 000 000
3	3 000 000
4	6 000 000
5	10 000 000
6	20 000 000
7	60 000 000
8	200 000 000
9	N/A

Source: CIDB (2019)

Contractors are also classified based on the category of work they can carry out (see Appendix A). This study focuses on the Civil Engineering (CE) category. The CIDB requires the following documents for application (CIDB, 2011a):

- Application form (see Appendix B);

- Proof of company registration;
- Identity documents;
- Tax clearance certificate;
- Electrical certificate for EB works;
- Financial statement for the two years immediately preceding the application;
- Track record documents (appointment or award letter, completion certificate, and payment certificate).

The requirement which CIDB further requires for new contractors is that they need to be registered with the South African National Treasury Central Database. Thereafter, proof of payment is also required for each class of works which contractors wish to operate on (i.e., R450 for each class of work)

It is interesting to note that only electrical works (EB) require some form of certification, which is not the case with civil engineering (CE) and general building (GB) works. The CIDB 2012/2013 annual report states that amendments to the registration regulations were proposed (CIDB, 2013). These amendments include:

- Removal of the requirement for contractors to have registered professionals in their employee base;
- Reduction in the annual turnover requirements;
- Reduction in track record requirements;
- Provision for review of the tender value limits;
- Removal of the Method B registration option where enterprises are registered with high financial capacity but no track record; and
- Improvement to the grading calculation of joint ventures.

According to CIDB (2013), these amendments were designed to better align the Register of Contractors with developments in the construction industry, and with the state of development of the emerging sector. It is observed from the requirements that for

contractors to progress from one grade to the next, not much emphasis is placed on the contractor's technical knowledge and expertise. It is assumed that when contractors have implemented projects and are financially within the required specifications, they are then competent to move to the next grade. The proposed amendments are further indication that the CIDB does not put much emphasis on the technical knowledge and expertise of the contractor. The CIDB has put key systems in place like the Register of Contractors and Register of Projects to assist in executing its mandate.

3.3.1 Current available systems in CIDB

3.3.1.1 Register of projects

In terms of the CIDB Act 38 of 2000, the Construction Industry Development Board (CIDB) must establish a Register of Projects (RoP) that gathers information on the nature, value, and distribution of projects and provides the basis for a best practice project assessment scheme to promote the performance of public and private sector clients in the development of the construction industry.

The CIDB has thus established an i-tender to facilitate the Register of Projects. The i-tender enables clients to advertise tenders on the CIDB website. This automatically alerts contractors who are registered with CIDB, by email and SMS. The i-tender further enables projects to be registered by logging the award of contracts on the CIDB website and allows registered contractors to comply easily with legislative requirements (CIDB, 2010). The i-tender form is attached as Appendix D.

Any construction works contract which exceeds the following values, including VAT need to be registered with the CIDB using the i-tender form:

- Public sector: R 200 000
- Private sector: R 10 000 000

A construction works contract means a contract for the provision of a combination of goods and services for the development, extension, installation, repair, maintenance,

renewal, removal, renovation, alteration, dismantling or demolition of a fixed asset, including building and engineering infrastructure (CIDB, 2010).

Public sector and private sector employers must register contracts within one month and three months, respectively, from the date on which the contractor's offer to perform a construction works contract is accepted in writing. Thus, the purpose of the i-tender form is for employers to obtain an employer number to use the online i-tender facility to inform contractors about tenders, register a contract, register the cancellation/termination of a contract, register the completion of a contract, for employers to authorise users and for employers to inform CIDB of any changes of information (CIDB, 2010).

- **i-Tender as a compliance tool**

i-Tender acts as a tool for compliance for both the Register of Projects and the Register of Contractors. According to the CIDB (2010), the i-tender as a compliance tool:

- Enables the client to identify contractor grades relevant to the scope and value of the work being advertised.
- Forces clients to observe the minimum notice period required for compulsory tender briefing meetings and tender closure.
- Minimises misuse of the tendering process to manipulate prices through unreasonable withdrawal and re-advertising of tenders.

- **Benefits of the Register of Projects**

The Register of Projects provides the government and the industry access to information on:

- The value and geographic distribution of construction projects;
- Government institutions that are delivering on infrastructure projects;
- Trends in government usage of available infrastructure delivery capacity in terms of contractors that are allocated projects.

Moreover, the register of projects can inform government policy decisions on construction industry development and the role of construction in developing the economy and society

(CIDB, 2020a). All project registration is web-based, from registration of a tender or contract award to registration of project completion or termination. The entry gate into the Register of Projects is i-tender. Construction Industry Regulations 2004, as amended, require public sector clients to log tender adverts for infrastructure projects on the CIDB i-tender.

3.3.1.2 Register of contractors

Applying to all contractors who wish to complete work in the public sector, the Register of Contractors (RoC) supports clients in infrastructure procurement, and categorises and grades contractors from 1-9, according to financial and works capability. The Construction Industry Development (CID) Regulations of 2004, as amended, bind public sector clients to award construction contracts only to CIDB-registered contractors (CIDB, 2019a).

A CIDB grading is valid for three years, which expires on the anniversary of registration. After three years the contractor must apply to the CIDB for renewal. After six years the contractor must prove that they still meet the qualifying criteria to remain in the grade by submitting new supporting documentation (CIDB, 2019a).

Presently, the Register of Projects and the Register of Contractors are not linked, they operate as standalone systems. The contractor grading process will be outlined below to get an understanding of the process and criteria which are utilised to grade contractors.

3.4 CONTRACTOR GRADING PROCESS

The CIDB grade is a license for trading with the government. It certifies contractors who are graded as capable of delivering projects up to a pre-determined contract value in each class of work. Currently, the grading system is based on two key determinants, construction works or track record and available capital. Capital relates to funds presumed available to a contractor to start a new project.

When assessing track record, the CIDB looks at projects that the contractor has completed in the last five years, in the field or class of work the contractor is applying for. This is a basic requirement when applying for any grade between 2 and 9. Appendix C is the application form for grades 2 and 9.

Basic documentation required are:

- Copy of the project award from the client who awarded the project to the contractor;
- A certificate of project completion;
- Payment certificates;
- Bank statements.

The CIDB may request additional supporting documentation where necessary. The following table indicates the works capability of contractors, as well as the maximum value of the contract that a contractor is considered capable of performing and the track record. The track record consists of the largest contract completed during the five years preceding the application in the class of construction work for which the contractor is applying.

Table 3.2 Contractor works capability requirements

Grade	Maximum value of contract (R)	Track record (R)
2	1 000 000	130 000
3	3 000 000	450 000
4	6 000 000	900 000
5	10 000 000	1 500 000
6	20 000 000	3 000 000
7	60 000 000	9 000 000
8	200 000 000	30 000 000
9	No limit	90 000 000

Source: CIDB (2020)

3.4.1 Requirements for capital

As indicated, that grading is based on two key determinants which are construction works or track record and then capital, which relates to funds presumed available to start a new project. To assess a contractor's available capital, the CIDB looks at the contractor's financial statements for the immediate past two years. The most critical information is the contractor's annual turnover during this period. To determine grading, the CIDB will consider the contractor's best annual turnover of the past two years, as depicted in Table 3.3.

Table 3.2 indicates the maximum value of the contract that a contractor is considered capable of performing in terms of the largest contract completed during the five years immediately preceding the application in the class of construction works applied for in South African Rands. The following are the best annual turnover and available capital requirements in the different grades.

Table 3.3 Contractor's best annual turnover and available capital

Grade	Best annual turnover (R)	Available capital (R)
2	-	-
3	1 000 000	100 000
4	2 000 000	200 000
5	3 250 000	650 000
6	6 500 000	1 300 000
7	20 000 000	4 000 000
8	65 000 000	13 000 000
9	200 000 000	40 000 000

Source: CIDB (2020)

Table 3.3 indicates the contractor's best annual turnover and available capital. There are no requirements for available capital of Grade 2 contractors. Grades 3 and 4 contractors are required to have available capital of R100 000 and R200 000, which is equivalent to 10% of the best annual turnover. Grades 5-9 are required to have 20% of the available capital of the best annual turnover. The higher the grade, the higher the annual turnover and available capital requirements. This is the case because the higher the grade the higher the contract value of works.

The CIDB also allows contractors to use sponsorship as a measure to boost capital requirements if the contractors' turnover falls short. A financial sponsorship is a guarantee or surety by a 3rd party to cover liabilities should the contractor be unable to meet its financial obligations. Sponsorship may be provided by a financial institution or anybody else. If the sponsor is not a financial institution, its sponsorship may not exceed 15% of its net asset value. There are further provisions if the sponsor is also a shareholder in the company.

3.4.2 Renewal

It should be noted that contractors are required to renew their grades every three years. The CIDB requires the following documents for renewal:

- Completed and signed 3-year renewal application form;
- Company registration documents;
- Copy of identity documents of directors;
- Copy of shareholder certificate(s);
- Copy of electrical license (if applying for EB class of work);
- Proof of payment;
- Proof of tax compliance;
- Track record; and
- Latest financial statements.

Failing to renew the grading every three years may lead to a dormant status and the CIDB may suspend the contractor grading. It is noted that presently, the CIDB does not have regulation of entry into the construction sector. Anyone can operate in the construction sector at any point in time if they wish to do so.

3.5 JOINT VENTURES

A joint venture refers to a business entity established for the purpose of several construction business operators jointly accepting and conducting one project, as opposed to the usual case where one construction business operator accepts and conducts a project alone (Japan Ministry of Land, Infrastructure, Transport and Tourism, 2008). As indicated above, the CIDB grades, from 1 to 9, determine the value of tender a firm can bid for based on its annual turnover, value of projects undertaken and available working capital. This system thus regulates the extent to which firms can participate in bids in the public sector. There are, however, provisions in the CIDB regulations to allow firms to enter joint ventures, such that they could receive a higher grade in order to bid for larger projects, as shown in Table 3.4.

Table 3.4 CIDB grading for joint ventures

Designation	Deemed to satisfy joint venture arrangements
3	Three contractors registered in contractor grading designation 2
4	Three contractors registered in contractor grading designation 3
5	Two contractors registered in contractor grading designation 4; and Two contractors registered in contractor grading designation 3
6	Two contractors registered in contractor grading designation 5; One contractor registered in contractor grading designation 5; and Two contractors registered in contractor grading designation 4.
7	Two contractors registered in contractor grading designation 6; One contractor registered in contractor grading designation 6; and Two contractors registered in contractor grading designation 5.
8	Three contractors registered in contractor registered in contractor grading designation 7.
9	Three contractors registered in contractor grading designation 8.

Source: CIDB Regulation (as amended, 2013)

The joint venture arrangements set out in the CIDB regulations ensure that firms are provided with an opportunity to bid for work that they would otherwise not qualify for individually. For instance, in the case of large projects with a value of over R130 million (grade 9), there is a provision for a joint venture by three grade 8 firms, which could provide some scope for competition for grade 9 contractors. Since joint ventures are established to conduct business jointly, there are construction procurement processes that still need to be adhered to.

3.6 CIDB CONSTRUCTION INDUSTRY INDICATORS

The CIDB Construction Industry Indicators (CIIs) are measures of the industry, focusing on clients, the client's agent consultant, and contractors. In 2007, 2008, and 2009, the indicator measured the industry in terms of client satisfaction, contractor satisfaction, profitability, payment delays, procurement indicators, and health and safety. While the overall performance results for the industry were encouraging, the challenge has been to improve the performance of the industry. Clients were neutral or dissatisfied with the performance of contractors on 18% of the projects surveyed in 2009. Significantly, clients were least satisfied with the performance of contractors in the residential building sector, followed by civil works and special works (CIDB, 2009). The results of the recent equivalent survey have not been released yet.

Around 12% of the projects surveyed had levels of defects which are regarded as inappropriate. Safety on building and construction sites, as well as transportation to the sites, remains a concern (CIDB, 2009). The 2021/22 CIDB Annual Report has indicated that the South African economy is underperforming, with low growth and an expanding budget deficit, at 7.7% of GDP, according to the National Treasury Budget Review 2022. As a result, the government is fiscally constrained, limiting its capacity to provide stimulus to the economy by increasing infrastructure expenditure.

The confidence of general building contractors declined from 35 to 30 despite stable building activity. Civil engineering confidence rose to 38 in the first quarter of 2022, notwithstanding the deterioration in civil construction activity (CIDB, 2022a). The study will focus on improving the performing outputs of the civil engineering project performance by developing an enhanced framework for grading and performance evaluation which is one of the indicators for measuring performance under the business conditions in CIDB reporting.

3.7 CONSTRUCTION SECTOR PROCUREMENT

According to Paleneeswaran and Kumaraswamy (1999), contractors play a major part in any construction project, hence contractor selection constitutes a critical decision for any client/client's representative. The relative complexity and adversity of the construction industry aggravate the various risks and uncertainties faced by contractors, which influence their ultimate performance levels. Clients, in turn, risk shortfalls in meeting their goals and objectives through contractor failures on various performance aspects such as cost, time, and quality.

There are different procurement methods that could be adopted in the construction sector which are open tendering, selective/restricted tendering, negotiated tendering and framework contracts. However, procurement routes have become more complex, thus tenders may be sought for a wide range of goods and services. Irrespective of the goods or services being sought, securing tenders generally follows one of several basic procurement processes indicated.

It should be noted that the procurement processes vary from country to country, but the tendering system is aimed at identifying an array of eligible contractors/contractors who will perform work in line with the client's requirements. Several researchers, such as Hatush and Skitmore (1997), Holt *et al.* (1994), Kumaraswamy (1996a), and Russell *et al.* (1992) have identified common criteria for prequalification and bid evaluation and have proposed improved methodologies for construction contractor selection. Holt *et al.* (1996) proposed a Highlight Optimum Legitimate Tender (HOLT) technique, a quantitative multi-attribute-based model, which is a 3-tier process and Holt (1998) discussed several decisional methods that are being applied to the contractor evaluation and selection.

Kumaraswamy (1996a) discussed contractor evaluation through an appraisal of inputs and assessment of outputs using `feedforward' and `feedbackward' approaches. Hatush and Skitmore (1997) prescribe a Program Evaluation and Review Technique (PERT)-based methodology for assessing and evaluating contractor data for prequalification and bid evaluation.

Mohemad *et al.* (2010) indicate that planning for a construction project is a challenging and complex task faced by multiple parties such as clients, consultants, and contractors. The successful execution of a construction project is heavily impacted by making the right decision at the right time. Tendering process is in the first stage of the procurement process (Vee & Skitmore, 1995).

Tendering processes in the construction industry are fragmented and different from the other domain of tendering practices (Kong & Gray, Undated). Managing tender procedures is often very complex and uncertain, involving the coordination of many tasks and individuals. Different individuals have different priorities and objectives. It increases the need for efficient decisions from clients, consultants (acting on behalf of clients) or contractors. For example, the contractor is required to make the decision to determine whether to participate in the tender or not.

Conventionally, decision makers tend to make decision based on a blend of their intuition, and subjective judgement which is based on experiences and emotions. This kind of practice does not guarantee consistent decision and can lead to bias. In a complex

environment, undetermined and insufficient external information as input during decision making could lead to unfair, incomplete, and poorly constructed results (Sauter, 2005). This chapter aims at evaluating various tendering systems which are available in the construction industry.

3.7.1 Tendering processes in the construction industry

As defined by Halaris *et al.* (2003), tendering is the combination of processes to produce, display, and manage tender documents by client or consultant. It also involves action to perform bidding by interested contractors to win the contract by responding to tenders with their capabilities and skills. Meanwhile, according to Ng *et al.* (Undated), tendering processes begin with the analysis to ensure that the tender specification meets the requirements of the end user. This is followed by tender invitation, contractor selection and contract awarding, and contract monitoring. There are four different types of tenders that clients can make use of to acquire the relevant contractor. The four different types of tendering are as follows:

- Open tender: all interested contractors are invited to submit tenders. This method opens the opportunity for new or unfamiliar contractors to compete for the contract (Ogunsemi & Aje, 2006).
- Restricted/selected tender: only invited/selected contractors are allowed to bid for the tender. This approach makes competition among contractors less. Normally, restricted tendering is applied when a construction contract needs special expertise and high technology. Only those contractors who fill these requirements are invited. Most organisations in the United Kingdom (UK) and many other countries will adopt this method (Ng & Skitmore, 1999).
- Negotiated tender: the client consults the chosen contractors and negotiates the terms of the contract with them. Normally, it is applied under special circumstances such as when the construction contract is too complex or unique to identify technical and financial properties, when there is an emergency that requires the project to be completed in a short time, when there is only one contractor that fulfils

the contract requirement in terms of expertise and technology, or when it involves a security project of national importance (Mohamed *et al.* 2010).

- Framework tendering: uses an ‘umbrella agreement’ that sets out principal terms (such as elements of price, quality, and scope) under which contracts can be made throughout the agreement. The framework is an agreement between a single employer (or several employers grouped together as a recognised organisation) and multiple individual suppliers engaged to provide services within a specified scope (Gale, 2013).

These types of tenders are largely practised in Europe (Lambropoulos, 2007), Nigeria (Ogunsemi & Aje, 2006), Malaysia (Noor Maizura, 2005; Lee, 2006), and Turkey (Topcu, 2004). In South Africa, these types of tender processes are available and utilised subject to supply chain management conditions. The South African tendering system is discussed in Section 3.7.3.

3.7.2 General tendering processes

Tendering processes in the construction sector involve a set of parties. They are client and consultants as contracting authorities, as well as interested organisations or contractors. In many countries, the government is the largest construction client. The client is also identified as the project owner (Topcu, 2004), the consultant as the information broker, and the contractor as the provider or tenderer (Halaris *et al.*2003). Despite the use of different terms for describing actors in tendering, the role of each of them remains similar.

Conventional tendering involves advertising tender, receiving tender bids from prospective contractors, evaluating the tender bids, and awarding the tender to the successful contractor. This conventional tendering process is implemented on paper, meaning that it is done manually. The approach remains predominant in developing countries such as Malaysia, Nigeria, and South Africa. Lou and Syed Alwee (2006), as well as Mastura et al. (2007), have emphasised the need for ICT in Malaysian construction tendering through the analysis of the Technology Readiness Index. However, until now, the implementation of Web-based technology in Malaysian, Nigerian, and South African

construction tendering faced implementation challenges. Most countries in other regions such as the United States, Europe, the Middle East, and Asia have similar execution of paper-based tendering.

The tendering process starts when a client initiates a construction project. This research focuses on public-sector construction tendering processes. The client hires a consultant to prepare the tender specification by conducting a feasibility study. It involves typical activities such as determining estimated cost, time for project completion, and procurement procedures. The consultant is also responsible for preparing tender documents, including qualification documents and bill of quantities. These documents require approval from the client.

Normally, the client advertises the notice within a period on media such as newspapers, or websites. Construction tendering procedures under European Union legislation require a notice to be displayed in the official Journal of the European Commission (Lambropoulos, 2007). Meanwhile, in Nigeria, contractors are invited to tender through advertisements in major national publications (Olatunji, 2008). In South Africa, construction contractors are invited for tender submission through advertisements in major national publications and the advertisement must also be advertised on the Construction Industry Development Board (CIDB) website. The procedure is also known as Request for Tender (RFT), Notice to Bidders, or Invitation to Tender (ITT) (Ratshisusu, 2014).

Subsequently, a contractor who intends to bid for the tender will purchase the tender documents give the appropriate information required, and then submit the completed tender before the deadline. Normally, tender documents consist of information regarding instructions to tenderers, conditions of the contract, technical specifications, drawings, bill of quantities (BOQ), and a list of forms to be completed by the contractor. All the submitted tenders are aggregated and opened after the deadline (Topcu, 2004).

All the tenders received are assessed to select the most eligible contractor. Assessment is the most crucial stage in the tendering process because it contributes to the decision in choosing the most qualified contractor who will be awarded the tender. It is a structured

and complex process where many criteria need to be considered during assessment such as bid price, time for project completion, financial capability, work experience, technical staff available, equipment facilities, and current list of works. These criteria contribute to identifying a potential contractor who can deliver high-quality completed service, within the time and budget allocated (Topcu, 2004).

Usually, the assessment is carried out by the Bid Evaluation Committee appointed by the client. In China, this task is under the responsibility of the client or the representative of the client and tender administration committee (Chan, 1999). In South Africa, the management of tender committees in the public sector is the responsibility of the supply chain management department. There are two stages of assessment before qualified contractors are shortlisted. The first stage of evaluation is the prequalification stage for contractors where they are primarily evaluated for their minimum capabilities to satisfactorily carry out the contract if they are awarded (Ng & Skitmore, 1999). In this research, we called this stage as prequalification phase.

This stage helps to screen out ineligible or unsuitable candidates thus reducing the number of available contractors on the list. Different countries or organisations might evaluate dissimilar criteria. For example, in Hong Kong, South Africa, and Malaysia, the criteria for the first stage evaluation are based on basic requirements specified in tender notification or advertisement such as sufficiency of tender documents submitted (compulsory and supporting documents), consistency of information provided, adequate financial resources and others. It is different in other countries like Turkey and Nigeria where their first evaluation is based on detailed technical evaluation. Contractors who have passed these requirements which are indicated in the tender advertisement will proceed to the next stage of evaluation (Mohamed *et al.* 2010).

The second stage of evaluation normally comprises a detailed technical evaluation of prequalified candidates. For instance, in Hong Kong, South Africa, and Malaysia, contractors are evaluated according to critical criteria such as work experience, current work performance, technical staff, plant, and equipment, as well as estimated project duration. Some evaluation practices only consider the lowest bidding price as implemented in Nigeria and Turkey (Mohamed *et al.* 2010).

The qualified applicants who have fulfilled all the requirements and conditions are ranked in ascending order according to their points/credits. Contractors who do not fulfill any stage of evaluation will be automatically removed from the list. Finally, the result is announced by clients and displayed either on printed media or websites. Generally, the construction contract is awarded to the contractor with the highest score (Mohamed *et al.* 2010).

3.7.3 The South African tendering system

It is well known that the construction industry is very challenging as it is very competitive and unstable during economic downturns (De Valence & Runeson, 2011). The parameters of project success are measured in terms of time, cost, and quality achieved, in addition to health and safety (H&S), which is due to excessive construction accidents. However, the said parameters of project success impact the client's decision to choose the best contractor who will provide value for money on the project (Alsugair, 1999). According to Topcu (2004), contractors play a major role in achieving project outcomes, which is why contractor selection constitutes a critical decision for construction clients.

The process of selecting the best contractor should be investigated in terms of a contractor with the potential to fulfill the outcomes of completing on time, within cost, and to the right quality. In the past, the selection was usually based on the lowest tender being awarded the contract, but due to numerous reasons, this is no longer the case in South Africa (Topcu, 2004). Instead, a set of criteria is used to control the process, based on an 80/20 preference point system for the acquisition of goods or services for Rand value equal to or above R30 000 and up to R50 million.

The 80% is based on price and 20% is based on the contractor's Broad-Based Black Economic Empowerment (BBBEE) status as defined in the Broad-Based Black Economic Empowerment Act (No. 53 of 2003). Section 1 of the BBBEE Act (No. 53 of 2003) indicates that "black people" is a generic term that means Africans, Coloureds, and Indians. Whilst "broad-based black economic empowerment" means the economic empowerment of all black people including women, workers, youth, people with

disabilities, and people living in rural areas, through diverse but integrated socio-economic strategies that include, but are not limited to-

a) increasing the number of black people that manage, own and control productive and enterprises assets;
b) facilitating ownership and management of enterprises and productive assets by communities, workers, cooperatives and other collective enterprises;
c) human resource and skills development;
d) achieving equitable representation in all occupational categories and levels in the workforce;
e) preferential procurement; and
f) investment in enterprises that are owned or managed by black people.

The 90/10 preference point system is for the acquisition of goods or services with a Rand value above R50 million. The 90% is based on price and 10% is based on the contractor's Broad-Based Black Economic Empowerment (BBBEE) status as defined in the Broad-Based Black Economic Empowerment Act (No. 53 of 2003).

Despite the intent of the Preferential Procurement Policy Framework Act (No. 05 of 2000) in South Africa, it is notable that the environment for judging capable contractors is complex because of competing stakeholder values and complicated relationships that are laden with ambiguity and conflicting objectives (Watts *et al.*2010). Therefore, the current selection process in South Africa has been vulnerable to loopholes that are exploited by firms that are not averse to opportunism (Emuze *et al.* 2013).

With all the complexities surrounding selecting the best contractor, the question arises: Is price more important than capability, expertise, or performance? The criteria clearly state that the lowest tender does not necessarily mean will be awarded the contract. All advertised bids are subjected to the Construction Industry Development Board (CIDB) grading of contractors; and when a contractor has the highest points according to the criteria, an evaluator can still select a different one altogether because of the different advantages one has over the other based on the specified criteria. The important consideration from the client is the criterion that decides the final choice of contractor to be awarded a project.

The importance of looking into the South African tendering system is because the system is open to different interpretations by whoever evaluates the tenders to justify the choice that they have made. In other words, unqualified contractors can still be awarded contracts because of the poor judgment of evaluators. Despite the importance of contractor selection in achieving the outcomes of the project, this aspect is largely unexplored in South Africa (Monyane & Emuze, 2015). There is a heavy reliance on procurement policies such as the Preferential Procurement Policy Framework Act (No. 05 of 2000) and the Broad-Based Black Economic Empowerment (No 53 of 2003). One method that could assist the South African construction sector is contractor pre-qualification.

3.8 CONTRACTOR PREQUALIFICATION

A research study by Korytarova *et al.* (2015) identifies qualification criteria as an important risk for corruption in the Czech Republic and Poland. In addition, Korytarova *et al.* (2015) state that strict qualification criteria for contracts result in the removal of effective competition, and contracts can even be tailor-made for specific contractors/suppliers. Korytarova *et al.* (2015) added that cancellation of the economic and financial qualification criteria carries the risk that incompetent contractors can participate in the tender process because they can allege competency by a simple statement.

Palaneeswaran and Kumaraswamy (1999) indicate that a general (non-project specific) prequalification exercise is performed to identify `eligible' contractors from a group of `interested' applicants and to classify them according to their technical and financial capacity, organisational and managerial expertise, and track records in terms of past performance, occupational health and safety, environmental concerns and even at times on their attitudes towards claims. This exercise aims to facilitate and not replace the tender assessment and some objectives are as follows:

- To eliminate contractors who are not responsive, responsible, and competent;
- To enhance and/or assure bidding opportunities for `eligible' contractors;
- To encourage healthy competition among `eligible' contractors;
- To avoid/minimise risks of contractor failure and improve client satisfaction;

- To optimise the contractor selection in terms of achieving a better balance between price and performance parameters.

Apart from securing lower prices, clients would normally prefer to select bidders who are responsive, responsible, and competent. ‘Responsiveness' is reflected in the prompt delivery of correct information required by the prequalification questionnaire. The responsiveness may be checked on a ‘pass/fail' binary decision exercise and/or scored/measured on the scales of completeness. `Responsibility' can be attributed according to the contractor's track record and compliance with other mandatory/desirable requirements such as quality system, registration with societies/organisations, safety policy, conformance with bylaws, standards and regulations, and experience in/ attitude to partnering. The responsibility of the bidders can thus be evaluated based on past performance records and reports.

The ‘competency' of the bidders is their capability to undertake contracts of the type usually awarded by the given organisation or a specific contract with respect to their resources and capacities such as financial capacity, technical capacity, plant and equipment, human resources, organisational and management capabilities. The competency of the bidders can be evaluated based on available resources, track record, and current workload.

Prequalification of bidders is performed either on a project-by-project basis or periodically (normally annually) also called `registration'. The project-by-project prequalification is dynamic and has the advantage of considering project-specific requirements, whereas the periodic prequalification (‘registration') is static (over the registration/ prequalification period). However, it may classify eligible contractors into different ranges of work capacity levels, depending on their perceived capabilities. Of course, shortlists could also be derived from the `registered' lists, for specific projects based on updated information on the registered contractors, as well as any project requirements.

The construction industry heavily relies on loans to maintain their commercial operations and always faces financial constraints, necessitating the assessment of the financial capacity of construction contractors (Huang *et al.* 2013). In the absence of direct links between clients’ goals and the criteria for the selection of contractors in current evaluation

procedures, it is assumed that, if contractors comply with the selection criteria, they will automatically be capable of meeting the goals (ElSawalhi *et al.* 2007). Furthermore, El-Sawalhi *et al.* (2007) contend that acceptable contractors' pre-qualification criteria are financial stability, management and technical ability, experience, past performance, resources, and the performance criteria of cost, environment, H&S, time, and quality. The main concern of the clients is how the performance of the candidate contractor could be predicted prior to awarding the contract to the selected contractor.

According to Morote and Ruz-Vila (2012), prequalification is a decision involving multi-criteria and is largely dependent on the improbability and imprecision in the kind of construction projects and biased verdict of those given the task of evaluating tenders. In addition, Morote and Ruz-Vila (2012) listed the following aspects to be considered when designing a common set of criteria for the pre-qualification of contractors:

- Technical capacity: The contractor must demonstrate that it has the technical capacity to perform the activities of the specific project for which it is seeking prequalification.
- Experience: The contractor must demonstrate its participation in other previous projects, especially if they are similar to the project that will be executed.
- Management capability: The contractor must demonstrate that it is capable of planning, organising, and controlling a project.
- Financial stability: The client must reach an informed opinion regarding the overall financial position and capability of the contractor.
- Past performance: Considering the past performance of each contractor, the project manager will have a higher or lower degree of confidence in the possible contractors regarding the quality, time, and cost control requirements.
- Past relationship: The client must collect and analyse information about the contractor's past relationship with other entities which participate in the construction activities.
- Reputation: The project manager must have an overall estimation or opinion about how good the contractor is.

- Health and safety: To encourage contractors to establish and maintain effective systems to manage the risks to the H&S of employees, arising from the nature of the work.

It is posited herein that the same set of criteria that are used to prequalify contractors for awarding tenders should be the set of criteria that are used to grade contractors. The grading system should also allow for the downgrading of contractors in cases where contractors are failing to perform and in cases where key technical staff members leave the organisation and replacements are not found within the specified period. This will assist in consistency in contractor performance and would assist in contractor grading in terms of reflecting the true capability of contractors in line with the grade.

3.9 CONTRACTOR SELECTION

Contractor selection constitutes a critical decision for project owners (Izadi & Mohammadi, 2013). The importance of contractor evaluation and contractor selection remains immensely vital to clients for reaching project goals (Watts *et al.* 2010). According to Bochenek (2014), selecting the best suitable contractor in a public procurement process plays a crucial role in the achievement of project success and objectives. Bochenek (2014) concluded in a study undertaken in 13 selected European countries that poor workmanship, non-completion of a project within a stipulated duration, or a contractor's decision to walk off site may all be because of the incorrect evaluation of tender and contract award.

Furthermore, Bochenek (2014) proved that in many countries. contractor selection is not strictly linked with price; the applied criteria allow for choosing the most economically advantageous tender. However, in a study by Heralova (2015), price was a contributing factor to the selection of the best contractor. Heralova (2015) further stresses that the lowest tender continued to bring serious problems as the prices in public tenders were lower than those expected by the clients. In addition, the bid prices only reached 60-70% of the anticipated price determined by the client.

The overall objective of the contractor selection process is to reduce project risk, maximise the overall value to the project owner, and build close and long-term

relationships between members of the project. Several studies have looked at the problem of contractor selection using different models (Izadi & Mohammadi, 2013). In South Africa, models to channel the decision of choosing the best contractor for executing the works through preference are adopted. The current contractor selection method is not as efficient and effective as should be. The selection of poor contractors in South Africa could be because of the inefficient grading system of the Construction Industry Development Board (CIDB) as noted by Ratshisusu (2014). The CIDB is empowered to regulate the construction sector to promote the growth and development of the sector. There are regulatory requirements that firms must adhere to, particularly for the register of contractors, which the CIDB keeps and uses to grade firms according to their capacity to carry out construction work.

Ratshisusu (2014) proposed that the CIDB grading of contractors is a necessary tool to ensure that firms in the sector meet certain minimum requirements to undertake projects. This is however not the case as the CIDB grading system has deficiencies. According to Ratshisusu (2014), the grading does not provide sufficient information to clients on the capacity and ability of firms to undertake construction works. It could assist clients if the grade of the contractors matched the capacity and ability of the contractor concerned to undertake a construction project at a given point in time, which information can be made available by the CIDB.

Secondly, the provisions in the CIDB regulations for joint venture arrangements to allow firms to compete for CIDB grade 9 projects limit that possibility to only a consortium of three grade 8 firms at a time. There is thus no flexibility to allow a group of emerging contractors, at different stages of development, to form consortia to compete for large infrastructure projects.

In Mauritius, the Construction Industry Development Board requires contractors who wish to form a joint venture to submit to the Notice of Bid for which the parties want to bid for an organogram of the joint venture, documents finalising the joint venture, documents formalising collaboration with the local contractor, Certificate of Registration of the Joint Venture (if applicable), Identity Document/Passport of authorised Signatory and Power of

Attorney/Board Resolution of the authorised Signatory (Mauritius CIDB, 2022). This joint venture shall be eligible to obtain the Grade of the highest-graded party in that joint venture. For example, if an application is made by a JV comprising “Medium I” and “Medium II” contractors, then the JV will obtain Grade “Medium II” (Mauritius CIDB, 2022). It should be noted that the grades of Mauritius CIDB in ascending order are Small, Medium I, Medium II, and Large. This means that a JV cannot be graded for a higher grade which neither of the joint contractors possesses. The South African CIDB allows a certain number of JVs to qualify for a higher grade which neither of the JVs possesses as indicated above.

In Japan, joint ventures can be formed, and the formation can be in two forms. The first formation is through the Special Construction Joint Venture (Special JV) which is a joint venture established on a per-project basis in the case of a large scale or technically difficult project of a size and type of construction work necessitating a joint venture to secure stable execution of the work through concentration of technical skills. The second formation is through the Ordinary Construction Joint Venture (Ordinary JV). This refers to a joint venture established by small and middle-sized construction business operators for the purpose of strengthening operating and project execution potential through secure and continuous business relations. A joint venture is formed as an Ordinary JV at the time of application for a contracting body and qualification evaluation for tendering participation (generally at the beginning of a financial year) and is registered for a set duration as if it were an individual company.

Like Japan, a Malaysian joint venture can only be appointed to carry out a construction project, which must register with the CIDB based on the project awarded. The registration certificate issued is only valid for the construction of projects as stated within it. There are two types of consortiums or joint venture contractor registration with the Malaysian CIDB, a joint venture between local contractor companies and a joint venture between local and foreign contractors (CIDB Malaysia, 2016). Between the local companies, one of the local contractors must be registered with CIDB by the grade appropriate for the value of the project. For a joint venture between local and foreign companies, the local contractor must

be registered with CIDB by the grade appropriate for the value of the project. The foreign contractor equity in the joint venture agreement must not exceed 30%. If it is more than 30%, the joint venture must complete the specified required form. If the local company is not registered with CIDB, the consortium or joint venture is registered as a foreign contractor (CIDB Malaysia, 2016).

The United States of America's regulation on joint ventures differs from state to state: for example, in Florida, a declaration of joint venture form is required to be submitted. The form will indicate the joint venture participation percentages of each entity that makes up the joint venture. The percentage indicates the percentage of proposed contract work to be debited against each entity's current capacity, and the total percentage must be 100 percent (Darr, 2020).

Generally, in the United States, joint venture contractors are advised to have a written joint venture agreement when bidding on a project. The agreement will specify, among other things, who will be responsible for obtaining insurance, who will provide equipment for the project, how the profits from the project will be split, and many other aspects of the project which may also include splitting of the project work (Darr, 2020). The importance of project work and performance in the construction sector is very important for this research and its context is required to be understood to assist in assessing the need to include project performance parameters as one of the measuring criteria in the framework development.

For this reason, most of the emerging contractors in South Africa rely on subcontracting work, thus limiting their potential to grow. Ratshisusu (2014) proposes that the CIDB grading system needs to be reviewed to take into consideration the ability of a contractor to execute the work as well as past performance.

The thresholds must be revised based on the allowable annual turnover thresholds to ensure that contractors do not take on work beyond their capacity to perform. As per the current formulation, the thresholds do not provide a limit on the number of projects a firm

can take within a grade: that is, a firm may simultaneously take multiple projects of equal value but lack the capacity to deliver on all (Rathisusu, 2014). It is on this basis that this research is conducted to address the aforementioned need by developing a decision support framework that integrates multiple decision criteria, and guides decision makers on registration and grading contractors and monitoring and evaluation of infrastructure project performance. The study will further propose minimum entry requirements for new contractors who intend to register construction firms.

3.10 GAPS IN EXISTING APPROACHES

Different countries apply different contractor evaluation methods. Authors like Bochenek (2014) showed that in many countries, contractor selection is not strictly linked with price. The applied criteria allow for choosing the most economically advantageous tender. Authors like Heralova (2015) indicated that price was the contributing factor to the selection of the best contractor. Haberbush (2000) and Gupta (2001) advocate for better-designed bid processes to reduce the incentives for firms to collaborate. Haberbush (2000) recommends that procurement processes should require firms to disclose compliance programmes when bidding for work. Other measures include redesigning bid documents to move away from the requirements of awarding tenders to the lowest bid, removing restrictions on bidder eligibility to bid and improving bid evaluation processes to detect bid rigging patterns, as well as introducing stronger punishment for firms involved in bid rigging (Haberbush, 2000).

Dorée (2004) concurs with Haberbush (2000) that to improve the situation of the construction industry, non-conventional procurement methods that are less based on the lowest bid in line with construction reform policies adopted around the world should be introduced. According to Dorée (2004), key drivers of the construction sector should be based on value and quality-driven competition, integrated team delivery, and long-term commitments.

Instead of rules that require projects to be awarded to the lowest qualifying bid, consideration should be given to the benchmarking model (or other alternative models)

whereby the winning bid is based on a range of the prices of the bids at some percentile (Haberbush, 2000). The benchmarking model is similar to second-price sealed bids (one type of Vickery auctions) in which bidders bid independently, but the winning highest bid pays the second-best price. In the case of construction-type bids, the second-best price would be second lowest. The benchmarking model could make it difficult to determine the price that would win the tender (Ratshisusu, 2014).

Transparent tender evaluation and adjudication processes were also found lacking in the South African tendering system by Ratshisusu (2014). It is important to have a good tender document to avoid scope for bidders to manipulate the process. It should be a standard requirement that the supply chain management framework is structured such that separate committees manage the development of specifications, evaluation of bids, and the award of tenders. The decision for the tender award, and reasons thereof, should be communicated to all firms that bid. Key legislative prescripts governing the construction sector will be discussed below to understand the South African construction sector legislative framework.

3.11 LEGISLATIVE FRAMEWORK GOVERNING THE CONSTRUCTION SECTOR

3.11.1 The preferential procurement policy framework

The Preferential Procurement Policy Framework Act 5 of 2000 intends to give effect to Section 217(3) of the Constitution by providing a framework for the implementation of the procurement policy contemplated in Section 217(2) of the Constitution and to provide for matters connected therewith. The framework for the implementation of preferential procurement policy lies in the precept that an organ of the state must determine its preferential procurement policy and implement it within the following framework:

a) *A preference point system must be followed;*
b) *(i) for contracts with a Rand value above a prescribed amount a maximum of 10 points may be allocated for specific goods as contemplated in paragraph (d) provided that the lowest acceptable tender scores 90 points for price;*

(ii) for contracts with a Rand value equal to or below a prescribed amount a maximum of 20 points may be allocated for specific goods as contemplated in paragraph (d) provided that the lowest acceptable tender scores 80 points for price;

c) *any other acceptable tenders which are higher in price must score fewer points, on a pro rata basis, calculated on their tender prices in relation to the lowest acceptable tender, in accordance with a prescribed formula;*

d) *the specific goals may include:*

   (i) contracting with persons, or categories of persons historically disadvantaged by unfair discrimination based on race, & gender or disability;

   (ii) implementing the programmes of the Reconstruction and Development Programme as published in Government Gazette No. 16085 dated 23 November 1994;

e) *any specific goal for which a point maybe awarded, must be clearly specified in the invitation to submit a tender;*

f) *the contract must be awarded to the tenderer who scores the highest points, unless objective criteria in addition to those contemplated in paragraphs (d) and (e) justify the award to another tenderer; and*

g) *any contract awarded on account of false information furnished by the tenderer in order to secure preference in terms of this Act, maybe cancelled at the sole discretion of the organ of state without prejudice to any other remedies the organ of state may have.*

(2) Any goals contemplated in subsection 1(e) must be measurable, quantifiable and monitored for compliance (Preferential Procurement Policy Framework Act 5 of 2000).

Section 3.7.3 of this chapter critiques the application of the preferential procurement policy framework. Another piece of legislation which plays a key role in the South African construction sector is the Broad-based Black Economic Empowerment Act 53 of 2003.

3.11.2 Occupational Health and Safety

The Occupational Health and Safety Act No 85 of 1993 aims to provide for the health and safety of persons at work and for the health and safety of persons in connection with the use of plant and machinery; the protection of persons other than persons at work against hazards to health and safety arising out of or in connection with the activities of persons at work; to establish an advisory council for occupational health and safety; and to provide for matters connected therewith.

There are various requirements within the construction industry to ensure a safe workplace and legislative compliance. One of the most important construction-specific requirements is the Letter of Good Standing in terms of the Compensation for Occupational Injuries and Diseases Act, Act No. 130 of 1999 (COIDA). Construction projects are generally awarded to a contractor subject to a valid and paid-up Letter of Good Standing with the Compensation Commissioner at the Department of Labour, or the Federated Employers' Mutual Assurance Company Limited (FEMA).

The purpose of the Letter of Good Standing is to ensure that a business can meet the requirements set out in COIDA. In exchange for an annual fee, the business receives assurance of compensation for claims relating to occupational injuries, diseases, or deaths. Without this legal document, an entity is regarded as being non-compliant. All claims are subject to investigation. Compensation cannot be claimed for injuries, diseases, or deaths that take place outside the workplace (Marie, 2019).

Secondly, registration with the South African Council for the Project and Construction Management Professions (SACPCMP) is important. The SACPCMP is a statutory body that regulates the registration of construction professionals, such as construction officers, managers, and agents. In the interest of providing work that is up to standard and in line with legislation, as stated in Construction Regulation 8(5), a contractor is required to appoint a competent safety officer, considering the size and duration of the project (Marie, 2019).

In the building industry specifically, contractors need to ensure that First Aiders, Safety Representatives, and Fire Fighters are the first in line for training. In addition to training, it is a legal requirement that all employees submit to a medical assessment to receive a “fit for work” medical certificate (clean bill of health). Employers are subject to different demands in terms of medical requirements, competencies, and training, depending on their type of business within the building industry. For instance, roofers working at heights are required to undergo working-at-height medicals and to attend working-at-height rescue training.

Section 37(2) of the Occupational Health and Safety Act requires mandatory agreements with contractors. A mandatory written contractual agreement should be entered into between a client and a contractor in terms of work and/or services to be provided, subject to the terms and conditions of the Mandatory Agreement. The agreement states that the client has put in place certain health and safety rules and regulations to ensure compliance on-site and that it is the prerogative of the client to expect all contractors to adhere to these rules and regulations (Marie, 2019).

Section 37(1) places full responsibility and liability on the employer in terms of compliance, unless a Mandatory Agreement has been signed between the client and contractor, as proof of instruction from the client, to prohibit certain actions or conditions that would be in contravention of the Occupational Health and Safety Act. Only when the agreement has been signed can full liability and responsibility be placed on the contractor for actions taken by the contractor in contravention of the Act. The Mandatory Agreement between the client and contractor ensures that both parties involved accept responsibility and liability for health and safety compliance on site (Marie, 2019).

Approved health and safety files are also critical in construction projects. Contractors should not be allowed access to a construction site without an approved health and safety file compiled by a qualified and competent safety officer or safety team. The OHS file includes documentation such as the Health and Safety Plan, Safe Operating Procedures, Letter of Good Standing, employee details, Fall Protection Plan, Emergency Plan, and

Risk Assessments. Most of these documents can only be compiled by a trained and competent practitioner (Marie, 2019).

3.11.2.1 General safety and administration regulations

General Safety Regulations and General Administration Regulations draw their mandate under Section 43 of the Occupational Health and Safety Act, 1993 (Act 85 of 1993). These regulations were developed in consultation with the Advisory Council for Occupational Health and Safety to ensure that there are general safety and administration regulations that govern employers in South Africa including those in the construction sector.

3.11.2.2 Construction Regulations, 2014

These Regulations are applicable to all persons involved in construction work. Regulations 3 and 5 are not applicable where the construction work carried out is in relation to a single-story dwelling for a client who intends to reside in such dwelling upon completion thereof. A client who intends to have construction work carried out, must at least 30 days before that work is to be carried out apply to the provincial director in writing for a construction work permit (attached as Annexure E) to perform construction work if the intended construction work will:

(a) exceed 180 days.

(b) will involve more than 1800 person days of construction work: or

(c) the works contract is of a value equal to or exceeding thirteen million rand or Construction Industry Development Board (CIDB) grade level 6.

Construction Regulations 2014 further details the duties of a client, designer, principal contractor, and contractor as well as risk assessment for construction work. Thus, any construction work that will take more than six months with more than 1800 persons or CIDB grade six level, or thirteen million rand will require the construction permit.

3.11.3 The broad-based black economic empowerment

The Broad-based Black Economic Empowerment Act 53 of 2003 intends to establish a legislative framework for the promotion of black economic empowerment; to empower the

Minister to issue codes of good practice and to publish transformation charters; to establish the Black Economic Empowerment Advisory Council; and to provide for matters connected therewith.

The objectives of this Act are to facilitate broad-based black economic empowerment by:

a) *promoting economic transformation to enable meaningful participation of black people in the economy;*
b) *achieving a substantial change in the racial composition of ownership and management structures and in the skilled occupations of existing and new enterprises;*
c) *increasing the extent to which communities, workers. cooperatives and other 50 collective enterprises own and manage existing and new enterprises and increasing their access to economic activities, infrastructure, and skills training:*
d) *increasing the extent to which black women own and manage existing and new enterprises, and increasing their access to economic activities, infrastructure, and skills training;*
e) *promoting investment programmes that lead to broad-based and meaningful participation in the economy by black people to achieve sustainable development and general prosperity;*
f) *empowering rural and local communities by enabling access to economic activities. land, infrastructure, ownership, and skills; and*
g) *promoting access to finance for black economic empowerment.* (Broad-Based Black Economic Empowerment Act 53 of 2003)

This piece of legislation is applicable to the South African construction industry because the Preferential Procurement Policy Framework Act is based on the 80/20 and 90/10 principles. This means that 80% or 90% is based on price and 20% or 10% is based on the contractor's Broad Based Black Economic Empowerment (BBBEE) status as defined in the Broad Based Black Economic Empowerment Act (No. 53 of 2003). Thus, the legislation was established for the promotion of black economic empowerment in South Africa.

3.12 CHAPTER SUMMARY

This chapter focused on the Construction Industry Development Board processes, construction sector procurement, as well as legislative framework. The South African CIDB processes have been outlined and the key lessons learned are as follows:

- It is noted that the CIDB has a register of contractors and a register of projects. However, there seems to be no linkages between these two systems to render them more effective.
- It has been noted that generally, tendering systems vary from country to country. The main aim of the tendering system is to identify an array of eligible contractors/contractors who will perform work in line with the client's requirements.
- In South Africa, the bid evaluation process is manual with a preferential system that is open to different interpretations by whoever evaluates the tenders to justify the choice that they have made. In other words, unqualified contractors can still be awarded contracts because of the poor judgment of evaluators. The government should consider a complete online tendering system that also records the decisions of bid evaluation committees and bid adjudication committees. This will assist in eliminating subjectivity and bring forth an element of accountability to the bid committee members.
- Various authors agree on having a set of criteria to prequalify and evaluate contractors. The criteria that these authors agree to be evaluated are financial stability, management and technical ability, experience, past performance, and resources.

It is posited herein that the same set of criteria that are used to prequalify contractors for awarding tenders should be the set of criteria that are used to grade contractors. This will assist in consistency in contractor performance and would also assist the contractor grading system in reflecting the true capability of contractors in line with the contractor grade. Lastly, relevant legislative prescripts governing the construction sector have also been outlined. The main legislation is the Preferential Procurement Policy Framework Act No 5 of 2000, Broad-based Black Economic Empowerment No 53 of 2003, Construction Regulations 2014, Occupational Health and Safety Act No 85 of 1993, General Safety Regulations, and General Administration Regulations.

CHAPTER 4 RESEARCH METHODOLOGY

4.1 INTRODUCTION

In Chapter 2, literature was reviewed on the state of the construction sector, project performance, multi-criteria decision-making frameworks, and other related concepts were introduced as a frame of reference for identifying and understanding the construction sector registration, grading, and performance assessment processes. This chapter outlines the research methodology which was adopted for the study. The aim of this chapter, therefore, is to discuss the relevant research methodology which was adopted for the study.

4.2 EMPIRICAL RESEARCH DESIGN

The research execution plan was divided into four phases. The first phase incorporated a broad literature study on contractor grading system and criteria, project performance, decision support frameworks, and regulation of business entry as well as the state of the civil construction sector. The second phase incorporated a scope definition and collection of data. The primary data comprised questionnaires from the South African Institution of Civil Engineering members, Construction Industry Development Board contractors, and the South African Council for the Project and Construction Management members. They were asked to complete the questionnaire as they rendered services to the selected market leaders and were recognised for their sustainability and experience in the civil construction field.

In the third phase, the framework was developed and tested. The results from the questionnaire formed the basis for determining the criteria for registering and grading contractors. The Analytical Hierarchy Process was utilised. Thereafter, simulated scenarios were used to validate the framework.

A purposive sampling method was adopted in selecting the respondents. According to Crossman (2020), a purposive sample is a non-probability sample that is selected based

on the characteristics of a population and the objective of the study. Crossman (2020) indicates that there are seven types of purposive sampling which are as follows:

1. Maximum variation/heterogeneous purposive sampling

A maximum variation/heterogeneous purposive sample is one which is selected to provide a diverse range of cases relevant to a particular phenomenon or event. The purpose of this kind of sample design is to provide as much insight as possible into the event or phenomenon under examination. For example, when conducting a street poll about an issue, a researcher would want to ensure that he or she speaks with as many kinds of people as possible to construct a robust view of the issue from the public's perspective.

2. Homogeneous purposive sampling

A homogeneous purposive sample is selected for having a shared characteristic or set of characteristics. For example, a team of researchers wanted to understand what the significance of black skin—blackness—means to black people. Black people will be the participants based on race.

3. Typical case sampling

Typical case sampling is a type of purposive sampling useful when a researcher wants to study a phenomenon or trend as it relates to what are considered "typical" or "average" members of the affected population. If a researcher wants to study how a type of educational curriculum affects the average student, then they choose to focus on average members of a student population.

4. Extreme/deviant case sampling

Conversely, extreme/deviant case sampling is used when a researcher wants to study the outliers that diverge from the norm as regards a particular phenomenon, issue, or trend. By studying deviant cases, researchers can often gain a better understanding of the more regular patterns of behavior. If a researcher wanted to understand the relationship between study habits and high academic achievement, they should purposively sample students considered high achievers.

5. Critical case sampling

Critical case sampling is a type of purposive sampling in which just one case is chosen for study because the researcher expects that studying it will reveal insights that can be applied to other like cases. Pascoe (2011) studied sexuality and gender identity development among high school students, and the sample consisted of an average high school in terms of population and family income so that the findings from this case could be more generally applicable.

6. Total population sampling

With total population sampling, a researcher chooses to examine the entire population that has one or more shared characteristics. This kind of purposive sampling technique is commonly used to generate reviews of events or experiences, which is to say, it is common to studies of groups within larger populations.

7. Expert sampling

Expert sampling is a form of purposive sampling used when research requires one to capture knowledge rooted in a particular form of expertise. It is common to use this form of purposive sampling technique in the early stages of a research process when the researcher is seeking to become better informed about the topic at hand before embarking on a study. Doing this kind of early-stage expert-based research can shape research questions and research design in important ways.

This study adopted the expert sampling approach to establish the experts' views on entry regulation, contractor grading, and performance evaluation criteria in the construction sector. Thus, only selected participants were requested to complete the questionnaire, as there are thousands of civil construction contractors and professionals in South Africa, and it is impossible to reach each one of them. Therefore, the empirical study was performed on selected relevant participants within South Africa. The following are organisations the members of which were requested to complete the questionnaire due to their role in the South African construction sector:

- The South African Institution of Civil Engineering

The South African Institution of Civil Engineering (SAICE) is the industry body for civil engineering professionals in South Africa. It aims *to promote growth, excellence, and*

sustainability in the industry by advancing professional knowledge and improving the practice of civil engineering in South Africa (SAICE, 2022).

- Construction Industry Development Board

The Construction Industry Development Board (CIDB) *promotes a regulatory and developmental framework that builds the construction industry delivery capability for South Africa's social and economic growth* (CIDB, 2022).

- The South African Council for the Project and Construction Management Profession

The South African Council for the Project and Construction Management Profession (SACPCMP) *was established to regulate and promote specific Built Environment Management Professions and is a juristic person established by the Project and Construction Management Professions Act* (Act No.48 of 2000): *To provide for the registration of professionals, candidates and specified categories in the project and construction management professions; to provide for the regulation of the relationship between the South African Council for the Project and Construction Management Professions and the Council for the Built Environment; and to provide for matters connected therewith* (SACPCMP, 2022).

The Council is further tasked with the protection of public interest, which is achieved by ensuring suitably qualified and registered professionals in specific Built Environment Management Professions in South Africa through promoting and enforcing high standards of professional ethics and conduct within the Built Environment (SACPCMP, 2022). The Engineering Council of South Africa (ECSA) was approached. ECSA indicated that they do not distribute research questionnaires to their members, and that SAICE should be approached.

The selected groups are relevant to the study because they operate within the construction sector in South Africa. They were requested to complete the questionnaire as they render services to the selected market leaders and are recognised for their sustainability and experience in the civil construction field. Valuable information can be derived from the questionnaire as these participants need to ensure that the quality of the

service rendered is aligned with the end-user's expectations. The essence of the construction industry's success and competitive advantage depends on their ability to perform their service delivery to the standard required by the client.

The results of the questionnaires provided guidance on relevant criteria and entry requirements that could be considered for the construction sector for registering, grading, and assessing the project performance of construction contractors in South Africa. The method followed in any study is informed by a broad literature review and aspects such as the nature of the phenomenon under study, the research questions being asked, and the problem that set off the enquiry. The research method followed in this study is descriptive research using a quantitative research method. According to its design, a descriptive research method aims to describe a population, situation, or phenomenon (Mccombes, 2022) accurately and systematically.

For this study, a descriptive research design was used as the underlying relationship of the problem is understood. With a descriptive focus, the aim is to provide a summary of the sample or population in terms of the variables of interest. Several statistical techniques can be used to undertake a descriptive analysis. These include frequency distributions, location measures (mode, median, and mean), variability measures (index of diversity, range, variance, standard deviation), and skewed and kurtosis measures (Venter, 2010).

In this study, the quantitative research method was used with the aim of establishing contractor grading and project performance parameters of the civil engineering construction sector. Data collection consisted of questionnaires and thereafter analysis of the questionnaire and a framework development that may assist in enhancing the construction sector. Thus, the study was based on insights from the body of knowledge and from the empirical data that was collected.

The research statements propose that, if the construction sector is managed well, this will improve the performance outputs of the construction sector. A quantitative approach was used for data collection, in particular questionnaire (see Annexure H). Questionnaires

were developed to gather inputs regarding the construction sector entry requirements, grading system, and grading criteria, as well as project performance evaluation criteria.

4.2.1 Goals of the empirical research

To reach the goal of developing a decision support framework for registering, grading, and assessing the performance of contractors, the empirical study investigated the following issues:

- Importance of regulation of entry in the construction sector
- Assessment of the current grading system
- Assessment of the current grading criteria
- Project performance evaluation of contractors

Figure 4.1 shows the methodology followed for the research from the literature review until the finalisation of the research report.

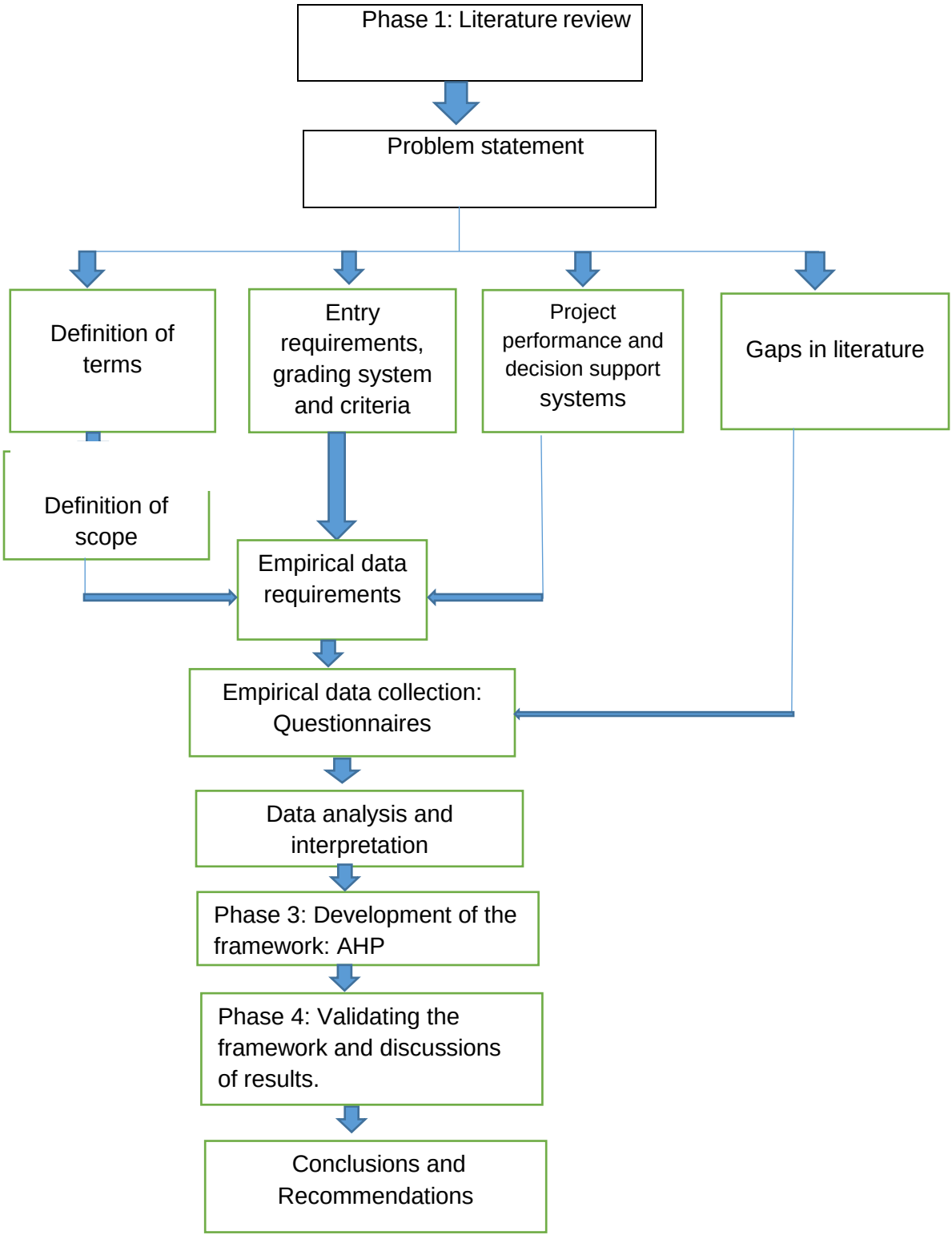


Figure 4.1 Research method and process diagram (Source: author)

The results from the empirical data were analysed and a determination of the requirements was made and incorporated into the framework to develop recommendations for registering, grading, and evaluating the project performance of contractors. The empirical data as well as the results of the study are presented both quantitatively and qualitatively for analysis. Thereafter, the framework was developed and a formulation of recommendations and drawing of a conclusion followed.

4.2.2 Limitations of the empirical study

Employees working in public or private sector construction companies are not included in the study because employees working in the construction companies should be associated or registered with the South African Institution of Civil Engineers, the South African Council for Project and Construction Management, and/or the Construction Industry Development Board.

Although registration or association with these institutions is not a mandatory legislative requirement, most professionals in South Africa are associated with these institutions. Moreover, all public sector contractors in South Africa are required to be registered with the Construction Industry Development Board.

The questionnaire provided guidance on the development of the framework which is dependent on the opinions of the respondents.

- The integrity of the research process

According to the Edinburgh Research Office (2021), research integrity means conducting research in such a way that allows others to have confidence and trust in the methods and the findings of the research. It relates to the scientific integrity of conducted research and the professional integrity of researchers. Key elements of the research integrity include honesty, rigour, transparency and open communication, the care and respect of all participants, and accountability. These elements should be present at all stages of the research and research ethics is one of the key criteria of research integrity. Korenmann (2006) explains the elements of research integrity as follows:

- Honesty and fairness in proposing, performing, and reporting research;
- Accuracy and fairness in representing contributions to research proposals and reports;
- Proficiency and fairness in peer review;
- Collegiality in scientific interactions, communications and sharing of resources;
- Disclosure of conflicts of interest;
- Protection of human subjects in the conduct of research;
- Humane care of animals in the conduct of research;
- Adherence to the mutual responsibilities of mentors and trainees.

While science encourages vigorous defense of one's ideas and work, ultimately research integrity means examining the data with objectivity and being guided by the results rather than by preconceived notions (Korenmann, 2006). The relevant research ethical and integrity processes were followed in this study. Appendix F details the participants' information sheet, whilst Appendix G details the invitation email and Appendix H is the research questionnaire.

4.2.3 Reliability

According to Bryman and Bell (2014), reliability has to do with the question of whether the results of a study are repeatable. It refers to a measurement that supplies consistent results with equal values (Blumberg *et al.*2005). It measures consistency, precision, repeatability, and trustworthiness of research (Chakrabartty, 2013). It indicates the extent to which it is without bias, and hence ensures consistent measurement across time and the various items in the instruments. Some qualitative researchers use the term ‘dependability’ instead of reliability (Haradhan, 2017). It is the degree to which an assessment tool produces stable (free from errors) and consistent results. It indicates that the observed score of a measure reflects the true score of that measure. It is a necessary, but insufficient component of validity (Feldt & Brennan, 1989).

In quantitative research, reliability refers to the consistency, stability, and repeatability of results, that is, the result of a researcher is considered reliable if consistent results have

been obtained. But, in qualitative research, it is referred to as when a researcher's approach is consistent across different researchers and different projects (Twycross & Shields, 2004) at the time the test is completed. Although it is impossible to give an exact calculation of reliability, an estimate of reliability can be achieved through different measures. The three attributes of reliability are described as follows:

- Homogeneity (or internal consistency): The extent to which all the items on a scale measure one construct.
- Stability: The consistency of results using an instrument with repeated testing.
- Equivalence: Consistency among responses of multiple users of an instrument, or alternate forms of an instrument.

Cronbach's α is the most used test to determine the internal consistency of an instrument. In this test, the average of all correlations in every combination of split halves is determined. Instruments with questions that have more than two responses can be used in this test. The Cronbach's α result is a number between 0 and 1. An acceptable reliability score is 0.7 or higher (Lobiondo-Wood & Haber, 2013; Shuttleworth, 2015).

Thus, the study tested Cronbach α using the Statistical Package of Social Scientists (SPSS) to determine the internal consistency of the questionnaire.

4.2.4 Validity

Bryman and Bell (2014) indicated that validity is concerned with the integrity of the conclusions that are generated from a piece of research. Heale and Twyross (2015) define validity as the extent to which a concept is accurately measured in a quantitative study. Heale and Twyross (2015) describe three major types of validity:

- Content validity: The extent to which a research instrument accurately measures all aspects of a construct.
- Construct validity: The extent to which a research instrument (or tool) measures the intended construct.

- Criterion validity: The extent to which a research instrument is related to other instruments that measure the same variables.

Middleton (2019) indicates that face validity is the fourth type of validity which considers how suitable the content of a test seems to be on the surface. However, it is like content validity, but face validity is a more informal and subjective assessment. Construct validity refers to whether you can draw inferences about test scores related to the concept being studied. There are three types of evidence that can be used to demonstrate a research instrument has construct validity (Heale & Twyross, 2015):

1. Homogeneity—meaning that the instrument measures one construct.
2. Convergence—this occurs when the instrument measures concepts like that of other instruments, although if there are no similar instruments available this will not be possible to do.
3. Theory evidence—this is evident when behaviour is like theoretical propositions of the construct measured in the instrument. For example, when an instrument measures anxiety, one would expect to see that participants who score high on the instrument for anxiety also demonstrate symptoms of anxiety in their day-to-day lives (Korb, 2012).

Construct validity was tested for the study. The questionnaire covered all relevant parts of the research which include the entry regulation, grading system, grading criteria, and project performance evaluation criteria.

Pearson Correlation was used to test the validity of the results of the study. According to Nettleton (2014), the Pearson correlation method is the most common method to use for numerical variables; it assigns a value between −1 and 1, where 0 is no correlation, 1 is a total positive correlation, and −1 is a total negative correlation. This is interpreted as follows: a correlation value of 0.7 between two variables would indicate that a significant and positive relationship exists between the two. A positive correlation signifies that if variable A goes up, then B will also go up, whereas if the value of the correlation is negative, then if A increases, B decreases. Because this research focuses on relevant

key players in the civil construction sector in South Africa, it can thus be said that the results can be generalisable.

4.2.5 Structural equation modelling approach

This study statistically analysed the measurement and structural models using Smart PLS software for the Structural Equation Modelling (SEM) technique. In structural equation modelling (SEM), the measurement model refers to the relationships between latent variables and their manifest variables, while the structural model represents the hypothesised causal relationships among research constructs (Sarstedt *et al.* 2021). In contrast to AMOS and LISREL, which are covariance-based methods, Smart PLS is a path analysis-derived regression-based method.

Smart PLS has emerged as an effective technique for investigating causal models with multiple constructs and multiple indicators (Purwanto *et al.* 2021). Under non-normal conditions, Smart PLS, a component-based method can model latent constructs that are uncontaminated by measurement error. It can handle complex predictive models with modest to small sample sizes. Bootstrapping resampling was utilised to ascertain the statistical significance of the relationships.

4.2.6 Measurement model assessment

The structural equation model comprises two interconnected models: the measurement model and the structural model (Petko *et al.*2018). The measurement model, also known as confirmatory factor analysis (CFA), defines the model's constructs (latent variables) and assigns observed variables to each, whereas the structural model, also known as regression or path analysis, defines the model's hypothetical relationship between the latent variables (Zhang, 2022; Hult *et al.*2018). Notably, a latent variable represents an unobservable theoretical construct that can be exogenous (independent variable) or endogenous (dependent variable) in the model (Zhang, 2022).

When implementing SEM, Hair *et al.* (2006) recommend a two-step procedure. During the first step, the unidimensionality, reliability, and validity (convergent and discriminant) of a measurement model are evaluated. In the second step of structural model evaluation,

causal relationships between theoretically proposed latent constructs are confirmed using path significance (see Table 5.2). This section provides evidence of the reliability and validity of the measurement model.

4.2.7 Reliability and validity test in confirmatory factor analysis

Using previous research as a guide, the first step consisted of evaluating the reliability and validity of the instrument (Devine & Hughes, 2016; Canivez, 2016; Willoughby *et al.*2017). Item reliability is "the proportion of an item's variance that is attributable to its underlying construct rather than to error" (Chau, 1997). To assess reliability, Cronbach's alpha and composite reliability were utilised. Yu (2018) defines convergent validity as the degree to which a construct is reflected in its measurement items.

According to Voorhees *et al.* (2016), a low correlation between variables in a conceptual model indicates discriminant validity, while a high loading of items on their familiar construct indicates convergent validity. As suggested by Crego *et al.* (2015), the discriminant and convergent validity of the Average Variance Extracted (AVE) was also evaluated. The correlation matrix and factor loadings demonstrating discriminant and convergent validity are presented in Tables 5.3 to 5.7.

4.3 THE TARGET POPULATION

The study population is the group from which the sample is drawn. The study population included people whose opinions would yield information for answering the research questions. Purposive sampling was used to select the sample for the study.

Other groups such as quantity surveyors, architects, and electrical and mechanical engineers were not targeted for the study because the study aims to develop a decision support framework for grading civil engineering contractors and evaluation of project performance for civil construction projects. Thus, the selected target population are key role players in the civil construction sector.

4.4 SAMPLE SIZE AND SELECTION

To choose the correct sample size, it is important to consider a few different factors that affect the research study. A sample size formula is used to ensure that a high probability of the survey is statistically accurate. To ensure that an accurate sample size is obtained, the formula for determining sample size should be used which considers population size, margin of error, confidence level, and standard deviation (Qualtrics, 2022). Graglia (2023) states that 100 responses are needed for a population of 3000 to 10,000,000 for a 10% margin of error. Thus, 100 responses are needed for marginally acceptable accuracy (Great Brook, 2023).

The sample consisted of members from the South African Institution of Civil Engineering database, approximately 10,000 civil engineers. Project and construction managers from the South African Council for Project and Construction Management Profession have 8220 registered project and construction managers. The Construction Industry Development Board Civil Engineering contractors, Grades1-9 contractors, roughly 10,000 civil engineering contractors. Thus, using the stated assumptions, the feedback received from respondents is 149, which is considered adequate for a 10% margin of error (Graglia, 2023).

4.5 PILOT TESTING

According to Venter (2010), pilot testing is important if the researcher wants to be satisfied that the questionnaire will perform its function. The pilot-testing is the most inexpensive insurance the researcher can buy to assure the success of the questionnaire and the research project (Churchill *et al.* as cited by Venter, 2010). The questionnaire was pre-tested using industry experts to identify weaknesses in the construction, formulation of the questions, the assessment of the validity and comprehension. Feedback was carefully considered, and suggestions were incorporated before the final questions were distributed.

4.6 DATA COLLECTION

A quantitative research method was followed for the research study. Quantitative research is primarily descriptive research. It is the process of collecting and analysing numerical data. It can be used to find patterns and averages, make predictions, test causal relationships, and generalise results to wider populations (Bhandari, 2020)

Electronic-based questionnaires were sent to the target population. A well-constructed and well-administered questionnaire of limited length will generally a yield higher response rate. The following concerns were identified while designing the questionnaire:

- How to keep the questionnaires simple, short, and related to the objectives.
- The time factor to complete the questionnaire.
- How to improve the rate of response.

Since the questionnaire is the core component of the research, each facet of the document must be critically examined before being finalised for dispatch. Thus, a pilot test was done with researchers to ensure that any weaknesses in the questionnaire were addressed.

4.6.1 Aspects regarding the questionnaire

The quality of data is largely determined by the design of the questions and the way interviews are done. The broad literature review formed the framework in which the questions were constructed. An email was sent to the target population with the questions (see Annexure G).

4.7 DATA ANALYSIS

Computer data capturing packages included spreadsheets (Excel or Quattro), or Statistical Package for Social Science (SPSS) data entry (software package). The data collected from the completed questionnaires were analysed by the researcher. Structured equation modelling (SEM) and Statistical Package for Social Science were used for data analysis. This statistical method has grown in popularity for testing theories in a variety of academic fields (Karakaya-Ozyer & Aksu-Dunya, 2018).

According to Qureshi and Kang (2014), structural equation modelling (SEM) is a popular multivariate statistical method for examining the relationships between latent variables (or constructs) and observed variables that comprise a model (Schermelleh-Engel *et al.* 2017). In addition, according to Bollen (1980), Brewer *et al.* (2015), Byrne (2016), Hair *et al.* (2016), Henseler *et al.* (2015) and Hair *et al.* (2017), it is a statistical method that enables researchers to develop theoretical concepts and validate proposed causal relationships by employing two or more structural equations.

SEM is comparable to regression analysis, but it is more common because it evaluates the causal relationship between constructs while controlling for measurement error (He *et al.* 2012; Sartedt *et al.* 2014). According to Preacher *et al.* (2016), the ability of SEM to address numerous modelling challenges, the endogeneity of constructs, and the composite underlying data structure found in a wide range of phenomena can be assumed to be a factor in its popularity.

SEM is a framework that incorporates the simultaneous solution of linear systems of equations and procedures such as regression, factor analysis, and path analysis (Harrell, 2015). SmartPLS was used to conduct concurrent Confirmatory Factor Analysis (CFA) and Path Analysis (Davari & Rezazadeh, 2015). The objective of CFA is to determine how well the latent variables are measured by the observed variables (Li, 2016), whereas the objective of path analysis is to examine causal relationships between unobserved variables (Mueser *et al.* 2017). The results of the data analysis are in Chapter 5.

4.8 ETHICAL CONSIDERATION

For the sake of confidentiality, the names of the participants who were used for the study and their company names as well as their contact details were not included in the report. This information was used solely for the analysis. The first page of the questionnaire is a participant information sheet (see Annexure F) detailing the reasons for the study and assuring the respondents of the confidentiality of their responses. The ethics clearance number for the study is H22/11/08 and was issued by the University of Witwatersrand on 10 February 2023.

4.9 DEVELOPMENT OF FRAMEWORK

This section focuses on the development of the enhanced contractor grading and performance assessment framework using the Analytical Hierarchy Process (AHP). The AHP is one of the multiple decision-making methods that model decision-making processes mathematically and are used to solve complex problems (Saaty, 1980). The AHP aims at solving the hierarchical model by including in the model the criteria that are effective in the decision-making process by adding second or higher-order layers to the scaling techniques.

Unlike multi-criteria decision-making algorithms, the AHP aims to combine qualitative and quantitative factors and arrive at a single judgement (Alsamaray, 2017). Advantages of the AHP method include the use of hierarchical and ratio scales, comparisons of intuitive, qualitative, quantitative, and rational factors, comparison of both criteria and alternatives according to criteria, and solving decision problems that have objective and subjective criteria (Bhutta & Huq, 2002). Multi-criteria decision-making (MCDM) is adopted in the study to confirm the requirements for registering and grading contractors as outlined in Chapter 5.

The multicriteria decision-making process entails structuring and solving decision and planning problems comprising multiple criteria. It involves assessing various criteria and evaluating alternatives based on each criterion. MCDM problems have been studied under the general classification of operations research (OR) problems, which deal with decision-making in the presence of several often-conflicting criteria (Bhushan & Rai 2004). Some of the unique characteristics of MCDM include the presence of multiple non-commensurable and conflicting criteria, different units of measurement among the criteria, and the presence of quite different alternatives.

The difference in the methods of MCDM are the weighted sum model (WSM) which is the original method, which was later modified, and the weighted product model introduced to overcome some of the weaknesses of the WSM method. A later development emerged: the analytic hierarchy process (AHP) proposed by Saaty (1980), which has become

popular. The analytical hierarchy process (AHP) (Saaty, 1980) method is used for this study due to its flexibility and ability to consider both the qualitative and quantitative criteria, as well as objective and subjective criteria.

4.9.1 The analytical hierarchy process

According to Saaty (1990), the AHP is a technique widely used to make the decision-making processes in a multi-criteria and multi-stakeholder environment. In general terms, this technique arranges the factors that are important for the decision in a hierarchic structure descending from an overall goal to criteria, sub-criteria, and alternatives in successive levels; it values the importance of criteria and makes possible an assessment of several alternatives according to these criteria.

The advantage of the AHP consists of integrating qualitative aspects which are often counted out of analytical processes, but they can be relevant to some actors involved in the decision-making process. Some of these qualitative factors are the risk of the decision, the uncertainty, the equity, and the participation level, to mention a few (Ávila, 2000).

The AHP splits a complex multi-factor problem into a hierarchy. It uses hierarchic structures and linear algebra to understand the problem better and support the final decision. The AHP determines weights for each criterion and alternatives by analysing the judgmental matrices and by applying the mathematical theory of eigenvalues and eigenvectors. The AHP combines both subjective and objective judgements in an integrated framework based on ratio scales from simple pairwise comparisons.

In this study, the AHP was crucial and relevant given that contractor grading and performance evaluation is a multi-criteria decision-making process. Contractor grading and performance evaluation is not only a multi-criteria decision-making process, but the key criteria to be considered in the decision making are both qualitative and quantitative. This thus made the use of Analytical Hierarchy Process for this study to be relevant due to the simplicity and flexibility of the AHP method which makes it easier to understand the context of the problem and to carry out properly the decision-making process (Ávila, 2000).

Moreover, the AHP seems to be a useful tool for discovering the core of decision problems, including differences and similarities between the stakeholders' different points of view (Nielsen & Mathiesen, 2006). This advantage applies to this study given that the framework which is developed is intended to be utilised by the South African Construction Industry Development Board (CIDB) and the CIDB operates with various stakeholders. This thus made the AHP more applicable to the study as the AHP also makes it possible to assess the consensus rate among different stakeholders in a specific issue (Masozera, 2002).

These advantages were considered very important to this research in the sense that the framework may assist the CIDB to better explain the context of their contractor grading and performance evaluation decisions to their clients. Furthermore, the application of the AHP may assist the CIDB to easily clarify and open the decision process to their clients.

As indicated, the AHP process includes defining the project objective and structuring elements in criteria, sub-criteria, and alternatives. Then, it involves making a pairwise comparison of the elements in each group, calculating weighing and consistency ratios, evaluating alternatives according to weighing, and lastly, getting the ranking. The goal, main criteria, sub-criteria, and alternatives are arranged in a hierarchical structure.

The goal is to grade public sector construction contractors and evaluate the performance of these contractors. The framework may however also be utilised by the private sector. The aim is to grade and evaluate contractors based on their level of experience, qualifications, skills, and other relevant criteria.

4.9.2 Criteria priority vectors

The first step after the development of a hierarchy is to compute the weights for each criterion; a pairwise comparison matrix **A** is created using the AHP scale in Table 4.1 below which articulates the importance of one criterion relative to another. Two industry experts (civil engineering professional engineers) were consulted during the pairwise comparison to deliberate and affirm the weights of the criteria. The AHP scale has been validated for effectiveness, not only in many applications by several people but also through theoretical comparisons with many other scales (Saaty, 1989).

Table 4.1 AHP comparison scale (Tanyimboh & Kalungi, 2009)

Intensity of importance on an absolute scale	Relative importance	Explanation
1	Equal	Two activities contribute equally to the objective
3	Moderate	Experience and judgement strongly favour one activity over another
5	Essential or strong	Experience and judgement strongly favour activity over another
7	Very strong	An activity is strongly favoured, and its dominance is demonstrated in practice
9	Extreme	The evidence favouring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values	Used when compromise is needed
Reciprocals		
If activity J has one of the above numbers assigned to it when compared with activity k, the k has the reciprocal value when compared with j		
Rationales	Ratios arising from the scale	

During the development of matrix **A,** the researcher raises questions like: “Of the two criteria being compared, which criterion is considered more important with respect to the overall goal of contractor grading?”.

The matrix **A** is a *n*x*n* real matrix, where *n* is the number of evaluation criteria considered. Each entry *ajk* of the matrix **A** represents the importance of the *j*th criterion relative to the *k*th criterion. If;

ajk > 1: *j*th criterion is more important than the *k*th criterion,

ajk < 1: *j*th criterion is less important than the *k*th criterion,

ajk = 1: *j*th criterion is of the same importance as the *k*th criterion.

Therefore, for a given set of *n* items A1, ..., An, quantified judgements on pairs of items Aj and Ak are represented by the following matrix of pairwise comparisons shown in Equation 1.

$$\mathbf{A} = \begin{matrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \cdots & a_{2n} \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \cdots & 1 \end{matrix} \qquad (1)$$

where **A** is the matrix and the numerical values which criteria may take as indicated in table 1. After building matrix **A**, the *normalised pairwise comparison matrix* **B** depicted as b*jk* can be derived from matrix **A** by making the sum of entries on each column are equal to 1; see Equation 2.

$$\boldsymbol{b_{jk}} = \frac{a_{jk}}{\sum_{i=1}^{n} a_{jk}} \qquad (2)$$

where bjk is matrix **B** and *ajk* is the criteria value divide by the total value of the overall criteria values. Finally, the priority vector **P** is then obtained by averaging the entries in each row of matrix **B**.

$$\boldsymbol{p_j} = \frac{\sum_{k=1}^{n} b_{jk}}{n} \qquad (3)$$

4.9.3 Checking consistency

Inconsistencies arise when performing many pairwise comparisons and the AHP makes provision for checking such inconsistencies. For example, if three criteria (A*i*, A*j* and A*k*) are being considered and the decision maker evaluates that A*i* is more important than A*j* and A*j* more important than A*k*; an inconsistency is encountered if the decision maker evaluates by mistake that A*k* is equally or more important than Ai.

The consistency ratio (CR) is defined by Equation 4 below:

$$\boldsymbol{CR} = \frac{CI}{RI} \qquad (4)$$

Where CI, the consistency index (see equation 7 below) is the matrix of comparisons **A** (Equation 1), the priority vector **P** = (p*1, . . . , pn)T* (Equations 2 and 3), the column vector

X = (x1, . . . , xn)T (Equation 5) and λmax the maximum eigenvalue (Equation 6) of the pairwise comparison matrix **A**.

$$\boldsymbol{X} = AP \qquad (5)$$

$$\boldsymbol{\lambda max} = \frac{1}{n}\sum_{i=1}^{n}\frac{x_i}{p_i} \qquad (6)$$

$$\boldsymbol{CI} = \frac{\lambda\text{max}-\text{n}}{n-1} \qquad (7)$$

The comparison, i.e., the elements of A is tolerated/considered satisfactory when equation 8 is satisfied.

$$\frac{CI}{RI} \leq 0.1 \qquad (8)$$

A perfectly consistent comparison will be CI = 0. RI in equation 8 is the *Random Index*, i.e., the consistency index when the entries of **A** are completely random. The values of *RI* for small problems (*n* ≤ 10) are shown in Table 5.2.

Table 4.2 Values of the Random Index (RI) for small problems (Source: Saaty, 1987)

n	2	3	4	5	6	7	8	9	10
RI	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.51

4.9.4 Evaluating project priority vectors

In a multicriteria decision-making problem, each option should be assessed with respect to each criterion (Tanyimboh & Kalungi, 2009). In doing so, the following process applies:

Step 1: Performing pairwise comparisons between alternatives for each sub-criterion to quantify how much each alternative satisfies a particular sub-criterion compared with the other design. Matrix **A** (Equation 1) is obtained for each sub-criterion; then project priority vector for each sub-criterion is derived from (Equations 2 and 3).

Step 2: Producing a project priority matrix for each main criterion by accumulating all project priority vectors for sub-criteria under each main criterion in Matrix **C** called the project priority matrix. The following equation applies:

$$\boldsymbol{D} = (P_1/P_2) \tag{9}$$

where D is the project priority matrix and P1 and P2 are project priority vectors for each sub-criterion derived in Equation 3 above. Equation 10 is the derivation of the project priority vector S for each main criterion and is obtained as follows:

Step 3: Derivation of the project priority vector **S** for each main criterion is obtained as follows:

$$\boldsymbol{S} = D \times P_S \tag{10}$$

where S is the project priority vector for each main criterion, D is the project priority matrix derived in Equation 9 and Ps is the sub-criteria priority vector. The elements of the Project Priority Vector **S** for each main criterion rate the performance of each alternative according to the main criterion in question (Tanyimboh & Kalungi, 2009). Therefore, Equation 11 involves obtaining the overall rankings of the respective projects as

$$\boldsymbol{V} = EP_m \tag{11}$$

where V is the overall project priority vector and E is the overall project priority matrix.

$$\boldsymbol{E} = (S_1/S_2\,/\,\ldots/S_n) \tag{12}$$

S1, S2, . . . Sn are Project Priority Vector for each main criterion derived in step 3, *n* is the number of the main criteria, and **P** is the main criterion vector.

The elements of the overall project priority vector **E** are indicative of the merits of each design alternative with respect to all criteria used in the analysis (Tanyimboh & Kalungi, 2009).

4.10 CHAPTER SUMMARY

This chapter outlined the research methodology that was adopted for the study. The study made use of questionnaires to gather expert inputs from the relevant key role players in the construction sector. Structural Equation Modelling and SPSS were used for data analysis. Cronbach α was used to test the consistency of the questionnaire whilst Pearson correlation was conducted to test the validity of the results.

Thereafter, the results obtained from the questionnaires guided the relevant criteria to be adopted when developing the framework to register, grade, and assess the performance of contractors. The Analytical Hierarchy Process was adopted for the development of the framework because contractor grading, and performance evaluation is a multi-criteria decision-making process. The validation of the model was done by the application of sensitivity analysis which is described and discussed in Chapter 6.

CHAPTER 5 STATE OF PRACTICE SURVEY

5.1 INTRODUCTION

Previous chapters provided the basis of the research, including the research thesis, conceptual basis and the research methodology, and literature review related to various aspects of this dissertation. However, it was thought necessary to assess the existing state of the practice from the role players involved in the construction sector. This was necessary so that the study could be broad enough to incorporate the views of relevant parties, in this case, the registered contractors with the Construction Industry Development Board, members of the South African Institution of Civil Engineering, and members of the South African Council for Project and Construction Management Profession.

This chapter provides valuable information on data analysis and discussion on the current state of the practice on contractor grading and contractor performance evaluation and presents the results of the survey conducted to address the aforementioned matter. The findings of the survey have been utilised to provide research thesis justification and to provide the basis for the development of the framework.

5.2 SURVEY RESPONSE CHARACTERISTICS

Research suggests that questionnaire surveys are the most frequently used research method, specifically for psychological, management, and marketing research (Woodside, 2010). The questionnaire method is based on the logic that the responding individual represents not only his/her thinking process but also that of others who are involved in the decision process over the span of the respondents' experience. The usual reported response rate to such studies is typically in the range of 8% to 30% (Woodside, 2010).

Table 5.1 Number of participants questionnaire sent to.

Institution	Sent
SAICE	10 000
CIDB	10 000
SACPCMP	8220
Total	38220

Table 5.1 depicts the institutions where the survey was sent to as well as the number of potential participants. 149 responses were received.

5.3 DEMOGRAPHICS

The demographics of the respondents are as follows:

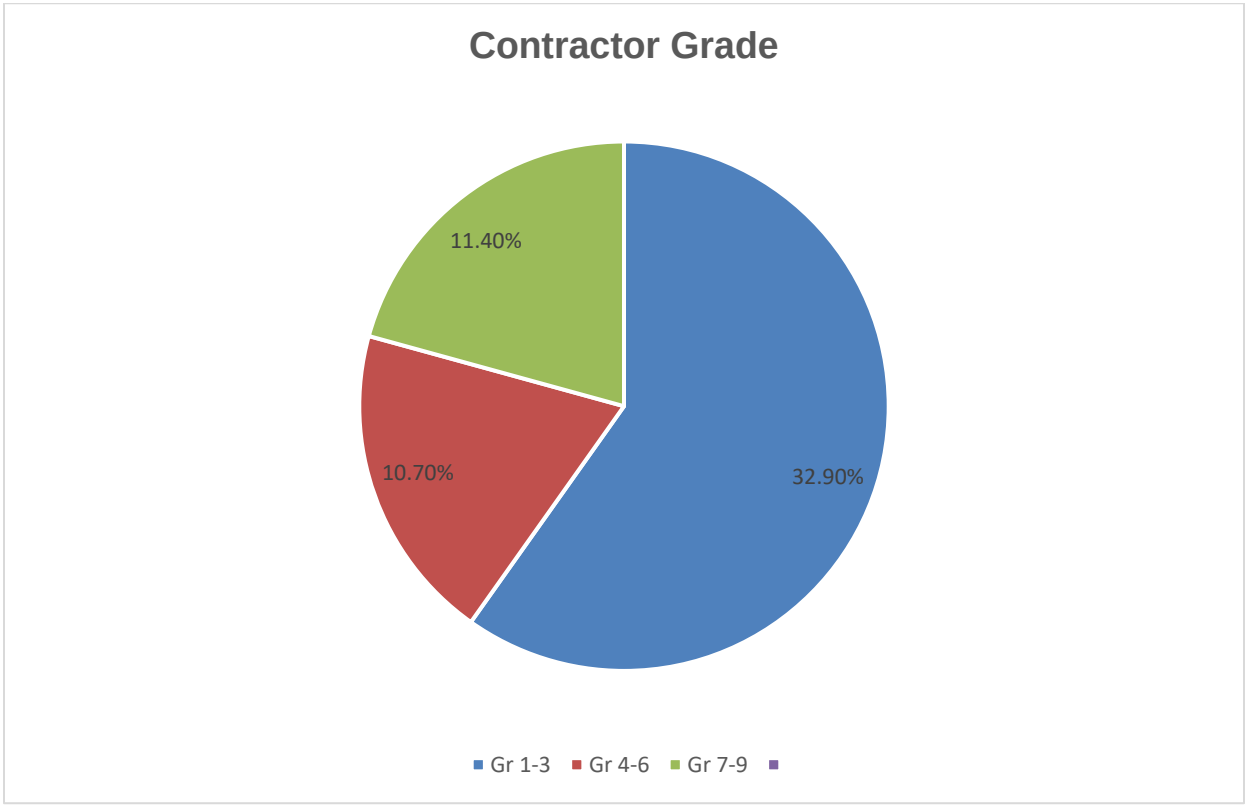


Figure 5.1 Contractor grading

Figure 5.1 indicates that out of the 149 respondents, 49 respondents (32.9%) are registered as Grades 1, 2, and 3 contractors, 16 respondents (10.7%) respondents are registered as Grades 4, 5, and 6 contractors and 17 respondents (11.4%) are registered as Grades 7,8 and 9 contractors. The remaining 67 (44,97%) respondents are members of the South African Institute of Civil Engineering and the South African Council of Project and Construction Management Profession.

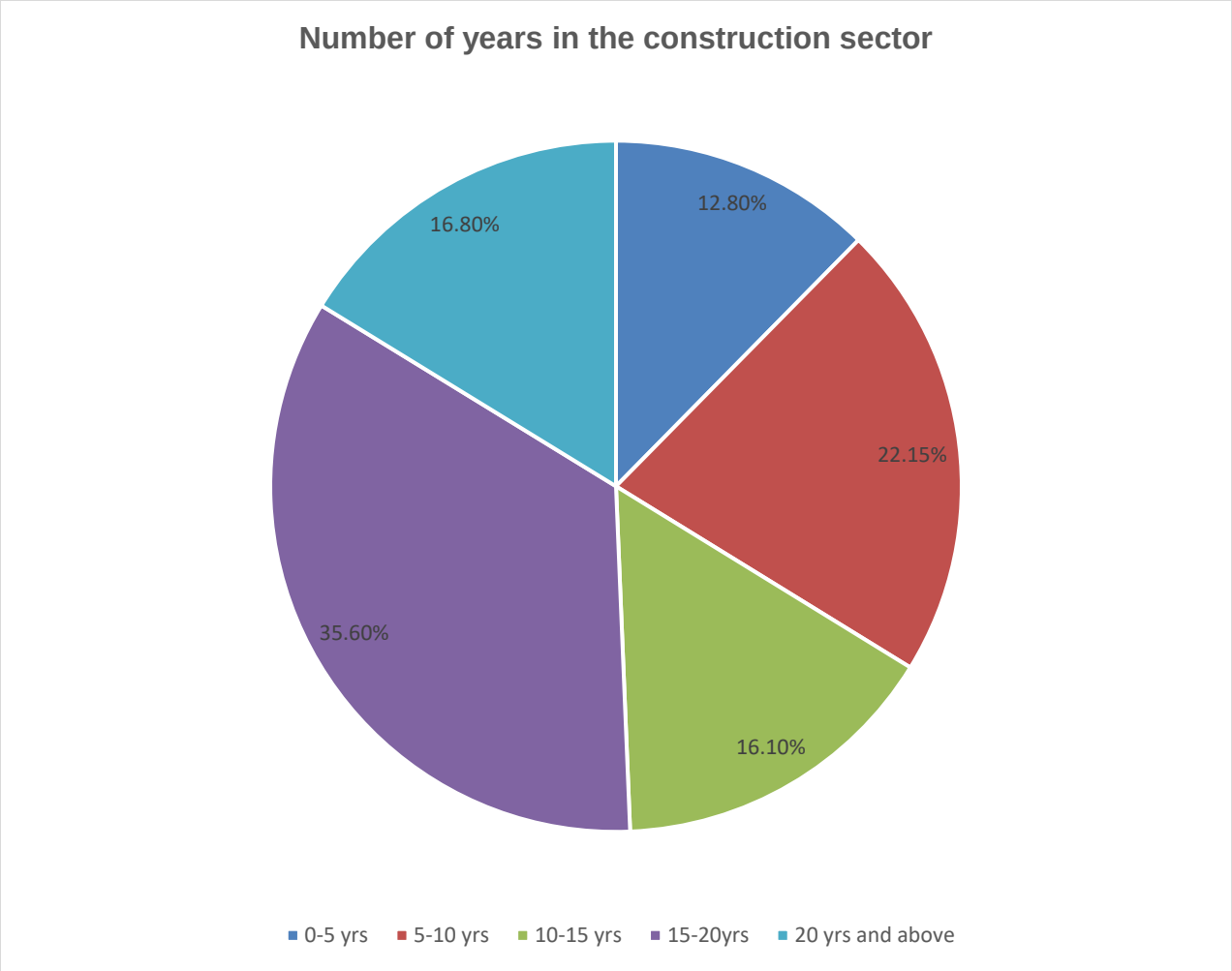


Figure 5.2 Number of years in the construction sector

Of the 149 respondents, 19 respondents (12.8%) have between 0-5 years construction sector experience, 33 respondents (22.15%) have between 5-10 years construction sector experience, 24 respondents (16.1%) have 10-15 years construction sector experience whilst 14 respondents (9.4%) have 15-20 years construction sector experience and 53 respondents (35.6%) have over 20 years experience in the construction sector.

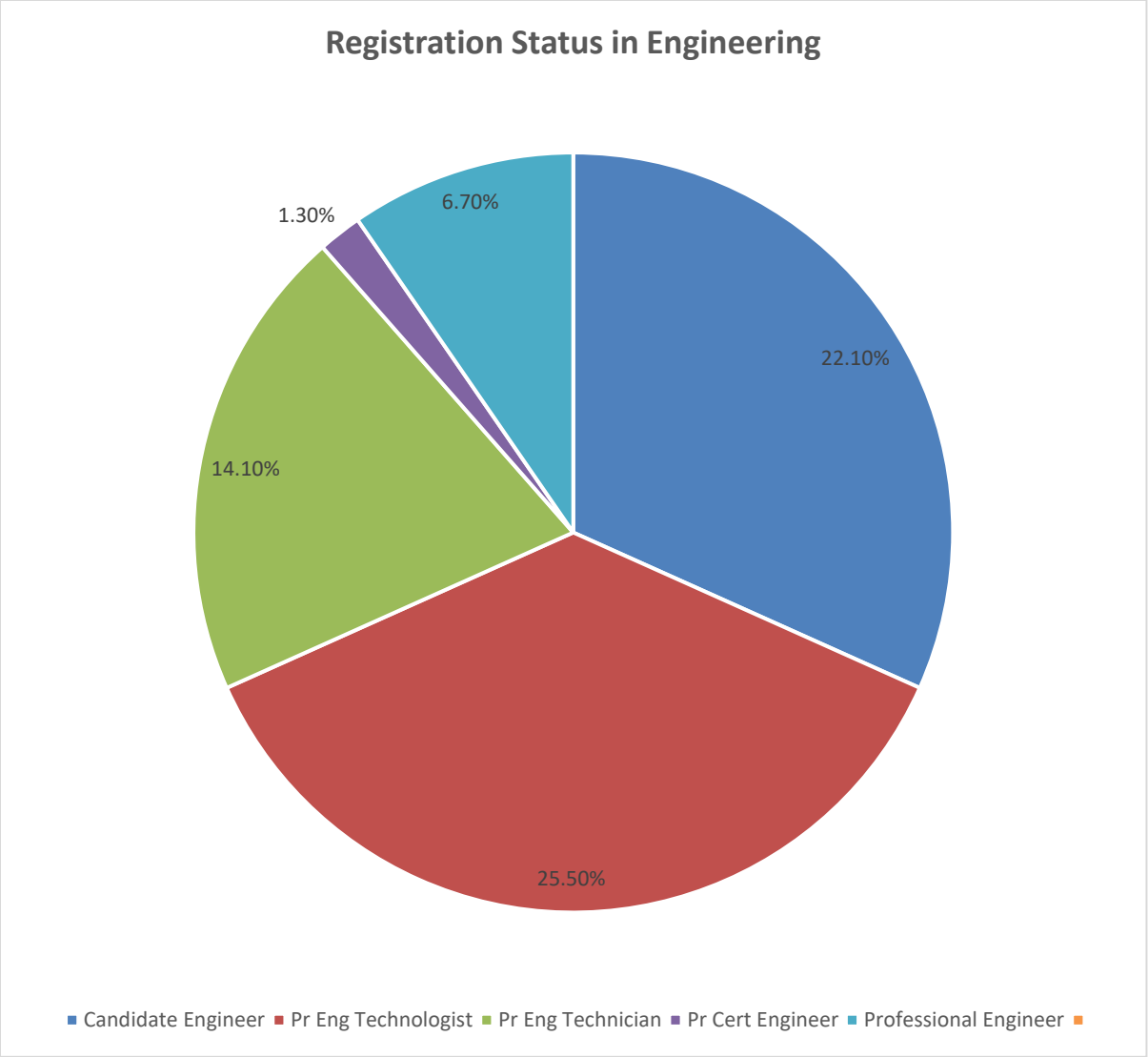


Figure 5.3 Registration status in engineering

The figure above shows that 33 respondents (22.1%) are registered Candidate Engineers, 38 respondents (25.5%) are registered as Professional Engineers, 21 respondents (14.1%) are registered as Professional Engineering Technologists, 2 respondents (1.3%) are registered as Professional Certificated Technologists whilst 10 respondents (6.7%) are registered as Professional Engineering Technicians and the remaining 45 (30,20%) respondents are not registered with the Engineering Council of South Africa.

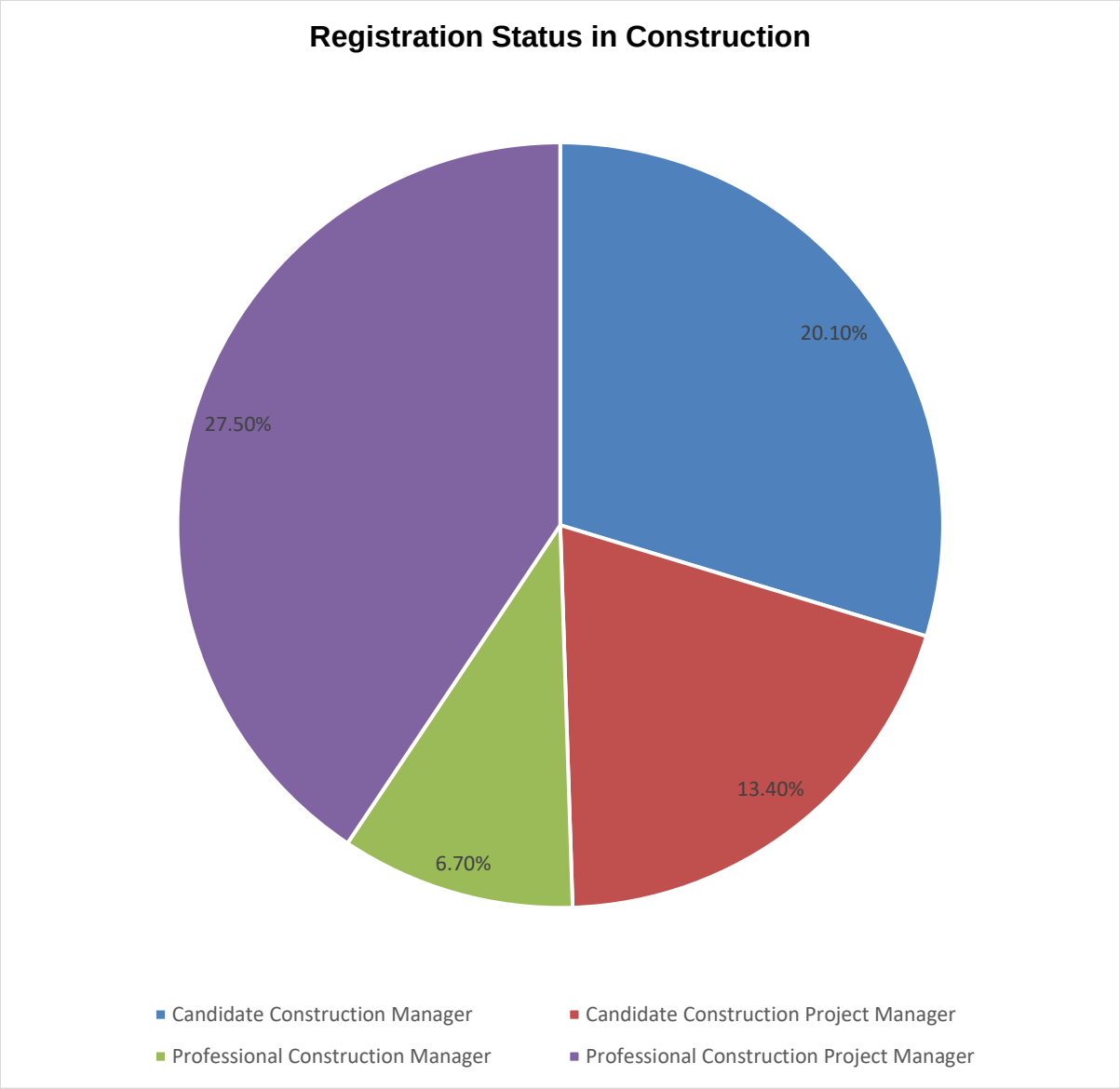


Figure 5.4 Registration status in construction

Figure 5.4 depicts that 30 respondents (20.1%) are registered as Candidate Construction Managers, 20 respondents (13.4%) are registered as Candidate Project Manager, 10 respondents (6.7%) are registered as Professional Construction Managers whilst 41 respondents (27.5%) are registered as Professional Construction Project Managers. The remaining 48 (32.21%) respondents are not registered with the South African Council for Project and Construction Management Profession.

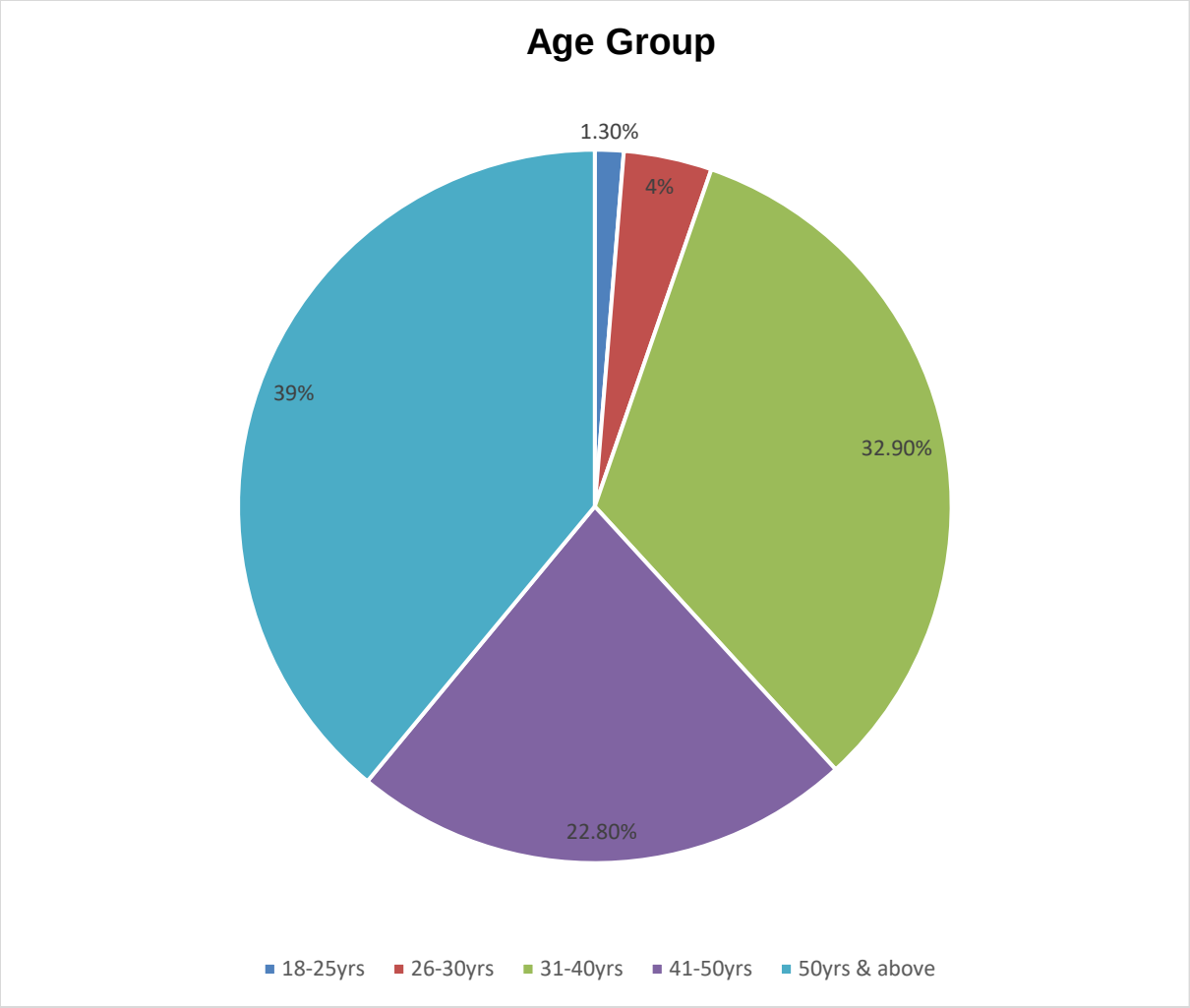


Figure 5.5 Respondents age group

Figure 5.5 shows that only 2 respondents (1.3%) are aged 18-25 years, 6 respondents (4%) are aged 26-40 years, 49 respondents (32.9%) are aged 31-40 years whilst 34 respondents (22.8%) are aged 41-50 years. The remaining 58 respondents (39%) are above 50 years of age.

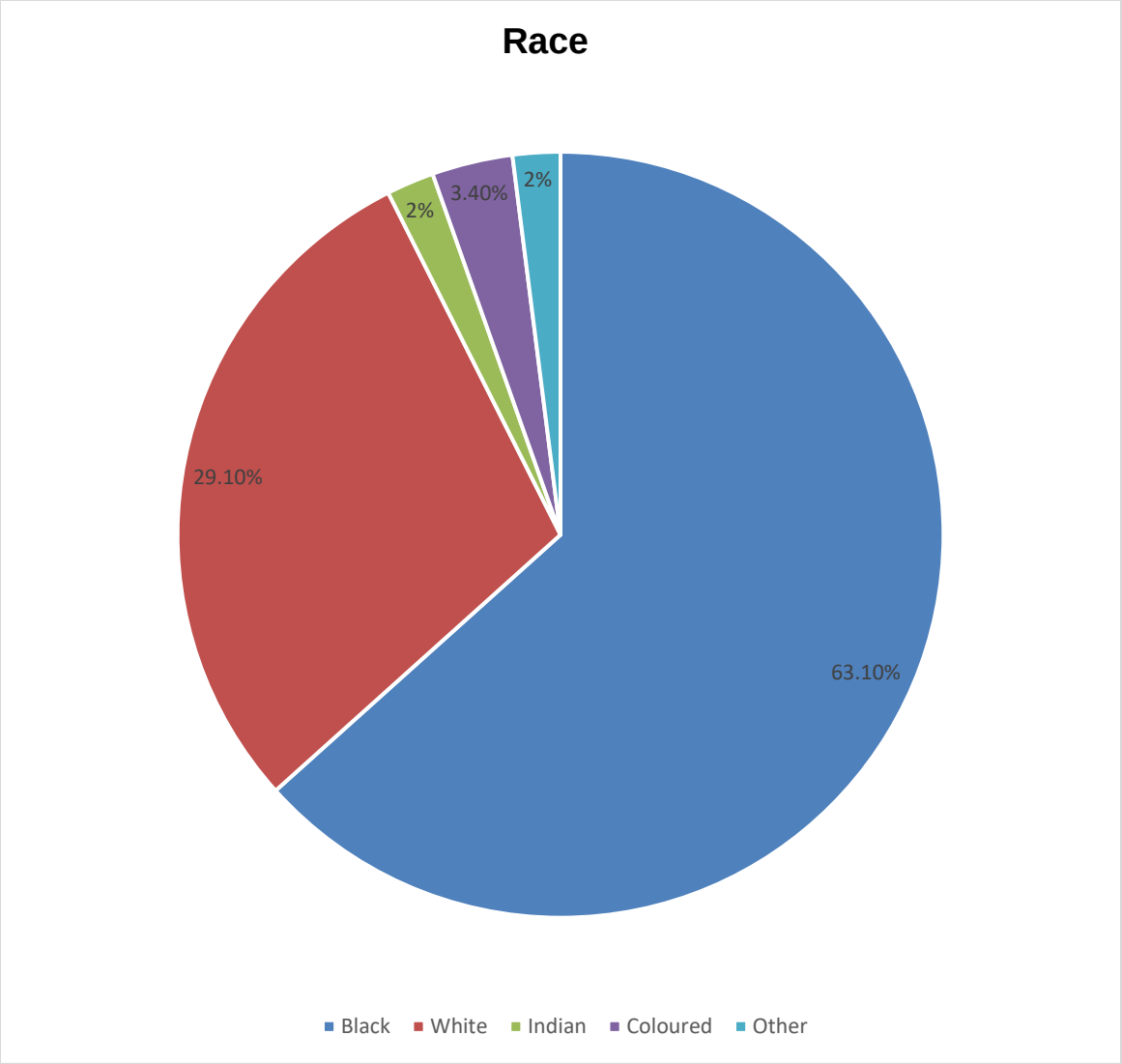


Figure 5.6 Race category

Figure 5.6 illustrates that 94 respondents (63.1%) are black, 44 respondents (29.1%) are white, 3 respondents (2%) are Indian whilst 5 respondents (3.4%) are coloured people. The remaining 3 respondents (2%) did not indicate their racial category.

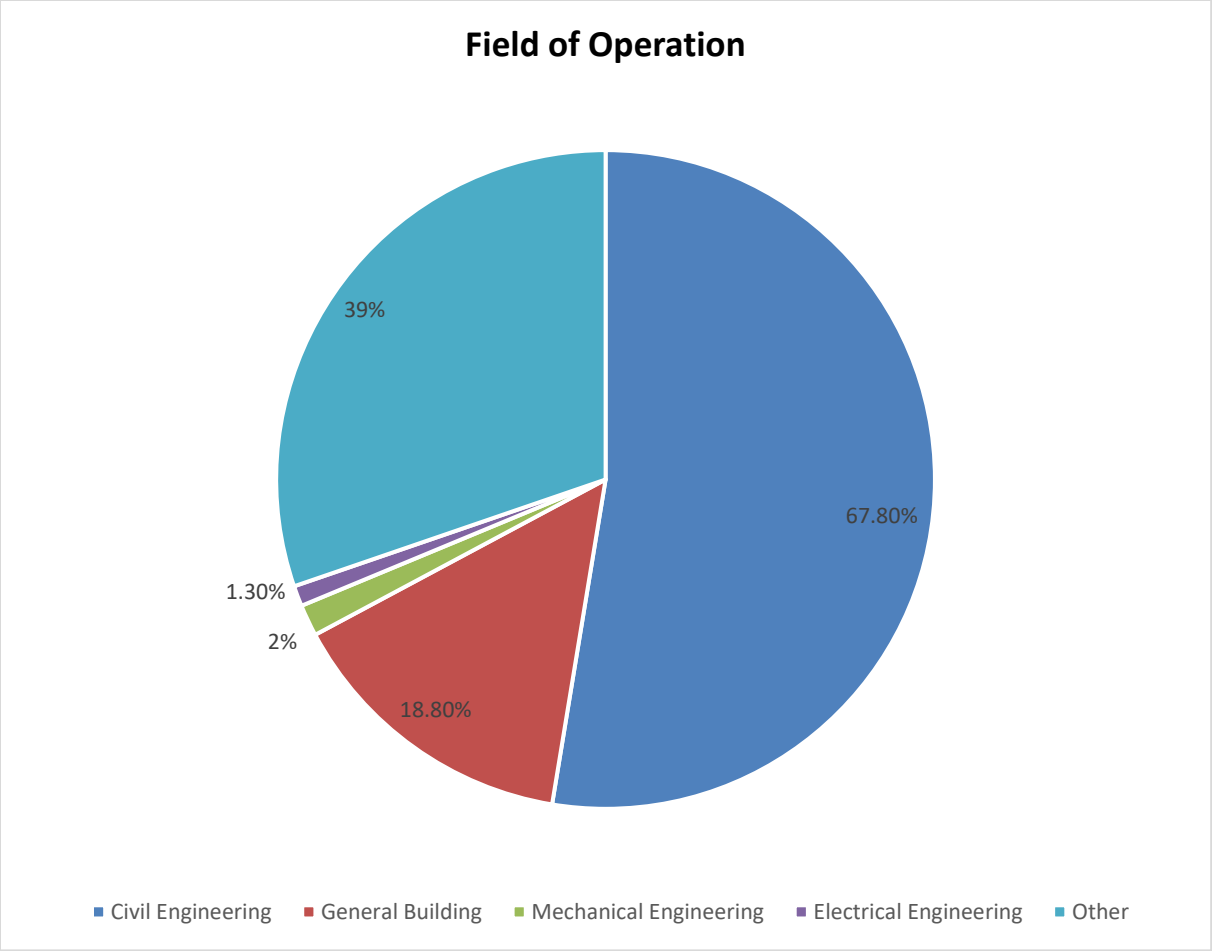


Figure 5.7 Field of operation

Figure 5.7 delineates that 101 respondents (67.8%) are operating in the civil engineering field, 28 respondents (18.8%) are in the general building, 3 respondents (2%) are operating in the mechanical engineering field whilst 2 respondents (1.3%) are operating in the electrical engineering field. The remaining 15 respondents (10.1%) are operating in other fields which include: the construction of large integrated projects from cradle to grave, project management, water management, general property development, toll road operation and maintenance, government, and mega project delivery.

5.4 RELIABILITY ANALYSIS ASSESSMENT

Cronbach's alpha statistics ranged from 0.805-0.832, and Composite Reliability statistics ranged from 0.873-0.888. Each indicator's reliability statistic exceeds the minimum threshold of 0.70. (Schuberth, 2021). Consequently, construct reliability is established.

Table 5.2 Construct Reliability Analysis (Cronbach Alpha and Composite Reliability)

	Cronbach's Alpha	Composite Reliability
ER	0.817	0.880
GC	0.805	0.873
GS	0.830	0.888
GSE	0.832	0.883
IPPE	0.809	0.887

Note: ER = Construction Entry Requirements, GC = Efficacy of the Grading and Performance Evaluation Criteria, GS = Contractor Grading System, GSE = Efficacy of the Grading System, IPPE = Enhanced Contractor Capabilities and Project Performance

5.5 CONVERGENT VALIDITY

In this study, convergent validity was evaluated using outer loadings and average variance extracted (AVE). This study's outer loadings and the average variance extracted (AVE) are shown in Table 5.3. According to Chinomona (2014), outer loadings are anticipated to be greater than 0.5, indicating that instruments will measure at least 50% of what they were designed to measure. According to Table 5.3, all outer loadings are greater than 0.534, confirming the discriminant validity.

Table 5.3 Convergent validity assessment

Research construct		Average Variance Extracted	Outer Loadings (Factor Loadings)
ER	**ER4**	0.648	0.710
	ER5		0.834
	ER6		0.850
	ER7		0.819
GC	**GC2**	0.635	0.682
	GC4		0.803
	GC5		0.848
	GC6		0.843
GS	**GS4**	0.665	0.740
	GS5		0.857
	GS6		0.846
	GS7		0.813
GSE	**GSE1**	0.606	0.836
	GSE2		0.829
	GSE3		0.826
	GSE4		0.822
	GSE5		0.534
IPPE	**IPPE2**	0.723	0.814
	IPPE3		0.892
	IPPE4		0.843

Note: ER = Construction Entry Requirements, GC = Efficacy of the Grading and Performance Evaluation Criteria, GS = Contractor Grading System, GSE = Efficacy of the Grading System, IPPE = Enhanced Contractor Capabilities and Project Performance

Convergent validity is the degree of agreement between multiple attempts to measure the same concept. If there are valid measures of concept, two or more measurements of the same thing should vary significantly (Clark & Watson, 2019; Hair *et al.*2020). When the AVE value is greater than or equal to the recommended value of 0.50, items converge to measure the underlying construct, thereby establishing convergent validity (Fornell & Larcker, 1981; Hamari *et al.*2016). In the current study, all constructs met the recommended convergent validity threshold of 0.50 based on the AVE statistics.

5.6 DISCRIMINANT VALIDITY

Discriminant validity is the degree to which measures of different concepts are distinct. The notion is that if two or more concepts are unique, then valid measures of each should not correlate to highly" (Rönkkö & Cho, 2022; Hair *et al.*2014).

5.6.1 Fornell and Larker criterion

According to Hamid, Sami and Sidek's (2017) and Fornell and Larcker's (1981) criterion, discriminant validity is established when the square root of AVE for a construct is greater than its correlation with all other constructs. In this study, the square root of AVE (in Bold and Italics) for a construct was found greater than its correlation with other constructs (Table 5.4). Hence, providing strong support for establishment discriminant validity.

Table Discriminant validity- Fornell and Larker criterion

	ER	GC	GS	GSE	IPPE
ER	***0.805***				
GC	0.627	***0.797***			
GS	0.768	0.659	***0.815***		
GSE	-0.302	-0.131	-0.332	***0.779***	
IPPE	0.502	0.585	0.495	-0.123	***0.850***

Note: ER = Construction Entry Requirements, GC = Efficacy of the Grading and Performance Evaluation Criteria, GS = Contractor Grading System, GSE = Efficacy of the Grading System, IPPE = Enhanced Contractor Capabilities and Project Performance

5.6.2 Cross Loading Criterion

Cross loadings assist in determining whether an item belonging to a specific construct strongly loads onto its own parent construct as opposed to other constructs in the study. The results (Table 5.5) indicate that the factor loading of all the items is more strongly associated with the underlying construct to which they belong than with the other study construct (Knekta *et al.* 2019). Based on the evaluation of cross-loading, discriminant validity is therefore achieved.

Table 5.4 Cross loadings

	ER	GC	GS	GSE	IPPE
ER4	0.710	0.443	0.611	-0.406	0.307
ER5	0.834	0.481	0.621	-0.228	0.404
ER6	0.850	0.575	0.650	-0.165	0.523
ER7	0.819	0.509	0.590	-0.194	0.359
GC2	0.465	0.682	0.553	-0.197	0.361
GC4	0.553	0.803	0.553	-0.192	0.536
GC5	0.502	0.848	0.495	-0.003	0.491
GC6	0.465	0.843	0.494	-0.020	0.459
GS4	0.579	0.486	0.740	-0.393	0.370
GS5	0.694	0.512	0.857	-0.340	0.416
GS6	0.611	0.562	0.846	-0.198	0.408
GS7	0.616	0.588	0.813	-0.153	0.417
GSE1	-0.269	-0.072	-0.314	0.836	-0.103
GSE2	-0.208	-0.161	-0.252	0.829	-0.123
GSE3	-0.267	-0.076	-0.271	0.826	-0.060
GSE4	-0.272	-0.154	-0.273	0.822	-0.114
GSE5	-0.126	-0.031	-0.152	0.534	-0.075
IPPE2	0.450	0.545	0.443	-0.204	0.814
IPPE3	0.436	0.503	0.401	-0.037	0.892
IPPE4	0.386	0.431	0.414	-0.060	0.843

Note: ER = Construction Entry Requirements, GC = Efficacy of the Grading and Performance Evaluation Criteria, GS = Contractor Grading System, GSE = Efficacy of the Grading System, IPPE = Enhanced Contractor Capabilities and Project Performance

If an indicator has a higher correlation with another latent variable than with its respective latent variable, the appropriateness of the model should be reconsidered (Henseler *et al.*2009).

5.6.3 Hetero Trait-Mono Trait (HTMT) Ratio (Inter-Construct Correlation Matrix)

According to Hair *et al.* (2014), to determine whether discriminant validity exists, it is necessary to determine if the observed variable has a higher loading on its construct than on any other construct included in the structural model. As suggested by Chinomona (2011), to assess discriminant validity, one must determine whether the correlation between the research constructs is less than 1. As demonstrated in Table 5.6, the intercorrelation values for all paired latent variables are less than 1.0, validating the existence of discriminant validity.

Table 5.5 Hetero Trait-Mono Trait (HTMT) ratio (Inter-Correlation Matrix)

	ER	GC	GS	GSE	IPPE
ER					
GC	0.768				
GS	0.732	0.808			
GSE	0.367	0.189	0.693		
IPPE	0.606	0.715	0.602	0.748	

Note: ER = Construction Entry Requirements, GC = Efficacy of the Grading and Performance Evaluation Criteria, GS = Contractor Grading System, GSE = Efficacy of the Grading System, IPPE = Enhanced Contractor Capabilities and Project Performance

Table 5.6 testifies that discriminant validity is high since the values are less than 0.8 which is highly recommended by O'Rourke and Hatcher (2013).

5.7 SUMMARY OF MEASUREMENT MODEL ACCURACY STATISTICS

The following table summarises the descriptive statistics and assessment statistics for the measurement model. The mean values presented below indicate that most respondents (>3-5) agreed with the requested measures. The standard deviations were less than 2, indicating that the mean values accurately reflect the average perceptions of the majority. In the reliability and validity assessment sections, a comprehensive and detailed explanation of the measurement model statistics is provided.

Table 5.6 Scale accuracy analysis

Research construct		Scale item		Cronbach's Alpha	CR	AVE	Outer Loadings (Factor Loadings)
		Mean	SD				
ER	**ER4**			0.817	0.880	0.648	0.710
	ER5						0.834
	ER6						0.850
	ER7						0.819
GC	**GC2**			0.805	0.873	0.635	0.682
	GC4						0.803
	GC5						0.848
	GC6						0.843
GS	**GS4**			0.830	0.888	0.665	0.740
	GS5						0.857
	GS6						0.846
	GS7						0.813
GSE	**GSE1**			0.832	0.883	0.606	0.836
	GSE2						0.829
	GSE3						0.826
	GSE4						0.822
	GSE5						0.534
IPPE	**IPPE2**			0.809	0.887	0.723	0.814
	IPPE3						0.892
	IPPE4						0.843

Note: ER = Construction Entry Requirements, GC = Efficacy of the Grading and Performance Evaluation Criteria, GS = Contractor Grading System, GSE = Efficacy of the Grading System, IPPE = Enhanced Contractor Capabilities and Project Performance

SD= Standard Deviation CR= Composite Reliability AVE= Average Variance Extracted

** Scores: 1 – Strongly Disagree; 3 – Moderately Agree; 5 – Strongly Agree*

5.7.1 Model fit assessment

Model Fit Assessment is performed to determine if the collected data corresponds to the conceptual model. In this study, the Smart PLS statistics, including the Normed Fit Index (NFI) and the Standardised Root Mean Residual (SRMR), as well as the Global Fit Index, were used to evaluate the Model Fit's acceptability.

Figure 5.8 demonstrates that the research model explains more than 59%, 11%, 43.4%, and 37.5% of the variance in the endogenous variables for ER, GSE, GC, and IPPE,

respectively. The global goodness-of-fit (Gof) statistic for the research model was computed using formulas provided by Tenenhaus *et al.* (2005):

$$GoF = \sqrt{\overline{AVE} * \overline{R^2}}$$

The calculated global goodness of fit (GoF) is 0.375, which exceeds the GoF>0.36 threshold established by Khojasteh and Lo (2015). This study concludes that the research model has a strong relationship between latent variables, indicating a good fit overall (Chinomona *et al.* 2010).

Table 5.7 Model Fit Indices

	Saturated Model	Estimated Model
SRMR	0.063	0.067
NFI	0.878	0.875

A standard bootstrapping procedure was conducted using SmartPLS 4. Nitzl *et al.* (2016) define SRMR as the variance between the observed correlation and the implied correlation matrix of the model. The average magnitude of the difference between the observed and expected correlation is measured as a comprehensive evaluation criterion for model fit. The Normed fit index (NFI) equals 1 minus the Chi value of the null model (Nitzl *et al.* 2016).

The NFI value should fall within the range of 0 and 1; the closer it is to 1, the better the fit. (Sahoo, 2019) NFI is the first proposed measure of model fit in the scientific literature. It is recommended that SRMR be less than 0.08 and NFI be greater than 0.90 for the estimated fit indices of SRMR and NFI, respectively (Chinomona, 2014; Nitzl *et al.* 2016). The SRMR was 0.063 and the NFI was 0.877 in this study. The NFI statistic indicated that the conceptual model for this study had a marginally good fit, but it could have been stronger with an NFI value of 0.9. This is because both the SRMR and the Global Fit Index were acceptable.

5.7.2 Structural model assessment

Since the measurement model assessment met the entire required threshold, this study proceeded to assess the structural model. Path analysis was therefore done for this purpose. Path coefficients for each proposed hypothesis were generated, and the bootstrapping results provided t-statistics and p-values for significance level assessment.

5.8 PATH MODELLING

Path analysis comprised the next phase of SEM-based data analysis (Beran *et al.* 2010; Stein *et al.* 2012). Path modelling describes the relationship between observed or measured variables and theoretical constructs (Roche *et al.* 2011) and assesses the structural paths of a conceptualised research model (Anderson *et al.*1998). The purpose of this SEM procedure was to demonstrate and test the theoretical foundations of the study and the significance of the relationship between model constructs (Jenatabadi *et al.* 2014). The structural model of the study was evaluated by examining p-values and standardised regression coefficients (Held & Ott, 2018). In path modelling, it is essential to explain both the standardised regression coefficients and the predictive ability (Wu, 2010)

Below is Figure 5.8 showing a structural model result for the proposed hypothesis.

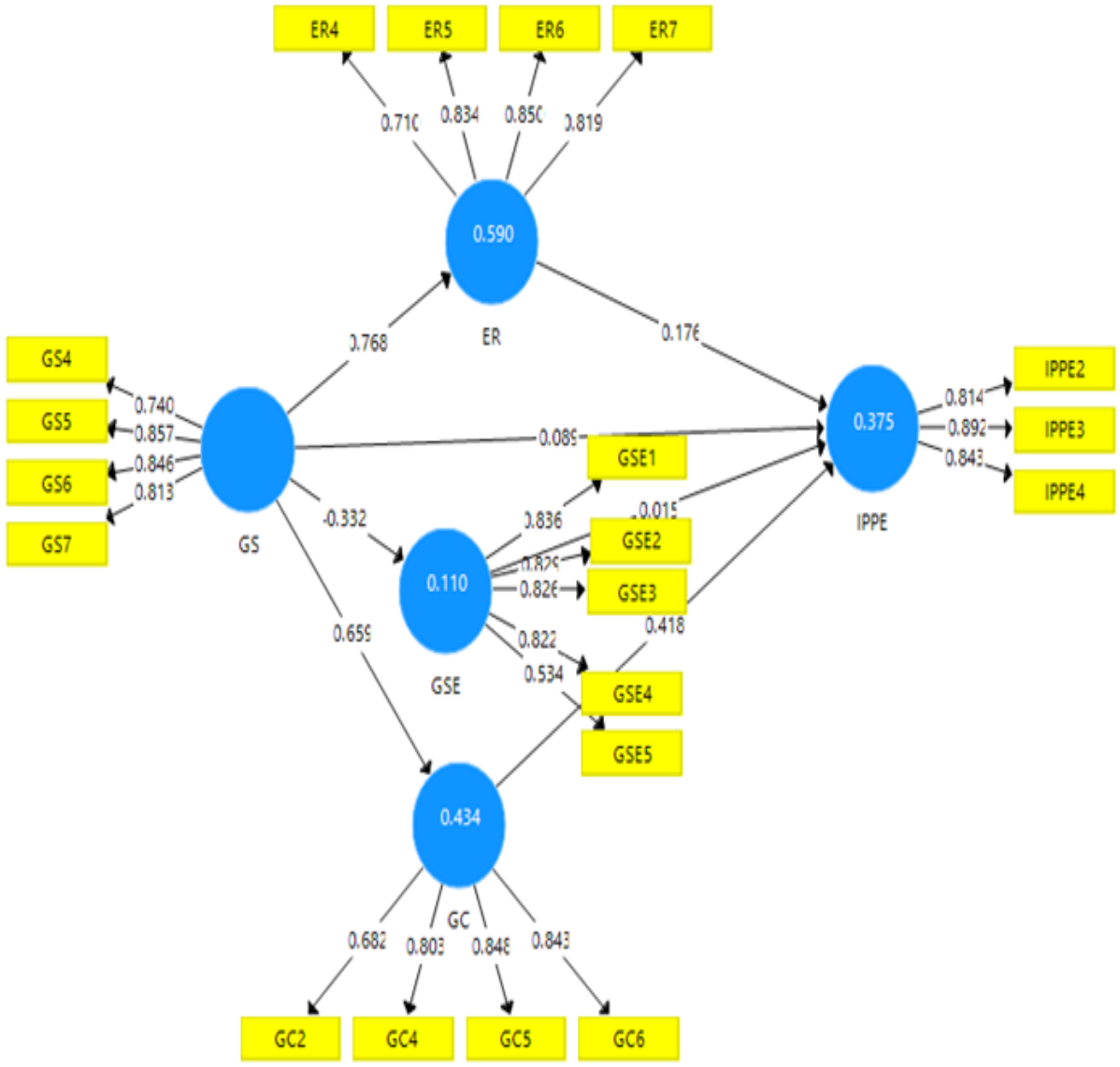


Figure 5.8 Structural model

Note: ER = Construction Entry Requirements, GC = Efficacy of the Grading and Performance Evaluation Criteria, GS = Contractor Grading System, GSE = Efficacy of the Grading System, IPPE = Enhanced Contractor Capabilities and Project Performance

5.9 HYPOTHESIS TESTING

After the assessment and finalisation of the measurement and structural models, the next step was to examine the causal relationship between latent variables using path analysis

(Mueller & Hancock, 2018). Clark and Watson (2019), citing Nusair et al. (2010), state that SEM asserts that specific latent variables directly or indirectly influence other variables within the model, resulting in estimation results that depict the relationship between these latent variables.

The estimation results derived from hypothesis testing for this study are displayed in Table 5.9. The table displays the proposed hypothesis, the path coefficients, the t-statistics, and whether the hypothesis is rejected or supported. Literature suggests that t > 1.96 indicates a significant relationship and higher path coefficients indicate a strong relationship between latent variables (Zhang, 2021).

Table 5.8 Hypothesis testing results

Hypothesized relationship	Hypothesis	Path Coefficient (β)	t-Statistics (t)	p- Value	Rejected/ Supported
GS -> IPPE	H_1	0.089	0.117	**0.474**	Supported but insignificant
GS -> ER	H_2	0.768	16.335	**0.000**	Supported but insignificant
GS -> GSE	H_3	-0.332	5.023	**0.000**	Rejected
GS -> GC	H_4	0.659	11.288	**0.000**	Significant and supported
ER -> IPPE	H_5	0.176	1.534	**0.126**	Supported but insignificant
GSE -> IPPE	H_6	0.015	0.215	**0.829**	Supported but insignificant
GC -> IPPE	H_7	0.418	3.665	**0.000**	Significant and supported

Note: GS = Contractor Grading System, ER = Construction Entry Requirements, GSE = Efficacy of the Grading System, GC = Efficacy of the Grading and Performance Evaluation Criteria, IPPE = Enhanced Contractor Capabilities and Project Performance

Drawing from the results in Table 5.9 above, seven hypotheses were proposed in the study. All hypotheses (H_1, H_2, H_4, H_5, H_6, H_7) were found to be statistically supported (based on the positive or negative effect of the relationship) except for H_3.

Contractor grading system and enhanced contractor capabilities and project performance

H_1: Contractor Grading System has a positive relationship with Enhanced Contractor Capabilities and Project Performance

Upon testing a potential relationship between the Contractor Grading System and Enhanced Contractor Capabilities and Project Performance, findings revealed that Contractor Grading System has a positive effect on Enhanced Contractor Capabilities and Project Performance. In addition, the results indicate that the relationship between Contractor Grading System and Enhanced Contractor Capabilities and Project Performance is marginally positive (β= 0.08, t = 0.71, p = 0.474). Even though a positive correlation is observed between Contractor Grading System and Enhanced Contractor Capabilities and Project Performance, this association is statistically insignificant. At a confidence level of 95%, this positive relationship was deemed insignificant because the t-statistic was less than 1.96. H1 is therefore supported but insignificant.

Contractor Grading System and Construction Entry Requirements

H_2: Contractor Grading System has a positive relationship with Construction Entry Requirements

According to the results of the study, a positive correlation exists between Contractor Grading System and Construction Entry Requirements. Based on an estimate from path modelling, the relationship between these two constructs is the strongest in the proposed model (β=0.768, t=16.335, p=0.000). This indicates a positive correlation between the Contractor Grading System and Construction Entry Requirements. Moreover, at a significance level of 95%, we find a significant relationship between the two variables; this provides sufficient evidence to conclude that the Contractor Grading System positively affects Construction Entry Requirements. H2 is acceptable.

Contractor Grading System and Efficacy of the Grading System

H_3: Contractor Grading System has a positive relationship with the Efficacy of the Grading System

The third hypothesis (H3) is not supported by the data and is deemed statistically insignificant as a result. This positive relationship between Contractor Grading System and Efficacy of the Grading System was found to be significant at the 95% confidence level, with a path coefficient of -0.332 and a t-value of 5.023. The statistical analysis indicates that there is evidence to support the hypothesis that the Contractor Grading

System has a negative effect on the Grading System's Efficacy (β= -0.332; t= 5.023; p= 0.000).

Contractor Grading System and Efficacy of the Grading Criteria

H_4: Contractor Grading System has a positive relationship with Efficacy of the Grading Criteria

According to the findings of the study, there is a positive relationship between Contractor Grading System and Grading Criteria Efficacy. Based on the findings of this study, it can be confirmed that a positive Contractor Grading System can result in a higher Grading Criteria Efficacy. The results demonstrated that the Contractor Grading System affects the Grading Criteria's Efficacy (β=0.659, t=11.288, p=0.000). As estimated by the path modelling, the relationship between these two constructs is the second strongest in the proposed model. Therefore, H4 is supported.

Construction Entry Requirements and Enhanced Contractor Capabilities and Project Performance

H_5: Construction Entry Requirements have a positive relationship with Enhanced Contractor Capabilities and Project Performance

Testing a potential relationship between Construction Entry Requirements and Enhanced Contractor Capabilities and Project Performance revealed that the Contractor Grading System has a positive impact on Enhanced Contractor Capabilities and Project Performance. In addition, the correlation between Construction Entry Requirements and Enhanced Contractor Capabilities and Project Performance is positive and insignificant (β= 0.041, t = 0.530, p = 0.596). Even though a positive correlation is observed between Construction Entry Requirements and Enhanced Contractor Capabilities and Project Performance, this correlation is statistically insignificant. At a confidence level of 95%, this positive relationship was deemed insignificant because the t-statistic was less than 1.96. H5 is therefore supported but insignificant.

Efficacy of the Grading System and Enhanced Contractor Capabilities and Project Performance

H_6: *Efficacy of the Grading System have a positive relationship with Enhanced Contractor Capabilities and Project Performance*

The findings confirm a positive relationship between Efficacy of the Grading System, Enhanced Contractor Capabilities, and Project Performance. In other words, if the greater the Efficacy of the Grading System, the greater the Enhanced Contractor Capabilities and Project Performance (β=0.015, t=0.215, p=0.829), it is clear that despite a positive relationship between the two variables, this relationship is very weak due to the estimated path modelling equal to 0.015. In other words, the Efficacy of the Grading System has less of a positive impact on Enhanced Contractor Capabilities and Project Performance than Construction Entry Requirements and the Efficacy of the Grading Criteria. Moreover, although the results indicate a positive relationship between the Efficacy of the Grading System and Enhanced Contractor Capabilities and Project Performance, this association is statistically insignificant.

Efficacy of the Grading and Performance Evaluation Criteria and Enhanced Contractor Capabilities and Project Performance

H_7: Efficacy of the Grading and Performance Evaluation Criteria have a positive relationship with Enhanced Contractor Capabilities and Project Performance

The relationship between the Efficacy of the Grading and Performance Evaluation Criteria and Enhanced Contractor Capabilities and Project Performance is unavoidably positive, based on the results obtained. Consequently, the Enhanced Contractor Capabilities and Project Performance will be more favourable as the Grading Criteria's effectiveness rises. Further to the path modelling results (β=0.418, t=3.665, p=0.000). In other words, the Efficacy of the Grading and Performance Evaluation Criteria has a substantial and positive effect on the Enhanced Contractor Capabilities and Project Performance. In addition, the results indicate that the relationship between Grading and Performance

Evaluation Criteria and Enhanced Contractor Capabilities and Project Performance is positive and statistically significant. H7 is supported.

5.9.1 Overall analysis of hypotheses testing results

The respective path coefficients for H1, H2, H3, H4, H5, H6 and H7 were 0.089, 0.768, -0.332, 0.659, 0.176, 0.015, and 0.418. These results indicate that, except for H3, all hypothesised relationships have a positive association. The contractor Grading System has the strongest positive relationship with Construction Entry Requirements, as indicated by the path coefficient value of 0.768, whereas the Efficacy of the Grading System to Enhance Contractor Capabilities and Project Performance has the weakest relationship, as indicated by the path coefficient value of 0.015.

5.10 RESULTS AND ANALYSIS CORRELATION ANALYSIS

The Pearson product-moment correlation was calculated using Statistical Package for Social Scientist software (SPSS version 23) to explore the direction, strength, and significance of bivariate relationships of contractor grading system, construction entry requirements, grading and performance evaluation criteria and enhanced contractor capabilities and project performance. Multiple regression analysis was employed to test the hypotheses. Before running these parametric tests, it is appropriate to examine data distribution assumptions of normality. Plots are useful for the validation of the assumption of normality, linearity, equality of variances, detecting outliers, unusual observations, influential cases, and homoscedasticity (Tabachnick & Fidell, 2013).

A scatter plot was used to verify that a relationship is linear to detect outliers, and to graphically depict a relationship. Testing of this assumption is required before analysing data through Pearson product-moment correlation, and multiple regression analysis.

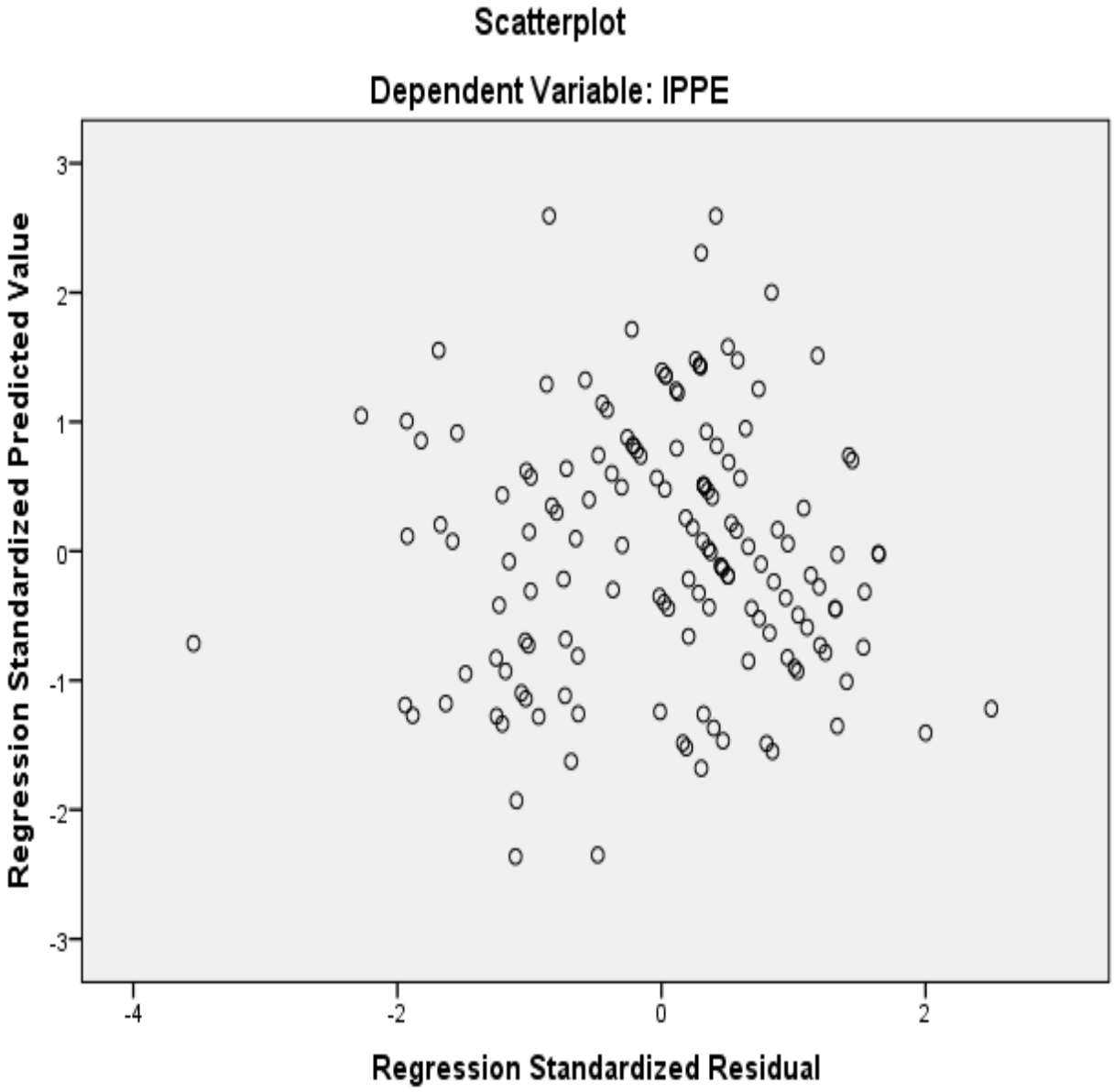


Figure 5.9 Scatter plot of scores

A scatter plot shown in Figure 5.9 depicted linear distribution of data points which implies that there is a linear relationship between the predictors and outcome.

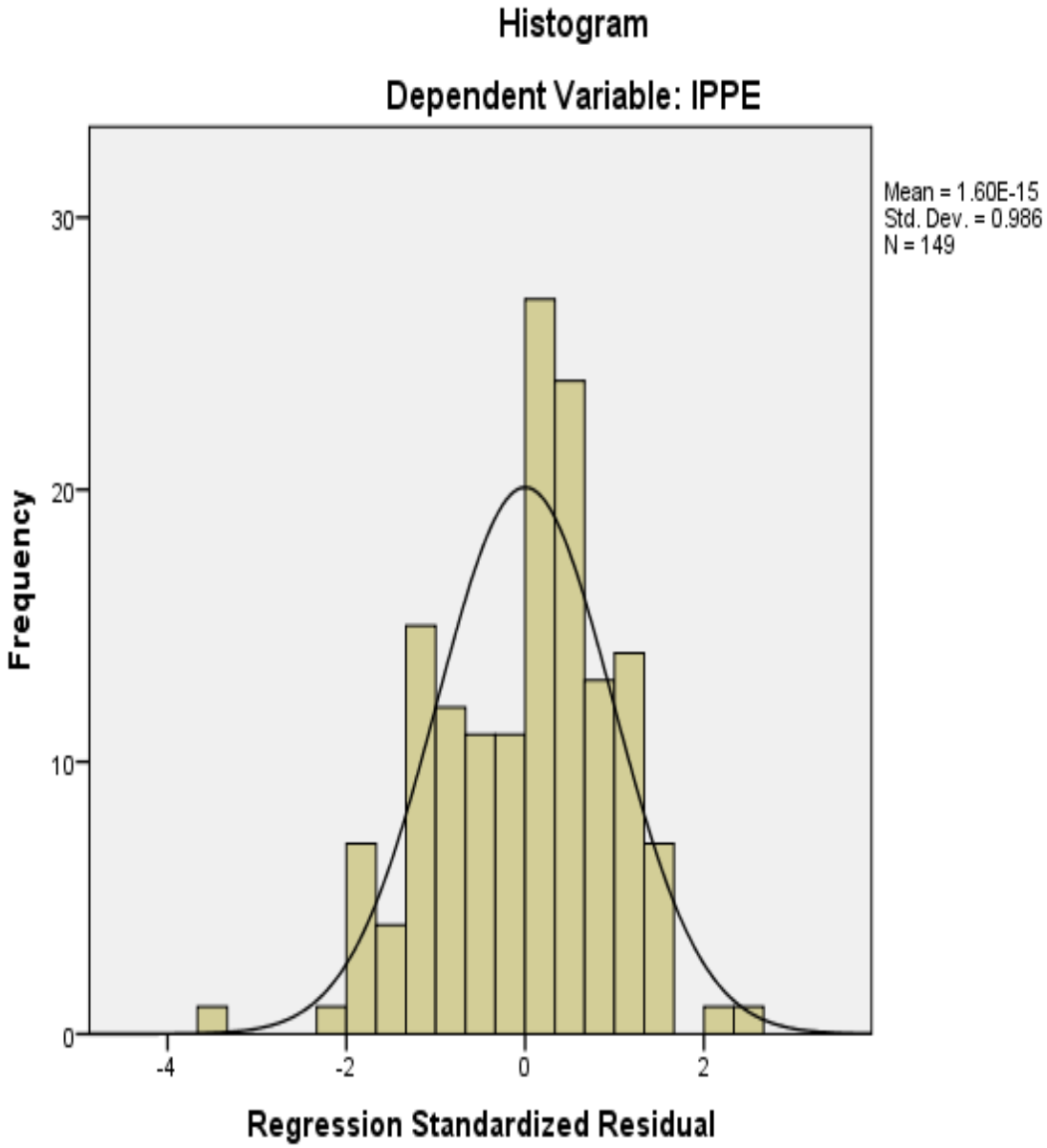


Figure 5.10 Normality of data points

A histogram of residuals shown in Figure 5.10 illustrated a normal distribution of data. A P-P plot of residuals found in Figure 5.11 also indicated that residuals fell close to the straight line, which indicated normality in the population. A violation of unequal variances or linearity does not exist.

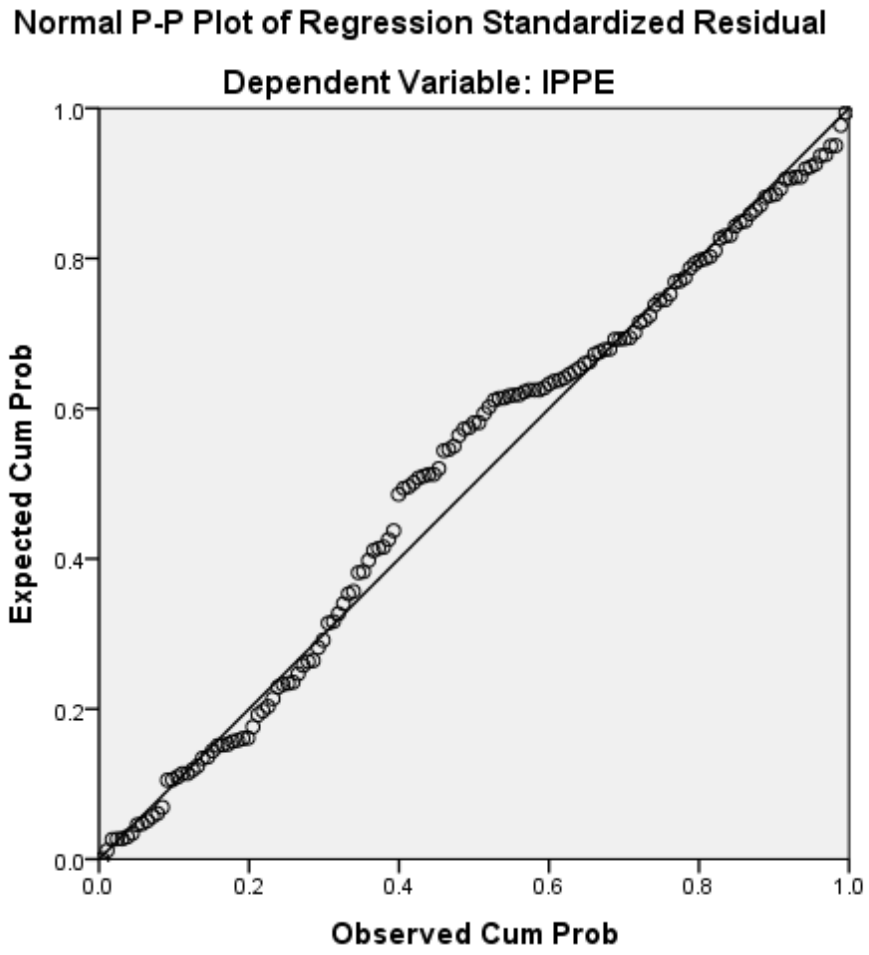


Figure 5.11 Normal P-P plot of regression residuals

Thus, the results of normality tests allow us to proceed with calculating Pearson product-moment correlation and run multiple regression analysis.

5.11 RELIABILITY TEST ASSESSMENT

Cronbach's alpha was utilised to determine the dependability of the scales. Acceptable dependability levels exceed 0.5 (Lobiondo & Haber, 2013; Shuttleworth, 2015). Cronbach's alpha coefficient of dependability was (α=0.638) for Contractor Grading System, (α=0.677) for Construction Entry Requirements, (α=0.682) for Efficacy of the Grading System, (α=0.630) for Efficacy of the Grading and Performance Evaluation Criteria, and (α=0.575) for Enhanced Contractor Capabilities and Project Performance.

Table 5.9 Psychometric properties of the scale

Research constructs	Items	Cronbach's Alpha value α
Contractor Grading System	7	0.638
Construction Entry Requirements	7	0.677
Efficacy of the Grading System	6	0.682
Efficacy of the Grading and Performance Evaluation Criteria	14	0.630
Enhanced Contractor Capabilities and Project Performance	12	0.575

5.12 VALIDITY ASSESSMENT

Table 5.11 illustrates the validity assessment. The validity of the measurement instruments was measured using the correlations between the research constructs as provided below in Table 5.11.

Table 5.10 Inter-construct correlation matrix

Correlations						
Research construct		ER	GS	GSE	GC	IPPE
ER	Pearson	1				
	Sig. (2-tailed)					
GS	Pearson	.709**	1			
	Sig. (2-tailed)	.000				
GSE	Pearson	.095	.157	1		
	Sig. (2-tailed)	.247	.056			
GC	Pearson	.532**	.640**	.355**	1	
	Sig. (2-tailed)	.000	.000	.000		
IPPE	Pearson Correlation	.436**	.384**	.245**	.552**	1
	Sig. (2-tailed)	.000	.000	.003	.000	

Note: GS = Contractor Grading System, ER = Construction Entry Requirements, GSE = Efficacy of the Grading System, GC = Efficacy of the Grading and Performance Evaluation Criteria, IPPE = Enhanced Contractor Capabilities and Project Performance

Correlation describes the degree of association between two variables (Bagozzi & Yi, 2012). When the correlation between two or more variables is high or very strong, it invariably indicates a strong association, whereas a low correlation indicates a weak relationship (Bagozzi *et al.*2012). When a relationship is quantified, the direction and

intensity of the relationship between variables are quantified by a correlation coefficient (Bagozzi *et al.*2012). This coefficient varies from -1 to 1. Importantly, a -1 coefficient implies a perfect negative association, whereas a +1 coefficient reflects a perfect positive relationship (Grace, 2006). The inter-construct correlation coefficients given in Table 5.11 for this study are all less than 1. Therefore, there is discriminant validity.

5.13 INFERENTIAL STATISTICS

The researcher formulated hypotheses to determine the meaning of data to establish whether there is a relationship between the proposed variables. Multiple regression analysis was used to determine whether the Contractor Grading System, Construction Entry Requirements, Efficacy of the Grading System and Efficacy of the Grading and Performance Evaluation Criteria influence Enhanced Contractor Capabilities and Project Performance in the South African construction sector. Multiple regression was performed concerning the following hypothesis and the results are outlined in the tables below:

H0: Contractor Grading System does not predict Enhanced Contractor Capabilities and Project Performance

H1: Contractor Grading System predicts Enhanced Contractor Capabilities and Project Performance

H0: Construction Entry Requirements do not predict Enhanced Contractor Capabilities and Project Performance

H2: Construction Entry Requirements predicts Enhanced Contractor Capabilities and Project Performance

H0: Efficacy of the Grading System does not predict Enhanced Contractor Capabilities and Project Performance

H3: Efficacy of the Grading System predicts Enhanced Contractor Capabilities and Project Performance

H0: Efficacy of the Grading and Performance Evaluation Criteria does not predict Enhanced Contractor Capabilities and Project Performance

H4: Efficacy of the Grading and Performance Evaluation Criteria predicts Enhanced Contractor Capabilities and Project Performance

In Table 5.12, the model shows an R^2 value of 0.343, indicating that 34% of the variance of the dependent variable being studied in this research which is to develop a framework which will assist in Enhancing Contractor Capabilities and Project Performance is explained by the independent variables.

Table 5.11 Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.586[a]	.343	.325	.79201

a. Predictors: (Constant), GC, GSE, ER, GS
b. Dependent Variable: IPPE

Table 5.13 findings demonstrate that F=18.804 had a significant p-value of 0.000. There is no association between the dependent and independent variables, and vice versa, if the p-value associated with the f-statistic equals or is larger than 0.05. Given the aforementioned statistic, the p-value is less than 0.05, indicating that the model is significantly more accurate than the mean value in forecasting Enhanced Contractor Capabilities and Project Performance.

Table 5.12 Anova[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	47.180	4	11.795	18.804	000[b]
	Residual	90.328	144	.627		
	Total	137.508	148			

a. Dependent Variable: IPPE

b. Predictors: (Constant), GC, GSE, ER, GS

Table 5.13 The results of regression analysis

Independent Variables	Standardized Bet	t-statistics	Sig	Collinearity Statistics	
				Tolerance	VIF
Techno-overload	-.103	-.966	.336	.401	2.496
Techno-complexity	.262	2.697	.008	.485	2.064
Techno-invasion	.076	1.045	.298	.861	1.162
Techno-uncertainty	.452	4.783	.000	.510	1.960
R Square	.343				
F	18.804				
Sig. of F value	.000				
Durbin Watson	2.094				

Given this data as indicated in Table 5.13, it can be concluded that the model is accurate and useful for forecasting Enhanced Contractor Capabilities and Project Performance.

5.14 DISCUSSION OF RESULTS

Table 5.12 shows multiple regression analysis between independent variables and dependent variables. The result showed that the value for R^2 is .343, in which all independent variables which are Contractor Grading System, Construction Entry Requirements, Efficacy of the Grading System, and Efficacy of the Grading and Performance Evaluation Criteria explained 70.7% of the variance (R square) in Enhanced Contractor Capabilities and Project Performance, with Sig. of F value of .000. Besides, the value for Durbin Watson was 2.094 which is the range of 1.5 to 2.5 as fulfilling one of the accepted assumptions for bivariate and multivariate correlation analyses.

H_1: Contractor Grading System and Enhanced Contractor Capabilities and Project Performance

Based on the results, there is a low relationship between the Contractor Grading System and Enhanced Contractor Capabilities and Project Performance, with a beta value of -0.103, and an insignificant p-value of 0.336. The null hypothesis, according to which the Contractor Grading System does not predict Enhanced Contractor Capabilities and Project Performance, is thus confirmed. In addition, these results also indicate that for every 1-unit increase in the Contractor Grading System, there is a

corresponding -.103 units increase in Enhanced Contractor Capabilities and Project Performance.

H_2: Construction Entry Requirements and Enhanced Contractor Capabilities and Project Performance

According to the findings in Table 5.14, Construction Entry Requirements have a negative effect on Enhanced Contractor Capabilities and Project Performance with a beta value of 0.262 and a significant p-value of 0.008. The results of the statistical analysis showed that Enhanced Contractor Capabilities and Project Performance were proven to be influenced by Construction Entry Requirements, or in other words, Hypothesis 2 was accepted. The null hypothesis, according to which Construction Entry Requirements do not predict Enhanced Contractor Capabilities and Project Performance, is thus rejected. Additionally, these findings show that there is a .262-unit increase in Enhanced Contractor Capabilities and Project Performance for every unit increase in Construction Entry Requirements.

H_3: Efficacy of the Grading System and Enhanced Contractor Capabilities and Project Performance

The findings show that the Efficacy of the Grading System has a positive but insignificant influence on Enhanced Contractor Capabilities and Project Performance, with a beta value (β=.076, p=.298). The null hypothesis, which claims that the Efficacy of the Grading System does not predict Enhanced Contractor Capabilities and Project Performance, is thus confirmed. In addition, these results also indicate that for every 1-unit increase in Efficacy of the Grading System, there is a corresponding .076 units increase in Enhanced Contractor Capabilities and Project Performance.

H_4 Efficacy of the Grading and Performance Evaluation Criteria and Enhanced Contractor Capabilities and Project Performance

According to the results of statistical analysis, there is a positive relationship between Efficacy of the Grading Criteria and Enhanced Contractor Capabilities and Project Performance with the beta value (β=.452, p=.000. The null hypothesis, which claims

that Efficacy of the Grading Criteria does not predict Enhanced Contractor Capabilities and Project Performance, is thus rejected. In addition, these results also indicate that for every 1-unit increase in Efficacy of the Grading Criteria, there is a corresponding .452 units increase in Enhanced Contractor Capabilities and Project Performance.

To summarise the results using a model, the model of the study can be presented as shown in Figure 5.12

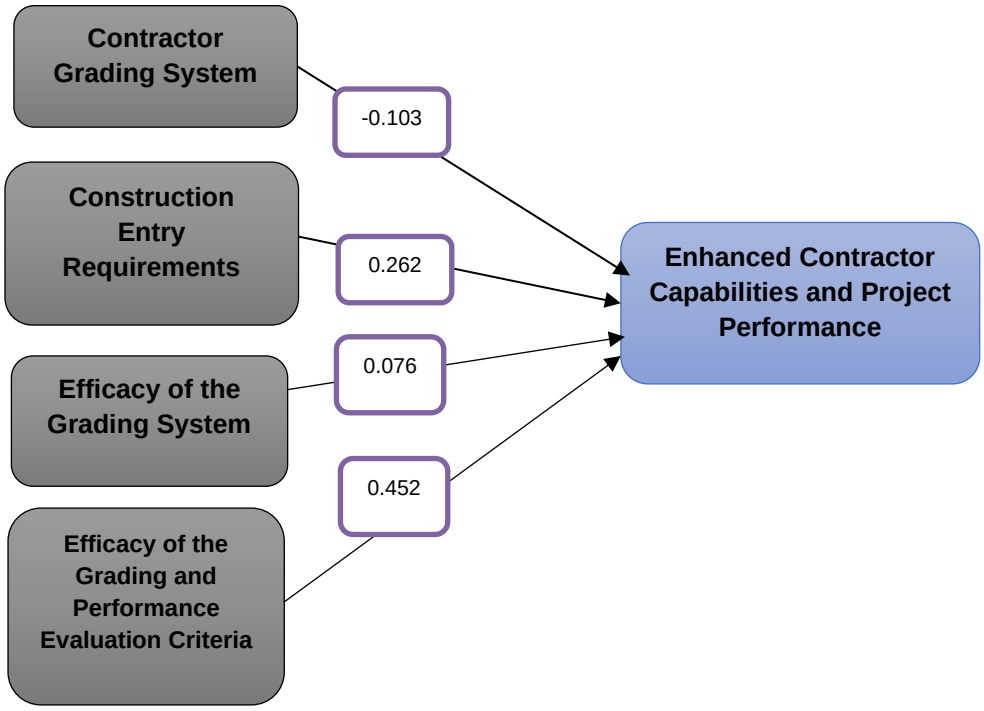


Figure 5.12 The research model with beta coefficients

The model of the study indicates that Efficacy of the Grading and Performance Evaluation Criteria highly influences Enhanced Contractor Capabilities and Project Performance given a positive beta coefficient of 0.452 followed by Construction Entry Requirements and Efficacy of the Grading System with a positive beta coefficient of 0.262 and 0.076 respectively. Contractor Grading System negatively influences Enhanced Contractor Capabilities and Project Performance, given a beta coefficient equal to -0.103. An efficient

contractor grading system will have a positive influence on enhanced contractor capabilities as compared to a contractor grading system which is not efficient.

5.15 PARTICIPANTS THOUGHTS AND COMMENTS ABOUT THE STUDY

The last section of the questionnaire asked participants whether they thought that the proposed study would be useful for the construction sector. Figure 5.13 depicts the feedback from respondents.

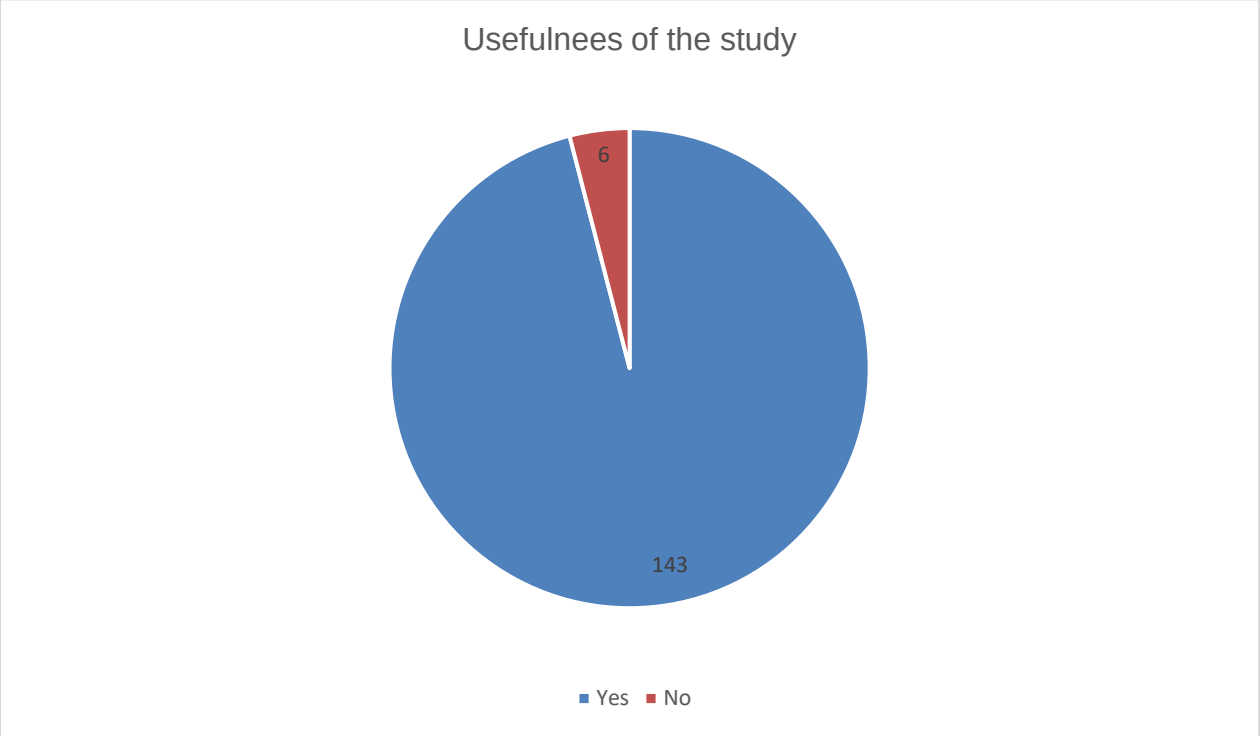


Figure 5.13 Usefulness of the study for the construction sector

Figure 5.13 shows that 143 (96%) of the respondents have indicated that the study would be useful for the construction sector and 6 (4%) have responded that the study will not be useful. Participants were also requested to provide reasons for their thoughts about the usefulness of the study for the construction sector. The responses differed but overall, they were positive in terms of the study's contribution to the construction sector. One respondent has indicated that "the current CIDB grading system does not work and needs to be enhanced".

It was also indicated that the current CIDB grading criteria need vast improvement to ensure quality projects and the sustainability of the construction sector. It was noted that the CIDB grading is too simple in the current form and that the study would assist in influencing the decision of the CIDB and the ministerial committee to amend the CIDB criteria for upgrading contractors.

Moreover, it was indicated that the study is useful for the construction industry because it will help to:

- Establish an effective construction industry;
- Establish effective localised contractors;
- Improve the attractiveness of the industry;
- Provide a sound base for the implementation of a wide range of infrastructure projects;
- Provide confidence in the sustainability of the infrastructure and;
- Build a sustainable support industry.

One respondent indicated that the study would assist in finding better criteria, however, the questions posed in the questionnaire are dealt with in the tender evaluation process. It should be noted that public sector organisations are given the liberty to determine the scope of works and evaluation criteria for each construction project which they implement. However, it remains the responsibility of the CIDB as indicated in Section 4 of the CIDB Act (no 38 of 2000) to ensure that the construction sector provides strategic leadership that stimulates sustainable growth, reform, and improvements of the construction sector. Moreover, the CIDB ought to determine and establish the best practice that promotes improved industry stability, performance, efficiency, and effectiveness as well as public sector delivery management.

It was also indicated that improvement is required to have competent contractors. A scenario was also cited by a respondent indicating that they had “a Resident Engineer on a construction project wherein there was no knowledge and experience on basic concrete construction for a project which was awarded. It is important that contractors are correctly vetted at the CIDB level before a grading is granted”.

Concern was also raised that many contractors experience difficulties and end up in business rescue or being liquidated. This was cited as a lack of experience, financial capacity, and technical control. Again, relevant training, health and safety, and management capability were cited as important criteria for consideration. This indicates that experience, technical and financial capability, health and safety, and technical capacity are key criteria for consideration when grading contractors.

It was indicated that the construction industry is struggling with non-performance and quality of workmanship due to corruption and the study could assist in enhancing appropriate contractor selection. Moreover, it was hinted that the grading system is an important tool that is used by clients, owners, and consumers and therefore requires scrutiny to ensure relevance, quality, and effectiveness in meeting its goals. The findings of the study would therefore serve as valuable input to the CIDB.

An emphasis was made on considering criteria other than financial capacity, such as timely completion of projects, scope adherence (quality), management of the project and cost, number of projects a contractor can handle based on available resources, past performance as well as contractors' good standing with law enforcement. It was indicated that the study will help in ensuring that qualifying contractors are awarded projects. A respondent indicated that they "have personally seen gaps in contractors that have the grading, but they cannot perform the work".

Another respondent indicated that they "have been involved in several construction projects where the contractor is inexperienced, lacks finances, and yet has the CIDB grading to carry out the work". Because of this, the contractor ends up being liquidated or terminated by the client due to a lack of ability to conduct the work. The gaps in the construction sector were also noted to hamper service delivery and utilisation of funding effectively and as such, the evaluation criteria require to be reviewed regularly to ensure industry relevance to industry norms and standards.

Other respondents indicated that if the study were considered by the CIDB and public works, it would be beneficial to the construction sector, and it could assist in improving construction performance. Again, a concern was noted by a respondent indicating that the “contractors get into a higher grade than earned and fail to perform”. The study will help in addressing the current gaps at the CIDB which will require amendments resulting in competent contractors at various grades.

A need to conduct research was seen in the construction sector, which will assist in formulating solutions for the current challenges the industry is facing especially with contractors’ growth, development, and performance. This was further indicated as a way to unleash the construction sector’s potential for economic growth and development and to professionalise the construction sector. It was further indicated that the entry requirements should be restricted to technical people and that N6 should be a minimum qualification. A firmer approach to entry and the advancement of the contractor grading based on technical, managerial, and financial ability in the context of experience gained on successful projects was also proposed.

There seems to be distrust in the current CIDB grading system; one respondent cited that “there are many contractors with high CIDB gradings which are dubious and are failing the construction sector, hence the need to improve the registration and grading of contractors”. Another respondent indicated that “the present system is rife with nepotism and corruption”. The current grading system was indicated to have flaws and a debate on overhauling the grading system was overdue as the current grading system is not providing the desired results. It was further indicated that the current CIDB grading system is useful and could be revised however, it should not be overly complicated.

It was indicated that the current CIDB system does not consider the capabilities of the contractors which results in failed projects. A need to analyse the failures was considered to be important because there are too many inexperienced contractors being granted contractor grading causing project delays, failures, and state financial losses. Professional development was noted as an area that is critical and requires to be

prioritised because project performance is determined by the management of the project on-site. A need to provide adequate skill for the emerging contractors was noted.

The evaluation criteria were noted to be unclear which is then used to extort money from contractors due to unclear requirements. The study will help the CIDB with clear scoring for contractors and enhance contractors' knowledge about the construction sector. A constant review of the grading system was noted as the need to improve the grading system always.

It was indicated that the study will assist in evaluating the progression of the construction industry because it will help in improving the quality of performance outputs and growing contractors' business. Moreover, the study will help to improve the grading system, and contractor performance, gather information, implement necessary measures, and enable opportunities for improvement in the construction sector.

A concern was noted that the performance of the contractors is not a true reflection of the contractor's grade. In some instances, contractors subcontract all the work to another entity and then get the CIDB grading which is not a true reflection. Also, contractors who have a CIDB grade above 5 should require such companies to appoint a professional person to avoid poor quality and project performance outputs. This indicates a need to conduct due diligence during the assessment of contractors before grading can be granted to a contractor.

5.16 CHAPTER SUMMARY

This chapter provides results, analysis, and discussion from the questionnaire which was conducted with the members of the South African Institution of Civil Engineering, Construction Industry Development Board Civil Engineering Contractors and members of the South African Council for Project and Construction Management Profession. Data were analysed using the Structural Equation Modelling Approach and Statistical Package for Social Scientist software. The validity and reliability of the questionnaire were confirmed. The results further indicated that having construction sector entry

requirements, an efficient grading system and criteria will result in enhanced contractor capabilities and project performance.

CHAPTER 6 MULTI-CRITERIA ANALYSIS FOR CONTRACTOR GRADING AND PERFORMANCE EVALUATION

6.1 INTRODUCTION

Chapter 4 described the details of the theory of the Analytical Hierarchy Process (AHP) and Chapter 5 solicited inputs through questionnaires from the construction sector role players to assist in the determination of relevant grading criteria, entry requirements and contractor project performance evaluation. This chapter therefore describes a step-by-step approach to the application of the AHP model for decision-making in the process of contractor grading and performance evaluation using relevant contractor grading and performance evaluation criteria which were sought through a literature review and state-of-practice survey.

6.2 PROGRAMME FOR THE ANALYTICAL HIERARCHY PROCESS

The Microsoft Excel spreadsheet-based software programme was used to calculate the criteria priority vectors, and project priority vectors, check the consistency of pairwise comparisons and produce the overall ranking of alternatives. The Microsoft Excel spreadsheet-based programme was set up using the principle of the Analytical Hierarchy Process. The programme's decision framework, the structure plan for the programme and the input and output data requirements are presented in the following sub-sections.

6.2.1 Overview of the programme's decision framework

The criteria and sub-criteria ultimately adopted were formulated in this project and informed by the literature and state of practice survey. The selection process for criteria and sub-criteria entailed a search of factors that a contractor should possess.

6.2.2 Structure plan for making judgement

In order to obtain the overall ranking of the policy alternatives, the following steps were performed:

- The research goal was stated, and then the main criteria and sub-criteria that govern the goal were identified.

- Based on the literature review, results from the questionnaire and discussions with industry experts, a decision was made on policy alternatives and a hierarchy of the decision criteria, sub-criteria, and alternatives with clear definitions of all elements were structured.

- Thereafter, criteria were prioritised by the three industry experts (civil engineering professional engineers) with respect to their impact on the overall goal and the sub-criteria with respect to their criteria.

- Pairwise comparisons for the criteria were performed with the industry experts with reference to the AHP scale for pairwise comparisons. Subsequently, a comparison matrix was formed and priority vectors (Pm) for the comparison matrix were calculated. The consistency of the pairwise comparison matrices was checked.

- Pairwise comparisons for the sub-criteria were performed with reference to the AHP scale and a comparison matrix formed and priority vectors (Ps) for the comparison matrix calculated. The consistency of the pairwise comparison matrices was checked.

- Relative weights of the options with respect to each sub-criterion were derived by pairwise comparisons of the options to give project priority vectors and consistency was checked.

- Project priority vectors for each sub-criterion were accumulated to form a matrix that was then multiplied by sub-criteria priority vectors Ps to obtain the project priority vector (S) showing the ranking of options with respect to each of the main criteria.

- To obtain the overall ranking, project priority vectors (S) for each criterion were accumulated to form the overall priority matrix (E) that was then multiplied by criteria priority vectors (Pm) to obtain the overall ranking (V).

6.2.3 Programme input

Data input requirements are as follows:

- The structure of the hierarchy, the policy alternatives, decision criteria and sub-criteria.
- Pairwise comparison results based on the AHP scale.

6.2.4 Programme output

Output data are as follows:

- Comparison matrices and priority vectors for decision criteria and sub-criteria.
- Overall ranking of alternatives for contractor grades.

6.3 MODEL APPLICATION

The AHP was applied in decision-making to assist in contractor grading considering qualitative and quantitative criteria. The goal is to grade contractors by assessing contractors' performance concerning the criteria. The requirement for contractors increases as the contractor progresses to higher grades.

6.3.1 Hierarchical representation of the system

The hierarchical structure for the contractor grading developed for this study is presented in Figure 6.1.

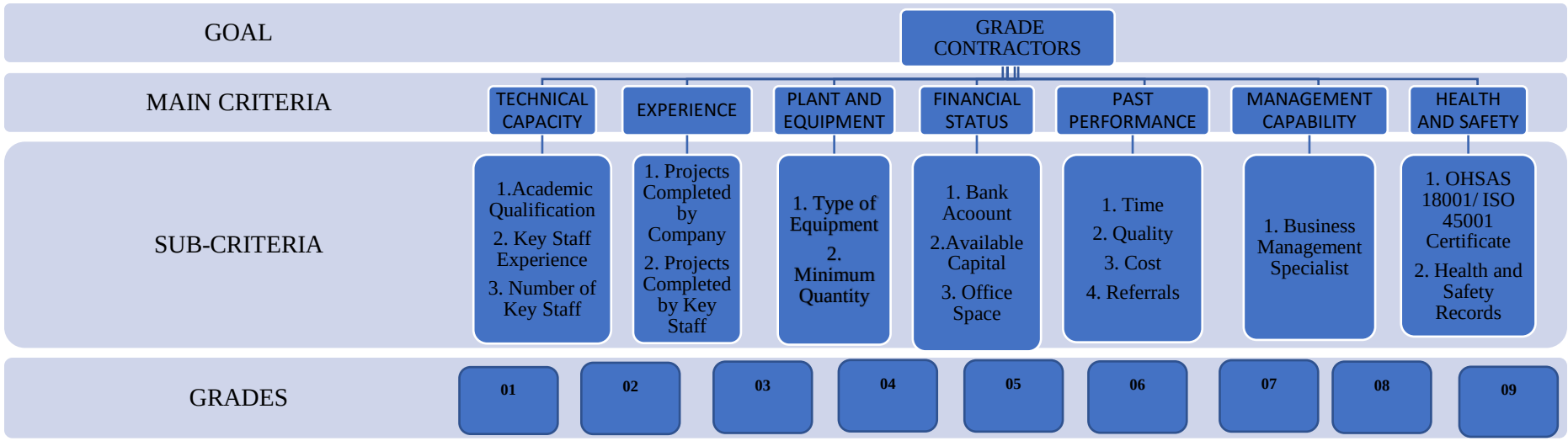


Figure 6.1 AHP for grading contractors

The top level indicates that the overall goal is to grade contractors. A contractor grade needs to provide a true reflection of the contractor's capabilities. The second level shows the seven main criteria (technical capacity, experience, plant and equipment, financial status, past performance, management capability, and health and safety). The third level shows sub-criteria against which each option is evaluated.

6.3.1.1 Evaluation criteria

According to Kalbar *et al.* (2012), a common sequence for assessment of a proposed development is to consider technological feasibility, economic consequences, and other impacts such as environmental/ecological, political, and social/cultural factors. The selected criteria should characterise all the aspects of the alternatives to be evaluated.

For this study, technical capacity, experience, plant and equipment, financial status, past performance, management capability, and occupational health and safety were selected as the main criteria for contractor grading and building toward the development of the contractor grading framework which is in Chapter 7.

6.3.1.2 Evaluation of sub-criteria

Technical capacity criteria are defined as the contractor's ability to demonstrate that they have the technical capability to perform the activities of the specific project for which they are seeking the grading. Experience criteria consider the contractor's experience considering participation in other previous projects. Table 2.5 in Chapter 2 indicates the various sources for key criteria in contractor performance.

Financial status considers the contractor's available capital, office space, and business account, and plant and equipment criteria consider the contractor's plant and equipment and the quantity. Considering the past performance of each contractor, CIDB will have a higher or lower degree of confidence in the possible contractor regarding the project management of the contractor which includes quality, time, and cost control requirements. CIDB must collect and analyse information about the contractor's past relationship with other entities for which the contractor has executed construction works. After considering

the contractor's performance, the Construction Industry Development Board must be able to decide on the performance of the contractor.

In terms of management capability, the contractor must demonstrate that it has the business management capacity and number of managerial staff with relevant business-related qualifications and skills to contribute to the sustainability of the business. Over and above these criteria, the CIDB must consider occupational health and safety to establish and maintain effective systems and manage the risks to the OHS of employees arising from construction work. A criterion that is not included is reputation because it may be highly subjective and a contractor who performs well in the set of criteria that are included in this model is likely to be considered to have a good reputation.

6.4 ESTABLISHING PRIORITIES USING THE ANALYTICAL HIERARCHY PROCESS

The first step after developing a hierarchy is to compute the weights for each criterion and sub-criterion. The decision-makers must apply judgment by obtaining the relative importance of each criterion about the overall goal of grading contractors. Thereafter, judgment must be applied by obtaining the relative importance of each sub-criterion about the main criteria.

6.4.1 Pairwise comparisons for the main criteria (level 1)

A pairwise comparison matrix A is created using the AHP scale in Table 9.1 (see Appendix M for all Chapter 6 tables). The AHP scale articulates the importance of one criterion relative to another. The AHP scale has been validated for effectiveness, not only in many applications by various researchers but also through theoretical comparisons with many other scales (Saaty,1989). When developing matrix A, the question that the author and the industry expert asked was: "Of the two criteria being compared, which criterion is considered more important with respect to the overall goal of contractor grading". This also takes into consideration the literature reviewed and results from the survey. Details of paired comparisons for the main criteria are shown in Table 9.2.

6.4.1.1 Comparison matrix for level 1

The comparison matrix for level 1 involved pairwise comparisons between the seven main criteria. The comparison matrix is shown in Table 9.3. Technical capacity criteria are of weak, strong, very strong and extreme importance relative to the experience, plant and equipment, financial status, past performance, management capability and occupational health and safety criteria, thus it took the numerical values 3, 5, 7 and 9 respectively.

Experience criteria are of weak, strong, and very strong importance relative to the plant and equipment, financial status, past performance, management capability and occupational health and safety criteria, hence it took the numerical values 3, 5 and 7 respectively. Plant and equipment are of weak importance relative to the management capability; hence it took the numerical value 3. Financial status is of weak and strong importance relative to plant and equipment and management capability; hence it took numerical values 3 and 5 respectively.

Past performance criteria are of weak, strong, and very strong importance relative to the plant and equipment, financial status, management capability, and occupational health and safety criteria, hence it took the numerical values 3, 5 and 7 respectively. Past performance and experience criteria are of equal importance; hence it took numerical value 1. Occupational health and safety criterion is of weak and strong importance relative to plant and equipment, financial status, and management capability criterion, hence it took the numerical value of 3 and 5 respectively.

6.4.1.2 Computation of the Vector of Priorities for contractor grading

The priority of each criterion in relation to the overall goal of contractor grading is calculated using the pairwise comparison matrix A in Table 9.3. The vector of priorities was worked out as described in Chapter 4. Table 9.3 shows the normalised comparison matrix (Matrix B), and the main priority vector is [0.380, 0.199, 0.038, 0.071, 0.199,0.023, 0.090] for technical capacity, experience, plant and equipment, financial status, past performance, management capability and occupational health and safety issues respectively. The obtained priority vector indicates that the technical capacity criterion is

the most important followed by the experience and past performance criterion then occupational health and safety, financial status, plant, and equipment and lastly, the management capability criterion. Figure 6.2 depicts the weights for the main criteria using equation 1-3 (as indicated in Chapter 4):

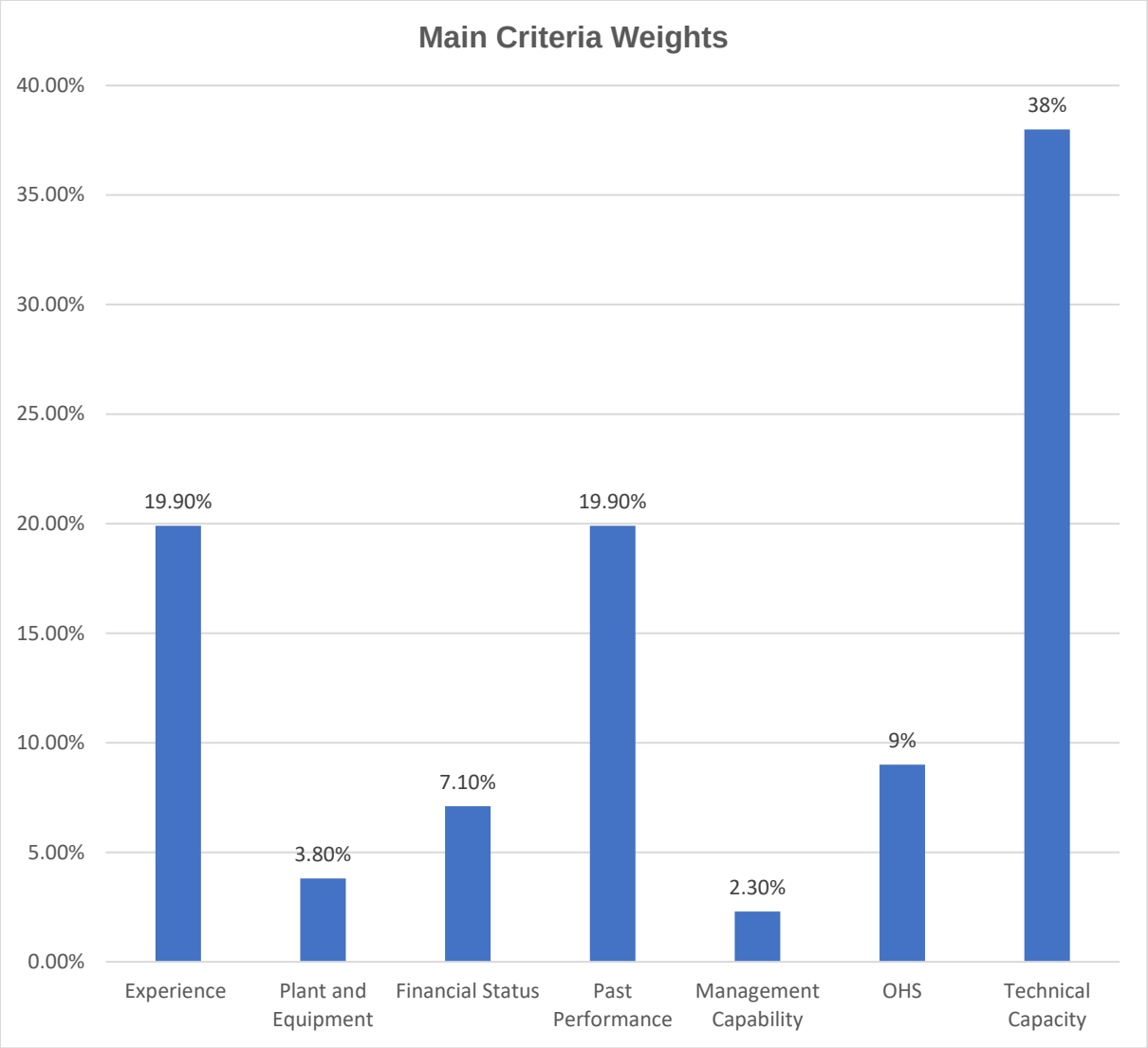


Figure 6.2 Main criteria weights

6.4.1.3 Consistency

The AHP makes provision for checking inconsistencies that may arise when performing a lot of pairwise comparisons. This is done by calculating the consistency ratio (CR) as described in Chapter 4. A consistency ratio greater than 0.1 indicates inconsistency,

therefore, if obtained, the comparisons will need to be checked and revised. Table 9.3 shows calculations for the main criteria comparison matrix consistency ratio. The product of the comparison matrix (Matrix A) and the priority vector (Pm) [0.380, 0.199, 0.038, 0.071, 0.199,0.023, 0.090], gave column vector (X) [2.99, 1.61, 0.27, 0.52, 1.61, 0.17, 0.69] (Equation 11). The elements of column vector (X) were then divided by the corresponding elements of the priority vector (Pm) and gave another column vector (X1) [7.88, 8.10, 7.11, 730, 8.10, 7.29, 7.65.] and the average of values obtained for X1 gave the maximum eigenvalue as 7.63 (Equation 10).

The consistency index (CI) was calculated as (7.63 – 7)/ (7 – 1) = 0.011 (Equation 7). To determine consistency, the consistency index was divided by the random index (RI). The random index for n = 7 is 1.32 (Table 9.4). The consistency ratio (CR) of 0.080 was obtained. Therefore, the pair-wise comparison judgements are consistent and acceptable because the consistency ratio is less than 0.1. A consistency ratio greater than 0.1 means that the judgements are not consistent.

6.4.2 Pairwise comparisons for the sub-criteria (level 2)

The procedure in sub-section 6.4.1 was repeated for level 2. Pairwise comparisons matrix A for sub-criteria were carried out.

6.4.2.1 Comparison matrix for level 2

The comparison matrix for level 2 involved pairwise comparisons between the sub-criteria in relation to each main criterion. Priority vectors (Ps) for each main criterion were obtained by assessing the weight of each sub-criterion in terms of its contribution to the respective criteria. The pairwise comparison matrices and priority vectors are shown in Tables 9.5 to 9.8. Technical capacity criterion has three sub-criteria which are academic qualifications, key staff experience, and number of key staff. Academic qualifications are of moderate and have a strong importance relative to key staff experience and a number of key staff, hence the numerical values 3 and 5 respectively. The weights obtained were 0.633, 0.260 and 0.106 for academic qualifications, key staff experience and a number of key staff respectively (Table 9.5).

The maximum eigenvalue is 3.04, and the consistency index (CI) was calculated as (3.04 – 3)/ (3 – 1) = 0.02 (Equation 7). To determine consistency, the consistency index was divided by the random index (RI). The random index for n = 3 is 0.58 (Table 9.4). A consistency ratio (CR) of 0.033 was obtained. Therefore, the pair-wise comparison judgements are consistent and acceptable because the consistency ratio is less than 0.1.

Experience criterion has two sub-criteria which are projects completed by the company and projects completed by key staff. Key staff experience is of very strong importance relative to projects completed by the company hence the numerical value 7 respectively. The weights obtained were 0.125 and 0.875 for projects completed by the company and projects completed by key staff respectively. The maximum eigenvalue, the consistency index (CI) and the consistency ratio (CR) were not calculated since the matrix elements are less than three for the experience criterion (Table 9.6).

Plant and equipment criterion has two sub-criteria which are plant and equipment and minimum quantity. Equipment type is of strong importance relative to minimum quantity hence the numerical value 5. The weights obtained were 0.833 and 0.167 for equipment type and minimum quantity respectively. The maximum eigenvalue, the consistency index (CI) and the consistency ratio (CR) were not calculated since the matrix elements are less than three for the experience criterion (Table 9.7).

The financial status criterion has three sub-criteria which are a bank account, available capital, and office space. Available capital is of very strong and strong importance relative to key bank account and office space hence the numerical values 5 and 7 respectively. The weights obtained were 0.083, 0.724 and 0.193 for bank account, available capital, and office space respectively (Table 9.8).

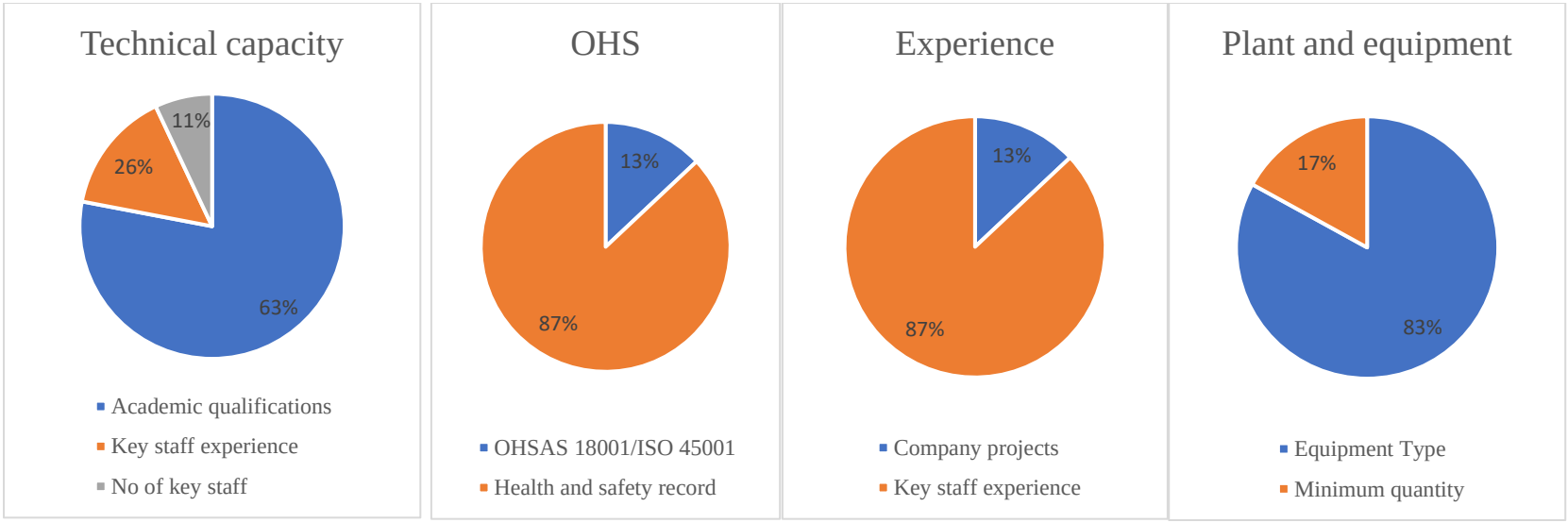
The maximum eigenvalue is 3.07, the consistency index (CI) was calculated as (3.07 – 3)/ (3 – 1) = 0.03 (Equation 7). To determine consistency, the consistency index was divided by the random index (RI) (Equation 8). The random index for n = 3 is 0.58 (Table 6.4). The consistency ratio (CR) of 0.057 was obtained. Therefore, the pair-wise

comparison judgments are consistent and acceptable because the consistency ratio is less than 0.1.

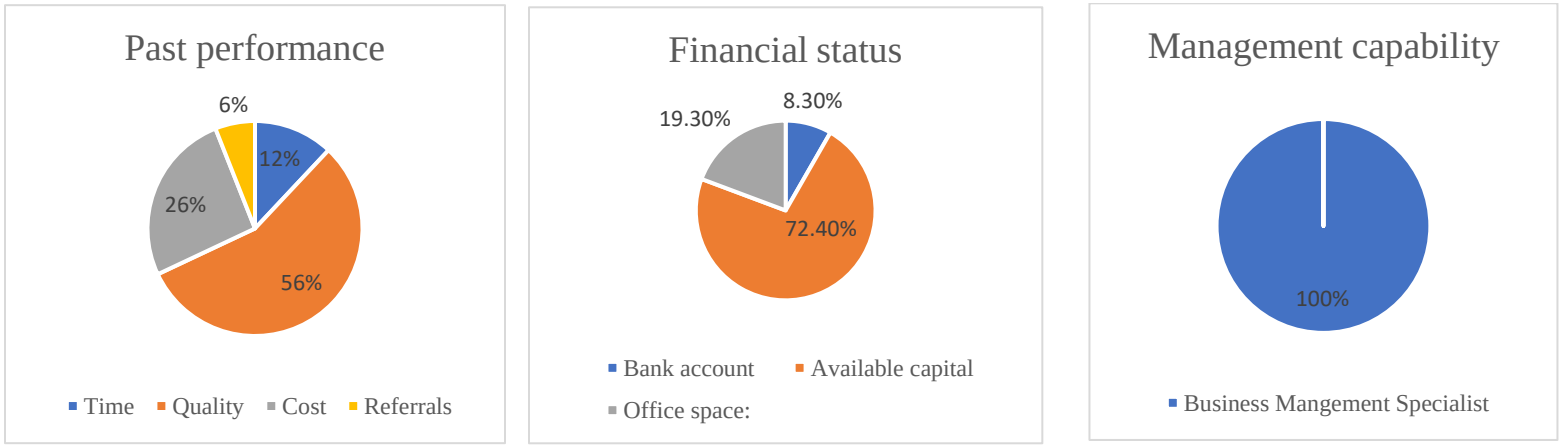
The past performance criterion is subdivided into four sub-criteria which are time, quality, cost, and referrals. Quality is of weak, strong, and very strong importance relative to time, cost, and referrals, hence the numerical values 3, 5, and 7 respectively. Cost is of weak and strong importance relative to time and referrals thus the numerical value of 3 and 5 respectively. Time is of weak importance relative to referrals hence it has a numerical value of 3. The priority vector obtained was [0.122, 0.558, 0.263, 0.057] for time, quality, cost, and referrals respectively. The maximum eigenvalue of 4.12 was obtained, the consistency index (CI) of 0.04, and a consistency ratio (CR) of 0.044 were obtained. Therefore, the pair-wise comparison judgments are consistent and acceptable (Table 9.9).

Management capability criterion has one sub-criterion which is business management specialist, hence the numerical value of 1. The priority vector obtained was [0.100]. The maximum eigenvalue, the consistency index (CI), and consistency ratio (CR) were not calculated since the matrix elements are less than three for the management capability criteria (Table 9.10).

Occupational Health and Safety criterion has two sub-criteria which are Occupational Health and Safety certificate (OHSAS 18001/ISO 45001) and health and safety records. Health and safety records is of very strong importance relative to the occupational health and safety certificate hence the numerical value 7. The priority vector obtained was [0.125, 0.875] for occupational health and safety certificate and health and safety record respectively. The maximum eigenvalue, the consistency index (CI), and consistency ratio (CR) were not calculated since the matrix elements are less than three for the occupational health and safety criteria (Table 9.11). Figure 3 depicts the sub-criteria weight.



(a) Weights for techical capacity sub-criteria (b) Weights for experience sub-criteria (c) Weights for plant and equipment sub-criteria (d) Weights for OHS sub-criteria



(e) Weights for past performance sub- creiteria (f) Weights for financial status sub-criteria (g) Weights for management capability sub-criteria

Figure 6.3 Sub-criteria weights

6.5 PAIRWISE COMPARISON FOR LEVEL 3

At level 3 of the hierarchy, a priority vector for sub-criteria (academic qualifications, key staff experience, number of key staff, projects completed by key staff, projects completed by company staff, type of equipment, minimum quantity, bank account, available capital, office space, time, quality, cost, referrals, business management specialist, occupational health and safety certificate and health and safety records) was obtained. None of the sub-criteria is further subdivided into any other parameter therefore the priority vectors for each sub-criterion have a weight of 1.

Matrices of pairwise comparisons for the alternatives relative to each sub-criterion were formed to obtain the relative weight of the options for each of the sub-criteria. Before forming matrices for each policy alternative sub-criteria assessment for each option was conducted. Tables 9.32 to 9.38 illustrate the summaries of the sub-criteria assessments, respectively.

6.6 COMPOSITE VECTOR PRIORITIES

To obtain the vector of composite priorities for the sub-criteria as indicated in Tables 9.12 to 9.28, the weights of the options relative to each sub-criterion were combined into matrix B (Equation 2). Equation 3 was then applied to obtain project priority vectors. The project priority vectors were multiplied by the priority vector for academic qualifications [0.777] to obtain composite priorities [0.111, 0.111, 0.111,0.111,0.111,0.111,0.111,0.111,0.111]. All composite priorities for the rest of the sub-criteria were determined the same way.

Figure 6.2 shows a graphical presentation of the overall priority matrix ratings for each option/grade. Option 9 has the highest rating while Option 1 has the lowest rating. As the grading options increase, the requirements become steeper in terms of the academic qualifications, key staff experience, number of key staff, projects completed by the company, projects completed by key staff, type of equipment, minimum quantity, available capital, business management specialist and occupational health and safety.

The sub-criterion academic qualifications, bank account, occupational health and safety certificate have equal importance on all the options/grades. The sub-criterion for projects completed by the company, number of projects completed by company, time, quality, cost, referrals, health, and safety records have equal importance from options 2 to 9. This is so as option 1 is an entry option thus these sub-criteria will not be applicable for entry requirements (projects completed by company, number of projects completed by company, time, quality, cost, referrals, health, and safety records).

Over and above these criteria which are not applicable for option 1 are available capital, office space, type of equipment as well as minimum quantity. Thus, the criteria which are relevant for option 1 are academic qualifications, number of key staff, bank account and occupational health and safety certificate.

To obtain the project priority vectors for the main criteria at level 2 of the hierarchy, the sub-criteria composite priorities for each criterion were combined into a priority matrix for the criteria as indicated in Table 9.29. The composite priorities for academic qualifications, key staff experience, and a number of key staff were combined into a priority matrix for technical capacity criterion. The composite priorities for projects completed by the company and projects completed by key staff were combined into a priority matrix for experience criterion. The composite priorities for the type of equipment and minimum quantity were combined into a priority matrix for plant and equipment criterion.

The composite priorities for bank account, available capital and office space were combined into a priority matrix for financial status criterion. The composite priorities for time, quality, cost, and referrals were combined into a priority matrix for past performance. The composite priority for business management specialists became the priority matrix for management capability. The composite priority for the occupational health and safety

certificate and occupational health and safety records were combined into a priority matrix for occupational health and safety.

The obtained vector of priorities (S) for technical capacity criterion for options 1 to 9 is [0.077, 0.081, 0.081, 0.094, 0.094, 0.118, 0.118, 0.167, 0.167] respectively (Equation 10). The obtained vector for the experience criterion for options 1 to 9 is [0.014, 0.123, 0.123, 0.123, 0.123, 0.123, 0.123, 0.123, 0.123]. For the plant and equipment criterion for options 1 to 9 it is [0.020, 0.020, 0.020, 0.059, 0.059, 0.126, 0.126, 0.285, 0.285].

Financial status vector priorities for options 1 to 9 is [0.028, 0.030, 0.046, 0.053, 0.086, 0.099, 0.163, 0.189, 0.304]. The obtained vector for the past performance criterion for options 1 to 9 is [0.014, 0.123, 0.123, 0.123, 0.123, 0.123, 0.123, 0.123, 0.123]. The obtained vector for the management capability criterion for options 1 to 9 is [0.030, 0.030, 0.030, 0.030, 0.030, 0.126, 0.126, 0.223, 0.373] and [0.026, 0.122, 0.122, 0.122, 0.122, 0.122, 0.122, 0.122, 0.122] for options 1 to 9 for the occupational health and safety criterion.

6.7 SELECTION OF THE BEST OPTION

To obtain the overall ranking, the priority vectors obtained in Table 9.29 were combined to form the overall priority matrix and multiplied by the main priority vectors (Pm) (level 1). Equation 11 yields overall weights (V) of [0.040, 0.094, 0.96, 0.102, 0.105, 0.120, 0.124, 0.153, 0.164] for options 1 to 9 respectively (Table 9.30).

6.8 DISCUSSION

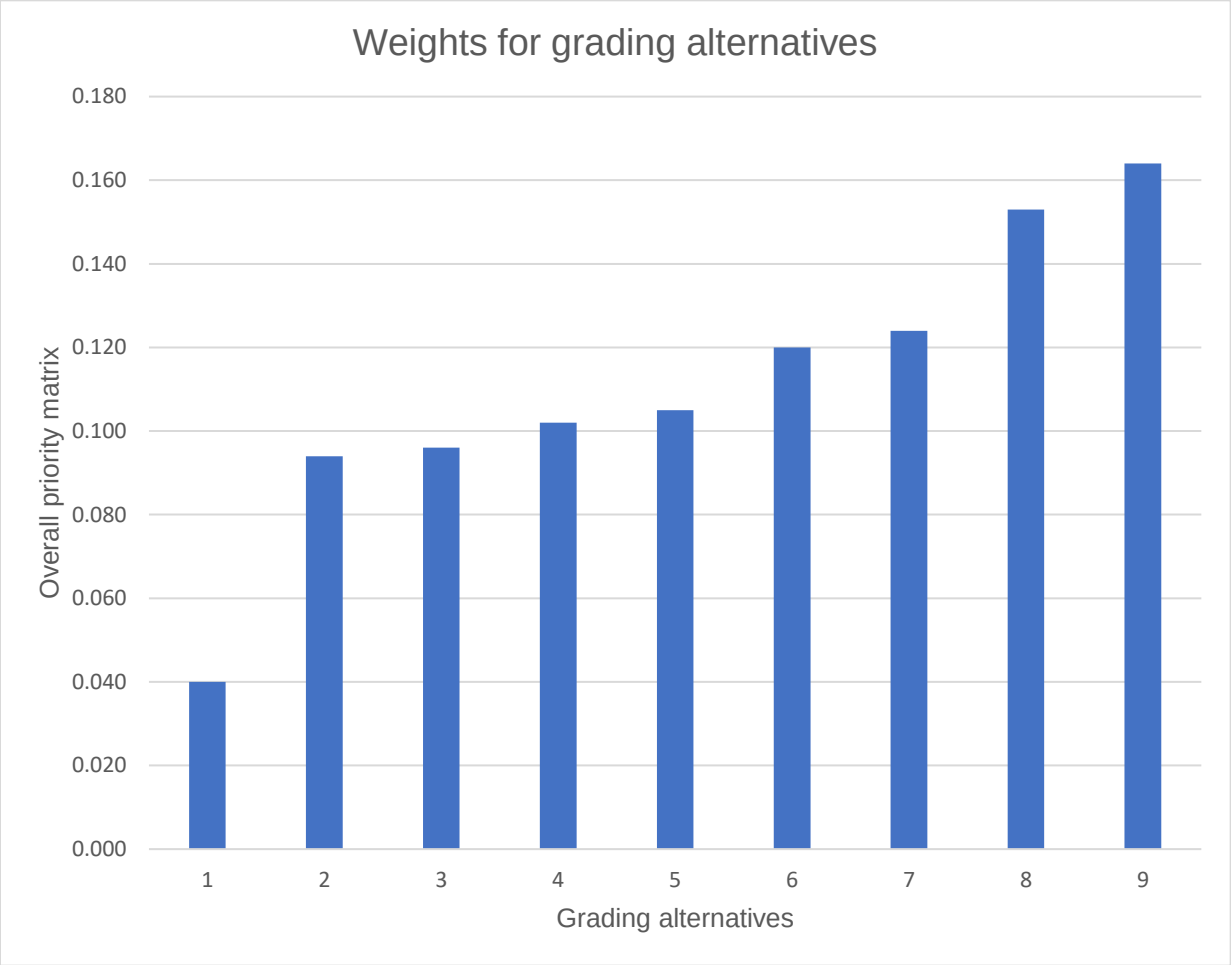


Figure 6.4 Weights of the overall priority matrix for grading alternatives

Figure 6.4 depicts that grade 9 has the overall highest priority matrix of 0.164, followed by grades 8, 7, 6, 5, 4, 3, 2, 1 with the overall priority matrix of 0.153, 0.124, 0.120, 0.105, 0.102, 0.096, 0.094, and 0.040 respectively. In terms of technical capacity, options 2 and 3 have similar requirements whilst options 4 and 5 have similar requirements as well as options 6 and 7 and options 8 and 9. For example, it will be expected that in practice the requirements for academic qualifications, projects completed and number of key staff for options 2 and 3 will be similar. However, there are differences in other criteria for options 2 and 3. Similarly, the requirements for academic qualifications, projects completed, and some key staff will also be similar for Grades 4 and 5, Grades 6 and 7, and Grades 8 and

9. The proposed grading requirements for progression on all the grades are detailed in Chapter 8.

Experience criteria have the same ranking in all the grades except for grade 1. This is so because grade 1 contractors are expected not to have previous practical contractor experience in the construction field. However, experience is very vital as you progress to the next grade. Plant and equipment are important in the construction sector, and it is important for contractors to own some plant and equipment to avoid unnecessary construction delays due to the unavailability of key plant and equipment. Thus, the results indicate that grades 1, 2, and 3 have similar results whilst grades 4 and 5 have similar results, grades 6 and 7 and grades 8 and 9 have similar results. These results were also used as a basis for proposing the requirements for grading progression in all the grades in Chapter 8.

The financial status criteria overall results do not have similar results in all the grades. Grade 9 has the overall highest rank while grade 1 has the lowest rank in the options. This is so as the grades have different financial/tender values which contractors can tender for. It is expected that contractors must have available capital to be sustainable and be able to execute work when awarded. The amount to be retained per grade will vary due to the variances in financial/tender value in the grades. This thus explains the distinctions in the results for the financial status criteria.

Like the experience criteria, past performance criteria have the same ranking in all the grades except for grade 1. This is so because grade 1 contractors are expected not to have previous practical contractor experience in the construction field. However, past performance is also vital as you progress to the next higher grade. Management criteria results indicate that grades 1 to 5 have similar results whilst grades 6 and 7 also have similar results. Grades 8 and 9 have different results.

There are no requirements for business management specialists from grades 1 to 5. From grade 6, it is expected that businesses will have a business management specialist who will oversee the financial management and business management. This is to enable the business sustainability of the construction sector.

Occupational health and safety criteria have the same ranking in all the grades except for grade 1. This is because grade 1 contractors are expected to only possess an occupational health and safety certificate in grade 1. The other grades (2-9) are expected to have occupational health and safety certificates and have occupational health and safety records.

6.9 SENSITIVITY ANALYSIS

Sensitivity analysis is an analytical method that is used to identify how much variations in the input values for a given variable will impact the results of a mathematical model. When the results of a study or computation do not significantly change due to variations in underlying assumptions, they are considered to be robust. If variations in foundational inputs or assumptions significantly change outcomes, sensitivity analysis can be employed to determine how changes in inputs, definitions, or modelling can improve the accuracy or robustness of any results (Maverick, 2021).

A sensitivity analysis was carried out following the standard Analytical Hierarchy Process procedure on six different scenarios to further check the reliability and robustness of the AHP results achieved. The overall priority matrix of each scenario is attached in Appendix I. Figure 6.3 illustrates the summary of the overall weights of the grades for each scenario.

6.9.1 Scenarios

Scenario A

Scenario A incorporated professional registration as the fourth sub-criterion for technical capacity criteria. Professional registration is defined as registration with a professional

body within the Built Environment Profession. Thus, this may include registration with one of the six Councils for the Built Environment Professions - Architecture, Landscape Architecture, Engineering, Property Valuers, Project and Construction Management, and Quantity Surveying. This sub-criterion was considered in the context of turnkey projects which would require the construction firms to plan, design construct, and hand over a project to the client.

When incorporating professional registration as a sub-criterion, the priority vectors for the academic qualification, key staff experience, number of key staff, and professional registration are 0.422, 0.218, 0.073, and 0.287 respectively with a consistency ratio of 0. Before incorporating the professional registration, the priority vector of academic qualification, key staff experience, and a number of key staff were 0.633, 0.260, and 0.106 respectively with a consistency ratio of 0.0333.

Incorporating professional registration has improved the consistency ratio: in practice, this criterion, however, may be difficult to incorporate by the CIDB due to the high representation of historically disadvantaged individuals, who are among Grade 1 contractors which highlights the importance of this category as a route towards transformation of the construction industry (CIDB, 2016). This however does not seem to favour the construction sector due to the poor technical performance of the sector.

Moreover, professional registration for university degree holders requires graduates to work for a certain number of years before they may be considered for registration (ECSA, 2022). The number of years and requirements for registration for those with technical certificate holders become even greater (ECSA, 2022) which would make it even more difficult for business entry. If the construction sector was not noted as a route for transformation for previously disadvantaged individuals, it would assist the sector performance if criteria for entry were strengthened by the mandatory additional requirements of professional registration for the benefit of the industry’s image, outputs, and economy.

Thus, the overall priority vector obtained for grades 1 to 9 is 0.047, 0.102, 0.104, 0.112, 0.114, 0.133, 0.137, 0.174, and 0.185 respectively. The overall priority vector for grades 1 to grade 9 without professional registration as a sub-criterion is 0.040, 0.094, 0.096, 0.012, 0.105, 0.120, 0.124, 0.153, and 0.164. It is noted that the overall priority vector has slightly increased because of the increase in stricter requirements when professional registration is incorporated. This means that the addition of professional registration as a sub-criterion further strengthens the requirements for technical capacity criteria. It should further be noted that the inclusion of this sub-criterion may exclude more people in South Africa given that South Africa presently lacks adequate professional engineers, as noted by Mail and Guardian (2017) and the Engineering Council of South Africa (ECSA, 2013).

Scenario B

This Scenario checks the effect of variations in the main criteria weighting. The plant and equipment and financial status criteria have equal weighting. The priority vector for the main criteria before the effects of variations for technical capacity, experience, plant and equipment, financial status, past performance, management capability and occupational health and safety is 0.380, 0.199, 0.038, 0.071, 0.199, 0.023 and 0.090 respectively. The priority vector after the effects of variations is 0.328, 0.180, 0.071, 0.088, 0.180, 0.060, and 0.091 respectively. It is noted that when plant and equipment and financial status have equal weight, there are slight changes in the priority vectors as the priority vectors for plant and equipment and financial status slightly increase.

The overall weights for grades 1 to grade 9 become 0.038, 0.088, 0.089, 0.097, 0.100, 0.119, 0.125, 0.161, and 0.180 respectively. This scenario indicates that when plant and equipment and financial status criteria are of equal weighting, there is a slight increase in the overall project priority vector from grade 7 to grade 9. This should be the case given that plant and equipment and financial status play a critical role in these higher grades. In construction projects, it is expected that the higher the project value, the higher the grading would be required, and more plant and more equipment would be expected to be utilised in a civil construction project.

Scenario C

Scenario C checks the effect of variations in the experience sub-criteria of weightings. Projects completed by key staff is reduced by 50% and company project completion is increased by 50%. The overall weights of grade 1 to grade 9 are 0.040, 0.094, 0.096, 0.102, 0.105, 0.120, 0.124, 0.153, and 0.164. There is no change in the overall weights of the grades. However, in practice, the projects completed by key staff should carry more weight than projects completed by the company. This is so as companies may change staff now and then due to turnover and other various reasons. There should however be a balance between projects completed by the company and projects completed by individuals to ensure that the company succeeds in the planning and execution of projects.

Scenario D

This Scenario checks the effect of variations in the past performance sub-criteria weighting. Time, cost, quality, and referrals sub-criteria have equal weighting. The priority vector for time, cost, quality, and referrals before the effects of variations are 0.122, 0.558, 0.263, and 0.057 respectively. The priority vector after the effects of variations is 0.250, 0.250, 0.250, and 0.250 respectively.

The overall weights of grade 1 to grade 9 are 0.040, 0.094, 0.096, 0.102, 0.105, 0.120, 0.124, 0.153 and 0.164. There is no change in the overall weights of the grades. In project management, management of time, cost, quality, and client satisfaction needs to be equally balanced to ensure that the project becomes a success. El-sokhn and Othman (2014) state that from a project management perspective, success means the delivery of the project within the deadlines, budgets, and its functionality fulfils the mission and the planned objectives and meets the required expectations of the stakeholders.

Scenario E

Scenario E checks the effect of variations in the main criteria weighting. All the main criteria have equal weighting. The priority vector for the main criteria before the effects of variations for technical capacity, experience, plant and equipment, financial status, past performance, management capability, and occupational health and safety is 0.380, 0.199, 0.038, 0.071, 0.199, 0.023, and 0.090 respectively. The priority vector after the effects of variations is 0.143, 0.143, 0.143, 0.143, 0.143, 0.143, and 0.143 respectively.

The overall weights for grade 1 to grade 9 become 0.030, 0.076, 0.078, 0.087, 0.91, 0.120, 0.129, 0.178, and 0.214 respectively. This scenario indicates that when all the main criteria have equal weight, the overall weight for grades 1 to 5 slightly reduce, whilst the overall priority vector for grade 6 remains the same. From grades 7 to 9, the overall weight slightly increases. It should be noted that it is highly unlikely that all the main criteria will have equal weighting in practice.

However, this scenario emphasises the significance of considering all the relevant sub-criteria in the grading of contractors. The relevant sub-criteria will vary depending on the grade which is applied for. For example, the relevant sub-criteria for grade 1 contractors are academic qualification, business bank account, and occupational health and safety certificate. For a grade 6 or grade 9 contractor, the contractor will be expected to not only have a business bank account, but they must also have 10% of available capital.

Scenario F

Scenario F incorporated leadership skills as the second sub-criterion for management capability criteria. Leadership skills are defined as the contractor's ability to manage the project team, problem-solving, as well as the ability to communicate and negotiate as indicated by Edum-Fotwe and McCaffer (2000). When incorporating leadership skills as a sub-criterion, the priority vectors for the business specialists and leadership skills are 0.833 and 0.167.

Leadership skill is important in managing projects as it may assist in timeous completion of projects which may in turn reduce project cost variations due to unwarranted extension of times. In practice, it may however be difficult to assess this criterion although it plays a key role which may also be assessed through the number of projects completed by key staff criteria. Thus, the overall priority vector obtained for grade 1 to grade 9 is 0.040, 0.094, 0.096, 0.012, 0.105, 0.120, 0.124, 0.153 and 0.164.

It is noted that the overall priority vector does not change when leadership skills are incorporated.

6.10 DISCUSSIONS ON SCENARIOS

The AHP results indicated that the overall rankings of grades 2 and 3, grades 4 and 5, and grades 6 and 7 are close to one other, and this could be attributed to the fact that the criteria requirements of these grades are closely related. This may also suggest that the number of grades may be reduced. However, it should be noted that the current nine grades allow for adequate contractor developmental process to occur because the current education attainments in South Africa are still low (OECD, 2019). In terms of technical capacity, grades 2 and 3 have the same weighting of 0.081, grades 4 and 5, grades 6 and 7 and grades 8 and 9 also have the same overall weight of 0.094, 0.118 and 0.167 respectively.

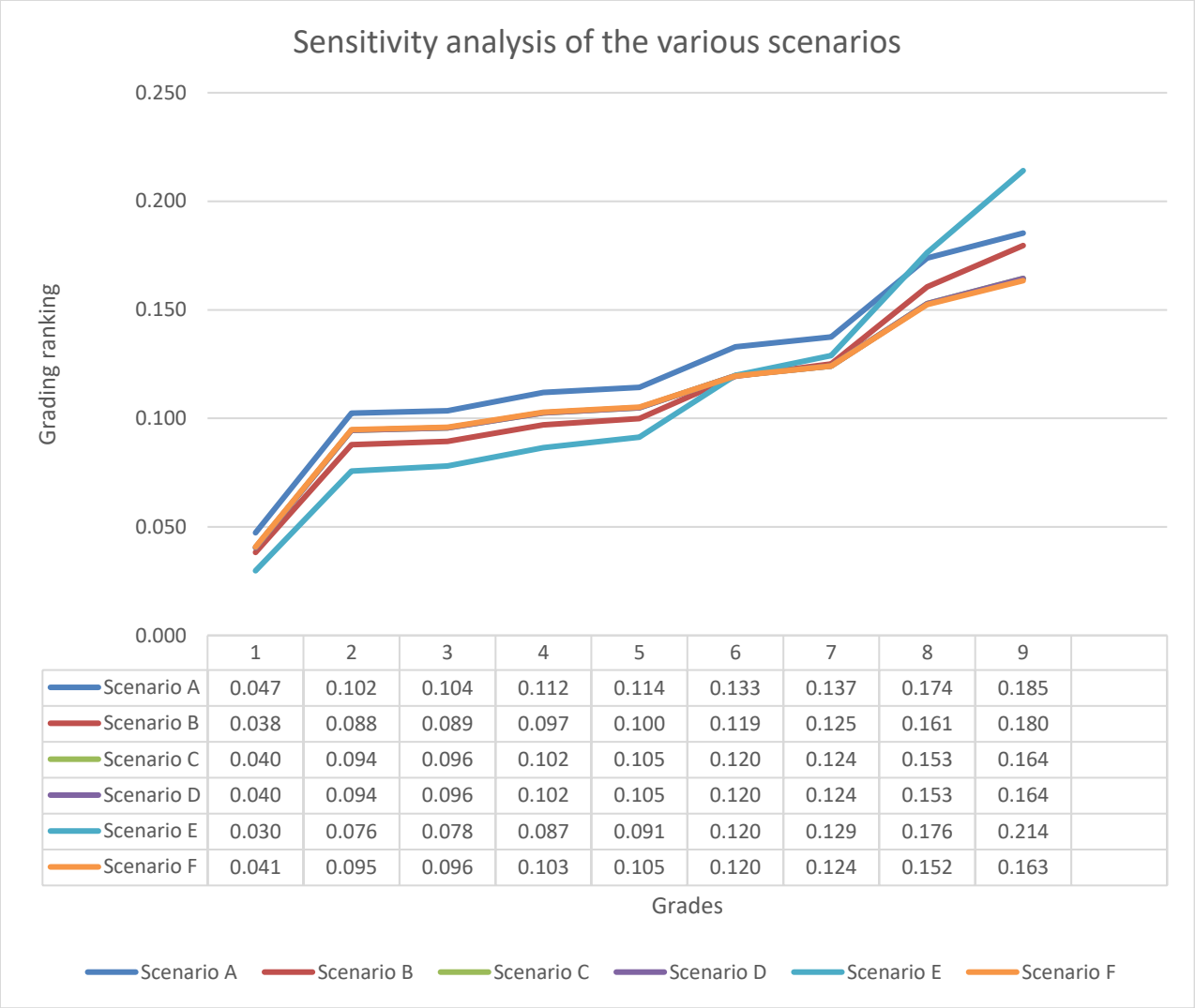
These similarities are also observed in plant and equipment and management capability criteria whereby grades 2 and 3 have the same weighting of 0.020, grades 4 and 5, 6 and 7 and 8 and 9 also have the same overall weight of 0.059, 0.126 and 0.285 for plant and equipment. For management capability criteria, grades 2, 3, 4 and 5 have the same weighting of 0.030 and grades 6 and 7 also have the same overall weight of 0.126 respectively.

These similarities are also observed in the scenarios, the criterion for technical capacity for scenario A for grades 2 and 3 have the same weighting of 0.102, grades 4 and 5, grades 6 and 7 and grades 8 and 9 also have the same overall weight of 0.119, 0.153 and 0.222 respectively. Grades 2 and 3 for plant and equipment criteria have the same

weighting of 0.020, grades 4 and 5, and grades 6 and 7 and grades 8 and 9 also have the same overall weight of 0.059, 0.126, and 0.285 for plant and equipment. For management capability criteria, grades 2, 3, 4, and 5 have the same weighting of 0.030, and grades 6 and 7 also have the same overall weight of 0.126 respectively.

Scenarios B, C, D, and E have similar results for technical capacity, plant and equipment, and management capability criteria. In terms of technical capacity, grades 2 and 3 have the same weighting of 0.081, grades 4 and 5, grades 6 and 7, and grades 8 and 9 also have the same overall weight of 0.094, 0.118, and 0.167 respectively. Plant and equipment criteria's overall weight for grades 2 and 3 have the same weighting of 0.020, grades 4 and 5, 6 and 7, and 8 and 9 also have the same overall weight of 0.059, 0.126, and 0.285 for plant and equipment. For management capability criteria, grades 2, 3, 4 and 5 have the same weighting of 0.030, and grades 6 and 7 also have the same overall weight of 0.126 respectively.

In scenario F, the management capability criteria are similar for grades 1 to 5, with a weighting of 0.044 and 0.124 for grades 6 and 7, 0.204 for grade 8 and 0.329 for grade 9. Figure 6.5 depicts the sensitivity analysis of the various scenarios.



	1	2	3	4	5	6	7	8	9
Scenario A	0.047	0.102	0.104	0.112	0.114	0.133	0.137	0.174	0.185
Scenario B	0.038	0.088	0.089	0.097	0.100	0.119	0.125	0.161	0.180
Scenario C	0.040	0.094	0.096	0.102	0.105	0.120	0.124	0.153	0.164
Scenario D	0.040	0.094	0.096	0.102	0.105	0.120	0.124	0.153	0.164
Scenario E	0.030	0.076	0.078	0.087	0.091	0.120	0.129	0.176	0.214
Scenario F	0.041	0.095	0.096	0.103	0.105	0.120	0.124	0.152	0.163

Figure 6.5 Overall grading rankings of the sensitivity analysis

It can be noted in Figure 6.5 that the findings of the scenarios are closely related. Scenario E has the highest overall weight of 0.214. This is when the effects of variations are identified when all the main criteria carry the same weight. It has been, however, indicated that in practice, this will not be possible for all criteria to carry the same weight. Different criteria will carry different weight based on their importance in contractor grading. Overall, the results indicate that there are slight variations in the various scenarios. The results for all the scenarios are attached as Appendix I.

6.11 MULTI-CRITERIA ANALYSIS FOR THE EVALUATION OF CONTRACTOR PROJECT PERFORMANCE

This section describes the application of the AHP model for decision making in the evaluation of contractor project performance which was sought through the literature review and state-of-practice survey. The results from the developed AHP Microsoft Excel spreadsheet-based programme will be elaborated and are attached as Annexure M. The hierarchical structure for the evaluation of contractor project performance developed for this study is presented in Figure 6.6. The top level indicates that the overall goal is to evaluate project performance. The second level shows the seven main criteria (technical capacity, experience, plant and equipment, financial status, past performance, management capability, and health and safety). The third level shows sub-criteria against which each option is evaluated. The last level shows the project performance evaluation options.

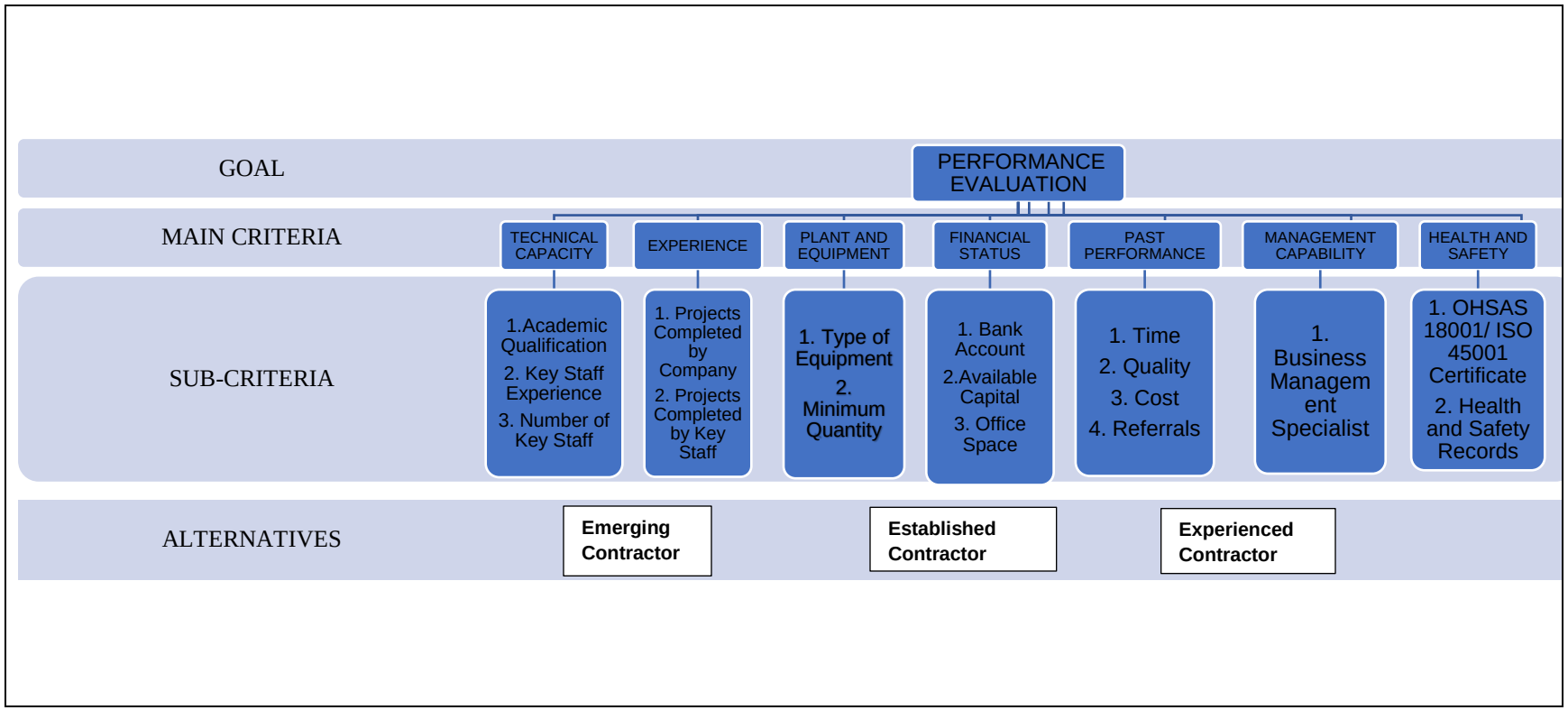


Figure 6.6 AHP for performance evaluation of contractors

6.11.1 Comparison matrix for level 1

The comparison matrix for level 1 involved pairwise comparisons between the seven main criteria. The comparison matrix is shown in Table 9.1. Technical capacity criteria are of weak, strong, very strong, and extreme importance relative to the experience, plant and equipment, financial status, past performance, management capability, and occupational health and safety criteria, thus it took the numerical values 3, 5, 7, and 9 respectively.

Experience criteria are of weak, strong, and very strong importance relative to the plant and equipment, financial status, past performance, management capability, and occupational health and safety criteria, hence it took the numerical values 3, 5, and 7 respectively. Plant and equipment are of weak importance relative to the management capability; hence it took the numerical value 3. Financial status is of weak and strong importance relative to plant and equipment and management capability; hence it took numerical values 3 and 5 respectively.

Past performance criteria are of weak, strong, and very strong importance relative to the plant and equipment, financial status, management capability, and occupational health and safety criteria, hence it took the numerical values 3, 5, and 7 respectively. Past performance and experience criteria are of equal importance; hence it took numerical value 1. Occupational health and safety criterion is of weak and strong importance relative to plant and equipment, financial status, and management capability criterion, hence it took the numerical value of 3 and 5 respectively.

6.11.2 Computation of the Vector of Priorities

The priority of each criterion in relation to the overall goal of contractor grading is calculated using the pairwise comparison matrix A in Table 9.1. The vector of priorities was worked out as described in Chapter 4. Table 9.31 shows the normalised comparison matrix (Matrix B), and the main priority vector is [0.380, 0.199, 0.038, 0.071, 0.199,0.023, 0.090] for technical capacity, experience, plant and equipment, financial status, past

performance, management capability and occupational health and safety issues respectively. The obtained priority vector indicates that the technical capacity criterion is the most important followed by the experience and past performance criterion then occupational health and safety, financial status, plant, and equipment and lastly the management capability criterion. Figure 6.1 in depicts the weights for the main criteria using equations 1-3 (as indicated in Chapter 4).

6.11.3 Consistency

The AHP makes provision for checking inconsistencies that may arise when performing a lot of pairwise comparisons. This is done by calculating the consistency ratio (CR) as described in Chapter 4. A consistency ratio greater than 0.1 indicates inconsistency and therefore if obtained the comparisons will need to be checked and revised. Table 9.31 shows calculations for the main criteria comparison matrix consistency ratio. The product of the comparison matrix (Matrix A) and the priority vector (Pm) [0.380, 0.199, 0.038, 0.071, 0.199,0.023, 0.090] gave column vector (X) [2.99, 1.61, 0.27, 0.52, 1.61, 0.17, 0.69] (Equation 11). The elements of column vector (X) were then divided by the corresponding elements of the priority vector (Pm) and gave another column vector (X1) [7.88, 8.10, 7.11, 730, 8.10, 7.29, 7.65.] and the average of values obtained for X1 gave the maximum eigenvalue as 8.63 (Equation 10).

The consistency index (CI) was calculated as (7.63 – 7)/ (7 – 1) = 0.011 (Equation 7). To determine consistency, the consistency index was divided by the random index (RI). The random index for n = 7 is 1.32 (Table 9.4). The consistency ratio (CR) of 0.080 was obtained. Therefore, the pair-wise comparison judgments are consistent and acceptable because the consistency ratio is less than 0.1. A consistency ratio greater than 0.1 means that the judgments are not consistent.

6.11.4 Pairwise comparisons for the sub-criteria (level 2)

The procedure in sub-section 6.4.1 was repeated for level 2. Pairwise comparisons matrix A for sub-criteria were carried out.

6.11.4.1 Comparison matrix for level 2

The comparison matrix for level 2 involved pairwise comparisons between the sub-criteria in relation to each main criterion. Priority vectors (Ps) for each main criterion were obtained by assessing the weight of each sub-criterion in terms of its contribution to the respective criteria. The pairwise comparison matrices and priority vectors are shown in Tables 9.34 to 9.37. Technical capacity criterion has three sub-criteria which are academic qualifications, key staff experience, and number of key staff. Academic qualifications are of moderate and strong importance relative to key staff experience and several key staff, hence the numerical values 3 and 5 respectively. The weights obtained were 0.633, 0.260, and 0.106 for academic qualifications, key staff experience, and number of key staff respectively (Table 9.32).

The maximum eigenvalue is 3.04, and the consistency index (CI) was calculated as (3.04 – 3)/ (3 – 1) = 0.02 (Equation 7). To determine consistency, the consistency index was divided by the random index (RI). The random index for n = 3 is 0.58 (Table 9.4). The consistency ratio (CR) of 0.033 was obtained. Therefore, the pair-wise comparison judgements are consistent and acceptable because the consistency ratio is less than 0.1. A consistency ratio greater than 0.1 means that the judgements are not consistent.

Experience criterion has two sub-criteria which are projects completed by the company and projects completed by key staff. Key staff experience is of very strong importance relative to projects completed by the company hence the numerical value 7 respectively. The weights obtained were 0.125 and 0.875 for projects completed by the company and projects completed by key staff respectively. The maximum eigenvalue, the consistency index (CI), and the consistency ratio (CR) were not calculated since the matrix elements are less than three for the experience criterion (Table 9.33).

Plant and equipment criterion has two sub-criteria, which are plant and equipment and minimum quantity. Equipment type are of strong importance relative to minimum quantity, hence the numerical value 5 respectively. The weights obtained were 0.833 and 0.167 for equipment type and minimum quantity respectively. The maximum eigenvalue, the consistency index (CI), and the consistency ratio (CR) were not calculated since the matrix elements are less than three for the experience criterion (Table 9.34).

Financial status criterion has three sub-criteria which are a bank account, available capital, and office space. Available capital is of very strong and strong importance relative to key bank account and office space, hence the numerical values 5 and 7 respectively. The weights obtained were 0.083, 0.724, and 0.193 for a bank account, available capital, and office space respectively (Table 9.35).

The maximum eigenvalue is 3.07, and the consistency index (CI) was calculated as (3.07 – 3)/ (3 – 1) = 0.03 (Equation 7). To determine consistency, the consistency index was divided by the random index (RI) (Equation 8). The random index for n = 3 is 0.58 (Table 9.4). The consistency ratio (CR) of 0.057 was obtained. Therefore, the pair-wise comparison judgements are consistent and acceptable because the consistency ratio is less than 0.1. A consistency ratio greater than 0.1 means that the judgements are not consistent.

Past performance criterion is subdivided into four sub-criteria which are time, quality, cost, and referrals. Quality is of weak, strong, and very strong importance relative to time, cost, and referrals hence the numerical values 3, 5, and 7 respectively. Cost is of weak and strong importance relative to time and referrals thus the numerical value of 3 and 5 respectively. Time is of weak importance relative to referrals; hence it has a numerical value of 3. The priority vector obtained was [0.122, 0.558, 0.263, 0.057] for time, quality, cost, and referrals respectively. The maximum eigenvalue of 4.12 was obtained, the consistency index (CI) of 0.04, and a consistency ratio (CR) of 0.044 were obtained.

Therefore, the pair-wise comparison judgments are consistent and acceptable (Table 9.36).

Management capability criterion has one sub-criteria which is business management specialist. Thus, the business management specialist criterion is of equal importance relative to the business management specialist criteria hence the numerical value of 1. The priority vector obtained was [0.100] respectively. The maximum eigenvalue, the consistency index (CI), and consistency ratio (CR) were not calculated since the matrix elements are less than three for the management capability criteria (Table 9.37).

Occupational Health and Safety criterion has two sub-criteria which are Occupational Health and Safety certificate (OHSAS 18001/ISO 45001) and health and safety records. Health and safety records are of very strong importance relative to the occupational health and safety certificate hence the numerical value 7. The priority vector obtained was [0.125, 0.875] for occupational health and safety certificate and health and safety record respectively. The maximum eigenvalue, the consistency index (CI), and consistency ratio (CR) were not calculated since the matrix elements are less than three for the occupational health and safety criteria (Table 9.38).

6.11.4.2 Pairwise comparison for level 3

At level 3 of the hierarchy, a priority vector for sub-criteria (academic qualifications, key staff experience, number of key staff, projects completed by key staff, projects completed by company staff, type of equipment, minimum quantity, bank account, available capital, office space, time, quality, cost, referrals, business management specialist, occupational health and safety certificate and health and safety records) was obtained. None of the sub-criteria is further subdivided into any other parameter, therefore the priority vectors for each sub-criterion have a weight of 1.

Matrices of pairwise comparisons for the alternatives relative to each sub-criterion were formed to obtain the relative weight of the options for each of the sub-criteria. Before forming matrices for each policy alternative sub-criteria assessment for each option was conducted. Tables 9.39 to 9.55 illustrate the summaries of the sub-criteria assessments, respectively.

6.11.5 Composite vector priorities

To obtain the vector of composite priorities for the sub-criteria as indicated in Tables 9.39 to 9.55, the weights of the options relative to each sub-criterion were combined into matrix B (Equation 2). Equation 3 was then applied to obtain project priority vectors. The project priority vectors were multiplied by the priority vector for academic qualifications [0.777] to obtain composite priorities [0.333, 0.333, 0.333]. All composite priorities for the rest of the sub-criteria were determined the same way.

Figure 6.7 shows a graphical presentation of the overall priority matrix ratings for each option. Option 3 has the highest rating while Option 1 has the lowest rating. It is expected that experienced contractors' overall rating will be higher than established contractors. This is the case as an experienced contractor would likely have good requirements in terms of academic qualifications, key staff experience, number of key staff, projects completed by the company, projects completed by key staff, type of equipment, minimum

quantity, available capital, business management specialist, and occupational health and safety.

The sub-criterion academic qualifications, bank account, referrals, occupational health, and safety certificate have equal importance on all the options. This is expected to be the case for this criterion as academic qualifications should be of equal importance although the level of qualification may differ. Also, business bank accounts, referrals, and occupational health and safety certificates are important for all contractors to possess.

To obtain the project priority vectors for the main criteria at level 2 of the hierarchy, the sub-criteria composite priorities for each criterion were combined into a priority matrix for the criteria as indicated in Table 9.56. The composite priorities for academic qualifications, key staff experience, and number of key staff were combined into a priority matrix for technical capacity criterion. The composite priorities for projects completed by the company and projects completed by key staff were combined into a priority matrix for experience criterion. The composite priorities for the type of equipment and minimum quantity were combined into a priority matrix for plant and equipment criteria.

The composite priorities for bank account, available capital, and office space were combined into a priority matrix for financial status criterion. The composite priorities for time, quality, cost, and referrals were combined into a priority matrix for past performance. The composite priority for business management specialists became the priority matrix for management capability. The composite priority for the occupational health and safety certificate and occupational health and safety records were combined into a priority matrix for occupational health and safety.

The obtained vector of priorities (S) for the technical capacity criterion for options 1 to 3 is [0.273, 0.318, 0.408] respectively (Equation 10). The obtained vector for the experience criterion for options 1 to 3 is [0.064, 0.267, 0.669]. For the plant and equipment criterion for options 1 to 3, it is [0.064, 0.267, 0.669].

Financial status vector priorities for options 1 to 3 are [0.086, 0.272, 0.641]. The obtained vector for the past performance criterion for options 1 to 3 is [0.079, 0.271, 0.650]. The obtained vector for the management capability criterion for options 1 to 3 is [0.064, 0.267, 0.669] and [0.098, 0.275, 0.627] for options 1 to 3 for the occupational health and safety criterion.

6.11.6 Selection of the best option

To obtain the overall ranking, the priority vectors obtained in Table 9.56 were combined to form the overall priority matrix and multiplied by the main priority vectors (Pm) (level 1). Equation 11 yields overall weights (V) of [0.151, 0.288, 0.534] for options 1 to 3 respectively (Table 9.57). Option 3 has the highest ranking followed by options 2 and 1 respectively.

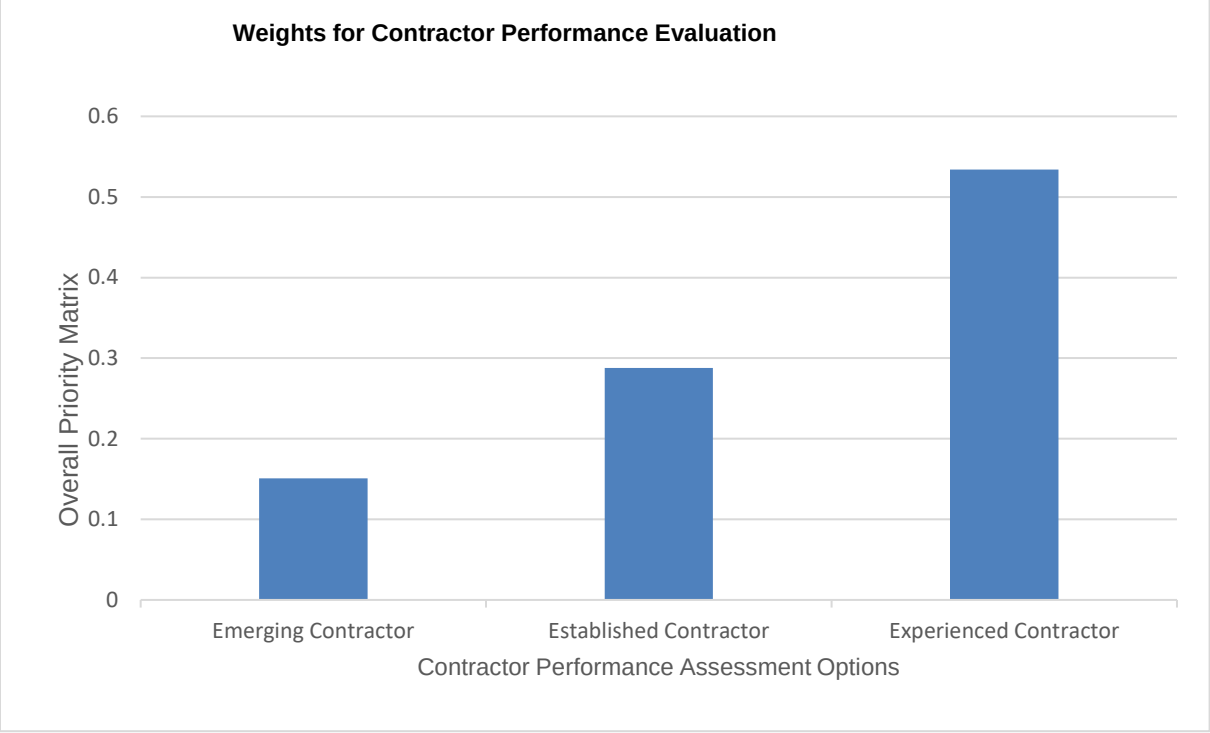


Figure 6.7 Weights for the overall priority matrix for contractor performance evaluation

Figure 6.7 depicts that experienced contractor has the overall highest priority matrix of 0.534, followed by established contractor with a priority matrix of 0.288 and 0.151 priority matrix for emerging contractors respectively. As indicated above that it is expected that

an experienced contractor would likely be experienced in project management and have good requirements in terms of the academic qualifications, key staff experience, number of key staff, projects completed by company, projects completed by key staff, type of equipment, minimum quantity, available capital, business management specialist and occupational health and safety.

6.11.7 Performance evaluation discussion

The Analytical Hierarchy Process indicates that option 3 has the highest ranking followed by options 2 and 1 respectively. Any contractor in the South African construction industry who contracts with the public sector should aspire to be an experienced contractor. This means that contractors should strive to improve their project performance and other requirements in terms of academic qualifications, key staff experience, number of key staff, projects completed by the company, projects completed by key staff, type of equipment, minimum quantity, available capital, business management specialist and occupational health and safety.

Thus, the AHP results indicate that option 3 is the best contractor performance option since it has the highest project priority vector. The overall ranking for options 1, 2, and 3 is [0.151, 0.288, 0.534] respectively. It is noted that the weighting for experience, plant and equipment, and management capability is the same for all options [0.064, 0.267, 0.669]. This is expected because experience, plant and equipment and management capability should play a similar critical role in all the grades. Option 1 has the lowest weighting in all the criteria followed by options 2 and 3.

It is expected that when contractors' performance moves from emerging contractor to an established contractor and ultimately to an experienced contractor, the contractors' performance in all the criteria should also be improving. The idea is to encourage contractors to improve in all the criteria which are relevant for their development and performance to improve the state of the construction sector's performance and contractor capabilities.

Thus, contractors should strive to improve on their technical capacity, experience, plant and equipment, financial status, performances, management capability and on occupational health and safety aspects. This will assist in improving the state of the construction sector and the economy of the country.

6.11.8 Sensitivity analysis

A sensitivity analysis was carried out following the standard Analytical Hierarchy Process procedure on two different scenarios to further check the reliability and robustness of the AHP results achieved. Results of the AHP calculations of each scenario are attached as Annexure J. Figure 6.8 illustrates the summary of the overall weights of the grades for each scenario.

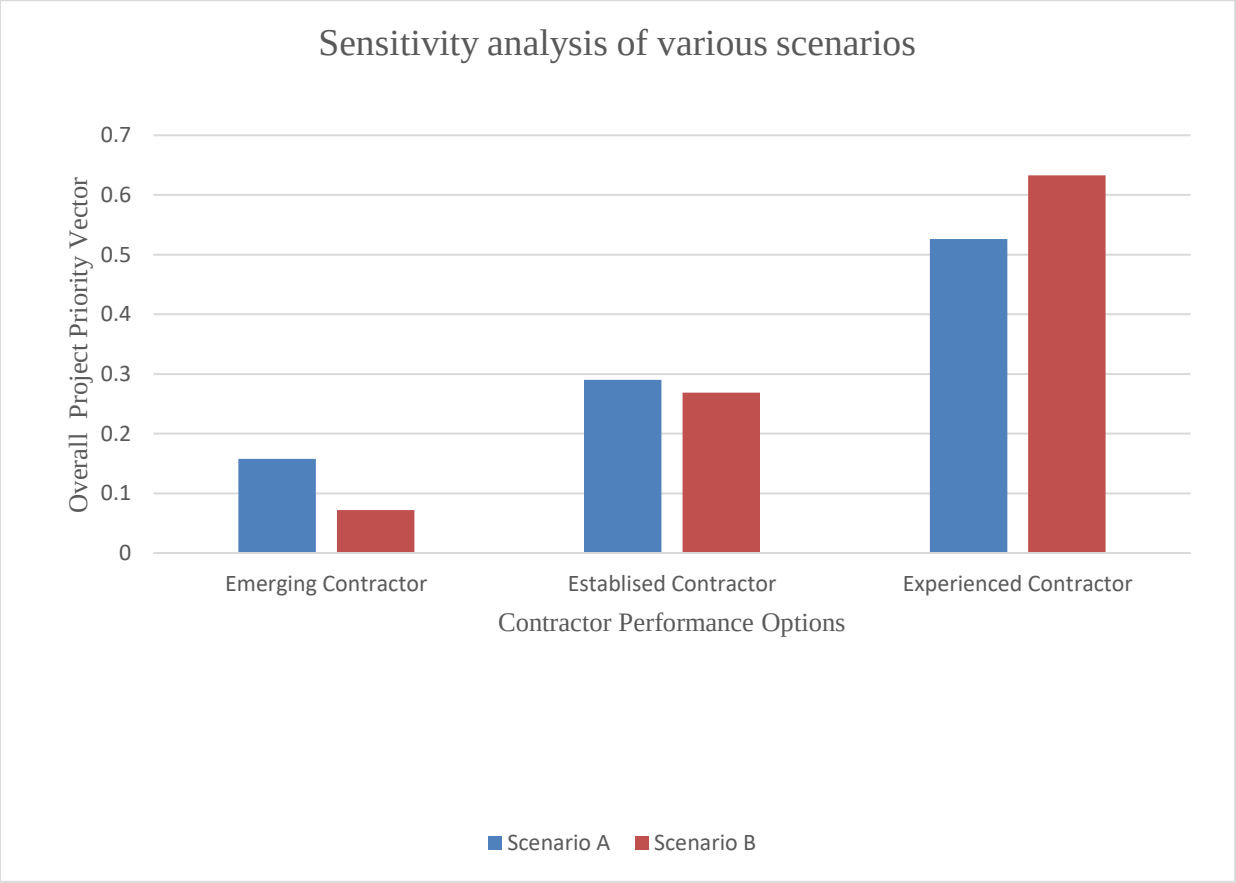


Figure 6.8 Sensitivity analysis of the two scenarios for performance evaluation alternatives

The results of the scenarios indicate that there is no significant change due to variations in underlying assumptions. Scenario A considered time to be of equal importance to all the contractors whilst in scenario B, technical capacity and experience were of equal importance. It is noted that these scenarios have similar results for technical capacity, experience, plant and equipment, and management capability criteria and slight variations in other criteria. The overall project priority vector for scenario A is 0.158, 0.290, and 0.526 and the overall project priority vector for scenario B is 0.072, 0.269, and 0.633 for emerging, established, and experienced contractors respectively. The overall project priority vector for both scenarios is higher for an experienced contractor, followed by an established contractor and an emerging contractor.

6.12 CHAPTER SUMMARY

Chapter 6 was developed to determine the multi-criteria requirements for contractor grading and evaluation of project performance using the Analytical Hierarchy Process. It was also developed to assist in the development of the contractor grading and performance evaluation framework. Thus, contractors have the alternative to choose the grade for which they wish to apply if they meet the minimum multi-criteria requirements. This means that contractors have nine grading alternatives to choose from, and they will be placed in line with the grade requirements after a performance evaluation of a contractor has been made.

The alternatives for which contractors will be eligible for a grade will be based on the contractor meeting the stipulated requirements in line with the grade. The AHP has confirmed the multi-criteria requirements of contractor grading. The higher the grade, the steeper the grading requirements and the grade alternatives will be applied when contractors are applying for a grading.

Sensitivity analysis was conducted using the standard Analytical Hierarchy Process procedure on six different scenarios to check the reliability and robustness of the AHP results achieved. The results indicate that there is no significant change due to variations

in underlying assumptions. It is noted that scenarios B, C, D, and E have similar results for technical capacity, plant and equipment, and management capability criteria and slight variations in other criteria. Scenarios A and F also have similar overall weights in plant and equipment with slight variations on the other criteria and sub-criteria.

The performance of the Contractor may be classified as emerging, established, or experienced depending on the contractor's performance on the criteria. The weighting of an experienced contractor is higher than the weighting of an established and emerging contractor. This is expected as contractor performance should increase in all the relevant criteria. This will enable contractors to continuously develop and improve on their capabilities and at the same time improve the performance of the construction sector in South Africa. A sensitivity analysis was also conducted on different scenarios to check the reliability and robustness of the AHP results achieved. The results indicate that there is no significant change due to variations in underlying assumptions.

CHAPTER 7 THE DEVELOPMENT OF A FRAMEWORK TO REGISTER, GRADE, AND ASSESS THE PERFORMANCE OF CONTRACTORS

7.1 INTRODUCTION

In this chapter, the contractor grading and project performance framework has been developed. The aim is to utilise the AHP grading, and project performance results obtained in the previous chapters to develop the framework. The framework is aimed at providing guidance on the grade in which contractors may be placed and to evaluate contractor's project performance.

Other key proposals for development for consideration are also indicated. It is proposed that there should be linkages between a Register of Contractors and a Register of Projects of the Construction Industry Development Board. This may assist in enhancing the performance of contractors and clients will be able to make a better determination of contractors' performance before awarding contracts.

7.2 THE DEVELOPMENT OF THE FRAMEWORK

In developing the framework, the results of the comparison matrix for level 2 in Appendix M (Tables 9.5-9.11 and 9.35-9.41) which involved pairwise comparisons between the sub-criteria in relation to each main criterion were utilised. The allocation of the weighting for the framework is explained below.

7.2.1 Weight Allocation

In Chapter 6, the requirements for these sub-criteria were proposed. To determine the weight of the sub-criteria for academic qualifications, the following was applied; The overall weight obtained of the sub-criteria in level 2 was divided by the number of criteria. For example, academic qualification is sub-divided into five criteria. The weight of the criterion (0.633) was divided by 5 which equals 0.1266. To get the criterion for the lowest qualification, the value obtained (0.1266) was further divided by 2 because the lowest qualification is the second after "no qualification". Thereafter, the same answer would be added to get the next higher level. The formula is as follows:

Weight of academic qualifications= 0.633 (from level 2 of the AHP model results) divided by number of academic qualifications sub criteria=0.1266 divided by 2=0.0633,

Therefore, 0.0633 is the weight for the lowest criteria for academic qualifications which is a certificate. The next criterion weight is the criteria weight of the lowest criteria plus the same criterion weight= 0.0633+ 0.0633= 0.1266,

Then, 0.1266 is added with 0.0633 to get the next higher criterion weight which is 0.1899. To get the criterion weight for the last criteria, the weights of the four criteria are added which equals 0,3798. Therefore, the weight of the academic qualifications 0.633 less 0.3798 equals the weight of the last criterion 0.2532.

The weight of all the criteria equals the overall weight obtained of the sub-criteria in level 2 which is 0.633. This principle was adopted in calculating all the criteria weights. Thus, Tables 7.1-7.7 depict the sub-criteria weights.

Table 7.1 Weights of the academic qualifications sub-criteria

Technical Capacity					
Academic qualifications	Weight	Key staff experience	Weight	Number of key staff	Weight
No certificate	0	0 years	0	0	0
Certificate	0.0633	0-2 years	0.026	1	0.0106
Diploma	0.1266	3-5 years	0.052	2	0.0212
Degree	0.1899	5-10 years	0.078	3	0.0318
Postgraduate	0.2532	More than ten years	0.106	More than 3 key staff	0.0424
Total	0.633		0.260		0.106

Similarly, key staff experience is subdivided into five criteria. The weight of the criterion (0.260) was divided by 5 which equals 0.052. To get the criterion for the lowest number of experiences, the value obtained (0.052) was further divided by 2 which equals 0,026. Therefore, 0.026 is the weight for the lowest criteria for key staff experience which is 0-2 years of working experience. The next criterion weight is the criteria weight of the lowest criterion plus the same criteria weight= 0.026+ 0.026= 0.052.

Then, 0.50 is added with 0.026 to get the next higher criteria weight which is 0.078. To get the criteria weight for the last criteria, the weights of the four criteria are added which equals 0.154. Therefore, the weight of the key staff experiences 0.260 less 0.154 equals the weight of the last criterion 0.106.

Number of key staff is sub-divided into five criteria. The weight of the criterion (0.106) was divided by 5 which equals 0.0212. To get the criterion for the lowest number of key staff, the value obtained (0.0212) was further divided by 2 which equals 0,0106. Therefore, 0.0106 is the weight for the lowest criterion for the number of key staff which is 1. The next criterion weight is the criterion weight of the lowest criteria plus the same criteria weight 0.0106+ 0.0106= 0.0212. Then, 0.212 is added with 0.0106 to get the next higher criterion weight which is 0.0318. To get the criterion weight for the last criterion, the weights of the four criteria are added which equals 0.0636. Therefore, the weight of the number of key staff 0.106 less 0.0636 equals the weight of the last criterion 0.0424.

Table 7.2 Weights of the experience sub-criteria

Experience			
Project completed by company	Weight	Projects completed by key staff	Weight
0	0	0	0
1	0.0125	1	0.0875
2	0.025	2	0.175
3	0.0375	3	0.2625
More than 3 projects	0.050	More than 3 projects	0.350
Total	0.125		0.875

Projects completed by the company are subdivided into five criteria. The weight of the criterion (0.125) was divided by 5 which equals 0.025. The projects completed are kept at a minimum (i.e., 1,2,3,4…) because the aim is not to restrict entry and progression but to manage the industry entrants and ensure that the relevant people with the relevant skills and knowledge operate within the civil construction sector. To get the criteria for the lowest number of projects completed by key staff, the value obtained (0.025) was further divided by 2 which equals 0,0125. Therefore, 0.0125 is the weight for the lowest criterion for a number of projects completed by key staff which is 1.

The next criteria weight is the criteria weight of the lowest criteria plus the same criteria weight 0.0125+ 0.0125= 0.025. Then, 0.025 is added with 0.0125 to get the next higher criteria weight which is 0.0375. To get the criteria weight for the last criteria, the weights of the four criteria are added which equals 0.075. Therefore, the weight of the

projects completed by the company is 0.125 less 0.075 equals the weight of the last criterion 0.050.

Projects completed by key staff are subdivided into five criteria. The weight of the criterion (0.875) was divided by 5 which equals 0.175. To get the criteria for the lowest number of projects completed by key staff, the value obtained (0.175) was further divided by 2 which equals 0,0875. Therefore, 0.0875 is the weight for the lowest criteria for a number of projects completed by key staff which is 1. The next criterion weight is the criterion weight of the lowest criterion plus the same criterion weight = 0.0875+ 0.0875= 0.175. Then, 0.175 is added with 0.0875 to get the next higher criterion weight which is 0.2625. To get the criteria weight for the last criteria, the weights of the four criteria are added which equals 0.525. Therefore, the weight of the projects completed by the company is 0.875 less 0.525 equals the weight of the last criterion 0.350. Annexure L details the plant and equipment.

Table 7.3 Weights of plant and equipment sub-criteria

Plant and Equipment			
Type of equipment	Weight	Minimum quantity	Weight
0	0	0	0
2	0.0833	2	0.0167
5	0.1666	5	0.0334
8	0.2499	8	0.0501
10 equipment and more	0.3332	10 and above	0.0668
Total	0.833		0.167

The type of equipment is sub-divided into five criteria. The weight of the criteria (0.833) was divided by 5 which equals 0.1666. To get the criterion for the lowest number of equipment, the value obtained (0.1666) was further divided by 2 which equals 0,0833. Therefore, 0.00833 is the weight for the lowest criterion for equipment type which is 2. The next criterion weight is the criterion weight of the lowest criterion plus the same criterion weight= 0.0833+ 0.0833= 0.1666. Then, 0.1666 is added with 0.0833 to get the next higher criterion weight which is 0.2499. To get the criteria weight for the last criteria, the weights of the four criteria are added which equals 0.4998. Therefore, the weight of the equipment type is 0.833 less 0.4998 equals the weight of the last criterion 0.3332.

The minimum quantity of equipment is sub-divided into five criteria. The weight of the criterion (0.167) was divided by 5 which equals 0.0334. To get the criterion for the lowest number of equipment, the value obtained (0.0334) was further divided by 2 which equals 0,0167. Therefore, 0.0167 is the weight for the lowest criterion for minimum equipment which is 2. The next criterion weight is the criteria weight of the lowest criterion plus the same criterion weight 0.0167+ 0.0167= 0.0334. Then, 0.0334 is added with 0.0167 to get the next higher criterion weight which is 0.0501. To get the criterion weight for the last criterion, the weights of the four criteria are added which equals 0.1002. Therefore, the weight of the equipment type is 0.167 less 0.1002 equals the weight of the last criterion 0.0668.

Table 7.4 Weights of financial status sub-criteria

Financial Status					
Bank Account	Weight	Available Capital	Weight	Office Space	Weight
No business account	0	No capital	0	No office space	0
New business account	0.010375	5% available capital	0.0724	Office space	0.193
Acc with (-) balance	0.02075	10% available capital	0.1448		
Acc with (+) balance	0.05186	15% available capital	0.2172		
		R60m available capital	0.2896		
Total	0.083		0.724		0.193

Bank account is subdivided into four criteria. The weight of the criterion (0.083) was divided by 4 which equals 0.02075. To get the criterion for the lowest number of equipment, the value obtained (0.02075) was further divided by 2 which equals 0,010375. Therefore, 0.010375 is the weight for the lowest criteria which is 2. The next criterion weight is the criterion weight of the lowest criterion plus the same criterion weight = 0.010375+ 0.010375= 0.02075. To get the criterion weight for the last criterion, the weights of the three criteria are added which equals 0.031125. Therefore,

the weight of the bank account is 0.083 less 0.031125 equals the weight of the last criterion 0.05186.

Available capital is sub-divided into five criteria. The weight of the criterion (0.724) was divided by 5 which equals 0.1448. To get the criterion for the lowest number of equipment, the value obtained (0.1448) was further divided by 2 which equals 0,0724. Therefore, 0.0724 is the weight for the lowest criteria for available capital. The next criteria weight is the criteria weight of the lowest criteria plus the same criterion weight 0.0724+ 0.0724= 0.1448. Then, 0.1448 is added with 0.0724 to get the next higher criterion weight which is 0.2172. To get the criterion weight for the last criterion, the weights of the five criteria are added which equals 0.4344. Therefore, the weight of the equipment type is 0.724; less 0.4344 equals the weight of the last criterion 0.2896.

Office space is subdivided into two criteria. The first criterion is no office which carries the weight of 0. Therefore, office space has a weight of 0.193.

Table 7.5 Weights of management capability sub-criteria

Management Capability	
Business Specialist	Weight
0	0
1	0.01
2	0.02
3	0.03
More than 3	0.04
Total	1.000

A similar method was followed for management capability which is sub-divided into five criteria. The weight for the criterion was divided by 5. The weights 0.01, 0.02, 0.03, and 0.04 for 1,2,3 and more than three business specialists.

Table 7.6 Weights of occupational health and safety sub-criteria

Occupational Health and Safety			
OHS Certificate	Weight	Health and Safety Record	Weight
No employee with OHS certificate	0	No health and safety record	0
1 employee with OHS certificate	0.0125	Incomplete health and safety record	0.0875

Occupational Health and Safety			
2 employees with OHS certificate	0.025	Complete health and safety record with major injuries	0.175
3 employees with OHS certificate	0.0375	Complete health and safety record with minor injuries	0.2625
More than 3 employees with OHS certificate	0.0875	Complete health and safety record without injuries	0.350
Total	0.125		0.875

A similar method was followed for occupational health and safety certificate which was sub-divided into five criteria. The weight for the criterion was divided by 5. The weights are 0.0125, 0.025, 0.0375, and 0.0875 for 1,2,3, and more than three employees with OHS certificates. Health and Safety Record was also subdivided into five criteria. The weight for the criterion was divided by 5. The weights are 0.0875, 0.175, 0.2625, 0.350.

Table 7.7 Weights of past performance sub-criteria

Past Performance					
	Time	Quality	Cost	Referrals	Weight
All projects completed timeously, within the agreed time, quality, and cost	0.0488	0.2232	0.1052	0 referrals	0
80-90% of projects completed timeously within the agreed time, quality, and cost	0.0366	0.1674	0.0789	1 referral letter	0.0057
50-79.99% of projects completed timeously within the agreed time, quality, and cost	0.0244	0.1116	0.0526	2 referral letters	0.0114
20-49.99% projects completed timeously within the agreed time, quality, and cost	0.0122	0.0558	0.0263	3 referral letters	0.0171

Past Performance					
	Time	Quality	Cost	Referrals	Weight
0-19.99% projects completed timeously within the agreed time, quality and cost	0	0	0	More than 3 referral letters	0.0228
Total	0.122	0.558	0.263		0.057

A similar method was followed for time, quality, and cost which was subdivided into five criteria. The weight for the criterion was divided by 5. The weight for time is 0.0488, 0.0366, 0.0244, 0.0122, whilst the weight for quality is 0.2232, 0.1674, 0.1116, 0.055 and the weight for cost is 0.1052, 0.0789, 0.0526, 0.0263 respectively. Referrals weights are 0.0057, 0.0114, 0.0171, 0.0228 for 1,2,3 and more than 3 referrals. Time, cost, quality, and referrals/client satisfaction performance should be measured as follows:

7.2.2 Time performance

To assess project performance, that is the timely completion of projects, the degree of delay can be calculated as indicated by Mohlala (2015). This provides a uniform measure for performance and allows for comparison of the different contractors and projects with different construction periods. The degree of delay (DoD) is calculated as a percentage over the specified construction period as follows:

$$\text{Degree of delay (DoD)} = \frac{\text{actual construction period} - \text{specified construction period}}{\text{specified construction period}} \times 100$$

$$= \frac{\text{time overrun}}{\text{Specified construction period}} \times 100$$

For example, the DoD for a three-month project that took six months to complete is:
= 6-3/3 x 100 = 100%

In a tabular format it can be reported as follows (as an example):

Table 7.8 Project degree of delay

	Project Name	Contractor	Specified construction period	Actual construction period	Time overruns	DOD (%)
1.	Project A	Contractor A	3	9	6	200
2.	Project B	Contractor B	3	6	3	100
3.	Project C	Contractor C	5	∞	∞	∞

For projects that were incomplete or had been abandoned the client can report the delay period and degree of delay by the symbol ∞.

7.2.3 Cost performance

The planned project cost is a budgeted cost to implement and execute a project. Whilst actual project cost is the cost which was incurred for the project until project completion. The difference is the sum of the planned project cost less the actual project cost. Whilst the difference against planned cost in percent is the amount of planned project cost not utilised or over-utilised for the project.

For example, a project in which the planned costs were R25 000 and at the end of the project, the actual cost was R30 000. The calculation for the project variance will be = R25 000-R30 000= R5000 (variance)

Therefore, % variance will be $\frac{\text{actual cost}}{\text{planned cost}} \times 100$

= 120, therefore the project cost overran by R5000 (i.e., 20%)

In a tabular format it can be reported as follows (as an example):

Table 7.9 Cost performance factor

	Project Name	Contractor	Planned Cost (R)	Actual Cost (R)	Variance (R)	Variance (%)
1.	Project A	Contractor A	100 000	100 000	0	0%
2.	Project B	Contractor B	50 000	75 000	25 000	50%
3.	Project C	Contractor C	500 000	∞	∞	∞

7.2.4 Quality and client satisfaction

Different projects have different quality criteria which can be assessed. Generally, project performance in South Africa is very poor in infrastructure projects. As indicated, this is the case as contracts are awarded to contractors who have limited technical capabilities and yet have progressed through the grades due to adequate financial capability and the number of projects completed.

Thus, it is important that explanations for projects which have not met the required specifications be provided. Projects which were not completed within the required specifications would be deemed as projects which were not completed within the agreed scope of work. Thus, the quality of the project would be deemed not good or poor. The Department of Water and Sanitation measures its performance quality mainly by defects and rework.

At the end of a project in most government institutions, beneficiaries sign a completion certificate (i.e., at commissioning). The signatories sign as an indication of satisfaction and agreement of all work done by the contractor. For that reason, the presence of a completion certificate usually indicates client (government organisation) and beneficiary satisfaction. Thus, a template (attached as Annexure B) can be used to assess the overall project implementation and client satisfaction can be adopted from the South African National Roads Agency (SANRAL). This template may however be used during project implementation, at the end of the project, or when a contractor abandons a project.

7.3 APPLICATION OF THE FRAMEWORK TO GRADE CONTRACTORS AND EVALUATE CONTRACTOR PERFORMANCE

Tables 7.1-7.7 have broken down the weights of the criteria in order to make better sense of the weighting and apply the results that may be used in practice. The results should guide how to grade contractors and rate contractor performance. The use of scenarios will be illustrated to indicate how contractors can be graded and rated in terms of performance.

Scenario A

This scenario assumes that Contractor A has a registered company and wants to register as a contractor and has a certificate in water engineering and occupational health and safety, 3 years of relevant technical experience, and has managed two water-related projects, and has a business account. In terms of the weight allocation as described above, this is how it will be annotated:

Table 7.10 Contractor A weighting allocation

Contract A weight allocation	Description
0.0633	Certificate in Water Engineering
0.052	3 years' experience
0.0106	1 technical staff
0.0175	Completed two projects
0.010375	Bank account
0.0125	OHS certificate
0.0166275	Total

To grade Contractor A, the total weight will be divided by the number of sub-criteria which is eighteen. The total is divided by the total number of the sub-criteria because the sub-criteria are what is considered when grading contractors. Therefore;

$$\frac{0.0166275}{18} = 0.00924$$

Therefore, Contractor A is a Grade 1 contractor because the overall project priority vector for Grade 1 contractors is 0.040. Thus, anything that is below 0.040 means that the contractor is a Grade 1. To determine the performance of the contractor, the total weight is divided by 7 which is the number of the main criteria. This is so because contractor performance is the overarching performance of the contractor.

$$\frac{0.0166275}{7} = 0.0024$$

The contractor's performance is for an emerging contractor because it is between 0-0151 which is the overall priority vector of emerging contractor. This is expected because Contractor A is new in the sector.

Scenario B

This scenario assumes that Contractor B is a registered Grade 1 Contractor and wants to upgrade. The Contractor has two employees with technical degrees in Civil Engineering and occupational health and safety, 2 years of relevant technical experience, and has managed 4 civil-engineering-related projects and has a business account. Moreover, the contractor has office space, two referral letters, and 90% of his projects were completed within time, cost, and the stipulated specifications. Thus, the weighting will be as follows:

Table 7.11 Contractor B weighting allocation

Contract B weight allocation	Description
0.3798	Two employees with Civil Eng
0.052	2 years' cumulative experience
0.0212	2 technical staff
0.035	Completed four projects
0.010375	Bank account
0.193	Office space
0.025	OHS certificate
1.313475	Total

To grade Contractor B, the total weight will be divided by the number of sub-criteria which is eighteen, Therefore;

$$\frac{1.313475}{18} = 0.07297$$

Therefore, Contractor B is a Grade 2 contractor because the overall project priority vector for Grade 2 contractors is 0.094. Thus, anything that is between 0.040 and 0.094 means that the contractor qualifies to be graded as a Grade 2. To determine the performance of the contractor, the total weight is divided by 7 which is the number of criteria;

$$\frac{1.313475}{7} = 0.1876$$

The contractor's performance is between emerging and established contractor. This is expected because Contractor B is still growing within the sector and project performance in terms of completion of projects within time, quality and cost is within 80-90%.

Scenario C

This scenario assumes that Contractor C has a registered company and wants to register as a contractor has a certificate in road management and occupational health and safety, does not have work experience, and has a business account. In terms of the weight allocation as described above, this is how it will be calculated:

Table 7.12 Contractor C weighting allocation

Contract C weight allocation	Description
0.0633	Certificate in Roads Management
0.0106	1 technical staff
0.010375	Bank account
0.0125	OHS certificate
0.005376	Total

To grade Contractor C, the total weight will be divided by the number of sub-criteria which is eighteen, Therefore;

$$\frac{0.005376}{18} = 0.0003$$

Therefore, Contractor C is a Grade 1 contractor because the overall project priority vector for Grade 1 contractors is 0.040. Because Contractor C is a new contractor, there will thus be no need to assess the project performance.

Scenario D

This scenario assumes that Contractor D is a Grade 8 Contractor and wants to upgrade. The Contractor has ten employees with technical degrees in Civil Engineering and occupational health and safety. Five of these employees have ten years of relevant technical experience, three have four years of relevant technical experience and two have two years of relevant technical experience. Moreover, the contractor completed more than 4 company projects and 7 of the key staff have completed more than 4 projects.

The company has more than ten relevant plant and equipment, as well as a positive bank account with 10% available capital. Contractor D has office space, and has 90% of his projects completed within time, cost, and the stipulated specifications. In terms

of referrals letters, Contractor D has seven good referrals and 2 business specialists with four employees with OHS certificates and OHS record with minor injuries. Thus, the weighting will be as follows:

Table 7.13 Contractor D weighting allocation

Contract D weight allocation	Description
1.899	10 employees with Civil Eng
0.0598	5 employees with 10 years' experience, 3 employees with 4 years' experience and 2 employees with two years' experience
0.0742	More than 3 technical staff
0.0875	More than 4 company projects
0.35	More than 4 company projects
0.3332	More than 10 plant and equipment
0.05186	Positive bank account
0.1448	10% available capital
0.193	Office space
0.0366	Time
0.1674	Quality
0.0228	Referrals
0.2	Business specialist
0.050	More than 3 employees with OHS
0.02625	Complete OHS record with minor injuries
4.61656	Total

To grade Contractor D, the total weight will be divided by the number of sub-criteria which is eighteen, therefore;

$$\frac{4.61656}{18} = 0.256476$$

Thus, Contractor D will be upgraded as a Grade 9 contractor because the overall project priority vector for Grade 9 contractors is 0.164. This means that any weighting that is above 0.164 means that the contractor qualifies to be graded as a Grade 9. To determine the performance of the contractor, the total weight is divided by 7 which is the number of criteria;

$$\frac{4.61656}{7} = 0.6595$$

Contractor D is an experienced contractor because the overall project priority vector for an experienced contractor is 0.534.

7.3.1 Construction industry development board grading scenarios

Scenario AA

This scenario considers the Construction Industry Development Board grading criteria which only considers track record and available capital. The assumption is that Company A is a Grade 4 Contractor. Thus, the company would need to have completed projects in Grade 3 which are worth more than R3 million and have available capital of R100 000. In terms of the enhanced grading criteria, the weighting of the company will be as follows based on information which would have been submitted to the CIDB:

Company A: Grade 4

Where there is no information which would have been provided to the CIDB because it is not the requirement, N/A is inserted.

Table 7.14 CIDB grading scenario: Company A

Technical Capacity					
Academic qualifications	Number of Employees Per Category	Key staff experience	Number of Employees Per Category	Number of key staff	Select one option
No certificate	N/A	0 years	N/A	0	N/A
Certificate	N/A	0-2 years	N/A	1	N/A
Diploma	N/A	3-5 years	N/A	2	N/A
Degree	N/A	5-10 years	N/A	3	N/A
Postgraduate	N/A	More than ten years	N/A	More than 3 key staff	N/A

Experience			
Project completed by company	Select one option	Projects completed by key staff	Select one option
0	N/A	0	N/A
1	N/A	1	N/A
2	N/A	2	N/A
3	N/A	3	N/A
More than 3 projects	N/A	More than 3 projects	N/A

Plant and Equipment			
Type of equipment	Select one option	Minimum quantity	Select one option

0	N/A	0	N/A
2 (Walk behind roller, Light delivery vehicle)	N/A	2	N/A
5 (Walk behind roller, Light delivery vehicle, Tipper truck, Steel roller, Truck flat)	N/A	5	N/A
8 (Walk behind roller, Light delivery vehicle, Tipper truck, Steel roller, Truck flat, Light delivery vehicle	N/A	8	N/A
10 equipment and more (Walk behind roller, Light delivery vehicle, Tipper truck, Steel roller, Truck flat, Light delivery vehicle, Water browse, grader, loader, Excavator)	N/A	10 and above	N/A

Financial Status					
Bank Account	Select one option	Available Capital	Select one option	Office Space	Select one option
No business account		No capital		No office space	
New business account		5% available capital		Office space	**x**
Acc with (-) balance		10% available capital	X		
Acc with (+) balance	**x**	15% available capital			
		R60m available capital			

Management Capability	
Business Specialist (Including accountants)	Select one option
0	N/A
1	N/A
2	N/A
3	N/A
More than 3	N/A
Occupational Health and Safety	

OHS Certificate	Select one option	Health and Safety Record	Select one option
No employee with OHS certificate	N/A	No health and safety record	N/A
1 employee with OHS certificate	N/A	Incomplete health and safety record	N/A
2 employees with OHS certificate	N/A	Complete health and safety record with major injuries	N/A
3 employees with OHS certificate	N/A	Complete health and safety record with minor injuries	N/A
More than 3 employees with OHS certificate	N/A	Complete health and safety record without injuries	N/A

Past Performance					
	Time (select one option)	Quality (select one option)	Cost (select one option)	Referrals	Select one option
All projects completed timeously, within the agreed time, quality, and cost	N/A	N/A	N/A	0 referrals	
80-90% of projects completed timeously within the agreed time, quality, and cost	N/A	N/A	N/A	1 referral letter	
50-79.99% of projects completed timeously within the agreed time, quality, and cost	N/A	N/A	N/A	2 referral letters	
20-49.99% projects completed timeously within	N/A	N/A	N/A	3 referral letters	**x**

the agreed time, quality, and cost					
0-19.99% projects completed timeously within the agreed time, quality, and cost	N/A	N/A	N/A	More than 3 referral letters	

Table 7.15 Company A weighting allocation

Company A weight allocation	Description
0.05186	Positive bank account
0.1448	10% available capital
0.193	Office space
0.0171	Referrals
0,40676	Total

To grade Company A, the total weight will be divided by the number of sub-criteria which is eighteen, therefore;

$$\frac{0.40676}{18} = 0.02259$$

Thus, Company A in terms of the weighting is supposed to be a Grade 1 Contractor because the Grade 1 contractor's overall project priority vector is 0.040. This is the case because currently, the CIDB does not request the other criteria information since it is not the requirement (only track record which is in the form of completion certificates and financial records). To avert this with regards to the current contractors, the CIDB will have to inform contractors of the new requirements and request the relevant information to be submitted. As such, companies will be requested to submit all the requested documentation for the purpose of filing not downgrading. Therefore, only companies wishing to upgrade to a higher grade will have to meet the new grading criteria requirements.

Alternatively, the CIDB could consider providing the current contractors with reasonable timeframes regarding the gaps which contractors will need to close to be considered eligible for their current grading. If this approach is considered, this may greatly assist with rapidly improving all the current contractors (i.e., those wishing to

upgrade and those who do not wish to upgrade) and performance outputs. This process can also be used by the CIDB to identify gaps for the purpose of contractor development. The Construction Industry Development Board will have to provide a reasonable timeline for companies to provide this information and for the contractor development process.

To determine the performance of the contractor, the total weight is divided by 7 which is the number of criteria;

$$\frac{0.40676}{7} = 0.05810$$

Company A is regarded as an emerging contractor because the overall project priority vector for emerging contractors is 0.151. It is highly likely that most of the current contractors' weighting may fall under the emerging contractor's overall project priority vector. This is the case because the enhanced grading criteria consider several key criteria whilst the current grading criteria only consider two criteria. The second CIDB scenario considers that the current contractor is a Grade 7 contractor.

Scenario AB

This scenario also considers the Construction Industry Development Board grading criteria which only considers track record and available capital. The assumption is that Company B is a Grade 7 Contractor. Thus, the company would need to have completed projects in Grade 6 which are worth more than R20 million and have available capital of R1 300 000 for two years. The weighting of the company will be as follows based on information that would have been submitted to the CIDB:

COMPANY B: GRADE 7

Where there is no information that would have been provided to the CIDB because it is not the requirement, N/A is inserted.

Table 7.16 CIDB grading scenario: Company B

Technical Capacity					
Academic qualifications	Number of Employees Per Category	Key staff experience	Number of Employees Per Category	Number of key staff	Select one option
No certificate	N/A	0 years	N/A	0	N/A
Certificate	N/A	0-2 years	N/A	1	N/A
Diploma	N/A	3-5 years	N/A	2	N/A
Degree	N/A	5-10 years	N/A	3	N/A
Postgraduate	N/A	More than ten years	N/A	More than 3 key staff	N/A

Experience			
Project completed by company	Select one option	Projects completed by key staff	Select one option
0	N/A	0	N/A
1	N/A	1	N/A
2	N/A	2	N/A
3	N/A	3	N/A
More than 3 projects	N/A	More than 3 projects	N/A

Plant and Equipment			
Type of equipment	Select one option	Minimum quantity	Select one option
0	N/A	0	N/A
2 (Walk behind roller, Light delivery vehicle)	N/A	2	N/A
5 (Walk behind roller, Light delivery vehicle, Tipper truck, Steel roller, Truck flat)	N/A	5	N/A
8 (Walk behind roller, Light delivery vehicle, Tipper truck, Steel roller, Truck flat, Light delivery vehicle	N/A	8	N/A
10 equipment and more (Walk behind roller, Light delivery vehicle, Tipper truck, Steel roller, Truck flat, Light delivery vehicle, Water browse, grader, loader, Excavator)	N/A	10 and above	N/A

Financial Status					
Bank Account	Select one option	Available Capital	Select one option	Office Space	Select one option
No business account		No capital		No office space	
New business account		5% available capital		Office space	**x**
Acc with (-) balance		10% available capital			
Acc with (+) balance	**x**	15% available capital	X		
		R60m available capital			

Management Capability	
Business Specialist (Including accountants)	Select one option
0	N/A
1	N/A
2	N/A
3	N/A
More than 3	N/A

Occupational Health and Safety			
OHS Certificate	Select one option	Health and Safety Record	Select one option
No employee with OHS certificate	N/A	No health and safety record	N/A
1 employee with OHS certificate	N/A	Incomplete health and safety record	N/A
2 employees with OHS certificate	N/A	Complete health and safety record with major injuries	N/A
3 employees with OHS certificate	N/A	Complete health and safety record with minor injuries	N/A
More than 3 employees with OHS certificate	N/A	Complete health and safety record without injuries	N/A
Past Performance			

	Time (select one option)	Quality (select one option)	Cost (select one option)	Referrals	Select one option
All projects completed timeously, within the agreed time, quality, and cost	N/A	N/A	N/A	0 referrals	
80-90% of projects completed timeously within the agreed time, quality, and cost	N/A	N/A	N/A	1 referral letter	
50-79.99% of projects completed timeously within the agreed time, quality, and cost	N/A	N/A	N/A	2 referral letters	
20-49.99% projects completed timeously within the agreed time, quality, and cost	N/A	N/A	N/A	3 referral letters	
0-19.99% projects completed timeously within the agreed time, quality, and cost	N/A	N/A	N/A	More than 3 referral letters	X

Table 7.17 Company B weighting allocation

Company B weight allocation	Description
0.05186	Positive bank account
0.2172	15% available capital
0.193	Office space
0.0228	Referrals

Company B weight allocation	Description
1,20486	Total

To grade Contractor D, the total weight will be divided by the number of sub-criteria which is eighteen, therefore;

$$\frac{1{,}20486}{18} = 0.06694$$

Therefore, Company B in terms of the weighting is supposed to be a Grade 2 Contractor because the Grade 1 contractor's overall project priority vector is 0.094.

To determine the performance of the contractor, the total weight is divided by 7 which is the number of criteria;

$$\frac{1.20486}{7} = 0.17212$$

Company B is regarded as an emerging contractor because the overall project priority vector for emerging contractors is 0.534.

7.4 OTHER KEY PROPOSED DEVELOPMENTS FOR CONSIDERATION

It is proposed herein that the register of projects and the register of contractors should be linked to provide insights into contractor performances. This means that after government institutions award a tender to a contractor, they will also have a responsibility of indicating who the tender was awarded to as well as the contract duration and costs. The CIDB will thus have to link all tenders that were awarded to a certain contractor. When one opens the register of contractors, the register should also indicate the tenders which the contractor is awarded as well as previous tenders. Government institutions will also have the responsibility to report on the performance of the contractor in terms of four main project management criteria: time, cost, quality, and client satisfaction at the end of the project. A proposed contractor performance evaluation report which could be adopted is attached as Appendix K.

It is posited herein that if the performance of a contractor is reported on the Register of Projects, the system will automatically link to the relevant contractor through the Register of Contractors (RoC). This will assist in enhancing the selection of contractors

in tender awards as the performance of contractors in all projects will be indicated in both the RoC and RoP.

Moreover, this could assist in establishing the contractor's development needs so that the clients can identify the contractor's key development areas and target them for interventions when planning projects. Moreover, this will also enable clients to view contractors who are failing to execute projects within the specified time, quality, and budgetary requirements.

According to Harrison and Lock, (2004), Turner, (1999), and Cheung, Suen, and Cheung (2004), the four most used project performance indicators are time, cost, quality, and client satisfaction. The time factor can be used to assess the project performance of contractors in construction projects. Timely completion of projects is commonly regarded as the major indicator of project success (Rwelamila & Hall, 1995). A generic method which is indicated in Sections 7.2.1.1-7.2.1.3 could be adopted on how government institutions can be reporting.

7.5 CHAPTER SUMMARY

In this chapter, a framework was developed to grade and assess project performance assessment of contractors. In developing the framework, the results of the comparison matrix for level 2 which involved pairwise comparisons between the sub-criteria in relation to each main criterion were utilised to dissect the sub-criteria to provide weighting using a standardised formula. Thereafter, various scenarios and CIDB grading scenarios were created to apply the framework for grading contractors and assessing project performance.

It is noted that when applying the CIDB grading scenarios, contractors are likely to fall short due to several key criteria that are considered in the enhanced grading framework. Two proposals are made for managing the situation. Firstly, it is proposed that the current contractors will need to comply with the grading requirements when applying for an upgrade. Alternatively, the CIDB can provide reasonable timelines for contractors to adhere to the enhanced grading requirements. This will assist in contractor gap identification by the CIDB for contractor development.

Other key developments for consideration are also indicated. It is proposed that there should be links between the Register of Contractors and the Register of Projects. Linking projects that have been awarded to a contractor and reporting on performances (i.e., time, cost, quality, and client satisfaction) could assist the construction sector. A simple generic method has been proposed for adoption to calculate project time and cost to enable system user-friendliness.

Moreover, a template has also been introduced which may be adopted by the CIDB to be filled by clients at the end of each project to provide an overview of the contractor's performance. This is in line with the mandate of the CIDB, which is stipulated in Sections 5 (1) and 5(2) of the CIDB Act (no 38 of 2000), which requires the CIDB to provide strategic direction and to promote best practices.

The integration of these systems and regulating the reporting of project performance by clients may assist in enhancing sector performance. This will also enable clients to easily assess the performance of contractors before awarding contracts and identify contractors' developmental needs. Furthermore, the CIDB can work with clients and National Treasury to blacklist contractors who have performed poorly or have abandoned projects.

CHAPTER 8 DEVELOPMENT OF ENTRY AND GRADING REQUIREMENTS FOR THE CONSTRUCTION SECTOR

8.1 INTRODUCTION

As discussed earlier, the purpose of this research is to develop a decision-support framework for registering, grading, and managing contractors to improve the construction sector's project performance. The framework will assist decision-makers in registering new entrants and grading contractors who wish to progress to a higher grade. The proposed framework can be adopted by both the public and the private sector.

Previous chapters reviewed the literature on project performance, the role of the Construction Industry Development Board, regulation of business entry, contractor grading, and performance of the construction sector. Moreover, a framework for registering, grading, and evaluating contractors was developed. The aim was to establish the basis for this research and identify requirements to be addressed by this research. This chapter focuses on developing the requirements to be proposed for the regulation of new entrants into the construction sector and the minimum requirements for consideration to the next grade. Proposals are also made on the requirements for grade progression. The focus of the study is to develop requirements for the Civil Engineering (CE) category.

The aim is to enhance the current contractor registration and grading framework to improve the robustness of the framework. A point of departure is to note that responses from the questionnaire indicate that the majority (88.6%) of the respondents agree that enhancing the current construction sector entry requirements could assist in improving contractors' capabilities. Again, the majority (90.6%) of the respondents have indicated that enhancing the current construction sector entry requirements will assist in improving the performance outputs of the construction sector.

It should further be noted that 84.6% of the respondents agreed that enhancing the current grading system could assist in improving contractors' capabilities and improve the performance outputs of the construction sector. The view indicated by

Ratshisusu (2014) that the CIDB needs to improve the grading system is therefore supported by the survey. This chapter proposes entry requirements and grading requirements which may be considered by the construction sector.

8.2 MINIMUM ENTRY REQUIREMENTS IN THE CONSTRUCTION SECTOR

The Construction Industry Development Board (CIDB) has various disciplines under the Civil Engineering category. Civil Engineering is defined by CIDB (2017) as construction works primarily concerned with materials such as steel, concrete, earth, and rock and their application in the development, extension, installation, maintenance, removal, renovation, alteration, or dismantling of building and engineering infrastructure. Basic work types include water, sewerage, roads, railways, harbours and transport, urban development, and municipal services.

Typical examples include structures such as cooling tower, bridge culvert, dam, grandstand, road, railway, reservoir, runway, swimming pool, silo, and tunnel. The operations may include dredging, earthworks, and geotechnical processes, township services, water treatment and supply, sewerage works, sanitation, soil conservation works, irrigation works, stormwater and drainage work, coastal works, ports, harbours, airports, and pipelines.

From the definition, it is evident that civil engineering is very broad. So, it will be advisable to subcategorise civil engineering. As indicated in Chapter 3, the CIDB has twenty classes of work, and one of the classes of work is Civil Engineering. A point to note is that a contractor who registers as a Civil Engineering contractor is eligible to contract in any field of the Civil Engineering domain. As indicated the Civil Engineering category is very broad, a contractor who intends to register as a Grade 1 should not be eligible to do all works of civil engineering. In line with the broad definition of civil engineering by the CIDB (2017), the proposed sub-categories under civil engineering are as follows:

Table 8.1 Proposed sub-categories under civil engineering.

Sub-Category	Field of Civil Engineering
01	Construction (Roads, Infrastructure and Airfields)
02	Railways
03	Dams
04	Road surfacing
05	Bridges
06	Water supplies, sanitation reticulation and Irrigation works
07	Water and sewerage treatment plant works
08	Water engineering works
09	Specialised construction work
10	Drilling works
11	Roads and ancillary works

The minimum requirements for entry into the construction sector should consider three key criteria as defined in Chapter 2.

The proposed minimum entry requirements for Construction (Roads, Infrastructure and Airfields: Subcategory 01) are depicted in Table 8.2.

Table 8.2 Grade 1 entry requirements for construction works (Roads, Infrastructure and Airfields: Subcategory 01)

Civil Engineering Works; Subcategory 01: Construction (Roads, Infrastructure and Airfields)								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
1	R500 000	None	None	Bank account	Certificate in highway engineering or Roads technician certificate and OHS certificate	1	None	None

As shown in Table 8.2, the proposed criteria for minimum entry requirements are:

- Technical capacity (academic qualification)
- Financial status (bank account)
- Occupational health and safety (certificate)

The views gathered from the survey have further proposed that the entry requirements should be restricted to technical people and that N6 should be a minimum qualification. The view from the questionnaire is similar to the views of Burger and Zulch (2018), who recommended that National Qualification Framework (NQF) Level 6 and NQF Level 7 should be the minimum academic qualifications for construction project managers and should be used in combination with knowledge gained through industry experience to assist construction project managers in developing their knowledge sets and ensuring the successful execution of projects (Burger & Zulch, 2018).

An analysis performed by Sheppard (2009) as cited by Stumpf *et al.* (2009) using Statistics South Africa's Community Survey (2007) shows that in 2007, nearly 700 000 young people between the ages of 18 and 24 who were unemployed were in possession of a school leaving certificate or a FET college certificate which allowed them to continue with further studies at post NQF Level 4, including higher education studies.

The NQF Level 4 is equivalent to the National Senior Certificate (or Grade 12) level for the schooling sector and post the National Certificate (Vocational) NQF Level 4 for the FET college sector. Most of the population in South Africa have an upper secondary or post-secondary non-tertiary qualification as their highest level of education which is equivalent to NQF Level 4 (OECD, 2019). Thus, the current status quo must be taken into consideration when determining the entry education level in the construction sector.

It should be noted that the Occupational Health and Safety (OHS) certificate is a requirement in all the proposed categories and grades (i.e., from grades 1-9). The OHS certificate is noted as a requirement because the CIDB (Undated) has indicated that construction continues to contribute to a disproportionate number of fatalities and injuries, and there continues to be a high level of non-compliance with the Health &

Safety Regulations in South Africa. The high levels of fatalities and injuries are not only a South African challenge but a worldwide challenge, as noted by Adinyira *et al.* (2020) and Schmidt *et al.* (2019).

Improving OH&S in the construction industry, therefore, continues to remain a priority, including being a priority for the CIDB. A requirement to have OHS as an entry-level requirement may assist in reducing the disproportionate number of fatalities and injuries. Another typical example of the proposed minimum entry requirements for water supplies, sanitation reticulation and irrigation work – Subcategory 06 is as follows:

Table 8.3 Grade 1 entry requirements for water supplies, sanitation reticulation and irrigation work- Subcategory 06

Civil Engineering Works: Subcategory 06- water supplies, sanitation reticulation and irrigation works								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
1	R500 000	None	None	Bank account	Certificate in Civil/Water Engineering and OHS certificate	1	None	None

Tables 8.8- 8.15 indicate the entry requirements for the proposed 11 civil engineering sub-categories. The entry requirements are the same; the difference is in the qualification required. The owner of a business company who holds a three-year qualification in civil engineering (i.e., NQF Level 7) should be allowed to register in all categories of civil engineering.

8.3 CONTRACTOR PROGRESSION

For progression through the grades, the following seven criteria should be considered as defined and explained in Chapter 2:

- Technical capacity

- Experience
- Plant and equipment
- Financial status and
- Past performance
- Management capability
- Occupational health and safety

Thus, the entry requirements for contractors to progress to the next grade in subcategories of civil engineering can use Table 8.7 as guidelines for requirements for progression through the grades for contractors who wish to operate in the subcategory of construction (Roads, Infrastructure and Airfields). The requirements for progression through the grades of the remaining ten subcategories of civil engineering are indicated in Tables 8.16-8.30. The type of plant and equipment is attached as Annexure L.

Table 8.4 Grade 2-9 entry requirements for construction works (Roads, Infrastructure and Airfields) subcategory 01 (adapted from: World Bank, 2018).

Civil Engineering Works; Subcategory 01: Construction (Roads, Infrastructure and Airfields)								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
2	R1 000 000	None	None	Bank account	Certificate in Highway engineering or Roads technician certificate	1	2 years	2 projects of similar nature from grade 1
				Office space				
3	R3 000 000	None	None	Bank account and 5% available capital	Certificate in Highway engineering or Road's technician certificate	1	3 years	2 projects of similar nature from grade 2

Civil Engineering Works; Subcategory 01: Construction (Roads, Infrastructure and Airfields)								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
				Office space				
4	R6 000 000	Walk behind roller	1	Bank account and 5% available capital	Diploma in Civil Engineering AND	1	3 years	3 projects of similar nature from grade 3
		Light delivery vehicle	1	Office space	Certificate in Highway engineering or Roads technician certificate	1	2 years	
5	R10 000 000	Walk behind roller	1	Bank account and 10% available capital	Diploma in Civil Engineering AND	1	4 years	3 projects of similar nature from grade 4
		Light delivery vehicle	1	Office space	Certificate in Highway engineering or Roads technician certificate	1	3 years	
6	R20 000 000	Tipper truck	1	Bank account and 10% available capital	Degree in Civil Engineering AND	1	2 years	2 projects of similar nature from grade 5
		Steel roller	1	Office space	Diploma in Civil Engineering	1	2 years	
		Truck flat	1					
		Light delivery vehicle	1					
		Water bowser/ grader/ loader	1 of them					

Civil Engineering Works; Subcategory 01: Construction (Roads, Infrastructure and Airfields)								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
7	R60 000 000	Tipper truck	1	Bank account and 10% available capital	Degree in Civil Engineering AND	1	2 years	2 projects of similar nature from grade 6
		Steel roller	1	Office space	Diploma in Civil Engineering	1	2 years	
		Track flat	1					
		Light delivery vehicle	1					
		Water bowser/ grader/ loader	1 of them					
8	R200 000 000	Tipper truck	2	Bank account and 10% available capital	Degree in Civil Engineering AND	1	4 years	2 projects of similar nature from grade 7
		Steel roller	1	Office space	Degree in Quantity Surveying or equivalent AND	1	2 years	
		Truck flat	1		Diploma in Civil Engineering	1	2 years	
		Light delivery vehicle	1					
		Water bowser	1					
		Grader	1					
		Loader	1					

Civil Engineering Works; Subcategory 01: Construction (Roads, Infrastructure and Airfields)								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
9	No limit	Tipper truck	3	Bank account and R60 000 000 available capital	Degree in Civil Engineering AND	1	4 years	2 projects of similar nature from grade 8
		Steel roller	1	Office space	Degree in Quantity Surveying or equivalent AND	1	4 years	
		Truck flat	1		Diploma in Civil Engineering	1	2 years	
		Light delivery vehicle	1					
		Water bowser	1					
		Grader	1					
		Loader	1					
		Excavator	1					

Table 8.4 depicts the proposed requirements for contractor progression for grades 2-9. The projects of similar nature are projects of the similar sub-category in which grading progression is sought (e.g., sub-category 07, water, and sewerage treatment plant works).

8.4 CONTRACTOR CONTINUOUS DEVELOPMENT POINTS

Over and above the stipulated minimum requirements, it is proposed that contractors may be required to acquire training to attain Contractor Continuous Development

(CCD) Points. The points required for different grades and renewal periods are proposed in Table 8.5, modelled on the Malaysian requirements:

Table 8.5 Required Contractors Continuous Development Points for the renewal of application (adapted from: CIDB Malaysia, 2016)

Grade (G)		Renewal Period		
	1 Year (Minimum points)		2 Years (Minimum points)	3 Years (Minimum points)
G1 to G3	10		20	30
G4 to G6	20		40	60
G7 and G8	30		60	90
G9	40		80	120

CCD points are required for approval of a renewal application to extend the registration certificate. Only CCD points obtained by the company owner, director, or full-time employee or a certificate held by the company are considered (CIDB Malaysia, 2016). Contractors will be required to capacitate themselves to stay abreast of developments in the construction and business sectors.

8.4.1 Accumulation of Contractor Continuous Development (CCD) Points

A renewal application to extend the registration certificate is approved based on the CCD points accumulated during the current registration period. Only CCD points obtained by the company owner, director or full-time employee, or a certificate held by the company are considered. CCD points required for different renewal periods are indicated in Table 9.9.

Documents to support the application renewal include a certificate of participation, a certificate of attendance, and letter of recommendation. The proposed contractor development programme points should be as follows:

Table 8.6 Contractor development programme points (Adapted from Malaysia CIDB, 2016)

No	CCD Events	Code	Description	CCD Points	Evidence/ Documents
1	Convention, forum, seminar, workshop, lecture, technical visit, course, training	A	Attending related convention, conference, forum, seminar, workshop, short course, and programme, organised by CIDB, private training companies and related government agencies, as a participant i. 2 days or more ii. ii. full day	 25 15	Certificate of attendance / confirmation letter

No	CCD Events	Code	Description	CCD Points	Evidence/ Documents
			iii. iii. half day	10	
		B	Attending related convention, conference, forum, seminar, workshop, short course, and program, organised by other parties recognised by CIDB, as participant i. 2 days or more ii. ii. full day iii. iii. half day	 20 10 5	Certificate of attendance / confirmation letter
		C	Technical visit / international investment mission organized by CIDB, or other related parties recognised by CIDB	15	Confirmation letter
		D	Contractor certified training centre (PLBK) i. Contractor Management Course (4/5 days) ii. ii. Contractor Management Course (2 days)	 40 25	Certificate of attendance Certificate of attendance
			Certified training centre i. Youth training	40	Certificate of Skills Competency
			Safety Induction for Construction Worker course (SICW)	10	Certificate of attendance
			Integrity course	10	Certificate of achievement
		E	Accreditation Program (Local employee) i. Training & accreditation ii. ii. Accreditation only	 40 15	Certificate of Skills Competency
2	Involvement in CIDB development programs	A	CIDB board of directors	20 (per annum)	Confirmation letter and attendance list
		B	CIDB committee member (group; specialist / specific / activity, etc.)	20 per annum	Meeting invitation letter/ appointment
		C	CIDB's mediator, adjudicator, etc.	20	Accreditation certificate
		D	i. Participation in CIDB-organised competition ii. ii. Booth exhibition in CIDB organised programs	10 10	Assessment of participation declaration Confirmation letter
		E	Participation in CIDB-organized evaluation programs	15	Evaluation certificate
		F	Construction industry survey by CIDB	5	Certificate/ letter/ other documents
3	Keynote or paper work presentation		Speaker, chairman or panel member in the preparation and presentation of keynote or paperwork for conference, convention, forum, seminar, workshop, course, etc.		Offer letter/appointment letter/certificate
		A	Organised by CIDB	15	
		B	Organised by other CIDB recognised parties	10	
4	Service to the profession	A	Registered owner of construction companies serving construction societies / associations		Confirmation letter

No	CCD Events	Code	Description	CCD Points	Evidence/ Documents
			recognized by CIDB, at national or state level i. President iii. Vice President iv. Committee member v. iv. Ordinary member	10 10 10 5	
		B	Representing the association for any official event	5	Confirmation letter
5	Book or article publication / article publication in journal, magazine or news related to the profession	A	Book publication related to the profession, 100 pages or more	20	Confirmation letter/ printed material and publication
		B	Book publication related to the profession, less than 100 pages	15	
		C	Book publication related to the profession, less than 30 pages	10	
6	Contribution to construction-related association activities	A	Attending association annual general meeting at national, state and branch level	5	Confirmation letter & proof of attendance
7	Other	A	Awards and recognition by CIDB-recognized bodies / institutions (i.e., ISO 9001, 14001, 18001)	40	Accreditation certificate
		B	Corporate Social Responsibility (CSR) (i.e., construction related community service, etc.)	10	Letter/declaration/ supporting documents
			Practical / industrial training (on the job training)	10	Office letter and acceptance letter

8.5 TECHNICAL PERSON QUALIFICATION

A technical person is the company owner, director, or full-time employee. They must be a South African citizen or a foreign national with a certificate/ diploma/ degree/ certificate of competency in construction-related fields. Foreign national qualifications need to be vetted with the South African Qualification Authority. Table 8.7. indicates the minimum qualification of the technical person for the different grades.

Table 8.7 Minimum qualification of the technical person for the different grades (adapted from: CIDB Malaysia, 2016)

Grade	Qualification of technical person	Other requirements
1 2 3	A technical certificate holder (equivalent to NQF Level 4)	
4 5	A technical diploma holder	The technical person's degree/ diploma/ certificate must be related to the civil engineering construction field and is recognised by the South African Qualification Authority.
6 7	A technical degree holder as well as the business accounting diploma.	
8 9	2- technical degree holders as well as 2 business accounting diploma. 2-technical degree holders as well as well as two business accounting degree and qualified as CFA/CA SA.	

The importance of technical qualification is important in the construction sector. Orando and Isabirye (2018) revealed that construction worker skills development and good technical educational background in construction and worker skill attitude are very important for work productivity improvement. NQF Level 4 is the entry level because the majority of South Africans have acquired NQF Level 4 (OECD, 2019).

8.6 ADDITIONAL REQUIREMENTS

Applicants must fulfil or comply with other terms and conditions of the CIDB Contractor Registration Certificate, namely;

a) Integrity and Code of Ethics Course for New Contractors

A new contractor registered with CIDB should be required to attend and pass the Contractor Integrity and Code of Ethics Course within one (1) year from the date of issue of the Contractor Registration Certificate. This requirement may assist the construction sector in South Africa to reduce the remarkable levels of unethical practices and poor performance as noted by Maseko (2017). The Contractor Integrity

and Code of Ethics Course can be attended by the company owner, director, or key management personnel. Application for the first renewal of the registration certificate must be attached with the Contractor Integrity and Code of Ethics Course certificate. Failure to do so will disqualify the registration certificate renewal application.

8.7 PROPOSED ENTRY AND PROGRESSION REQUIREMENTS FOR GRADES 1-9

Tables 8.8 to 8.17 propose requirements for consideration for grades 1-9 in all the subcategories.

Table 8.8 Grade 1 entry requirements for construction works (Subcategory 01-08)

Civil Engineering Works; Subcategory 01: Construction (Roads, Infrastructure and Airfields)								
Grade & Sub-category	Tender value less than or equal to	Plant and Equipment		Financial status	Qualification of key staff			Experience of the company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staff relevant experience	Number of successfully completed projects by the company or key staff
Grade 1 (Roads, Infrastructure & Airfields: Subcategory 01)	R500 000	None	None	Bank account	Certificate in Highway engineering or Road technician certificate	1	None	None
Grade 1 (Roads, railway works: Subcategory 02)	R500 000	None	None	Bank account	Certificate in Highway engineering or Road technician certificate	1	None	None
Grade 1 (Dams: Subcategory 03)	R500 000	None	None	Bank account	Certificate in Civil/Water Engineering	1	None	None
Grade 1 (road surfacing: Subcategory 04)	R500 000	None	None	Bank account	Certificate in Highway engineering or Road technician certificate	1	None	None
Grade 1 (Bridges: Subcategory 05)	R500 000	None	None	Bank account	Certificate in Civil Engineering	1	None	None
Grade 1 (water supplies, sanitation, reticulation & irrigation works: Subcategory 06)	R500 000	None	None	Bank account	Certificate in Civil/Water Engineering	1	None	None

Civil Engineering Works; Subcategory 01: Construction (Roads, Infrastructure and Airfields)								
Grade & Sub-category	Tender value less than or equal to	Plant and Equipment		Financial status	Qualification of key staff			Experience of the company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staff relevant experience	Number of successfully completed projects by the company or key staff
Grade 1: (Water and sewerage treatment works: Subcategory 07)	R500 000	None	None	Bank account	Certificate in Civil/Water Engineering Certificate in Mechanical Engineering	1 1	None None	None None
Grade 1 (water engineering: subcategory 08)	R500 000	None	None	Bank account	Certificate in Mechanical Engineering Certificate in Civil/Structural/Water Engineering	1 1	None	None

Table 8.9 Grade 1 entry requirements for specialised construction work- subcategory 09

Sub codes	Civil Engineering Works; Subcategory 09- specialised construction work								
	Grade	Tender value less than or equal to (R)	Plant and Equipment		Financial status	Qualification of key staff			Experience of the company or key staff
			Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
Sub code 01- Sports field (turf and running track)	1	R500 000	None	None	Bank account	Diploma in Civil Engineering	1	None	None
	2-9	No limit	Grader	1	Bank account	Degree in Civil Engineering	1	2 years	2 projects of similar nature from grade 1
			Roller	1	Office space				
Sub code 02- Pilling/Underpinning	1	R500 000	None	None	Bank account	Diploma in Civil/ Structural Engineering	1	None	None
	2-9	No limit	Piling rig	1	Bank account	Degree in Civil/ Structural Engineering	1	2 years	2 projects of similar nature from grade 1
					Office space				

Table 8.10 Grade 1 entry requirements for specialised construction work- subcategory 10

Sub codes	Civil Engineering Works; Subcategory 10- drilling works								
	Grade	Tender value less than or equals to (R)	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
			Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
Sub code 01- Drilling and Borehole Development	1	R500 000	Light delivery vehicle	1	Bank account	Any trade across all built environment discipline	1	None	None
			Drilling rig	1	Office space				
	2-9	No limit	Light delivery vehicle	1	Bank account	Any trade across all discipline	1	4 years	2 projects of similar nature from grade 1
			Drilling rig	1	Office space				
Sub code 02- Test pumping	1	R500 000	Light delivery vehicle	1	Bank account	Any trade across all discipline	1	None	None
			Drilling rig	1	Office space				
	2-9	No limit	Light delivery vehicle	1	Bank account	Any trade across all disciplines	1	4 years	2 projects of similar nature from grade 1
			Drilling rig	1	Office space				

Table 8.11 Grade 1 entry requirements for roads ancillary works- subcategory 11

Sub codes	Civil Engineering Works; Subcategory 11- Roads Ancillary Works (Note: 100% owned citizens only)								
	Grade	Tender value less than or equals to (R)	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
			Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
Sub code 01- Road Marking	1	500 000	Road Marker	1	Bank account	Certificate in Civil Engineering	1	None	None
	2-9	No limit	Light delivery vehicle	1	Bank account	Certificate in Civil Engineering	1	2 years	2 projects of similar nature from grade 1
			Road marker	1	Office space				
Sub code 02- Signs	1	R500 000	None	None	Bank account	Certificate in Civil Engineering	1	None	None
	2-9	No limit	Light delivery vehicle	1	Bank account	Certificate in Civil Engineering	1	2 years	2 projects of similar nature from grade 1
					Office space				
Sub code 03- Routine Maintenance (Labour Based)	1	R500 000	None	None	Bank account	Certificate in Civil Engineering	1	None	None
	2-9	No limit	Light delivery vehicle	1	Bank account	Certificate in Civil Engineering	1	2 years	2 projects of similar nature from grade 1

Sub codes	Civil Engineering Works; Subcategory 11- Roads Ancillary Works (Note: 100% owned citizens only)								
	Grade	Tender value less than or equals to (R)	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
			Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
					Office space				
Sub code 04- Road Guard rails/Kerbing	1	R500 000	None	None	Bank account	Certificate in Civil Engineering	1	None	None
	2-9	No limit	Light delivery vehicle	1	Bank account	Certificate in Civil Engineering	1	2 years	2 projects of similar nature from grade 1
					Office space				
Sub code 05- Road bush clearing/ Destumping	1	R500 000	None	None	Bank account	Certificate in Civil Engineering	1	None	None
	2-9	No limit	Light delivery vehicle	1	Bank account	Certificate in Civil Engineering	1	2 years	2 projects of similar nature from grade 1
			Grader	1	Office space				

Proposed Requirements for Contractor Grading Progression

Table 8.12 Grade 2-9 entry requirements for railways-subcategory 02

Civil Engineering Works; Subcategory 02: Railways								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
2	R1 000 000	None	None	Bank account	Certificate in Highway engineering or Roads technician certificate	1	2 years	2 projects of similar nature from grade 1
				Office space				
3	R3 000 000	None	None	Bank account and 5% available capital	Certificate in Highway engineering or Roads technician certificate	1	3 years	2 projects of similar nature from grade 2
				Office space				
4	R6 000 000	Walk behind roller	1	Bank account and 5% available capital	Diploma in Civil Engineering AND	1	3 years	3 projects of similar nature from grade 3
		Light delivery vehicle	1	Office space	Certificate in Highway engineering or Roads technician certificate	1	2 years	
5	R10 000 000	Walk behind roller	1	Bank account and 10% available capital	Diploma in Civil Engineering AND	1	4 years	3 projects of similar nature from grade 4
		Light delivery vehicle	1	Office space	Certificate in Highway engineering or Roads technician certificate	1	3 years	
6	R20 000 000	Tipper truck	1	Bank account and 10% available capital	Degree in Civil Engineering AND	1	2 years	2 projects of similar nature from grade 5
		Steel roller	1	Office space	Diploma in Civil Engineering	1	2 years	
		Truck flat	1					
		Light delivery vehicle	1					
		Water browser/ grader/ loader	1 of them					
7	R60 000 000	Tipper truck	1	Bank account and 10% available capital	Degree in Civil Engineering AND	1	2 years	2 projects of similar nature from grade 6
		Steel roller	1	Office space	Diploma in Civil Engineering	1	2 years	
		Track flat	1					
		Light delivery vehicle	1					

		Water browser/ grader/ loader	1 of them					
8	R200 000 000	Tipper truck	2	Bank account and 10% available capital	Degree in Civil Engineering AND	1	4 years	2 projects of similar nature from grade 7
		Steel roller	1	Office space	Degree in Quantity Surveying or equivalent AND	1	2 years	
		Truck flat	1		Diploma in Civil Engineering	1	2 years	
		Light delivery vehicle	1					
		Water bowser	1					
		Grader	1					
		Loader	1					
9	No limit	Tipper truck	3	Bank account and R60 000 000 available capital	Degree in Civil Engineering AND	1	4 years	2 projects of similar nature from grade 8
		Steel roller	1	Office space	Degree in Quantity Surveying or equivalent AND	1	4 years	
		Truck flat	1		Diploma in Civil Engineering	1	2 years	
		Light delivery vehicle	1					
		Water bowser	1					
		Grader	1					
		loader	1					
		Excavator	1					

Table 8.13 Grade 2-9 entry requirements for road surfacing-subcategory 04

Civil Engineering Works; Subcategory 03 Dams								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
2	R1 000 000	None	None	Bank account	Certificate in Civil/Water Engineering	1	2 years	2 projects of similar nature from grade 1
				Office space				
3	R3 000 000	None	None	Bank account and 5% available capital	Certificate in Civil/Water Engineering	1	3 years	2 projects of similar nature from grade 2
				Office space				
4	R6 000 000	Tipper truck/ water bowser	1 of them	Bank account and 5% available capital	Diploma in Civil Engineering AND	1	3 years	3 projects of similar nature from grade 3
		Compactor	1	Office space	Certificate in Civil/Water Engineering	1	2 years	
		Front end loader	1					
		Light delivery vehicle	1					
5	R10 000 000	Tipper truck/ water bowser	1 of them	Bank account and 10% available capital	Diploma in Civil Engineering AND	1	4 years	3 projects of similar nature from grade 4

Civil Engineering Works; Subcategory 03 Dams								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
		Compactor	1	Office space	Certificate in Civil/Water Engineering	1	3 years	
		Front end loader	1					
		Light delivery vehicle	1					
6	R20 000 000	Tipper truck/water bowser	1 of them	Bank account and 10% available capital	Degree in Civil Engineering AND	1	2 years	2 projects of similar nature from grade 5
		Compactor	1	Office space	Diploma in Civil Engineering	1	2 years	
		Front end loader	1					
		Light delivery vehicle	1					
		Excavator/ grader	1 of them					

Civil Engineering Works; Subcategory 03 Dams								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
7	R60 000 000	Tipper truck/water bowser	1 of them	Bank account and 10% available capital	Degree in Civil Engineering AND	1	2 years	2 projects of similar nature from grade 6
		Compactor	1	Office space	Diploma in Civil Engineering	1	2 years	
		Front end loader	1					
		Light delivery vehicle	1					
		Excavator/ grader	1 of them					
8	R200 000 000	Tipper truck	2	Bank account and 10% available capital	Degree in Civil Engineering AND	1	4 years	2 projects of similar nature from grade 7
		Excavator	1	Office space	Degree in Quantity Surveying or equivalent AND	1	2 years	
		Water bowser	1		Diploma in Civil Engineering	1	2 years	

Civil Engineering Works; Subcategory 03 Dams								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
		Steel roller	1					
		Front end loader	1					
		Light delivery vehicle	1					
		Compactor	1					
9	No limit	Tipper truck	3	Bank account and R60 000 000 available capital	Degree in Civil Engineering AND	1	4 years	2 projects of similar nature from grade 8
		Excavator	1	Office space	Degree in Quantity Surveying or equivalent AND	1	4 years	
		Water bowser	1		Diploma in Civil Engineering	1	2 years	
		Steel roller	1					
		Front end loader	1					

Civil Engineering Works; Subcategory 03 Dams								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
		Light delivery vehicle	1					
		Compactor	1					
		Grader	1					
		Bull dozer						

Table 8.14 Grade 2-9 entry requirements for road surfacing-subcategory 04

Civil Engineering Works; Subcategory 04: Roads Surfacing								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
2	R1 000 000	None	None	Bank account	Certificate in Highway engineering or Road's technician certificate	1	2 years	2 projects of similar nature from grade 1
				Office space				

Civil Engineering Works; Subcategory 04: Roads Surfacing								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
3	R3 000 000	None	None	Bank account and 5% available capital	Certificate in Highway engineering or Road's technician certificate	1	3 years	2 projects of similar nature from grade 2
				Office space				
4	R6 000 000	Light delivery vehicle	1	Bank account and 5% available capital	Diploma in Civil Engineering AND	1	3 years	3 projects of similar nature from grade 3
		Chip spreader	1	Office space	Certificate in Highway engineering or Road's technician certificate	1	2 years	
		Mechanical broom	1					
		Tractor	1					
		Tipper truck	1					
5	R10 000 000	Light delivery vehicle	1	Bank account and 10% available capital	Diploma in Civil Engineering AND	1	4 years	3 projects of similar nature from grade 4
		Chip spreader	1	Office space	Certificate in Highway engineering or Road's technician certificate	1	3 years	
		Mechanical broom	1					
		Tractor	1					
		Tipper truck	1					
6	R20 000 000	Light delivery vehicle	1	Bank account and 10% available capital	Degree in Civil Engineering AND	1	2 years	2 projects of similar nature from grade 5
		Chip spreader	1	Office space	Diploma in Civil Engineering	1	2 years	
		Pneumatic roller	1					

Civil Engineering Works; Subcategory 04: Roads Surfacing								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
		Bitumen distributor	1					
		Mechanic broom	1					
		Tractor	1					
		Tipper truck	1					
		Front end loader	1					
		Steel roller	1					
7	R60 000 000	Light delivery vehicle	1	Bank account and 10% available capital	Degree in Civil Engineering AND	1	2 years	2 projects of similar nature from grade 6
		Chip spreader	1	Office space	Diploma in Civil Engineering	1	2 years	
		Pneumatic roller	1					
		Bitumen distributor	1					
		Mechanical broom	1					
		Tractor	1					
		Tipper truck	1					
		Front end loader	1					
		Steel roller	1					
8	R200 000 000	Light delivery vehicle	1	Bank account and 10% available capital	Degree in Civil Engineering AND	1	4 years	2 projects of similar nature from grade 7
		Chip spreader	1	Office space	Degree in Quantity Surveying or equivalent AND	1	2 years	
		Pneumatic roller	1		Diploma in Civil Engineering	1	2 years	

Civil Engineering Works; Subcategory 04: Roads Surfacing								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
		Bitumen distributor	1					
		Mechanical broom	1					
		Tractor	1					
		Tipper truck	2					
		Front end loader	1					
		Water bowser	1					
		Steel roller	1					
		Flat track	1					
9	No limit	Light delivery vehicle	1	Bank account and R60 000 000 available capital	Degree in Civil Engineering AND	1	4 years	2 projects of similar nature from grade 8
		Chip spreader	1	Office space	Degree in Quantity Surveying or equivalent AND	1	4 years	
		Pneumatic roller	1		Diploma in Civil Engineering	1	2 years	
		Bitumen distributor	1					
		Mechanical broom	1					
		Tractor	1					
		Tipper truck	2					
		Front end loader	1					
		Water bowser	1					
		Steel roller	1					
		Flat truck	1					

Table 8.14 Grade 2-9 entry requirements for bridges-subcategory 05

Civil Engineering Works; Subcategory 05 Bridges								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
2	R1 000 000	None	None	Bank account	Certificate in Civil Engineering	1	2 years	2 projects of similar nature from grade 1
				Office space				
3	R3 000 000	None	None	Bank account	Certificate in Civil Engineering	1	3 years	2 projects of similar nature from grade 2
				Office space				
4	R6 000 000	Tipper truck/ water bowser	1 of them	Bank account and 5% available capital	Diploma in Civil Engineering AND	1	3 years	3 projects of similar nature from grade 3
		Compactor	1	Office space	Certificate in Civil Engineering	1	2 years	
		Front end loader	1					
		Light delivery vehicle	1					
5	R10 000 000	Tipper truck/ water bowser	1 of them	Bank account and 5% available capital	Diploma in Civil Engineering AND	1	4 years	3 projects of similar nature from grade 4
		Compactor	1	Office space	Certificate in Civil Engineering	1	3 years	
		Front end loader	1					
		Light delivery vehicle	1					
6	R20 000 000	Tipper/flat truck	1	Bank account and 10% available capital	Degree in Structural Engineering AND	1	2 years	2 projects of similar nature from grade 5
		Compactor	1	Office space	Diploma in Civil Engineering	1	2 years	
		Steel roller	1					
		Loader/grader	1 of them					
		Truck flat	1					
		Light delivery vehicle	2					

Civil Engineering Works; Subcategory 05 Bridges								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
7	R60 000 000	Tipper/ flat truck	1	Bank account and 10% available capital	Degree in Structural Engineering AND	1	2 years	2 projects of similar nature from grade 6
		Compactor	1	Office space	Diploma in Civil Engineering	1	2 years	
		Steel roller	1					
		Loader/grader	1 of them					
		Truck flat	1					
		Light delivery vehicle	2					
8	R200 000 000	Tipper truck	2	Bank account and 10% available capital	Degree in Structural Engineering AND	1	4 years	2 projects of similar nature from grade 7
		Water bowser	1	Office space	Degree in Quantity Surveying or equivalent AND	1	2 years	
		Steel roller	1		Diploma in Civil Engineering	1	2 years	
		loader	1					
		Light delivery vehicle	1					
		Grader	1					
		Crane truck	1					
9	No limit	Tipper truck	3	Bank account and R60 000 000 available capital	Degree in Structural Engineering AND	1	4 years	2 projects of similar nature from grade 8
		Water bowser	1	Office space	Degree in Quantity Surveying or equivalent AND	1	4 years	
		Steel roller	1		Diploma in Civil Engineering	1	2 years	
		Loader	1					
		Light delivery	1					
		Light delivery vehicle	1					
		Grader	1					
		Crane truck	1					
		Excavator						

Table 8.15 Grade 2-9 entry requirements for Water supplies, sanitation reticulation and irrigation works -subcategory 06

Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
2	R1 000 000	None	None	Bank account	Certificate in Civil/Water Engineering	1	2 years	2 projects of similar nature from grade 1
				Office space				
3	R3 000 000	None	None	Bank account and 5% available capital	Certificate in Civil/Water Engineering	1	3 years	2 projects of similar nature from grade 2
				Office space				
4	R6 000 000	Tipper truck/ water bowser	1 of them	Bank account and 5% available capital	Diploma in Civil /Water Engineering AND	1	3 years	3 projects of similar nature from grade 3
		Compactor	1	Office space	Certificate in Civil/Water Engineering	1	2 years	
		Loader/grader	1					
		Light delivery vehicle	1					
5	R10 000 000	Tipper truck/ water bowser	1 of them	Bank account and 10% available capital	Diploma in Civil/ Water Engineering AND	1	4 years	3 projects of similar nature from grade 4
		Compactor	1	Office space	Certificate in Civil/Water Engineering	1	3 years	
		Loader/grader	1					
		Light delivery vehicle	1					
6	R20 000 000	Tipper truck/water bowser	1 of them	Bank account and 10% available capital	Degree in Civil/ Water Engineering AND	1	2 years	2 projects of similar nature from grade 5
		Compactor	1	Office space	Diploma in Civil/ Water Engineering	1	2 years	
		Loader/grader	1					
		Light delivery vehicle	1					
		Truck flat	1					
7	R60 000 000	Tipper truck/water bowser	1 of them	Bank account and 10% available capital	Degree in Civil/ Water Engineering AND	1	2 years	2 projects of similar nature from grade 6

Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
		Compactor	1	Office space	Diploma in Civil/ Water Engineering	1	2 years	
		Loader/grader	1					
		Light delivery vehicle	1					
		Truck flat	1					
8	R200 000 000	Tipper truck	2	Bank account and 10% available capital	Degree in Civil/Water Engineering AND	1	4 years	2 projects of similar nature from grade 7
		Compactor	1	Office space	Degree in Quantity Surveying or equivalent AND	1	2 years	
		Loader/ grader	1 of them		Diploma in Civil/Water Engineering	1	2 years	
		Truck flat	1					
		Light delivery vehicle	1					
		Water bowser	1					
		Excavator	1					
9	No limit	Tipper truck	3	Bank account and R60 000 000 available capital	Degree in Civil/ Water Engineering AND	1	4 years	2 projects of similar nature from grade 8
		Compactor	1	Office space	Degree in Quantity Surveying or equivalent AND	1	4 years	
		Loader	1		Diploma in Civil/ Water Engineering	1	2 years	
		Truck flat	1					
		Light delivery vehicle	1					
		Water bowser	1					
		Excavator	1					
		Grader	1					
		Steel roller	1					
		Crane truck	1					

Table 8.16 Grade 2-9 entry requirements for Water and sewerage treatment plant subcategory 07

Water Engineering Works; Subcategory 07 Water and sewerage treatment plant works								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
2	R1 000 000	None	None	Bank account	Certificate in Civil/Water Engineering AND	1	2 years	2 projects of similar nature from grade 1
				Office space	Certificate in Mechanical Engineering	1	2 years	
3	R3 000 000	None	None	Bank account and 5% available capital	Certificate in Civil/Water Engineering AND	1	3 years	2 projects of similar nature from grade 2
				Office space	Certificate in Mechanical Engineering	1	2 years	
4	R6 000 000	Compactor	1	Bank and 5% available capital account	Diploma in Civil /Water Engineering AND	1	3 years	3 projects of similar nature from grade 3
		Light delivery vehicle	1	Office space	Diploma in Mechanical Engineering	1	2 years	
		Truck flat	1					
5	R10 000 000	Compactor	1	Bank account and 10% available capital	Diploma in Civil/ Water Engineering AND	1	4 years	3 projects of similar nature from grade 4
		Light delivery vehicle	1	Office space	Diploma in Mechanical Engineering	1	3 years	
		Truck flat	1					
6	R20 000 000	Compactor	1	Bank account and 10% available capital	Degree in Mechanical Engineering AND	1	2 years	2 projects of similar nature from grade 5
		Light delivery vehicle	1	Office space	Diploma in Civil Engineering	1	2 years	
		Loader	1					
7	R60 000 000	Compactor	1 of them	Bank account and 10% available capital	Degree in Mechanical Engineering AND	1	2 years	2 projects of similar nature from grade 6

Water Engineering Works; Subcategory 07 Water and sewerage treatment plant works								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
		Light delivery vehicle	1	Office space	Diploma in Civil Engineering	1	2 years	
		Loader	1					
8	R200 000 000	Compactor	1	Bank account and 10% available capital	Degree in Mechanical Engineering AND	1	4 years	2 projects of similar nature from grade 7
		Light delivery vehicle	1	Office space	Diploma in Civil Engineering	1	2 years	
		Front end loader	1 of them					
		Truck flat	1					
9	No limit	Tipper truck/water bowser	1 of them	Bank account and R60 000 000 available capital	Degree in Mechanical Engineering AND	1	5 years	2 projects of similar nature from grade 8
		Compactor	1	Office space	Diploma in Civil Engineering	1	4 years	
		Loader/ grader	1					
		Drill machine	1					

Table 8.17 Grade 2-9 entry requirements for water engineering-storage tanks/reservoirs plant subcategory 08

Water Engineering Works; Subcategory 08 Water engineering-storage tanks/reservoirs								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
2	R1 000 000	None	None	Bank account	Certificate in Mechanical Engineering AND	1	2 years	2 projects of similar nature from grade 1
				Office space	Certificate in Civil/Structural/Water Engineering	1	1 year	
3	R3 000 000	None	None	Bank account and 5% available capital	Certificate in Mechanical Engineering AND	1	3 years	2 projects of similar nature from grade 2
				Office space	Certificate in Civil/Structural/Water Engineering		1 year	
4	R6 000 000	Light delivery vehicle	1	Bank account and 5% available capital	Diploma in Mechanical Engineering AND	1	3 years	3 projects of similar nature from grade 3
				Office space	Certificate in Civil/Structural/Water Engineering	1	2 years	
5	R10 000 000	Light delivery vehicle	1	Bank account and 10% available capital	Diploma in Mechanical Engineering AND	1	4 years	3 projects of similar nature from grade 4
				Office space	Certificate in Civil/Structural/Water Engineering	1	3 years	
6	R20 000 000	Light delivery vehicle	1	Bank account and 10% available capital	Degree in Mechanical Engineering AND	1	2 years	2 projects of similar nature from grade 5
				Office space	Diploma in Civil/Structural/ Water Engineering	1	2 years	
7	R60 000 000	Light delivery vehicle	1	Bank account and 10% available capital	Degree in Mechanical Engineering AND	1	2 years	2 projects of similar nature from grade 6
				Office space	Diploma in Civil/ Structural/Water Engineering	1	2 years	
8	R200 000 000	Light delivery vehicle	1	Bank account and 10% available capital	Degree in Mechanical Engineering AND	1	4 years	2 projects of similar nature from grade 7

Water Engineering Works; Subcategory 08 Water engineering-storage tanks/reservoirs								
Grade	Tender value less than or equals to	Plant and Equipment		Financial status	Qualification of key staff			Experience of company or key staff
		Type of equipment	Minimum quantity		Academic qualification	No of key staff	Key staffs relevant experience	Number of successfully completed projects by the company or key staff
				Office space	Diploma in Civil/ Structural/ Water Engineering	1	2 years	
9	No limit	Light delivery vehicle	1	Bank account and R60 000 000 available capital	Degree in Mechanical Engineering AND	1	4 years	2 projects of similar nature from grade 8
				Office space	Degree in Civil/ Structural/ Water Engineering	1	3 years	

8.8 CHAPTER SUMMARY

This chapter introduced the proposed requirements for new civil engineering contractor entrants as well as contractor grading progression requirements. The introduction of these requirements aims to manage the influx of construction sector entrants and assist in improving the sector's performance. The management of this should, however, not prohibit new entrants. The requirement for the new entrants considers the contractors' technical qualifications in the registered speciality. Furthermore, contractors will be required to indicate the subcategory in which they intend to contract. This is the case as contractors who wish to enter the construction sector must have some form of technical knowledge of the field in which they intend to operate.

Secondly, the proposed entry requirements took into consideration the financial status of the company and the experience of key staff. For grade 1 contractors, these requirements are very relaxed because new entrants are likely not to have business capital and practical experience. Grade 1 contractors are, however, required to attend an integrity and code of ethics course, and this course must be completed within the first year of registration. These requirements (i.e., financial status and experience of key staff) are also

considered in the progression through the grades. Another key factor that is considered is the contractor's continuous development points. This is critical for consideration of contractors' progression as contractors need to stay abreast with developments in their field and expand business knowledge to decrease business failure rates.

Thus, the minimum entry requirement in the construction sector is technical capacity (NQF Level four certificate), occupational health and safety certificate, and financial status (business bank account) whilst the requirements for grade progression (i.e., grades 2-9) consider technical capacity, experience, plant and equipment, financial requirements, past performance, management capability, and occupational health and safety.

CHAPTER 9 DISCUSSION OF RESULTS

9.1 INTRODUCTION

This chapter discusses the key results obtained in chapters five, six, seven, and eight. Chapter Five looked at the state of practice survey employing questionnaires distributed to the industry role players. In Chapter Six, the multi-criteria analysis using the Analytical Hierarchy Process for contractor grading and performance evaluation was conducted and this was followed by the development of a framework to register, grade, and assess the performance of contractors in Chapter Seven. The construction sector's entry grading requirements were developed in Chapter Eight. Although detailed discussions on the analysis of the results were done in these chapters, this chapter aims to discuss key findings from the results of these chapters and compare the findings with those from the literature.

9.2 KEY DISCUSSION OF RESULTS

The results of the questionnaire in Chapter 5 have indicated that the efficacy of the grading and performance evaluation criteria highly influences enhanced contractor capabilities and project performance given a positive beta coefficient of 0.452 followed by construction entry requirements and efficacy of the grading system with a positive beta coefficient of 0.262 and 0.076 respectively. The contractor grading system negatively influences enhanced contractor capabilities and project performance, given a beta coefficient equal to -0.103. An efficient contractor grading system will have a positive influence on enhanced contractor capabilities as compared to a contractor grading system which is not efficient. This is not surprising in the South African construction sector because Mohlala (2015) has noted that most government infrastructure projects in South Africa are delayed and experience cost overruns whilst other projects remain incomplete.

Again, participants have indicated that this study would assist in improving the efficiency of the South African grading system because the current state of project performance is poor. An emphasis was placed on improving the current grading system to improve the construction sector. This is not surprising because the deficiencies of the South African grading system were noted by Ratshisusu (2014). In essence, the overall results indicated that having construction sector entry

requirements, an efficient grading system and criteria will result in enhanced contractor capabilities and project performance. The importance of having changes in attitudes and procedures to enhance the chances of success in construction projects is supported by Dubois and Gadde (2002).

Moreover, in other countries like Malaysia, contractors are required to continuously earn Contractor Continuous Development points to progress from one grade to the next grade. Also, contractors are required to have a minimum certificate/diploma or degree in construction-related courses to register with a construction firm (CIDB Malaysia, 2016). This practice may assist in the improvement of the implementation of infrastructure as the contractor would have knowledge and interest in the industry before entry.

The United States of America also has requirements in the construction sector. According to Heaslip (2022), general contractor licensing requirements vary by state, but many states' standards include showing industry experience, financial stability, and specialised training. In Arizona State, contractors are required to get a pass mark of at least 70% in the chosen classification and complete a specific trade examination unless eligible for a waiver. Passing a trade examination is one of the requirements necessary to be approved for a contractor's license (Crawford, 2022).

Alabama State also requires that general contractors must have a state license and applicants must pass a trade examination, and a business and law examination. They also need to document their work experience, and show proof of general liability insurance (Crawford, 2022). From the above international practices on construction sector entry and grading requirements, it is noted that most countries in the world have some form of entry requirements and technical and non-technical criteria that are used to allow contractors to operate in the construction sector. The results of the questionnaire are therefore in line with what the literature suggests and with international practices.

In Chapter 6, the Analytical Hierarchy Process was used to determine the multi-criteria requirements for contractor grading and evaluation of project performance. It was also developed to assist in the development of the contractor grading and performance evaluation framework. Thus, contractors have the alternatives to choose the grade for which they wish to apply if they meet the minimum multi-criteria requirements. This

means that contractors have nine grading alternatives to choose from, and they will be placed in line with the grade requirements after a performance evaluation of a contractor has been made. The versatility and ease of use of the Analytical Hierarchy Process (Saaty, 1980) were well demonstrated in this study because the results of the AHP played a key role in the framework development for registering, grading, and performance evaluation of contractors.

The alternatives for which contractors will be eligible for a grade will be based on the contractor meeting the stipulated requirements in line with the grade. The AHP has confirmed the multi-criteria requirements of contractor grading. The higher the grade, the steeper the grading requirements and the grade alternatives will be applied when contractors are applying for a grading.

Sensitivity analysis was conducted using the standard Analytical Hierarchy Process procedure on six different scenarios to check the reliability and robustness of the AHP results achieved. The results indicate that there is no significant change due to variations in underlying assumptions. It is noteworthy to indicate that the performance of the Contractor may be classified as emerging, established, or experienced depending on the contractor's performance on the criteria. The weighting of an experienced contractor is higher than the weighting of an established and emerging contractor.

A sensitivity analysis was also conducted on different scenarios to check the reliability and robustness of the AHP results achieved. The results indicate that there is no significant change due to variations in underlying assumptions. The lack of significant change due to variations in underlying assumptions signifies that the results obtained are considered to be robust as stated by Maverick (2021).

In Chapter Seven, a framework was developed to grade and assess the project performance of contractors. In developing the framework, the results of the comparison matrix for level 2 which involved pairwise comparisons between the sub-criteria in relation to each main criterion were utilised to dissect the sub-criteria to provide weighting using a standardised formula. Thereafter, various scenarios and

CIDB grading scenarios were created to apply the framework for grading contractors and assessing project performance. There are no previously published studies that were conducted using the Analytical Hierarchy Process to grade civil engineering construction contracts.

However, it was noted that most countries in the world have some form of entry and grading requirements and technical and non-technical criteria that are used to allow contractors to operate in the construction sector. These requirements are put in place to ensure that competent contractors operate in the sector. This assists in safeguarding the sector and in ensuring the quality of performance outputs which is a cause for concern in South Africa, as indicated by the CIDB that around 12% of projects surveyed had levels of defects that are regarded as inappropriate (CIDB, 2011).

The development of this framework will assist the South African civil engineering sector in improving the performance outputs as well as enhancing the capabilities of contractors. This is supported by CIDB (2016) and Mohlala (2015) stating that most contractors in the South African public sector lack project management skills. As indicated, contractor performance in South Africa is affected by poor workmanship and contractor incompetence (Hanson *et al.,* 2003). This affects the contractors' track record or reputation and, therefore, the eligibility for future contracts as indicated by Gharakhani *et al.* (2013). Operational skills which include project management and business skills such as planning and financial accounting are crucial for the success of any business (Thwala & Mvubu, 2008). The incorporation of all these relevant sets of criteria in grading may assist the sector in this regard.

It is noted that when applying the CIDB grading scenarios, contractors are likely to fall short due to several key criteria that are considered in the enhanced grading framework. Two proposals were made for managing the situation. Firstly, it is proposed that the current contractors will need to comply with the grading requirements when applying for an upgrade. Alternatively, the CIDB can provide reasonable timelines for contractors to adhere to the enhanced grading requirements. This will assist in contractor gap identification by the CIDB for contractor development.

Other key developments for consideration are also indicated. It is proposed that there should be linkages between the Register of Contractors and the Register of Projects. Linking projects that have been awarded to a contractor and reporting on performances (i.e., time, cost, quality, and client satisfaction) could assist the construction sector. A simple generic method has been proposed for adoption to calculate project time and cost to enable system user-friendliness.

Moreover, a template has also been introduced which may be adopted by the CIDB to be filled by clients at the end of each project to provide an overview of the contractor's performance. This is in line with the mandate of the CIDB which is stipulated in Section 5 (1) and 5(2) of the CIDB Act (no 38 of 2000) which requires the CIDB to provide strategic direction and to promote best practice.

The integration of these systems and regulating the reporting of project performance by clients may assist in enhancing sector performance. This will also enable clients to easily assess the performance of contractors before awarding contracts and identify contractors' developmental needs. Furthermore, the CIDB can work with clients and National Treasury to blacklist contractors who have performed poorly or have abandoned projects.

In Chapter 8, proposed requirements for new civil engineering contractor entrants as well as contractor grading progression requirements are indicated. The introduction of these requirements aims to manage the influx of construction sector entrants and assist in improving the sector's performance. The management of this should however not prohibit new entrants. International practices on grading were considered (reference these). The requirement for the new entrants considers the contractors' technical qualifications in the registered speciality. Furthermore, contractors will be required to indicate the subcategory in which they intend to contract. This is the case as contractors who wish to enter the construction sector must have some form of technical knowledge of the field in which they intend to operate. This is similar to the requirements of the CIDB in Malaysia (CIDB Malaysia, 2016) and World Bank (2018)

Secondly, the proposed entry requirements took into consideration the financial status of the company and the experience of key staff. For grade 1 contractors, these requirements are very relaxed because new entrants are likely not to have business capital and practical experience. Grade 1 contractors are however required to attend

an integrity and code of ethics course and this course must be completed within the first year of registration which is also a requirement in Malaysia (CIDB Malaysia, 2016). These requirements (i.e., financial status and experience of key staff) are also considered in the progression through the grades. Another key factor that is considered is the contractor's continuous development points which is also required in Malaysia (CIDB Malaysia, 2016). This is critical for consideration of contractors' progression as contractors need to stay abreast with developments in their field and expand business knowledge to decrease failure rates of the business.

Thus, the minimum entry requirement in the construction sector is technical capacity (NQF Level four certificate), occupational health and safety certificate, and financial status (business bank account) whilst the requirements for grade progression (i.e., grades 2-9) consider technical capacity, experience, plant and equipment, financial requirements, past performance, management capability, and occupational health and safety.

9.3. CHAPTER SUMMARY

This Chapter has discussed key findings from chapters five, six, seven, and eight. The main findings are that the development of the framework to grade, register, and evaluate construction contractors would assist the South African construction sector. The development of the framework using the Analytical Hierarchy Process has played a key role in developing the entry, grading, and performance evaluation criteria for the civil engineering construction sector. The development of this framework will also play a key role in managing and improving the sector's performance and contractor capabilities.

The proposed framework is in line with international best practices. Different countries like the United States of America (Crawford, 2022), Malaysia (CIDB Malaysia, 2016), and Japan (Japan Ministry of Land, Infrastructure, Transport, and Tourism, 2008) as well as organisations like the World Bank (2018) have adopted similar frameworks that assist in the management of the construction sector.

CHAPTER 10 CONCLUSIONS, AND RECOMMENDATIONS

10.1 INTRODUCTION

The study focused on developing a decision support framework using the Analytical Hierarchy Process for grading and evaluating the project performance of civil engineering contractors. This was done by conducting a state-of-practice survey, thereafter Analytical Hierarchy Process was utilised for grading and evaluating the performance of contractors. The results of the AHP have thus played a key role in developing the enhanced framework for grading contractors and evaluating performance. Proposals were also made on the construction sector entry, grading, and performance evaluation requirements. Moreover, a brief review was conducted on the current systems that are in place at the South African Construction Industry Development Board with the aim of making proposals that may be put in place to assist in the evaluation of infrastructure project performance.

Registration of new contractors with the Construction Industry Development Board has been investigated to assess the way contractor registration is conducted in South Africa. This was done to look at how other countries and organisations register new entrants in the construction sector to improve on the registration of new entry requirements in the South African construction sector.

It was noted that several countries have grading systems in place for their contractors and several criteria are considered for entry into the construction sector and progression through the grades. The study has thus introduced criteria that can be used to register, grade, and evaluate the project performance of contractors. The aim is to regulate the construction industry to enhance the sector's performance without hampering new entrants. This chapter focuses on the research summary, conclusions, limitations, and recommendations.

10.2 SUMMARY, REFLECTIONS, AND CONCLUSIONS

This research investigated minimum entry and contractors' grading and performance evaluation requirements that could be adopted by the South African construction sector. This was done by looking at how countries worldwide regulate new entrants into the construction sector. A questionnaire was developed and distributed to solicit

inputs from key role players in the civil construction sector. The aim is to manage the influx of construction sector new entrants to ensure that only those with the relevant skills and experience enter the sector. These entry requirements may assist in improving the South African construction sector's performance. The management of the sector should however not prohibit new entrants unduly. The proposed requirements for the new entrants consider the contractor's technical qualification in the registered speciality/subcategory. Other requirements for new entrants such as experience, relevant plant and equipment, and completed projects are self-evidently not emphasised or prioritised as new entrants would likely have less experience and capital.

However, for progression through the grades, the criteria for technical capacity, experience, plant and equipment, financial status, past performance, management capability, and occupational health and safety are considered. The same criteria for contractor grading are to be utilised for evaluating contractor project performance. Evaluating contractor performance is a multi-criteria decision-making process. The evaluation of the contractor's performance considers three options, whether a contractor is emerging, established, or experienced. An experienced contractor has the overall highest priority matrix of 0.534, followed by an established contractor with a priority matrix of 0.288 and 0.151 priority matrix for emerging contractors respectively.

It is expected that an experienced contractor would be technically competent and have excellent project management skills and meet the performance evaluation criteria in terms of academic qualifications, key staff experience, number of key staff, projects completed by the company, projects completed by key staff, type of equipment, minimum quantity, available capital, business management specialist and occupational health and safety.

The aim was to develop a framework to register, grade, and evaluate the project performance of contractors. A step-by-step approach for the framework was introduced which will enable contractors to be graded and performance evaluated. The Analytical Hierarchy Process was utilised towards the development of the framework to register, grade, and evaluate project performance. The introduction of these criteria may assist the status quo of the construction sector in South Africa and contractors'

grades would match their capabilities. It must be noted that the defined requirements are for the construction of the civil engineering infrastructure but may also be adopted for use by other disciplines.

Consideration was also made on currently registered contractors to ensure alignment with the enhanced contractor entry and grading requirements. Two proposals are indicated, the CIDB will have to inform contractors of the new requirements and request the relevant information to be submitted. As such, companies will be requested to submit all the requested documentation for the purpose of filing to be not downgraded. Therefore, only companies wishing to upgrade to a higher grade will have to meet the new grading criteria requirements.

Alternatively, the CIDB could consider providing the current contractors with reasonable timeframes regarding the gaps that contractors will need to close to be considered eligible for their current grading. If this approach is considered, this may greatly assist with regards to rapidly improving all the current contractors (i.e., those wishing to upgrade and those who do not wish to upgrade) and performance outputs. This process could also be used by the CIDB to identify gaps for the purpose of contractor development. The Construction Industry Development Board will have to provide a reasonable timeline for companies to provide this information.

The CIDB could also consider providing support to enhance the skills of the currently active contractors in their database to align the skill set of the current contractors to be in line with the set criteria proposed in the study. Contractors in the different grades may also be given a reasonable specified timeframe failing which a downgrade may be considered by the CIDB.

Another key factor that is considered is the contractor's continuous development points. This is critical for consideration of contractor's progression as contractors need to stay abreast with development in their field and expand business knowledge to decrease firms' failure rates.

An evaluation of how the project performance of contractors can be enhanced by considering multiple project management parameters was done. This was also done by considering close working relationships with all spheres of government who are

specifically involved in the procurement of construction projects. The emphasis was mainly on enhancing the current systems that are in place at the CIDB to improve performance and for clients to easily identify poor-performing contractors.

The idea is to propose that there should be a linkage between the Register of Projects (RoP) and the Register of Contractors (RoC). It is posited herein that if the performance of a contractor is reported on the Register of Projects, the system will automatically link to the relevant contractor through the Register of Contractors. This will also assist in enhancing the selection of well-performing contractors in tender awards as the performance of contractors in all projects will be indicated in both the RoC and RoP.

10.3 RECOMMENDATIONS

The study recommends the following:

a) Construction sector entry requirements must be introduced and take into consideration various criteria.

The importance of introducing entry requirements into the construction sector cannot be emphasised enough. The study proposed that entry requirements must consider new entrants' technical capacity in the form of an NQF Level 4 technical certificate in the desired field of operation, business bank account as well as occupational health and safety certificate. Moreover, it is recommended that a new contractor registered with CIDB should be required to attend and pass the Contractor Integrity and Code of Ethics Course within one year from the date of issue of the Contractor Registration Certificate. The Contractor Integrity and Code of Ethics Course can be attended by the company owner, director, or key management personnel.

b) Contractor grading progression requirements should consider various criteria.

Given the status quo of the performance of the construction sector in South Africa, qualifying contractors based only on completed projects and availability of capital seems to be inadequate. Various other criteria need to be considered such as contractors' technical capacity, experience, plant and equipment, financial status, past performance, management capability, and occupational health and safety. This will improve contractors' performance outputs which may in turn improve the sector's performance.

c) Performance evaluation of contractors should consider various criteria.

Using the same grading criteria to evaluate the performance of contractors will assist contractors in knowing their performance level and provide a clear framework from which to improve. This will also assist clients and CIDB in knowing the performance of the contractor and put relevant measures in place to assist the contractor.

d) The Construction Industry Development Board should consider linking the Register of Projects and the Register of Contractors.

CIDB should consider linking these two key strategic tools it has in place. The linking of the Register of Projects and Register of Contractors will enable clients to identify the best-performing contractors. This will however need to be regulated to mandate government institutions which are involved in the procurement of construction contracts to report contractors' performance in the systems. Key reporting of project performance parameters may include project time, cost, quality, and client satisfaction.

e) Registration of contractor category and sub-categories.

The introduction of contractor categories and subcategories may assist the CIDB in registering contractors in their respective areas of expertise. The categories may include civil engineering, construction of buildings (i.e., general buildings), mechanical engineering, and electrical engineering. The study focused on the civil engineering category and has proposed eleven sub-categories under civil engineering.

f) Further studies could be conducted focusing on the requirements for the construction of buildings, mechanical engineering, and electrical engineering categories and subcategories.

g) The Construction Industry Development Board should consider regulating the contractor's project performance on the Register of Projects to assist in improving the construction sector's performance.

h) More awareness could be created by the CIDB with the assistance of academic institutions and relevant government institutions on contractor entry and grading requirements to aid preparedness for current and future contractors.

i) The Construction Industry Development Board should consider collaborating with clients and National Treasury to facilitate the blacklisting of poor-performing contractors and contractors who are abandoning projects.

j) Further research on measuring qualitative criteria of the subcategories of civil engineering projects should be carried out.

k) Further research on improving joint ventures and thresholds on contractors' projects and key staff thresholds should be carried out.

l) Further research on contractor demotion (i.e., from a higher grade to a lower grade) should be carried out.

m) Further research could be conducted on the construction industry entry restriction versus possible prohibition of innovation and capacity building.

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APPENDIX A CIDB CONTRACTOR REGISTRATION CATEGORIES

CIDB Classes of works

- General Building (GB)
- Mechanical engineerin g (ME)
- Electrical engineering works – buildings (EB)
- Electrical engineering works – Infrastructure (EP)
- Civil Engineering (CE)
- Asphalt Works (SB)
- Excavations, Shaft Sinking, Lateral Earth Support (SC)
- Corrosion protections (Cathodic, Anodic & electrolytic) (SD)
- Demolition and Blasting (SE)
- Fire protection and protection systems (SF)
- Glazing, Curtain Walls & Shop Front (SG)
- Landscaping, Irrigation and horticulture works (SH)
- Lifts, Escalators (Installation & Maintenance) (SI)
- Pilling & Specialized foundations for building structures (SJ)
- Road markings & signage (SK)
- Scaffolding, Structural steel works, (SL)
- Timber buildings and structures (SM)Waterproofing of basements, roofs & specialized wSN)
- Plumbing & drainage for building (SO)
- Fencing, Steel security or precast concrete (SQ)

APPENDIX B CIDB CONTRACTOR REGISTRATION FORM: GRADE 1

Construction Industry Development Board

DEVELOPMENT THROUGH PARTNERSHIP

Application Form

Application for Contractor Registration

Grade 1

Instructions:

When completing the application form:

- Print clearly, use black ink, and complete all sections relevant to your enterprise.
- Please submit the entire form to the cidb.
- Photocopy any pages that do not have sufficient space or add a page for additional information.
- Applications without relevant supporting documentation will not be processed. See checklist.
- For more information or assistance, please see our contact details on page 3.

Conditions of Registration:

The contractor must:

- pay the relevant administration fee(s), for each class of works applying for;
- notify the cidb of any change of particulars relating to an existing registration;
- be free from any restrictions to tender;
- comply with the Code of Conduct for All Parties Engaged in Construction Procurement, as published by the cidb in the Government Gazette no. 25656 of 2003 (also available at: www.cidb.org.za); and
- renew registration every three years for requalification of grades.

Section A

Type of application (please indicate with an "x")

cidb Registration Number (for registered contractors): _____

☐ New Application for registration
☐ Addition of a class of works
☐ Upgrade of class of work status
☐ 3 year renewal

Section B

About your Enterprise

SECTION B(i): Enterprise Particulars and Banking Details

Name of Enterprise: _____

Trading as: _____

Account name:		**Account number:**	
Bank:		**Bank code:**	
Branch:		**Account Type:**	

Type of Enterprise (please indicate with an "x")

☐ Public Company ☐ Private Company ☐ Close Corporation
☐ Sole Proprietor ☐ Partnership ☐ Section 21 Company
☐ Cooperatives ☐ Other: _____

Date enterprise registered: _____

Enterprise registration number: _____

Physical Address: _____ Postal Address: _____

_____ _____

_____ _____

_____ Code: _____ _____ Code: _____

Province: _____ Province: _____

Contact Person

Title: _____ Initials: _____ Surname: _____

Designation: _____ Email: _____

Telephone: (____) _____ Fax: (____) _____ Cell: _____

SECTION B(ii): Principals and Ownership/Interest

Complete details for each principal in the Enterprise and attach copy of Identity Document for each (see Section F: Checklist). A principal is a partner in a partnership, a sole proprietor, a director in a company or a member of a close corporation.
Note: Use separate list if necessary.

Initials and Surname	Identity Number	RSA Citizen		Black		Gender		% of work time devoted to enterprise	% of shares or interest held	% voting rights
		Y	N	Y	N	M	F			

SECTION B(iii): Tax Clearance Certificate

Tax Clearance Certificate Number: _____

Approved date: _____ Expiry date: _____

SectionC

Registration as a Potentially Emerging Enterprise

Please complete section C(i) below in order to be considered for potentially emerging enterprise status.

"Emerging Enterprise" means an enterprise which is owned, managed and controlled by previously disadvantaged persons and which is overcoming business impediments arising from the legacy of apartheid.

SECTION C(i): Management Decisions and Control

State the name of previously disadvantaged principals responsible for day to day management decisions and indicate with an "X" which activities they are responsible for.

Name	Manage assets	Authority to manage daily operations of the Enterprise	Authority to determine management of company policies	Financial Authority

SECTION C(ii): B-BBEE Status "OPTIONAL"

B- BBEE STATUS: _____ Date of Certification: D D M M Y Y Y Y Expiry Date: D D M M Y Y Y Y

(Attach proof of B-BBEE Certification.)

Section D

Requirement for Registration in Electrical Engineering

(Applicable to contractors applying for EB Class of Works)

Attach an originally certified and signed copy of the Electrical Contractor's certificate issued in the name of the enterprise applying for registration with the cidb (see Section F: Checklist).

Registration Number: _____ Expiry Date: _____

Section E

Fees Payable

Note: Contractors must pay for each class of works applying for.

Code	Class of Construction Works	Fees Payable	Please mark
GB	General Building	R450,00	
CE	Civil Engineering	R450,00	
EB	Electrical Engineering Works - Building	R450,00	
EP	Electrical Engineering Works - Infrastructure	R450,00	
ME	Mechanical Engineering	R450,00	
SB	Asphalt works (supply and lay)	R450,00	
SC	Building Excavations, shaft sinking, lateral earth support	R450,00	
SD	Corrosion protection (cathodic, anodic and electrolytic)	R450,00	
SE	Demolition and blasting	R450,00	
SF	Fire prevention and protection systems	R450,00	
SG	Glazing, curtain walls and shop fronts	R450,00	
SH	Landscaping, irrigation and horticulture works	R450,00	
SI	Lifts, escalators and travellators (installation, commissioning and maintenance)	R450,00	
SJ	Piling and specialised foundations for building and structures	R450,00	
SK	Road markings and signage	R450,00	
SL	Structural steelwork fabrication and erection	R450,00	
SM	Timber buildings and structures	R450,00	
SN	Waterproofing of basements, roofs and walls using specialist systems	R450,00	
SO	Water supply and drainage for buildings (wet services, plumbing)	R450,00	
SQ	Steel security fencing or precast concrete	R450,00	
	Total fees payable:		

How are you paying: ☐ Cash deposit * ☐ Credit/Debit card ☐ Electronic funds transfer

cidb account details: Standard Bank Current Account, **Branch:** Menlyn, **Account number:** 03 224 3464, **Branch code:** 01-23-45-15, **Account name:** Construction Industry Development Board NO.2

*** Please note that the cidb does not accept cash payments. Cash deposits may be transferred into the above-mentioned cidb account.**

Section F

Provide the following supporting documentation only for those sections you had to complete.

		Supplied by contractor		Received (office use only)	
		Yes	No	Yes	No
SECTION B(i): Enterprise Particulars					
Close Corporation (latest CK1/CK2)					
Company:	• Certificate of Incorporation (CM1)/CoR 14.3				
	• List of all active directors (CM29)/CoR 39				
	• Share certificates (must be originally certified by Commissioner of Oaths). The validity period of certification is three months.				
	• All name change certificates (CM9) (if applicable)				
Partnership (partnership agreement)					
Trust (a copy of the trust deed or JM21)					
Co-operatives – CR 10 (Certificate of Incorporation). A list of all directors in a table format with their names, surnames, ID numbers, addresses and signed by all					
SECTION B(ii): Principals and Ownership/Interest					
Attach originally certified copies of Identity Documents. The validity period for certification is 3 months. (Must be certified by Commissioner of Oaths). For external Companies, orginally notorised copy of passport.					
SECTION B(iii): Tax Clearance Certificate					
Attach valid and original Tax Clearance Certificate					
SECTION D: Requirements for Registration in Electrical Engineering for EB class of works					
Attach originally certified and signed copy of the enterprise's valid Electrical Contractor's Certificate *NB: (The validity period for certification is 3 months) (Must be certified by Commissioner of Oaths)					
SECTION E: Payment of Fees					
Attach proof of payment (please use your company name or CRS number as the reference number when making payment)					
SECTION G: Declaration					
Ensure that the declaration is signed					

Note: Registration is valid for a period of three years. Please notify the cidb of any change of your particulars. Incomplete applications result in delays in processing. Applications without relevant supporting documentation will not be processed.

Section G

Declaration by Contractor

Please tick the box if you consent to the sharing of financial information supplied to the cidb with an approved and authorised financial services provider: ☐

In support of facilitating access to finance for contractor growth and development, I hereby authorise the cidb to disclose financial information to an approved and authorised financial services provider upon request for such.

I, the undersigned, hereby:

- **declare that:**
  - I am duly authorised to sign this application on behalf of the enterprise;
  - The information furnished, as well as all documentation submitted in support of this application, is true and correct in every respect; and have been lawfully obtained;
  - The enterprise will abide by the Code of Conduct for All Parties Engaged in Construction Procurement, as published by the cidb in the Government Gazette no. 25656 of 2003. (Also available at: www.cidb.org.za);
  - Neither the name of the enterprise or the name of any partner, member, director, manager or person, who wholly or partly exercises, or may exercise, control over the enterprise, appears on the Register of Tender Defaulters established in terms of the Prevention and Combating of Corrupt Activities Act of 2004;
  - No partner, member, director, manager or other person, who wholly or partly exercises, or may exercise, control over the enterprise, has within the last five years been convicted of fraud or corruption;
  - I will provide to the cidb any additional information that may be required with regards to this application.
- **understand that:**
  - Registration is subject to the conditions referred to on the front cover of this form;
  - Incomplete applications result in delays in processing.
  - Applications without relevant supporting documentation will not be processed.
  - The administration fee payable per class of works applied for is non-refundable.
  - The cidb will grade my enterprise based on the information provided.
  - False information provided or a false declaration is a punishable offence in terms of the cidb ACT, Regulations and other applicable laws.
- **authorise:**
  - The cidb to verify the information supplied in this form;
  - The cidb to publicly display my contractor grading designation.

Enterprise Name: _____

Signature: _____ Date: D D M M Y Y Y Y

Designation: _____ Print Name: _____

cidb
Construction Industry Development Board

Tel 086 100 2432 · Anonymous Fraud Line 0800 112 432
E-mail cidb@cidb.org.za · www.cidb.org.za

Gauteng Provincial Office · Pretoria · cidbgp@cidb.org.za
Western Cape Provincial Office · Cape Town · cidbwc@cidb.org.za
Eastern Cape Provincial Office · Bisho · cidbec@cidb.org.za
Northern Cape Provincial Office · Kimberley · cidbnc@cidb.org.za
Free State Provincial Office · Bloemfontein · cidbfs@cidb.org.za
KwaZulu-Natal Provincial Office · Durban · cidbkzn@cidb.org.za
Limpopo Provincial Office · Polokwane · cidblp@cidb.org.za
Mpumalanga Provincial Office · Nelspruit (Mbombela) · cidbmp@cidb.org.za
North West Provincial Office · Mahikeng · cidbnw@cidb.org.za

APPENDIX C CIDB CONTRACTOR REGISTRATION FORM: GRADE 2-9



Table A

Use the following tables to guide you on which sections to complete (please refer to tables A(i) & A(ii) for guidance).

Table A(i)

Type of applications	What sections should you complete
New registrations	All sections
Upgrades *OR* Additional classes of works	Sections: A, B, D, E, F, G, H & I

Table A(ii)

Section		Please submit the required documents for each	Contractors applying for the following grades		
			2	3 - 4	5 - 9
	Checklist	• Checklist on page 1	✔	✔	✔
A	Type of application	• Application form	✔	✔	✔
B	About your enterprise	• Company registration documents • Originally certified identity documents • Tax clearance certificate	✔	✔	✔
C	Potentially emerging	• Copies of certified share certificates • Copy of Trust Deed if owned by a Trust	✔	✔	✔
D	Determining financial capability	• Financial statements for the two years immediately preceding the application • Proof of financial sponsorship (if applicable) • SARS VAT 201 Forms with corresponding VAT Statement of Account OR stamped business bank statements for verification of turnover for the period in question (NOT compulsory for audited financial statements)	✘	✔	✔
D(i)	Best annual turnover		✘	✔	✔
D(ii)	Available capital		✘	✔	✔
E(i)	Track record / Largest Contract	• Track record: award, completion and final payment	✔	✔	✔
E(ii)	Transfer of records	• Proof of change of enterprise - *if applying for a track record to be transferred from one entity to another. Refer to Regulations 11(4), (4A) and (4B).*	✔	✔	✔
F	Electrical Engineering EB	• Certified Electical Contractors Certificate - *if applying for EB*	✔	✔	✔
G	Contractor grading designation	• Section G on page -10	✔	✔	✔
H	Contractor grading designation fees payable	• Proof of payment	✔	✔	✔
I	Declaration	• Signed application form	✔	✔	✔

Table B

Classes of Construction Works

Definition	Basic Works Types	Examples
Civil Engineering (CE)		
Construction works primarily concerned with materials such as steel, concrete, earth and rock and their application in the development, extension, installation, maintenance, removal, renovation, alteration, or dismantling of building and engineering infrastructure.	Water, sewerage, roads, railways, harbours and transport, urban development and municipal services.	• Structures such as cooling tower, bridge culvert,dam, grand stand, road, railway, reservoir, runway, swimming pool, silo or tunnel. • The results of operations such as dredging, earthworks and geotechnical processes. • Township services, water treatment and supply, sewerage works, sanitation, soil conservation works, irrigation works, storm-water and drainage works, coastal works, ports, harbours, airports and pipelines.
Electrical Engineering Works – Building (EB)		
Construction works that are primarily concerned with the installation, extension, modification or repair of electrical installations in or on any premises used for the transmission of electricity from a point of control to a point of consumption, including any article forming part of such an installation.	All electrical equipment forming an integral and permanent part of buildings and/or structures, including any wiring, cable jointing and laying and electrical overhead line construction.	• Electrical installations in buildings. • Electrical reticulations within a plot of land (erf) or building site. • Standby plant and uninterrupted power supply. • Verification and certification of electrical installations on premises.
Electrical Engineering Works – Infrastructure (EP)		
Construction works that are primarily concerned with development, extension, installation, removal, renovation, alteration or dismantling of engineering infrastructure: a) relating to the generation, transmission and distribution of electricity; or b) Which cannot be classified as EB.	Electrical power generation, transmission, control and distribution equipment and systems.	• Power generation. • Street and area lighting. • Substations and protection systems. • Township reticulations. • Transmission lines.
General Building Works (GB)		
Construction works that: a) are primarily concerned with the development, extension, installation, renewal, renovation, alteration, or dismantling of a permanent shelter for its occupants or contents; or b) cannot be categorised in terms of the definitions provided for civil engineering works, electrical engineering works, mechanical engineering works, or specialist works.	Building and ancillary works other than those categorised as: • Civil engineering works; • Electrical engineering works; • Mechanical engineering works; • Specialist works.	• Buildings for domestic, industrial, institutional or commercial occupancies. • Car ports. • Stores. • Walls.
Mechanical Engineering Works (ME)		
Construction works that are primarily concerned with the development, extension, installation, removal, alteration, renewal of engineering infrastructure for gas transmission and distribution, solid waste disposal, heating, ventilation and cooling, chemical works, metallurgical works, manufacturing, food processing and materials handling	• Machine systems including those relating to the environment of building interiors • Gas transmission and distribution systems • Pipelines • Materials handling, lifting machinery, heating, ventilation and cooling, pumps • Continuous process systems, chemical works, metallurgical works, manufacturing, food processing such as that in concentrator machinery and apparatus, oil and gas wells, smelters, cyanide plants, acid plants, metallurgical machinery, equipment and apparatus, and works necessary for the beneficiation of metals, minerals, rocks, petroleum and organic substances or other chemical processes	• Air-conditioning and mechanical ventilation • Boiler installations and steam distribution • Central heating • Centralised hot water generation • Compressed air, gas and vacuum installations • Conveyor and materials handling installations • Continuous process systems involving chemical works, metallurgical works, oil and gas wells, acid plants, metallurgical machinery, equipment and apparatus, and works necessary for the beneficiation of metals, minerals, rocks, petroleum and organic substance and other chemical processes • Dust and sawdust extraction • Kitchen equipment • Laundry equipment • Refrigeration and cold rooms • Waste handling systems (including compactors)

Specialist Works

SB	The extension, installation, repair, maintenance or renewal, or removal of asphalt.	SJ	The development, installation, removal, or dismantling, as relevant, of piles and other specialised foundations for buildings and structures.
SC	The development, extension, installation, removal and dismantling, as relevant, associated with building excavations, shaft sinking and lateral earth support.	SK	The installation, renewal, removal, alteration or dismantling, as relevant, of road markings and signage.
SD	The development, extension, installation, repair, renewal, removal or alteration of corrosion protection systems (cathodic, anodic and electrolytic).	SL	The development, extension, installation, renewal, removal, renovation, alteration or dismantling of structural steelwork and scaffolding.
SE	Demolition of buildings and engineering infrastructure and blasting.	SM	Timber buildings and structures.
SF	The development, extension, installation, renewal, removal, renovation, alteration or dismantling of fire prevention and protection infrastructure (drencher and sprinkler systems and fire installation).	SN	The extension, installation, repair, maintenance, renewal, removal, renovation or alteration, as relevant, of the waterproofing of basements, roofs and walls using specialist systems.
SG	The development, extension, installation, renewal, removal, renovation, alteration or dismantling of glazing, curtain walls and shop fronts.	SO	The development, extension, installation, renewal, removal, alteration, or dismantling or demolition of water installations and soil and waste water drainage associated with buildings (wet services and plumbing).
SH	The development, extension, installation, maintenance, renewal, removal, alteration or dismantling, as relevant, of landscaping, irrigation and horticultural works.	SQ	The development, extension, installation, repairs, dismantling of precast walls, installation of wire perimeter fencing, diamond perimeter fencing, palisade steel fencing with posts and stay at intervals.
SI	The development, extension, installation, repair, maintenance, renewal, removal, renovation, alteration or dismantling of lifts, escalators, travellators and hoisting machinery.		

Note: For the Electrical Engineering (EB) class of construction works the applicant must submit an originally certified and signed electrical contractor's certificate issued in the name of the enterprise, by the Department of Labour.

How contractor grading designations are determined

- Your **contractor grading designation** is determined by your **financial capability** and your **works capability**.
- Your **financial capability** relates to your financial history (turnover), and the amount of working capital you can muster to sustain a contract, i.e. **available capital**. Available capital is the sum of retained income, shareholders or members loans and form of acceptable financial sponsorship.
- Your **works capability** is determined by the largest contract you have undertaken and completed in your class of construction works (completed during the 5 years immediately preceding the application).
- Your **contractor grading designation** will be used by Government (national, provincial, municipal and state-owned enterprises) to qualify your tender to be considered for a particular construction works contract. For example: if you are registered as a 5CE, you will be considered for public sector civil engineering works contracts of a value not exceeding R10 million. You may register for different classes of works, for example, you may be registered as a 5CE and as an 8ME. This means that you will also be considered for public sector mechanical engineering works contracts of a value not exceeding R200 million.
- **The records of one entity may be transferred to that of another entity and treated as if it were the same for the purposes of assessment where:**
  - the first contractor being a sole proprietor, partnership or trust who establishes a Company or Close Corporation in terms of the Companies Act, 2008 or the Close Corporations Act, 1984;
  - a change of name of a company;
  - the reconstruction of a company;
  - the amalgamation of companies;
  - the takeover of a company;
  - the conversion of a company to a close corporation in terms of section 27 of the Close Corporations Act, 1984; or
  - a change in membership or members' interests of a close corporation.
- **When appointing an accountant to compile financial statements for your company, please ensure that the accountant is registered with the relevant accounting body. Some of the registration bodies include:**
  - SAICA - The South African Institute of Chartered Accountants – www.saica.co.za
  - IRBA - Independent Regulatory Board of Auditors – www.irba.co.za

- ICSA - The South African Institute of Chartered Secretaries and Administrators – www.icsa.co.za
- ACCA - The Association of Chartered Certified Accountants – www.acca.org.za
- CIMA - Chartered Institute of Management Accountants – www.cimaglobal.com
- SAIPA - South African Institute of Professional Accountants – www.saipa.co.za
- IACSA - Institute of Administration and Commerce – www.iacsa.co.za
- SAIBA - South African Institute for Business Accountants – www.saiba.org.za

Determining Financial Capability

The financial capability requirements will be determined from the below, depending on the contractor grading designation being applied for:

- Best annual turnover from the two financial years immediately preceding the application.
- The available capital for the current year as determined on your financial statements.
- Financial sponsorships that you are able to mobilise should your available capital be insufficient.

Table C

Determining Works Capability

The specific requirements that you need to satisfy in respect of the contractor grading designation applied are:

Designation	Financial and Works Requirement
Grade 2	Must have completed a contract with the value of not less than R130 000.
Grade 3	Must have completed a contract with the value of not less than R450 000 and either have best turnover not less than R1 000 000 or have available capital not less than R100 000.
Grade 4	Must have completed a contract with the value of not less than R900 000 and either have best turnover not less than R2 000 000 or have available capital not less than R200 000.
Grade 5 and higher	Must have works and financial capability not less than that tabulated in Table C(i) below, for the contractor grading designation applied for.

Table C(i)

Determining Financial Capability

Designation	Upper limit of tender value range	Best annual turnover	Largest contract	Available capital
2	R1 000 000	–	R130 000	–
3	R3 000 000	R1 000 000	R450 000	R100 000
4	R6 000 000	R2 000 000	R900 000	R200 000
5	R10 000 000	R3 250 000	R1 500 000	R650 000
6	R20 000 000	R6 500 000	R3 000 000	R1 300 000
7	R60 000 000	R20 000 000	R9 000 000	R4 000 000
8	R200 000 000	R65 000 000	R30 000 000	R13 000 000
9	No limit	R200 000 000	R90 000 000	R40 000 000

*NB: A complete set of financial statements is required for grading designation 3 to 9 accompanied by SARS VAT 201 forms with a corresponding VAT Statement of Account OR stamped business bank statements for the period in question for verification of turnover as stated on the financial statements (NOT compulsory for audited financial statements).

Management Financial Statements are not acceptable, however interim Financial Statements SARS VAT 201 forms with corresponding VAT Statement of Account OR Stamped Business Bank Statements for verification of turnover for the period in question (NOT compulsory for audited financial statements).

The available capital is calculated by adding any financial sponsorships to the sum of the net asset value (NAV) of a contractor as indicated in the contractor's financial statements, subject to the contribution made by financial sponsorships to available capital being limited to the values provided in Table D(ii) (NAV & Sponsorship).

A financial sponsorship must be a collectable financial guarantee by one person to another, (the beneficiary)

- for amount or value determined;
- to support operations of the contractor concerned in order to complete projects;
- available to the beneficiary;
- if applicable, in a form acceptable to any financial institution in South Africa as defined in the Financial Services Board Act, 97 of 1990; and
- if not provided by a financial institution, to an amount which does not exceed 15% of the sponsor's net asset value as determined from the sponsor's latest financial statement.

*NB: Sureties and guarantees are not acceptable forms of sponsorship.

Table C(ii)

Determining the Maximum Contribution of Sponsorship to Available Capital (AC)

Sponsor Type	Maximum contribution of sponsorship to available capital	
	Designation	Amount
cidb registered contractor (with excess available capital) *or* Company with more than 50% shareholding in applicant (may sponsor up to 100% of the required AC)	3	R100 000
	4	R200 000
	5	R650 000
	6	R1 300 000
	7	R4 000 000
	8	R13 000 000
	9	R40 000 000
Company with more than 25% or more shareholding in applicant (may sponsor up to 75% of the required AC)	3	R75 000
	4	R150 000
	5	R487 500
	6	R975 000
	7	R3 000 000
	8	R9 750 000
	9	R30 000 000
Company with less than 25% shareholding in applicant (may sponsor up to 50% of the required AC)	3	R50 000
	4	R100 000
	5	R325 000
	6	R650 000
	7	R2 000 000
	8	R6 500 000
	9	R20 000 000

Table D

Largest contract executed in the last five years

Works capability		
Designation	Maximum value of contract that a contractor is considered capable of performing	Largest contract completed, during the 5 years immediately preceding the application, in the class of construction works applied for
2	R1 000 000	R130 000
3	R3 000 000	R450 000
4	R6 000 000	R900 000
5	R10 000 000	R1 500 000
6	R20 000 000	R3 000 000
7	R60 000 000	R9 000 000
8	R200 000 000	R30 000 000
9	No limit	R90 000 000

Important notes when submitting Track Record / Largest Contract

- **Letter of Award:** An award letter must be on a letterhead of the client, must be addressed to the contractor who

was awarded the contract and must include the tender/service order number and the contract amount. The award letter must be signed and dated by an official from the client.
- **Subcontracting work** must be accompanied by a sub-contract agreement.
- **Joint Venture** work must be accompanied by the Joint Venture agreement.

Please note that track record consisting of substantial provision of labour or plant Hire will not be accepted as Track Record / Largest Contract for cidb registration.

- **Certificate of Completion:** The Certificate of Completion must be on a letterhead of the client, must be addressed to the contractor who was awarded the contract and must include the tender/service order number and the contract amount. The Letter of Completion must be signed and dated by an official from the client.

- **Certificate of Payment:** The Final Payment Certificate must indicate the contract value and must be on a letterhead of the client. It must be addressed to the contractor using the track record and must include the tender/service order number. It should include all part payments made and must read as Final Payment Certificate. The Final Payment Certificate must be signed and dated by an official from the client. For public sector track record the payment stubs from the financial systems used by the public sector client (e.g. BAS) will be accepted, if only one payment was made.

  Note: If track record was from a private sector client, the contractor's supporting bank statements must be provided reflecting the payments received from the client into the company account. The bank statements must correlate with the initial value of the project award and must be stamped by the bank.

Potentially Emerging Enterprises

A registered, potentially emerging contractor may be awarded a contract at one level higher than the enterprise's registered contractor grading designation, if the client or employer:
- Is satisfied that such a contractor has the potential to develop and qualify to be registered in that higher grade; and
- Ensures that financial, management or other support is provided - in the context of a contractor development programme – to enable the contractor to successfully execute that contract.

Joint Ventures
- A joint venture is a grouping of two or more contractors who jointly undertake to perform a construction works contract.
- Any enterprise that tenders or enters a contract for construction works with the public sector must be registered.
- Joint ventures do not have to register. Each partner of the joint venture must be separately registered and the lead partner must have a contractor grading designation not lower than one level below the required grading designation in the class of construction works under consideration.
- The contractor grading designation for a once-off joint venture is assessed by the client, based on:
  - the sum of the best annual turnover of all the members of the joint venture;
  - the sum of the available capital of all the members of the joint venture;
- The cidb has developed a calculator to enable assessment of joint ventures. This calculator is available on the cidb website at www.cidb.org.za.

Notwithstanding any calculation, the following partnerships amongst registered contractors are deemed to satisfy the contractor grading requirements for a joint venture in the following designations:

Table E
Joint Venture Combinations

Joint Venture combinations to achieve a higher combined grade (deemed to satisfy joint venture arrangements)			Grade achieved by the Joint Venture
Three Grade **2** contractors			3
Three Grade **3** contractors			4
Two Grade **4** contractors	***or***	**One** Grade **4** and **Two** Grade **3** contractors	5
Two Grade **5** contractors	***or***	**One** Grade **5** and **Two** Grade **4** contractors	6
Two Grade **6** contractors	***or***	**One** Grade **6** and **Two** Grade **5** contractors	7
Three Grade **7** contractors			8
Three Grade **8** contractors			9

*NB: For other Joint Venture Combinations, refer to the Joint Venture Calculator on the cidb website.

Table G

Calculating Fees Payable

Contractor Grading Designation	Upper limit of tender value range designation	Administration/Renewal fee in respect of each grade applied for	Annual fees payable in respect of the highest contractor grading designation
2	R1 000 000	R450	R250
3	R3 000 000	R750	R350
4	R6 000 000	R750	R900
5	R10 000 000	R750	R1 750
6	R20 000 000	R750	R3 500
7	R60 000 000	R750	R9 000
8	R200 000 000	R750	R29 000
9	No limit	R750	R55 000

Example: Calculating Fees

A contractor applies for 2GB and 8CE. The contractor will be required to pay the following fees:

Table H

Example – Calculating Fees Payable

Tender value range	Class of construction works	Admin fee payable
2	GB	R450
8	CE	R750
	Sub-total	R1 200
	Plus annual fee (determined by highest tender value range applied for)	R29 000
	Total due (total admin plus annual fee)	**R30 200**

Payment

By Electronic Transfer or Bank Deposit. Our bank details are as follows:

Account name:	Construction Industry Development Board NO.2	**Account number:**	03 224 3464
Bank:	Standard Bank	**Bank code:**	01-23-45-15
Branch:	Menlyn	**Account Type:**	Current Account

***Note:** Please use your enterprise name as the reference when making payment. Contractors already registered with the cidb, should please use their cidb registration number (CRS number) as the reference.

Please note that the cidb does not accept cash payments and cheques over the counter.

Checklist

Use the checklist to make sure that you are submitting all the required supporting information. If you are not required to complete a specific section of the form, you are also not required to submit the required supporting documentation.

What to do with your completed application

- Double check that you have filled in all the required information correctly.
- Use the checklist on page 1 to make sure that you have attached all the required supporting documentation.
- Make a photocopy of the application to keep for your own records.
- Deliver your completed application, along with proof of payment and supporting documentation to the applicable addresses on the last page.

Checklist for supporting documentation

Provide the following supporting documentation only for those sections you had to complete. (See Table A(i) & A(ii) on Guidance page a for guidance on required sections to be completed).

		Supplied by contractor		Received (office use only)	
		Yes	No	Yes	No
SECTION B(i): Enterprise Particulars					
Close Corporation (latest CK1/CK2)					
Company:	• Certificate of Incorporation (CM1)/CoR 14.3				
	• List of all active directors (CM29)/CoR 39				
	• Share certificates (Must be certified by Commissioner of Oaths)				
	• All name change certificates (CM9) (if applicable)				
Partnership (partnership agreement)					
Trust (a copy of the trust deed or JM21)					
Co-Operatives – CR 10 (Certificate of Incorporation). A list of all directors in a table format with their names, surnames, ID numbers, addresses and signed by all					
SECTION B(ii): Principals and Ownership/Interest					
Attach originally certified copies of identity documents. The validity period for certification is 3 months. (Must be certified by Commissioner of Oaths). For external companies, originally notarised copies of passports					
SECTION B(iii): Tax Clearance Certificate					
Attach valid Tax Clearance Certificate					
SECTION D: Financial Requirements					
Attach a complete set of financial statements (compliant with IFRS / IFRS for SME's) for the 2 financial years immediately preceding the application.					
• Public/Private company - as per the provision of Companies Ac No. 71 of 2008 as amended					
• Trust – as per the provision of Companies Ac No. 71 of 2008 as amended					
• Close Corporation – as per the provision of Companies Ac No. 71 of 2008 as amended					
• Partnership – as per the provision of Companies Ac No. 71 of 2008 as amended					
• Sole Traders – compiled by a bookkeeper or Accounting Officer					
• Co-operatives – as per the provision of Cooperatives Act No. 14 of 2005 as amended					
SECTION D(i): Validation of Accounting Officer / Auditor					
Complete the registration details of the Accounting Officer who signed off the financial statements					
SECTION D(ii): Best Annual Turnover					
• Attach SARS VAT 201 forms and VAT Statement of Account OR stamped business bank statements for verification of turnover for the period in question (not compulsory for audited financials).					
SECTION D (iii): Available Capital and Sponsorship					
• Available capital is the sum of retained income, shareholders or members loans and any form of acceptable financial sponsorship					
Description and proof of financial sponsorship(s)					
• Registered financial institution sponsorship OR					
• Letter of sponsorship undertaking in the form of a member's resolution from a Close Corporation OR a Board Resolution from the					
• If sponsor is a not a financial institution, please attach the sponsor's latest financial statements (compliant with IFRS)					
SECTION E: Track Record / Largest Contract					
For each class of works applied for, attach copies of:					
• Letter of award on a letterhead of the client and addressed to contractor, signed and dated					
• Certificate of completion; and					
• Final payment certificate indicating the contract value. Maintenance contractors may provide latest payment certificate indicating the value of work done to date					
• Signed Joint Venture agreement (if applicable);					
• Signed sub-contract agreement and corresponding bank statements (stamped) may be requested.					
• Private Sector Contract – Purchase Orders or Contract Agreement, stamped business bank statements and corresponding tax invoices					
• Projects with more than one Class of Work – Submit a breakdown showing the value of each class of work applied for. The breakdown must be on the client or consultant's official letterhead and must be signed.					
SECTION E(iv): Transfer of Records					
Attach particulars of change as per Regulation 11 (4) Attach assessment committee approval for transfer of records.					
SECTION F : Requirements for Registration in Electrical Engineering for EB class of works					
Attach a copy of the enterprise's valid Electrical Contractor Certificate					
SECTION H: Payment of Fees					
Attach proof of payment (please use your enterprise registration number or CIDB Registration Number (CRS number) as the reference number when making payment)					
SECTION I: Declaration					
Ensure that the declaration is signed					

NB: Please ensure that all documents submitted are in English. All documents not in English must be translated. Foreign documents must be translated by accredited translator and originally notarised.

Section A

Type of application (please indicate with an "x")

cidb Registration Number/CRS Number (for registered contractors): _____

CSD Registration Number:_____

☐ New Application for registration
☐ Addition of a class of works
☐ Upgrade of class of work status
☐ 3 year renewal

Section B

About your Enterprise

SECTION B(i): Enterprise Particulars

Name of Enterprise: _____

Trading as: _____

Type of Enterprise (please indicate with an "x")

☐ Public Company ☐ Private Company ☐ Close Corporation
☐ Sole Proprietor ☐ Partnership ☐ Section 21 Company
☐ Other: _____

Date enterprise registered: _____ Date operations started:_____

Enterprise registration number: _____

Physical Address: _____ Postal Address: _____

_____ _____

_____ _____

_____ Code: _____ _____Code:_____

Province: _____ Province: _____

Contact Person

Title: _____ Initials: _____ Surname: _____

Designation: _____ Email: _____

Telephone: (____) _____ Fax: (____) _____ Cell: _____

SECTION B(ii): Principals and Ownership/Interest

Complete details for each principal in the enterprise and attach copy of identity document for each. A principal is a partner in a partnership, a sole proprietor, a director in a company or a member of a close corporation.

Note: Use separate list if necessary.

Initials and Surname	Identity Number	RSA Citizen		Black		Gender		% of work time devoted to enterprise	% of shares or interest held	% voting rights
		Y	N	Y	N	M	F			

SECTION B(iii): Tax Clearance Certificate or Tax Compliance Status (TCS) Pin

Tax Clearance Certificate Number: _____

Approved Date: _____ Expiry Date: _____

SectionC

Registration as a Potentially Emerging Enterprise

Please complete section C(i) below in order to be considered for potentially emerging enterprise status.
"Emerging Enterprise" means an enterprise which is owned, managed and controlled by previously disadvantaged persons and which is overcoming business impediments arising from the legacy of apartheid.

SECTION C(i): Management Decisions and Control

State the name of previously disadvantaged principals responsible for day-to-day management decisions and indicate with an "X" which activities they are responsible for.

Name	Manage assets	Daily operations of the enterprise	Management of the Enterprise	Financial Authority

SECTION C(ii): B-BBEE Status "OPTIONAL"

B- BBEE STATUS: _____ Date of Certification: D D M M Y Y Y Y Expiry Date: D D M M Y Y Y Y
(Attach proof of B-BBEE Certification.)

Section D

Determining Financial Capability

SECTION D(i): Validation of Accountant

Designated Accounting Officer: _____

Practice Number: _____ Accounting Body: _____

Registered Address: _____

_____

_____

NB: Application will be deemed non-compliant if financial statements were not compiled by the designated Accounting Officer.

SECTION D(ii): Best Annual Turnover

Attach financial statements for the 2 financial years immediately preceding the application and, if applicable, the description and proof of financial sponsorship. (See checklist)

From Annual Financial Statements:
Total Assets (as per the latest Financial Statements) R _____

Total Liabilities (as per the latest Financial Statements) R _____

Net Asset Value (the sum of total equity, retained income and shareholder's or member's loans): R _____

Financial Value of sponsorship(s) if any: R _____

Indicate the nature of your relationship with the sponsor(s): _____

Section E
Track Record

Provide contract details of the largest construction works contract completed during the 5 years immediately preceding the application. Attach copies of Letter of Award, Certificate of Completion and final Payment Certificate indicating the contract value. If applicable; contractors undertaking ongoing maintenance projects should submit copies of the Letter of Award and the latest progress payment certificate indicating the value of works completed to date (See Checklist.)
Make copies of SECTION E for each class of construction works applied for.

SECTION E(i): Particulars of Employer who commissioned the Works
Provide the following information on the Employer for whom the contract was performed.

Employer: _____

Employer's Contact Person: Title: _____ Initials: _____ Surname: _____

Telephone: (_____) _____ Cell: _____

SECTION E(ii): Particulars of Contract Administrator
Person responsible for administering the contract on behalf of the employer, e.g.: Principal Agent, Consulting Engineer, Architect, Project Manager, Construction Manager, etc.

Title: _____ Initials: _____ Surname: _____

Organisation: _____

Telephone: (_____) _____ Fax: (_____) _____

Cell: _____ Email: _____

SECTION E(iii): Contract Information

Contract Title: _____ Employer's Contract No: _____

Description of Contract: _____

Indicate the class of works to which the track record is applicable. Please indicate with an "X"

☐ General Building	☐ Electrical Engineering Infrastructure (EP)	☐ Civil Engineering
☐ Mechanical Engineering	☐ Electrical Engineering Building (EB)	☐ Specialist Works

Specify which class of specialist works: _____

Were you involved as: ☐ Main Contractor ☐ Sub Contractor ☐ Joint Venture Partner

Total value of your share of the contract, including VAT: R _____

Please indicate % share of Joint Venture _____ (Please attach the Joint Venture Agreement)

Contract Award Date: _____ Practical Completion Date: _____

Province: _____ Municipality: _____

***Note:** If sub-contractor: Attach Sub-contract Agreement and proof of payment in the form of stamped business bank statement copies reflecting receipts of payment(s) for the particular contract.

Section I

Declaration by contractor

Please tick the box if you consent to the sharing of financial information supplied to the cidb with an approved and authorised financial services provider. ☐

In support of facilitating access to finance for contractor growth and development, I hereby authorise the cidb to disclose financial information to an approved and authorised financial services provider upon request for such.

I, the undersigned, hereby:

- **declare that:**
  - I am duly authorised to sign this application on behalf of the enterprise; cash and cheque payments will not be accepted over the counter and via post/courier;
  - The information furnished, as well as all documentation submitted in support of this application, is true and correct in every respect; and have been lawfully obtained;
  - The enterprise will abide by the Code of Conduct for All Parties Engaged in Construction Procurement, as published by the cidb in the Government Gazette no. 25656 of 2003 (also available at: www.cidb.org.za);
  - Neither the name of the enterprise or the name of any partner, member, director, manager or person, who wholly or partly exercises, or may exercise, control over the enterprise, appears on the Register of Tender Defaulters established in terms of the Prevention and Combating of Corrupt Activities Act of 2004;
  - No partner, member, director, manager or other person, who wholly or partly exercises, or may exercise, control over the enterprise, has within the last five years been convicted of fraud or corruption;
  - I will provide to the cidb any additional information that may be required with regards to this application.
- **understand that:**
  - Registration is subject to the conditions referred to on the front cover of this form;
  - Incomplete applications result in delays in processing;
  - Applications without relevant supporting documentation will not be processed;
  - Non-compliant applications will be cancelled after 60 days;
  - Once an application is deemed non-compliant, upon receipt of all outstanding documents, the turnaround time will start to count from day one (1);.
  - The administration fee payable per class of works applied for is non-refundable;
  - The cidb will grade my enterprise based on the information provided;
  - False information provided or a false declaration is a punishable offence in terms of the CIDB ACT, Regulations and other applicable laws.
  - Declarations that are not signed will result in the application being deemed non-compliant.
- **authorise:**
  - The cidb to verify the information supplied in this form;
  - The cidb to publicly display my contractor grading designation.

Enterprise Name: _____

Signature: _____ Date: D D M M Y Y Y Y

Designation: _____ Print Name: _____

Gauteng
Blocks N & R, SABS Campus, 2 Dr Lategan Road Groenkloof, Pretoria
Tel: 0861 428 222
cidbgp@cidb.org.za

Western Cape
No 4 Dorp Street, Cnr Long & Dorp Street, Cape Town
Tel: 0861 100 2432
cidbwc@cidb.org.za

Eastern Cape
Dept of Public Works, Qhasana Building, Independence Avenue;
Tel: 0861 222 327
cidbec@cidb.org.za

Northern Cape
Regional Department of Transport, Roads and Public Works, 45 Schmidtdrift Road,; Kimberly
Tel: 0861 222 327
cidbnc@cidb.org.za

Free State
Fedsure Building, 62 St Andrews Street, Bloemfontein
Tel: 0861 377 222
cidbfs@cidb.org.za

KwaZulu-Natal
Department of Public Works Office Precinct, 428 Blink Bonnie Road, Mayville
Tel: 0861 100 2432
cidbkzn@cidb.org.za

Limpopo
Department of Public Works, 1st Floor, Works Tower Building, 43 Church Street, Polokwane
Tel: 0861 222 765
cidblp@cidb.org.za

Mpumalanga
Corner Samora Machel & Paul Kruger Street, Nelcity Building – Office G15-E, Nelspruit
Tel: 0861 678 222
cidbmp@cidb.org.za

North West
Dept.of Public Works, Old Parliament Building, Modiri Molema Road, Gate House, Mmabatho
Tel: 018 387 2150 / 2435
cidbnw@cidb.org.za

cidb Contact Centre:
086 100 2432

Anonymous Fraud Hotline:
0800 112 432

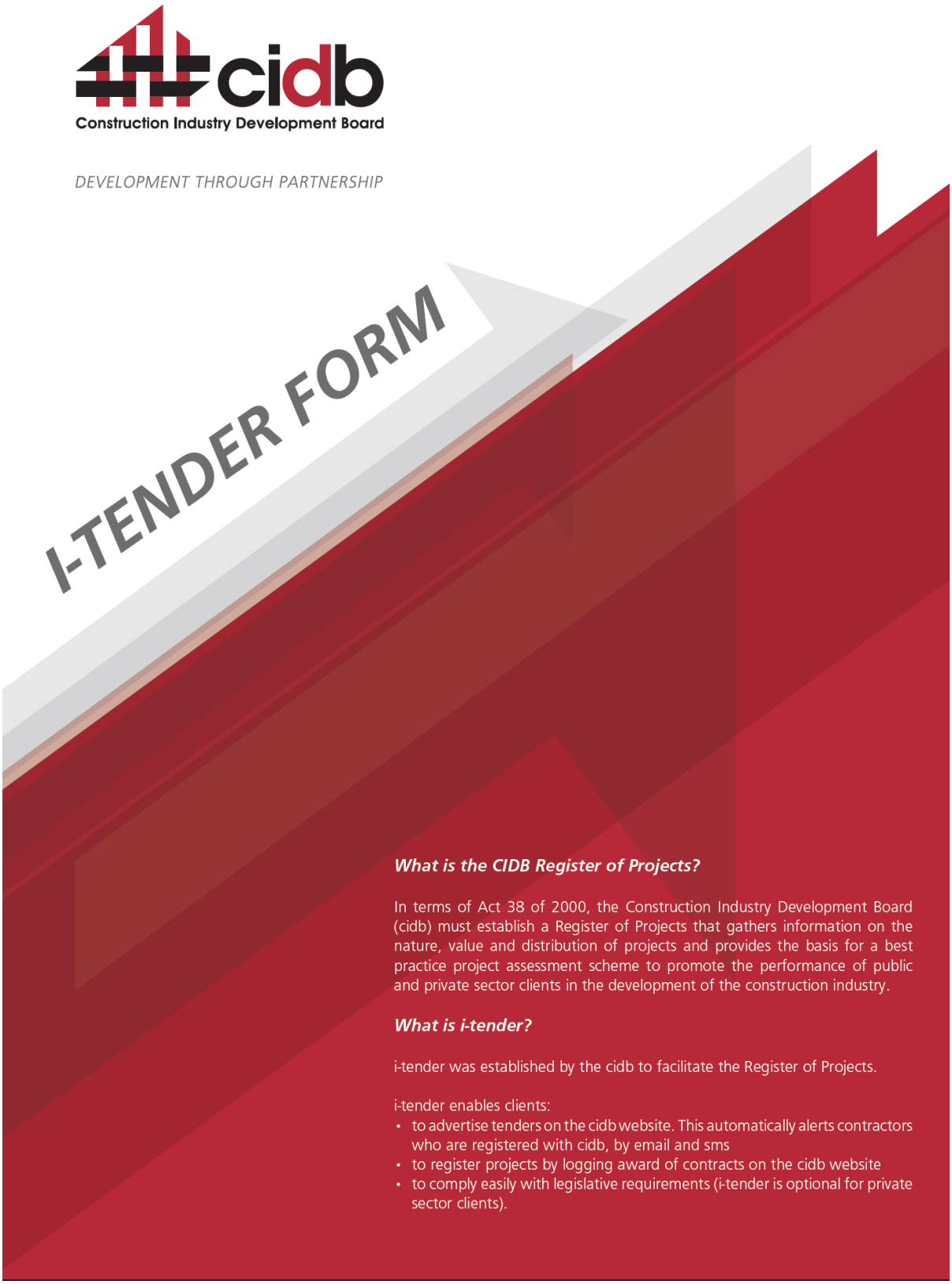
www.cidb.org.za

cidb
Construction Industry Development Board

FRAUD ALERT!!!

Be aware of fraudsters posing as cidb agents. The cidb does not use agents, and contractors are advised to only pay the fees stipulated in this form.

APPENDIX D CIDB I-TENDER FORM



Construction Industry Development Board

FORM CRS P1

APPLICATION FOR AN EMPLOYER NUMBER AND AUTHORISATION OF INTERNET USERS

Quick guide to advertising tenders and registering projects

Step 1

Apply for an Employer Number and Authorise Internet Users

Step 2

Advertise Tender (Optional for private sector clients)

Step 3

Register award of contract

Step 4

Register cancellation / termination of contract if contract has been cancelled or terminated

Step 5

Register Practical Completion (optional)

Note
This form is issued free of charge and is available only on the cidb website.

Note
Any construction project that relates only to the provision of homes as contemplated in the Housing Consumer Protection Measures Act 95 of 1998, is exempt from these regulations.

Which Projects Need to be Registered?
Any construction works contract which exceeds the following values, including VAT:

- Public sector: R 200 000
- Private sector: R 10 000 000

A construction works contract means a contract for the provision of a combination of goods and services arranged for the development, extension, installation, repair, maintenance, renewal, removal, renovation, alteration, dismantling or demolition of a fixed asset, including building and engineering infrastructure.

When do you Register your Project?
Public sector and private sector employers must register contracts within one month and three months, respectively, from the date on which the contractors offer to perform a construction works contract is accepted in writing.

What is the purpose of this form?
The purpose of this form is:

- for Employers to obtain an Employer Number in order to:
  - use the on-line i-Tender facility to inform contractors about tenders
  - register a contract
  - register the cancellation / termination of a contract
  - register the completion of a contract
- for Employers to authorise users
- for Employers to inform cidb of any changes of information.

Who needs to apply for an Employer Number and why?
Any person, body of persons or organ of State who enters into a prime contract with a contractor for the provision of construction works.

APPLICATION FOR AN EMPLOYER NUMBER AND AUTHORISATION OF INTERNET USERS

- To apply for an employer number, complete Section A
- To notify the cidb of authorised internet users, complete section B
- To update particulars, complete Sections A and B, as necessary
- Section C must be completed every time a form is submitted to the cidb
- Please print clearly, use black ink and complete all relevant sections.
- Once you have completed the form, please double check that you have correctly filled in all required information.
- To remove people, please fill in Section B

To fax your application:

- Tear off both pages in order to feed it through the fax machine.
- Be sure to fax the application side and not the information side of the pages.
- Fax the completed application to the cidb at 086 681 9995

To mail your application:

- Make a photocopy of the form to keep for your own records.
- You dont have to tear off pages to mail the form.
- Mail your form to: cidb Private Bag X14, Brooklyn Square 0075, Pretoria, South Africa

To deliver your application:

- Make a photocopy of the form to keep for your own records.
- Deliver your form to: cidb Blocks N & R, SABS Campus, Leyds Street Entrance, Groenkloof, Pretoria
- For more information or to apply online go to **www.cidb.org.za**. If you need help call **0860-103-353**.

APPLICATION FOR AN EMPLOYER NUMBER AND AUTHORISATION OF INTERNET USERS

Type of application _____ New application ☐ Update of information ☐

SECTION A: EMPLOYER INFORMATION

Section A i: Contact Information

Employer: A person, body of persons or organ of State who enters into a prime contract with a contractor for the provision of construction works.

Employer/Organisation *(If this an update on information)*:

Physical Address: _____ Postal Address: _____

_____ _____

_____ Code: _____ _____ Code: _____

Accounting Officer / Municipal Manager: Title: _____ Initials: _____ Surname: _____

Designation: _____ email: _____

Telephone: (___) _____ Fax: (___) _____ Cell: _____

Supply Chain Manager: Title: _____ Initials: _____ Surname: _____

Designation: _____ email: _____

Telephone: (___) _____ Fax: (___) _____ Cell: _____

SECTION A: EMPLOYER INFORMATION (CONTINUED)

General Contact: Title: _____ Initials: _____ Surname: _____

Designation: _____ email: _____

Telephone: (___) _____ Fax: (___) _____ Cell: _____

Please mark relevant boxes with an "X"

Type of organisation:
☐ Private Sector ☐ National Dept. ☐ Provincial Dept.
☐ Municipal Entity ☐ Local Municipality ☐ Metropolitan Municipality
☐ District Municipality ☐ State Owned Enterprise ☐ Other

If other, please specify: _____

Areas of Operation:
☐ Gauteng ☐ Free State ☐ KwaZulu-Natal
☐ Limpopo ☐ North West ☐ Eastern Cape
☐ Northern Cape ☐ Western Cape ☐ Mpumalanga
☐ National

Organisation Name: _____

SECTION B: AUTHORISATION OF INTERNET USERS

Employers may elect to either authorise users by filling in the section below or by authorising an administrator of users who will register authorised users on behalf of the Employer, at www.cidb.org.za

Infrastructure Manager: Title: _____ Initials: _____ Surname: _____

Designation: _____ email: _____

Telephone: (___) _____ Fax: (___) _____ Cell: _____

Note

- A user is a person mandated to register projects on behalf of the Employer e.g. Employees, Agents, Consultants and Representatives.
- Users will be issued with user names and passwords by the cidb via e-mail to the e-mail address corresponding to each user.
- Admin user is a person mandated to manager and administer the employer's account e.g. create new users, reset passwords, deactivate users and assign permissions.

Supply Chain

The following people are authorised as users on behalf of the employer. *(If you have more users, please add an extra space.)*

Admin User	Title			First Names	Surname	email Address	Contact Number
	Mr	Mrs	Ms				
	Mr	Mrs	Ms				
	Mr	Mrs	Ms				
	Mr	Mrs	Ms				
	Mr	Mrs	Ms				

SECTION B: AUTHORISATION OF INTERNET USERS (CONTINUED)

Infrastructure

The following people are authorised as users on behalf of the employer.

Admin User	Title			First Names	Surname	email Address	Contact Number
	Mr	Mrs	Ms				
	Mr	Mrs	Ms				
	Mr	Mrs	Ms				
	Mr	Mrs	Ms				
	Mr	Mrs	Ms				

The following people are to be removed.

Admin User	Title			First Names	Surname	email Address	Contact Number
	Mr	Mrs	Ms				
	Mr	Mrs	Ms				
	Mr	Mrs	Ms				
	Mr	Mrs	Ms				
	Mr	Mrs	Ms				

SECTION C: DECLARATION

I, the undersigned, declare that:

- I am duly authorised to make this application on behalf of the Employer;
- The information furnished is true and correct in every respect;
- I will inform the cidb of any change to the information supplied in this form;
- The employer and employers representative will abide by the Code of Conduct for all parties engaged in construction procurement, as published by the cidb in the Government Gazette no. 25656 of 2003. (Also available at: **www.cidb.org.za**).

Signature: _____ Date: D D M M Y Y Y Y

Designation: _____ Please Print Name: _____

Pretoria Head Office
+27 12 482 7200/+27 86 100 cidb

Gauteng Provincial Office
Pretoria • 0861 428 222

Western Cape Provincial Office
Cape Town • 0861 927 222

Eastern Cape Provincial Office
Bisho • 0861 222 327

Northern Cape Provincial Office
Kimberley • 053 861 9631

Free State Provincial Office
Bloemfontein • 0861 377 222

KwaZulu-Natal Provincial Office
Durban • 0861 596 222

Limpopo Provincial Office
Polokwane • 0861 222 765

Mpumalanga Provincial Office
Nelspruit (Mbombela) • 0861 678 222

North West Provincial Office
Mahikeng • 0861 243 222

Anonymous Fraud Line
0800 112 432
Call Centre: 0860 103 353
email: cidb@cidb.org.za
www.cidb.org.za

About the cidb

The cidb is committed to the transformation and sustainable development of the construction industry in South Africa.

In particular, the cidb aims to promote:

- sustainable industry growth and sustainable opportunities for participation by the emerging sector;
- improved industry performance and best practice;
- a transformed delivery environment underpinned by consistent and ethical procurement practice; and
- enhanced value to clients and society.

The national Construction Registers Service (CRS) has been established to shape and reflect progress in the capability and transformation of the construction industry in South Africa. The service includes:

- The national Register of Contractors, which registers all contractors who undertake construction work for the public sector. The Register supports risk management, reduces the administrative burden associated with the award of contracts, and promotes the performance and development of contractors.
- The national Register of Projects, which registers all public and private sector projects above a prescribed value. The Register provides information on the nature and distribution of projects and promotes the performance of public and private sector clients in the development of the construction industry.

The Construction Registers Service forms part of the cidb's mandate to create a regulatory and development framework that builds:

- The total construction delivery capability for South Africa's social and economic growth; and
- A proudly South African construction industry that delivers to globally competitive standards.

APPENDIX E CONSTRUCTION WORK PERMIT FORM

HEALTH AND SAFETY H.T.E. A BRAND WITHIN TRAINING AND ENVIRONMENTAL SERVICES www.htetrust.co.za	ANNEXURE 1 Application for a work permit to do construction work	**Date:**	2019/07
		Document Number:	S1 APCW
		Page Number:	Page **1** of **3**
		Revision Number:	2
Site:		**Contractor:**	

ANNEXURE 1

APPLICATION FOR A PERMIT TO DO CONSTRUCTION WORK

[In terms of Regulation 3(2) of Construction Regulations 2014]

This application must be submitted with the following documents:

1) Health and Safety specification.
2) Health and Safety plan.
3) Baseline risk assessment.

1. Name, postal address and telephone numbers of the client:

   _____

   _____

2. Details of the HTE Agent.
   a) Title, Surname and Initials: _____
   b) Identity number / Passport Number: _____
   c) Registration number with SACPCMP: _____
   d) Office Tel. number and/or Mobile Number : 082 4520 4420
   e) Postal address: 10 Baobab Ave Roodekrans Roodepoort 1724

3. Name, Postal address and telephone numbers of the appointed principle contractor:

   _____

   _____

   _____

4. Name, Postal address and telephone numbers of the designer of the project:

   _____

   _____

   _____

5. Name, Postal address and telephone numbers of the following persons:
   a) Construction Manager:

      _____

      _____

      _____

   b) Construction Health and safety manager:

      _____

      _____

      _____

   c) Construction Health and Safety Officer:

      _____

      _____

      _____

6. Exact physical address of the construction site office:

   _____

   _____

   _____

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7. Nature of construction work:

_____
_____
_____

8. Expected commencement date:

_____

9. Expected completion date:

_____

10. Estimated maximum number of persons on the construction site:

_____

11. Planned number of contractors on site accountable to principle contractor:

_____

12. Name(s) of the contractors appointed:

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

13. _____
Signature of Client/Client's Agent

14. _____
Signature of Principal Contractor

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FOR OFFICE ONLY

Authorization /Unique No.	**LABOUR CENTRE**	**OFFICIAL APPROVAL STAMP**

15. Date of application: _____

16. Submitted documents prescribed in Construction Regulation 5(4) (Please Tick √):

CR 5(1)(a)		CR 5(1)(b)		CR 5(1); (C-S)	

17. Result of the application (Please Tick √):	**Approved**		**Declined**	

18. Reason for declining the application:

_____

_____

_____

_____

19. _____
Signature of the Supervisor

20. _____
Signature of revoking Officer/ Inspector

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APPENDIX F PARTICIPANTS INFORMATION SHEET

Good day,

You are invited to participate in an academic research study conducted by Mrs Salome Chiloane-Nwabueze, a PhD Candidate (Civil Engineering) in the School of Civil and Environmental Engineering at University of Witwatersrand. I am currently working on my PhD research under the supervision of ***Professor Anne Fitchett and Advocate Alistair Glendinning from the School of Civil and Environmental Engineering***. My research is titled ***"***A Decision Support Framework for grading of civil engineering contractors and evaluation of project performance***."*** This research intends to provide a decision support framework for the public sector to be used in registering, grading, and assessing project performance of contractors. The aim is to assess the current status quo and make recommendation which may assist to improve the construction sector.

One of the key tasks included in my research approach is to survey contractors and professionals in the construction and civil engineering operating or contracting in the public sector. This is required to assess the current state-of-the-practice and identify potential needs to be addressed in my research. In this regard, I would like to invite you to participate in my survey. The survey is in an online user-friendly format, has been pre-tested for time and will not take more than 10-15 minutes for completion. Your response will remain strictly confidential, and the results of the survey will be reported only as a summary in an aggregated form, without links to individual responses. When I share the results of the research study, I will not include your name or anything else that could identify you. With your permission, other researchers may use the data collected from this research study, but your name and any personal information will not be used or passed on.

If you decide to take part in the research study, it should be because you want to volunteer. You do not have to take part. You can stop participating in the study at any time. You do not have to answer any questions if you do not want to. You will not get any direct benefits if you choose to join the research study. You will not lose any services, benefits or rights you would normally have if you decided not to join. Taking part in the research study will not cost you anything. Thus, completing and submitting the online questionnaire is taken to mean consent to participate.

This research study will be written up as a research report. The report will be available on the university website. If you would like to receive a summary of this report, I will be happy to send it to you. If you have any questions during or afterwards about this research study, feel free to contact me or my supervisor on the details listed below. If you have any concerns or complaints about the ethical procedures of this research study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za.

Following is the link to the survey (*either click or copy and paste in the web browser*):
https://forms.gle/wV9G7pwAyH9dnYJz7

If you think that someone else in your organization will be interested in the survey, you are welcome to forward this invitation to him/her.

Thank you in advance for your participation in this survey.

I appreciate your time and effort.

Yours Sincerely,

_____

Salome Chiloane-Nwabueze

Researcher

Email: 0511487H@students.wits.ac.za

Cell No: 072 375 2126

Supervisor: ***Professor Anne Fitchett***

Email: Anne.Fitchet@wits.ac.za

Tel No: 011 717 7104

APPENDIX G INVITATION EMAIL

Dear Sir/Madam,

You are invited to participate in a PhD study titled **"A Decision Support Framework for grading of civil engineering contractors and evaluation of project performance"**

This research study is being conducted by Salome Chiloane-Nwabueze under the supervision of Prof. Anne Fitchett and Advocate Alistair Glendinning at the School of Civil and Environmental Engineering, University of Witwatersrand.

This will be measured via an online questionnaire of various industry participants which takes only 10-15 minutes to complete.
Please click here to read the full Participant Information Leaflet and Consent form, as well as to Start the Survey: https://forms.gle/wV9G7pwAyH9dnYJz7

All responses and information collected will be kept in the strictest confidence and used only for academic purposes. No information will be recorded which could possibly identify yourself and/or your institution.

Thank you.

APPENDIX H QUESTIONNAIRE

Section A: Demographic profile

This section has questions that focus on your background information. Please indicate your answer by crossing (X) in the appropriate block or by filling in your answer.

A1	**Contractor Grade**	Grade 1-3	Grade 4-6	Grade 7-9	Not registered	Other, please specify…

A2	**Number of Years in the Construction Sector**	0-5 years	5-10 years	10-15 years	15-20 years	20 years and above	Other, please specify…

A3	**Engineering Registration Status**	Candidate Engineer	Professional Engineer	Professional Engineering Technologist	Professional Certificated Engineer	Professional Engineering Technician	Other, please specify…

A4	**Construction Registration Status**	Candidate Construction Manager	Candidate Construction Project Manager	Professional Construction Manager	Professional Construction Project Manager	Other, please specify….

A5	**Age Group**	25 years and below	26-33 years	34-41 years	42-49 years	50 years and above	Other, please specify

A6	**Race**	Black	White	Indian	Coloured	Other (Specify)…….

A7	**Field of operation**	Civil Engineering	General Building	Mechanical Engineering	Electrical Engineering	Other, please specify……

SECTION B: CONSTRUCTION SECTOR ENTRY REQUIREMENTS

We would like to find out more about your views regarding the construction sector entry requirements which is used by the Construction Industry Development Board (CIDB). Please indicate the extent to which you agree or disagree by ticking the corresponding number between 1 (Strongly disagree) and 7 (Strongly agree). A rating of (4) points towards a neutral view of the statement.

ENTRY REQUIREMENTS		Strongly Disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
B1	I know and understand the current construction sector entry requirements used by the Construction Industry Development Board.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
B2	The current construction sector entry requirements are adequate.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
B3	The current construction sector entry requirements are clear	**1**	**2**	**3**	**4**	**5**	**6**	**7**
B4	There are gaps in the current construction sector entry requirements	**1**	**2**	**3**	**4**	**5**	**7**	**5**
B5	The gaps in the construction sector entry requirements could be enhanced	**1**	**2**	**3**	**4**	**5**	**6**	**7**
B6	Enhancing the current construction sector entry requirements could assist to improve contractors' capabilities	**1**	**2**	**3**	**4**	**5**	**6**	**7**
B7	Enhancing the current construction sector entry requirements could assist to improve the performance outputs of the construction sector	**1**	**2**	**3**	**4**	**5**	**6**	**7**

SECTION C: PUBLIC SECTOR GRADING SYSTEM

We would like to find out more about your views regarding the current grading system to grade construction contractors which is used by the Construction Industry Development Board (CIDB). Please indicate the extent to which you agree or disagree by ticking the corresponding number between 1 (Strongly disagree) and 7 (Strongly agree). A rating of (4) points towards a neutral view of the statement.

GRADING SYSTEM		Strongly Disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
C1	I know and understand the current contractor grading system used by the Construction Industry Development Board.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
C2	The current contractor grading system is adequate for grading contractors	**1**	**2**	**3**	**4**	**5**	**6**	**7**
C3	The current contractor grading system requirements for grading contractors is clear	**1**	**2**	**3**	**4**	**5**	**6**	**7**
C4	There are gaps in the current contractor grading system	**1**	**2**	**3**	**4**	**5**	**7**	**5**
C5	The gaps in grading systems could be enhanced	**1**	**2**	**3**	**4**	**5**	**6**	**7**
C6	Enhancing the current grading system could assist to improve contractors' capabilities	**1**	**2**	**3**	**4**	**5**	**6**	**7**
C7	Enhancing the current grading system could assist in improving performance outputs of the construction sector	**1**	**2**	**3**	**4**	**5**	**6**	**7**

SECTION D: EFFICACY OF THE GRADING SYSTEM AND GRADING CRITERIA

We would like to find out more about your views regarding the efficacy of the current grading system and grading criteria. Please indicate the extent to which you agree or disagree by ticking the

corresponding number between 1 (Strongly disagree) and 7 (Strongly agree). A rating of (4) points towards a neutral view of the statement.

		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
GRADING SYSTEM EFFICACY								
D1	The current contractor grading system produces the desired results	**1**	**2**	**3**	**4**	**5**	**6**	**7**
D2	The current contractor grading system can adequately match contractors capabilities	**1**	**2**	**3**	**4**	**5**	**6**	**7**
D3	Contractor registration requirements are adequate	**1**	**2**	**3**	**4**	**5**	**6**	**7**
D4	Contractor grading requirements are adequate	**1**	**2**	**3**	**4**	**5**	**7**	**5**
D5	The requirements for contractor grading progression are clear	**1**	**2**	**3**	**4**	**5**	**6**	**7**
D6	The requirements for contractor grading progression need to be enhanced	**1**	**2**	**3**	**4**	**5**	**6**	**7**
GRADING CRITERIA								
D7	The current grading criteria is adequate for grading contractors	**1**	**2**	**3**	**4**	**5**	**6**	**7**
D8	There are gaps in the current contractor grading criteria	**1**	**2**	**3**	**4**	**5**	**6**	**7**
D9	The current contractor grading criteria is relevant for grading contractors	**1**	**2**	**3**	**4**	**5**	**6**	**7**
D10	The current contractor grading criteria could be improved	**1**	**2**	**3**	**4**	**5**	**6**	**7**
D11	Enhancing the current grading criteria could assist to improve contractors' capabilities	**1**	**2**	**3**	**4**	**5**	**6**	**7**
D12	Enhancing the current grading criteria could assist in improving the outputs of the construction sector	**1**	**2**	**3**	**4**	**5**	**6**	**7**
RELEVANT GRADING CRITERIA								
D13	Considering technical capacity criteria for grading could assist in improving contractors' capability	**1**	**2**	**3**	**4**	**5**	**6**	**7**
D14	Considering contractors experience for grading could assist in improving contractors' capability	**1**	**2**	**3**	**4**	**5**	**6**	**7**
D15	Considering contractors plant and equipment for grading could assist in improving contractors' capability	**1**	**2**	**3**	**4**	**5**	**6**	**7**
D16	Considering contractors financial status for grading could assist in improving contractors' capability	**1**	**2**	**3**	**4**	**5**	**6**	**7**
D17	Considering contractors past performance for grading could assist in improving contractors' capability	**1**	**2**	**3**	**4**	**5**	**6**	**7**
D18	Considering contractors management capability for grading could assist in improving contractors' capability	**1**	**2**	**3**	**4**	**5**	**6**	**7**
D19	Considering contractors occupational health and safety for grading could assist in improving contractors' capability	**1**	**2**	**3**	**4**	**5**	**6**	**7**
D20	Considering other relevant criteria for contractor grading could assist in improving contractors' capability	**1**	**2**	**3**	**4**	**5**	**6**	**7**

SECTION E: PUBLIC SECTOR INFRASTRUCTURE PROJECT PERFORMANCE EVALUATION AND CONTRACTOR CAPABILITIES

We would like to find out a little more about your views regarding the Construction Industry Development Board (CIDB) infrastructure project performance of contractors and contractor capabilities. Please indicate the extent to which you agree or disagree by ticking the corresponding number between 1 (Strongly disagree) and 7 (Strongly agree). A rating of (4) points towards a neutral view of the statement.

		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
INFRASTRUCTURE PROJECT PERFORMANCE EVALUATION								
E1	The current public sector (CIDB) infrastructure project performance evaluation framework is effective	**1**	**2**	**3**	**4**	**5**	**6**	**7**
E2	There is a need for an enhanced infrastructure project performance evaluation framework	**1**	**2**	**3**	**4**	**5**	**6**	**7**
E3	An effective project performance evaluation framework could assist the construction sector	**1**	**2**	**3**	**4**	**5**	**6**	**7**
E4	An effective project performance evaluation framework could assist the contractors to improve on performance	**1**	**2**	**3**	**4**	**5**	**7**	**5**
RELEVANT CRITERIA FOR THE EVALUATION OF CONTRACTORS PERFORMANCE								
E5	Considering contractors past performance for grading could assist in improving contractors capability	**1**	**2**	**3**	**4**	**5**	**6**	**7**
E6	Considering contractors experience for grading could assist in improving contractors' capability	**1**	**2**	**3**	**4**	**5**	**6**	**7**
E7	Considering contractors plant and equipment for grading could assist in improving contractors' capability	**1**	**2**	**3**	**4**	**5**	**6**	**7**
E8	Considering contractors financial status for grading could assist in improving contractors' capability	**1**	**2**	**3**	**4**	**5**	**6**	**7**
E9	Considering technical capacity criteria for grading could assist in improving contractors' capability	**1**	**2**	**3**	**4**	**5**	**6**	**7**
E10	Considering contractors management capability for grading could assist in improving contractors' capability	**1**	**2**	**3**	**4**	**5**	**6**	**7**
E11	Considering contractors occupational health and safety for grading could assist in improving contractors' capability	**1**	**2**	**3**	**4**	**5**	**6**	**7**
E12	Considering other relevant criteria for contractor grading could assist in improving contractors' capability	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Do you think that the proposed study is useful for the construction sector?

□ F1: Yes (Please Provide Reasons)

□ F2: No (Please Provide Reasons)

F3: If you have any further comments or inputs kindly share them?

Thank you for your time spent in responding to this survey. Your views are much appreciated.

APPENDIX I CONTRACTOR GRADING SCENARIOS OVERALL PRIORITY MATRIX

Scenario A: Overall Priority Matrix

Overall Priority Matrix

MAIN CRITERIA PRIORITY VECTORS		Options	Technical	Experience	P&E	Finance	Past Perform	Man Capability	OHS	Overall Project Priority Vector V
Technical	0.380	1	0.095	0.014	0.020	0.028	0.014	0.030	0.026	0.047
Experience	0.199	2	0.102	0.123	0.020	0.030	0.123	0.030	0.122	0.102
P&E	0.038	3	0.102	0.123	0.020	0.046	0.123	0.030	0.122	0.104
Finance	0.071	4	0.119	0.123	0.059	0.053	0.123	0.030	0.122	0.112
Past Perform	0.199	5	0.119	0.123	0.059	0.086	0.123	0.030	0.122	0.114
Man Capability	0.023	6	0.153	0.123	0.126	0.099	0.123	0.126	0.122	0.133
OHS	0.090	7	0.153	0.123	0.126	0.163	0.123	0.126	0.122	0.137
		8	0.222	0.123	0.285	0.189	0.123	0.223	0.122	0.174
		9	0.222	0.123	0.285	0.304	0.123	0.373	0.122	0.185

Scenario B: Overall priority matrix

Overall Priority Matrix

MAIN CRITERIA PRIORITY VECTORS		Options	Technical	Experience	P&E	Finance	Past Perform	Man Capability	OHS	Overall Project Priority Vector **V**
Technical	0.328	1	0.077	0.014	0.020	0.028	0.014	0.030	0.026	0.038
Experience	0.180	2	0.081	0.123	0.020	0.030	0.123	0.030	0.122	0.088
P&E	0.071	3	0.081	0.123	0.020	0.046	0.123	0.030	0.122	0.089
Finance	0.088	4	0.094	0.123	0.059	0.053	0.123	0.030	0.122	0.097
Past Perform	0.180	5	0.094	0.123	0.059	0.086	0.123	0.030	0.122	0.100
Man Capability	0.060	6	0.118	0.123	0.126	0.099	0.123	0.126	0.122	0.119
OHS	0.091	7	0.118	0.123	0.126	0.163	0.123	0.126	0.122	0.125
		8	0.167	0.123	0.285	0.189	0.123	0.223	0.122	0.161
		9	0.167	0.123	0.285	0.304	0.123	0.373	0.122	0.180

Scenario C: Overall priority matrix

Overall Priority Matrix										
MAIN CRITERIA PRIORITY VECTORS		**Options**	**Technical**	**Experience**	**P&E**	**Finance**	**Past Perform**	**Man Capability**	**OHS**	**Overall Project Priority Vector V**
Technical	0.380	1	0.077	0.014	0.020	0.028	0.014	0.030	0.026	0.040
Experience	0.199	2	0.081	0.123	0.020	0.030	0.123	0.030	0.122	0.094
P&E	0.038	3	0.081	0.123	0.020	0.046	0.123	0.030	0.122	0.096
Finance	0.071	4	0.094	0.123	0.059	0.053	0.123	0.030	0.122	0.102
Past Perform	0.199	5	0.094	0.123	0.059	0.086	0.123	0.030	0.122	0.105
Man Capability	0.023	6	0.118	0.123	0.126	0.099	0.123	0.126	0.122	0.120
OHS	0.090	7	0.118	0.123	0.126	0.163	0.123	0.126	0.122	0.124
		8	0.167	0.123	0.285	0.189	0.123	0.223	0.122	0.153
		9	0.167	0.123	0.285	0.304	0.123	0.373	0.122	0.164

Scenario D: Overall Priority Matrix

Overall Priority Matrix										
MAIN CRITERIA PRIORITY VECTORS		**Options**	**Technical**	**Experience**	**P&E**	**Finance**	**Past Perform**	**Man Capability**	**OHS**	**Overall Project Priority Vector V**
Technical	0.380	1	0.077	0.014	0.020	0.028	0.014	0.030	0.026	0.040
Experience	0.199	2	0.081	0.123	0.020	0.030	0.123	0.030	0.122	0.094
P&E	0.038	3	0.081	0.123	0.020	0.046	0.123	0.030	0.122	0.096
Finance	0.071	4	0.094	0.123	0.059	0.053	0.123	0.030	0.122	0.102
Past Perform	0.199	5	0.094	0.123	0.059	0.086	0.123	0.030	0.122	0.105
Man Capability	0.023	6	0.118	0.123	0.126	0.099	0.123	0.126	0.122	0.120
OHS	0.090	7	0.118	0.123	0.126	0.163	0.123	0.126	0.122	0.124
		8	0.167	0.123	0.285	0.189	0.123	0.223	0.122	0.153
		9	0.167	0.123	0.285	0.304	0.123	0.373	0.122	0.164

Scenario E: Overall priority matrix

Overall Priority Matrix										
MAIN CRITERIA PRIORITY VECTORS		**Options**	**Technical**	**Experience**	**P&E**	**Finance**	**Past Perform**	**Man Capability**	**OHS**	**Overall Project Priority Vector V**
Technical	0.143	1	0.077	0.014	0.020	0.028	0.014	0.030	0.026	0.030
Experience	0.143	2	0.081	0.123	0.020	0.030	0.123	0.030	0.122	0.076
P&E	0.143	3	0.081	0.123	0.020	0.046	0.123	0.030	0.122	0.078
Finance	0.143	4	0.094	0.123	0.059	0.053	0.123	0.030	0.122	0.087
Past Perform	0.143	5	0.094	0.123	0.059	0.086	0.123	0.030	0.122	0.091
Man Capability	0.143	6	0.118	0.123	0.126	0.099	0.123	0.126	0.122	0.120
OHS	0.143	7	0.118	0.123	0.126	0.163	0.123	0.126	0.122	0.129
		8	0.167	0.123	0.285	0.189	0.123	0.223	0.122	0.176
		9	0.167	0.123	0.285	0.304	0.123	0.373	0.122	0.214

Scenario F: Overall priority matrix

Overall Priority Matrix										
MAIN CRITERIA PRIORITY VECTORS		**Options**	**Technical**	**Experience**	**P&E**	**Finance**	**Past Perform**	**Man Capability**	**OHS**	**Overall Project Priority Vector V**
Technical	0.380	1	0.077	0.014	0.020	0.028	0.014	0.044	0.026	0.041
Experience	0.199	2	0.081	0.123	0.020	0.030	0.123	0.044	0.122	0.095
P&E	0.038	3	0.081	0.123	0.020	0.046	0.123	0.044	0.122	0.096
Finance	0.071	4	0.094	0.123	0.059	0.053	0.123	0.044	0.122	0.103
Past Perform	0.199	5	0.094	0.123	0.059	0.086	0.123	0.044	0.122	0.105
Man Capability	0.023	6	0.118	0.123	0.126	0.099	0.123	0.124	0.122	0.120
OHS	0.090	7	0.118	0.123	0.126	0.163	0.123	0.124	0.122	0.124
		8	0.167	0.123	0.285	0.189	0.123	0.204	0.122	0.152
		9	0.167	0.123	0.285	0.304	0.123	0.329	0.122	0.163

APPENDIX J PROJECT PERFORMANCE GRADING SCENARIOS OVERALL PRIORITY MATRIX

Scenario A Overall priority matrix

Overall Priority Matrix										
MAIN CRITERIA PRIORITY VECTORS		**Options**	**Technical**	**Experience**	**P&E**	**Finance**	**Past Perform**	**Man Capability**	**OHS**	Overall Project Priority Vector **V**
Technical	0.380	1	0.273	0.064	0.064	0.086	0.112	0.064	0.098	0.158
Experience	0.199	2	0.318	0.267	0.267	0.272	0.279	0.267	0.275	0.290
P&E	0.038	3	0.408	0.669	0.669	0.641	0.609	0.669	0.627	0.526
Finance	0.071									
Past Perform	0.199									
Man Capability	0.023									
OHS	0.090									

Scenario B Overall priority matrix

Overall Priority Matrix											
MAIN CRITERIA PRIORITY VECTORS		**Options**	**Technical**	**Experience**	**P&E**	**Finance**	**Past Perform**	**Man Capability**	**OHS**	**Overall Priority V**	**Project Vector**
Technical	0.380	1	0.064	0.064	0.064	0.086	0.079	0.064	0.098	0.072	
Experience	0.199	2	0.267	0.267	0.267	0.272	0.271	0.267	0.275	0.269	
P&E	0.038	3	0.669	0.669	0.669	0.641	0.650	0.669	0.627	0.633	
Finance	0.071										
Past Perform	0.199										
Man Capability	0.023										
OHS	0.090										

APPENDIX K CONTRACTOR EVALUATION TEMPLATE

CONTRACTOR PERFORMANCE REPORT

ISSUE OF A CONTRACTOR PERFORMANCE REPORT

SECTION A: EMPLOYER INFORMATION

cidb Employer Number

Employer Name

SECTION B: CONTRACT DATA

cidb Contract Number

Contract Title

Please indicate the project stage for which assessment is made

- Project initiation ☐
- Inception ☐
- Concept and viability ☐
- Design development ☐
- Documentation & procurement ☐
- Construction ☐
- Close out ☐
- Completion Date - -

SECTION C: REPORTING OFFICER'S INFORMATION

Organisation Name

Name of Reporting Officer — Title | Initials | Surname

Designation

Professional Registration Body (if applicable)

Registration Number

Email

Mobile 0 - -

Office Telephone 0 - -

Date submitted to Employer - -

Signature

SECTION D: CONTRACTOR PERFORMANCE INFORMATION

Please select the appropriate grading that reflects the Contractors performance on the project

Evaluation Criteria	Grading					
Definition	N/A	Poor (-1) Well below the acceptable standard of performance	Adequate (0) Meets the acceptance standard of performance	Good (1) Standard often exceeds the acceptable standard of performance		Excellent (2) Standard well above the acceptable standard of performance
TIME MANAGEMENT						
Ability to meet programmed milestones	☐	☐	☐	☐		☐
Timely allocation of appropriate resources to critical activities	☐	☐	☐	☐		☐
Overall progress of the work	☐	☐	☐	☐		☐
Timely submission of progress reports	☐	☐	☐	☐		☐
Sub-total						**0**
Aggregate (Sub-Total / 4)						0
10% of composite evaluation (0.1 x Aggregate)					A	0.00
MANAGEMENT OF RESOURCES						
Appropriateness of skills and experience of personnel assigned to the work	☐	☐	☐	☐		☐
Adequacy of the number of personnel assigned to the work	☐	☐	☐	☐		☐
Skill and commitment in management of subconsultants and other suppliers	☐	☐	☐	☐		☐
Coordination of interfaces	☐	☐	☐	☐		☐
Sub-total						0
Aggregate (Sub-Total / 4)						0
10% of composite evaluation (0.1 x Aggregate)					B	0.00
CO-OPERATIVE RELATIONSHIPS						
Adoption and commitment to a cooperative contracting approach with clients, subconsultants, joint venture partners, contractors and suppliers	☐	☐	☐	☐		☐
Commitment to resolving issues through open and effective communication with a non-adversarial approach	☐	☐	☐	☐		☐
General cooperation and responsiveness, adherence to commitments	☐	☐	☐	☐		☐
Response to instruction	☐	☐	☐	☐		☐
Response to problems and changing circumstances	☐	☐	☐	☐		☐
Sub-total						0
Aggregate (Sub-Total / 5)						0
10% of composite evaluation (0.1 x Aggregate)					C	0.00

Evaluation Criteria	Grading					
Definition	N/A	Poor (-1) Well below the acceptable standard of performance	Adequate (0) Meets the acceptance standard of performance	Good (1) Standard often exceeds the acceptable standard of performance		Excellent (2) Standard well above the acceptable standard of performance
STANDARD OF SERVICE (Stages)						
Stage 0 - Project initiation		WaS0				0
Stage 1 - Inception		WaS1				0
Stage 2 - Concept and viability		WaS2				0
Stage 3 - Design development		WaS3				0
Stage 4 - Documentation and procurement		WaS4				0
Stage 5 - Construction		WaS5				0
Stage 6 - Close-out		WaS6				0
STANDARD OF SERVICE (All Stages)						
Aggregated score for Stage 0 Project initiation (WaS0) only OR					Wa	0
Sum of Weighted Aggregate of Stages (WaS1 + WaS2 + WaS3 + WaS4 + WaS5 + WaS6)						0
D(i) = 75% Sum of weighted aggregates for Stages (0.75 x Wa)					D(i)	0.00
						0.00
STANDARD OF SERVICE (Overall)						
Compliance with brief	☐	☐	☐	☐		☐
Adherence to budget	☐	☐	☐	☐		☐
Reviews and reports delivered in accordance with the brief	☐	☐	☐	☐		☐
Sub-total						0
Aggregate (Sub-Total / 3)						0.00
D(ii) 25% Weighted aggregate of standard of service (0.25 x Aggregate score)						0.00
STANDARD OF SERVICE (Stages and Overall)						
D(iii) = D(i) + (Dii)						0.00
60% of composite evaluation (0.6 x D(iii))					D	0.00
Aggregated Score						
A + B + C + D					X	0.00 0%

SECTION E: CONTRACTOR / JV INFORMATION

Name of main Contractor	
Name of Joint Venture Partner	
Name of Joint Venture Partner	
Name of Joint Venture Partner	
Contact Person	Title: Initials: Surname:
Designation	
Professional Registration Body (if applicable)	
Registration Number	
Email	
Mobile	0 - -
Office Telephone	0 - -
I/we	with the Performance Assessment by the Reporting Officer
I/we appeal the Performance Assessment by the Reporting Officer	
Signature	
Date	- -

SECTION F: EMPLOYER'S REPRESENTATIVE INFORMATION

Contact Person	Title: Initials: Surname:
Designation	
Email	
Mobile	0 - -
Office Telephone	0 - -
Date	- -
I	with the Reporting Officer's Assessment of the PSP Assessment Report
Signature	

SECTION G: ADJUDICATOR'S INFORMATION (if applicable)

Name of Adjudicator	Title: Initials: Surname:
Designation	
Email	
Mobile	0 - -
Office Telephone	0 - -
Date	- -
Signature	

SECTION H: OUTCOME OF ADJUDICATION (if applicable)

	Employer's Rating	Contractor Rating	Adjudication
Time Management			
Management of Resources			
Cooperative relationships			
Standard of Service			

I, the undersigned warrant that:

· I am duly authorised to act as an Adjudicator;

· In my opinion, the outcome of this adjudication represents a fair outcome.

Signature

Date - -

On behalf of the Contractor, I note the outcome of this Adjudication process.

Signature: Contractors Representative

Date - -

On behalf of the Employer, I note the outcome of this Adjudication process.

Signature: Employer's Representative

Date - -

APPENDIX L PLANT AND EQUIPMENT



Figure 9.1: Walk behind roller



Figure 9.2: Light delivery vehicle



Figure 9.3: Tipper truck



Figure 9.4: Truck flat



Figure 9.5: Water bowser



Figure 9.6: Grader



Figure 9.7: Loader



Figure 9.8: Excavator



Figure 9.9: Compactor



Figure 9.10: Front end loader



Figure 9.11: Bull dozer



Figure 9.12: Mechanical broom



Figure 9.13: Chip spreader



Figure 9.14: Tractor



Figure 9.15: Pneumatic roller



Figure 9.16: Bitumen distributor



Figure 9.17: Crane truck



Figure 9.18: Drill machine



Figure 9.19: Roller/Steel roller



Figure 9.20: Pilling rig



Figure 9.21: Drilling rig



Figure 9.22: Road marker

APPENDIX M CONTRACTOR GRADING AND PERFORMANCE EVALUATION MATRIX PAIRWISE COMPARISON

Table 10.1 AHP comparison scale (Tanyimboh & Kalungi, 2009)

Numerical value	Relative importance	Explanation
1	Equal	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgement favour one item slightly over another
5	Essential or strong importance	Experience and judgement strongly favour activity over another
7	Very strong or demonstrated importance	An activity is strongly favoured, and its dominance is demonstrated in practice
9	Absolute	The evidence favouring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values	Used when compromise is needed
Reciprocals	If activity J has one of the above numbers assigned to it when compared with activity k, the k has the reciprocal value when compared with j	
Rational	Ratios arising from the scale	

Table 10.2 Depicts matrix of paired comparison of main criteria (Matrix A)

	Technical Capacity	Experience	Plant and Equipment (P&E)	Financial Status	Past Performance	Management Capability	Occupational Health and Safety (OHS)
Technical capacity	1.0	Importance of technical capacity relative to experience	Importance of technical capacity relative to plant and equipment	Importance of technical capacity relative to financial status	Importance of technical capacity relative to past performance	Importance of technical capacity relative to management capability	Importance of technical capacity relative to occupational health and safety
Experience	Importance of experience relative to	1.0	Importance of experience	Importance of experience	Importance of experience	Importance of experience relative to	Importance of experience relative to

	Technical Capacity	Experience	Plant and Equipment (P&E)	Financial Status	Past Performance	Management Capability	Occupational Health and Safety (OHS)
	technical capacity		relative to plant and equipment	relative to financial status	relative to past performance	management capability	occupational health and safety
Plant and Equipment	Importance of plant and equipment relative to technical capacity	Importance of plant and equipment relative to experience	1.0	Importance of plant and equipment relative to financial status	Importance of plant and equipment relative to past performance	Importance of plant and equipment relative to management capability	Importance of plant and equipment relative to occupational health and safety
Financial Status	Importance of financial status relative to technical capacity	Importance of financial status relative to experience	Importance of financial status relative to plant and equipment	1.0	Importance of financial status relative to past performance	Importance of financial status relative to management capacity	Importance of financial status relative to occupational health and safety
Past Performance	Importance of past performance relative to technical capacity	Importance of past performance relative to experience	Importance of past performance relative to plant and equipment	Importance of past performance relative to financial status	1.0	Importance of past performance relative to management capability	Importance of past performance relative to occupational health and safety
Management Capability	Importance of management capability relative to technical capacity	Importance of management capability relative to experience	Importance of management capability relative to plant and equipment	Importance of management capability relative to financial status	Importance of management capability relative to past performance	1.0	Importance of management capability relative to occupational health and safety
Occupational Health and Safety	Importance of occupational health and safety relative to technical capacity	Importance of occupational health and safety relative to experience	Importance of occupational health and safety relative to plant and equipment	Importance of occupational health and safety relative to financial status	Importance of occupational health and safety relative to past performance	Importance of occupational health and safety relative to management capability	1.0

Table 10.3 Pairwise Comparison for Main Criteria (Level 1)

Pairwise Comparison Matrix A							
	Technical Capacity	**Experience**	**P&E**	**Financial Status**	**Past Performance**	**Management Capability**	**OHS**
Technical Capacity	1.0	3.0	7.0	7.0	3.0	9.0	5.0
Experience	1/3	1.0	7.0	3.0	1.0	7.0	5.0
P&E	1/7	1/7	1.0	1/3	1/7	3.0	1/3
Financial Status	1/7	1/3	3.0	1.0	1/3	5.0	1/3
Past Performance	1/3	1.0	7.0	3.0	1.0	7.0	5.0
Management Capability	1/9	1/7	1/3	1/5	1/7	1.0	1/5
OHS	1/5	1/5	3.0	3.0	1/5	5.0	1.0

Normalised pairwise comparison and priority vectors for main criteria								
Matrix B								
	Technical Capacity	Experience	P&E	Financial Status	Past Performance	Management Capability	OHS	Priority Vector (P_m)
Technical Capacity	0.44	0.52	0.25	0.40	0.52	0.24	0.30	0.380
Experience	0.15	0.17	0.25	0.17	0.17	0.19	0.30	0.199
P&E	0.06	0.02	0.04	0.02	0.02	0.08	0.02	0.038
Financial Status	0.06	0.06	0.11	0.06	0.06	0.14	0.02	0.071
Past Performance	0.15	0.17	0.25	0.17	0.17	0.19	0.30	0.199
Management Capability	0.05	0.02	0.01	0.01	0.02	0.03	0.01	0.023
OHS	0.09	0.03	0.11	0.17	0.03	0.14	0.06	0.090

Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
2.99 1.61 0.27 0.52 1.61 0.17 0.69	7.88 8.10 7.11 7.30 8.10 7.29 7.65	7.63	0.11	1.32	0.080	YES

Table 10.4 Values of the Random Index (RI) for small problems (Saaty, 1987)

Number of Criteria	2	3	4	5	6	7	8	9	10
Random Index	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.51

Table 10.5 Pairwise comparisons of sub-criteria for technical capacity criterion (Level 2)

Pairwise Comparison Matrix A						
	Academic Qualifications			Key Staff Experience		No of key staff
Academic qualifications	1.0			3.0		5.0
Key Staff Experience	1/3			1.0		3.0
No of Key Staff	1/5			1/3		1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
	Academic Qualifications			Key Staff Experience	No of Key Staff	Priority Vector
Academic qualifications	0.65			0.69	0.56	0.633
Key Staff Experience	0.22			0.23	0.33	0.260
No of Key Staff	0.13			0.08	0.11	0.106
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
1.95 0.79 0.32	3.07 3.03 3.01	3.04	0.02	0.58	0.033	YES

Table 10.6 Pairwise comparisons of sub-criteria for experience criterion (Level 2)

Pairwise Comparison Matrix A			
		Company projects	Key staff projects
Company projects		1.0	1/7
Key staff projects		7.0	1.0
Normalised Pairwise comparison and priority vectors for main criteria			
Matrix B			
	Company projects	Key staff projects	Priority Vector (Ps)
Company projects	0.13	0.13	0.125
Key staff projects	0.88	0.88	0.875

Table 10.7 Pairwise comparisons of sub-criteria for plant and equipment criterion (Level 2)

Pairwise Comparison Matrix A			
		Equipment type	Minimum quantity
Equipment type		1,0	5.0
Minimum quantity		1/5	1.0
Normalised pairwise comparison and priority vectors for main criteria			
Matrix B			
	Equipment type	Minimum quantity	Priority vector (Ps)
Equipment type	0.83	0.83	0.8333
Minimum quantity	0.17	0,17	0.167

Table 10.8 Pairwise comparisons of sub-criteria for financial status criterion (level 2)

Pairwise Comparison Matrix A						
		Bank account		Available capital		Office space
Bank account		1.0		1/7		1/3
Available capital		7.0		1.0		5.0
Office space		3.0		1/5		1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Bank account		Available capital	Office space	Priority Vector (Ps)
Bank account		0.09		0.11	0.05	0.083
Available capital		0.64		0.74	0.79	0.724
Office space		0.27		0.15	0.16	0.193
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
0.25 2.27 0.59	3.01 3.14 3.04	3.07	0.03	0.58	0.057	YES

Table 10.9 Pairwise comparisons of sub-criteria for past performance criterion (level 2)

Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Time	Quality	Cost	Referrals	Priority Vector (Ps)
Time		0.11	0.12	0.07	0.19	0.122
Quality		0.54	0.60	0.66	0.44	0.558
Cost		0.32	0.20	0.22	0.31	0.263
Referrals		0.04	0.09	0.04	0.06	0.057
Pairwise Comparison Matrix A						
		Time		Quality	Cost	Referrals
Time		1.0		1/5	1/3	3.0
Quality		5.0		1.0	3.0	7.0
Cost		3.0		1/3	1.0	5.0
Referrals		1/3		1/7	1/5	1.0
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
0.49 2.36 1.10 0.23	4.04 4.22 4.17 4.04	4.12	0.04	0.90	0.044	YES

Table 10.10 Pairwise comparisons of sub-criteria for past performance criterion (level 2)

Pairwise comparison matrix A		
		Business Management Specialist
Business management specialist		1.0
Normalised pairwise comparison and priority vectors for main criteria		
Matrix B		
	Business Management Specialist	Priority Vector
Business Management Specialist	1.000	1.000

Table 10.11 Pairwise Comparisons of Sub-Criteria for occupational health and safety criterion (Level 2)

Pairwise Comparison Matrix A			
		OHSAS 18001/ISO 45001 Certificate	Company Health & Safety Records
OHSAS 18001/ISO 45001 Certificate Company Health & Safety Records		1.0 7.0	1/7 1.0
Normalised pairwise comparison and priority vectors for main criteria			
Matrix B			
	OHSAS 18001/ISO 45001 Certificate	Company Health and Safety Record	Priority Vector (Ps)
OHSAS 18001/ISO 45001 Certificate	0.13	0.13	0.125
Company Health and Safety Record	0.88	0.88	0.875

Table 10.12 Weight of options with respect to academic qualifications

Pairwise Comparison Matrix A										
		G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9
G 1		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 2		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 3		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 4		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 5		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 6		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 7		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 8		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 9		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Normalised pairwise comparison and priority vectors for main criteria										
Matrix B										
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	Project Priority Vector
G 1	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 2	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11

G 3	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 4	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 5	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 6	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 7	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 8	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 9	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11

Priority Vector for Academic Qualifications		Options	Academic Qualification	Composite Priorities
Academic Qualifications	1.00	G 1 G 2 G 3 G 4 G 5 G 6 G 7 G 8 G 9	0.11 0.11 0.11 0.11 0.11 0.11 0.11 0.11 0.11	0.11 0.11 0.11 0.11 0.11 0.11 0.11 0.11 0.11

X	X1	λ_{max}	CI	RI	CR	Consistent?
1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0	9.0 9.0 9.0 9.0 9.0 9.0 9.0 9.0 9.0	9.0	0.00	1.45	0.000	YES

Table 10.13 Weight of options with respect to key staff experience

Pairwise Comparison Matrix A									
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9
G 1	1.0	1/3	1/3	1/5	1/5	1/7	1/7	1/9	1/9
G 2	3.0	1.0	1.0	1/3	1/5	1/5	1/7	1/7	1/7
G 3	3.0	1.0	1.0	1/3	1/5	1/5	1/7	1/7	1/7
G 4	5.0	3.0	3.0	1.0	1.0	1/3	1/3	1/3	1/5
G 5	5.0	3.0	3.0	1.0	1.0	1/3	1/3	1/3	1/5
G 6	7.0	5.0	5.0	3.0	3.0	1.0	1.0	1.0	1/3
G 7	7.0	5.0	5.0	3.0	3.0	1.0	1.0	1.0	1/3
G 8	9.0	7.0	7.0	5.0	5.0	3.0	3.0	3.0	1.0
G 9	9.0	7.0	7.0	5.0	5.0	3.0	3.0	3.0	1.0

Normalised pairwise comparison and priority vectors for main criteria										
Matrix B										
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	Project Priority Vector
G 1	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.018

G 2	0.06	0.03	0.03	0.02	0.01	0.02	0.02	0.04	0.04	0.030
G 3	0.06	0.03	0.03	0.02	0.01	0.02	0.02	0.04	0.04	0.030
G 4	0.10	0.09	0.09	0.05	0.05	0.04	0.04	0.06	0.06	0.065
G 5	0.10	0.09	0.09	0.05	0.05	0.04	0.04	0.06	0.06	0.065
G 6	0.14	0.15	0.15	0.16	0.16	0.11	0.11	0.10	0.10	0.131
G 7	0.14	0.15	0.15	0.16	0.16	0.11	0.11	0.10	0.10	0.131
G 8	0.18	0.22	0.22	0.27	0.27	0.33	0.33	0.29	0.29	0.265
G 9	0.18	0.22	0.22	0.27	0.27	0.33	0.33	0.29	0.29	0.265

Priority Vector for Key Staff Experience		Options	Key Staff Experience	Composite Priorities
Key Staff Experience	1.000	G 1	0.018	0.018
		G 2	0.030	0.030
		G 3	0.030	0.030
		G 4	0.065	0.065
		G 5	0.065	0.065
		G 6	0.131	0.131
		G 7	0.131	0.131
		G 8	0.265	0.265
		G 9	0.265	0.265

Consistency Check						
X	X1	λ_{max}	CI	RI	CR	Consistent?
0.16	9.13					
0.27	8.89					
0.27	8.89					
0.59	9.14					
0.59	9.14	9.27	0.03	1.45	0.024	YES
1.25	9.52					
1.25	9.52					
2.55	9.61					
2.55	9.61					

Table 10.14 Weight of options with respect to number of key staff

Pairwise Comparison Matrix A									
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9
G 1	1.0	1/3	1/3	1/5	1/5	1/7	1/7	1/9	1/9
G 2	3.0	1.0	1.0	1/3	1/5	1/5	1/7	1/7	1/7
G 3	3.0	1.0	1.0	1/3	1/5	1/5	1/7	1/7	1/7
G 4	5.0	3.0	3.0	1.0	1.0	1/3	1/3	1/5	1/5
G 5	5.0	3.0	3.0	1.0	1.0	1/3	1/3	1/5	1/5
G 6	7.0	5.0	5.0	3.0	3.0	1.0	1.0	1/3	1/3
G 7	7.0	5.0	5.0	3.0	3.0	1.0	1.0	1/3	1/3
G 8	9.0	7.0	7.0	5.0	5.0	3.0	3.0	1.0	1.0
G 9	9.0	7.0	7.0	5.0	5.0	3.0	3.0	1.0	1.0
Normalised pairwise comparison and priority vectors for main criteria									
Matrix B									

	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	Project Priority Vector
G 1	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.018
G 2	0.06	0.03	0.03	0.02	0.01	0.02	0.02	0.04	0.04	0.030
G 3	0.06	0.03	0.03	0.02	0.01	0.02	0.02	0.04	0.04	0.030
G 4	0.10	0.09	0.09	0.05	0.05	0.04	0.04	0.06	0.06	0.065
G 5	0.10	0.09	0.09	0.05	0.05	0.04	0.04	0.06	0.06	0.065
G 6	0.14	0.15	0.15	0.16	0.16	0.11	0.11	0.10	0.10	0.131
G 7	0.14	0.15	0.15	0.16	0.16	0.11	0.11	0.10	0.10	0.131
G 8	0.18	0.22	0.22	0.27	0.27	0.33	0.33	0.29	0.29	0.265
G 9	0.18	0.22	0.22	0.27	0.27	0.33	0.33	0.29	0.29	0.265

Priority Vector for Number of Key Staff		Options	Number of Key Staff	Composite Priorities
Number of Key Staff	1.00	G 1	0.018	0.018
		G 2	0.030	0.030
		G 3	0.030	0.030
		G 4	0.065	0.065
		G 5	0.065	0.065
		G 6	0.131	0.131
		G 7	0.131	0.131
		G 8	0.265	0.265
		G 9	0.265	0.265

Consistency Check						
X	X1	λ_{max}	CI	RI	CR	Consistent?
0.16	9.13					
0.27	8.89					
0.27	8.89					
0.59	9.14					
0.59	9.14	9.27	0.03	1.45	0.024	YES
1.25	9.52					
1.25	9.52					
2.55	9.61					
2.55	9.61					

Table 10.15 Weight of options with respect to projects completed by company

Pairwise Comparison Matrix A									
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9
G 1	1.0	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/9
G 2	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 3	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 4	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 5	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 6	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 7	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 8	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 9	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Normalised pairwise Comparison and priority vectors for main criteria									

Matrix B										
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	Project Priority Vector
G 1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.014
G 2	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 3	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 4	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 5	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 6	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 7	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 8	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 9	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123

Priority Vector for Projects Completed by Company		Options	Projects Completed by Company	Composite Priorities
Company Projects	1.000	G 1	0.014	0.014
		G 2	0.123	0.123
		G 3	0.123	0.123
		G 4	0.123	0.123
		G 5	0.123	0.123
		G 6	0.123	0.123
		G 7	0.123	0.123
		G 8	0.123	0.123
		G 9	0.123	0.123

Consistency Check						
X	X1	λ_{max}	CI	RI	CR	Consistent?
0.12	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0	9.00	0.00	1.45	0.000	YES
1.11	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0					

Table 10.16 Weight of options with respect to projects completed by key staff

Pairwise Comparison Matrix A									
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9
G 1	1.0	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/9
G 2	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 3	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 4	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 5	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 6	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 7	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 8	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

G 9	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Normalised pairwise comparison and priority vectors for main criteria

Matrix B

	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	Project Priority Vector
G 1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.014
G 2	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 3	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 4	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 5	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 6	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 7	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 8	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 9	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123

Priority vector for Key Staff Projects		Options	Key Staff Projects	Composite Priorities
Key Staff Projects	1.000	G 1	0.014	0.014
		G 2	0.123	0.123
		G 3	0.123	0.123
		G 4	0.123	0.123
		G 5	0.123	0.123
		G 6	0.123	0.123
		G 7	0.123	0.123
		G 8	0.123	0.123
		G 9	0.123	0.123

Consistency Check

X	X1	λ_{max}	CI	RI	CR	Consistent?
0.12	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0	9.00	0.00	1.45	0.000	YES
1.11	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0					

Table 10.17 Weight of options with respect to type of equipment

Pairwise Comparison Matrix A									
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9
G 1	1.0	1.0	1.0	1/5	1/5	1/7	1/7	1/9	1/9
G 2	1.0	1.0	1.0	1/5	1/5	1/7	1/7	1/9	1/9
G 3	1.0	1.0	1.0	1/5	1/5	1/7	1/7	1/9	1/9
G 4	5.0	5.0	5.0	1.0	1.0	1/5	1/5	1/7	1/7
G 5	5.0	5.0	5.0	1.0	1.0	1/5	1/5	1/7	1/7
G 6	7.0	7.0	7.0	5.0	5.0	1.0	1.0	1/5	1/5

G 7	7.0	7.0	7.0	5.0	5.0	1.0	1.0	1/5	1/5
G 8	9.0	9.0	9.0	7.0	7.0	5.0	5.0	1.0	1.0
G 9	9.0	9.0	9.0	7.0	7.0	5.0	5.0	1.0	1.0

Normalised pairwise Comparison and priority vectors for main criteria

Matrix B

	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	Project Priority Vector
G 1	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.04	0.04	0.020
G 2	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.04	0.04	0.020
G 3	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.04	0.04	0.020
G 4	0.11	0.11	0.11	0.04	0.04	0.02	0.02	0.05	0.05	0.059
G 5	0.11	0.11	0.11	0.04	0.04	0.02	0.02	0.05	0.05	0.059
G 6	0.16	0.16	0.16	0.19	0.19	0.08	0.08	0.07	0.07	0.126
G 7	0.16	0.16	0.16	0.19	0.19	0.08	0.08	0.07	0.07	0.126
G 8	0.20	0.20	0.20	0.26	0.26	0.39	0.39	0.33	0.33	0.285
G 9	0.20	0.20	0.20	0.26	0.26	0.39	0.39	0.33	0.33	0.285

Priority vector for type of equipment		Options	Type of Equipment	Composite Priorities
Type of equipment	1.000	G 1	0.020	0.020
		G 2	0.020	0.020
		G 3	0.020	0.020
		G 4	0.059	0.059
		G 5	0.059	0.059
		G 6	0.126	0.126
		G 7	0.126	0.126
		G 8	0.285	0.285
		G 9	0.285	0.285

Consistency Check

X	X1	λ_{max}	CI	RI	CR	Consistent?
0.18	9.24					
0.18	9.24					
0.18	9.24					
0.55	9.21					
0.55	9.21	10.04	0.13	1.45	0.090	YES
1.37	10.93					
1.37	10.93					
3.19	11.18					
3.19	11.18					

Table 10.18 Weight of options with respect to minimum quantity

Pairwise Comparison Matrix A

	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9
G 1	1.0	1.0	1.0	1/5	1/5	1/7	1/7	1/9	1/9
G 2	1.0	1.0	1.0	1/5	1/5	1/7	1/7	1/9	1/9
G 3	1.0	1.0	1.0	1/5	1/5	1/7	1/7	1/9	1/9
G 4	5.0	5.0	5.0	1.0	1.0	1/5	1/5	1/7	1/7
G 5	5.0	5.0	5.0	1.0	1.0	1/5	1/5	1/7	1/7
G 6	7.0	7.0	7.0	5.0	5.0	1.0	1.0	1/5	1/5
G 7	7.0	7.0	7.0	5.0	5.0	1.0	1.0	1/5	1/5

G 8	9.0	9.0	9.0	7.0	7.0	5.0	5.0	1.0	1.0
G 9	9.0	9.0	9.0	7.0	7.0	5.0	5.0	1.0	1.0

Normalised pairwise comparison and priority vectors for main criteria

Matrix B

	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	Project Priority Vector
G 1	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.04	0.04	0.020
G 2	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.04	0.04	0.020
G 3	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.04	0.04	0.020
G 4	0.11	0.11	0.11	0.04	0.04	0.02	0.02	0.05	0.05	0.059
G 5	0.11	0.11	0.11	0.04	0.04	0.02	0.02	0.05	0.05	0.059
G 6	0.16	0.16	0.16	0.19	0.19	0.08	0.08	0.07	0.07	0.126
G 7	0.16	0.16	0.16	0.19	0.19	0.08	0.08	0.07	0.07	0.126
G 8	0.20	0.20	0.20	0.26	0.26	0.39	0.39	0.33	0.33	0.285
G 9	0.20	0.20	0.20	0.26	0.26	0.39	0.39	0.33	0.33	0.285

Priority Vector for Minimum Quantity		Options	Minimum Quantity	Composite Priorities
		G 1	0.020	0.020
		G 2	0.020	0.020
		G 3	0.020	0.020
		G 4	0.059	0.059
Minimum Quantity	1.000	G 5	0.059	0.059
		G 6	0.126	0.126
		G 7	0.126	0.126
		G 8	0.285	0.285
		G 9	0.285	0.285

Consistency Check

X	X1	λ_{max}	CI	RI	CR	Consistent?
0.18	9.24					
0.18	9.24					
0.18	9.24					
0.55	9.21					
0.55	9.21	10.04	0.13	1.45	0.090	YES
1.37	10.93					
1.37	10.93					
3.19	11.18					
3.19	11.18					

Table 10.19 Weight of options with respect to bank account

Pairwise Comparison Matrix A									
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9
G 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

G 8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Normalised pairwise comparison and priority vectors for main criteria

Matrix B

	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	Project Priority Vector
G 1	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 2	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 3	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 4	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 5	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 6	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 7	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 8	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 9	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11

Priority vector for bank account		Options	Bank account	Composite priorities
Bank account	1.00	G 1	0.11	0.11
		G 2	0.11	0.11
		G 3	0.11	0.11
		G 4	0.11	0.11
		G 5	0.11	0.11
		G 6	0.11	0.11
		G 7	0.11	0.11
		G 8	0.11	0.11
		G 9	0.11	0.11

Consistency check

X	X1	λ_{max}	CI	RI	CR	Consistent?
1.0	9.0					
1.0	9.0					
1.0	9.0					
1.0	9.0					
1.0	9.0	9.0	0.00	1.45	0.000	YES
1.0	9.0					
1.0	9.0					
1.0	9.0					
1.0	9.0					

Table 10.20 Weight of options with respect to available capital

Pairwise Comparison Matrix A									
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9
G 1	1.0	1.0	1/3	1/3	1/5	1/5	1/7	1/7	1/9
G 2	1.0	1.0	1/3	1/3	1/5	1/5	1/7	1/7	1/9
G 3	3.0	3.0	1.0	1.0	1/3	1/3	1/5	1/5	1/7
G 4	3.0	3.0	1.0	1.0	1/3	1/3	1/5	1/5	1/7
G 5	5.0	5.0	3.0	3.0	1.0	1.0	1/3	1/3	1/5
G 6	5.0	5.0	3.0	3.0	1.0	1.0	1/3	1/3	1/5

G 7	7.0	7.0	5.0	5.0	3.0	3.0	1.0	1.0	1/3
G 8	7.0	7.0	5.0	5.0	3.0	3.0	1.0	1.0	1/3
G 9	9.0	9.0	7.0	7.0	5.0	5.0	3.0	3.0	1.0

Normalised pairwise comparison and priority vectors for main criteria

Matrix B

	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	Project Priority Vector
G 1	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.04	0.021
G 2	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.04	0.021
G 3	0.07	0.07	0.04	0.04	0.02	0.02	0.03	0.03	0.06	0.043
G 4	0.07	0.07	0.04	0.04	0.02	0.02	0.03	0.03	0.06	0.043
G 5	0.12	0.12	0.12	0.12	0.07	0.07	0.05	0.05	0.08	0.089
G 6	0.12	0.12	0.12	0.12	0.07	0.07	0.05	0.05	0.08	0.089
G 7	0.17	0.17	0.19	0.19	0.21	0.21	0.16	0.16	0.13	0.178
G 8	0.17	0.17	0.19	0.19	0.21	0.21	0.16	0.16	0.13	0.178
G 9	0.22	0.22	0.27	0.27	0.36	0.36	0.47	0.47	0.39	0.336

Priority Vector for Available Capital		Options	Available Capital	Composite Priorities
		G 1	0.021	0.021
		G 2	0.021	0.021
		G 3	0.043	0.043
		G 4	0.043	0.043
Available Capital	1.0	G 5	0.089	0.089
		G 6	0.089	0.089
		G 7	0.178	0.178
		G 8	0.178	0.178
		G 9	0.336	0.336

Consistency Check

X	X1	λ_{max}	CI	RI	CR	Consistent?
0.20	9.19					
0.20	9.19					
0.39	9.07					
0.39	9.07					
0.84	9.39	9.39	0.05	1.45	0.034	YES
0.84	9.39					
1.73	9.74					
1.73	9.74					
3.29	9.76					

Table 10.21 Weight of options with respect to office space

Pairwise Comparison Matrix A									
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9
G 1	1.0	1/3	1/3	1/5	1/5	1/7	1/7	1/9	1/9
G 2	3.0	1.0	1.0	1/3	1/5	1/5	1/7	1/7	1/7
G 3	3.0	1.0	1.0	1/3	1/5	1/5	1/7	1/7	1/7
G 4	5.0	3.0	3.0	1.0	1.0	1/3	1/3	1/5	1/5
G 5	5.0	3.0	3.0	1.0	1.0	1/3	1/3	1/5	1/5
G 6	7.0	5.0	5.0	3.0	3.0	1.0	1.0	1/3	1/3

G 7	7.0	5.0	5.0	3.0	3.0	1.0	1.0	1/3	1/3
G 8	9.0	7.0	7.0	5.0	5.0	3.0	3.0	1.0	1.0
G 9	9.0	7.0	7.0	5.0	5.0	3.0	3.0	1.0	1.0

Normalised pairwise comparison and priority vectors for main criteria

Matrix B

	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	Project Priority Vector
G 1	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.018
G 2	0.06	0.03	0.03	0.02	0.01	0.02	0.02	0.04	0.04	0.030
G 3	0.06	0.03	0.03	0.02	0.01	0.02	0.02	0.04	0.04	0.030
G 4	0.10	0.09	0.09	0.05	0.05	0.04	0.04	0.06	0.06	0.065
G 5	0.10	0.09	0.09	0.05	0.05	0.04	0.04	0.06	0.06	0.065
G 6	0.14	0.15	0.15	0.16	0.16	0.11	0.11	0.10	0.10	0.131
G 7	0.14	0.15	0.15	0.16	0.16	0.11	0.11	0.10	0.10	0.131
G 8	0.18	0.22	0.22	0.27	0.27	0.33	0.33	0.29	0.29	0.265
G 9	0.18	0.22	0.22	0.27	0.27	0.33	0.33	0.29	0.29	0.265

Priority Vector for Office Space		Options	Office Space	Composite Priorities
Office Space	1.000	G 1	0.018	0.018
		G 2	0.030	0.030
		G 3	0.030	0.030
		G 4	0.065	0.065
		G 5	0.065	0.065
		G 6	0.131	0.131
		G 7	0.131	0.131
		G 8	0.265	0.265
		G 9	0.265	0.265

Consistency Check

X	X1	λ_{max}	CI	RI	CR	Consistent?
0.16	9.13					
0.27	8.89					
0.27	8.89					
0.59	9.14					
0.59	9.14	9.27	0.03	1.45	0.024	YES
1.25	9.52					
1.25	9.52					
2.55	9.61					
2.55	9.61					

Table 10.22 Weight of options with respect to time

Pairwise Comparison matrix A									
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9
G 1	1.0	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/9
G 2	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 3	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 4	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 5	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

G 6	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 7	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 8	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 9	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Normalised pairwise comparison and priority vectors for main criteria

Matrix B

	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	Project Priority Vector
G 1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.014
G 2	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 3	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 4	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 5	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 6	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 7	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 8	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 9	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123

Priority Vector for Time		Options	Time	Composite Priorities
Time	1.000	G 1	0.014	0.014
		G 2	0.123	0.123
		G 3	0.123	0.123
		G 4	0.123	0.123
		G 5	0.123	0.123
		G 6	0.123	0.123
		G 7	0.123	0.123
		G 8	0.123	0.123
		G 9	0.123	0.123

Consistency Check

X	X1	λ_{max}	CI	RI	CR	Consistent?
0.12	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0	9.00	0.00	1.45	0.000	YES
1.11	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0					

Table 10.23 Weight of options with respect to quality

Pairwise Comparison Matrix A									
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9
G 1	1.0	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/9
G 2	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 3	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

G 4	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 5	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 6	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 7	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 8	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 9	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Normalised pairwise comparison and priority vectors for main criteria										
Matrix B										
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	Project Priority Vector
G 1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.014
G 2	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 3	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 4	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 5	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 6	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 7	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 8	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 9	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123

Priority Vector for Quality		Options	Quality	Composite Priorities
Quality	1.000	G 1	0.014	0.014
		G 2	0.123	0.123
		G 3	0.123	0.123
		G 4	0.123	0.123
		G 5	0.123	0.123
		G 6	0.123	0.123
		G 7	0.123	0.123
		G 8	0.123	0.123
		G 9	0.123	0.123

Consistency Check						
X	X1	λ_{max}	CI	RI	CR	Consistent?
0.12	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0	9.00	0.00	1.45	0.000	YES
1.11	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0					

Table 10.24 Weight of options with respect to cost

Pairwise Comparison Matrix A								
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9

G 1	1.0	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/9
G 2	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 3	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 4	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 5	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 6	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 7	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 8	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 9	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Normalised pairwise comparison and priority vectors for main criteria

Matrix B

	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	Project Priority Vector
G 1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.014
G 2	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 3	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 4	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 5	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 6	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 7	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 8	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 9	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123

Priority Vector for Cost		Options	Cost	Composite Priorities
Cost	1.000	G 1	0.014	0.014
		G 2	0.123	0.123
		G 3	0.123	0.123
		G 4	0.123	0.123
		G 5	0.123	0.123
		G 6	0.123	0.123
		G 7	0.123	0.123
		G 8	0.123	0.123
		G 9	0.123	0.123

Consistency Check

X	X1	λ_{max}	CI	RI	CR	Consistent?
0.12	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0	9.00	0.00	1.45	0.000	YES
1.11	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0					

Table 10.25 Weight of options with respect to referrals

Pairwise Comparison Matrix A									
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9
G 1	1.0	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/9
G 2	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 3	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 4	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 5	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 6	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 7	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 8	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 9	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Normalised pairwise comparison and priority vectors for main criteria										
Matrix B										
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	Project Priority Vector
G 1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.014
G 2	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 3	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 4	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 5	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 6	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 7	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 8	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 9	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123

Priority Vector for Referrals		Options	Referrals	Composite Priorities
Referrals	1.000	G 1	0.014	0.014
		G 2	0.123	0.123
		G 3	0.123	0.123
		G 4	0.123	0.123
		G 5	0.123	0.123
		G 6	0.123	0.123
		G 7	0.123	0.123
		G 8	0.123	0.123
		G 9	0.123	0.123

Consistency Check						
X	X1	λ_{max}	CI	RI	CR	Consistent?
0.12	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0	9.00	0.00	1.45	0.000	YES
1.11	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0					

Table 10.26 Weight of options with respect to business management specialist

Pairwise Comparison Matrix A									
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9
G 1	1.0	1.0	1.0	1.0	1.0	1/5	1/5	1/7	1/9
G 2	1.0	1.0	1.0	1.0	1.0	1/5	1/5	1/7	1/9
G 3	1.0	1.0	1.0	1.0	1.0	1/5	1/5	1/7	1/9
G 4	1.0	1.0	1.0	1.0	1.0	1/5	1/5	1/7	1/9
G 5	1.0	1.0	1.0	1.0	1.0	1/5	1/5	1/7	1/9
G 6	5.0	5.0	5.0	5.0	5.0	1.0	1.0	1/3	1/5
G 7	5.0	5.0	5.0	5.0	5.0	1.0	1.0	1/3	1/5
G 8	7.0	7.0	7.0	7.0	7.0	3.0	3.0	1.0	1/3
G 9	9.0	9.0	9.0	9.0	9.0	5.0	5.0	3.0	1.0

Normalised pairwise comparison and priority vectors for main criteria										
Matrix B										
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	Project Priority Vector
G 1	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.03	0.05	0.030
G 2	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.03	0.05	0.030
G 3	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.03	0.05	0.030
G 4	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.03	0.05	0.030
G 5	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.03	0.05	0.030
G 6	0.16	0.16	0.16	0.16	0.16	0.09	0.09	0.06	0.09	0.126
G 7	0.16	0.16	0.16	0.16	0.16	0.09	0.09	0.06	0.09	0.126
G 8	0.23	0.23	0.23	0.23	0.23	0.27	0.27	0.19	0.15	0.223
G 9	0.29	0.29	0.29	0.29	0.29	0.45	0.45	0.56	0.44	0.373

Priority vector for Business Management Specialist		Options	Business Management Specialist	Composite Priorities
Business Management Specialist	1.000	G 1	0.030	0.030
		G 2	0.030	0.030
		G 3	0.030	0.030
		G 4	0.030	0.030
		G 5	0.030	0.030
		G 6	0.126	0.126
		G 7	0.126	0.126
		G 8	0.223	0.223
		G 9	0.223	0.223

Consistency Check						
X	X1	λ_{max}	CI	RI	CR	Consistent?
0.28	9.09					
0.28	9.09					
0.28	9.09					
0.28	9.09					
0.28	9.09	9.26	0.03	1.45	0.022	YES

1.16	9.17					
1.16	9.17					
2.17	9.72					
3.67	9.84					

Table 10.27 Weight of options with respect to OHSAS 18001/ISO 45001 certificate

Pairwise Comparison Matrix A									
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9
G 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Normalised pairwise comparison and priority vectors for main criteria										
Matrix B										
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	Project Priority Vector
G 1	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 2	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 3	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 4	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 5	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 6	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 7	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 8	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
G 9	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11

Priority vector for OHSAS 18001/ISO 45001 Certificate		Options	OHSAS 18001/ISO 45001 Certificate	Composite Priorities
OHSAS 18001/ISO 45001 Certificate	1.000	G 1	0.11	0.11
		G 2	0.11	0.11
		G 3	0.11	0.11
		G 4	0.11	0.11
		G 5	0.11	0.11
		G 6	0.11	0.11
		G 7	0.11	0.11
		G 8	0.11	0.11
		G 9	0.11	0.11

Consistency Check						
X	X1	λ_{max}	CI	RI	CR	Consistent?
1.0	9.0					
1.0	9.0					

1.0	9.0					
1.0	9.0					
1.0	9.0	9.0	0.00	1.45	0.000	YES
1.0	9.0					
1.0	9.0					
1.0	9.0					
1.0	9.0					

Table 10.28 Weight of options with respect to health and safety records

Pairwise Comparison Matrix A									
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9
G 1	1.0	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/9
G 2	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 3	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 4	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 5	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 6	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 7	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 8	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
G 9	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Normalised pairwise comparison and priority vectors for main criteria										
Matrix B										
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	Project Priority Vector
G 1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.014
G 2	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 3	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 4	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 5	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 6	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 7	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 8	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123
G 9	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.123

Priority Vector for Health and Safety Records		Options	Health and Safety Records	Composite Priorities
Health and Safety Records	1.000	G 1	0.014	0.014
		G 2	0.123	0.123
		G 3	0.123	0.123
		G 4	0.123	0.123
		G 5	0.123	0.123
		G 6	0.123	0.123
		G 7	0.123	0.123
		G 8	0.123	0.123
		G 9	0.123	0.123

Consistency Check						
X	X1	λ_{max}	CI	RI	CR	Consistent?
0.12	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0	9.00	0.00	1.45	0.000	YES
1.11	9.0					
1.11	9.0					
1.11	9.0					
1.11	9.0					

Table 10.29 Project priority vectors for main criteria

Priority matrix for technical capacity						
Priority for technical capacity- Matrix C		Options	Academic qualifications	Key staff Experience	Number of key Staff	Project priority vector S
Academic Qualifications	0.633	G1	0.111	0.018	0.018	0.077
		G2	0.111	0.030	0.030	0.081
		G3	0.111	0.030	0.030	0.081
		G4	0.111	0.065	0.065	0.094
Key Staff Experience	0.260	G5	0.111	0.065	0.065	0.094
		G6	0.111	0.131	0.131	0.118
		G7	0.111	0.131	0.131	0.118
		G8	0.111	0.265	0.265	0.167
Number of Key Staff	0.106	G9	0.111	0.265	0.265	0.167
Priority matrix for experience						
Priority for Experience- Matrix C		Options	Projects Completed by Company	Projects Completed by Key Staff	Project Priority Vector S	
Projects Completed by Company	0.125	G1	0.111	0.018	0.018	
		G2	0.014	0.014	0.014	
		G3	0.123	0.123	0.123	
		G4	0.123	0.123	0.123	
		G5	0.123	0.123	0.123	
		G6	0.123	0.123	0.123	
		G7	0.123	0.123	0.123	
		G8	0.123	0.123	0.123	
Projects Completed by Key Staff	0.875	G9	0.123	0.123	0.123	
Priority Matrix for Plant and Equipment						
Priority for Experience- Matrix C		Options	Type of Equipment	Minimum Quantity	Project Priority Vector S	
Type of Equipment	0.833	G1	0.020	0.020	0.020	
		G2	0.020	0.020	0.020	

		G3	0.020	0.020	0.020
		G4	0.059	0.059	0.059
		G5	0.059	0.059	0.059
		G6	0.126	0.126	0.126
		G7	0.126	0.126	0.126
		G8	0.285	0.285	0.285
Minimum Quantity	0.167	G9	0.285	0.285	0.285

Priority matrix for financial status

Priority for Financial Status- Matrix C		Options	Bank Account	Available Capital	Office Space	Project Priority Vector S
Bank Account	0.083	G1	0.111	0.021	0.018	0.028
		G2	0.111	0.021	0.030	0.030
		G3	0.111	0.043	0.030	0.046
		G4	0.111	0.043	0.065	0.053
Available Capital	0.724	G5	0.111	0.089	0.065	0.086
		G6	0.111	0.089	0.131	0.099
		G7	0.111	0.178	0.131	0.163
		G8	0.111	0.178	0.265	0.189
Office Space	0.193	G9	0.111	0.336	0.265	0.304

Priority matrix for past performance

Priority for Past Performance- Matrix C		Options	Time	Quality	Cost	Referrals	Project Priority Vector S
Time	0.122	G1	0.014	0.014	0.014	0.014	0.014
		G2	0.123	0.123	0.123	0.123	0.123
Quality	0.558	G3	0.123	0.123	0.123	0.123	0.123
		G4	0.123	0.123	0.123	0.123	0.123
		G5	0.123	0.123	0.123	0.123	0.123
Cost	0.263	G6	0.123	0.123	0.123	0.123	0.123
		G7	0.123	0.123	0.123	0.123	0.123
		G8	0.123	0.123	0.123	0.123	0.123
Referrals	0.057	G9	0.123	0.123	0.123	0.123	0.123

Priority matrix for management capability

Priority for experience- matrix C		Options	Business management specialist	Project priority vector
Business management specialist	1.000	G1	0	0.020
		G2	0.030	0.030
		G3	0.030	0.030
		G4	0.030	0.030
		G5	0.030	0.030
		G6	0.126	0.126
		G7	0.126	0.126
		G8	0.223	0.223
		G9	0.373	0.373

Priority matrix for occupational health and safety

Priority for experience- matrix c	Options	OHSAS 18001/ISO	OHS records	Project priority vector S

			45001 Certificate		
OHSAS 18001/ISO 45001 Certificate	0.833	G1	0.020	0.014	0.026
		G2	0.111	0.123	0.122
		G3	0.111	0.123	0.122
		G4	0.111	0.123	0.122
		G5	0.111	0.123	0.122
		G6	0.111	0.123	0.122
		G7	0.111	0.123	0.122
		G8	0.111	0.123	0.122
OHS Records	0.167	G9	0.111	0.123	0.122

Table 10.30 Overall weights of options

Priority matrix for past performance										Overall
Main Criteria Priority Vector		Options	Technical	Experience	P&E	Financial status	Past performance	Management capability	OHS	project priority vector V
Technical	0.380	G1	0.077	0.014	0.020	0.028	0.014	0.030	0.026	0.040
Experience	0.199	G2	0.081	0.123	0.020	0.030	0.123	0.030	0.122	0.094
P&E	0.038	G3	0.081	0.123	0.020	0.046	0.123	0.030	0.122	0.096
Financial status	0.071	G4	0.094	0.123	0.059	0.053	0.123	0.030	0.122	0.102
Past performance	0.199	G5	0.094	0.123	0.059	0.086	0.123	0.030	0.122	0.105
Management Capability	0.023	G6	0.118	0.123	0.126	0.099	0.123	0.126	0.122	0.120
OHS	0.090	G7	0.118	0.123	0.126	0.163	0.123	0.126	0.122	0.124
		G8	0.167	0.123	0.285	0.189	0.123	0.223	0.122	0.153
		G9	0.167	0.123	0.285	0.304	0.123	0.373	0.122	0.164

Table 10.31 Pairwise Comparison for Main Criteria (Level 1)

Pairwise Comparison Matrix A							
	Technical Capacity	Experience	P&E	Financial Status	Past Performance	Management Capability	OHS
Technical Capacity	1.0	3.0	7.0	7.0	3.0	9.0	5.0
Experience	1/3	1.0	7.0	3.0	1.0	7.0	5.0
P&E	1/7	1/7	1.0	1/3	1/7	3.0	1/3
Financial Status	1/7	1/3	3.0	1.0	1/3	5.0	1/3
Past Performance	1/3	1.0	7.0	3.0	1.0	7.0	5.0
Management Capability	1/9	1/7	1/3	1/5	1/7	1.0	1/5
OHS	1/5	1/5	3.0	3.0	1/5	5.0	1.0

Normalised pairwise comparison and priority vectors for main criteria								
Matrix B								
	Technical Capacity	Experience	P&E	Financial Status	Past Performance	Management Capability	OHS	Priority Vector (P_m)
Technical Capacity	0.44	0.52	0.25	0.40	0.52	0.24	0.30	0.380
Experience	0.15	0.17	0.25	0.17	0.17	0.19	0.30	0.199
P&E	0.06	0.02	0.04	0.02	0.02	0.08	0.02	0.038
Financial Status	0.06	0.06	0.11	0.06	0.06	0.14	0.02	0.071
Past Performance	0.15	0.17	0.25	0.17	0.17	0.19	0.30	0.199
Management Capability	0.05	0.02	0.01	0.01	0.02	0.03	0.01	0.023
OHS	0.09	0.03	0.11	0.17	0.03	0.14	0.06	0.090

Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
2.99 1.61 0.27 0.52 1.61 0.17 0.69	7.88 8.10 7.11 7.30 8.10 7.29 7.65	7.63	0.11	1.32	0.080	YES

Table 10.32 Pairwise Comparisons of Sub-Criteria for technical capacity criterion (Level 2)

Pairwise Comparison Matrix A						
		Academic Qualifications		Key Staff Experience		No of key staff
Academic qualifications Key Staff Experience No of Key Staff		1.0 1/3 1/5		3.0 1.0 1/3		5.0 3.0 1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Academic Qualifications		Key Staff Experience	No of Key Staff	Priority Vector
Academic qualifications Key Staff Experience No of Key Staff		0.65 0.22 0.13		0.69 0.23 0.08	0.56 0.33 0.11	0.633 0.260 0.106
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
1.95 0.79 0.32	3.07 3.03 3.01	3.04	0.02	0.58	0.033	YES

Table 10.33 Pairwise Comparisons of Sub-Criteria for experience criterion (Level 2)

Pairwise Comparison Matrix A			
		Company projects	Key staff projects
Company projects Key staff projects		1.0 7.0	1/7 1.0
Normalised Pairwise comparison and priority vectors for main criteria			
Matrix B			
	Company projects	Key staff projects	Priority Vector (Ps)
Company projects Key staff projects	0.13 0.88	0.13 0.88	0.125 0.875

Table 10.34 Pairwise Comparisons of Sub-Criteria for plant and equipment criterion (Level 2)

Pairwise Comparison Matrix A			
		Equipment type	Minimum quantity
Equipment type Minimum quantity		1,0 1/5	5.0 1.0
Normalised pairwise comparison and priority vectors for main criteria			
Matrix B			
	Equipment type	Minimum quantity	Priority vector (Ps)
Equipment type Minimum quantity	0.83 0.17	0.83 0,17	0.8333 0.167

Table 10.35 Pairwise Comparisons of Sub-Criteria for financial status criterion (Level 2)

Pairwise Comparison Matrix A						
		Bank account		Available capital		Office space
Bank account Available capital Office space		1.0 7.0 3.0		1/7 1.0 1/5		1/3 5.0 1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Bank account		Available capital	Office space	Priority Vector (Ps)
Bank account Available capital Office space		0.09 0.64 0.27		0.11 0.74 0.15	0.05 0.79 0.16	0.083 0.724 0.193
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
0.25 2.27 0.59	3.01 3.14 3.04	3.07	0.03	0.58	0.057	YES

Table 10.36 Pairwise Comparisons of Sub-Criteria for past performance criterion (Level 2)

Pairwise Comparison Matrix A					
	Time		Quality	Cost	Referrals
Time	1.0		1/5	1/3	3.0
Quality	5.0		1.0	3.0	7.0
Cost	3.0		1/3	1.0	5.0
Referrals	1/3		1/7	1/5	1.0
Normalised Pairwise comparison and priority vectors for main criteria					
Matrix B					
	Time	Quality	Cost	Referrals	Priority Vector (Ps)
Time	0.11	0.12	0.07	0.19	0.122
Quality	0.54	0.60	0.66	0.44	0.558
Cost	0.32	0.20	0.22	0.31	0.263
Referrals	0.04	0.09	0.04	0.06	0.057
Consistency Check					
X	X_1	λ_{max}	CI	RI	CR	Consistent?
0.49 2.36 1.10 0.23	4.04 4.22 4.17 4.04	4.12	0.04	0.90	0.044	YES

Table 10.37 Pairwise Comparisons of Sub-Criteria for management capability criterion

(Level 2)

+Pairwise Comparison Matrix A		
		Business Management Specialist
Business management specialist		1.0
Normalised pairwise comparison and priority vectors for main criteria		
Matrix B		
	Business Management Specialist	Priority Vector
Business Management Specialist	1.000	1.000

Table 10.38 Pairwise Comparisons of Sub-Criteria for occupational health and safety criterion (Level 2)

Pairwise Comparison Matrix A			
		OHSAS 18001/ISO 45001 Certificate	Company Health & Safety Records
OHSAS 18001/ISO 45001 Certificate		1.0	1/7
Company Health & Safety Records		7.0	1.0
Normalised pairwise comparison and priority vectors for main criteria			
Matrix B			
	OHSAS 18001/ISO 45001 Certificate	Company Health and Safety Record	Priority Vector (Ps)
OHSAS 18001/ISO 45001 Certificate	0.13	0.13	0.125
Company Health and Safety Record	0.88	0.88	0.875

Table 10.39 Weight of options with respect to academic qualifications

Pairwise Comparison Matrix A						
		Emerging contractor		Established contractor		Experienced contractor
Emerging contractor		1.0		1.0		1.0
Established contractor		1.0		1.0		1.0
Experienced contractor		1.0		1.0		1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Emerging contractor		Established contractor	Experienced contractor	Priority Vector (Ps)
Emerging contractor		0.33		0.33	0.33	0.333
Established contractor		0.33		0.33	0.33	0.333
Experienced contractor		0.33		0.33	0.33	0.333
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
1.00 1.00 1.00	3.00 3.00 3.00	3.00	0.00	0.58	0.000	YES

Table 10.40 Weight of options with respect to key staff experience

Pairwise Comparison Matrix A						
		Emerging contractor		Established contractor		Experienced contractor
Emerging contractor		1.0		1/5		1/9
Established contractor		5.0		1.0		1/3
Experienced contractor		9.0		3.0		1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Emerging contractor		Established contractor	Experienced contractor	Priority Vector (Ps)
Emerging contractor		0.07		0.05	0.08	0.064
Established contractor		0.33		0.24	0.23	0.267
Experienced contractor		0.60		0.71	0.69	0.669
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
0.19 0.81 2.04	3.01 3.03 3.06	3.03	0.01	0.58	0.025	YES

Table 10.41 Weight of options with respect to number of key staff

Pairwise Comparison Matrix A						
		Emerging contractor		Established contractor		Experienced contractor
Emerging contractor		1.0		1/5		1/9
Established contractor		5.0		1.0		1/3
Experienced contractor		9.0		3.0		1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Emerging contractor		Established contractor	Good performing	Priority Vector (Ps)
Emerging contractor		0.07		0.05	0.08	0.064
Established contractor		0.33		0.24	0.23	0.267
Experienced contractor		0.60		0.71	0.69	0.669
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
0.19 0.81 2.04	3.01 3.03 3.06	3.03	0.01	0.58	0.025	YES

Table 10.42 Weight of options with respect to number of key staff

Pairwise Comparison Matrix A						
		Emerging contractor		Established contractor		Experienced contractor
Emerging contractor		1.0		1/5		1/9
Established contractor		5.0		1.0		1/3
Experienced contractor		9.0		3.0		1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Emerging contractor		Established contractor	Good performing	Priority Vector (Ps)
Emerging contractor		0.07		0.05	0.08	0.064
Established contractor		0.33		0.24	0.23	0.267
Experienced contractor		0.60		0.71	0.69	0.669
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
0.19 0.81 2.04	3.01 3.03 3.06	3.03	0.01	0.58	0.025	YES

Table 10.43 Weight of options with respect to projects completed by company

Pairwise Comparison Matrix A						
		Emerging contractor		Established contractor		Experienced contractor
Emerging contractor		1.0		1/5		1/9
Established contractor		5.0		1.0		1/3
Experienced contractor		9.0		3.0		1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Emerging contractor		Established contractor	Good performing	Priority Vector (Ps)
Emerging contractor		0.07		0.05	0.08	0.064
Established contractor		0.33		0.24	0.23	0.267
Experienced contractor		0.60		0.71	0.69	0.669
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
0.19 0.81 2.04	3.01 3.03 3.06	3.03	0.01	0.58	0.025	YES

Table 10.44 Weight of options with respect to projects completed by key staff

Pairwise Comparison Matrix A						
		Emerging contractor		Established contractor		Experienced contractor
Emerging contractor		1.0		1/5		1/9
Established contractor		5.0		1.0		1/3
Experienced contractor		9.0		3.0		1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Emerging contractor		Established contractor	Good performing	Priority Vector (Ps)
Emerging contractor		0.07		0.05	0.08	0.064
Established contractor		0.33		0.24	0.23	0.267
Experienced contractor		0.60		0.71	0.69	0.669
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
0.19 0.81 2.04	3.01 3.03 3.06	3.03	0.01	0.58	0.025	YES

Table 10.45 Weight of options with respect to type of equipment

Pairwise Comparison Matrix A						
		Emerging contractor		Established contractor		Experienced contractor
Emerging contractor		1.0		1/5		1/9
Established contractor		5.0		1.0		1/3
Experienced contractor		9.0		3.0		1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Emerging contractor		Established contractor	Good performing	Priority Vector (Ps)
Emerging contractor		0.07		0.05	0.08	0.064
Established contractor		0.33		0.24	0.23	0.267
Experienced contractor		0.60		0.71	0.69	0.669
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
0.19 0.81 2.04	3.01 3.03 3.06	3.03	0.01	0.58	0.025	YES

Table 10.46 Weight of options with respect to minimum quantity

Pairwise Comparison Matrix A						
		Emerging contractor		Established contractor		Experienced contractor
Emerging contractor		1.0		1.0		1.0
Established contractor		1.0		1.0		1.0
Experienced contractor		1.0		1.0		1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Emerging contractor		Established contractor	Experienced contractor	Priority Vector (Ps)
Emerging contractor		0.33		0.33	0.33	0.333
Established contractor		0.33		0.33	0.33	0.333
Experienced contractor		0.33		0.33	0.33	0.333
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
1.00 1.00 1.00	3.00 3.00 3.00	3.00	0.00	0.58	0.000	YES

Table 10.47 Weight of options with respect to bank account

Pairwise Comparison Matrix A						
		Emerging contractor		Established contractor		Experienced contractor
Emerging contractor		1.0		1/5		1/9
Established contractor		5.0		1.0		1/3
Experienced contractor		9.0		3.0		1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Emerging contractor		Established contractor	Experienced contractor	Priority Vector (Ps)
Emerging contractor		0.07		0.05	0.08	0.064
Established contractor		0.33		0.24	0.23	0.267
Experienced contractor		0.60		0.71	0.69	0.669
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
0.19 0.81 2.04	3.01 3.03 3.06	3.03	0.01	0.58	0.025	YES

Table 10.48 Weight of options with respect to available capital

Pairwise Comparison Matrix A						
		Emerging contractor		Established contractor		Experienced contractor
Emerging contractor		1.0		1/5		1/9
Established contractor		5.0		1.0		1/3
Experienced contractor		9.0		3.0		1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Emerging contractor		Established contractor	Experienced contractor	Priority Vector (Ps)
Emerging contractor		0.07		0.05	0.08	0.064
Established contractor		0.33		0.24	0.23	0.267
Experienced contractor		0.60		0.71	0.69	0.669
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
0.19 0.81 2.04	3.01 3.03 3.06	3.03	0.01	0.58	0.025	YES

Table 10.49 Weight of options with respect to office space

Pairwise Comparison Matrix A						
		Emerging contractor		Established contractor		Experienced contractor
Emerging contractor		1.0		1.0		1.0
Established contractor		1.0		1.0		1.0
Experienced contractor		1.0		1.0		1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Emerging contractor		Established contractor	Experienced contractor	Priority Vector (Ps)
Emerging contractor		0.33		0.33	0.33	0.333
Established contractor		0.33		0.33	0.33	0.333
Experienced contractor		0.33		0.33	0.33	0.333
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
1.00 1.00 1.00	3.00 3.00 3.00	3.00	0.00	0.58	0.000	YES

Table 10.50 Weight of options with respect to time

Pairwise Comparison Matrix A						
		Emerging contractor		Established contractor		Experienced contractor
Emerging contractor		1.0		1/5		1/9
Established contractor		5.0		1.0		1/3
Experienced contractor		9.0		3.0		1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Emerging contractor		Established contractor	Experienced contractor	Priority Vector (Ps)
Emerging contractor		0.07		0.05	0.08	0.064
Established contractor		0.33		0.24	0.23	0.267
Experienced contractor		0.60		0.71	0.69	0.669
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
0.19 0.81 2.04	3.01 3.03 3.06	3.03	0.01	0.58	0.025	YES

Table 10.51 Weight of options with respect to quality

Pairwise Comparison Matrix A						
		Emerging contractor		Established contractor		Experienced contractor
Emerging contractor		1.0		1/5		1/9
Established contractor		5.0		1.0		1/3
Experienced contractor		9.0		3.0		1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Emerging contractor		Established contractor	Experienced contractor	Priority Vector (Ps)
Emerging contractor		0.07		0.05	0.08	0.064
Established contractor		0.33		0.24	0.23	0.267
Experienced contractor		0.60		0.71	0.69	0.669
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
0.19 0.81 2.04	3.01 3.03 3.06	3.03	0.01	0.58	0.025	YES

Table 10.52 Weight of options with respect to cost

Pairwise Comparison Matrix A						
		Emerging contractor		Established contractor		Experienced contractor
Emerging contractor		1.0		1.0		1.0
Established contractor		1.0		1.0		1.0
Experienced contractor		1.0		1.0		1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Emerging contractor		Established contractor	Experienced contractor	Priority Vector (Ps)
Emerging contractor		0.33		0.33	0.33	0.333
Established contractor		0.33		0.33	0.33	0.333
Experienced contractor		0.33		0.33	0.33	0.333
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
1.00 1.00 1.00	3.00 3.00 3.00	3.00	0.00	0.58	0.000	YES

Table 10.53 Weight of options with respect to referrals

Pairwise Comparison Matrix A						
		Emerging contractor		Established contractor		Experienced contractor
Emerging contractor		1.0		1/5		1/9
Established contractor		5.0		1.0		1/3
Experienced contractor		9.0		3.0		1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Emerging contractor		Established contractor	Experienced contractor	Priority Vector (Ps)
Emerging contractor		0.07		0.05	0.08	0.064
Established contractor		0.33		0.24	0.23	0.267
Experienced contractor		0.60		0.71	0.69	0.669
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
0.19 0.81 2.04	3.01 3.03 3.06	3.03	0.01	0.58	0.025	YES

Table 10.54 Weight of options with respect to OHSAS Certificate

Pairwise Comparison Matrix A			
	Emerging contractor	Established contractor	Experienced contractor
Emerging contractor	1.0	1/5	1/9
Established contractor	5.0	1.0	1/3

Experienced contractor		9.0		3.0		1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Emerging contractor		Established contractor	Experienced contractor	Priority Vector (Ps)
Emerging contractor Established contractor Experienced contractor		0.33 0.33 0.33		0.33 0.33 0.33	0.33 0.33 0.33	0.333 0.333 0.333
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
1.00 1.00 1.00	3.00 3.00 3.00	3.00	0.00	0.58	0.000	YES

Table 10.55 Weight of options with respect to health and safety record

Pairwise Comparison Matrix A						
		Emerging contractor		Established contractor		Experienced contractor
Emerging contractor Established contractor Experienced contractor		1.0 1.0 1.0		1.0 1.0 1.0		1.0 1.0 1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Emerging contractor		Established contractor	Experienced contractor	Priority Vector (Ps)
Emerging contractor Established contractor Experienced contractor		0.07 0.33 0.60		0.05 0.24 0.71	0.08 0.23 0.69	0.064 0.267 0.669
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
0.19 0.81 2.04	3.01 3.03 3.06	3.03	0.01	0.58	0.025	YES

Table 10.56 Weight of options with respect to business management specialist

Pairwise Comparison Matrix A						
		Emerging contractor		Established contractor		Experienced contractor
Emerging contractor Established contractor Experienced contractor		1.0 5.0 9.0		1/5 1.0 3.0		1/9 1/3 1.0
Normalised Pairwise comparison and priority vectors for main criteria						
Matrix B						
		Emerging contractor		Established contractor	Experienced contractor	Priority Vector (Ps)
Emerging contractor Established contractor		0.07 0.33		0.05 0.24	0.08 0.23	0.064 0.267

Experienced contractor		0.60		0.71	0.69	0.669
Consistency Check						
X	X_1	λ_{max}	CI	RI	CR	Consistent?
0.19 0.81 2.04	3.01 3.03 3.06	3.03	0.01	0.58	0.025	YES

Table 10.57 Project priority vectors for main criteria

Priority Matrix for Technical Capacity						
Priority for technical capacity- Matrix C		Options	Academic qualifications	Key Staff Experience	Number of Key Staff	Project Priority Vector S
Academic Qualifications	0.777	1	0.333	0.064	0.064	0.273
Key Staff Experience	0.155	2	0.333	0.267	0.267	0.318
Number of Key Staff	0.069	3	0.333	0.669	0.669	0.408
Priority Matrix for Experience						
Priority for Experience- Matrix C		Options	Projects Completed by Company	Projects Completed by Key Staff		Project Priority Vector S
Projects Completed by Company	0.125	1	0.064	0.064		0.064
Projects Completed by Key Staff	0.875	2	0.267	0.267		0.267
		3	0.669	0.669		0.669
Priority Matrix for Plant and Equipment						
Priority for Experience- Matrix C		Options	Type of Equipment	Minimum Quantity		Project Priority Vector S
Type of Equipment	0.833	1	0.064	0.064		0.064
		2	0.267	0.267		0.267
Minimum Quantity	0.167	3	0.669	0.669		0.669
Priority Matrix for Financial Status						
Priority for Financial Status- Matrix C		Options	Bank Account	Available Capital	Office Space	Project Priority Vector S
Bank Account	0.083	1	0.333	0.064	0.064	0.086
Available Capital	0.724	2	0.333	0.267	0.267	0.272
Office Space	0.193	3	0.333	0.669	0.669	0.641
Priority Matrix for Past Performance							
Priority for Past Performance- Matrix C		Options	Time	Quality	Cost	Referrals	Project Priority Vector S
Time	0.122	1	0.333	0.064	0.064	0.333	0.112
Quality	0.558	2	0.333	0.267	0.267	0.333	0.279
Cost	0.263	3	0.333	0.669	0.669	0.333	0.609
Referrals	0.057						
Priority Matrix for Management Capability							
Priority for Experience- Matrix C		Options	Business Management Specialist			Project Priority Vector	

Business Management Specialist	1.000	1 2 3	0.064 0.267 0.669	0.064 0.267 0.669

Priority Matrix for Occupational Health and Safety					
Priority for Experience- Matrix C		Options	OHSAS 18001/ISO 45001 Certificate	OHS Records	Project Priority Vector S
OHSAS 18001/ISO 45001 Certificate OHS Records	0.125 0.875	1 2 3	0.333 0.333 0.333	0.064 0.267 0.669	0.098 0.275 0.627

Table 10.58 Overall weights of options

Priority Matrix for Past Performance										Overall Project Priority Vector V
Main Criteria Priority Vector		Options	Technical	Experience	P&E	Financial Status	Past Performance	Management Capability	OHS	
Technical	0.380	1	0.273	0.064	0.064	0.086	0.112	0.064	0.098	0.158
Experience	0.199	2	0.318	0.267	0.267	0.272	0.279	0.267	0.275	0.290
P&E	0.038	3	0.408	0.669	0.669	0.641	0.609	0.669	0.627	0.526
Financial Status	0.071									
Past Performance	0.199									
Management Capability	0.023									
OHS	0.090									