THE EFFECT OF A LACK OF KNOWLEDGE AND EXPERIENCE ON THE PART OF THE PROJECT MANAGER AFFECTING THE CRITICAL SUCCESS FACTORS WITHIN THE PROJECT LIFE CYCLE PHASES

Hercules Visser

Student No: 0609687A

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DECLARATION

I hereby declare that this dissertation is my own unaided work apart from the advice of my supervisor and that it has not been submitted before for any degree or examination in any other university. It is submitted in fulfilment of the requirements for the degree of **Master of Science in Engineering** to the University of the Witwatersrand, Johannesburg.

Hercules Visser

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ABSTRACT

After being a project manager for many years and overseeing projects in South Africa and beyond the researcher began to ask questions about the reasons for so many project failures.

The researcher was motivated to investigate the effect of project managers' lack of knowledge and experience on the critical success factors within the project life cycle phases. The main objective of this study was to identify the most critical success factors in a project and discover why the implementation of these factors ensures the successful delivery of a project. This research was intended for the engineers who wish to enter the office of the project manager.

A comprehensive literature review on project management principles laid the foundation for the research methodology.

The researcher formulated a pilot questionnaire which was reviewed by a panel of experienced engineers. The questionnaire was based on the five-point Likert scale instrument, designed to address both quantitative and qualitative applications with minor changes (ranking versus rating method). The software used for analysing the quantitative questionnaires was the IBM SPSS Statistics 24 and the software for data capturing was the MySQL. Using quantitative as well as qualitative research and integrating the two research methods exposed the shortcomings in project management practice.

The research presented in this study highlighted the concerns raised by the researcher by addressing the research objective and the research questions. This research was aimed to prove that project failures are caused by the failure to apply sound project and construction management principles regarding the critical success factors within the project life cycle phases and lack of site experience. The success factors identified through this research were in many cases the root of the problems that occurred in practice. The research delivered a successful result with conclusions and recommendations.

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I would like to acknowledge and thank the people who participated in this research in order to equip the engineer/project manager in the execution of his/her duties as project manager. I could not have achieved this without a strong support group.

I would like to thank my Creator for the ability and guidance He gave me during this study. Without His support, this work would not have been possible.

“What shall I render unto the Lord
For all His benefits toward me?”
Ps. 116:12

I would like to thank my wife Ria, family and friends for their encouragement and support and most importantly Prof Robert McCutcheon for his patience and wise guidance.

‘Coming together is the beginning,
Keeping together is progress,
Working together is success’
Henry Ford

PREFACE

As happens all over the world, the South African construction industry experience problems that can be traced back to a lack of project management knowledge and experience within the project life cycle phases which then affect the critical success factors of project management principles strategies. Construction projects are often in the news because of accusations of malpractice, pertaining to poor quality work and/or high risk practices.

After more than thirty years of project management experience overseeing many projects of billions of Rands in South Africa and beyond its borders and observing many failed projects, this researcher began to ask questions about the reasons for those project failures. Does the Bachelor's degree in engineering not equip the engineer with the knowledge necessary for his profession? Where and when is he supposed to acquire knowledge of project management? What are the shortcomings and latent factors that the project manager fails to identify and that therefore lead to project failure?

The basis for this research stemmed from the researcher's passion for post-graduate project management knowledge and in-depth site experience and to find solutions to avoid project failures. It was important for the researcher to investigate the possible shortcomings and latent project factors that the project manager experiences but fails to identify, as this can easily lead to project failure. The researcher was motivated to investigate the reasons and critical success factors influencing the outcome of a project, to find answers to his questions and to possibly find solutions for some of the problems occurring in engineering and construction projects.

This research was intended for the engineers who wish to enter the office of the project manager and to be able to deliver a project successfully. The purpose of this research is to address the project related concerns as defined within the research topic affecting the critical success factors of the project life cycle phases within the South African engineering and construction environment.

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SUCCESS FACTORS (SF)

LIST OF DIAGRAMS

LIST OF ABBREVIATIONS

ADD	Approve of design drawings
BoQ	Bill of quantities
CIDB	South African construction industry publication
CoC	Contract of conditions
CP	Contractual payments
CPD	Continuing Professional Development
CRD	Contract related documents
CSF	Critical success factors
DoL	Department of Labour
DT	Design team
ECSA	Engineering Council of South Africa
EO	Economic overview
ES	Environmental studies
FDI	Foreign Direct Investment
FPP	Financial progress payments
FS	Feasibility studies
GDP	Gross Domestic Product growth
HS	High risk
IDC	International Development Corporation
ISO	International Organisation for Standardisation
N	Number
PDLCM	Project development life cycle methodology
PLC	Project life cycles
PLCP	Project life cycle phases

PM	Project management / project manager
PMBOK	Project management institute's Guide
PMC	Project monitoring and controlling
PMI	Project Management Institute
PMM	Project management methodology
PP	Project proposal
PQC	Project quality control
PRM	Project risk management
PRTID	Project related technical information documents
PS	Project specifications / Procurement strategy
PTP	Procurement and tender procedures
PwC	Price Waterhouse Cooper
QC	Quality control
QM	Quality management
QS	Quantity surveyor
R & D	Research and Development
RMP	Risk management plan
SF	Success factors
SACPCMP	South African Council for project and construction management professions
SoP	Schedule of prices
SoW	Scope of work
VO	Variation order
WBS	Work breakdown structures

CHAPTER 1 INTRODUCTION TO THE RESEARCH

1.1 INTRODUCTION

Construction is often seen as a relay race. Designers produce drawings, which are presented to contractors, which are then used as a design for the construction of a project. The completed project is then submitted to the client. Project and construction management is far more intricate than this. Apart from the designer, contractor and owner there are also the subcontractors and project manager to consider in order to see the full picture. It is therefore important to fully investigate the extent of the knowledge and experience of the engineer/project manager before employing him/her to oversee the project. Thornberry (1987) states the lack of experience and understanding can cause the engineer/project manager to fail in his duty as manager. One of the most difficult areas for engineers to improve on is project management skills when he moves into a project management position.

Each stage is managed by different role players to ensure the delivery of a successful end-result. These are the points of contact through which different worlds connect. In most cases in the project and construction domain, firms have no idea what the functions of the different project partners are. To the contractor, a design firm is a machine with mysterious and largely irrelevant persons that produce drawings. This view of the construction industry is of course very superficial, but it illustrates a core problem that is refined in the project life cycle domain.

The South African construction industry experience problems that can be traced back to a lack of project management knowledge and experience on the part of the project manager in the project life cycle phases which then affect the critical success factors of project management principles strategies.

Projects are often in the news when poor quality materials or work and/or other high risk construction practices lead to accusations of malpractice.

The reason is that there are always various uncontrolled latent conditions and unspecified activities within engineering project. Other possible reasons for project and construction failure could be due to the advancement in technology and lack of frequent site supervision.

The project manager of today wants to control the project from his/her office and mostly relies on the word of mouth via the contractor and his/her staff. First-hand knowledge by being on site on a permanent basis will always be the best controlling method used by the project and construction manager.

As stated by Lientz and Rea (2003) the engineer who is also the project manager must be aware that no project can be managed from a remote office and that he or she should be at the project site. According to them the project manager must be frequently or even permanently on site to discuss any problem as it arises with the contractor and related staff. The project manager must be fully committed to the project until the project is completed and signed off by the client.

The purpose of this research is to investigate these principles in order to improve the quality of projects and to make recommendations to improve project and construction management skills in South Africa. The purpose is also to reveal the reasons as to how, why and at what stage of a project life cycle the effect of a lack of knowledge and experience on the part of the project manager could affect the critical success factors of the project. The researcher also wants to prove the importance of teamwork between all role players in the successful management, completion and delivery of a project.

Based on personal experience, the researcher believes that the engineer, after completion of his/her degree and training, is not fully equipped to undertake a project managerial position. He/she will require post-graduate education in project management as well as in-depth site experience under the supervision of a well experienced project manager for a minimum period of two years.

1.2 BACKGROUND TO THE STUDY

The first section of the research provides the purpose of the study. An overview of this study is given focusing on related problems in the industry.

Research in this field has indicated that the number of development projects constructed each year continues to grow, as do the number of project failures because of lack of knowledge and experience within the project life cycle phases. These failures affect the critical success factors within the project management life cycle phases as can be shown by reviewing selected case studies. Relevant literature and case studies also indicate that construction projects are frequently completed with large cost overruns, extended schedules and major quality concerns.

The researcher raises the question whether project management participants (the project team) are adequately equipped to form partnerships with one another during the project life cycle phases to ensure that successful project execution has taken place. Van Wyk (2003 and 2004).

According to Kerzner (2009) project success is to meet the customer's expectations regardless of whether or not the customer is internal or external. A project can also be deemed successful when constraints of time and cost are overcome and the project is completed. Lewis (2008) argues that a project fails when it does not meet time, cost and performance or scope objectives.

De Wit (1988) suggests in his research that project success means taking all stakeholders' objectives during the project life cycle into consideration as well as during all levels of the project. De Wit (1988) further states that as a project always has various objectives, it is difficult to measure project success objectively. Unforeseen circumstances and latent defects can also contribute to the failure of a project.

Tan and Andrew (2006) are of the opinion that, in order to achieve project success, effort should come from “the entire project team from various disciplines with appropriate project management processes”. Tan and Andrew (2006) further suggest project managers should have leadership as well as people skills. People skills on all levels are needed to ensure positive and successful project management and are some of the most important components of critical success factors for project success.

Munns and Bjeirmi (1996) on the other hand, state that a project must achieve a defined objective. They claim that every project has a definite start and finish with scheduled working dates, i.e. a series of work tasks and activities that need resources to be utilised and must be executed within the contract specification. Project and construction management is viewed as using companies’ organisational structures and resources and applying project management tools, techniques and standards to control and obtain the project objectives. According to Munns and Bjeirmi (1996) it shows that there is an overlap between the project and project management and indicates that project management is planned to achieve short-term and specific objectives. These objectives differ from the long-term and broader goals of the specific project as indicated by Munns and Bjeirmi (1996).

Industry practices and international standards have been used to develop project management methods for design and construction of projects that have a reasonable success rate.

Ilincuta and Jergeas (2003) argue that these kinds of methods have been effectively used in large institutes and organisations. However, during the design and construction stages of projects there is often a lack of trustworthy methods used by project teams in large organisations. Rowe (2007) argues that as project teams find themselves pressured to reach the client’s demands, it is common practice for smaller organisations to neglect or waive formal project management principles. Rowe claims that this practice is often due to the fact that small projects are viewed as simple to manage and therefore given low prioritisation by the organisation.

According to the Project Management Institute's (*PMBOK*) *Guide* (*a Guide to the Project Management Body of Knowledge: 2008)* current project management standards based on best-practices can be applied to all projects, large and small.
The above statements form the basis on which the research literature will be reviewed below. The design and construction of projects within the various phases of its life cycle processes complement the project scope of work.

According to Pinto and Mantel (1987) and the *PMBOK Guide* (2013) the project development life cycle indicated four or five phases:

(1) Conception
(2) Planning
(3) Execution
(4) Closeout

This study will focus on these four phases.

Despite the fact that project and construction management has received a lot of research attention over the last decade, there are still latent defects that influence the success factors in the project life cycle domain. This study will reveal these by means of a research survey questionnaire and selected case studies.

This research will investigate the current state of project management practice in South Africa and how the selected research methods affect the construction environment.

1.3 RESEARCH OBJECTIVES

Project management in the construction environment involves various participants or role players to ensure a successful project.

Kerzner (1992) states that project management is the process that deals with elements of the unknown and uses the personal commitment of project team members to ensure the project is successfully terminated when agreed upon objectives have been met within time, cost and performance parameters.

The main objective of this study is to identify success factors related to the project and construction management environment and grouping these success factors with the various project life cycle phases as discussed by Pinto and Slevin (1989).

The ultimate goal is to improve the effectiveness of project management during the execution of the project life cycle processes regarding the following critical success factors:

1 Describing current project management practices.
2 Identifying primary and secondary success factors affecting the project life cycle domain.
3 Bringing together theory and practical case study analyses.
4 Assessing and reviewing current project and construction management practice which affects the project life cycle from "project conception, planning and execution to close-out".

1.4 RESEARCH QUESTIONS

This study requires identifying and assessing the quality of project management practices in South Africa.

The following research questions will be addressed:

The primary research question is:

1 What are the main success factors in project management in the design and construction industry?

The secondary research questions are as follows:

2 How do the critical success factors affect the project life cycle?

3 How can the effect of a lack of knowledge and experience on the part of the project manager within the project life cycle phases influence the critical success factors of project management?

4 Why are these critical success factors important to be implemented?

1.5 JUSTIFICATION FOR THE RESEARCH PROBLEM STATEMENT

This study will identify and assess the quality of project management practices in the project life cycle domain affecting the critical success factors of projects in South Africa. The researcher also intends to prove that an engineer with a bachelor's degree in engineering needs further education in project and construction management as well as some hands-on experience on site in order to successfully manage, complete and deliver a construction project. The researcher also wants to prove the importance of teamwork between all role players in the successful delivery of a project.

Although most of the construction projects in South Africa are completed, many suffer from cost overruns, time delays and other high-risk factors. Sometimes new problems develop and persist despite efforts to implement success factors.

Mbande (2010); Construction Industry Development Board (CIDB) (2004) and Van Wyk (2004 and 2003) highlight the differences between available skills and required skills in project and construction management. It is a concern and needs urgent attention to ensure improved quality of workmanship that will also enhance the safe environment of the project. Van Wyk (2004 and 2003) claims that the high rate of project failure reflects instability, high levels of non-completion, poor management skills and low productivity.

The *SA Construction Industry Journal* (2013) for instance, regards safety as a serious problem. It is noted in the journal that the building and construction sector are identified as one of high-risk sectors. In the building and construction sector in the period 2007 - 2010 there were 171 fatalities and 755 injuries reported. In fact, various stakeholders such as the Department of Labour (DoL) and several trade unions signed a Construction and Health Safety Accord in (2013).

A large body of research identifies major causes of project concerns disputing and identifying a range of success factors. This research will review the following research statement by Pinto and Slevin (1989): “They seem to tabulate individual factors rather than grouping them according to some criteria to help analyse the interaction between them and the possible consequences”. This statement will be verified as it relates to project and construction management within the South African construction industry by means of a quantitative survey and a qualitative case study analysis.

By applying and verifying Pinto and Slevin’s statement (1989, pages 31-35) this research hopes to reveal the concerns of the current topic, which is “The effect of a lack of knowledge and experience on the part of the project manager affecting the critical success factors within the project life cycle phases”.

Furthermore, the success of a project plays a key role in achieving organisational growth and development. Most project managers believe that exceptional management is important if the project objectives and success are to be accomplished.

The study of Müller and Turner (2007) was inconclusive in respect to project success in relation to meeting project life cycle stages. This implies that research may be necessary to determine the correlation between project successes and project life cycles. Their research further shows that project management methodology plays a key role in ensuring successful execution. The correct emphasis must be placed on the project team, which will ensure proper decision making at various stages of project life cycle, which in its turn, will result in the project being completed within budget, time and quality.

1.6 RESEARCH METHODOLOGY

While bodies of research exist that investigate problematic project failures and its causes, this research will use research literature, survey research and case studies to address the research topic and so improve project and construction management performance. For example, *PMBOK Guide* (2013) as well as the argument of Pinto and Slevin (1989) regarding the ranking versus rating method will be included in the research.

The study adopts an exploratory, empirical and theoretical approach, utilising a quantitative survey research and a qualitative case study analysis method to define and evaluate the related data of project management life cycle methodologies.

The research methodology will consist of two sections:

Section 1 Literature research to determine the research focus on the four phases of the project life cycle as reviewed in Section B and C in chapter two.

Section 2 This section consists of three phases namely:

- **Phase 1.** A quantitative survey research to assess the engineer's level of knowledge and understanding of the project life cycle principles and applications as well as the importance of frequent site visits.

- **Phase 2**. A qualitative case study analyses to analyse the effect of a lack of knowledge and experience on part of the project manager affecting the critical success factors during project execution.

- **Phase 3.** Primarily and secondary research factors will be selected for application of content analysis to investigate the reliability of the research findings.

1.7 LIMITATIONS AND RESTRICTIONS OF THE STUDY

In terms of geographical coverage, this study was conducted in South Africa and therefore will only be available to members of the South African engineering profession who participated in the survey. The research is limited to the margins as defined in the research objective. Because of the formulation of the problem and the scope of the research, some differentiation is called for to ensure a concise and in-depth analysis of the research areas as proposed above. The area of project management has attracted much attention from many different perspectives, especially in the development, construction and engineering fields. Therefore, the theoretical boundaries of this subject are very broad.

The research will cover the area of project and construction management principles affecting the project life cycles phases and its critical success factors affecting the construction industry in South Africa.

1.8 ETHICAL CONSIDERATIONS

Survey participants were given information regarding the background to and purpose of the research and were assured that their identity and the identity of the company would not be revealed and that the information they provided was exclusively and solely for the use of academic purposes. They had to confirm that they were participating in the research voluntarily.

1.9 OUTLINE OF THE RESEARCH

The research format follows the logical steps of establishing the research question, developing the methodology, gathering and analysing data, and drawing conclusions.

The research is structured into the following seven chapters:

Chapter 1 This chapter will cover the introduction and background of the research by highlighting the research problems, research purpose, research objectives and a justification of the research. It will address the proposed research methodology, limitations of the study, ethical considerations, and draw some conclusions.

Chapter 2 This chapter consists of a comprehensive review on project management principles that are related to the project environment as indicated by the *PMBOK Guide* (2013). The literature research will cover the following three sections: (a) project literature, (b) project participants and (c) project management principles covering the entire project environment.

Chapter 3 The research methodology will be based on an exploratory, empirical and theoretical research analysis. Firstly the researcher will validate the literature in chapter 2 and secondly the researcher will define the research topic by execution of the life cycle phases as proposed by the *PMBOK Guide* (2013) and Pinto and Slevin's theory (1989). Pinto and Slevin (1989) state "*Although several lists of factors are generated, they seem to tabulate individual factors rather than grouping them according to some criteria, to help analyse the interaction between them and the possible consequences".*

This chapter will also seek to identify the causes of defects and lack of knowledge and experience in the project life cycle domain by ranking the essential primary and secondary success factors used to improve project management performance.

The research methodology will be discussed in Chapters 3 to 6.

Chapter 4 A quantitative survey using the ranking versus rating method on a five point Likert scale will be performed to identify the primary and secondary success factors.

Chapter 5 This chapter comprises qualitative research using four case studies. Data collection procedures and analysis are described to assess the critical success factors and failures thereof.

Chapter 6 The reviewed data collection, techniques and data analysis will be validated through application of content analysis. This chapter presents the data collected and proposes an interpretation of the research information.

Chapter 7 Conclusions and recommendations.

1.10 SUMMARY

This introductory chapter provided a background to the study; a statement of the research problem; objective and research questions of the study; justified the necessity for the investigation; and layout of the chapters to follow.

CHAPTER 2 LITERATURE REVIEW LAYOUT

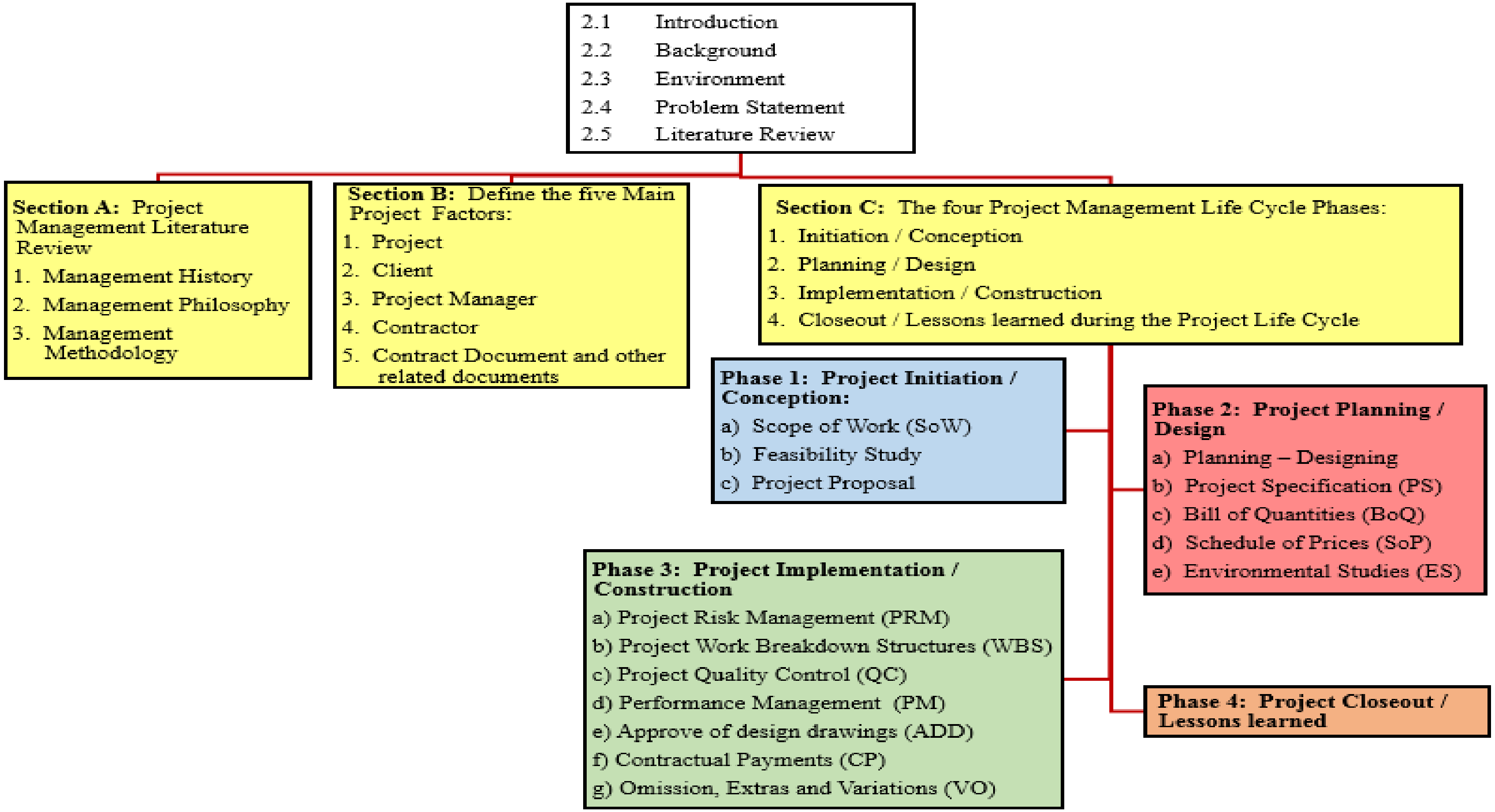


Diagram 2.1: Literature review layout

2.1 INTRODUCTION

The first chapter introduced the research problem that poses the question whether the project management methodology that is widely used, is adequate to ensure successful project management implementation throughout a project life cycle. This chapter will deal with the academic literature related to the research topic and places it in the context of the research subject and research question. There has been considerable debate in recent years about construction education with reference to the delivery of a successful project. According to Haupt (2009a) there is a disconnection between the academically qualified engineer and one with experience in construction management.

The aim of this chapter is to provide a literature background and principles of project and construction management and project life cycle phases. This will be done to formulate a basis whereby the research methodology can explain and implement the research question through the application of quantitative and qualitative research procedures.

In addition to the above this chapter will also formulate the roadmap (chapter layout) to guide the project manager/reader through the proposed project and construction management processes to ensure a successful project completion and delivery. This roadmap (Diagram 2.1, pp. 29) is a clear indication for any engineer who intends to become a project manager of what is expected from him regarding his experience and knowledge in order to execute his duties. Bennett (1996) confirms that successful project managers tend to grow into their jobs over an extended period. Project and construction management is a complex activity in which uncertainty, intangibles and risk abound.

The literature review will cover the following sections:

Section A: History, philosophy and methodology of project management.

Section B: The project, client, project manager, contractor and contract document.

Section C: The four phases of the project life cycle: initiation, planning, implementation and closeout.

2.2 BACKGROUND

Project management methods have developed out of industry practices and international standards to ensure an advanced and higher rate of success in the construction and design industry.

IIincuta and Jergeas (2003) confirm that these methods are used effectively in large organisations. However, when projects are implemented in the construction environment, there is seldom an established method of project management or skilled project mentors.

Ahadzie, Proverbs and Olomolaiye (2008) state during the past decades, organisations have increasingly begun to adapt the project approach for construction. Examples include planning and categorising a marketing drive for a new development or product, upgrading the detailed planning of the project and research and development (R&D) work. The rapid growth in the use of project management techniques and principles is mainly due to the powerful management tools available to the project manager.

2.3 THE PROJECT ENVIRONMENT

According to Ahadzie *et al*. (2008) the construction industry is one of the most used examples of project-based industries. They characterise it as complex because of cost, time and risk challenges. Because construction projects are currently very dynamic and challenging, they draw capital, new technologies and innovation, and also represent the largest sectors of the industry in most developing economies of the world.

Managing a project successfully is a complex process; that may be the reason why project management has generated significant amounts of literature. Project success factors were first introduced by Rubin and Seeling (1967); Belassi and

Tukel (1996) as well as Nguyen, Ogunlana and Lan (2004). They agree that the success factors have since been used frequently in project and construction management literature.

Chan, Scott and Chan (2004) indicate that studies on project success factors are valued as an important way to improve project effectiveness although there are certainly various perceptions of project success. When defining project success, researchers have considered different project boundaries from the perspectives of different stakeholders. Rockart (1982) calls critical success factors a way to prioritise project tasks as the project plan is being executed. Applying them will ensure that all activities are completed to a high standard of quality and that project goals are achieved.

Bryde and Robinson (2005) as well as Toor and Ogunlana (2009) claim that the client is the main person in construction projects. This attracted a lot of attention regarding project success, but resulted in little research being done from the contractor’s perspective. The above-mentioned authors further state that the relationship between the client and the contractor is the most important requirement for successful projects.

Because of the diversity of opinions in this matter, this research will look at all the role players’ views on success.

2.4 PROBLEM STATEMENT

This study will identify the effect of a lack of knowledge and experience in the project life cycle domain affecting the critical success factors of project management in the construction industry of South Africa.

According to the *PMBOK Guide* (2008) projects, provisional and short-term activities are undertaken to meet exceptional goals and objectives within a defined scope, budget and time zone. These typically occur throughout the life cycle of various phases within a project. The project life cycle is a confined sequence of activities to be executed so that the project's goals can be reached and is managed by various participants with different roles or responsibilities.

According to Pinto and Slevin (1989) there can be uncertainty when the success or failure of a project is determined by the opinion of the stakeholders as each one will have a different opinion.

The authors give two main reasons for this uncertainty:

- Firstly, "it is not clear how to measure project success because the parties who are involved in the projects perceived project success or failure differently as they evaluate project success differently" and according to them will value the outcome differently.
- Secondly, Pinto and Slevin (1989) are of the opinion that although there are several lists of factors generated, "they seem to tabulate individual factors rather than grouping (ranking) them according to some criteria, to help analyse the interaction between them and the possible consequences". The authors conclude by saying that it is usually a combination of many factors at different stages of a project life cycle that will result in project success or failure.

This chapter will assess Pinto and Slevin's (1989) statement by discussing it in the context of the literature about project and construction management. It will be done in <u>three</u> Sections:

Section A: Project management literature review: Three stages.
Section B: Definition of five main factors in the project life cycle.
Section C: Review of the four project management life cycle phases.

LAYOUT OF ABOVE THREE SECTIONS:

2.5 SECTION A: Project management literature review
2.5.1: Literature review: Project management <u>history.</u>
2.5.2: Literature review: Project management <u>philosophy.</u>

2.5.3: Literature review: Project management methodology.

2.6 SECTION B: Definition of the five main factors in the project life cycle

2.6.1: The project

2.6.2: The client

2.6.3: The project manager

2.6.4: The contractor

2.6.5: The contract document and other related documents

2.7 SECTION C: The four project management life cycle phases

2.7.1: Phase 1. Project initiation/conception

2.7.2: Phase 2. Project planning/design

2.7.3: Phase 3. Project implementation/construction

2.7.4: Phase 4. Project closeout/lessons learned during the project life cycle.

2.5 SECTION A: Project management literature review

2.5.1 LITERATURE REVIEW: Project management history

2.5.1.1 INTRODUCTION

During the previous four decades a number of studies investigated project success factors, in other words, those factors which led to the outcome of a successful completion of the project, and in particular those that affected project success more than others according to Baker, Murphy and Fisher (1983) and Pinto and Slevin (1989).

Some of the first studies to present lists of critical success factors were undertaken by Ashley, Lurie, and Jaselskis (1987). These authors identified the important sequence of factors that can influence the success rate of complete construction projects. Mengesha (2004) indicates that research into critical success factors has been undertaken since 1967 and mentions that the development of information on critical success factors was based on empirical and theoretical studies.

Ruben and Seeling, (1967); Cleland and King (1983); Pinto and Slevin (1987); Tukel and Rom (1995); and Walid and Oya (1996) have the same opinion.

Several authors, Slevin and Pinto (1986); Morris and Hough (1987); Baker *et al*. (1983) argue that success in a construction project can be evaluated only when the evaluation dimensions are well-defined. Furthermore, in any project the evaluation dimensions always correspond to the traditional constraints of time, cost, and quality parameters.

Ashley *et al.* (1987) define project success as an outcome "better than expected or normally observed in terms of quality, time, cost, safety and participant satisfaction".

2.5.1.2 THE PROJECT DELIVERABLES

Archibald (1976) argues that a project has a definable goal or purpose, as well as well-defined end-times, deliverables or results, usually specified in terms of cost, schedule and performance requirements.

Any project or development needs capital. Bennett (1995) classifies items such as buildings, factories, offices, equipment, industrial development and infrastructural development under the same topic.

Archibald (1976) concludes that the "producer" includes technical personnel to produce designs and specifications to satisfy the client's needs during the typical pre-project negotiation phase. The total project cost and capital will remain a risk factor, however depending on market investment and the Gross Domestic Product (GDP) (2013) growth (*IDC - SA Economic Overview report*, 2013)

2.5.1.3 THE CONSTRUCTION INDUSTRIES

The construction industry can be characterised as complex, cost and time consuming as well as uncertain and risky. However, construction projects are also dynamic and challenging, which attracts capital, new technologies and brilliant people with knowledge and experience. Housing and development projects in particular represent one of the largest sectors of the construction industry in most of the developing economies of the world (Ahadzie *et al.* (2008).

2.5.1.4 CAPITAL NEEDED

The South African economy is known as a highly attractive general business prospect. In the *IDC - SA Economic Overview report* (2013) it forecasts an economic growth of 2.7% to 3.2% year on year.

According to the Foreign Direct Investment (FDI) (2012) report documented in the *IDC - SA Economic Overview report* (2013) and South African Reserve Bank (SARB) there was a substantial economic turnaround resulting in an estimated 10.3% growth for 2012 as a whole. They reported that "South Africa thus outperformed the rest of the African continent, for which estimates indicated a 4.8% increase in FDI". According to Statistics South Africa (2013) published in the *Price Waterhouse Cooper* (2013) report, there are more than 1.18 million people employed in the construction industry either on a contract basis or permanent basis.

The *Industrial Development Corporation's* (IDC) *report* (2013) indicates that the South African construction sector's contribution to the Gross Domestic Product (GDP) shows its impact on the sustainable economic growth of the country at any given period of time, normally on a quarterly or annual basis.

Fig.2.1 below shows the contributions of the construction industry to South Africa's GDP from 1980 to 2004. It is estimated to have been between 2% and 5% during that period. The growth leads one to assume that there is a strong connection between the country's economic growth and the contributions of the construction industry.

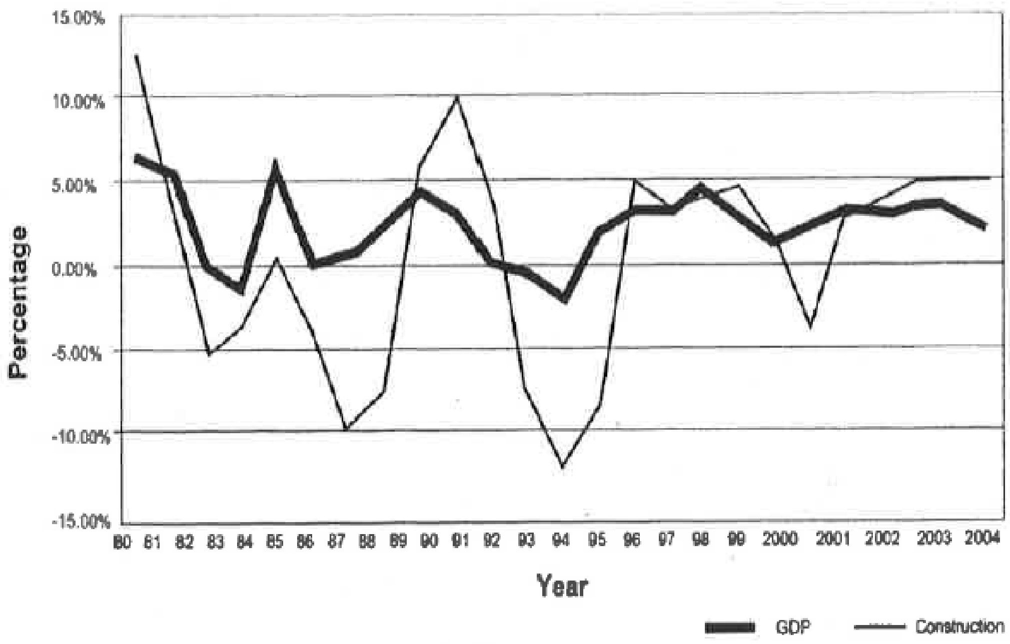


Figure 2.1: Economic growth versus growth in South African construction industry. Source: Adapted from Aiyetan (2010)

2.5.1.5 RISK FACTORS

It is safe to say that every project tends to succeed if there are knowledgeable and experienced project managers and proper management. However, risk factors also play an important role because of uncertainty (latent factors) in the industry. The current situation in the South Africa construction industry is difficult and often it is a challenge to deliver a successful project outcome.

The Department of Labour (DoL) confirms in the *SA Construction Industry* (2013) *annual report* that the construction sector has "increasingly come under scrutiny for the high number of injuries and fatalities experienced". It therefore raises the question whether success factors in the project can be responsible for safety problems in the industry.

Relevant literature in the form of case studies performed or reviewed by Manavazhia and Adhikarib (2002) as well as Chan and Kumaraswamy (2002) indicates that construction projects are often completed with large cost overruns, extended schedules and major quality concerns.

Extended time schedules are defined as the time overruns beyond the completion date specified either in the contract or beyond the date that the parties agreed upon for delivery of the project. Losses are the result of delays in the construction industry and can affect many aspects of the project or even the entire project. According to the above-mentioned authors the effects of delays include time overruns, cost overruns, disputes, arbitration, litigation and total abandonment of the project. Some studies have been done to investigate delays and attempt to address these concerns, find their causes and suggest ways to avoid them. (Baldwin and Manthel, 1971 and Assaf, Alkhalil and Al-Hazmi 1995).

Project management principles have not changed much over the years. History has shown that since the 1950s most of the work on project and construction management focused on project scheduling because it was assumed that better scheduling techniques would result in better management and therefore in the successful completion of projects. It was also assumed that a project was regarded as a failure if the project completion time exceeded its due date, expenses overran the budget, or outcomes did not satisfy the client's predetermined performance criteria. Today we know however, that determining whether a project is a success or a failure is a more complex process.

Avots (1969); Balachandra and Raelin (1984); Bedell (1983); Hall (1980) and Morgan and Soden (1979) argue that there are many other factors outside the control of project management, which contribute to or even determine the success or failure of a project. These factors are referred to as "*critical success or failure factors*". The above authors have also noticed that most of the studies on the subject focus on the reasons for project failure rather than project success.

2.5.1.6 THE NEED FOR RESEARCH

Pinto and Slevin (1989) indicate that inadequate information in the scope of work (SoW), incomplete or latent information in the specification or drawings, and undefined and unclear goals and objectives have a major impact on the outcome of a project and its success factors. It is the researcher's opinion that this statement is directly related to the research topic.

A project can be considered a success by the client but a failure by management if the project outcomes do not meet management specifications. The reason for this is that the various role players have different views of the success of the project and therefore evaluate its outcome differently. Nguyen *et al.* (2004) argue that the reason why the definitions of project success factors differ is that the opinion of success is often dependent on the perspective the evaluator chooses when he or she assess the project.

2.5.2 LITERATURE REVIEW: Project management philosophy

2.5.2.1 INTRODUCTION

Project management is the application of knowledge, skills, tools, and techniques in order to meet the client and other role players' needs and expectations regarding the project. In many instances, the traditional organisational structures or methods are not adequately accessible or even flexible enough and therefore use of new advanced project management techniques may bridge this gap. New management methods and tools are needed to cope with the current complexity of project and construction management, the exponential expansion of knowledge and the evolution of very competitive global markets. To remain competitive, much attention must therefore be given to satisfying all participants.

The *PMBOK Guide* (2008) states that to be able to meet client and main role players' needs and expectations, project managers have to balance the following:

- Scope, time, cost, and quality;
- The vast difference in needs and expectations of participants and clients; and

- Identified and unidentified requirements (expectations).

Thomas and Mullaly (2008) are of the opinion that extensive project management research has already been accomplished in specialised developments such as construction, engineering and technology. They further state that larger industry sectors have already been able to increase the value of project development practices by introducing formalised project and construction management procedures.

Carden and Egan (2008) indicate in their study that the industry sectors are also investigating whether these management practices can bring about improved project success. According to them, management practices may have been overlooked or ignored in the past because of a lack of knowledge. They base their opinion of the fact that engineers and project managers have witnessed the results achieved by project management, such as better utilisation of resources and the application of work breakdown scheduling.

Thomas and Mullaly (2008) also state in their research that improved project success can result in less professional and industrial distraction, which allow them to concentrate on the outcome of a successful project. Thomas and Mullaly (2008) also claim that industries such as civil, electrical and mechanical engineering benefit from using project management methodology for developing projects and delivering solutions for external and internal clients. The value of excellence in project management for the control of project delivery and execution has been acknowledged and has become a topic of research in the past few years.

2.5.2.2 THE CONSTRUCTION INDUSTRY

Projects encounter some rather unique challenges. Project roles are often assigned to a minimum number of people in order to cut costs and frequently the project manager is charged with the management as well as the physical execution of the project.

Turner, Ledwith and Kelly (2008) argue in their research that organisations generally adopt a non-bureaucratic method of conducting business. This is partly due to their poor organisational structures. In light of the above, a combination of the methods of the *PMBOK Guide* (2013) and Kerzner (1989) could be advantageous in these situations. Indeed, Turner *et al*. (2008) see this as a worthwhile topic for further investigation.

2.5.3 LITERATURE REVIEW: Project management methodology (PMM)

2.5.3.1 INTRODUCTION

Construction projects are often in the news, occasionally because of problems owing to cost overruns, safety and risk problems, quality standards and insufficient supervision on site. A typical example is the collapse of the temporary walkway bridge over the Grayston Road crossing on the N1 Highway between Johannesburg and Pretoria on the 14th October 2015. An investigation into the cause of the collapse is still in progress. There were two fatalities and nineteen injured. Although many factors are mentioned after the collapse of bridge, many questions may still arise such as labour, material or environmental factors, safety risk matters, design and many more.

According to Cleland and King (1983) this method of practice can only work on small construction projects that are less complex. It is therefore recommended that on large projects, architects and contractors must stay in their specialised domains of interest. Implementing a project management methodology (PMM) is in itself a significant benefit in guiding the management of projects so that deliverables meet the client’s needs and the required specification standards. For the development of a deliverable, the implementation of a project life cycle model is a complementary component of project management. Cleland and King (1983) state that the project life cycle is a documented project application model. Project managers/engineers should use the PMM process to ensure that they proceed in a structured way by following certain principles and procedures on how to manage a project.

2.5.3.2 DEFINITION OF PROJECT MANAGEMENT

The *PMBOK Guide* (2013) defines project management as "the application of knowledge, skills, tools, and techniques to project activities to meet projects requirements".

Kerzner (1989) defines that project management is "the planning, organising, directing and controlling of company resources for a relatively short-term objective that has established complete specific goals and objectives".

Silverman (1988) on the other hand, states that project management "is characterised by the use of specialised control techniques". Stuckenbruck (1981) thinks that project and construction management must be appointed to a single person who can take full responsibility for the success or failure of one of these temporary undertakings.

According to Spinner (1981) the valid definition of the scope of work (SoW) is the goal of meeting established objectives "in time, cost and technical results".

2.5.3.3 PROJECT AND CONSTRUCTION MANAGEMENT SUCCESS

Project and construction management success is something that can be measured during the course of the project life cycle and relates to the conventional criteria of cost, time and quality. Cooke-Davis (2002); Han, Yusof, Ismail and Aun (2012); Shenhar and Levy (1997) and Ika (2009) all claim that project management success relates to internal as well as external actions and that project success is more about the holistic view of a project. They also state that project and construction management success requires new methods and tools.

According to de Wit (1988); Pinto and Slevin (1989) and Nguyen *et al.* (2004) a specific measurement approach is needed in order to evaluate whether a project is a success or a failure. De Wit (1988) is of the opinion that perceived success is more important than real success.

These different opinions held by different authors make it clear that when a project is evaluated, it is important to consider both objective and subjective measurements to prevent possible confusing and misleading results. An evaluation process is an individual process for each project due to the fact that projects operate in different environments and cultures, that they differ in size and procurement strategies and that each project has its own norms (Hughes, Tippett and Thomas (2004) and Toor and Ogunlana (2009). Toor and Ogunlana (2009) agree and state that the first reason for doing a project specific evaluation is that each project has its own unique characteristics.

Researchers have to consider different boundary approaches and conditions for each project evaluation study. They also state that there are different perceptions of project success. Researchers often hesitate between two different perceptions, namely the macro perspective described as the overall objectives of the project and the micro perspective that concerns project success. The micro perspective includes the different viewpoints of the individual stakeholders.

The above statement is further strengthened by the research of Chin (2012) which states that to ensure successful completion, the components of the project management methodology must include project and construction management processes such as initiating, planning, executing and monitoring project progress.

Thornberry (1987) states in his research that project management is one of the most challenging jobs in the industry for two reasons:

- Firstly, it requires management skills and abilities which are different from those required in a traditional functional management position.
- Secondly, there is very little training support available to engineers moving into a project and construction management position. This statement will be reviewed in the research analysis in Chapter 3 and 4.

Kerzner (1992) states a qualified and experienced project manager is the key to successful project execution.

Roberts and Biddle (1994) are of the opinion that the transition from purely technical engineering to the role of project manager is often difficult and only partially successful. Their research confirms the importance of postgraduate management education for engineers to improve their managerial skills. Inadequate postgraduate education in project management as well as a lack of hands-on experience in project management can result in project failure.

Babcock (1978) believes in their research that the engineering manager is distinguished from other managers by the fact that he or she has to possess both the ability to apply engineering principles and the skills to delegate workers and team players during the life cycle of projects.

He states that the engineer has to be qualified for two types of jobs:

- Managing of technical functions such as design and production; and
- Construction and project management.

Babcock (1978) further states that as engineers of various disciplines move higher into management, they experience problems of managing technology and project management.

Chatfield (2007) argues that project management has gained popularity over the last decades as a distinct management concept used to drive not only projects objectives, but also economic development, real estate development, event planning and product development. This results in placing heavy emphasis on the use of project management as a tool to optimise the rate of success.

2.5.3.4 THE PROJECT LEVEL

Projects are launched today for numerous reasons, e.g. to develop and construct new buildings or to upgrade existing properties and developments. The question of assessing the success of those projects has always been controversial and dependent on the assessor’s point of view.

For Guterl (1994) project success is regarded as successful when it has come close to achieving its budget and scheduling goals. Although this may seem appropriate in the short term, it will not always be a sufficient long-term criterion of success. In many cases a very troubled project suffering enormous delays and extensive cost overruns can turn out to be a great success in years to come.

Shenhar, Levy and Dvir (2004) state that it is important to remember that client satisfaction and meeting all requirements must be part of a project success assessment. It is also important that assessors should consider the iron triangle objectives of cost, time and quality/performance when measuring project success.

2.5.3.5 COMPONENTS OF A PROJECT ENVIRONMENT

Implementing the management processes as outlined in the proposed methodology model is a challenge. Kerzner (1992, 2001 and 2003) states that many project managers fail to recognise that project methodology is important to ensure a successful project outcome. Standard procedures are often ignored in order to meet impossible deadlines.

In this research, emphasis will therefore be placed on the fact that the process, if followed, will accomplish the desired results.

The managerial team and client often follow their own methods without considering standards and code of conduct procedures with disastrous results.
Baccarini (1999) states that managers must take some blame for unsuccessful projects if proper actions were not taken and standards were not followed during the execution of the project.

As indicated in the *PMBOK Guide* (2008) and the survey of Jugdev and Thomas (2002), the project manager drives the project management process. The above authors are of the opinion that the tools or documents are designed to monitor personal commitments as well as to ensure that the project progresses according to an accepted and approved plan. Approval of the project management plan is the vehicle for accepting this commitment.

2.5.3.6 DEFINING PROJECT SUCCESS

Defining project success poses another challenge. In general project success can be defined as the ability to meet the technical goals although care must be taken not to deviate from the three constraints of scope, time and cost. The value of the project as perceived by the stakeholders and the project team, according to Kerzner (1992, 2001, 2003), will allow the performance of the project to be assessed over and over. With this in mind, project success or failure can only be effectively measured at the completion of the project.

The above statement corresponds with Baccarini's (1999) definition of project success. He is of the opinion that project success or failure can be measured by the elements of the project life cycle methodology. Projects generally fail as a result of poor planning due to constant changes in the scope, deadline and budget funding, as well as a lack of site monitoring and control by the project manager.

Several other authors such as De Wit (1988), Pinto and Slevin (1988) and Baccarini (1999) introduce ways of measuring project satisfaction regardless of project scope, size or project duration:

1 Project delivery as per client's desire or need.
2 Quality delivery as consistent with price.
3 Project completion within the timeframe stipulated by the customer.
4 Delivering the desired degree of feedback that the customer desires.
5 Having a system of conflict resolution that is fair to both the customer and the development team.

2.5.3.7 PLANNING TECHNIQUES

Pinto and Mantel (1990) argue that the key to successful project management entails proper planning and well-defined management disciplines.

According to the *PMBOK Guide* (2013) and Kerzner (1992) successful project management must involve effective planning techniques as they will ensure successful project execution.

The planning techniques consist of the following requirements:

1 The statement of work (SoW).
2 The project specification (PS).
3 The work breakdown structure (WBS).

2.5.3.8 THE IRON TRIANGLE THEORY

In order for a project to meet its objectives, it must comply with the so-called "iron triangle" theory, according to which project success depends on "three main pillars", namely time, cost and quality/performance. Certain project related procedures need to be put in place and followed through to monitor the processes and progress of activities. These procedures will identify a series of activities executed by selected role players and entities.

After conducting research on 650 projects, Baker, *et al.* (1983) decided that when a project meets the project scope, the function to perform, the satisfaction among all participants and the client, then the project is considered an overall success.

2.5.3.9 PROJECT EFFICIENCY: TIME, COST AND QUALITY

The time dimension measures express the efficiency with which the project has been managed. It tells us how the project met its resources constraints, and whether it was completed on time and within the specified budget and according to other specifications. This immediate dimension is usually used for project assessment during execution and right after completion.

Wheelwright and Clark (1992) argue that, although meeting time and budget (cost) constraints can indicate a well-managed, efficient project, it may not prove that this project was successful in the long term or that the organisation has benefited in the longer term. On the other hand, with increased competition and shorter project life cycles, time to construct (i.e. time from initial concept to completion) becomes a critical competitive component which could affect the project cost in the second dimension. It is therefore crucial that improved project efficiency should be seen as adding to project competitiveness.

2.5.3.10 MEETING THE CUSTOMER'S NEEDS

The third dimension of the iron triangle which is quality refers to the customer's needs. Wheelwright and Clark (1992) indicate that this dimension addresses the importance of a customer's requirements and meeting the customer's needs.

The following also play a major role in the third dimension or constraint of the triangle: meeting performance standards, functional requirements, and technical specifications (quality). These elements are part of the third dimension of the iron triangle and not, as is commonly assumed, part of meeting the project plan. It is important to the customer that performance objectives and quality are met because the customer is the best person to assess whether the mission has served her or his needs. Within this framework, meeting performance objectives is one of the central elements of meeting the client's needs and scope of work.

2.5.3.11 QUALITY MANAGEMENT (QM)

Quality in the context means that it implies specifications or needs have been met. The project team can be competitive when they are aware of the needs of the client and agree that the client's expectations will be met on a consistent basis.

Wheeler and Chambers (1992) argue that meeting specifications is not always sufficient however clients who are leaders in their field expect cutting-edge planning, service delivery, meeting time, cost and quality specifications and being on target with minimum variance. It is important to understand that specifications alone cannot ensure that the client will be satisfied with the result or that the contractor will receive gratitude or repeat business from the client.

Yourdan (1998) argues that a quality project is one that mostly satisfies the client's requirements. He is of the opinion that devoting too much attention to any particular section (by, for instance, eliminating all defects) may prevent the contractor from fulfilling other requirements that are more important. Good project estimation is therefore important as it will ensure the successful development of structures of satisfactory quality.

SECTION B: Definition of the five main factors in the project life cycle

2.6.1 THE PROJECT

2.6.1.1 INTRODUCTION

A project is defined as a process or development requested by a client. This definition makes it clear that understanding the project requirements right from the start is necessary if the needs of the client are to be satisfied.

Frame (1987) states that the main task of defining the client's needs in a project and its requirements is to perform a feasibility analysis, do a high-level requirements analysis, determine start and end dates of the project and do a design review. This exercise will reflect the needs and desires of the client, as well as those of management, project members and stakeholders. Meredith and Mantel (1995) define a project as a "specific, pre-determined task, usually a one-time activity with a well-defined set of desired outcomes that must be achieved".

Wysocki, Beck and Crane (2000) describe a project as a series of unique, multi-faceted and connected activities having one goal in mind. It must also be completed by a specific time, within budget, and according to specifications.

Finally, the project must reflect the needs and desires of the management, stakeholders and the clients of the project or development.

Projects differ from a routine set of activities or daily operations. Meredith and Mantel (2000) describe a project as a continuous process with a planned end.

Projects are characterised by general attributes such as purpose, life cycle, uniqueness, interdependency and conflict.

According to Merna and Al-Thani (2008) a project is a unique and diverse investment of resources to achieve specific objectives in order to make a profit or to provide a service for a community. They define a project as an irreversible change with a life cycle and defined start and completion dates.

2.6.1.2 PROJECT DIVERSITY CRITERIA

The construction industry is an accumulation of diverse segments of activities. Project success can therefore be seen as meeting the required expectations of the stakeholders or clients and achieving its intended purpose.

According to Archibald (1976) this can be achieved by understanding the outcome and deliverables of the project. For a project to be successful, it is essential to understand the required scope of work (SoW) of the project right from the start and to have a defined project plan. The SoW provides the right framework to facilitate successful project completion.

This topic, scope of work will be discussed in more detail in the first section of Section C of this chapter under 2.7.1 (a) Contract scope of work (SoW).

2.6.1.3 SUCCESS CRITERIA

Other authors base success criteria on the fact that different stakeholders perceive success differently. Stuckenbruck (1986) states that relevant success criteria must represent different views, since construction projects involve many different stakeholders, such as clients, managers, contractors, workers, suppliers, and end-users.

Bryde and Robinson (2005) are of the opinion that different views of success criteria between contractors and clients delay an effective working relationship. They state that contractors put more effort into reducing costs and time, whereas the client considers satisfying the needs of the other stakeholders as more important. The view of the client has attracted more attention than other stakeholders, because the client is often considered as the main person in a construction project.

Frödell, Josephson and Lindahl (2008) explored the client's perspective on success criteria and state that different clients have different interests. Consequently, they suggest that measurement of project success should be based on different groupings of client types.

Sanvido, Grobler, Parfitt, Guvenis and Coyle (1992) reviewed literature and grouped success criteria into the different perspectives of client, designer and contractor. From these groupings they were able to identify certain common as well as unique criteria for all perspectives. The designer's desire to improve professional development and professional satisfaction, the contractor's concern for safety and the client's interest in knowing that the constructed project will function as intended, are all examples of unique success criteria.

2.6.1.4 PROJECT SUCCESS CRITERIA

Cooke-Davis (2002) and Han *et al.* (2012) argue that in order to understand project success, it is important to distinguish the difference between project success and project management success. As mentioned by various authors, project success can be measured only after completion of the project and refers to the overall objective of the project.

Baccarini (1999) is of the opinion that product success is a component of project management. Therefore, project success is defined as the "effects" of the project's final product.

Stuckenbruck (1986) defines project success as the effect of the project's final outcome. According to Stuckenbruck (1986) the most appropriate time to evaluate a project is after completion. However, this is seldom done because contractors consider a completed project as the end of construction. In addition, the project and construction managers tend to ignore this evaluation process because they are of the opinion that new projects are far more interesting and important than the current completed project. Stuckenbruck further argues that this view results in a huge loss as knowledge and experience is not gained from the projects, regardless of whether it ended in a failure or as a success.

For Pinto and Mantel (1990) the key to project success is comprehensive planning. While the topic of planning is wide and far ranging, this section is intended as an introduction to some of the fundamentals in the project planning process.

Pinto and Mantel (1990) define project success according to three different dimensions:

a) The efficiency of the implementation process is "an internally oriented measure of the performance of the project team, including such criteria as staying on schedule, staying on budget, meeting the technical goals of the project, and maintaining smooth working relationships within the team and parent organisations".
b) Project success is the perceived quality of the project including the project team's perception of the value and usefulness of the project deliverables.
c) The client's satisfaction or an external performance measure of the project team's performance on the project outcome is also regarded as important for project success.

Atkinson (1999) is of the opinion that project success criteria are something that projects can be measured against. Sanvido *et al.* (1992) claim that success criteria point to the expectations of the project and expectations dependent on stakeholders, scope of services, project size, technological implications and other factors.

Atkinson (1999) has found that most project managers only use the iron triangle as criteria for measuring success, something he regards as an incomplete definition of project management. He feels that this definition of success criteria can and does result in a biased measurement of project success and can be seen as negative or positive. He adds that in many cases a project can be perceived as unsuccessful even though the known success criteria were met. Therefore he feels that the iron triangle does not consider how well the project is used by the client or perceived by the stakeholders. Atkinson (1999) further states that if the stakeholders continue to use an incomplete set of success criteria, it would result in repeated failures. He therefore considers the following as additional criteria for a successful project: the technical strength of the resultant system, the benefits to the organisation and the benefits to the wider participant community.

Lim and Mohammed (1999) classify the perspectives of project success into two categories: the macro and micro viewpoints.

1 In the **macro** viewpoint, the question must be asked if the requested project concept has been achieved. If so, the project should be considered successful. If not, the project should be considered as less successful or even a failure. The question can only be answered in the functioning phase after the construction of the project and generally it is the client, users, participants and the general public who look at project success from this point of view.

2 The **micro** viewpoint is the smaller components of the project and here the conclusion of the construction phase and concerns of the construction parties are considered. Lim and Mohammed (1999) suggest completion and satisfaction as criteria for the micro viewpoint, completion and satisfaction representing two sets of criteria for determining project success. It is important to realise that the criteria that have to do with completion will vary, depending on the viewpoint of the evaluator. From the micro point of view, completion typically involves the contractor's concerns and the manner in which he considers achieving his or her own project objectives,

such as time, cost, quality, performance and safety. Lim and Mohammed (1999) further state that the criteria that involve satisfaction have to do with the users' perceived success of the project. Here the finished project is typically assessed by its appearance and according to its acceptance.

2.6.1.5 SUCCESS CRITERIA FOR PROJECT MANAGEMENT

Project and construction management success can be measured over the project life cycle as a whole but also relates to cost, time and quality (Cooke-Davies, 2002; Han *et al.* 2012). With this in mind, de Wit (1988) states that project management success is not required in order to achieve project success and the other way around.

Arguments by Shenhar and Levy (1997) and Ika (2009) contradict the previous statement. They claim that project management success relates to internal actions and a holistic view of the project. All of the above implies that project management success is necessary in order to achieve project success, which means that the latter cannot be accomplished without the former.

Pinto and Slevin (1989); Nguyen *et al.* (2004) and de Wit (1988) all emphasise that perceived success is more important than the real success.

Stuckenbruck (1986) is of the opinion that top management and clients are the most important stakeholders and that this is something that the project and construction manager has to consider very seriously.

It is clear that there is no fixed definition for project success. Therefore, people choose to define project success depending on various preferences and values.

2.6.2 THE CLIENT

2.6.2.1 INTRODUCTION

The new development process starts with the search for ideas.

Hippel (1986) argues that developers and engineering companies should state how much effort should be devoted to developing breakthrough ideas on project development, modifying and renovating existing developments, as well as copying competitors' projects. He continues that the marketing development concept holds that client needs and wants is the logical place to start the search for ideas. Hippel (1986) has shown that the highest percentage of ideas for new industrial projects originate with clients. A company can define its target market successfully but fail to correctly understand the customers' needs.

Hamel and Prahalad (1994) state that it is not always easy to understand the client's needs and wants because some clients are not fully aware of what they need due to lack of knowledge. Product success entails satisfying the client and stakeholder's needs relating to the project goal and purpose (Shenhar, Levy and Dvir 2004).

PMI (2004) and International Standardisation Organisation (ISO) (2004) advise that when different stakeholders have conflicting needs and expectations, differences should be resolved in favour of the client. Wideman (2005) argues that the real measure of project success should be client satisfaction.

Jenkins (1976) suggests a concept or model that addresses all the relevant needs of the client. His model includes the following:

1 Needs identification and conceptual design.
2 Design and feasibility analysis to cover the scope of work.
3 Detailed development construction plan.
4 Commissioning closeout of the project.

The client's satisfaction or an external performance measure for the project is defined by Au and Hendrickson (1985) as follows:

1 A project must meet market demands or needs in a well-timed manner.

2 In order to select the best possible approach during the conceptual planning stage, the technical and economic feasibility alternatives must be assessed and compared with alternative options to ensure that the scope of work will meet the client's requirements.

3 A detailed feasibility study, engineering design and a detailed cost estimate will also help to satisfy the client's needs.

4 A work breakdown structure for the proposed project must be implemented to involve the client from the initial stage of the project.

5 After the construction is completed, there is usually a brief period of start-up or hand-over.

2.6.2.2 THE CLIENT'S EXPOSURE TO THE PROJECT

Hamel and Prahalad (1994) state the client usually does not have sufficient technical knowledge to enable him or her to specify the work to be done. The client therefore employs an engineer/project manager or consulting company to advise him or her and to prepare the implementation process. This first meeting between the client and the consulting company may take a high level approach and certain criteria of agreements may be approved and noted. The client should be involved in all decisions right from the initial stage of the project.

2.6.2.3 IDENTIFYING THE CLIENT'S NEEDS

Cooper (1998) presents a methodology to identify the client's needs. He is of the opinion that a little structure goes a long way in facilitating an effective project development process.

He formulates the following four important steps to ensure that the needs of the client will be met:

- Define the scope and purpose of the project.
- Gather and interpret raw data from the customer in order to meet the customer's needs.

- Categorise the needs into a chain of command of primary, secondary, and (if necessary) tertiary needs.
- Create a list of relative priority of the needs.

Hamel and Prahalad (1994) argue that identifying the client's needs for more detail is a process of evaluating concepts with respect to the customer's needs and other criteria. The evaluation of needs to compare the relative strengths and weaknesses of the various design concepts and a selection of one or more concepts will be further investigated. Design concept selection is the activity in which various ideas and stated needs are drawn together into one preferred design concept.

According to Hanan (1993) development design usually requires several iterations and refinement within design proposal phases. Thorough planning at this stage will, however, ensure that the client and the design engineer are both on the same level of understanding regarding the project and the scope of work.

2.6.2.4 CLIENT PARTICIPATION IN PROCUREMENT INVOLVEMENT

The successful outcome of client participation will finally form the basis of the contract of conditions (CoC), which will include the bill of quantities (BoQ) that will cover the full scope of works (SoW). This will result in a signed contract agreement between the various parties. It is imperative that the client take part in the preparation and the layout of the procurement process as it will encompass the three above-mentioned documents.

This topic will be furthered reviewed under Section B: "The contract document".

2.6.3 THE PROJECT AND CONSTRUCTION MANAGER

2.6.3.1 INTRODUCTION

Meredith and Mantel (1995) describe the project manager as a generalist with an excellent background of experience and knowledge. The project manager must oversee many functional areas, each with its own specialists and role-players. He or she therefore has to have the ability to put many pieces together to form a coherent whole. In other words, a project and construction manager must have people skills and site experience as well as knowledge in various fields whereas the functional manager must be skilled at analysis.

Pinkerton (2003) suggests that the competencies of the individual role players should be grouped to achieve the objectives of the project. A functional manager uses an analytic approach while a project and construction manager uses a systems approach.

Belassi and Tukel (1996) state in their research that the project manager is in fact one of the key participants in a construction project and his competence and vast experience is a critical factor that affects project planning, scheduling and communication.

Chua, Kog and Loh (1999) state variables under this factor consist of the project manager's skills, commitment, competence, experience and authority. All of these are of immense value to ensure a successful completion of the project.

The Project Management Institute (PMI, 2008) makes the following statement: "For a project to be successful the project manager must have the requisite knowledge of project management, which is defined as the planning, organisation, monitoring and control of all aspects of a project and the motivation of all involved to achieve project objectives safely and within defined time, cost and performance". The project manager is responsible for managing projects, structures and developments using a project management methodology hypothesis.

The project and construction manager also follows a project development life cycle methodology as specified by *PMBOK Guide* (2013). This model emphasises the following project phases: initiation / concept, planning / feasibility, implementation / construction and the closeout of the project.

Before any effective work on a project can commence, five main "role players" need to be involved in the project life cycle: the project, client, project manager, contractor and the contract conditions. It is therefore vital to select a suitable, experienced and competent project and construction manager to lead the project from start to finish. The project manager's role commences at the project initiation stage and continues until completion of the entire project.

This will be reviewed in more detail in Section C, item 2.7.1(a) "Contract scope of work (SoW)".

2.6.3.2 THE PROJECT MANAGER'S SKILLS

An important trait of good project and construction manager is training skills. Babcock (1978); Badawy (1983) and Cleland and King (1983) agree that a project manager needs a certain number of technical skills, traits and knowledge. They further argue that these traits are based upon suitable training, diverse management experience (technical and business), good interpersonal skills, integrity, honesty, patience, an understanding of what is required of a project manager and knowledge of processes with a quality orientation. These traits should also be developed in team members in order to keep them motivated.

Raudsepp (1983) argues that the project manager should be a visionary who focuses on delivering of a successful project. The project manager plays an important role in the environment by showing his diversity in project management. He or she must be enthusiastic, decisive and dedicated, have self–confidence and be willing to lead by taking a stand. The project manager should further have a broad range of skills and tools to deal effectively with the complexities of project and construction management.

2.6.3.3 THE PROJECT MANAGER AS MENTOR

A project and construction manager must have the willingness to teach or mentor team members through role modelling and providing on-the-job-training. The project manager must also be willing to accept the status quo with an open mind.

Badawy (1983) states that the project manager should also be fully committed to develop the project team players. Good project managers are people who are not concerned about their own careers but rather about the careers of those who work with him as a team. The industry puts great value on the ability of individuals to work in teams.

O'Connor (1994) therefore argues that competitiveness should not be centred on individuals but on the teams working together to complete the project. This means that the project manager as a mentor must have maturity of judgement besides being strong and steady and not influenced by the impulses or aggressiveness of individual team players.

Project management is an ongoing process that spans the entire project life cycle, and it is important to accept that the aptitudes, characteristics and abilities outlined above are crucial.

For this reason the researcher will design a questionnaire to determine the level of the engineer's practical experience and his ability to measure and resolve design, project and construction related problems on a daily basis in order to avoid delays throughout the life cycle phases of the project. This will also enable the project manager to identify the shortcomings of his team and to mentor accordingly.

2.6.3.4 COMPETENT PROJECT MANAGERS

A lack of experience and understanding can cause a project and construction manager to fail in his duty as a manager. Thornberry (1987) asks the following questions: "Who is competent to be a project manager? Are technical skills important? How about conceptual skills? Does it mean that the project manager's management skills increase, the need for technical competence decreases while the importance of taking a holistic view increases? Does it mean that he must have the ability to see the whole rather than a part and to be able to explain or demonstrate in simple terms to an individual?"

All areas are important, interrelating and necessary for a project to be completed successfully.

2.6.3.5 PROJECT MANAGER'S PERFORMANCE

Drucker (1954) claims that project performance can be measured very easily. The project must meet the requirements, the time schedule, and the estimated budgeted costs in order to deliver a successful project to the members and clients. Shannon (1980) argues that performance is a function of commitment and the completion or non-completion of the tasks can be used to show the measure of dedication that went into the project. To measure the project manager's performance one needs to know where time was invested and what was accomplished during the project life cycle time, which includes the cost, time and quality of the performance to meet or not to meet the final needs of the client.

Performance can be increased significantly if everyone participates in an incentive programme. This will include excellent quality control and service objectives. A project objective reflects the needs and desires of management, project participants and clients of the end product.

2.6.3.6 THE PROJECT MANAGER'S RESPONSIBILITIES

The project and construction manager is responsible for defining the most cost-effective task, bringing together and motivating his team to develop the clients' needs.

Archibald (1976) made the following comments:

- The project must be divided into specific tasks which are called the work breakdown structure (WBS).
- Specific tasks must be assigned to specific members of the project team.
- Communication, negotiation, interaction with other people (especially role players), and monitoring the development during the life cycle of the project, are important for a successful outcome of the project.

- The main assignment of the project manager is to deliver the project within the scheduled time and budget, and in accordance with the technical specifications as specified in the contract of conditions.
- It is the duty of the project manager to solve project related problems on a daily-basis in order to avoid delays.
- He also has to deal with crises and resolve conflicts, suggest alternatives and make recommendations when objectives cannot be achieved.

According to Archibald (1976) the project manager must stay in touch with all his team players, clients, stakeholders, management and the main contractor in order to avoid unaddressed or latent problems. The project manager must also be a skilled representative, negotiator, liaison person and partner during the life cycle of the project.

In view of these demands, development of project management skills is perhaps one of the most important investments that the client or company can make.

2.6.3.7 THE PROJECT MANAGER AS A GENERALIST

The project and construction manager oversees the work of many functional areas. Meredith and Mantel (1995) are of the opinion that the project manager cannot be an expert in all of the various areas. Firstly, the project manager is usually more of a generalist than a specialist as would be the case with a functional manager. Secondly, the role of the project manager is primarily that of a facilitator.

According to Meredith and Mantel (1995) the project manager's role and responsibilities can be divided into three categories:

1 The corporate company/client.
2 The project (his main responsibility).
3 The project team members.

2.6.4 THE CONTRACTOR

2.6.4.1 INTRODUCTION

The Collins Concise Dictionary (2001) defines that "a contractor is a person or firm that undertakes a contract to provide materials or labour to perform a service or do a job".

2.6.4.2 THE CONTRACTOR'S DUTIES

The duties of the contractor consist of delivering the project according to the client's requirements (needs) as specified within the conditions of the contract (CoC), scope of work (SoW), and bill of quantities (BoQ). During the initial meeting the specification of delivering the objectives within time, cost and quality constraints will be defined.

Biggs, Birks and Atkins (1980) argue that the SoW is the most important factor besides cost and schedules and project performance should depend on how well the project meets the technical design and specification requirements as the client seeks to retain some measure of control over any contracted work. The main contractor may subcontract various parts of the project works, and will be responsible for their performance as well, and therefore will co-ordinate the work of all the subcontractors and suppliers of material or equipment plant accordingly.

Bockrath (1986) and Hirsch (1986) emphasise the importance of the contractor's knowledge of the detailed drawings and their interpretation. Subcontractors or material suppliers often have the task to prepare these drawings, and a good example is reinforcing steel drawings that show fabrication and installation details beyond those provided by the design engineer. Bockrath (1986) is of the opinion that it must be clearly stated in the contract that the client/representative/project manager must approve all drawings prior to manufacturing according to the design specifications. Even in the best of all projects there will be unknown factors hidden within the project sites and waiting to be disclosed.

This statement will be contested during the case studies analysis in chapter 4.

2.6.4.3 HEALTH AND SAFETY

Firstly, it is the duty and responsibility of the main contractor to implement a health and safety plan to comply with local governmental general standards as well as those of the Occupational Health and Safety Act and Amendments (2014) of the Department of Labour as related to construction conditions on site and to ensure that all persons on site comply with the regulations. Secondly, it needs to be remembered that no two clients or contractors are the same, also regarding the interpretation of and adherence to health and safety regulations. However, it must be clear to all on site that safety regulations apply to all in spite of differing viewpoints about the matter.

2.6.5 THE CONTRACT DOCUMENT

2.6.5.1 INTRODUCTION

During the initial stage of the project the client should develop the procurement strategy (PS) of the project in consultation with the project manager (PM) and the design team (DT). This decision requires consideration of the objectives of the project, and can vary from project to project. There are many types of procurement strategies; for the purpose of this research, we will review four types below (item 2.6.5.6).

2.6.5.2 DEFINE THE CONTRACT

Lynden, Reitzel and Roberts (1985) define a contract as “a promise or set of promises for the breach of which the law gives a remedy or the performance of which the law in some way recognises as a duty”.

Vaughn (1983) suggests that “a contract is an agreement enforceable at law” and must meet certain requirements such as:

1 All parties concerned must be competent to enter into the contract.
2 The agreement between the parties must consist of an offer and an acceptance.
3 The contract must be correct and well understood by all parties involved.
4 The agreement must be in the correct form and layout.

5 Both the client and the contractor have an obligation towards the project. The contractor's obligation is to meet the contract conditions and the client's needs. The client obligations are to ensure performance payment when it is due.

The study of Sweet (1989) points out two attributes of such contracts that set them apart from ordinary commercial contracts. Firstly, it is often the case that clients are relatively inexperienced in such contractual matters and should be instructed by qualified people in this regard. Secondly, the initial phase of the contract formation is often rather vague and informal, something which can cause major problems at a later stage in the project cycle.

2.6.5.3 DRAFTING THE CONDITIONS OF THE CONTRACT

The document, to which the parties agree and sign, certifies that the contract is sealed between the parties and becomes a legal contract agreement with terms and conditions (called a contract under seal). A contract under hand merely recites the names of the parties including in some cases, the sureties, and set out the terms of the agreement by which the contractor agrees to perform all the work in accordance with the relevant documentation, drawings and standards. It is a "simple contract", but also signed by all parties involved.

Drafting the conditions of the contract (CoC) is normally the work of the client's lawyer, the engineer merely giving such assistance on technical matters as the lawyer may require. However, the engineer's main concern is the preparation of the drawings, specifications and bill of quantities (BoQ) and other relevant documents and supervising the construction after the work has commenced. The engineer wants to seek clauses in the conditions of the contract (CoC) that will enable him to deal with any difficulties which may arise during the contract execution.

2.6.5.4 CONDITIONS OF THE CONTRACT (CoC)

Conditions of contract (CoC) covers important items and secure a base upon which the entire project's scope of work (SoW) is founded. The drawings will show the complete layout of all work activities, as well as all measurements and the construction workmanship indicated in the specifications and SoW. The bill of quantities (BoQ) describes all materials and related quantities with related time, cost, labour and equipment machinery rates.

Sweet (1989) emphasises that the conditions of the contract lays down in detail the relations between the client, the engineer/project manager and the contractor, from the moment the agreement is accepted.

2.6.5.5 CONTRACT RELATED DOCUMENTS (CRD)

The contract document also accommodates the following documents and conditions of importance: feasibility studies (FS), environmental studies (ES), financial progress payments (FPP), variation orders (VOs') procedures, work breakdown structures (WBS), project monitoring and controlling (PMC), statement of work (SoW), contractors' aptitude and capability to execute the project, health and safety management plan (HS), risk management plan (RMP), procurement and tender procedures (PTP) and project quality control (PQC). All these and many more are required to ensure that the appropriate project life cycle methodology will be followed and the client's conditions of time, cost and quality will be met, in other words, that the project will be successfully completed.

The above conditions of contract (CoC) and project deliverables will be discussed in more detail in Section C: Project life cycle.

2.6.5.6 TYPES OF CONTRACTS

In this research four well-known project procurement methods will be reviewed because they are of the four main factors in the project life cycle domain. The finer detail of the project procurement strategy, conditions of contract will be explored in more detail in Section C: 2.7.2 Project planning and design.

In the early stages of the project, the client should develop the procurement strategy for the project in consultation with the project manager and the design team. This has to be done with an eye to the objectives of the project and will vary from project to project.

According to Hirsch (1986) the client must retain some measure of control over any contracted work. The contract should clearly specify the areas of the project over which the project and construction manager has ultimate authority (on behalf of the client) for supervision and decision-making, and also for tracking project progress.

There are many types of procurement strategies of which four will be discussed briefly as this is not the focus of this research.

A Traditional methods

When this strategy is followed, according to Gordon (1994), the design is finalised before the tender process commences. This type of contract gives the client a great deal of control over quality, specifications and cost. However, the timescale may have to be changed to be able to complete the project. The client carries the risk in terms of the consultant's design and any unforeseen items, such as ground conditions, and also cannot benefit from the contractor's input on building ability, as he or she is only brought in once the design has been completed.

As the contractor has no responsibility for the design, the client or project manager is responsible for any mistakes or omissions in the design. Although some risk is shared with the contractor the majority of the risk is taken by the client/project manager.

Cook and Williams (1998) argue that the traditional procurement approach is a good method provided that:

- The design is completed before the tender stage, as this will ensure that the client knows the cost of the project.
- The design does not change substantially during construction as this will cause delays and disruption.
- The designer understands how the construction will be carried out, as this will ensure the practical execution of the project.

Advantages: The client/project manager maintains control of the quality and specifications of the project.
Disadvantages: The client/project manager is responsible for any risk as there are usually little or no interaction between the design team and the contractor.

B Design and build

This strategy transfers the risk to the contractor at a much earlier stage in the project. There are various sub-types of design and build; however, the basic parameters remain the same. The contractor becomes responsible for completing the design and construction of the project at a certain point of time for a fixed amount. Cost is achieved at an early stage and therefore offers the client a high level of certainty. The client's design team designs the project to the first design proposal stage. At this point, the project is tendered in either a single or a two-stage process, and risk is transferred to the contractor who becomes responsible for the design and construction from that point onward. The design team is for all purposes unrelated to the contractor and the client no longer has any control over them. Most project managers choose to retain the services of a quantity surveyor (QS) so that some control can be maintained over project costs expenses.

Ndekugri and Turner (1994) state that the contractor must provide a fixed price based on the client's requirements document which can range from a simple accommodation schedule (for a basic project) to a fully worked out design. Adequate time must be allowed for the client's proposals to be prepared, including completed layout data sheets. After signing the contract, the contractor assumes responsibility for developing the design in accordance with the client's requirements. If the client requires any changes during the work, they are controlled by the contractor. Additional costs are the responsibility of the client.

It is the responsibility of the client to ensure that the tender adequately describes the extent of the development and scope of the work (SoW). It must be remembered that no changes will be accommodated during the construction stage unless there is a validated reason. It is also suggested that the client's concept of design and SoW be clearly defined within the contract agreement. The bill of quantities (BoQ) price schedules must include all related design and building costs including the execution of all construction in compliance with related design and building, construction and professional code of conduct standards. The contract price must include all related services, material, labour, equipment, tools, health and safety supervision and accidental insurance cover.

Ndekugri and Turner's (1994) survey confirm that time and cost savings appear to be the main reason why clients select this procurement strategy. The authors are of the opinion that this strategy provides better value for money, particularly where the time of completion is of the essence.

Advantages: The contractor takes the risk.
Disadvantages: The client is usually not much involved with the project and the end product may not meet his or her expectations according to Barrie and Paulson (1992). These authors also think that this strategy provides better value for money, particularly where the time of completion is of the essence.

C Management contracting

Here the contracting organisation manages the project.
The construction management and the design team are direct in contact with the client (Naoum and Langford (1987). The contractor selects and appoints his team on a competitive basis (usually on a fixed price) as the design develops.

Where speed and control of quality are of paramount importance, a management contract may be an acceptable choice. In this instance, the design team has the responsibility for the design of the whole project but the contractor is responsible for defining the packages of work and then arranging for these to be carried out through separated trades or works contracts. The advantage of this strategy is time, as the detailed design can be developed in parallel with the construction works and an early start can be made on site. Design changes can be done during the course of the works but only where these will not affect the work packages that have already been assigned.

Barrie and Paulson (1992) claim the disadvantage of this approach is that the client does not have cost certainty until the final package has been assigned. This strategy is therefore often considered risky for the client. The client retains control and responsibility for the design and therefore, if the design is not fully co-ordinated and the design team fails to produce information on time, virtually all risks remain with the client throughout the entire project. There is no risk transfer to the contractor. Whilst this option is suited to projects where it is not viable to complete the design prior to commencing work on site, this high level of risk is an unpopular option.

Barrie and Paulson (1992) also argue that the construction manager does not usually guarantee either the overall price or the quality of the work.

Advantage: The client/project manager has full control of the design aspects of the project. This strategy is a viable possibility in the case of shorter programmes.
Disadvantage: There is no transfer of risk to the contractor and the client carries a high risk if the design is not fully co-ordinated. There is no cost certainty until late in the project.

D Construction management

There is generally an overlap between the preparation of the design and work on site (as is also the case in management contracting). All the contracts for the work packages are between the client and the trade contractors; therefore, the client has a considerable duty in managing the separate contracts. The final cost of the project is not known until the last work package is assigned.

Barrie and Paulson (1992) suggest that full-time interaction between the project manager’s design team and the construction team functions not only ensures effective overlapping of design and construction, but also provides for value engineering and ensures constructability of the design.

Advantages: The client retains full control of the design, something which is possible especially in the case of shorter programmes.

Disadvantages: The client negotiates the package with the contractor directly. The construction manager has no contractual role and the client carries the largest risk if the design is not fully co-ordinated. There is no cost certainty until late in the project and also no transfer of risk to the contractor.

2.6.5.7 PROJECT RELATED DOCUMENTATION

The conditions of the contract (CoC) actually include the preliminary clauses of a specification and other related documentation.

Goldbloom (1992) states that the output from the construction documents phase is a set of documents that will form the basis of a contract with the construction contractor. This includes the final drawings and technical specifications as well as general and special conditions. The method allows the project and construction manager to invite tenders who will affect the contents of the specification and the successful execution of the project. Goldbloom (1992) therefore suggests that the best method is to issue to each contractor tendering a complete set of documents comprising the conditions of the contract, the specification and the bill of quantities with all other related documentation so that they can submit a justified bid. The contractor will then be left in no doubt as to what his obligations will be should his estimate or bid price be approved.

2.7 SECTION C: The four project management life cycle phases

- Phase 1: Project initiation/conception
- Phase 2: Project planning/design
- Phase 3: Project implementation/construction acknowledgement
- Phase 4: Closeout/lessons learned

The researcher is aware that the South African Council for Project and Construction Management Professions (SACPCMP) work with the concept of six life cycle phases in projects. For the purpose of this research, however, the researcher chose to work with four phases and to cross-relate activities with one another. The phases concept, feasibility studies and project initiation were merged into one phase (see Fig 2.1). In this study the researcher therefore worked with four phases, namely concept and initiation; planning (including design); construction; and close-out in order to ensure a positive reply in the survey questionnaire.

There is no fixed number of life cycles in any project; the complexity of a specific project will determine the number of life cycle phases for that project. Moore and Tushman (1982) identified only three stages in a project life cycle, namely introductory, growth and maturity. Adams and Brandt (1983); Cleland and King (1983); and Burke (2001) based their life cycle phases on PMBOK (2013) principles and accordingly also identified five life cycle phases.

Moore (1991), on the other hand composed a five stage project life cycle programme by including a phase he called “crossing the chasm”. This phase refers to latent problems that emerge during the course of the project, for example an unexpected underground water fountain found during the construction phase.

This researcher accommodated the above phase (crossing the chasm) into phases 1 and 2 of his research. He also listed it as SF19 and SF20 (environmental and feasibility studies) in his questionnaire.

The researcher also decided to use a four phase life cycle for this study and his questionnaires by merging some of the six life cycle phases identified by SACPCMP and ultimately working with four life cycle phases.

2.7.1 PHASE 1: PROJECT INITIATION / CONCEPTION

The project life cycle begins with the identification of a need or the suggestion of a project opportunity; it might come from researchers, salespeople or customers.

PMBOK Guide (2013) defines a project as the entire sequence of activities from the initial idea invention through the research and development phase to the development process. *PMBOK Guide* (2013) states that a project is a dynamic activity with a distinguished life cycle of its own. The activities can originate from the client or the research and development functions and are rooted in the dynamic life of civil and construction engineering. The life cycle of a project has its own structure because the managerial considerations of the project change significantly as the project progresses.

PMBOK Guide (2001) describes the project life cycle as the project phase, the relationship to each other and to the project. This includes an overview of the organisational structure that can influence the project and the way the project is managed. *PMBOK Guide* (2001) suggests the following four phases, adding that constant monitoring and evaluation across all four phases of the project life cycle is important: (1) the initiation phase, project planning, (2) feasibility and design phase, (3) the implementation and construction phase and (4) the project closeout and lessons learned phase.

The above four phases also require different management and support services from the corporate management. Each phase in the project life cycle requires different levels of effort in terms of planning, monitoring and evaluation.

Kyriakopoulos (2011) emphasises the importance of regular project monitoring and planning during the initiation phase and involving all stakeholders and team players. This will keep the project vibrant and on track and make sure that it fulfils and meets its objectives.

PMBOK Guide (2001) also refers to a project as a temporary undertaking to provide a unique product or service. It consists of a series of sequential phases from its initiation to its closure, and these can be broken down into functional or practical objectives. A project has transitional results or deliverables and specific milestones within the overall scope of work or financial availability.

The Project Management Institute (PMI) (2013) states that every project has a definite start and end as well as with specific deliverables and activities. The proposed life cycle provides the basic framework for managing the project. Careful attention to detail, the ongoing involvement of key participants and proper documentation at each stage are all important to ensure an excellent outcome of the project.

2.7.1 (a) CONTRACT SCOPE OF WORK (SoW)

Scope of work (SoW) defines the major task that will need to be performed to accomplish the work to be done and produce all the project deliverables. The SoW defines what the project team or the contractor will do.

Manzi (1984) and Schoumacher (1986) argue that the scope of the design work during the construction phase is often the most difficult to define. The engineer or architect has some responsibility for assisting the project manager with contractor selection, including advertising the project, receiving and evaluating proposals, and awarding the contract. The above authors claim that the design engineer or architect has a responsibility to represent the client and the project and construction manager on site during the actual construction site meetings.

PMBOK Guide (2013) argues that the project scope defines what needs to be done, in other words everything that must be done to produce all the project deliverables and satisfy the client or stakeholders that all the work and deliverables met the requirements and acceptance criteria, and accomplished the project objectives. The scope of works identifies all the major tasks that will need to be performed to complete the project deliverables. The SoW also defines the duties of the project team and/or the contractor. If something is not specified or defined in the SoW, it will not be done. Having the contractor or project team review the SoW with the client provides an opportunity to make sure everything that the client expects is included.

Scope of work involves specifying the full breadth of the project and the full span of its outputs, end-results, or deliverables. The defined end-items to be delivered or constructed by the project are termed inclusions, meaning they are included in the project.

Frame (1988) states in his research that scope definition should focus primarily on determining outputs and deliverables, not on time and cost alone. Time and cost restrict or dictate the potential deliverables and must therefore be accounted for as constraints in the scope definition.

Archibald (1976) argues that sometimes uncertainty stems from lack of effort. He states that management should in general strive for the clearest, most definitive scope of work and project objectives. During the project however, changes in project design or schedules occur due to project concept changes or developmental barriers. These are outside the control of the project participants, but the original cost estimate should then be updated and become the new baseline for tracking and controlling project costs.

Many consider this initial phase in the project life cycle to be the most important one, because if the correct requirements and problems are not identified, the project will be in trouble from the start.

Walker (1995) claims that project scope is a useful forecaster to estimate construction time. Other authors, such as Akinsola, Potts, Ndekugri and Harris

(1997); Songer and Molenaar (1997); Belout (1998); Chua *et al*. (1999); Dissanayaka and Kumaraswamy (1999) and Kumaraswamy and Chan (1999) concur. The attributes used to measure this factor are types of project, nature of project, number of floors, project environment and the complexity of the project and the size of the project.

- **Project scope of works clarity**

Bahill and Chapman (1993) argue that the needs of the client are not always clearly or well defined in the concept development phase. They are of the opinion that alternative perceptions are created to formulate a meaningful presentation on which various other success factors will depend. The most important phase in the project life cycle is therefore the concept development phase, as this is the phase where all the client requirements and related success factors can be clarified and described. The concept proposal should be reviewed by various role players as many times as necessary before the project is moved to the next phase (the design phase).

Akao and Ed (1990) and Bahill and Chapman (1993) all state that a design concept is a description of the form, function and features of a project. They also state that a set of specifications, an analysis of competitive alternatives, a feasibility study and a breakdown of cost, material and labour should be included in the concept documents to justify the project cost and reason for development. This activity is known as a bill of quantities (BoQ). Documents for this phase usually include descriptions of several methodologies and success factors to ensure that all aspects of the scope of works (SoW) are addressed and agreed upon before full and final approval of the project is given.

Frame (1987) states that the concept development phase demands more coordination than the other phases as many of the development methodologies are concentrated in this phase. The purpose of the activities of this phase is to gain an understanding of the client's needs and to communicate them effectively to the planning and design team. It is important to have a set of carefully constructed client needs statements, structured in a classified list.

Kaplan and Norton (1996) highlight the important role of a qualified and experienced project manager in satisfying the expectations of the client, stakeholders and the participants.

Argus and Gunderson (1997) emphasise that concept development time should be used to explore analytically the space of the project concept in order to satisfy client needs. Concept development includes a description of external factors, creative problem solving within the team and a systematic exploration of the various solutions. The exercise usually results in a set of two to five concepts, each typically represented by a sketch and brief descriptive text.

Cooper (1986) and Kaplan and Norton (1996) all state that the general function of design is often overlooked in efforts to ensure client satisfaction. Raw data should be obtained from the client at the earliest possible stage to ensure that the project concept is appropriate for its intended users. Harrison (1981) mentions typical changes that can influence the clarity and outcome of the project, such as the following: changes in the project scope and specifications during the early stages of development, changes in the project design caused by errors or omissions and unidentified ecological factors embedded in latent conditions.

Hanan (1993) argues that it is important for an executive committee representing all project related participants to review each idea against a set of criteria.

The following should be asked:

- Does the proposed design entity meet the stated needs?
- Would it offer superior value and quality?
- Can it meet the client's needs?
- Does the company have the necessary capital?
- Will the new project deliver the expected growth and profit for the client?

The result of this action is usually a set of one to five concepts, and again each must be represented by a sketch and brief descriptive text. Hanan concludes with the opinion that the project mission and design usually requires several iterations and may even initiate additional concept refinement in order to define the goals, objectives and the scope of works (SoW).

- **Initial needs of competence and commitment**

Baccarini (1999) indicates that project management success in each project life cycle phase requires the competence and commitment of all parties involved. Only then can the scope of the work related to the specific criteria of the project be carried out successfully.

McKillip (1987) indicates that a need is a value judgment that points to an existing problem. However, different parties in an identical situation will perceive the situation differently and therefore a need must always be identified with respect to a particular party or client. That is why the first and second phases are vital for the project development process and why they should be executed in depth.

- **Project initiation protocol**

The conception phase according to Biggs, Birks and Atkins (1980) has two stages:

1. During the first stage it is established that a need or problem exists and that the matter is worthy of investigation.
2. During the second stage the feasibility of a detailed investigation of the need or problem is proposed, possible solutions are sought and the best solutions to the need or problem are selected. It is important that this phase ends with agreement on the specific solution to be presented to the client.

According to McKillip (1987) the above two stages should be underpinned by the fundamental principle. This will ensure that the project will be based on a thorough functional and feasibility analysis, that all participants will benefit and that the client's needs will be met.

- **Identification of needs**

Cusumano and Selby (1995) declare that identification of the need for the project commences with a document from a client which management has approved. It concludes with a preliminary analysis of the scope of work required.

Frame (1987) suggests that the proposed project be analysed and a feasibility study with a project proposal be reviewed and approved by the client. Frame (1987) is of the opinion that in identifying the customer's needs is a process and he presents a five-step methodology. He believes that a little structure goes a long way in facilitating effective project development practices, and that this structure should be viewed as a starting point for continuous improvement and refinement.

Frame's five steps are:

1. Collect raw data from the client to define the scope of work involved.
2. Interpret the raw data in terms of the client's needs by conducting a research analysis to show the feasibility of the proposed solutions and project.
3. Determine the relative importance of the client's needs.
4. Restate and document the client's needs according to the information gained during steps 2 and 3.
5. Review the reformulated needs with the client for his approval.

Concept selection is the process of evaluating concepts with respect to the client's needs and other criteria. It is important to compare the relative strengths and weakness of the concepts, and select one or more concepts for further investigation or development.

2.7.1 (b) FEASIBILITY STUDIES (FS)

Biggs *et al.* (1980) state that the feasibility process is a study of the need, investigation of the problem, and search for solutions in a detailed analysis to determine if the idea is economically viable and worth developing. The current situation regarding a feasibility analysis, the preferred solutions and reasons for their selection will be highlighted in such a study. This phase includes critical success factors such as an environmental study, risk assessment, time and cost estimates and a conceptual design layout. The above authors argue that the feasibility study, combined with the project plan and prices forms the project proposal.

During this initiation phase the purpose, objectives and scope of the proposed project are presented and the functional requirements determined.

Frame (1988) writes that the size of the development is assessed and the scope of the potential project determined during the investigation. He agrees with Biggs *et al.* (1980) that this will serve as a framework for a feasibility study. Frame further states that determining functional requirements at this stage can cause problems for many individuals. He regards it as a simple concept task, however: *what* should be determined is *what* is required, not *how* it should be done. He further recommends obtaining a copy of an existing functional requirements document and using it as a model to measure various alternatives and solutions. He concludes that it is important to have an approved project initiation document available as a platform for approving the assignment of resources.

It is understandable that sufficient information may not be available in the design proposal to do a detailed cost estimate. This will only be possible after the completion of the feasibility and the client has approved the initial presentation. As the project progresses more information will become available and estimates will be more reliable.

The results of the feasibility study are a statement of the problem, a list of needs and reasons for its selection. The feasibility study, when combined with the project plan, bid price and contractor qualification form part of the project proposal.

Roman (1986) is of the opinion that the outcome of the feasibility and proposal study can put the focus on the problem and reveal the list of needs and reasons for selection. The feasibility study forms part of the proposal if it is combined with the project plan, bid price and contractor qualifications. The development process is costly and therefore project investigation frequently requires that a preliminary study, known as a feasibility study be included.

Daft (2005) states the term “feasibility studies” include all the objective and subjective analyses. It also includes economic projections, the legality of the proposed project and its environmental impact. He emphasises the fact that the purpose of the feasibility study is to evaluate different options and to analyse the costs involved. The benefits of each option must be explored so that the most feasible option for development can be proposed. He concludes by saying that a feasibility study is the process of measuring the proposed project against suitable criteria that can influence the go/no-go decision about the project.

The feasibility study is time-consuming and very costly and may take weeks or months to complete, especially in the case of technical projects where a full scale demonstration of the proposed solution has to be included.

2.7.1 (c) PROJECT PROPOSAL (PP)

Hajek (1984) emphasises that developing a proposal can be the equivalent of a good-sized project. Nothing should be overlooked in the proposal preparation and the project manager should use checklists to make sure he includes all the necessary and important items in the proposal. Before the proposal can be submitted to the client, the contractor and top management must be briefed about the project’s scope, required resources, price, etc., and approve it. Hajek (1984) also states that the proposal provides the client with necessary information about the duties of the contractor, his/her basis for selecting the most cost, time and performance effective contractor.

According to Roman (1986) a proposal includes a feasibility study, scope of work and a work breakdown structure (WBS). The project proposal also describes the various procurement options accessible to the client for the specific project and may recommend some of them. After approval of the initial proposal, the project manager will select the project team to prepare the inclusive proposal which will be presented to the client for his review, comments and approval.

2.7.2. PHASE 2: PROJECT PLANNING / DESIGN STAGE

Once the initial project scope and requirements have been established, the high-level design develops through a series of phases such as the conceptual, preliminary, development and, detailed design phases.

Akao and Ed (1990) and Bahill and Chapman (1993) state that the evaluative function must be completed at the end of each major phase of the design process, before proceeding to the next phase to ensure that the design is correct. The evaluation function includes both the informal day-to-day project coordination from data review and the formal design review.

The planning and designing drawings are prepared by professional people and they illustrate the project details graphically. According to Firmage (1980) the design drawings, prepared by the engineer and architect, are referred to as contract drawings after the contract has been signed.

Bockrath (1986) states that a typical set of drawings for the construction of a building consists of the following: (1) general layout and civil works such as roads and parking areas, drainage and landscaping; (2) architectural drawings illustrating all dimensions and locations of all features of the building; (3) mechanical drawings including plumbing, heating, ventilation, air conditioning, special equipment and electrical installations; (4) drawings illustrating the building excavations, foundation types, concrete beams, floor slabs, roof structures, concrete reinforcing designs, steel and other detail structures. Bockrath (1986) concludes by stating that the ecological as well as the feasibility and economical studies must meet the conditions of the various standard codes of conduct and that this should be taken into account during the above stages.

Hamel and Prahalad (1994) argue that another important process is evaluating concepts with respect to the customer's needs. Design concept selection is the activity where various project analyses and needs are included into one design concept.

According to Hanan (1993) the development design usually requires several modifications during the design proposal phases. This ensures that the client and the design engineer will be in agreement regarding the project scope of works.

Lehmann, Gupta and Steckel (1997) think that the engineer should not define the client's problem too broadly or too narrowly and propose the following evaluation process plan:

1 Identify the problem and research the objectives.
2 Develop the research plan.
3 Collect the information.
4 Analyse the information.
5 Present the findings to the client and the team members.

They further recommend that the needs be evaluated against the strengths and weaknesses of the various design concepts, and that a selection of one or more concepts should be further investigated, if necessary. The above authors mention that project related technical information documents underpin and reinforce the project during the planning and design phase.

Dellacave (1996) advises that the engineer or project manager assists the client in determining general project feasibility. He suggests that the following questions be answered:

- Is the project viable at all?
- What sites are available that should be considered?
- What is the cost of the various alternatives?
- How much time is needed to execute the project?

Even though the client receives preliminary information at this stage, he needs it in order to:

- Decide whether to proceed; and
- Seek the funding, if it is decided to proceed.

During the design phase, the project manager will often engage the services of outside designers/consultants who will be responsible for specialised aspects of the design, such as electrical installation, the reinforcement designs for foundation, concrete columns, beams, floors slabs and structural steel and roof designs. The contract should state who would have responsibility for the design and whether there would be site supervision.

2.7.2 (a) PROJECT DESIGN AND ANALYSIS

After the client's needs have been determined, the proposed design goes through successive stages as the design cycle is repeated by one engineer after the other. According to Akao and Ed (1990) and Bahill and Chapman (1993) the analysis provides specifications based on a detailed investigation of the feasibility studies. Project design is a design for an efficient and effective project structure that complies with the specifications obtained during the analysis stage. The feasibility research will balance the specifications, bill of quantities, and time, cost and fairness requirements of the project.

- **Design requirements**

Akao and Ed (1990) and Bahill and Chapman (1993) emphasise that this function is part of phase 1 and 2. It involves feasibility, environmental and design reviews and is one of the most important aspects to be addressed. In the traditional approach to verification checklists of attributes are used, such as:

1 Each requirement should be noted as being mandatory, secondary or tertiary.
2 The client should approve the requirements.
3 Each requirement should be confirmed in the developed project plan.

The above requirements are to ensure that the client is involved in all activities of the project (SoW). One example is the matter of soil analysis. These conditions are very difficult to predict, especially when environmental and feasibility studies have not been executed during the second phase of the project. At the first site inspection the soil may seem to be suitable but soil analysis density test may show different results. The type of soil will determine the foundation design required for the development loadings.

The results of a soil density test can therefore have cost implications or result in a later completion date. They can also lead to the conclusion that the project is not economically viable at all. It is vital that a full layout of all items and activities be stipulated from an early stage on all design documents. This needs to be monitored by way of a check list and relevant dates and signed and approved by the relevant role players. In this way there will be a traceable path of evidence on record.

- **Design of the concept**

Reswick (1962) states design process starts with the recognition of a need and the conception of an idea to meet that need. These steps are followed by the definition of the problem and a programme of research and development. These lead to the construction and evaluation of a project. Reswick (1962) also states that the design is the process of creating a model that will meet an identified need. The engineer carries out some logical sequence of activities, decisions, and analyses to develop a solution to the problem within the development design process. However, this solution is of little use unless the engineer communicates the solution via drawings, specifications, financial estimates, written reports, and oral presentations to the client and the other project participants.

- **Elements of design**

Akao and Ed (1990) and Bahill and Chapman (1993) state that design elements can be evaluated by checklists similar to those used in stage 1 where requirements are clarified to meet the specifications of the client. An important aspect of design elements is the analysis of risk factors. There are several analytic methods and standard codes of practice available with which to analyse design proposals.

These methods are used to ensure that elements of verification loads and the reliability of the proposed design will meet standard codes of conduct.

Cooper (1986) is of the opinion that only one out of every four fully-developed new projects becomes a success.

- **Design and quality requirements**

As indicated by Biggs *et al*. (1980) the first phase of project development is defining the design problem or scope.

During this phase, the project manager should ask questions such as:

1. What is the function and intension of the desired project?
2. What performance characteristics must be met?
3. What restrictions, including legal restrictions, limit the solution?
4. What methods will be used to evaluate the quality of the design solution?

Wilson and Wilson (1970) identify four categories of objectives and goals for the solution:

- Musts: requirements that must be met.
- Must not: constraints defining what the project must not be or do.
- Wants: features what significantly enhance the value of the solution.
- Do not want: characteristics that reduce the value of the solution.

Wilson and Wilson (1970) think that these measures may lead to a set of functional requirements that the design solution should be made to achieve. It is crucial at this stage to have a preliminary identification of the potential barriers to the development and presentation of the project.

- **Project cost estimation**

During either the initiation stage or a later stage a need will arise for an estimate of the length and, by extension, the cost of the project.

Harrison (1981) and Kerzner (1992) refer in their research to this form of estimate as an ongoing exercise during projects. They usually involve cost increases. An "estimate" is a package of information that describes the anticipated potential resource requirements for a particular project and its specific characteristics and attributes.

Archibald (1976) in his research argues that a project design schedule is necessary because of concept changes, development barriers, strikes and legal cost estimates. He thinks that the project design schedule should be regularly updated so that it remains a valid baseline for tracking and controlling project costs. For him an "estimate" is one possible scenario among many that make up a set of possible solutions. An estimate is bound by project risks and/or uncertainties. A specific amount called a contingency fund or budget reserve is usually added to the original estimate to be used in the case of unavoidable cost overruns (i.e. VOs).

- **Project planning process**

Meredith and Mantel (1995) state that planning provides a process for the organisation to identify significant development aspects that should be addressed by the project management process (PMP).

Project planning does not require justification, of course. It can be defined as the planning of a project by breaking the main objective down into manageable events and tasks; scheduling these events and tasks in a certain order; and assigning funds with which to complete the events (deliverables). It is important that the components of the project be managed and the results evaluated.

- **Planning objectives**

According to Manzi (1984) and Schoumacher (1986) development planning has both strategic and calculated aspects. Strategic planning defines the objective; evaluate macro issues and shows where you want to be in any given period. Tactical planning uses the strategic plan to develop a detailed road map of how the results will be achieved. This plan should describe who is to do what; how long it will take; in what sequence the activities are to be undertaken; and at what cost. These aspects will give all participants a common direction and a frame of reference within which they are empowered to make decisions.

A detailed plan provides a formal medium for the project and construction manager to accept responsibility for the project or to decline to do so. The detailed plan will indicate to the project manager that all the participants are in agreement regarding the scope and objectives of the project. Signing the plan will establish the relationship between role players and their commitment to deliverables and the anticipated activities that will lead to a common goal, the end project. The purpose of the detailed plan is to determine the best way to complete a project on time and within budget.

2.7.2 (b) PROJECT SPECIFICATION (PS)

The goal of construction or engineering documents is to communicate the needs of the client as represented by a design in a way that is easily understood by those responsible for the construction project.

Goldbloom (1992) reminds us of a fundamental legal principle: when there is disagreement over specification language, the courts will most likely interpret the language against the party who authored it, who is usually the project manager or engineer. He emphasises the importance of clarity, briefness, and simplicity in construction specifications.

Specifications outline the quality levels and the standards which will make the construction of a development possible. A specification is a detailed description of all workmanship and materials necessary to execute a specific project in accordance with detailed drawings.

The following should be included in the specifications:

1 A description of the work to be performed, including material and equipment requirements and conditions for that performance.

2 The manner in which the quality and acceptability of the work will be determined.

3 Allowable tolerances and how deviations from these tolerances will be handled within the standard design parameters.

4 The manner in which payment for the work will be made.

5 The manner in which changing conditions are to be managed.

Bockrath (1986) and Vaughn (1983) argue that it is essential that contractors have this information as they base their tender bids and their plans for managing and executing the work if their bid is accepted on the specifications. After the contract has been agreed upon and signed, no additional duties or restrictions can be imposed on the contractor without modifying the contract.

2.7.2 (c) THE BILL OF QUANTITIES (BoQ)

The bill of quantities (BoQ) does not always form an essential part of the contract as do the drawings and specifications. Sometimes the bill is excluded from the contract on purpose, except in so far as it is supplied as a list of prices by which variations and extras can be valued. By basing the contract on the drawings, specifications and conditions of the contract and inviting contractors to include everything necessary for the completion of the work as shown in the specifications, the client will have the full scope of what the project will cost him when the project is delivered, including omissions in the bill of quantities.

2.7.2 (d) SCHEDULE OF PRICES (SoP)

An alternative document, similar to the bill of quantities and also as part of the contract is a schedule of prices (SoP), which is a list of all materials and labour necessary, or likely to be necessary for the completion of the work as stated by Kerzner (1989) and Eisner (1988).

In some cases it can include approximate quantities of each item for the guidance of the contractor in his pricing. The contractor puts his unit price to each activity/item in the SoP and the total then determines the contract price, which is finally calculated upon completion of all said activities.

2.7.2 (e) ENVIRONMENTAL STUDIES (ES)

It is essential to consider the impact of the design on the environment. Environment, in this context, refers to the numerous external factors that must be considered in the development process. In addition to the technological and economic factors, one must deal with ecological, political and social considerations as well according to Harrison (1981). The system being developed must be compatible with its environment and must ultimately exist within that environment.

A full environment study must be done to consider the following: temperature, shock, vibration, humidity, pressure, wind, salt spray, sand, dust, rain, fungus, radiation, and traffic and noise levels. The results must form part of the overall design. In addition a soil analysis, access to the site and delivery of materials to the site must form part of the investigation. The full range of conditions, including extremes, must be specified and properly addressed.

2.7.3 PHASE 3: PROJECT IMPLEMENTATION / CONSTRUCTION

The life cycle of projects can usually be broken into sequential phases which are differentiated by the technical work required for each phase. The Project Management Institute (2004) states that key role players produce the deliverables and determine the ways in which these are controlled and approved.

As indicated in the research review above, the conditions required to ensure project management success in each life-cycle phase involve the skills and commitment of the concerned parties in carrying out the scope of work of the various phases, as well as other external environmental conditions of these activities.

The *PMBOK Guide* (2001) states that planning, monitoring and controlling the project work is “the process of tracking, reviewing, and regulating the progress to meet the performance objectives defined in the project management plan”. *PMBOK* (2001) also writes that planning and monitoring include regular status reporting, progress measurement and forecasting. Regular performance reports provide information on the project's performance with regard to scope, schedule, cost, resources, quality and risk, all of which can be used as inputs in other processes.

Baccarini (1999), Liu and Walker (1998) and Pinto and Mantel (1990) attempt to define project success by means of three different measurements:

1. The efficiency of the implementation process that is "an internally oriented measure of performance of the project team". This includes criteria such as staying on schedule, on budget, meeting the technical goals of the project, and maintaining smooth working relationships within the team and parent organisation;
2. The supposed quality of the project and the project team's perception of the value and usefulness of the project deliverables;
3. External measurement of project performance and the project team as well as the client's satisfaction.

Martin (1974), Locke (1984), and Pinto and Slevin (1987) are of the opinion that careful recruitment of the right project manager and personnel is crucial to project success. Cleland and King (1983) highlight the value of effective training to build the capacities required for the project. White and Fortune (2002) add that relevant project experience and competencies play a vital role in project success.

Project execution is the phase where visions become reality. This is the logical conclusion after all the documents have been drawn up and approved by the client.

2.7.3 (a) PROJECT RISK MANAGEMENT (PRM)

Argus and Gunderson (1997) describe risk as a type of work or technical function, such as engineering risk associated with construction or product manufacturing. Risk identification starts in the conception phase and focuses on those high risk factors that would make the project difficult or destined to fail. They further state that sources or causes of high risk must be studied and well understood before the project can be approved and funds committed. Risk identified in the conception phase are often broadly defined and subjectively assessed, though they can also be analysed using the assessment and reliability as well as feasibility methods.

Project risk management requires project and construction managers to be proactive and prepare for possible events in advance, rather than reacting to them after they have occurred.

- **Risk management involves three elements:**

1 Risk identification:

Risk identification must be sub-divided into two distinct forms of risk: business risk and insurable risk. Business risk involves the likelihood of profit from any business endeavour (*PMBOK Guide* (1987) and VanScoy (1992). Insurable risk is only negative in nature; there is no change, only loss. In assessing probability of both types of risk, it is important to analyse the environmental issues seeking to determine the relevant risk factors as early as possible which may derail the project.

2 Impact analysis:

Impact analysis is another element of risk management. It is important to determine the potential sources of risk in the environment but equally important to assess the impact that each intervening event can have on project success. Impact analysis, in its simplest form, typically consists of breaking down each project activity or external intervening event into categories of high risk, moderate risk, and low risk. VanScoy (1992) further argues that the likelihood of each source of risk occurring should be examined to develop a clearer picture of the status or degree of risk of the project.

3 Response planning:

According to *PMBOK Guide* (1987) the final component of risk management is response planning. Project risk should be associated with complementary contingency plans so that problems can be addressed if and when they are discovered. Pinto and Mantel (1990) claim that the biggest single cause of project failure is the absence of adequate contingency plans to bring a project back on track in the event of an accidental failure.

2.7.3 (b) PROJECT WORK BREAKDOWN STRUCTURES (WBS)

It is the opinion of Cleland and King (1983) that the work task defined in the SoW section along with the detailed list of deliverables is the basis for outlining the WBS. The WBS is the main breakdown of the project into manageable components that produce the project deliverables. It is a technique for organising and subdividing all the work and deliverables into more manageable components and forms the framework for further planning by creating a baseline plan to execute the project work. A high-level WBS may include a graphic chart format.

Archibald (1976) explains the importance of milestones, the key dates for major project phases or activities. He regards them as vital for detailed planning. They make possible the coordination of the workforce during the entire project. Examples from a typical project are: “go-ahead” (start), design reviews ending each design phase, 90% drawing release, start of each major test phase and delivery of first prototype of concrete precast beams. Milestones also include the customer’s required delivery dates.

2.7.3 (c) PROJECT QUALITY CONTROL (QC)

Crosby (1979) claims that a major concern in any construction project is quality; the non-achievement of quality often leads to client dissatisfaction.

According to Dainty, A.R.J., Cheng, M. and Moore, D.R. (2003) skills shortages, which is a problem in the construction industry, leads to poor quality results? Bach (1995) questions the validity of the term “good quality”. He feels that striving for the best possible quality often results in a very expensive project and those clients often do not notice the difference between the best possible quality and pretty good quality.

Crosby (1979) argues that the clients do not really know what the actual meaning of good quality is especially when the client purchases a particular product or service instead of competing alternatives because of its higher quality. Crosby (1979) concludes that in this context, quality will refer to a higher level of reliability at a given level of performance to the specified specifications. This occurs when contractors employ unskilled labour to perform project construction related tasks.

A well-structured quality control plan must include the following: specifications, industry or government standards (for design, testing, safety, construction, and so forth), and codes that must be used to meet performance standards of the project design and construction execution.

Kransdroff (1996) makes the statement that quality control can be contrasted to scope verification whereas scope verification refers to the acceptability of project deliverables by the client. Quality control refers to validating the trustworthiness of specifications and standards already set out in the specifications. Scope confirmation includes verifying the acceptability of those specifications and standards. It is the opinion of Kransdroff that the quality control inspections should make sure that deliverables will meet the specifications and design code standards before handover to the client.

Industrial standard codes of practice and local building codes are fundamental when choosing materials and building the design structure’s foundations, columns, beams, roof structures and supporting walls and these codes must be stated and noted in the appropriate project documents such as technical specifications and acceptance criteria. It is vital that these standards be communicated to the members of the project team at the outset of the project and before construction begins. The quality plan may also require suppliers to provide documentation certifying that the materials they supply meet certain required specification standards.

- **Expectations in service delivery**

Parasuraman, Zeithaml and Berry (1985) argue in their research that there are five main requirements for delivering quality service:

1. There is often a difference between the expectations of the client and other participants.
2. There can often be a misunderstanding between management (company) perception and quality specification in order to specify a performance standard code.
3. There may be a discrepancy between service-quality, specifications and service delivery. Problems in this regard occur when personnel have an inadequate level of expertise or are poorly trained and are therefore incapable of meeting the required performance standard.
4. A communication breakdown may lead to misconceptions. It is very important that the project team must realise that statements made during presentations as well as during the phase of service delivery can affect the client's expectations.
5. There is often a discrepancy between perceived service and expected service. This can lead to a client having misconceptions regarding service quality.

Kaminetzky (1991) expresses the importance of the client being able to convey the purpose and requirements of the structure to the designer. He claims that a major problem is that the client's real requirements may not be made fully clear during the initial planning stage. He is of the opinion that it is the duty of the project manager and team to make sure, through in-depth discussions, that they understand the client's needs, as well as the design and the scope of work.

2.7.3 (d) PERFORMANCE MANAGEMENT

Performance in this context is meeting the conditions as specified in the SoW.
Bockrath (1986) defines substantial performance as the accomplishment of all things essential to the fulfilment of the purpose of the contract, although there may be insignificant deviations from certain contractual terms or specifications.

Shannon (1980) states performance management steps are simple but important:

- The first step establishing the standard of performance is essential and should always be part of effective planning. It is important that standards should be measurable, verifiable and tangible. In this step, the standard rate of production by work measurement of time and motion studies should be identified and put in place.
- Secondly, the actual level of performance achieved by measurement of time and motion studies must be calculated.
- The third step is to compare two measurements of the variance (deviations between them).
- The final step is taking corrective action if required.

According to Pillai, Joshi and Rao (2002) a performance measurement system should be implemented to reflect the needs and expectations of all the stakeholders during all the phases of the project. This system, according to the above authors, can be in terms of technical design, construction or commercially related subjects. Measurement should be at the planning and design, manufacturing and construction levels and includes the overall performance of the company.

- **Effective communication**

Kerzner (1992) confirms that a project manager should create a working climate conductive to teamwork. He should nurture a spirit of open communication between all project related team members as well as between the client, contractor and his top management.

Blake and Mouton (1969) are of the opinion that planning and communication are as barriers. They argue that the character of supervision is often the underlying cause of communication difficulties and that the style of supervision is influenced by the supervisor’s knowledge of theories of human behaviour (or lack thereof). A project manager may be technically competent, but if he does not have a good understanding of human motivation and group dynamics he will not be able to generate the best results. Such a manager will not be able to establish a climate that provides clear objectives, full commitment, and the closeness of cooperation within the project team.

- **Kick-off meeting**

Before the contractor starts working on the site, the project and construction manager must hold a kick-off meeting which all relevant parties will attend. The purpose of this meeting is to introduce all parties to one another and to review the requirements of the project.

Archibald (1976) writes that the contractor commences the mobilisation stage immediately after his appointment. He appoints subcontractors for the first stage of the project and also begins to set up the site. The project manager has to check that the contractor's insurance and health and safety plans are in place.

Archibald (1976) also states that the project manager has to clarify the following with the main contractor:

- Contract documents are prepared, agreed and signed off.
- The work breakdown study (WBS) is completed.
- Handover of the site to the contractor.
- Contractor's construction schedule and method statements.
- Regular site meetings to monitor the progress of the project.
- Monitoring of construction activities and performance.
- The timeous provision of relevant design information is given to the contractor.
- Regular site inspections and quality control.
- Progress report to the client.
- Statutory approvals are obtained.
- Environmental issues are addressed.

All the above actions need to be taken if the contractor is to deliver the development in accordance with the contract and standard codes of conduct.

- **Regular site meetings**

The project manager will chair regular meetings, the primary method of controlling and reviewing progress. According to Archibald (1976) the main points to be covered are:

- Progress versus programme, procurement and resources management.
- Relevant information required should reflect in the programme.
- Change control; or technical queries and instructions.
- Method statements in particular for plant change-over and disruptive works which must be planned in advance.
- Commercial issues such as warranties, claims, valuations and the agreement on variations (VOs).

2.7.3 (e) APPROVED DESIGN DRAWINGS

The output from the construction documents phase is a set of documents that will form the basis of the contract between the contractor and the client. It includes final drawings and technical specifications, as well as general and special conditions and other written literature that will be part of the construction contract.

During the design phase projects such as a new development, alterations on existing buildings, renovations, road-crossing bridges or other construction related work requiring the service of an engineer and project manager, may require one or more design review meetings. This is to ensure that the client agrees and approves the design and development approach development by the project team or contractor.

In many projects, more than one meeting is needed for the following reasons:

1 A preliminary design review meeting occurs when the project team or the contractor/engineer has completed the initial design, concept drawings, specifications or flowchart. The purpose of this meeting is to get the client's agreement that the design approach meets the requirements and purpose as well as to gain approval from the client before ordering certain materials. There is often a long delivery time and this meeting eliminate unnecessary delays in the project schedule.

2 A final design review meeting occurs when the project team or contractor has completed the detailed drawings and has to make sure that they meet the client's expectations.

Firmage (1980) argues that design drawings should include the standard code of practice specifications and feasibility assessment reports as well as other related documents. The design drawings should be prepared by the engineer or architect. At this stage they are called design drawings but after the contract has been signed and the drawings incorporated in the contract, they are referred to as contract drawings.

The purpose of the final design review meeting is to gain approval from the client before starting the construction and project deliverables.

2.7.3 (f) CONTRACTUAL PAYMENTS (CP)

West Ridge Natural Science Facility (1992) prescribed 65 general conditions on which contractual payments to the contractor will be paid by instalments during the progress of the work. It is necessary to precisely lay down the conditions under which the client or project manager will make these payments. Firstly, the contractual payments are made on the authority of the project manager who is not a party to the contract. Secondly, unless agreed otherwise, payment for work completed and the entire lump sum become due only when the work is completed.

The project manager's authority for payment is given in the form of certificates in writing and issued from time to time to the contractor, usually when the value of the work executed and materials delivered has reached the amount specified in the conditions of the contract (CoC). Payment is then due on fixed proportional intervals of the rated value, up to 90 per cent of that value. The balance of 10 per cent is paid in two instalments, one when the work is completed and handed over to the client, the other at the end of the maintenance period which is usually six months after hand-over and when the project manager has given his final certificate that the entire work has been carried out and maintained to his satisfaction.

The client is liable for payment to the contractor and the only grounds to resist payment would be fraud by the project manager, project team of contractor.

2.7.3 (g) OMISSIONS, EXTRAS AND VARIATIONS (VOS')

Bockrath (1986) emphasises that the project manager should be responsible to oversee the project on behalf of the client. The construction document is a set of documents that form the basis for entering into a contract with the contractor. It includes final drawings and technical documentation, BoQ, WBS, SoW and a specification of works. The general and special conditions as well as all other written literature will be part of the construction contract. Bockrath (1986) further states that in the absence of special provisions added to the contract, a contract cannot be altered in terms and there can be no omissions, additions or variation orders (VO) without the consent of the parties concerned. Care should be taken in the preparation of the drawings and specifications to avoid those extras but construction works can often not be carried out without some variation from the original design. It is therefore necessary to include a clause in the conditions of the contract permitting the client or project manager to make alterations if necessary.

Silverman (1988) proposes that the project manager should have complete control of such alterations and it must be made clear that no omissions, alterations or variations may be made without the written authority of the engineer via the project manager and the client. This is particularly important in the case of alterations, as they may give rise to a claim for extra payment if there is no guarantee that the work can be carried out in the manner shown on the drawings or described in the specifications. For this reason most contracts have a provision that the contractor must include everything necessary for the due performance of the work in his contract and specifications.

The amount to be paid for extra work known as the variation order (VO) is determined by the engineer or project manager who uses the prices in the bill of quantities that are applicable for work of a similar character. If no price in the bill is applicable, the contract should provide for the settlement of the amount to be paid before the commencement of the work.

SECTION 3: PHASE 4

2.7.4 CLOSE-OUT AND LESSONS LEARNED PHASE

The fourth and final phase of the project life cycle is closing the project.

The close-out meeting is held after the project work has been completed and the client has accepted the project and its final deliverables. Such deliverables may include training or procedure manuals, drawings and spare equipment parts. An important activity during the closing phase is ensuring that all payments have been collected from the customer. Many contracts include a progress payment clause which specifies that the client is to make the final payment at the completion of the project. After all payments have been received and made, the accounting records can be finalised and a financial analysis of the project in which final actual costs are compared to the project baseline budget can be made.

The project manager can make sure that the following activities were successfully addressed:

- How successful was the project?
- How did the final scope of work compare to the scope of work at the start of the project?

- Was the client expectations addressed and was he satisfied with the capital investment in the project?

2.7.5 SUMMARY

This chapter has reviewed comprehensive literature on project management principles and laid the foundation on which the following chapters will be formulated to review and assess the proposed quantitative survey and qualitative case study research. This was important to investigate and validate the research objective and the research questions. The comprehensive literature covered in this chapter provides a framework for the project manager and shows that it is his or her responsibility to identify and determine the risk factors inherent in the project and to formulate a plan of action which will ensure the successful delivery of the project (as illustrated in Diagram 2:1 Chapter layout, pp. 29) The layout demonstrates the most important activities during the project; if they are executed all the needs and requirements of the project should be addressed successfully and the project manager should be able to take the project successfully through all its life cycles.

Any project whether it's a construction development, manufacturing of an aircraft or a mining development requires a plan of action. Some projects are more complicated than others due to latent elements. These hidden aspects which can result in problems and delays can have many causes, such as people, environment, project scope, risk, time, quality, cost, project and construction knowledge and experience. The project and construction manager must have sufficient experience and knowledge to pinpoint the possibility of the existence of these elements within the life cycle phases of the project, keep possible solutions in mind and reconcile them with the demands of the project and needs of the client before the commencement of the project. The importance of knowledge of project management principles, leadership skills, and therefore, postgraduate education is of the utmost significance.

Although the engineer with a bachelor's degree does have academic knowledge regarding project management, the researcher argues that all projects have latent issues within the above-mentioned elements that need to be exposed well ahead of the start of the project if the project is to be safeguarded from failing. This argument will be fully investigated and contested by means of a qualitative case study analysis (Chapters 5 and 6) by means of which the extent of the knowledge and experience of the engineer as project manager will be revealed.

The researcher agrees with Hoffman (1989) when he argues that it takes years of experience and knowledge to recognise and identify latent issues during the initial project phases and to rectify them before it is too late.

The researcher further argues that failure regarding a single element may well impact the effect of a lack of knowledge and experience in the project life cycle phases which can affect the critical success factors of project management during any stage or phase of a project. Project management is a specialised field of engineering demanding a high level of postgraduate academic knowledge and practical experience and engineers who wish to attain that level of expertise should be encouraged and given every opportunity to do so (Roberts and Biddle, 1994).

CHAPTER 3 RESEARCH METHODOLOGY

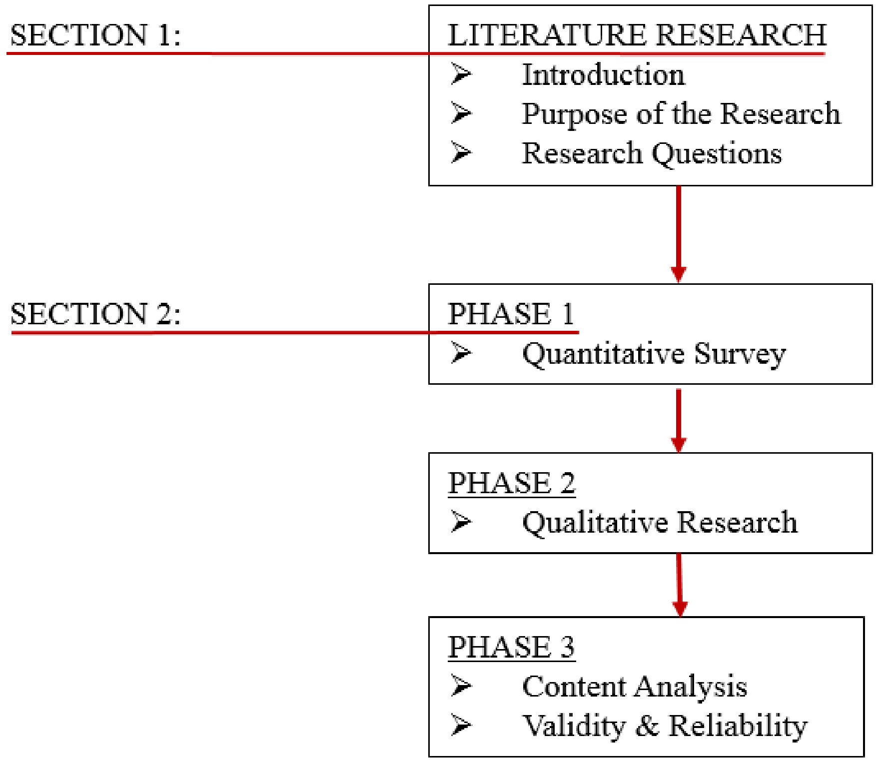


Diagram 3.1: Chapter Layout

SECTION 1

3.1 INTRODUCTION

Research is always conducted for a specific reason, for instance to answer a specific question, to solve a particular problem or to resolve an argument. The purpose of this study is to identify the effect of a lack of knowledge and experience on the part of the project manager affecting the critical success factors of project management.

The previous chapter discussed the literature on project management philosophy and methodology and then formulate essential project management principles. The research literature also formulates the basis required to disclose uncertainty in the research topic by way of discussing the research objectives and research questions. Because of possible uncertainty the researcher decided to conduct a study which includes both quantitative and qualitative research analyses.

3.1.1 PURPOSE OF THE RESEARCH

In order to address the research topic, the literature on project management methodology and project success factors was reviewed in chapter 2.

The literature review also form the basis of the research topic and research questions as presented by Creswell (1994 and 2008).

The discussion on the research method will include the following:

1 The research topic.
2 The research problem.
3 Evidence gathered from the literature that justifies the research.
4 Deficiencies in evidence.
5 Identify the primary and secondary success factors.
6 Importance of the programme for the client, stating the following:
   - The case study evaluation will be conducted by means of coding and content analysis.
   - The research problem: why and how the effect of a lack of knowledge and experience in the project life cycle can influence the critical success factors.
   - Twenty-five critical success factors are mentioned in the questionnaire. Quantitative as well as qualitative surveys will determine fifteen most critical success factors.
   - Factual evidence will be provided from the literature and then amalgamated with practical evidence from the project management and construction environment.

3.1.2 RESEARCH INSTRUMENT

A quantitative survey instrument (five point Likert scale) was used to rank the critical success factors. The instrument was used to implement a ranking analysis instead of a rating analysis. Kohn (1977) and Rokeach (1973) argue that ranking (qualitative) is often viewed as conceptually more appropriate for value measurement but also difficult for the participants. According to them ratings (quantitative) are thought to be easier to administrate and less difficult for participants.

The five point Likert scale will also be suitable to accommodate Pinto & Slevin's (1989) hypothesis of "to tabulate individual factors rather than grouping them according to some criteria to help analyse the interaction between them and the possible consequences".

The survey instrument will also determine the fifteen most critical success factors of the twenty-five listed in the questionnaire. Why and how a lack of knowledge and experience on the part of the project manager within the project life cycle phases affecting the critical success factors will also be determined. The qualitative research analysis will prove the statement of Pinto & Slevin (1989) given above, while both the quantitative and qualitative analyses answer the research questions.

This research will identify what the reasons are to reveal the research objectives listed above. This process will be further reviewed in more detail in chapter four.

3.2 RESEARCH QUESTION

Spradley (1980) states that a researcher normally reduces her or his research study by formulating a single, overarching central question and following that up with several secondary questions.

Following Spradley, the main and secondary questions of this research were formulated as follows:

The primary research question is:

What are the main success factors in project management in the design and construction industry?

The secondary research questions are as follows:

2 How do the critical success factors affect the project life cycle?

3 How can the effect of a lack of knowledge and experience on the part of the project manager within the project life cycle phases influence the critical success factors of project management?

4 Why are these critical success factors important to be implemented?

3.3 RESEARCH METHODOLOGY

When the relevant literature has been studied and the research questions formulated, the next step in the research process is to decide on the most suitable methodology approach.

Cooper and Schindler (2003) argue that the research approach limits itself to the chosen data collection methodology or case studies. The literature reviewed in the previous chapter pointed to the fact that the complexity of the field of study would require more than a simple research methodology. A combination of a quantitative survey and a qualitative case study analysis was therefore chosen. The quantitative survey should be completed first, as the case study will allow questions or problems that arose from the results of the quantitative survey to be addressed.

Hence the sequence will be:

Phase 1 Quantitative survey study and sample size (Pinto and Slevin 1987)

Phase 2 Qualitative case study analyses

Phase 3 Content analysis

Ranking versus rating on a Likert scale was performed. Harzing *et al.* (2009) and Creswell (1994) argue that qualitative research questions should be open-ended, evolving and without limitations.

Quantitative survey research was carried out by sending the survey questionnaires to various participants to identify the critical success factors and grouping these factors by a ranking versus rating theory.
Qualitative case study analysis: Evaluation and verification of four case studies will be reviewed and assessed in correlation to the questionnaire for a reliable outcome.

3.4 RESEARCH ANALYSIS

The research procedures and analyses will be discussed and assessed in chapters 4 and 5.

To find solutions for the research questions, Pinto and Slevin's (1989) theory of ranking versus rating will be applied. The research will be conducted by means of the five point Likert scale application as defined by Krosnick and Alwin (1988) and Alwin and Krosnick (1985) for both the quantitative analysis and qualitative studies.

3.5 TARGET POPULATION AND/OR PARTICIPANTS

Asmussen and Creswell (1995) suggest that a variation of case studies be selected to cover maximum differences as a sampling strategy which will, in turn, make a diverse case analysis possible.

Carey (1975) states that there are no definitive guidelines regarding sample size, both in a quantitative or qualitative study. The final decision will be a compromise between the practical and theoretical requirements of the study. Other considerations such as time, cost and resources available to the researcher also have to be taken into account.

The sample size will be obtained by inviting a large number of engineers in Gauteng, S.A. via email or handouts to participate voluntarily in the research. Those who indicate that they are willing to participate and, in fact, complete the questionnaire, will form the size of the sample. The participants will be assured that their answers and identity or company will be treated with confidentiality and that the survey will not request any identification from the respondent**.** See response rate in Chapter 4; Table 4.1 and 4.2.

For this research selected participants in the construction and development environment were targeted. These participants represent the engineering profession as engineers, project managers, consultants and contractors in South Africa.

A concern about quality expressed by the *South African Construction Industry publication (CIDB)* (2011) justifies the decision to target this specific industry. The researcher shares the above concerns and with this in mind drew up a questionnaire based on available information. The proposed questionnaire (questionnaire specimen) will indicate the extent to which the five main factors (Chapter 2: Section B) in the project life cycle have contributed to the research topic after the participants have replied and when the selected case studies have been analysed.

3.6 RESEARCH DESIGN

The design and methodology of this research was chosen to assess project teams' knowledge and practice and to discover the most important ways in which it affects the current project life cycle phases. Both qualitative and quantitative procedures are used to find out whether there is a correlation between critical success factors for project management in construction industry and to assess the critical factors affecting the project life cycle domain.

In the construction and development industry there are several ways to discover which success factors are critical. The researcher also needs to find out why and how these success factors influence typical industry problems and at what stage in the project life cycle they emerge.

Bryman and Bell (2003) are of the opinion that both quantitative and qualitative techniques are useful for conducting a research while other authors believe that qualitative techniques are more appropriate for researching development issues.

Ghauri and Gronhaug (2002) and Reichardt and Cook (1979) on the other hand, strongly support the qualitative approach. They find it to be more factual. When the scope of this research is taken into account, it must be said that quantitative methods will probably provide more valid data. However qualitative methods are more flexible and can be used to include different aspects of the research question and therefore develop a more in-depth study.

Jankowicz (1991) argues that these two research approaches can complement each other and lead to a sound analysis of the research.

Bryman and Bell (2003) support the above author's statement. One advantage of using the two approaches together is that it enforces the triangulation or content analysis model. When data from different sources are considered, there should also be an increase in the validity of the findings.

Semi–structured interviews were chosen as a data collection technique to explore the research question in depth and add value to our knowledge of success factors in the construction industry.

3.7 SURVEY DESIGN

According to Kothari (2004) a descriptive design involves planning and organising as well as the analysis of the data to provide the information that is being sought. This design provides a great depth of responses, and therefore results in a better understanding of the phenomenon under study.

The survey design involves the gathering of data that will describe certain events, as well as the tabulation and interpretation of those data.

Descriptive studies represent the variables by answering who, what and how questions (Babbie 1998). According to Mugenda and Mugenda (2003) descriptive design is a process of collecting data in order to test hypothesis or answer the questions of the current status of the research. This method is used extensively to describe behaviour, attitude, characteristic and values. The survey design evaluates the research topic at hand.

SECTION 2

3.8 QUANTITATIVE SURVEY METHODOLOGY

3.8.1 PHASE 1: RESEARCH DESIGN INSTRUMENT

According to Beardsworth (1980) there are several stages involved in developing a sampling strategy. Firstly, the range of the content to be studied (the participants of your research) has to be defined. Secondly, a decision is to be made about what the sampling unit is to represent. Beardsworth (1980) is of the opinion that the sample consists of people or institutions, the sampling unit is self-evident, but that the unit of analysis is not readily identified when texts are involved. Some quantitative content analysis studies have a very precise focus.

Gill and Johnson (2010) argue that questionnaires tend to be used for descriptive or explanatory research. They add that although questionnaires may be used as the only data collection method, it may be better to link them with other methods in a research design.

3.8.2 QUANTITATIVE RESEARCH METHOD

A quantitative research method is a systematic approach whereby data of various relationships and phenomena are gathered. This method will ask specific questions to collect and analyse numerical data using a statistical instrument. The quantitative research questionnaire is designed to collect data from experiments and other surveys and by means of correlation (Creswell, 2008). Statistics from the data derived from quantitative research allow the researcher to check the relationship between variables.

Pekrun and Stephens (2010) explain that the data collection method relies on various samples, and that the structured data collected are made to fit into predetermined response categories.

Saunders, Lewis and Thornhill (2007 and 2009) claims that the results from quantitative methods are straightforward and easy to categorise, compare and summarise. The core of quantitative research is testing the hypothesis or research question that was formulated after a preliminary study of a phenomenon and/or various theories.

In this research the participants were selected to evaluate the research questionnaire and to give their personal evaluations. The participants were selected from the design and construction environment industry. The outcomes of the questionnaires were statistically categorised.

3.8.3 RESEARCH QUESTION

The main research question is: What are the main success factors in project management in the design and construction industry?

3.8.4 DESIGNING THE QUESTIONNAIRE

Pinto and Slevin (1989) considered the success factors identified by themselves and eleven other international researchers (Martin (1976); Locke (1984); Sayles and Chandler (1971); Baker, *et.al* (1983); Morris and Hough (1987); and Cleland and King (1983) and found a total of 71 of these success factors in the literature. The above researchers then reviewed these success factors, deleted duplications and narrowed the number down to 40 success factors. Pinto and Slevin (1989) concluded: "*Although several lists of factors are generated, they seem to tabulate individual factors rather than grouping them according to some criteria, to help analyse the interaction between them and the possible consequences*". By using various criteria Pinto and Slevin (1989) then reduced the number of success factors to 25.

For the purpose of this study the researcher also selected 25 critical success factors out of 71 identified by the thirteen authors. The survey questionnaire requested the participants to select, out of the 25 success factors listed and across all four phases, the 15 or more critical success factors that they deemed the most important.

This research questionnaire was designed by using a template used by various researchers such as mentioned above (Annexure 1: National Survey Questionnaire as compiled by the researcher, pp. 218).

Foddy (1994) discusses validity and reliability in terms of the questions and answers. In particular, he emphasises that the questions must be understood by the participant in the way intended by the researcher. The answer given by the participant must be understood by the researcher in the way intended by the participant. This means that there are various stages that must occur if the question is to be valid and reliable. It also means that the design stage is likely to involve substantial rewriting in order to ensure that the participant decodes the question in the way the researcher intended.

A descriptive survey design was adopted for this study. According to Kothari (2004) a descriptive design involves the planning, organising, collecting and analysing of data so as to provide the information being sought. This design provides a great depth of responses resulting in a better and more detailed understanding of the study.

This research design involved gathering data that described events and then organise, tabulate, represent and described the data. Descriptive studies must portray the variables by answering who, what and how questions as noted by Babbie (1998).

3.8.5 THE LIKERT SCALE INSTRUMENT

In this research a five point Likert scale instrument will be used as survey instrument in both the quantitative and the qualitative research studies.

The questionnaire example and explanation is attached below (Table 3.1: National survey questionnaire example, pp. 115).

3.8.6 QUESTIONNAIRE EXAMPLE AND EXPLANATION

The participant has to comply with the instructions as indicated on the survey form (Annexure 1: National Survey Questionnaire as compiled by the researcher, pp. 218).

The aim of the research and questionnaire is to identify the most important factors which influence project success in the construction industry. The research has an “A and B” section. Section A consists of twelve (12) personal questions. Section B consists of a questionnaire which covers the four phases of the project life cycle (concept, planning, implementation / construction and closing out) and the fifth phase stating the success factor ratings of choice.

Questions are based on overall experience in project management of design and construction projects. The participant must select not less than the 15 most important success factors (SF) of his/her choice for each of the phases 1, 2, 3 and 4 by marking them with an X. (The request that participants identify their selected preferences in the questionnaire by marking them with an X, allowed the researcher and the participant to be unbiased).

Phases 1, 2, 3 and 4 represent the project life cycles.

In phase 5 (the ranking phase), the participant must rate the 25 success factors from 1 to 25 starting with the most important or favoured success factor (1) and continuing to the least important success factor as (25).

EXAMPLE: NATIONAL SURVEY QUESTIONNAIRE

SUCCESS FACTORS	Phase 1 Concept	Phase 2 Planning	Phase 3 Implementa-tion Construction	Phase 4 Closeout	Success Factor Rating 1 to 25
1. Competent project manager.	X	X	X	X	1
2. Client participation and approval on project, design – construction	X		X	X	2
3. Project mission – clearly defined goals, objectives, scope of works.		X	X		10
4. Top management support.	X		X		4
5. Competence of project team.		X	X		5
6. Sufficient project resources.				X	9
7. Effective communication between participants.		X			7
8. Reliable and experienced contractor services.	X		X	X	3

Table 3.1: National questionnaire example. (Participant to complete)

3.8.7 RESEARCH INSTRUMENT

The primary data for this study was collected by using a survey questionnaire. The questionnaires that were used consisted of a mixture of open-ended and closed-ended questions and were designed to address Pinto and Slevin's (1989) theory and Dillman, Smith and Christian (2014) tailored design method.

This allows for intensity and richness of individual perceptions in responses. The study uses questionnaires because they are flexible and facilitates the capture of participants' in-depth knowledge, promote participant cooperation and allow for further probing in order to clarify certain issues. Andersen, Barton and Wrieden (2004) state that questionnaires for data collection are appropriate because they are easy to analyse and are cost-effective.

A complete survey questionnaire and letter requesting information were delivered to all the participants (see Annexure 1: National survey questionnaire, pp. 218).

3.8.8 PILOT TESTING

After many years of project and construction management experience and also reviewing many research papers related to the research subject, this researcher formulated a pilot questionnaire. Initially there would have been a list of not more than fifteen questions but the literature review convinced the researcher to deviate from standard practice and use another method of research and evaluation.

This research questionnaire was designed to complement Pinto and Slevin's (1989) statement and therefore twenty-five (25) relevant success factors were selected and the participant was asked to select not less than fifteen success factors (of his/her choice) for each phase from that list. Phases 1 to 4 comprise the project life cycle phases and here the participant needs to mark his fifteen or more selected success factors (out of a total of 25) with an "X". In phase 5 the participant has to rate all 25 factors from his/her most preferred factor (nr 1) to his least important factor (nr 25).

Bell and Waters (2014) and Dillman *et al.* (2014) advice, "however pressed for time you are, do your best to give the questionnaire a trial run, as without a trial run, you have no way of knowing whether your questionnaire will succeed".

The questionnaire was sent to eight senior engineering managers that are well acquainted with the project management and construction industry for their review, input and feedback. They suggested a few changes after which a second and final review was done. The final questionnaire was then e-mailed, run online and hand delivered to selected professional participants of companies in the design and construction industry. These participants included participants with many years' experience, project directors, senior project managers, senior design engineers and construction managers. All of them were graduated engineers.

3.8.9 QUESTIONNAIRE SURVEY INSTRUMENT

For this research a quantitative questionnaire survey was used for collecting the primary data. The motivation was to remove the bias from the researcher and the participant. The researcher predicts that Pinto and Slevin's (1989) statement can possibly address the concerns and questions associated with the research topic.
Bruner (2013) confirms that ranking surveys normally involve the use of a five point Likert scale instrument on which the participants rate their level of agreement or the level of importance of a series of statements on a predefined number of scale points. In order to use Pinto and Slevin's (1989) theory and address the outcomes of the research topic, the five point Likert scale was converted to rating and ranking both the quantitative and qualitative research assessments.

The same questionnaire instrument will be used to assess and validate the case studies qualitatively by utilising the coding numbering method. (See both examples below).

QUANTITATIVE SURVEY ANALYSIS (OUTCOME EXAMPLE)

	Success factor	Phase 1 Concept		Phase 2 Planning		Phase 3 Implementation / Construction		Phase 4 Closeout		Average across project	
		% that selected factor	*Rank of %*	*% that selected factor*	*Rank of %*	*% that selected factor*	*Rank of %*	*% that selected factor*	*Rank of %*	*% that selected factor*	*Rank of %*
1	Competent project manager	64.40%	7	88.90%	1	92.20%	3	81.10%	1	81.65%	2
2	Client participation and approval on project, design – construction	90.00%	1	84.40%	3	84.40%	9	70.00%	3	82.20%	1
25	Contract and dispute procedures	18.90%	20	40.00%	23	64.40%	20	60.00%	5	45.82%	19

Table 3.2: Quantitative survey results (example).

The above example demonstrates the final outcome analysis of the survey questionnaire.

QUALITATIVE CASE STUDY ANALYSIS (OUTCOME EXAMPLE)

	Success factor	Phase 1 Concept		Phase 2 Planning		Phase 3 Implementation / Construction		Phase 4 Closeout		Average across project	
		Count of code	*Rank*	*Count of code*	*Rank*	*Count of code*	*Rank*	*Count of code*	*Rank*	*Count of code*	*Rank*
1	Competent project manager	10	2	15	1	20	5	12	4	57	1
2	Client participation and approval on project, design – construction	12	4	18	3	24	13	12	7	66	12
25	Contract and dispute procedures	3	17	25	9	38	4	24	2	90	7

Table 3.3: Qualitative analysis results (example).

The above example demonstrates the final outcome analysis of the case study ranking and coding of success factors.

3.8.10 DATA COLLECTION METHOD

Questionnaires were used to collect the quantitative survey data information. The primary data was collected by using semi-structured questionnaires, which included a five point Likert scale questionnaire. The structured questions give the participant limited and pre-determined response options. The answers given to these structured questions were easy to analyse but they left no room for other possible responses. The questionnaires were self-administrated by an e-mail coding programme (online) with a send and response programme with a single receipt and reply option, email as well as hand-delivered. These methods were used to ensure confidentiality and avoid receiving more than one response from a single participant.

The process of gathering essential data and preparing them for analysis is called data collection. As mentioned by Saunders *et al.* (2007 and 2009) there are many approaches to collect the data required for research purposes.

One research method was used for both the qualitative and quantitative data collection process but gave different results.

3.9 QUALITATIVE CASE STUDY METHODOLOGY

3.9.1 PHASE 2: INTRODUCTION

Case studies are a method of research that is difficult to characterise with a simple definition. A case study gives the history and observation during construction of a project and is of much value in case of any dispute or failure (collapse) during the construction period.

Yin (1989) defines a case study as an experimental investigation for the following reasons:

1. To investigate a current phenomenon within its real-life context.
2. To use it as a methodology when boundaries between phenomenon and context are not clearly evident, and

3 To use multiple sources of evidence already collected.

According to Yin (1989) the use of case studies is a form of approach that is different from other non-experimental methods.

3.9.2 CASE STUDY METHODOLOGY

In this section the proposed research methodology will be made clear. The theory of knowledge, especially with regards to different methods and the distinction between what is justified and what is someone's opinion will also be established.

Eisner (1988) argues that there are no specific formats for conducting a qualitative study. He further states that a case study is expected to capture the complexity of a single incident. Case study methodology is often used in the fields of sociology, economics, environmental studies and education.

Yin (1994), Merriam (1988 and 1998), Stake (1995, 1998), Gillham (2001) and Miles and Huberman (1994) all agree that there are different viewpoints about the definition and purpose of case studies.

In general it is agreed that a case study should have a "case" which is the object of the study and that it can be described as follows:

- It is contemporary of nature.
- A case can be investigated in its natural context with a multitude of methods.

The case study researchers mentioned above emphasise different features but Stake (1998) argues that it is crucial to keep in mind that the object of study is a case and that a case study research is not the method of investigation. A case study must be seen as the interest in an individual case and not by the methods of inquiry used.

In contrast Yin (1994) places more emphasis on the method and techniques that are used in a case study.

3.9.3 THE CASE STUDIES

In the qualitative research a number of selected case studies were reviewed and assessed. Thirty four case studies were reviewed after which four case studies were randomly selected by the researcher as the sampling to review. All thirty four case studies were related to the construction industry and contained various instances of failure and defects. Chapter 2 discussed the relevant terminology as well as the selected success factors.

According to Flyvberg (2011) and Denzin and Lincoln (1994) choosing a case study and determining its boundaries are key factors in defining a case study. He further argues that once a case study is defined, the research sets out to understand the dynamics of the topic being studied within its settings or its context.

Eisenhardt (1989) and Eisenhardt and Graebner (2007) are of the opinion that understanding the dynamics of the topic refers to the interactions between the subject of the case and its context.

The selected case studies will ultimately answer the research question, as it will be discovered how and why they were reported to be accidental failures during their project life cycle phases. The Likert scale instrument that was used for the quantitative research survey was also used for coding the case study analyses with minor changes to fit its purpose. The application and the methodology of the Likert scale instrument were adapted so that it could be used in both research interventions under the following topics:

Phase 2:

1 Research strategy
2 Data analysis
3 Research approach
4 Categorisation of data
5 Interpretation of data

Phase 3:

1 Identification of patterns

2 Synthesis and generalisation

3 Validity and reliability

3.9.3.1 RESEARCH STRATEGY

The research literature is applicable for both the quantitative and the qualitative research information described under items 3.1.2 to 3.7.

The research information below will analyse the qualitative case studies according to the methods used by Creswell (1994) and Stake (1995). According to McCuen (1996) the term research refers to the development of new information for the body of knowledge. Scientific research refers to the systematic, controlled, experimental and critical investigation of a hypothetical proposition in order to find the solution to a problem or discover and interpret new knowledge.

According to Stone (1978) a scientific investigation and verification of the research knowledge involve empirical research based on the belief that all knowledge originates in experience.

The research presented in this study deals with facts that have objective reality and are based on empirical research. In this research informed and critical questioning of an existing phenomenon led to a problem statement and formulation of the research question.

Multiple case studies were analysed and scrutinised.

Yin (1993) states when case studies are analysed for qualitative research, replication methods and not sampling logic should be used. This means that two or more cases should be included within the same study precisely because the researcher predicts that similar results (replication) will be found. If such replications are indeed found in several cases, the researcher can have confidence in the overall results. The development of consistent findings over multiple cases can underpin the reason for the research and be considered a very forceful finding.

He further states that examining a number of cases enhances the accuracy, validity and reliability of the results.

3.9.3.2 DATA ANALYSIS

Stake (1995) argues that case study analysis consists of making a detailed description of cases and their settings. If the case reveals an order of events it is important to analyse multiple sources of data to determine events for each step or phase in the development. Direct interpretation as well as naturalistic generalisation should be used here.

3.9.3.3 RESEARCH APPROACH

The following approach is useful when research is conducted:

1 Hypothesis: The formal expression of a preconceived factual relationship and provides an uncertain explanation or solution to the problem in question.

2 Experimentation: Using a specific design of the study to lead to a systematic and controlled testing of the hypothesis or research question.

3 Induction: An overview of the experimental results which will lead to the formal statement of the theory.

4 Empirical research has a number of different approaches to research strategies.

Yin (2003) points out that a research strategy is not distinguished by the following directives:

1 Case studies are appropriate for the explanatory/descriptive phase of an investigation.

2 Surveys are appropriate for the descriptive phase.

3 Experiments are the only way of developing explanations for casual inquiries.

It is, however, distinguished by conditions such as:

- The type of research question created;

- The extent of control that the researcher has over actual behavioural events, and
- The degree of focus on contemporary as opposed to historical events.

The research questions for this study are:

- How are the success factors related to the research topic?
- What are the real causes that influence the research topic?

The particular research question and the variables involved in the research will determine a research strategy among the various strategies available to the researcher.

3.9.3.4 CATEGORISATION OF DATA

Historical research is concerned with historical events or a specific approach to contemporary events or problems. Historical research can also be used to help solve problems through an examination of what occurred in the past (Bennet 1991).

The researcher therefore used case studies to examine contemporary events, especially as the relevant behaviour of the phenomenon being studied could not be manipulated, as is possible in experiments.

Case studies have two sources of evidence namely: direct observation and systematic interviewing.

In this section the proposed research methodology will be explained. The different viewpoints of the research will be established, as well as the methods that were used in this particular venture.

3.9.3.5 INTERPRETATION OF DATA

Yin (2014) refers to a case study as an event, an entity, an individual or even a unit of analysis. A case study is empirical research that investigates a contemporary phenomenon within its real life context using multiple sources of events. According to Yin (2014) there are three types of case study research namely exploratory, descriptive, and explanatory research. For example, the exploratory case study can be used as a basis for formulating questions or testing theories. In the descriptive case study a phenomenon is described and the facts of how and what happened are given. Explanatory research can be useful to study processes in companies.

In this research four case studies will be contrasted and reviewed and how and why questions will be answered.

Anderson (1993) states that case studies are concerned with how and why things happen, and are used to investigate background realities and the differences between what was planned and what actually occurred. He agrees that a case study is not intended as a study of the entire organisation but is intended to focus on a particular issue, feature or unit of analysis. Patton (1987) states that case studies are used to probe an area of interest. Case studies become particularly useful where one needs to understand a particular problem or situation in great-depth.

PHASE 3: CONTENT ANALYSIS

3.10 IDENTIFICATION OF PATTERNS

Yin (2014) emphasises that pattern-matching involves predicting a pattern of outcomes based on theoretical propositions to explain what you expect to find when you analyse your data.

3.10.1 CONTENT ANALYSIS

Multiple case studies are used to improve the outcomes of the research and to explain the importance of knowledge and experience in the design and construction environment. The choice for multiple cases is appropriate given that Yin (1993) argues that multiple-case studies should follow a replication and not a sampling logic. This means that two or more cases should be included within the same study precisely because the researcher expects similar results (replication).

According to the researcher the outcomes of the case studies analysed together with the questionnaire interpretation will reveal the reliability and validity of the study. The development of consistent findings, over multiple cases, can then be considered a very robust finding.

Yin (1993) states that examining a number of cases enhances the accuracy, validity and reliability of the results and reveals the essence of the subject studied.

3.10.2 VALIDITY OF INSTRUMENT

According to Bell and Waters (2014) the researcher has to explain to the participant the purpose of pilot testing and its validity, namely that a pilot test involves a preliminary testing of data collection tools and procedures to identify and eliminate problems and then to make corrective revisions to the instruments and data collection procedures. This is done to ensure that the data eventually collected will be reliable and valid. Bell and Waters (2014) further emphasise that the reliability and validity of research instruments determine the quality of data collection and hence that of the whole research. Information given by participants in the pilot test was used to improve the reliability and validity of the final questionnaire. After the feedback had been analysed, questions found to generate unreliable or invalid information were adapted or changed in order to ensure more reliable and valid information.

Bloomberg, Cooper and Schindler (2014) emphasise that the validity of a questionnaire refers to the ability of that questionnaire to measure what you intend it to measure.

Literature on the subject was extensively reviewed in order to establish a reliable and viable instrument.

3.11 SUMMARY

The purpose of this chapter was to describe the research framework and explain how it will be implemented into the research. This chapter also laid the foundation for the subsequent discussion of the research data and the conclusions drawn from them.

Case study research (qualitative) and survey analysis (quantitative) were used in this study and the process of these particular methods will be discussed in detail in the chapters to follow. It will be further explained why case study research and survey analysis were both chosen as methods.

This chapter highlighted the sequential order of the steps taken in the research; the type of research design; data collection methods; and the validity; and reliability of both qualitative and quantitative research methods. The research objective and research questions will be addressed in the following chapters.

CHAPTER 4: QUANTITATIVE SURVEY ANALYSIS

4.1 INTRODUCTION

PMBOK Guide (2013) describes the project management process as a five life cycle scale process, while Adams and Barndt (1983) and Cleland and King (1983) refer to a four phase life cycle process. These two frameworks are widely accepted and are, in fact, recognised by most top management institutions. The five phase life cycle process is similar to the four phase life cycle process except for an additional phase, namely *monitoring and controlling of process groups.*

The fifth phase is covered in the research of Pinto and Slevin (1989) as well as in this research. Pinto and Slevin (1989) agree with other researchers on the previously selected 71 success factors distributed across the four phases of the project life cycle.

From those 71 factors this researcher selected 40 factors that he regards as the most relevant. He then narrowed the field to 25 success factors, and listed them in a questionnaire. These 25 success factors (SF) were used for both the quantitative and the qualitative studies and questionnaires.

Participants were requested to select the 15 success factors in each of the four phases of the questionnaire that they deemed most relevant. Regarding the rating of success factors in column 5, the number “1” is to be selected for the most important factor whereas “25” is for the least important factor (*PMBOK Guide* (2013). The results of the participants’ rating of success factors are presented in Table 4.3 and also displayed in the Spider-webs 4.1 to 4.5 and Bar and Line graphs 4.1 – 4.4 illustrating the most important factors in each of the life cycle phases.

This research will assess the research topic by reviewing the closeout lessons learned from executing and reviewing the survey research results of the questionnaire and doing the case study analysis. The research methods used were field interviews with project stakeholders, analysing relevant case studies as well as analysing the results of a questionnaire. All of these highlight the primary and secondary critical success factors of project management.

The main objective and the primary research question will be addressed in this chapter.

4.2 DATA PRESENTATION ANALYSIS AND INTERPRETATION PURPOSE OF THE RESEARCH

This chapter focuses on the presentation of the primary data analysis and includes discussions of the research study and conclusions drawn from it. The objectives of this study are to select the 15 most important success factors (in each of the four phases) from the 25 nominated success factors in the survey questionnaire and to determine their effect during the execution of the project life cycle phases (PLCP).

This study also aims to determine when, how and why these success factors affect the project life cycle phases (PLCP). Lastly the study hopes to measure the four projects described in the case studies against the 15 selected success factors in each of the four phases to discover the reasons for their failure (see Chapter 5).

The selection of success factors were discussed in chapter 2, hence they will only be referred to in this chapter when relevant. They are listed from 1 to 25 in the questionnaire.

4.3 PARTICIPATION IN THE SURVEY RESEARCH

Participation was entirely voluntarily and the researcher guaranteed the anonymity of all the responses received. A copy of the invitation to participate in the questionnaire is attached as Annexure 1: National survey questionnaire, pp. 218.

The questionnaire has two sections and follows the model of Pinto and Slevin (1989) that is described in Chapter 3. The survey will be evaluated by using a five point Likert scale instrument and a ranking versus rating analysis will be conducted.

4.4 GENERAL INFORMATION REGARDING THE SURVEY CONDUCT

The following information was used when the survey was conducted and also when a Likert scale instrument was used to test for the validity and reliability of the results.

The following authors discussed the use of ranking versus rating on a Likert scale:

- Harzing *et al.* (2009): ranking generally requires a higher level of attention than rating, as all the alternatives in the answer have to be considered before a choice can be made. As a result, ranking may lead to higher data quality (Alwin & Krosnick (1985) and Krosnick & Alwin (1988).
- Ranking scales are useful to avoid traditional response bias. Each choice on the scale may be used only once: most important to least important, most satisfactory to least satisfactory, most likely to least likely.
- "Although not stated explicitly in most literature, there is a consensus that the ranking approach is better than the rating approach because the ranking approach is more in accordance with the fundamental idea of the structure of individual values" (Moors (2010) and Vriens *et al*. (2015).
- Other (proponents of the ranking method) include:

  DeChiusole and Stefanutti (2011). Rating, ranking, or both? A joint application of two probabilistic models for the measurement of values. *Testing, Psychometrics, Methodology in Applied Psychology*. Vol. 18(1), pp. 49–60.

  - Harzing, A. W., Baldueza J., Barner-Rasmussen W., Barzantny C., Canabal A., Davila, A. & Zander L. (2009). Rating versus ranking: what is the best way to reduce response and language bias in cross-national research? *International Business Review*, 18(4), pp. 417– 432.
  - Krosnick J. A. & Alwin D. F. (1988). A test of the form resistant correlation hypothesis: ratings, rankings, and the measurement of values. *Public Opinion Quarterly*, 52(4); pp. 526–538.
  - Miethe, T. D. (1985). The validity and reliability of value measurements. *The Journal of Psychology*, 119(5); pp. 441–453.

- Van Herk, H. & Van de Velden M. (2007). Insight into the relative merits of rating and ranking in a cross national context using three-way correspondence analysis. *Food Quality and Preference*, 18(8); pp. 1096–1105.

The software used for analysing the 90 quantitative questionnaires was IBM SPSS Statistics 24 and the software used for data capturing was MySQL.

4.5 QUANTITATIVE ANALYSIS METHODS: PRIMARY SURVEY

Data collected from the questionnaire were cleaned and the sample scaled down to include only participants that met the following two criteria:

- The participant identified not fewer than 15 important success factors (SF) in each of phases 1 to 4 by selecting the box in the phase column marked with an “X”**.**
- They rated the 25 success factors in phase 5 from 1 to 25, 1 being the highest rating and 25 the lowest.

Ultimately a total of 90 participants were used for the analysis.

- Frequencies (distributions)
- Descriptive (mean and standard deviation)

4.6 RESPONSE RATE

From the research questionnaire the following response information was received and statistically verified to ensure its reliability and viability.

This table below shows the results on the response as verified.

Response rate

Population	Frequency	Percentage
Responded	90	70.3
No of defective responses	38	29.7
Total	128	100

Table 4.1: Response rate (participants)

From the study sample of 128 participants, 90 were found reliable and 38 were found to be defective. This constituted a 70.3% response rate. The questionnaires were self-administered to the participants and the purpose of the research explained to them by means of email and a give and take method. According to Oswald, Mossholder and Harris (1997) a response rate of 50 % and above are adequate for data analysis. The researcher made use of the five point Likert scale to perform a ranking and rating analysis. Iacobucci (2010) states that if a survey model is not overly complex and the data collected from a reliable source, a sample size of 50 can be adequate for meeting the research objective.

Quantitative: Participant description analysis (N=90)

Descriptor		N = 90	Valid percentage
Province	**Gauteng**	**83**	**93.26%**
	North West	**5**	**5.62%**
	Limpopo	**1**	**1.12%**
Highest qualification	**ND**	**1**	**1.12%**
	NC	**1**	**1.12%**
	HND	**6**	**6.74%**
	BSc	**40**	**44.94%**
	BEng	**22**	**24.72%**
	B.Tech	**1**	**1.12%**
	MSc	**11**	**12.36%**
	M.Eng	**7**	**7.87%**
Design work experience	**Less than 2 years**	**3**	**3.37%**
	2-5 years	**32**	**35.96%**
	6-10 years	**37**	**41.57%**
	More than 10 years	**17**	**19.10%**
Construction work experience	**Less than 2 years**	**4**	**4.71%**
	2-5 years	**19**	**22.35%**
	6-10 years	**50**	**58.82%**
	More than 10 years	**12**	**14.12%**
Area of specialisation	**Construction management**	**25**	**27.78%**
	Civil engineering	**28**	**31.11%**
	Structural engineering	**2**	**2.22%**
	Electrical engineering	**26**	**28.89%**
	Other	**9**	**10.00%**
Role in project	**Client / owner**	**2**	**2.30%**
	Consultant	**80**	**91.95%**
	Contractor	**3**	**3.45%**
	Other	**2**	**2.30%**
Position in organisation	**Project director**	**4**	**4.65%**
	Project manager	**48**	**55.81%**
	Contract manager	**5**	**5.81%**
	Project engineer	**20**	**23.26%**
	Consultant	**4**	**4.65%**
	Designer	**4**	**4.65%**
	Other	**1**	**1.16%**
Project type	**Building and construction works**	**33**	**38.37%**
	Civil and structural works	**24**	**27.91%**
	Mechanical works	**6**	**6.98%**
	Electrical works	**21**	**24.42%**
	Other	**2**	**2.33%**
Budgeted project cost	**Less than R10 million**	**4**	**4.49%**
	R10 million - R20 million	**9**	**10.11%**
	R20 million - R50 million	**6**	**6.74%**
	R50 million - R100 million	**31**	**34.83%**
	More than R100 million	**39**	**43.82%**
Planned project duration	**Less than 1 year**	**1**	**1.18%**
	1-3 years	**16**	**18.82%**
	More than 3 years	**68**	**80.00%**

Table: 4.2 Participant description analysis (N=90)

4.6.1 OVERVIEW OF QUANTITATIVE SURVEY ANALYSIS

The study sought to establish the profile of the participants in terms of the following:

Sample size description (N=90)

- The majority of the participants were located in Gauteng (93.3%) (N=83).
- The majority of the participants had a BSc degree (44.9%) (N=49).
- The work experience of the participants were typically 6-10 years' experience in design and construction work (N=37).
- The main areas of specialisation were civil engineering (31.1%) (N=28), electrical engineering (28.9%) (N=26) and construction management (27.8%) (N=25).
- The roles of project manager (55.8%) (N=48) and project engineer (23.3%) (N=20) were mainly filled by consultants (92%) (N=80).
- The majority of the projects were building and construction work projects (38.4%) (N=33) with large budgets (over R100 million) (43.8%) (N=39) and spanning more than 3 years (80%) (N=68).

The findings in Table 4.2 above point to the fact that participants in the questionnaire were literate and competent personnel who had experience of the performance principles used in project management.

4.7 REVIEW OF RANKING RESULTS

The quantitative five point Likert scale questionnaire listed 25 success factors (SF). The results as received from the participants were analysed using a ranking method as discussed by DeChiusole and Stefanutti (2011) and Harzing *et al*. (2009).

The software used for analysing the 90 quantitative questionnaires was IBM SPSS Statistics 24 and the software used for data capturing was MySQL.

- **Success factor analysis**

Success factor 1: a competent project manager was ranked (7, 1, 3 and 1) in the four phases 1 to 4. This means that random rating as discussed by DeChiusole and

Stefanutti (2011) was imposed. The result also complied with Pinto and Slevin's theory (1989). The other five success factors (numbers 2, 3, 4, 5 and 7) are indicated in the table below (Table 4.3 pp. 136). When the four phases were grouped together as one unit the 25 success factors were ranked from the highest to the lowest in one list (column 5: Average across project). The single most important success factor was therefore revealed, as well as the rankings of the other success factors.

Only the success factors rated above 60% were taken into consideration (Table 4.3).

The quantitative survey questionnaire. Selected critical success factors per phase. (Results from indicating minimum of 15 SF per phase with "X").

	Success factor	Phase 1 Concept		Phase 2 Planning		Phase 3 Implementation / Construction		Phase 4 Closeout		Average across project	
		% that selected factor	*Rank of %*	*% that selected factor*	*Rank of %*	*% that selected factor*	*Rank of %*	*% that selected factor*	*Rank of %*	*% that selected factor*	*Rank of %*
1	Competent project manager	64.4%	7	88.9%	1	92.2%	3	81.1%	1	81.7%	2
2	Client participation and approval on project, design – construction	90.0%	1	84.4%	3	84.4%	9	70.0%	3	82.2%	1
3	Project mission – clearly defined goals, objectives, scope of works.	88.9%	2	83.3%	4	68.9%	18	52.2%	10	73.3%	5
4	Top management support.	73.3%	3	60.0%	12	74.4%	13	42.2%	15	62.5%	7
5	Competence of project team.	72.2%	4	83.3%	4	87.8%	7	57.8%	7	75.3%	4
6	Sufficient project resources.	43.3%	11	60.0%	12	85.6%	8	35.6%	20	56.1%	13
7	Effective communication between participants.	71.1%	5	83.3%	4	92.2%	3	58.9%	6	76.4%	3
8	Reliable and experienced contractor services.	22.2%	19	43.3%	21	94.4%	1	72.2%	2	58.1%	12
9	Quality control on workmanship.	25.6%	17	51.1%	18	94.4%	1	62.2%	4	58.3%	10
10	Project planning, time, work breakdown structure (WBS).	54.4%	8	86.7%	2	73.3%	14	37.8%	18	63.1%	6
11	Project monitoring and controlling.	33.3%	16	60.0%	12	88.9%	5	54.4%	8	59.2%	8
12	Regular site visits and meetings.	17.8%	21	53.3%	17	88.9%	5	48.9%	12	52.2%	14
13	Clearly defined and detailed contract procurement processes.	35.6%	14	65.6%	9	73.3%	14	32.2%	21	51.7%	15
14	Project risk management.	45.6%	10	77.8%	7	71.1%	16	40.0%	16	58.6%	9
15	Project variation orders (VO's).	3.3%	25	12.2%	25	70.0%	17	46.7%	13	33.1%	25
16	Applicable training provision.	16.7%	22	50.0%	19	55.6%	21	25.6%	22	36.9%	23
17	Progress meetings.	24.4%	18	57.8%	15	80.0%	11	36.7%	19	49.7%	17
18	Well defined specifications and technical drawings with BoQ	34.4%	15	77.8%	7	77.8%	12	43.3%	14	58.3%	10
19	Environmental studies.	53.3%	9	63.3%	11	27.8%	24	13.3%	24	39.4%	21
20	Feasibility studies.	65.6%	6	64.4%	10	26.7%	25	7.8%	25	41.1%	20
21	Adequate financial resources.	38.9%	12	57.8%	15	66.7%	19	40.0%	16	50.8%	16
22	Contractor performance on site management and supervision.	13.3%	24	41.1%	22	84.4%	9	54.4%	8	48.3%	18
23	Decision procedures or latent issues	16.7%	22	35.6%	24	53.3%	22	50.0%	11	38.9%	22
24	Type and size of project.	38.9%	12	47.8%	20	35.6%	23	15.6%	23	34.4%	24
25	Contract and dispute procedures.	18.9%	20	40.0%	23	64.4%	20	60.0%	5	45.8%	19

Table 4.3: Selected critical success factors per phase (quantitative).

- Highlighting in the table above indicates where more than 60% of the participants marked the factor as important for that phase.

4.7.1 STATISTICAL ANALYSIS OF THE MOST IMPORTANT SUCCESS FACTOR IN PHASE 1

PHASE 1: CONCEPT ANALYSIS

Participants had to select the fifteen most important critical success factors from the list of 25 in the questionnaire. The seven success factors in phase 1 that they rated highest, and therefore regarded as the most important, are numbers 1, 2, 3, 4, 5, 7 and 20. These seven (7) success factors are also listed in the research of Martin (1976), Locke (1984), Cleland and King (1983) and Sayles and Chandler (1971). The most important success factors in each phase are rated above 60% and are the highest percentage over phases 1, 2 and 3 as indicated in Table 4.3, (pp. 136) and Spider-web 4.1, project life cycles (pp. 139), which in fact address the main research objective. Hence the fifteen (15) primary success factors are selected and indicated by the participants in phase 3, as they have nominated 20 success factors rated above 64%.

Table 4.3 indicates that success factors 1, 2, 3, 4, 5 and 7 within the ranking of phases 1 to 3 were rated as the highest among the 25 listed success factors and ranked (by grouping as the most important success factors) over these 3 phases. By omitting anyone of these SFs in phase 1, there cannot be a project. The importance of the outcome of the above selection of success factors revealed the vital academic knowledge of the participants to meet project management requirements.

The list below indicates in the ranking order of these 6 success factors to prove the theory of Pinto & Slevin (1989):
Success factor 1: competent project manager was ranked as a 2.
Success factor 2: client participation/design/construction was ranked as a 1.

Success factor 3: project mission/objectives and scope of work was ranked as a 5.
Success factor 4: top management support was ranked as a 7.
Success factor 5: competence of project team was ranked as a 4.
Success factor 7: effective communication between participants was ranked as a 3.
Participants selected the above mentioned success factors in the quantitative survey questionnaire, indicating that they indeed have the knowledge to deliver a project successfully.

The quantitative survey questionnaire led to the results shown above in Table 4.3, pp. 136.

In essence the survey analysis showed that the client's needs should be put first and that the project manager has to make sure that that happens by means of:

- Implementing a solid and effective communication environment.
- Selecting a competent team.
- Formulating a strategy to fulfil the project mission, set clearly defined goals, and meet the project objectives.
- Formulating a clear scope of works that will meet the project target and its intervention challenges.

4.7.2 STATISTICAL ANALYSIS OF THE MOST IMPORTANT SUCCESS FACTORS IN PHASE 2

PHASE 2: PLANNING ANALYSIS

It is evident from the survey analysis that fourteen (14) success factors were rated above 60% in phase 2 by the participants. Seven of those success factors had also been selected as important in phase 1. Additionally it has to be noted that SF number 20 (feasibility studies) was also selected in both phases 1 and 2 as important success factors, albeit not ranked most important SF due to the low rate of 26.6% in phase 3 as reflected in Table 4.3, pp. 136.

4.7.3 STATISTICAL ANALYSIS OF THE MOST IMPORTANT SUCCESS FACTORS IN PHASE 3

PHASE 3: CONSTRUCTION ANALYSIS

Although phases 1, 2 and 3 have a high rate of correlation proven during the selection of the questionnaire, success factors are of critical importance on the site where pick and shovel strike the ground and real-life construction has to deliver proof that the months of planning and preparation can lead to the successful execution of the project.

Participants selected twenty (20) success factors in phase 3 to be of critical importance (rated above 64%). This is remarkable in the sense that the participants here showed insight into the fact that the main challenge during this phase is delivering evidence that the project concept can become a viable project. The questionnaire indicates a very robust selection of the success factors necessary to manage and deliver a project to the satisfaction of all project activities on time, within the budged and of good quality.

The main objective of this study is to identify success factors related to the project management environment and grouping these factors with the various project life cycle phases. Success factors (SFs) 1, 2, 3, 4, 5 and 7 were ranked above 60% in phases 1 to 3 as indicated in Table 4.3.

It is important to note that SF 19 and 20 were rated at 27.8% and 26.7% respectively in phase 3 but were rated above 60% in phases 1 and 2. This indicates that the participants regarded investigation and research prior to the implementation of phase 3 as necessary and therefore important to ensure a positive outcome of the project.

These results show that the participants ranked 20 SFs above 60% and sixteen of those above 70%. This led the researcher to the conclusion that the primary research question was addressed when 20 SFs were rated in phase 3 and a minimum 14 SFs were selected in phase 2 (see Table 4.3, pp. 136).

4.7.4 STATISTICAL ANALYSIS OF THE MOST IMPORTANT SUCCESS FACTORS IN PHASE 4

PHASE 4: CLOSEOUT ANALYSIS

In the final phase only five (5) success factors gained a rate above 60%. However, eleven SFs achieved a rating of more than 50% which are still acceptable taking into account the high score of success factors in phase 3. This can be justified because all five main project factors (as indicated in Chapter 2: Literature layout: Section B, pp. 29) were selected as important success factors.

Selecting success factors such as numbers 1, 2, 8, 9 and 25 indicates thoughtful and considered choices by the participants. As this is a survey analysis it can be assumed that 50% or more of the participants had never met or worked with one another on a project. Therefore the vigorous results of this phase indicate that the engineers were well-educated and had good engineering knowledge on which to rely when they worked in the construction industry.

The success factors 3, 5, 7, 11, 22, and 23 were rated between 50% and 60%. This means that 50% to 60% of the participants considered these success factors the important for project success. The result also indicates that the participants acknowledged the value of these success factors during the execution of phase four of the project.

The above-mentioned factors needed to be evaluated in the context of their definition (phases 1 to 3) in order to discover their important role in the last and completion phase of the project, where the goal is to meet the objectives of all the role players.

SF 3 Project mission – clearly defined goals, objectives, scope of works;

SF 5 Competence of project team;

SF 7 Effective communication between participants;

SF 11 Project monitoring and controlling;

SF 22 Contractor performance on site management and supervision;

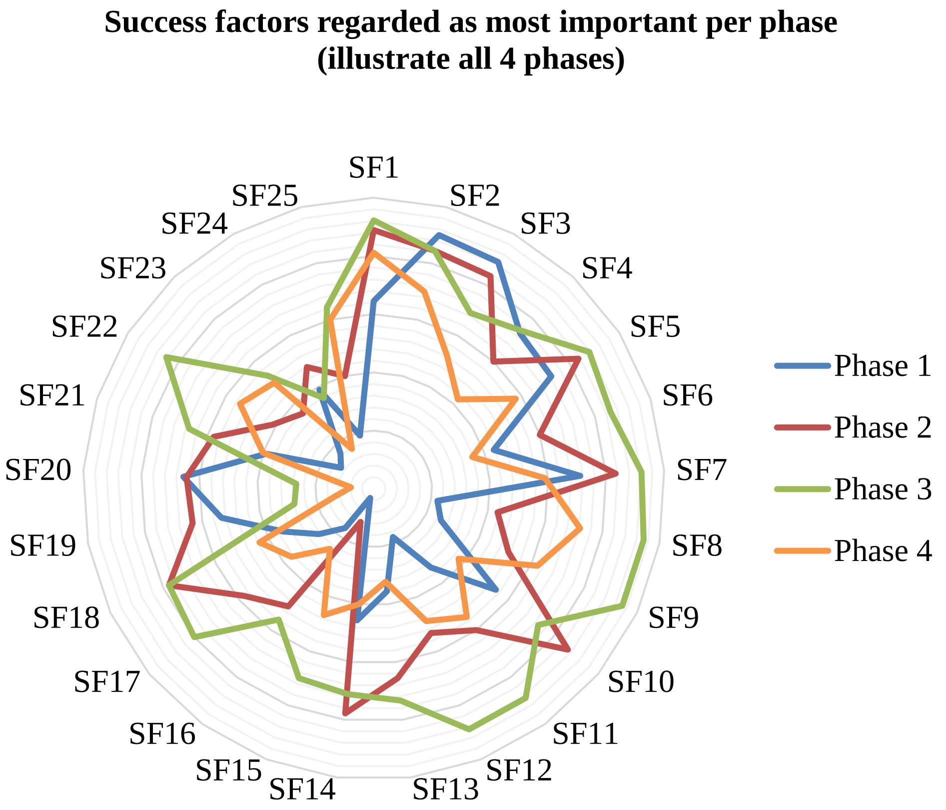
SF 23 Decision procedures or latent issues.

It is to be remembered however, that it is understood in all professions (not only in the engineering profession) that one will execute one's duty according to the code of conduct and standards of the profession, with knowledge and insight, and with respect for the client. Project success depends on who the project manager is and whether he/she is competent to deliver a specific task.

4.7.5 STATISTICAL ANALYSIS OF THE MOST IMPORTANT SUCCESS FACTORS IN PHASE 5

4.7.5.1 PHASE 5: RANKING THE FOUR PHASES

The spider-web displays the results of the participants' choices for the four project life cycle phases.



Spider-web 4.1: Success factors during the four project life cycles

HOW DO WE READ THE ABOVE SPIDER-WEB?

Note that the numbers of the success factors given above correlate to the numbers on the survey questionnaire.

To analyse the spider-web above within the various phase ratings as indicated in Table 4.3, the centre of the spider-web will be point zero while the outer circle will be rated at 100%. For the convenience of the reader, the success factors are listed below Spider-web 4.1. All four phases are indicated in different colours to make interpretation easier. The spider-web display the 25 success factors involved over all four project life cycle phases.

Phase 1 is analysed in part as an example.

Phase 1 (illustrated in blue): SF 1 refers to a competent project manager. Starting from the spider-web centre (zero) the score moves up to a level of 64.4%, indicating the success factor rating of the project manager by the participants. SF 2 (client participation) points to the outer circle and is 90%, indicating the importance of this success factor during phase 1 of the project. SF 3 (project mission) shows a rating of 88.8%, also indicating its importance during this phase for participants. Each success factor, up to SF 25 can be read in this way.

The spider-web charts below identify the critical success factors for each of the four phases of the project with explanations where necessary.

The reviewed spider-web 4.2 should be seen in conjunction with above Table 4.3 which highlights the following important information:

1 In the next category only SFs 1, 2, 3, 4, 5 and 7 were selected in phases 1, 2 and 3 and rated above 60%.

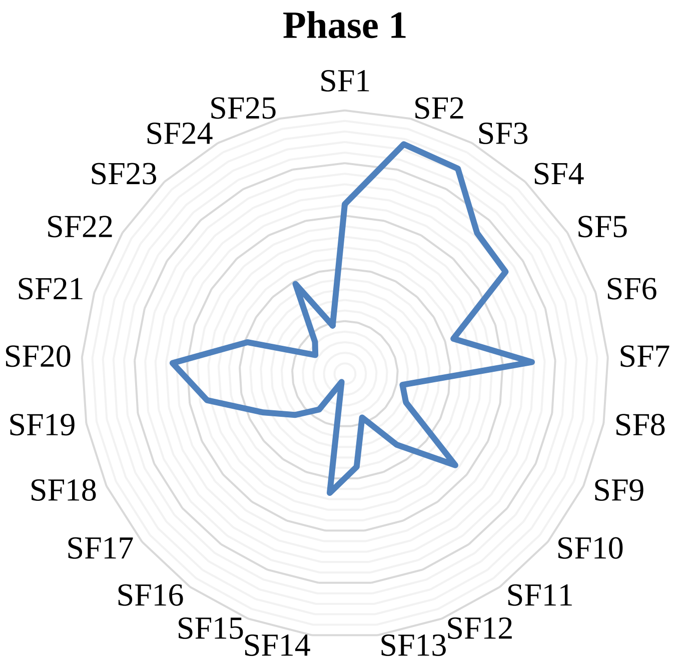
2 The only other SF selected in phase 1 was SF 20 (feasibility studies) and it was rated at 65.6%. It was also selected in phase 2 where it was rated at 64.4%.

These results confirm the research objective which is related to the theory of Pinto and Slevin (1989).

Note that the numbers in above spider-web correlate to the numbers of the success factors in the questionnaire.

SF 1 Competent project manager;
SF 2 Client participation and approval on project, design – construction;
SF 3 Project mission – clearly defined goals, objectives, scope of works;
SF 4 Top management support;
SF 5 Competence of project team;
SF 6 Sufficient project resources;
SF 7 Effective communication between participants;
SF 8 Reliable and experienced contractor services;
SF 9 Quality control on workmanship;
SF 10 Project planning, time and WBS;
SF 11 Project monitoring and controlling;
SF 12 Regular site visits / meetings;
SF 13 Clearly defined and detailed contract procurement processes;
SF 14 Project risk management;
SF 15 Project variation orders (VOs');
SF 16 Applicable training provision;
SF 17 Progress meetings;
SF 18 Well defined specifications and technical drawings with BoQ;
SF 19 Environmental studies;
SF 20 Feasibility studies;
SF 21 Adequate financial resources;
SF 22 Contractor performance on site management and supervision;
SF 23 Decision procedures or latent issues;
SF 24 Type and size of project;
SF 25 Contract and dispute procedures.

4.7.5.2 RANKING PHASE 1 SUCCESS FACTORS



Spider-web 4.2: Phase 1

Factors regarded most important in phase 1 (highest percentage over <u>all 4</u> phases per factor):

SF 2 Client participation and approval on project, design – construction (90%);

SF 3 Project mission – clearly defined goals, objectives, scope of works (88.9%);

SF 20 Feasibility studies (65.6%).

Note that SFs 1, 2, 3, 4, 5, 7 and 20 are all <u>above</u> 60% (7 success factors in total).

SF 1 Competent project manager;

SF 2 Client participation and approval on project, design – construction;

SF 3 Project mission – clearly defined goals, objectives, scope of works;

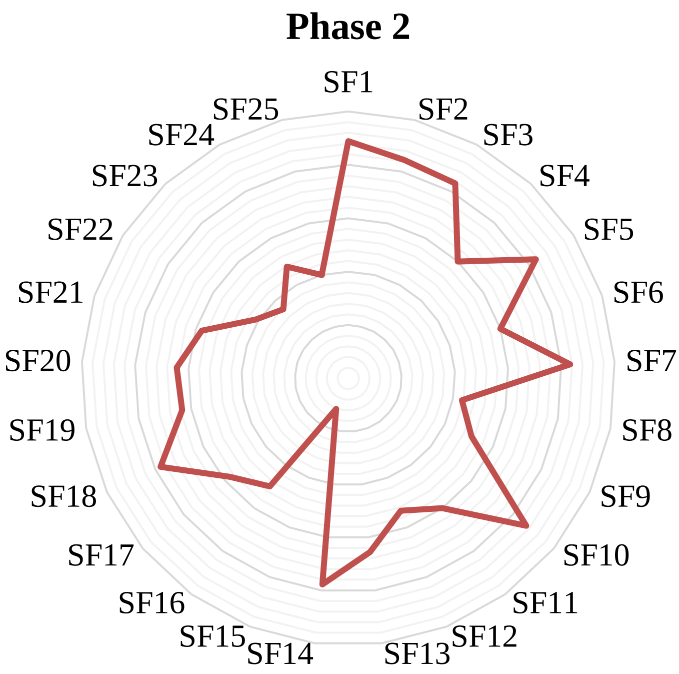
SF 4 Top management support;

SF 5 Competence of project team;

SF 7 Effective communication;

SF20 Feasibility studies.

4.7.5.3 RANKING PHASE 2 SUCCESS FACTORS



Spider-web 4.3: Phase 2

Note the numbers represent the number of the success factors <u>above</u> 60% (14 SFs) as per the questionnaire:

SF 1 Competent project manager;

SF 2 Client participation and approval on project, design – construction;

SF 3 Project mission – clearly defined goals, objectives, scope of works;

SF 4 Top management support;

SF 5 Competence of project team;

SF 6 Sufficient project resources;

SF 7 Effective communication between participants;

SF 10 Project planning, time and (WBS);

SF 11 Project monitoring and controlling;

SF 13 Clearly defined and detailed contract procurement processes;

SF 14 Project risk management;

SF 18 Well defined specifications and technical drawings with BoQ;

SF 19 Environmental studies;

SF 20 Feasibility studies.

The above spider-web for phase 2 displays the survey environment in which the design engineer and project manager have to perform their duties if they wish to address all the unknown factors. As indicated in phases 1 to 3 in Table 4.3, SFs 1, 2, 3, 4, 5 and 7, the ranking selection indicates clearly that the participants had been well equipped both during their engineering studies and their post-graduate training in their field.

Factors regarded most important in phase 2 (highest percentage over all 4 phases per success factor):

SF 10 Project planning, time (WBS);

SF 14 Project risk management;

SF 18 Well defined specifications and technical drawings with BoQ;

SF 19 Environmental studies;

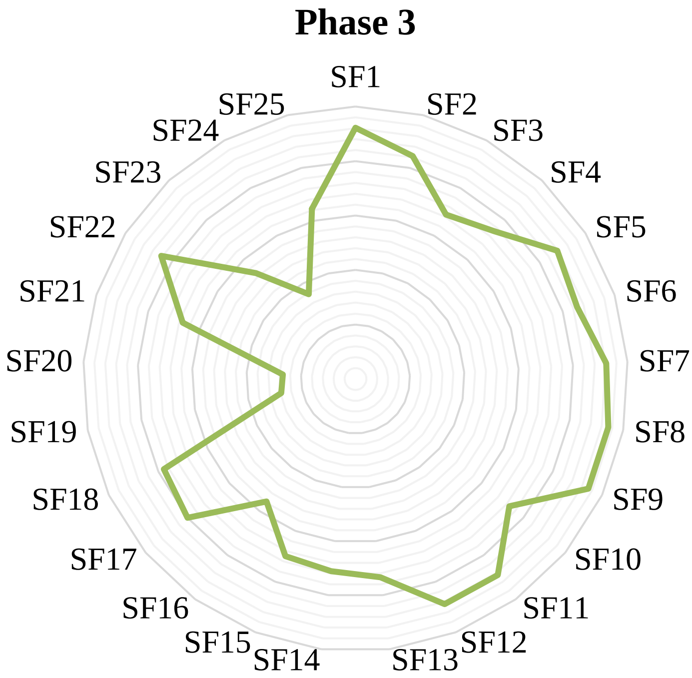
PROJECT PLANNING: PHASE 2

This is probably the most important phase of any project. All the pros and cons need to be investigated and considered. This stage also requires a full feasibility and environmental evaluation to assess whether the project will be economically viable and profitable to the client.

Construction projects are often in the news because poor quality work and/or high-risk construction practices resulted in malpractice of some kind. We have to keep in mind that each project is unique even when the same floor layout drawings are used for more than one project or different projects are executed on the same construction site. This is because there are always various uncontrollable latent conditions. These conditions are difficult to predict, especially when environmental and feasibility studies were not executed during the second phase of the project. For example, when a single soil sample is taken for analysis before the onset of the project, it is then often mistakenly assumed that the sample represents overall soil conditions of the site.

Spider-web 4.3 indicates the eight most important success factors (SFs 1, 2, 3, 5, 7, 10, 14 and 18) which were rated above 75% and therefore regarded as the most important during this phase. They point to the importance of the project manager's participation and knowledge during the execution of this phase.

4.7.5.4 RANKING PHASE 3 SUCCESS FACTORS



Spider-web 4.4: Phase 3

18 Success factors regarded most important in phase 3 (highest percentage over all 4 phases per factor):

SF 1 Competent project manager;

SF 4 Top management support;

SF 5 Competence of project team;

SF 6 Sufficient project resources;

SF 7 Effective communication between participants;

SF 8 Reliable and experienced contractor services;

SF 9 Quality control on workmanship;

SF 11 Project monitoring and controlling;

SF 12 Regular site visits / meetings;

SF 13 Clearly defined and detailed contract procurement processes;

SF 15 Project variation orders (VOs');

SF 16 Applicable training provision;

SF 17 Progress meetings;

SF 18 Well defined specifications and technical drawings with BoQ;

SF 21 Adequate financial resources;

SF 22 Contractor performance on site management and supervision;

SF 23 Decision procedures or latent issues;

SF 25 Contract and dispute procedures.

Notice is to be taken that phase 3 has indicated 20 success factors above 60%.

The least important SF selected in phase 3 under 60%:

SF 19 Environmental studies;

SF 20 Feasibility studies.

IMPLEMENTATION OF THE CONSTRUCTION: PHASE 3

During this phase the project team needs to prove their knowledge and expertise and complete the project. All construction implementation plans require the project manager or engineer to be involved in as many site activities as possible. This requirement becomes especially important when changes in the site activities become imperative. This is the best way to keep communication channels open and every project team player involved regarding the project process. The participants selected 20 important success factors above 60% in this phase and showed that during this phase activities are deemed very important, as the site can instantly turn into a high risk environment involving safety matters, quality inspections on latent issues, and misinterpretation of site instructions. All of these can lead to disputes and ultimately influence the project as a whole.

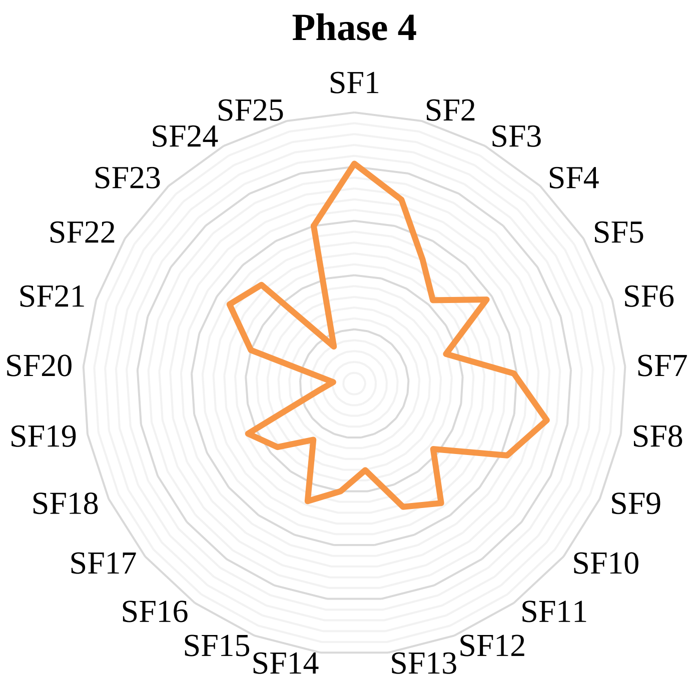
RATING THE PHASE 3 SUCCESS FACTORS

Participants regarded the excellent participation of all the role players to be important during phase 3 of the project.

Project delivery, project management, project safety and client's satisfaction are all of paramount importance in phase 3.

The low rating of SFs 19 and 20 can be due to the fact that participants felt that these success factors should have been addressed in phase 2 and would therefore not be important during phase 3 of this project. If not managed properly and followed through in phase 3, it can become a root of the problem and influence the outcome of the project.

4.7.5.5 RANKING PHASE 4 SUCCESS FACTORS



Spider-web 4.5: Phase 4

4.7.5.6 CLOSE-OUT PHASE

No factors were found most important in phase 4 based on the highest percentage over all 4 phases per factor.

The most important SF in phase 4 and <u>above</u> 60%:

SF 1 Competent project manager;

SF 2 Client participation and approval on project, design – construction;

SF 8 Reliable and experienced contractor services;

SF 9 Quality control and workmanship;

SF 25 Contract and dispute procedures;

All projects are different even if the floor layout design is identical and completion costs are equal. A single success factor in one unit can change the conditions of the closeout phase, thereby also changing the outcome of the project. In this last phase various success factors can be the reason why a project fails to meet the design criteria and/or the client's needs.

There is and will never be a project that will completely meet all the conditions for project success. The reason for that is simple; no two people are the same. There will always be differences regarding values and definitions of success. However, the correct selection of success factors will usually ensure a reasonably successful outcome in terms of time, cost and quality.

If a project turns out to be completed within its scheduled completion time and cost estimates and is of the required quality, the project manager, his design team and his contractor has delivered a service to the client that he has a right to expect and should be willing to pay for in full.

4.7.5.7 PHASE 5: RANKING ACROSS THE PROJECT DISTRIBUTIONS OF SUCCESS FACTORS

The participants were asked to rank the 25 factors in order of importance, where the most important factor was ranked as 1 and, the least important factor as 25.

The graphs (Annexure 2: Success factor ranking graphs 4.1 – 4.25, pp. 222 - 234) indicate the distribution (as a percentage of 90 participants) that provided each ranking, i.e. what percentage of the 90 participants ranked the specific factor for example second (the 2 on the axis).

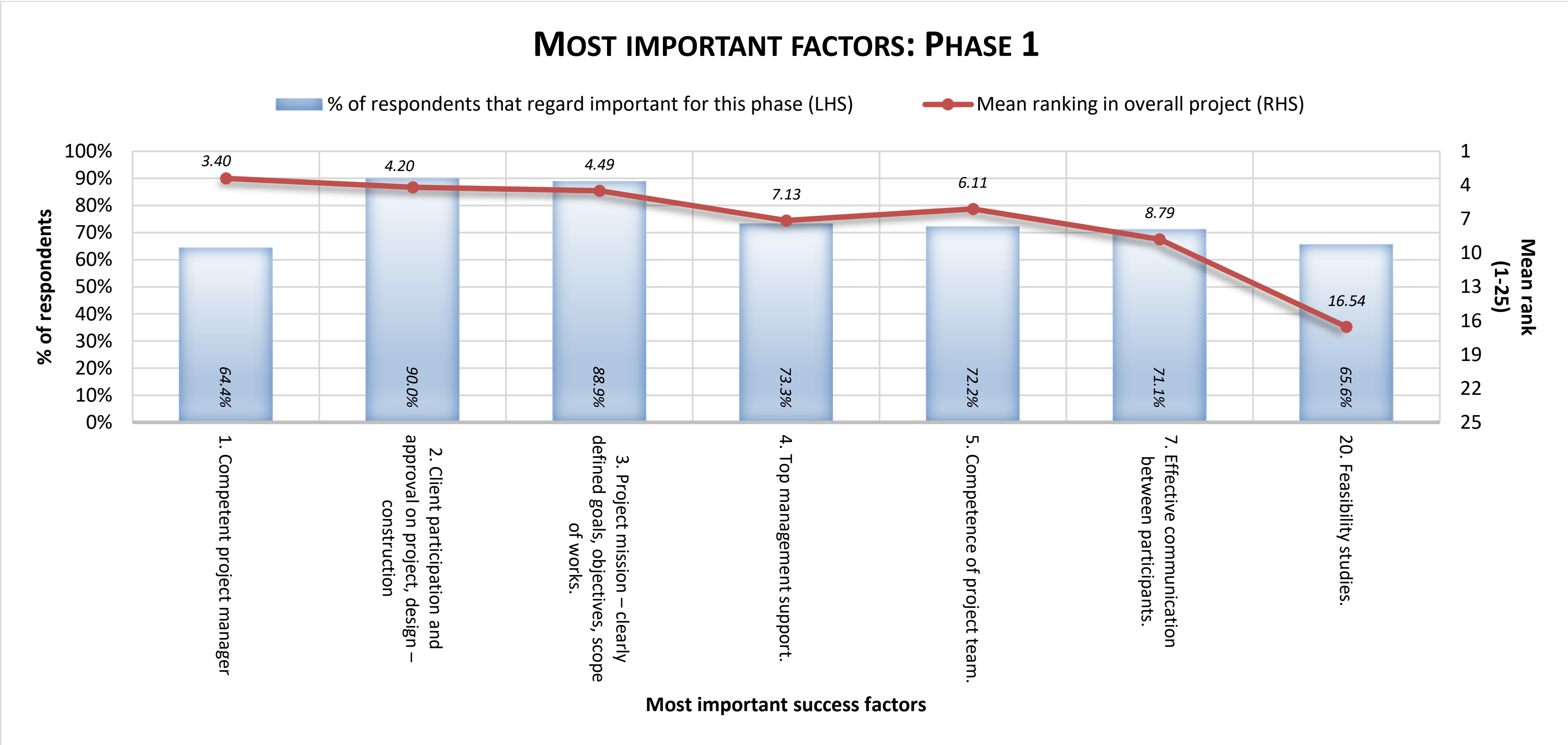
For ease of reference the rankings of the phase 5 graphs (average across project) are all listed with the necessary critical success factors (CSF) in chapter 2 and all listed 25 success factor graphs have an item notification referring to the importance of specific success factors.

The results discussed in Chapter 2 will therefore not be repeated here.

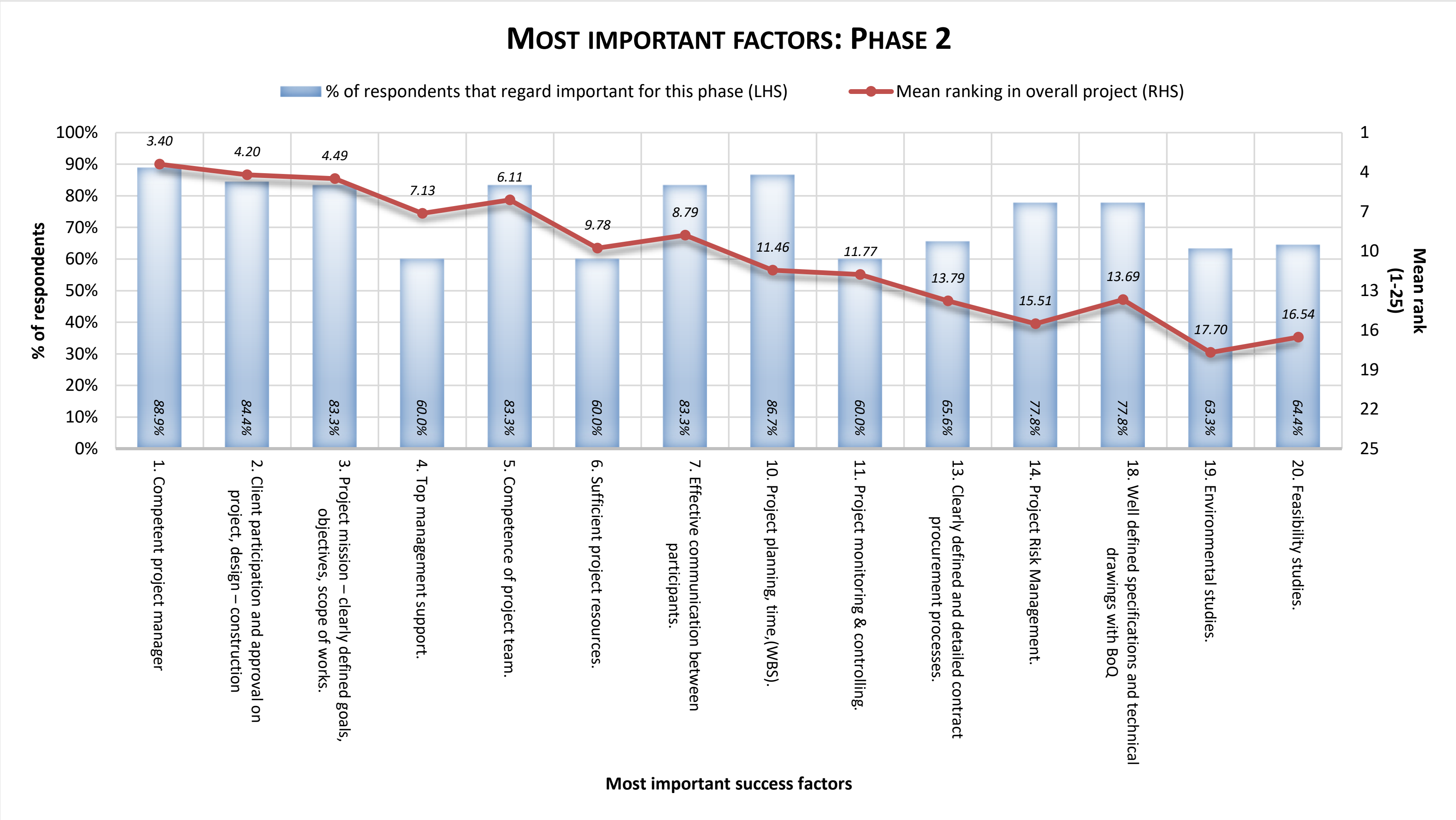
The four Bar and Line graphs below illustrate the most important factors per phase.

The following bar and line graphs provide the percentage of participants that indicated that the factor is important as well as each of the factors' overall ranking in terms of all 25 factors in the overall project.

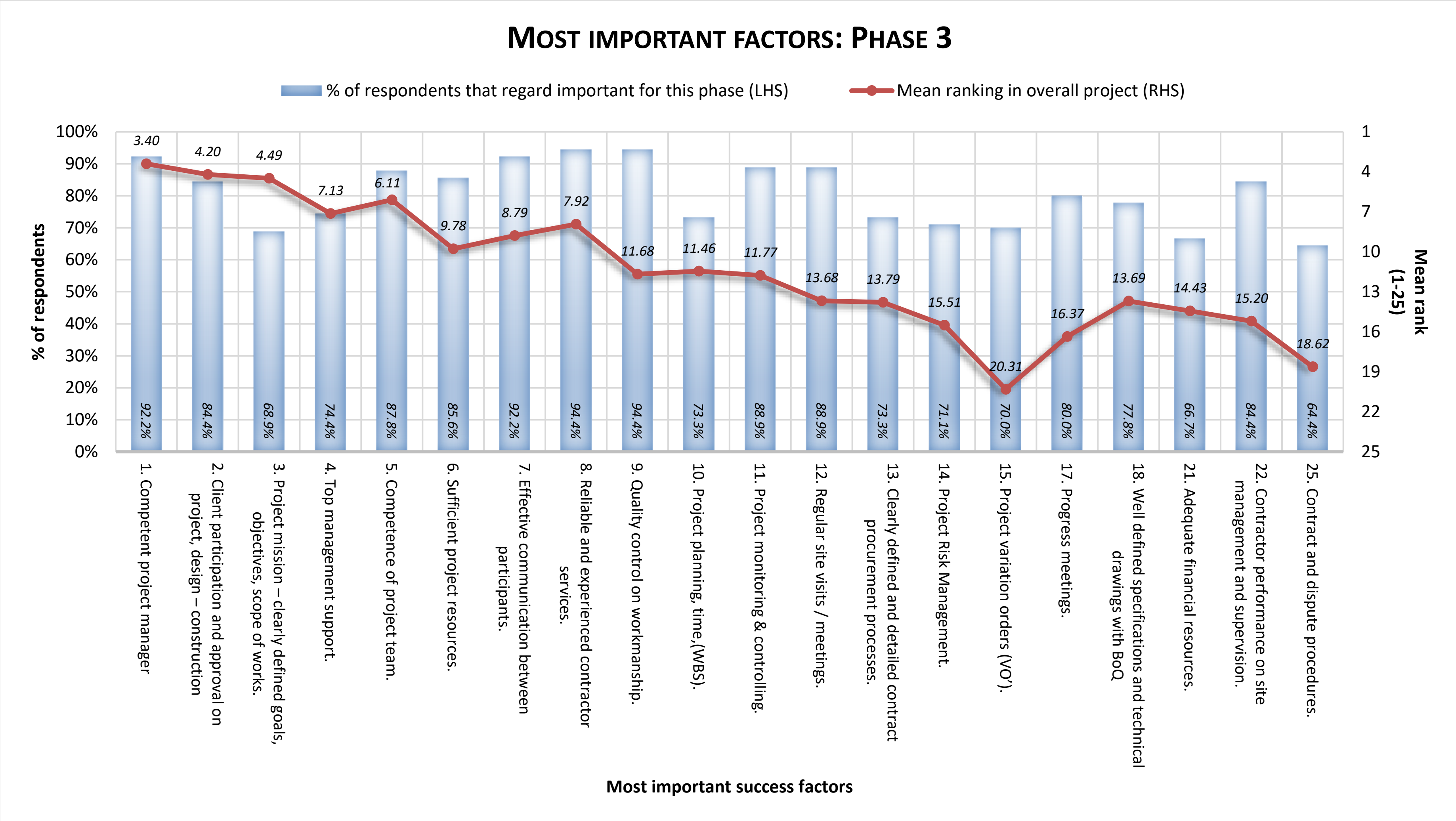
- (For interpretation one can consider something like: "Although 65.6% of the participants indicated that feasibility studies are important in phase 1, it is ranked relatively low (16.54%) when the overall lifespan of the project is taken into account").



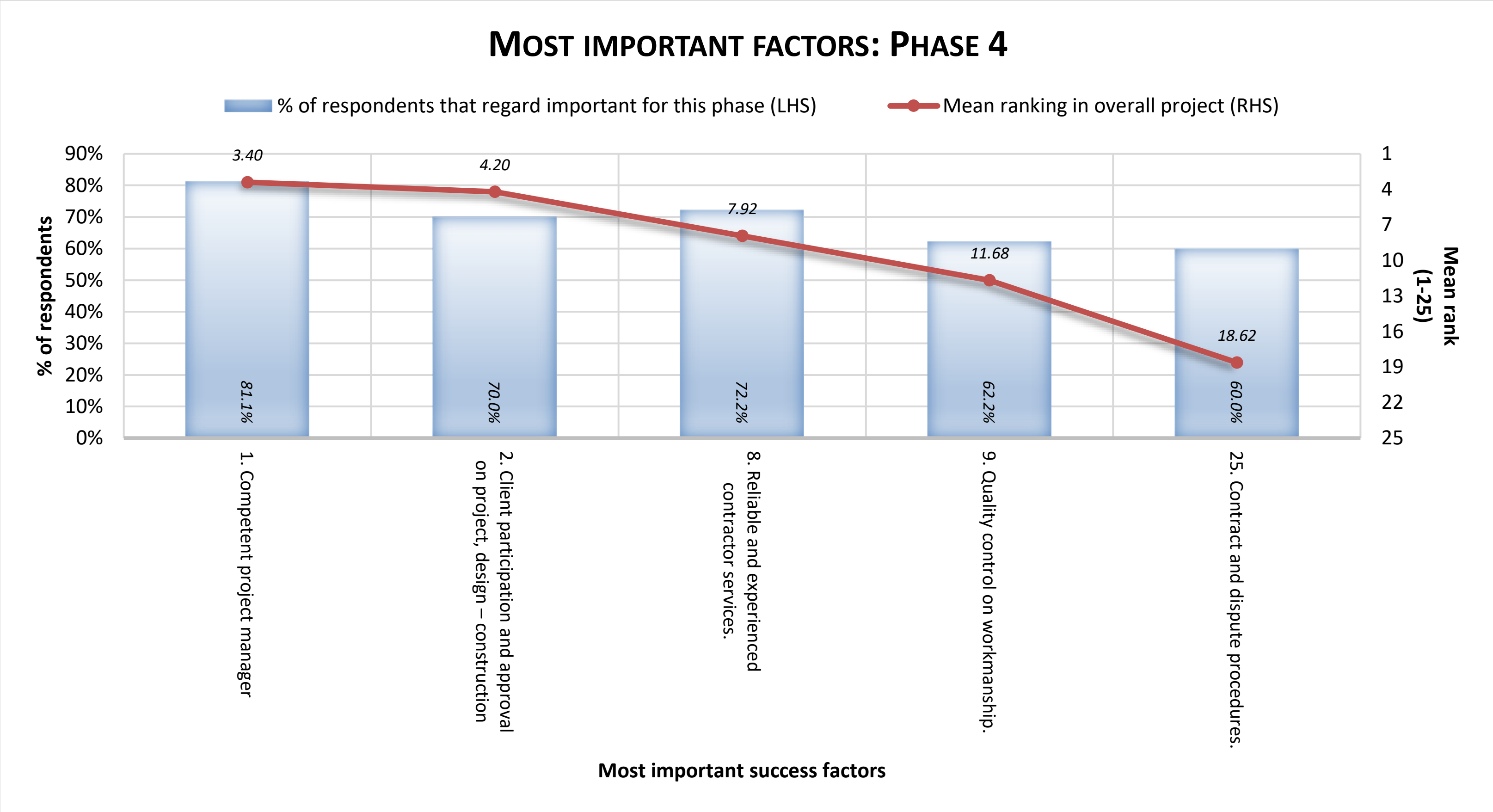
Bar and Line graph 4.1: Most important success factors – phase 1 (mean and standard deviation of ranking values).



Bar and Line graph 4.2: **Most important success factors - phase 2** (mean and standard deviation of ranking values).



Bar and Line graph 4.3: Most important success factors – phase 3 (mean and standard deviation of ranking values).



Bar and Line graph 4.4: Most important success factors – phase 4 (mean and standard deviation of ranking values).

4.8 SUMMARY

Chapter 4 described the implementation of the national survey questionnaire (see Annexure 1: National survey questionnaire, pp. 218) as the research instrument that is required to address the research objective and primary research question. Although 90 participants completed the research questionnaire it would have been of greater value if the research could had the support of all the engineering institutions and companies in Gauteng.

SUMMARY OF THE QUANTITATIVE PARTICIPANT DESCRIPTION ANALYSIS:

As indicated in the survey Table: 4.2, pp. 133 the following statistics are of importance: N=90.

- 50 of the 90 participants have between six and 10 years' experience in construction work (58.82% of the participants).
- 25 out of 90 participants have experience in construction management (27.78% of the participants).
- 28 out of 90 participants have experience in civil engineering (31.11% of the participants).
- 26 out of 90 participants have experience in electrical engineering (28.89% of the participants).

} **79**

The **79** engineers with experience in construction management, civil engineering and electrical engineering (87.77% of all participants) are at the top rate of the 90 participants in this research survey (see Table 4.2: Area of specialisation pp. 133).

- 80 out of 90 participants have had experience as consultants for a project (91.95% of the participants).
- 48 out of 90 participants hold the position of project manager in the organisation in which they are employed (55.81% of the participants).

REVIEWING THE SURVEY RESULTS

This research was justified by the results of the quantitative survey. An analysis of the results (see Table 4.3, pp. 136) indicated the following ranking:

1. The research objective was reached by ranking the phases 1 to 3. The resulting success factors 1, 2, 3, 4, 5, and 7 agreed with the Pinto and Slevin's research statement (1989) "by grouping them (the selected success factors) according to some criteria (SF description i.e. competent project manager), to help analyse the interaction between them (the selected success factors and phases) and the possible consequences (the outcome of the project)".
2. The primary research question was addressed in chapter 4, item 4.7.3 and illustrated in Table 4.3: phase 3, indicating twenty main success factors in project management of which the lowest (SF 25) was rated at 64.4%.
3. Spider-web 4.1, pp. 141 displays the survey results indicating a very well structured project management methodology, especially when it is taken into account that few, if any, of the participants have ever worked with one another in a project environment before. This spider-web displays all 4 phases as indicated in Table 4.3, pp. 136 presenting the 25 success factors.
4. This chapter also presented ranking graphs on all four phases illustrating the 25 success factors selected in the questionnaire (Spider-webs 4.2, 4.3, 4.4, and 4.5, pp. 144 - 149). These graphs indicate and explain how the participants rated the various success factors through the various project life cycle phases.

This chapter described the quantitative survey analysis, thereby addressing the research objective and the primary research question. Chapter 5 will describe and discuss this second part of the research, namely qualitative assessment, by means of a modified five point Likert scale instrument of four case studies. The secondary research questions will be addressed in chapter 5.

CHAPTER 5 QUALITATIVE CASE STUDY RESEARCH

5.1 INTRODUCTION

The quantitative research survey was accompanied by a letter of introduction which gave the background and purpose of the research. The letter assured the participants to participate voluntarily and that the researcher would not reveal the identity of the participants or their companies because of security concerns. The participants were assured that the information they provided would be used exclusively and solely for academic purposes and would be treated with the confidentiality it deserved. (See Annexure 1: National survey questionnaire, page 218). The assurances regarding the ethic aspects of the research hold true for both the quantitative and qualitative research.

The quantitative instrument was adjusted to accommodate the qualitative case study analysis and was based on the statement made by Pinto and Slevin (1989) that "they seem to tabulate individual factors rather than grouping them according to some criteria to help analyse the interaction between them and the possible consequences" as seen in Table 5.1: Specimen of case study, pp. 165.

The research methodology (chapter 3) laid the basis for both the quantitative and qualitative research. The quantitative survey constituted the primary research but it was complemented by the qualitative part of the research, the case study analysis. This analysis validated the assessment and application of the instrument. Four case studies were selected and assessed. When these assessments were documented and analysed, the neglected critical success factors in each case study were revealed. It was the neglect of these critical success factors that was the reason for the failed projects. (Annexure 2, pp. 222 - 239 and Annexure 3, pp. 240 - 261).

The total scores of the four selected and assessed case studies were ranked and are reflected as one score in the last column of Table 5.2: Total of complete project, pp. 170. For example: SF 1 (competent project manager) scored a total of 117 which reflects the number of activities that the project manager failed to execute properly or correctly during those phases.

Jackson (2008) states quantitative research is mainly concerned with the testing of hypotheses and statistical generalisations. Gerring (2004) argues that case study research involves the intensive study of a single unit for the purpose of understanding a larger class of similar units. The unit is observed at a single point in time or over some bordered period of time. Baxter and Jack (2008) and Tellis (1997a and 1997b) argue that case studies provide an opportunity for the researcher to gain a holistic view of the research problem and therefore can facilitate describing, understanding and explaining the research problem or situation.

The case study methodology, the questionnaire application and its validity on the case study analysis will be described below.

5.2 LITERATURE REVIEW OF THE VALIDITY OF CASE STUDIES

The secondary research questions were addressed by means of the case study analyses.

Yin (1994) states that there are generally four types of cases studies**:** teaching cases, case histories, case work and research case studies. The research type is mostly used by professionals and students. Professional skills are necessary to select this kind of case study and then to conduct the research. He further states that a methodological framework for the preparation and usage of research cases is of vital importance.

The following criteria are important for preparing a good research case study:

- Construct validity (requires using multiple data resources and establishing fundamental chains between processes and/or phenomena.
- Internal validity (includes well-documented pattern-matching and explanation of the process).

- External validity (includes multiple receivers) and reliability which means that a full dataset is applied in the study.
- The literature must be treated as valuable and reliable research case study methodology.

Xiao and Smith (2006) argue that the case study approach was criticised for years and treated as the research method of last resort. Stoecker (1991) is of the opinion that the case study approach as research method was unnecessarily disapprove of a theoretical area – specific and not following strictly defined procedures (Yin 1981). Campbell (1975) and Yin (1981) state that notes on case studies can be used as a valuable research method.

Cutler (2004) argues that methodological inflexibility in the methodology of case study building is of crucial importance. According to him, there is a need to define priorities for general aims and scopes in this methodology. Developed case studies are regarded as of high quality, because they do have a few important advantages such as innovation, testability and empirical validity.

5.3 THE CASE STUDY

The above four criteria are often treated as four principles for preparing valuable and reliable research case study literature.

Yin (1984) also states that there are three types of case study research methodologies, namely exploratory, descriptive, and explanatory methodology. Multiple case studies were used in this research study. The choice for multiple case studies is appropriate because multiple case studies should follow replication logic and not the sampling logic.

In this research an explanatory approach was followed to address the research questions as to why, how and what could resolve or reveal the research topic.

Other case study researchers such as Stake (1995), Simons (1980 and 1996) and Yin (1984) suggest techniques for organising and conducting the research successfully. They recommend the following steps:

- Determine and identify the applicable research questions.
- Select the case studies.
- Determine data gathering and analysis techniques.
- Organise to collect the data.
- Collect data in the field.
- Evaluate and analyse the data.
- Prepare the report to represent a complicated problem in a way that expresses experience and knowledge to the reader.

Yin (2002) defines a case study as a contemporary experience within its real life context, especially when the boundaries between a phenomenon and context are not clear and the researcher has little control over the phenomenon and context.

5.4 DEFINE THE SECONDARY RESEARCH QUESTIONS

The following case study questions (secondary research questions) were chosen for this research:

1. How do the critical success factors affect the project life cycle?
2. How can the effect of a lack of knowledge and experience on the part of the project manager within the project life cycle phases influence the critical success factors of project management?
3. Why are these critical success factors important to be implemented?

5.5 PREPARE TO COLLECT THE DATA

A suitable research topic will be found when an urgent need within the specified domain (in this case the construction and project management industry) is discovered.

The authors of the *South African Construction Industry Board (*CIDB (2013) and numerous stakeholders have raised their concerns on quality delivery due to the increased complexity of large-scale construction projects (see Chapter 3, paragraph 3.5: Target population). They are of the opinion that this kind of construction project requires outstanding project management and discipline at all levels.

These concerns initiated this research and preliminary answers were found by means of a quantitative survey instrument which highlighted the fifteen most relevant success factors. Further investigation was needed to reveal the reasons why these factors are so vital to the success of large projects. The investigation into success factors affecting the research topic was then undertaken by means of a qualitative research analysis on related case studies.

5.6 SELECTION OF CASE STUDIES

Four case studies were randomly selected out of thirty four case studies. The organisation that allowed access to the case studies wished to support the research investigation but also wished to remain anonymous.

As Ravitch and Riggan (2011) state, clearly defining the research problem is probably the most important step in the complete research project as a whole. Therefore a case study should begin with a comprehensive literature review and careful consideration of the research questions and study objective.

Chapter 2 laid the basis for both the quantitative and qualitative research studies. The thirty four selected case studies are all classified as not performing within the standard code of building practice. The four randomly selected case studies all pointed out the clients' requirements regarding delivery of the final project within the standards of the critical success factors.

5.7 QUALITATIVE DATA INSTRUMENT

The same five point Likert scale instrument that was used for the quantitative survey was used for the qualitative analysis. The quantitative application was slightly changed to accommodate the desired results for the qualitative analysis.

The original thirty four case studies had already been judged by the engineering council. The purpose of this research is not to judge the projects described in the case studies but to:

- Reach the research objective; and
- Answer the research questions and find out what led to the failure of these projects.

5.8 THE QUALITATIVE DATA INSTUMENT DESIGN

After considering the many different case study categories and identifying a theoretical perspective, the researcher can begin to formulate the study research design. This design links the collected data and draw conclusions which ultimately address the research question. Case studies are normally conducted on topics that are diverse.

Van Vugt (1994) argues that it is virtually impossible to outline any strict or universal method or design for conducting a case study. However, Yin (1993) suggests the following basic research design components:

1 A study question.
2 A study intention (if any).
3 A study unit of analysis.
4 The logical linking of data to the proposal.
5 The criteria for interpreting the findings.

The same data instrument that was used for the quantitative survey was used to analyse the four case studies, but with the following minor changes:

1 The instrument must display the following coding analysis information:
    - Success factors number (1 to 25).
    - Success factor description (competent project manager) 1 to 25.
    - Count of code and over all four phases.
    - Rank value over all four phases.

2 The instrument will display phases 1, 2, 3, 4 and 5. Phase 5 is the total for the project as a whole. The four phases will represent a success factor from 1 to 25, each with a coding description.

The total count of code has been analysed by ranking and displayed as in Table 5.2, pp. 170. The instrument will also display phases 1 to 4 and phase 5 with its ranking totals.

5.9 CASE STUDY EVALUATORS

A total of four case studies were reviewed by four evaluators. The researcher took the process further by overseeing the coding and auditing process to the final assessment.

1 The evaluators record their individual counts of coding of the case study from success factor 1 to 25 (see Table 5.1: Specimen of case study analysis for clarification, pp. 165).

2 When the evaluators assess the case studies and for example find that (**SF) success factor 2** (design/construction) contravened by failing to engage in the required practice, the evaluators must mark the success factor (SF) as '1' at all the various SF items related to this specific issue. In other words, the design problem can impact more than one success factor, for example items 2, 5, 8, 12, 11 and 18, over one or more phases (see specimen Table 5.1).

If SF 2 is only related to phase 2, the total will be '3' because one contravened SF can influence 3 activities, but if SF 2 affects phases 1, 2, 3 and 4 it will be illustrated in the column "Ranking SF totals" as a total of 10 (see Table 5.1, pp. 165). The total of '10' reflects the number of activities that the project manager contravened over those phases regarding SF 2. It is possible that the "design" SF can cover all four phases or a number of success factors (any number between 1 and 25 of the SF list).

3 Once the evaluators completed the assessment forms (see Annexure 3: Case studies assessments, pp. 240), each item in every phase must be counted and the total stipulated in phase 5 under "Ranking SF totals".

4 After the evaluators completed their assessments, they count the SF numbers in each phase and write the total in the "Phase 5: SF rating" column

(Annexure 3: Case study – Evaluator's form, pp. 265).

5 Ranking on a five point Likert scale was then performed according to the recommendations by Harzing *et al*. (2009), DeChiusole and Stefanutti (2011) and Krosnick and Alwin (1988).

SF NO	SUCCESS FACTORS (SF) Case – Study No: Coding Analysis SF CODING	Phase 1 Concept Ranking SF NO	Phase 2 Planning Ranking SF NO	Phase 3 Implementation Construction Ranking SF NO	Phase 4 Closeout Ranking SF NO	Phase 5 Success Factor Rating SF TOTALS
1.	Competent project manager.	111(3)	____	111111(6)	11(2)	**11**
2.	Client participation and approval on project, design – construction	1 (1)	111(3)	1111 (4)	11(2)	**10**
3.	Project mission – clearly defined goals, objectives, scope of works.	11(2)	1(1)	11(2)	1(1)	**6**

TABLE 5.1: Specimen of case study analysis

5.10 EVALUATION AND ANALYSIS OF DATA

Yin's (2002) declares that quantitative and qualitative research should be combined if a valid answer to the research question is to be found. He says that the investigation of data "consists of examining, categorising, tabulating, testing, or otherwise to combine both the quantitative and qualitative evidence to address the initial proposition of a study, which is compatible with his opposition to the bifurcation between quantitative and qualitative research".

In this research results from the quantitative and qualitative research were analysed separately and then combined in tables and graphs. The results were then seen to complement one another.

A number of success factors were deemed critical to the success of a project, and the absence of those success factors were revealed to be among the causes of the failures of the projects examined in the case studies.

5.10.1 DEFINING THE FEATURES OF THE CASE STUDY

Stake (1995) describes two ways to analyse data: categorical aggregation and direct interpretation. He regards them as two general strategies to handle case study data.

Merriam (1998) feels that her model of analysing qualitative data in a case study is mostly complementary to both Stake's and Yin's interpretations of case study analysis. She describes data analysis as the process of making sense out of data by consolidating, reducing and interpreting what people said and what the researcher saw and read. She also explains why and how data should be collected and analysed simultaneously. Merriam (1998) agrees on the importance of strategies to manage data; this viewpoint complements both Yin's and Stake's theories.

This research methodology will assess and clarify the various case studies within the context of the well-known tri-angle paradigm which Kerzner (1992), Pinto & Slevin (1989) and Meredith and Mantel (1995) define.

5.11 VALIDATING DATA

The three methodologists have different views on data validation which are associated with their notions of validity and reliability in investigations. The differences between Merriam (1998) and Stake's (1995) on the one hand and Yin's (2002) on the other hand relate to the differences in their philosophical viewpoints.

Yin (2002) thinks that data is validated through the triangulation of multiple sources of evidence, pattern-matching and generalisation. Stake (1995) thinks that validation occurs through the triangulation of data, theory and methodology.

Merriam (1998) is of the opinion that the researcher's work should consist of strategies, and explanation of the investigator's position with regards to the study, triangulation and the use of an audit trail. She suggests three external validity methods: the use of a comprehensive description, typicality or model categories, and multi-site designs.

Flower and Hayes (1981) argue that using multiple sources of evidence will increase the reliability and validity of the data for pattern-matching. Their suggestions were followed with those of Yin (2002) as indicated in item 5.3 above.

5.12 PROCESS OF CASE STUDY EVALUATION

The case studies evaluated were related to the research topic and also to the construction industry. The documented case study failures were directly observed and participants were interviewed; original evidence that existed at the time of the improper execution of the project was therefore available. The project failure was judged in terms of the rules of conduct for registered engineers. The four case studies were randomly selected from thirty four similar cases by the researcher. The researcher also selected four engineers (qualified and experienced in project management) to be part of the case study evaluation. The researcher gave these engineers instructions on how to approach and assess the case study at hand to ensure a reliable and valid assessment.

The assessment protocol was as follows:

The engineers remained anonymous and the case studies under review were not identified.

Each of the four engineers selected a case study (from the four already selected by the researcher) and was then shown how to apply the assessment questionnaire.

- Every SF and coding incident as identified in the case study counts one point.

Example: in coding case study 1: an investigation revealed that the quality of materials and workmanship produced by the contractor was substandard **(SFs 1, 2, 5, 7, 8 and 11).**

This implied the following: The project manager did not approve the bill of quantities **(1).** The designer failed to provide the specification for materials **(2).** Lack of client participation **(5).** No effective communication **(7).** Lack of reliable contractor service **(8).** Project monitoring and controlling was not carried out **(11),** and so forth. **One statement in the case study addressed 6 SF activities.**

- Read the case study through and prepare for unknown questions to be clarified before filling in the questionnaire which will then be discussed before dealing with the assessment review.
- Every item (failure or not according to the standard code of practice) on the case study should be identified and coded individually within its specific phase and the numbers added in the SF rating column (Assessment form).
- One incident of case activity may have numerous of the same SF applicable within the same criteria and context. The design engineer can be involved four or five times in the same paragraph depending on the area under question. **For example**: In question SF criteria 2, the design can have an impact on SFs 2, 6, 8, 16 and 20, and therefore your reply will be coded as '1' at each of those identified SF numbers i.e. 2(1 point), 6(1), 8(1), 16 (1), and 20 (1). A total of 5 points is then written in the Rating SF totals column.
- The assessment must be coded and include numbers 1 to 25 in the case study assessment table.

The four case study assessments took four evaluators an average of 2.5 hours each to complete. The assessment was then finalised and recorded in a data base so that the contents of the four case studies could be analysed and ranked.

5.13 PREPARE THE REPORT

The purpose of the qualitative study was to code the selective case study information and find out whether it validated the quantitative survey research results.

By analysing the contents of four anonymous case studies the critical success factors that were neglected were identified and therefore resulted in the failure of the project. Table 5.2 (pp.170) provides a summary of the number of occurrences of each code (i.e. failure or absence of the success factor) which forms part of the report.

Ranking of the success factors indicating the failures regarding a case study are articulated in the last column "Total of complete project" seen in the ranking column. For example: SF 1 indicated a count of 117 = ranking as 1, indicating the highest SF failure. See Table 5.2: Qualitative case study analysis, pp 170.

The reviewed case study assessments are indicated in the pattern-matching graphs 6.1, 6.2, 6.3 and 6.4, pp. 179 - 181.

To validate the results in the Table, a summary of each case study will be included in the report.

	Success factor	Phase 1 Concept		Phase 2 Planning		Phase 3 Implementation / Construction		Phase 4 Closeout		Total of complete project	
		Count of code	*Rank*	*Count of code*	*Rank*	*Count of code*	*Rank*	*Count of code*	*Rank*	*Count of code*	*Rank*
1	Competent project manager	20	*3*	49	*1*	36	*6*	12	*5*	117	*1*
2	Client participation and approval on project, design – construction	20	*3*	33	*4*	34	*8*	20	*2*	107	*3*
3	Project mission – clearly defined goals, objectives, scope of works.	22	*2*	36	*3*	31	*12*	12	*5*	101	*4*
4	Top management support.	8	*8*	9	*18*	7	*20*	7	*16*	31	*19*
5	Competence of project team.	23	*1*	39	*2*	40	*2*	12	*5*	114	*2*
6	Sufficient project resources.	2	*20*	1	*22*	1	*23*	2	*22*	6	*23*
7	Effective communication between participants.	14	*5*	30	*5*	33	*10*	13	*4*	90	*5*
8	Reliable and experienced contractor services.	11	*6*	26	*8*	34	*8*	11	*10*	82	*10*
9	Quality control on workmanship.	11	*6*	27	*7*	35	*7*	14	*3*	87	*7*
10	Project planning, time,(WBS).	2	*20*	8	*20*	9	*19*	5	*18*	24	*20*
11	Project monitoring & controlling.	5	*13*	15	*14*	37	*5*	9	*14*	66	*12*
12	Regular site visits / meetings.	3	*17*	9	*18*	21	*14*	9	*14*	42	*17*
13	Clearly defined and detailed contract procurement processes.	6	*11*	20	*11*	24	*13*	3	*20*	53	*13*
14	Project Risk Management.	8	*8*	28	*6*	33	*10*	12	*5*	81	*11*
15	Project variation orders (VO').	0	*23*	1	*22*	4	*22*	2	*22*	7	*22*
16	Applicable training provision.	0	*23*	0	*25*	0	*25*	0	*25*	0	*25*
17	Progress meetings.	6	*11*	10	*17*	13	*18*	10	*11*	39	*18*
18	Well defined specifications and technical drawings with BoQ	8	*8*	25	*9*	39	*3*	12	*5*	84	*9*
19	Environmental studies.	5	*13*	19	*12*	19	*15*	4	*19*	47	*15*
20	Feasibility studies.	5	*13*	18	*13*	18	*17*	7	*16*	48	*14*
21	Adequate financial resources.	0	*23*	1	*22*	1	*23*	1	*24*	3	*24*
22	Contractor performance on site management and supervision.	4	*16*	15	*14*	58	*1*	10	*11*	87	*7*
23	Decision procedures or latent issues	3	*17*	15	*14*	19	*15*	10	*11*	47	*15*
24	Type and size of project.	1	*22*	3	*21*	7	*20*	3	*20*	14	*21*
25	Contract and dispute procedures.	3	*17*	25	*9*	38	*4*	24	*1*	90	*5*

Table 5.2: Qualitative case study analysis (Shading indicates the five factors that had the most problematic occurrences for all four case studies).

5.14 ASSESSMENTS OF THE FOUR SELECTED CASE STUDIES

The four case studies and assessments can be seen in Annexure 3: Case study assessment, pp. 240 – 261

Evaluator’s assessment: Case study 1

It is clear from the above case study analysis that the engineer/project manager did not utilise support, knowledge and expertise available to him/her when supervising the project. The engineer’s misrepresentation to the owner to cover up for the contractor is a violation of the engineering code of conduct.

Neither the engineer nor the contractor should have allowed the use of substandard materials.

When the five highest scores for CSFs in the case study evaluation are selected, it is evident that the engineer/project manager and the contractor neglected or failed to execute success factors 1, 2, 3, 5, 7, 9, 22 and 25. These results indicate the most important instances of poor project management practice.

The analysis of this case study revealed that the engineer/project manager and contractor rendered a substandard service (SF 5: competence of project team).

This conclusion is shown in merging (patter-matching) graphs 6.1, 6.2, 6.3 and 6.4 (pp. 179 – 181) and Table 5.2 which indicate high ratings in critical success factor (CSF) 5:

> Phase 1 rated 23, phase 2 rated 39 and phase 3 rated 40.
>
> The project ranking factor indicates that this was the second highest risk factor with a count code of 114.
>
> These CSFs were rated as very important in Chapter 4, Table 4.3, pp. 136 when the engineer rated the CSF 5 at 72.2% in phase 1, 83.3% in phase two and 87.8% in phase 3.

There is no doubt that both the engineer and the contractor should take full responsibility for the financial loss (and its impact on the client's investment) caused by the reduction in the floor-to-floor height.

The project's final rating was a **4** which indicated the **fourth** lowest project service delivery out of 25 CSFs. Project SFs ratings are determined by meeting SF 3 (mission, goals and SoW). This assessment count of code was 101 (Table 5.2, pp. 170).

The researcher's point of view is that the engineer was not equipped with sufficient project experience or knowledge to oversee this project through its various phases.

Evaluator's assessment: Case study no 2

This was a large project which required a high level of specialised professional engineering services. For this reason the client appointed a firm of consulting engineers to provide the required services and to execute the requirements in terms of the project scope of work. This type of project often contains latent defects, necessitating the knowledge and supervision of an experienced engineer/project manager. An additional problem was the fact that the owner limited the engineer's site visits, something which later proved to has been crucial oversight.

The most important success factors defined in the case study evaluation were SFs 1, 2, 3, 5, 7, 9, 21, 18, 22 and 25.

As noted in Chapter 2 the project manager/engineer is supposed to take full responsibility of the project team. He should have taken the lead in advising the client, design team, contractors and other role players about the full scope of work, communication, overall quality control and the complexity of the project.

According to the evaluator's assessment the project manager failed to do the following:

- He did not formulate a full scope of work, something which would have identified the client's needs. There was no written project mission, no risk and project implementation, no testing of the reliability of work force, a lack of the experience and knowledge required for the specific design components of the project and no environmental and feasibility studies to assess latent factors.
- Other success factors indicated in Table 5.2 were also neglected.
- The project manager failed to take control and lead in managing, advising and overseeing the client's needs. This was probably because of his lack of managerial and leadership experience.
- The client limited the engineer's site inspections probably to cut costs. The project manager/engineer did not advise the owner of the risks inherent in his decision, and this decision led to his violating the building code of conduct.

From the above evaluator's analysis it is clear that the most important critical success factors are 1, 2, 3, 5, 7, 9, 14, 18, 22 and 25. This was illustrated in phases 1, 2 and 3 and as indicated in the success factor ratings.

The above mentioned factors are shown in merging (pattern-matching) graphs 6.1, 6.2 and 6.3 (pp. 179 – 180) where the three project phases were displayed.

Evaluator's assessment: Case study no 3

The assessment of this case study led to the conclusion that the engineer was not competent to design the structure. His method of executing the design and drawings showed that he did not take the complexity of the design into consideration, and this affected the entire project. The most important critical success factors 1, 2, 3, 5, 7, 18, 22 and 25 were shown to be relevant for this project.

The engineer/project manager maintained *inter alia* that the collapse was not caused solely by him, that he was not responsible for producing the structural

design, that he did not err when reacting to the punching failure, that the design was altered without his knowledge and that his scope of work included only limited visits to the site. The engineer claimed that the design changes altered the loading on the structure, culminating in overloading during construction.
However, the engineer/project manager signed the local authority's form '*A19 form*', confirming his appointment as the responsible person for the design and overseeing the project.

- He failed to discharge his duties to his client and the public with skill, efficiency, professionalism, knowledge, competence, due care and diligence.
- He undertook work of a nature for which his education, training and experience had not rendered him competent.
- He failed to engage in or adhere to acceptable practices (SFs 1, 2, 3, 5, 7, 8, 9, 11, 12, 13, 14, 18, 19, 24 and 25).
- He did not have due regard for public health, safety and interest (SF 14).
- He did not provide work or services of quality and scope or on a level corresponding to accepted standards and practices in the profession (SF 9).

The engineer did not conform to the design and construction codes of conduct, and did not pay attention to the critical success factors. He also did not do soil analysis to ascertain the soil conditions of the site, something which is necessary when the foundation design loadings are calculated. The most important success factors as defined in the survey research (Table 4.3, pp. 136) namely SFs 1, 2, 3, 5 and 7 as well as the success factors listed in phases 2 and 3 (which are above 60%) were ignored.

CSFs 1, 2, 3, 5, 7, 9, 11, 14, 19, 22, 23, and 25 were shown by the quantitative research to be regarded as very important. In this project they were all disregarded, leading to a negative outcome for the project. Regarding phases 1, 2 and 3 scope of work (SF 3) the engineer and the contractor's competence to execute their duties (SF 19) environmental studies, (SF 14) risk control and well defined specification and technical drawings were not listed as a high priority on this project.

The above mentioned factors are illustrated in merging (pattern-matching) graphs 6.1, 6.2 and 6.3 which display the three project phases.

Evaluator's assessment: Case study no 4

The developer commissioned a registered professional engineer to design and monitor the construction of this project. The client also employed the service of an architect and a contractor. The engineer as the civil designer worked in conjunction with the architect, contractor and the client, and they were known as 'the project team'. The project manager/engineer was expected to have the required knowledge and experience to design and oversee a project of this size, and to act as the *de facto* project manager.

The case study analysis indicated that very little attention was paid to most of the important success factors (see Table 4.3, pp. 136). The comments in the case study report were in fact alarming given in the requirements for the job. The outcome of the project showed clearly that the engineer was not qualified to execute and oversee the project successfully.

The following critical success factors (CSFs) were disregarded: CSFs 1, 2, 3, 5, 7, 8, 11, 14, 18, 19, 22, 23, and 25. It is clear that the violation of the standard design and practice code of conduct as well as inexperience and lack of knowledge regarding project management had serious implications for all the role players as well as the project as a whole. The most important CSFs in this case study were ignored: SFs 1, 2, 3, 8, 11 and 22.

The case study analysis indicated that very little attention was given to most of the important success factors quoted in Table 4.3.

In this fourth and last case study the assessment revealed that the CSFs as ranked in Table 5.2: ("Total of complete project – Ranking code") indicates a lack of knowledge and experience on the part of the engineer/project manager. The ranking codes 1, 3, 4, 2, 5, 7, 9, 7, and 5 are all applicable here and affect all four phases of the project.

5.15 SUMMARY

The fundamental structure for the second part of the research, a case study analysis, was formulated in the chapter which discussed the literature on quantitative and qualitative research. This was followed by the survey research to address the research objective and the research questions.

The literature overview made it clear that the research topic could only be addressed through the application of a quantitative survey as well as a qualitative case study analysis. After assessing the views of various researchers on case study analysis, it was decided that the views of Yin (2002) and Flower and Hayes (1981) were the most appropriate for this research.

The results of all four case study analyses are shown in Table 5.2, pp. 170. The appalling results revealed in the case studies will be merged in chapter 6 when pattern-matching analysis will be applied to validate the concerns of the researcher.

The results of the qualitative case study described in this chapter were integrated into the quantitative survey results to form a basis from which the secondary research questions could be addressed.

CHAPTER 6 MERGING THE QUANTITATIVE AND QUALITATIVE RESULTS

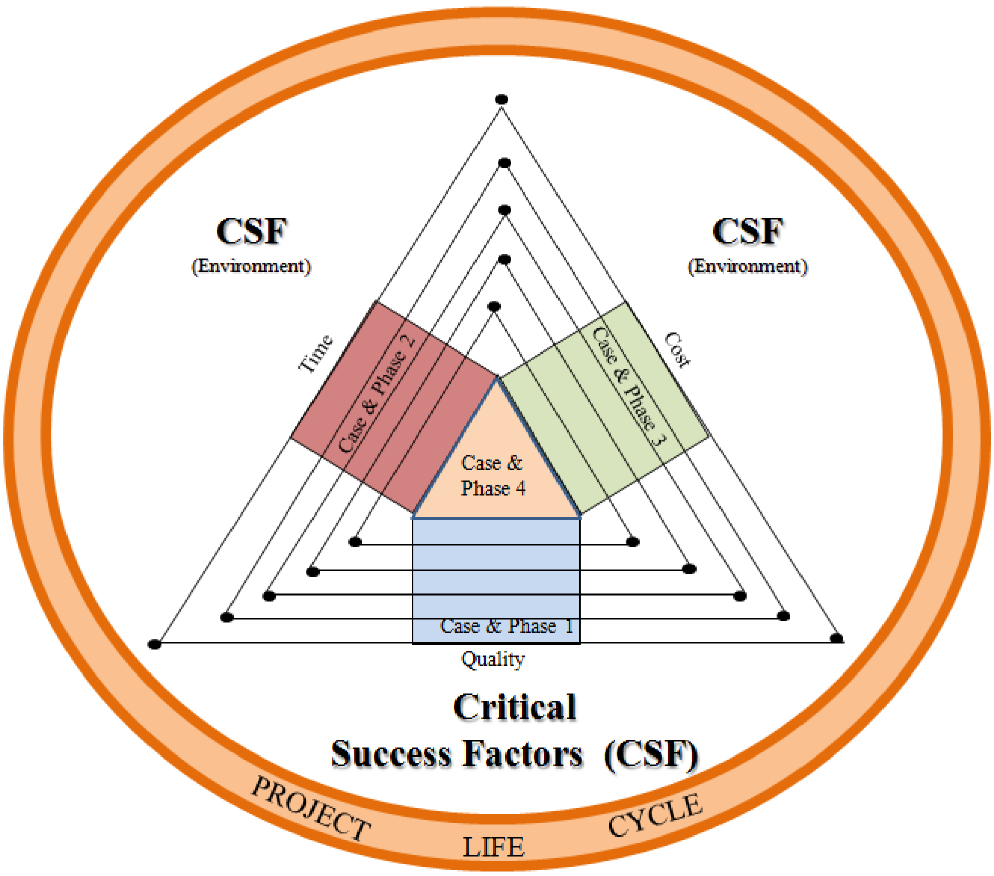


Figure 6.1: Iron Triangle (Barnes 1988, and Gardiner and Stewart 2000).

6.1 INTRODUCTION

Patton (2002) in his research discusses the following four types of triangulation in doing case study evaluation using triangulation as a method:

1 Identifying data within the case study (data triangulation).

2 Identifying data among different evaluators of case studies (investigator triangulation).

3 Using evaluators' perspectives to evaluate the same set of data (theory triangulation).

4 Using appropriate methods to formulate conclusions (methodological triangulation).

Patton (2002) further states that when the researchers use various resources to find evidence they should develop their own analytic strategies. Trochim (1989) argues that one of the most desirable techniques is to use pattern-matching logic or a comparison method. He is of the opinion that if the observed and predicted patterns appear to be similar, the results can support and strengthen the internal validity.

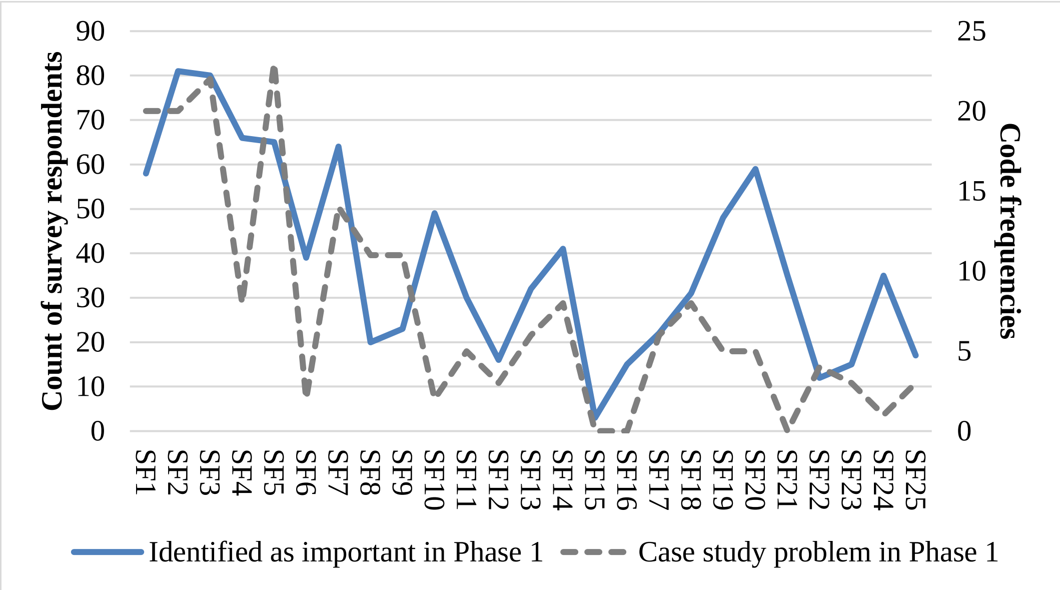
Quantitative and qualitative pattern-matching can clearly be seen in the graphs below (pattern-matching graphs 6.1 to 6.4).

6.2 PATTERN-MATCHING

Merging the quantitative and qualitative results

The graphs in this section indicate the number of participants that identified each success factor as important per phase (as measured on the left-hand axis) and the frequencies that each success factor was identified as the root of the problem revealed in the case studies analysed (as measured on the right-hand axis).

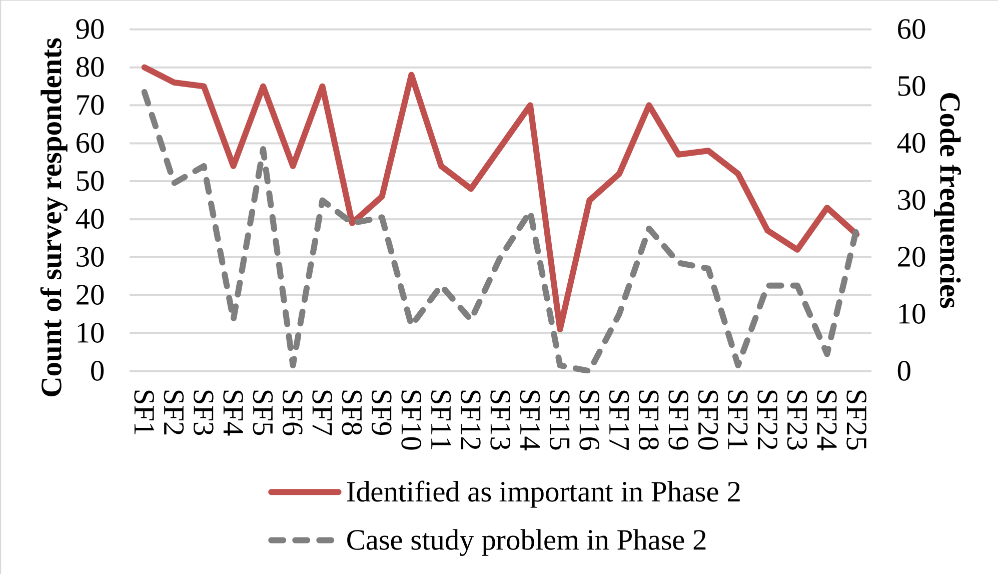
Phase 1



Graph 6.1: Pattern-matching phase 1

- Similar trends, in other words the factors identified as important by the participants (that corresponds to theory) are in many cases the root of problems in practise such as **SF 5** coded at 23 in Table 5.2 (phase 1). **Similar trends can be noticed in graphs 2 to 4 regarding SF 5.**
- The exceptions in phase 1 are with SF 19 (environmental studies) and SF 20 (feasibility studies), where the participants indicated them as important and these were not the root of problems during this phase. This could imply that these studies are conducted and therefore do not create risks for the project's success.

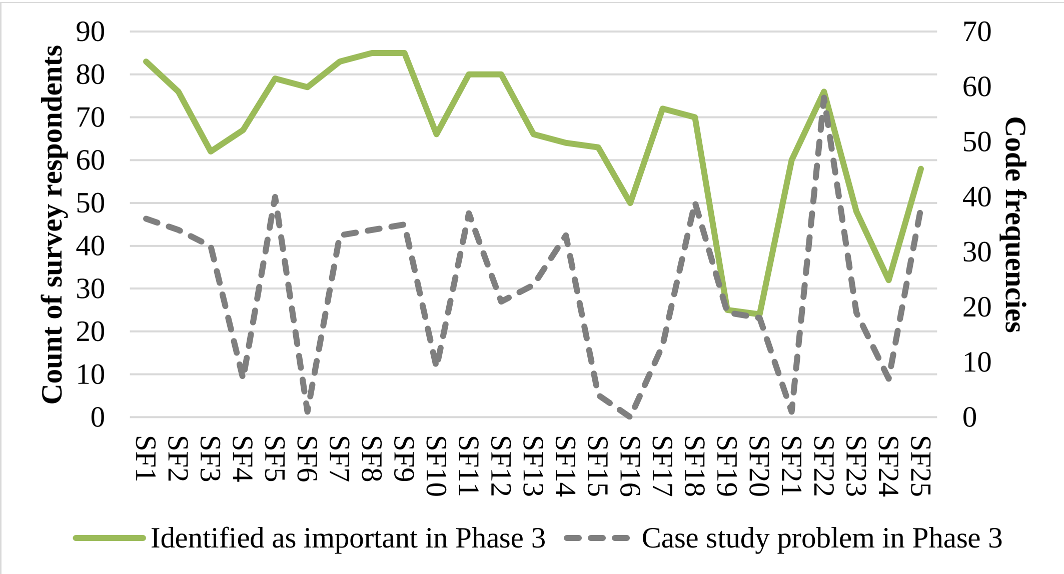
Phase 2



Graph 6.2: Pattern-matching phase 2

- Similar trends, in other words the factors identified as important by the participants (that corresponds to theory) are in many cases the root of problems in practise.

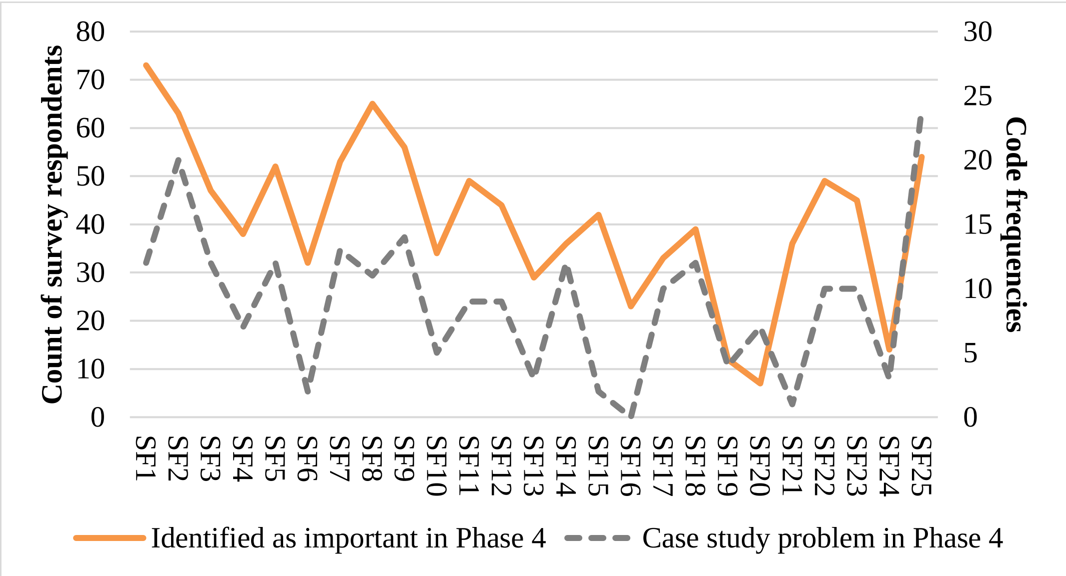
Phase 3



Graph 6.3: Pattern-matching phase 3

- Similar trends, in other words the factors identified as important by the participants (that corresponds to theory) are in many cases the root of problems in practise.

<u>Phase 4</u>



Graph 6.4: Pattern-matching phase 4

- Similar trends, in other words the factors identified as important by the participants (that corresponds to theory) are in many cases the root of problems in practise.

CRITICAL SUCCESS FACTOR RATING AND RANKING

Critical success factor		**Rank of average rating of importance from survey (phase 5)**	**Rank of total frequency as root of problem in case studies**
SF1	Competent project manager	**1**	**1**
SF2	Client participation and approval on project, design – construction	**2**	**3**
SF3	Project mission – clearly defined goals, objectives, scope of works.	**3**	**4**
SF4	Top management support.	**5**	19
SF5	Competence of project team.	**4**	**2**
SF6	Sufficient project resources.	8	23
SF7	Effective communication between participants.	7	**5**
SF8	Reliable and experienced contractor services.	6	10
SF9	Quality control on workmanship.	10	7
SF10	Project planning, time, (WBS).	9	20
SF11	Project monitoring & controlling.	11	12
SF12	Regular site visits / meetings.	12	17
SF13	Clearly defined and detailed contract procurement processes.	14	13
SF14	Project risk management.	17	11
SF15	Project variation orders (VOs’).	24	22
SF16	Applicable training provision.	23	25
SF17	Progress meetings.	18	18
SF18	Well defined specifications and technical drawings with BoQ	13	9
SF19	Environmental studies.	20	15
SF20	Feasibility studies.	19	14
SF21	Adequate financial resources.	15	24
SF22	Contractor performance on site management and supervision.	16	7
SF23	Decision procedures or latent issues	22	15
SF24	Type and size of project.	25	21
SF25	Contract and dispute procedures.	21	**5**

Table 6.1: Ranking versus rating

The above Table 6.1 provides a summary of ranking of the analysed critical success factors based on the results from the research analysis and total frequencies of root of problem in all the case studies.

This serves as evidence that the factors identified as the most important factors that are critical to the success of a project were mainly the root of project failures in practice as based on the four case studies (selected out of 34 case studies) that were analysed.

6.3 SUMMARY

Analysis of the case studies, questionnaires and graphs revealed a lack of theoretical (academic) and scientific knowledge about project management on the part of the project manager, which impacted negatively on their projects and in some cases led to project failure. This finding is in agreement with the research by Thornberry (1987) and Thamhain (1983). The case study evaluators who reviewed and assessed the various case studies and took into account the practical experience and the theoretical and scientific knowledge came to similar conclusions as did Yin (1994) in his research. The lack of scientific knowledge (includes scientific equipment and analysis done in a laboratory or on site) was clearly demonstrated in the results seen in Chapter 6, graphs 6.1, 6.2, 6.3 and 6.4. Over all four phases the following success factors were identified: SF 1, 2, 3, 5 and 7 as critical success factors.

As indicated by Patton (2002) and Yardley (2009) (see Chapters 5 and 6) the above graphs indicate the results that answer the secondary research questions and address said authors' theory in terms of meeting the evidence of reliability and triangulation of the case study results.

The secondary research questions below as indicated in Chapter 1.4:

- **Secondary research question 2**: "How do the critical success factors affect the project life cycle?" is answered in merging graphs 6.1, 6.2, 6.3 and 6.4.

The most important factors that are critical to the success of a project were mainly the root of project failures in practise as based on the case studies that were analysed.

- **Secondary research question 3**: "How can the effect of a lack of knowledge and experience on the part of the project manager within the project life cycle phases influence the critical success factors of project management?" Inexperienced engineers who are employed as project and construction managers and lack experience and knowledge in project management practice will not be able to deliver a project successfully. These engineers cannot identify latent defects within the critical success factors which can affect all the phases of the life cycle as indicated in the above pattern-matching graphs and case study analyses.
- **Secondary research question 4**: "Why are these critical success factors important to be implemented?" Possible answers to the question are given in Table 4.3: Selected critical success factors per phase (pp.136). This table indicates phases 1, 2 and 3, highlighting SFs 1, 2, 3, 4, 5 and 7 as the most important success factors to ensure the successful outcome of a project. Phases 2 and 3 (shown the Table 4.3, pp. 136) indicate various success factors above 60% which are ranked as a unit (SFs 2, 1, 5, 7, 4 and 3) as indicated in the column marked as "average across project" and are equally important. Pattern-matching of all four phases clearly illustrate that lack of knowledge and experience on the part of the project manager can be catastrophic to the outcome of any project because it will affect all the life cycle phases.

As stated by Trochim (1989) a case study consists of the evaluators' findings and conclusion. If these conclusions agree with the conclusions of the quantitative survey, they increase the internal validity of the research as a whole.

This chapter has proved the value of doing quantitative as well as qualitative research to solve a problem. A combination of the two kinds of research made an in-depth interpretation of the results of the study possible. The two research instruments delivered different values but useful information was revealed when the two methods were combined, and that information made answering the research questions possible.

The information obtained from the case studies and shown in the merging graphs clarified a number of concerns which had been left unresolved after the investigations of the failed projects.

The final and total score of success factor 1 (competent project manager) showed a total rating of 117 (highest rating) and indicates the incompetency of the project manager, ranked as 1 in the total of complete project column (Table 5.2). The relevance of this finding for this research is shown in the merging (pattern-matching) graphs 6.1 to 6.4 above, as the pattern-matching of all four phases illustrate the lack of knowledge and experience of the engineer when operating in the office of a project manager.

CHAPTER 7 CONCLUSION AND RECOMMENDATIONS

7.1 CONCLUSION

The purpose of this research was to examine the Project Management Principles that are applied in the South African Design and Construction Industry by assessing and evaluate the engineer's or project manager's practical knowledge and experience in the application of project methodology principles. The aim was to address the project related concerns as defined within the research topic affecting the critical success factors of project management and project delivery.

The purpose of this research was also to identify critical success factors related to the project management environment and group them with the various project life cycle phases. This survey questionnaire was utilised to gather information, as well as to rank and group the most critical success factors as indicated in the survey results.

The partnership of expertise and knowledge is a complex one and includes the operational (practical) knowledge of being able to execute a project in its entirety and work through all its life cycles to reach a successful end, in this case the successful delivery of a project. Full responsibility to meet the objectives of the project rests fully on the shoulders of the project manager. He/she has to be able to apply the theoretical and scientific knowledge (obtained at a university) to the construction project action. Theoretical and scientific knowledge forms the underpinning of his work as it explains why a project should be performed in a particular way, and it gives the project manager the ability to integrate the individual tasks that have to be performed from initiation to completion if the project as a whole is to be delivered successfully.

The research done by Thornberry (1987) and Thamhain (1983) point to a possible cause for project failures: a lack of both theoretical (lack of practical application dealing in theory) and scientific knowledge (scientific equipment, sample tests on site and/or laboratories confirming with methods used in science, e.g. soil analysis as revealed in the case studies) and practical experience on site on the part of the project manager during the execution of his duties.

Case study 3 serves as a good example of the need to combine theoretical and scientific knowledge and practical know-how. In this project the project manager followed the example of what had been done at surrounding properties and did not carry out a geotechnical investigation of the specific property before foundations were designed. It was only discovered at a later stage that the design of the structure did not take latent soil conditions into account. Soil conditions will have an effect on the type of selected foundations and its safety / risk factors to accommodate the required foundation design to sustain the full building load. This example shows that the project failed because the project manager did not do environmental studies before he started on the project. His lack of theoretical and scientific knowledge of the correct procedures during the early stages of the project as well as his lack of practical experience in the field had an adverse effect on the project as a whole (Tomlinson 1980).

In this research the analysis of the four case studies as well as the questionnaire results and the graphs confirm the researcher's conclusions. Analysis of the research questionnaire and the quantitative research revealed that the engineers had sufficient knowledge to operate in their environment. However, the qualitative case study analyses revealed that the engineers had a lack of knowledge where project management was concerned.

The academic engineering courses offered by the universities equip young engineers with sufficient knowledge to start their careers in the field of their choice.

However, beginner engineers lack practical on-site experience. It therefore seems logical that they need to start their careers by working under the supervision of an experienced and knowledgeable engineer, especially regarding the responsibility of managing a large project.

Due to the complexity and the scope of the research topic which involves survey research and case study analyses, the researcher developed a research methodology applying both quantitative and qualitative research technique assessments to address the research objective and research questions.

The quantitative survey and qualitative case study analyses revealed the following results:

1 The quantitative survey: The engineer with a Bachelor's degree was found to be competent when the survey was done regarding his/her academic knowledge concerning project management practices (rating his/her academic knowledge).

2 The qualitative case study analysis showed that the engineers lacked post-graduate project management knowledge and on-site experience (pattern-matching graphs 6.1 to 6.4).

3 Through the case study analyses the researcher proved the importance of on-going collaboration between the project management team and other role players as well as post-graduate project management knowledge and in-depth site supervision if a project is to be delivered successfully. The lack of collaboration was a major concern as revealed in the merging (pattern-matching) graphs 6.1, 6.2, 6.3 and 6.4 (Pattern-matching phases 1, 2, 3, and 4). These graphs bring the quantitative and qualitative results together and revealed the root of problems in practise.

The researcher found no reason to regard the quality of a Bachelor's degree in engineering to be inadequate or a possible cause for the failure of a project for which the engineer was responsible. Registered professional engineers are equipped with scientific knowledge about engineering in general as well as the specific field of his/her choice. Thereafter the engineer has to follow a lengthy process before he/she can be registered with the Engineering Council of South Africa (ECSA). Engineers have to gain practical experience at a company or in their field of interest, usually for a period of 2 to 3 years, after which they have to submit a report of their experience. This is followed by a review and oral examination by ECSA and only then can the engineer apply for full registration with ECSA.

The research presented in this study highlighted the concerns raised by the research topic by addressing the research objective and the research questions.

The **main objective of the research** was to identify success factors related to the project and construction management environment and to group these success factors with the various project life cycle phases as discussed by Pinto and Slevin (1989). Critical success factors 1, 2, 3, 4, 5 and 7 were successfully identified and grouped in phases 1, 2 and 3 according to some criteria. In order to resolve the concerns of the research topic a five point Likert scale instrument was used to measure the ranking versus rating results and revealed the above neglected critical success factors. The ranking order for phases 1 to 3 (success factors 1, 2, 3, 4, 5 and 7) correlate with the ranking order presented in phase 5.

The **primary research question** was illustrated in phases 2 and 3 indicating between 14 and 20 success factors rated above 60% (see Table 4.3). Most of these critical success factors were neglected and were found in the reviewed case studies to be the root of problems in practise (pattern-matching graphs 6.1 to 6.4, pp. 179 – 181).

The **secondary research questions** revealed the following:
The most important success factors that are critical to the success of a project were mainly the root of project failures in practise as based on the case studies that were analysed. Inexperienced engineers who are employed as project and construction managers and lack experience and knowledge in project management practice will not be able to deliver a project successfully. Pattern-matching of all four phases clearly illustrate that lack of knowledge and experience on the part of the project manager can be catastrophic to the outcome of any project because it will affect all the life cycle phases.

Four **case studies** were analysed and when the results of the quantitative survey research and the qualitative analysis were merged, the following came to light:

1 During various stages in the qualitative case study analysis there was an indication that a combination of activities were not performed during the execution of the project live cycle process and that those led to project failure and an inability by the main role players to fulfil the client's needs.

2 The assessment of the four case studies showed that the knowledge, skills, experience, practical abilities, as well as the communication between the various role players were below the required standard and code of conduct.

3 The results also showed that the project mission was lacking, that goals and objectives were undefined and that there was insufficient monitoring and controlling during site meetings and activities. Physical inspections of the real progress of the project and regular site meetings were often replaced by weekly reports by the contractor.

4 Examination of the case studies indicated that the engineers regularly overlooked or neglected to study the planning techniques and scope of work in its fullness, and that this affected the critical success factors of the project throughout the project life cycle. Examples of aspects that were neglected are feasibility and environmental studies and risk management assessments.

5 The case studies indicated that the project manager did not visit the project regularly and allowed the contractor to take control and make important decisions on his own.

6 It was shown that communication and participation between all relevant role players were not up to standard.

7 The case study analysis of all four phases indicated that the effect of a lack of knowledge and experience in the project life cycle domain had a negative impact on the critical success factors of project management. (Table 5.2: Qualitative case study analysis, pp. 170).

8 The information obtained from the case studies and shown in the merging (pattern-matching) graphs 6.1 to 6.4 clarified a number of concerns which had been left unresolved after the investigation and judgement of the failed projects.

The dual application of quantitative and qualitative research exposed shortcomings in the knowledge (and therefore probably the training) of the engineer when he needs to act as manager of a project. Integrating the two research instruments brought to light the effect of a lack of project management knowledge and site experience affecting the critical success factors within the project life cycle phases.

The researcher concludes that there is a statistically significant correlation between the quantitative survey and the qualitative analysis. These case studies showed that project failure occurred when project management principles were not followed. This is therefore an area of major concern. The results of the research (using a quantitative survey, qualitative case study analyses, and five point Likert scale instruments), stated that the engineer as project manager needs further project management education and site experience in order to deliver a successful project.

The purpose of this research was fulfilled in the results of the surveys and showed that latent factors as well as the inexperience of engineers as project managers led to project failures.

Fayol (1949) is of the opinion the future of the project manager will rest much on his technical knowledge and ability but more on his managerial skills.

7.2 RECOMMENDATIONS

The researcher proposes that ECSA examine (and possibly adjust) its registration conditions in order to better prepare engineers to become effective project managers in their field of choice.

Adjustments and changes to the procedure can ensure that the candidate's registration is only valid within the boundaries of his or her experience. Should an engineer wish to add a field of expertise to his/her resume, ECSA should be informed and a new application process may be necessary.

The researcher further proposes the following requirements for some of the fields of project management and registering with ECSA:
The graphs 6.1, 6.2, 6.3 and 6.4 and Table 5.2 reveal the most critical success factors that need to be attended to. Over all four phases the following success factors were identified: SF 1, 2, 3, 4, 5 and 7.

In order to address the identified lack of practical knowledge in engineers regarding project management and therefore to ensure a more reliable performance outcome (i.e. successful projects), the researcher recommends the following:

> The Continuing Professional Development (CPD) and other relevant, registered courses should be expanded to include the areas where there is a marked lack of knowledge especially in the field of project management. These areas are identified in Table 5.2 as success factors 1, 2, 3, 5 and 7, across all phases of the project. Relevant diplomas or certificates approved by these institutions should be obtained.
>
> A post graduate degree in project management should equip an engineer with the necessary knowledge and skills to become a successful project manager. This should be the choice of the engineer who seeks the office of project manager.

In addition to the above two options, an engineer should gain at least two years' (full time) site experience on project management under the supervision of a senior engineer before being allowed to manage a project on his own.

Engineers with a bachelor's degree should not be able to become project managers in the construction and engineering environment without further post-graduate knowledge, training and experience.

Badawy (1995) indicates that 63% of the engineers in the USA are employed as managers at the age of 65 because of their relevant experience in this field.

The researcher agrees with Roberts and Biddle (1994) when they state that postgraduate management education is important for engineers if they are to improve their managerial skills.

The research presented in this study highlighted the concerns raised by the research topic and addressed the research questions. The research also confirmed the importance of postgraduate knowledge in project management principles and full-time site experience for a minimum period of two years.

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ANNEXURE 1: NATIONAL SURVEY QUESTIONNAIRE

CRITICAL SUCCES SFACTORS FOR PROJECT MANAGEMENT IN SOUTH AFRICA DESIGN AND CONSTRUCTION PROJECTS

Dear Sir / Madam and Respondent,

This is a national survey.

We request your participation and support in our research on Success Factors in the Project Management and the Construction Industry in South Africa.

The aim of this survey is to identify the most important factors, which determine the success of the construction project. Dr Harry Visser is conducting this survey as part of the requirements for completion of a post-graduate research study at the University of the Witwatersrand.

This survey comprises of an "A" and "B" section. **Section A** covers twelve (12) personal questions. **Section B** comprises of a matrix questionnaire pertaining to the selection and rating of success factors necessary for the delivery of an engineering project across its entire life cycle. **Regarding Section B, you need to select no less than 15 success factors in respect of project phases 1 to 4 (i.e. columns 1 to 4 respectively) <u>in addition,</u> to rating the 25 success factors relevant to the management of a project in general (i.e. column 5).**

The outcome of this survey will be available to respondents upon written request thereof.

Please be assured that your answers will be treated with confidentiality and that the survey DOES NOT request any identification from the respondent. Your frank and honest opinion(s) is sought and the information obtained will be strictly used for academic purposes and statistical analysis only. The identity of respondents will not be revealed. Participation in this survey is entirely voluntarily and there is no penalty if you do not participate. There is no risk associated with filling in the survey since the researcher guarantees anonymity of the responses. E-mail information will be used to track the number of responses only and will not be shared with anybody outside the group. Kindly take a few minutes of your time to complete this survey and return it to the researcher within 2 weeks from receipt thereof.

Your cooperation is appreciated.

Please email the completed survey to:**hv@lpcmanagement.co.za**

Study Leader, Prof Robert McCutcheon**: robberttmccutcheon@gmail.com**
011 717 7129

SECTION: A Please mark (**x**) ONE answer only most suitable and particular to you:

1. **Province: ____________________**

2. **Email address: ____________________________** (Only if interested in the outcome of the research.)

3. **Your highest academic qualification:** Example: B.Eng. X

O ND.	NC	
O HND.	HNC.	
O B.Sc.	B.Eng.	B.Tech.
O M.Sc.	M.Eng.	M.Tech.
O PhD.	D.Eng.	D.Tech.

O Others: …………………………………………………………

4. **Design working experience:**

O Less than 2 years.

O 2–5years.

O 6–10years.

O More than 10 years.

5. **Construction working experience:**

O Less than 2 years.

O 2 – 5 years.

O 6 – 10 years.

O More than 10 years.

6. **Area of specialisation:**

O Construction management.

O Civil engineering.

O Structural engineering.

O Electrical engineering.

O Others: Please specify. ………………………………………..

7. Role in the project:

- ○ Client / owner.
- ○ Consultant.
- ○ Contractor.
- ○ Others:……………………………………………………………..

8. Position in the project organisation:

- ○ Project Director.
- ○ Project Manager.
- ○ Contract Manager.
- ○ Project Engineer.
- ○ Consultant.
- ○ Others: ……………………………………………………………

9. The project type:

- ○ Building and construction projects.
- ○ Civil or structural projects.
- ○ Mechanical projects.
- ○ Electrical projects.
- ○ Other: ………………………………………………………………

10. The project cost (as budgeted):

- ○ Less than RM10 million.
- ○ RM10 – 20 million.
- ○ RM 20 – 50 million.
- ○ RM 50 – 100 million.
- ○ More than RM 100 million.

11. The project duration (as planned):

- ○ Less than 1 year.
- ○ 1 – 3 years.
- ○ More than 3 years.

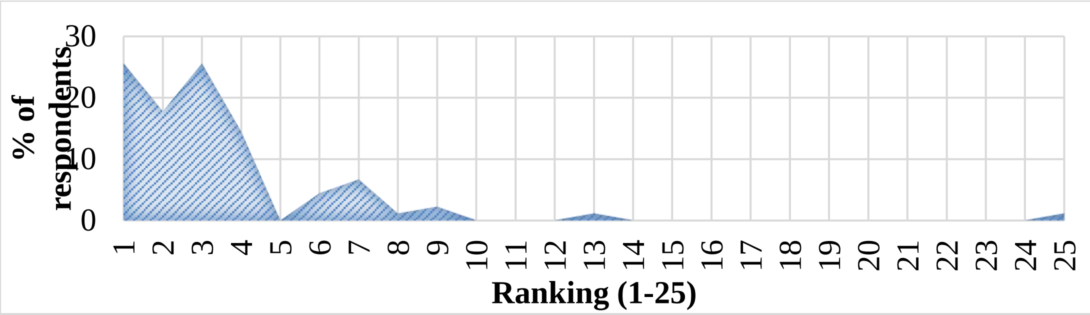
SECTION: B. Based upon your overall experience in project management of design and construction projects, select no less than the 15 most important success factors (SF) of your choice in each **project phases 1 to 4.**

NOTE: REGARDING THE RATING OF SUCCESS FACTORS IN COLUMN 5, THE NUMERAL "1" IS TO BE SELECTED FOR YOUR MOST IMPORTANT FACTOR FOR PROJECT MANAGEMENT WHEREAS "25" IS FOR YOUR LEAST IMPORTANT FACTOR.

SUCCESS FACTORS	**Phase 1** Concept	**Phase 2** Planning	**Phase 3** Implementa-tion Construc-tion	**Phase 4** Closeout	**Success Factor Rating 1 - 25**
1 Competent project manager.					
1 Client participation and approval on project, design – construction					
2 Project mission – clearly defined goals, objectives, scope of works.					
3 Top management support.					
4 Competence of project team.					
5 Sufficient project resources.					
6 Effective communication between participants.					
7 Reliable and experienced contractor services.					
8 Quality control on workmanship.					
9 Project planning, time, (WBS).					
10 Project monitoring & controlling.					
11 Regular site visits / meetings.					
12 Clear defined and detailed contract procurement processes.					
13 Project Risk Management.					
14 Project variation orders (VO').					
15 Applicable training provision.					
16 Progress meetings.					
17 Well defined specifications and technical drawings with BoQ					
18 Environmental studies.					
19 Feasibility studies.					
21. Adequate financial resources.					
22. Contractor performance on site management and supervision.					
23. Decision procedures or latent issues					
24. Type and size of project.					
25. Contract and dispute procedures.					

ANNEXURE 2: SUCCESS FACTOR GRAPHS (1 – 25)

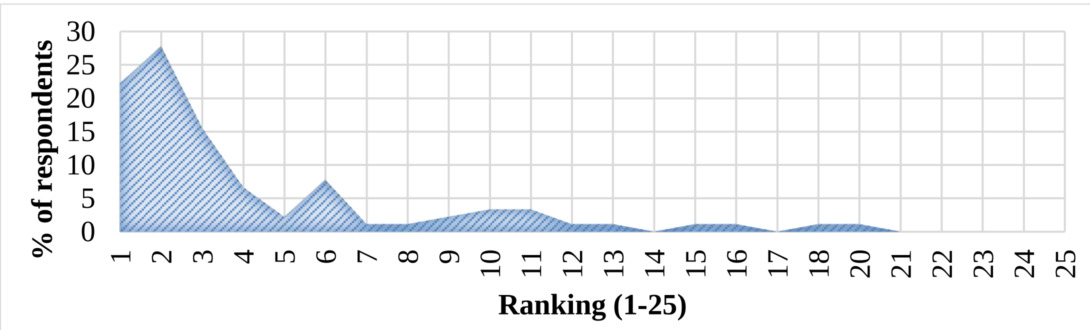
Graph 4.1 SF 1: Competent project manager (see Chapter 2: item 2.6.3)



1	2	3	4	5	6	7	8	9	10	11	12	13
25.6 %	17.8 %	25.6 %	14.4 %	-	4.4 %	6.7 %	1.1 %	2.2 %	-	-	-	1.1 %
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
-	-	-	-	-	-	-	-	-	-	-	1.1 %	

Regarded as very important as 68.9% of the participants ranked this as 1, 2 or 3

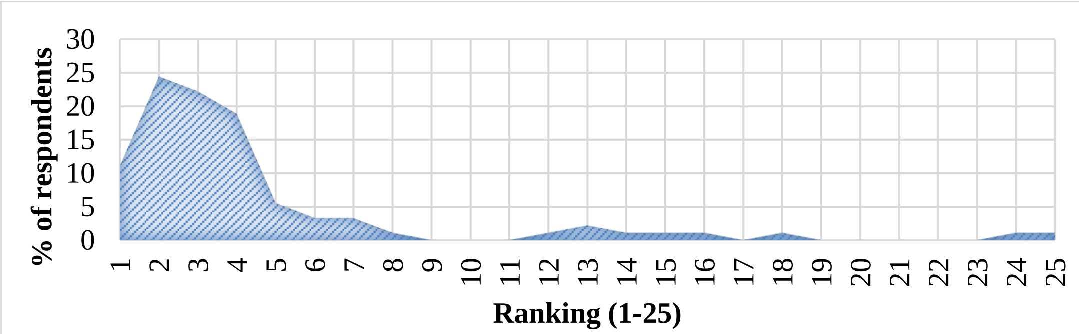
Graph 4.2 SF 2: Client participation and approval on project, design – construction (see Chapter 2: item 2.6.1 and 2.6.2)



1	2	3	4	5	6	7	8	9	10	11	12	13
22.2 %	27.8 %	15.6 %	6.7 %	2.2 %	7.8 %	1.1 %	1.1 %	2.2 %	3.3 %	3.3 %	1.1 %	1.1 %
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
-	1.1%	1.1%	-	1.1 %	1.1 %	-	-	-	-	-	-	

Regarded as very important as 65.6% of the participants ranked this as 1, 2 or 3

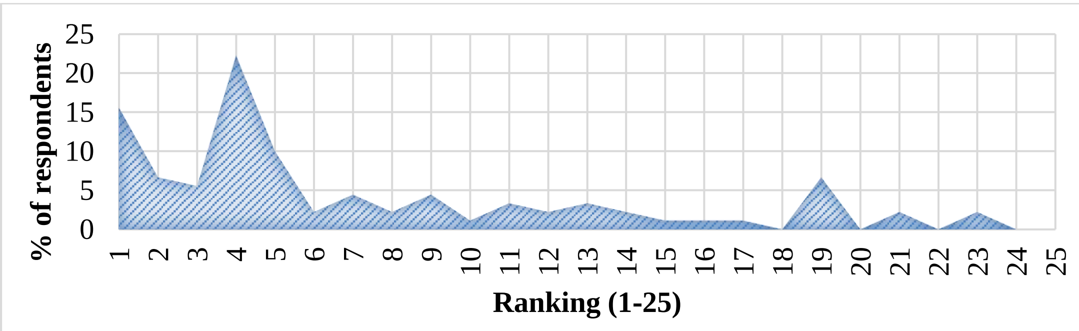
Graph 4.3 SF 3: Project mission – clearly defined goals, objectives, scope of works (See Chapter 2: item 2.6.2.3).



1	2	3	4	5	6	7	8	9	10	11	12	13
11.1 %	24.4 %	22.2 %	18.9 %	5.6 %	3.3 %	3.3 %	1.1 %	-	-	-	1.1 %	2.2%
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
1.1%	1.1%	1.1%	-	1.1 %	-	-	-	-	-	1.1 %	1.1 %	

Regarded as important as 65.6% of the participants ranked this as 2, 3 or 4

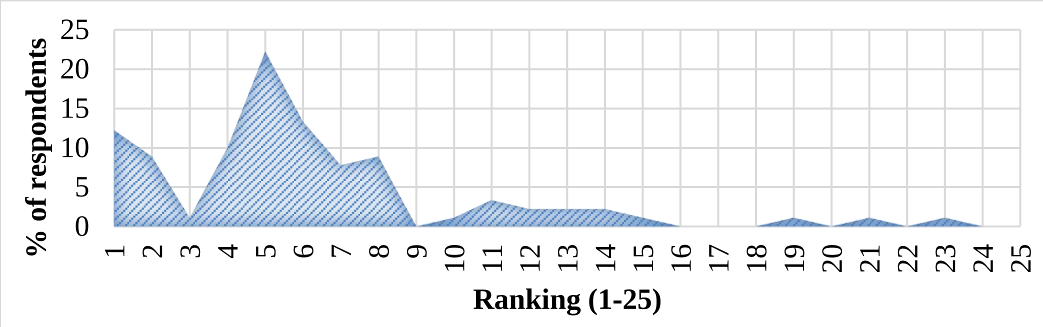
Graph 4.4 SF 4: Top management support (see Chapter 2: item 2.5.4.2)



1	2	3	4	5	6	7	8	9	10	11	12	13
15.6 %	6.7 %	5.6 %	22.2 %	10.0 %	2.2 %	4. 4%	2.2 %	4.4 %	1.1 %	3.3 %	2.2 %	3.3 %
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
2.2 %	1.1 %	1.1 %	1.1 %	-	6.7 %	-	2.2 %	-	2.2 %	-	-	

Regarded as important as 15.6% of the participants ranked this as 1, while 32.2% ranked this as 4 or 5.

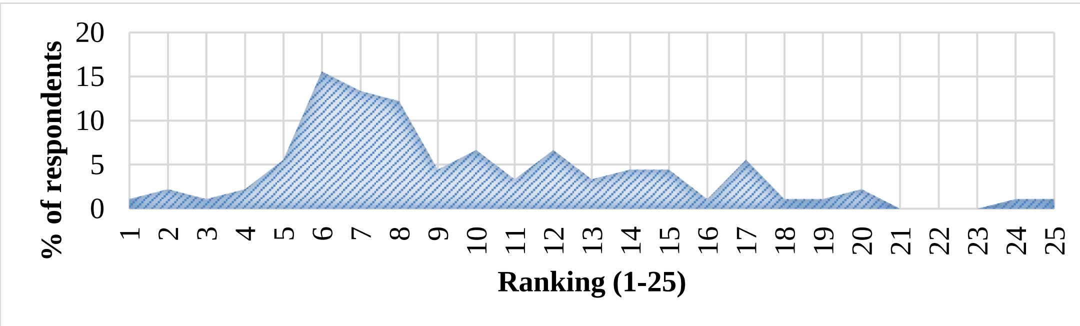
Graph 4.5 SF 5: Competence of project team (see Chapter 2: item 2.5.2.2)



1	2	3	4	5	6	7	8	9	10	11	12	13
12.2%	8.9%	1.1%	10.0%	22.2%	13.3%	7.8%	8.9%	-	1.1%	3.3%	2.2%	2.2%
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
2.2%	1.1%	-	-	-	1.1%	-	1.1%	-	1.1%	-	-	

Regarded as important as 45.6% of the participants ranked this as 4, 5 or 6.

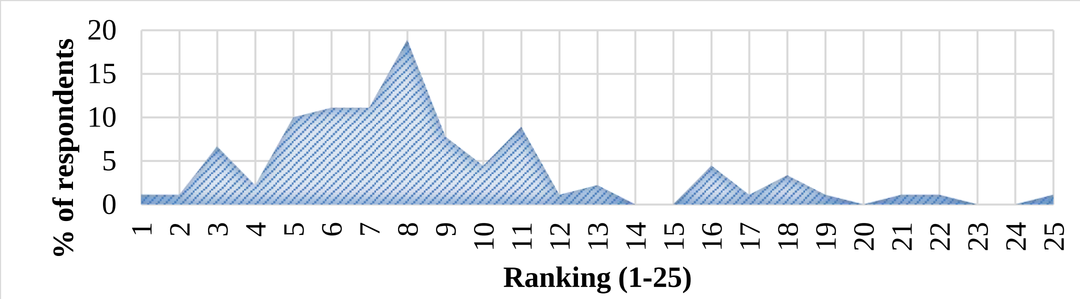
Graph 4.6 SF 6: Sufficient project resources (see Chapter 2: item 2.7.1 and 2.7.2)



1	2	3	4	5	6	7	8	9	10	11	12	13
1.1%	2.2%	1.1%	2.2%	5.6%	15.6%	13.3%	12.2%	4.4%	6.7%	3.3%	6.7%	3.3%
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
4.4%	4.4%	1.1%	5.6%	1.1%	1.1%	2.2%	-	-	-	1.1%	1.1%	

41.1% of the participants ranked this 6, 7 or 8, the majority ranking this as 6.

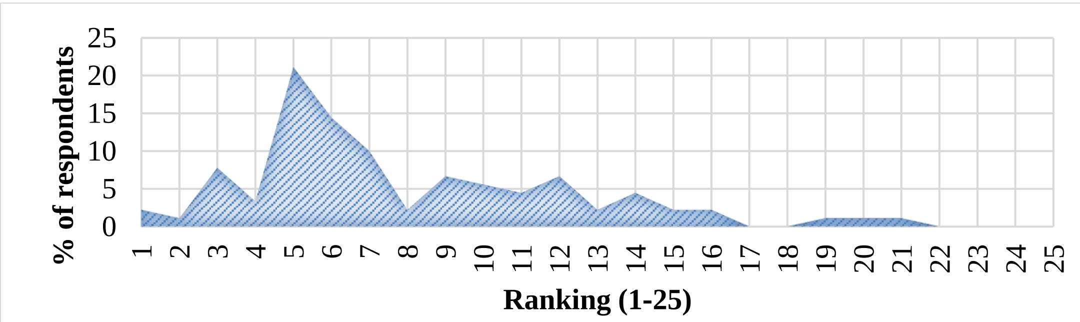
Graph 4.7 SF 7: Effective communication between participants (see chapter 2: item 2.6.3.4)



1	2	3	4	5	6	7	8	9	10	11	12	13
1.1%	1.1%	6.7%	2.2%	10.0%	11.1%	11.1%	18.9%	7.8%	4.4%	8.9%	1.1%	2.2%
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
-	-	4.4%	1.1%	3.3%	1.1%	-	1.1%	1.1%	-	-	1.1%	

51.1% of the participants ranked this as 5, 6, 7 or 8, the majority ranking it as 8.

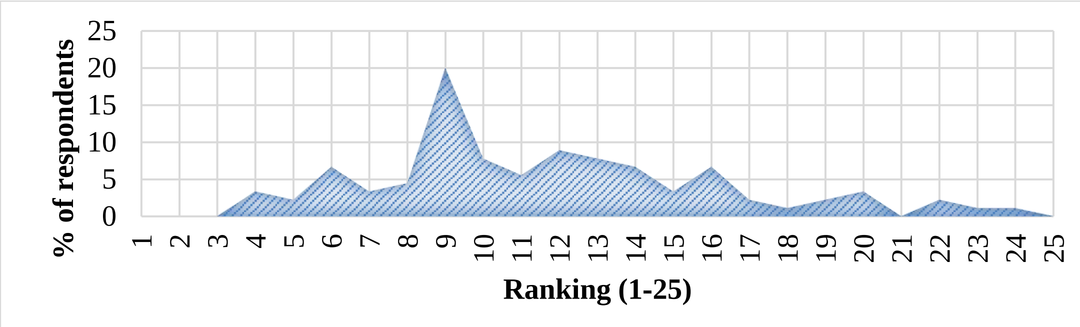
Graph 4.8 SF 8: Reliable and experienced contractor services (see Chapter 2: item 2.6.4.2)



1	2	3	4	5	6	7	8	9	10	11	12	13
2.2%	1.1%	7.8%	3.3%	21.1%	14.4%	10.0%	2.2%	6.7%	5.6%	4.4%	6.7%	2.2%
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
4.4%	2.2%	2.2%	-	-	1.1%	1.1%	1.1%	-	-	-	-	

45.6% of the participants ranked this as 5, 6, or 7, the majority ranking it as 5.

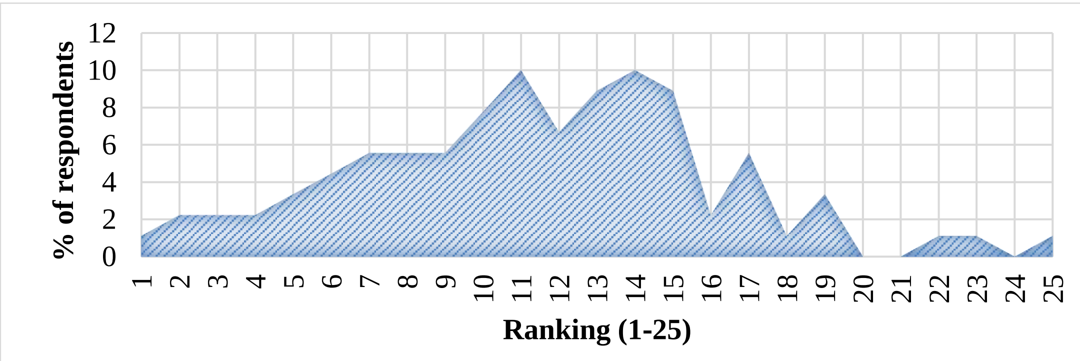
Graph 4.9 SF 9: Quality control on workmanship (see Chapter 2: item 2.7.3 (c)



1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
-	-	-	3.3 %	2.2 %	6.7 %	3.3 %	4.4 %	20.0 %	7.8 %	5.6 %	8.9 %	7.8 %
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
6.7 %	3.3 %	6.7 %	2.2 %	1.1 %	2.2 %	3.3 %	-	2.2%	1.1 %	1.1 %	-	

20.0% of the participants ranked this as 9.

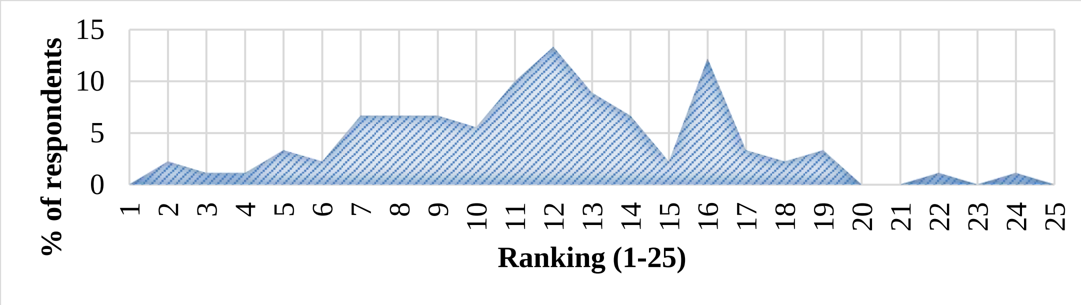
Graph 4.10 SF 10: Project planning, time, (WBS) (see Chapter 2: item 2.7.3 (b)



1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1.1%	2.2 %	2.2 %	2.2 %	3.3 %	4.4 %	5.6 %	5.6 %	5.6 %	7.8 %	10.0 %	6.7 %	8.9 %
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
10.0 %	8.9 %	2.2 %	5.6 %	1.1 %	3.3 %	-	-	1.1 %	1.1 %	-	1.1 %	

Relatively flat dispersion as the highest proportion of the participants (10%) ranked this either as 11 or 14.

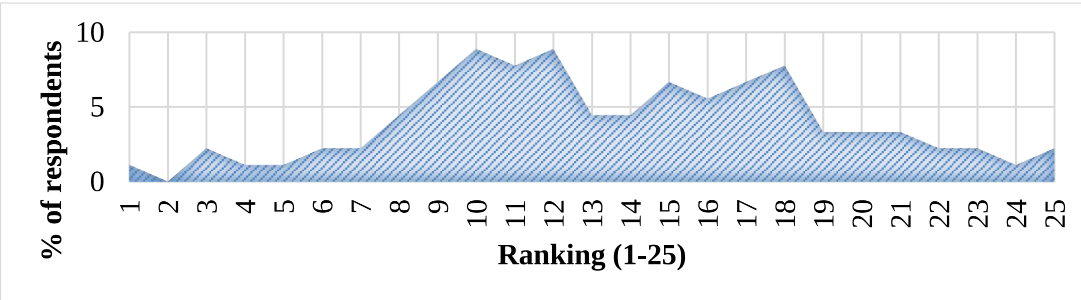
Graph 4.11 SF 11: Project monitoring and controlling (see chapter 2: item 2.7.3 (c, d, e, f, g and h)



1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
-	2.2%	1.1%	1.1%	3.3%	2.2%	6.7%	6.7%	6.7%	5.6%	10.0%	13.3%	8.9%
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
6.7%	2.2%	12.2%	3.3%	2.2%	3.3%	-	-	1.1%	-	1.1%	-	

Relatively flat dispersion 23.3% of the participants ranked this as 11 or 12 and 12.2% ranked this as 16.

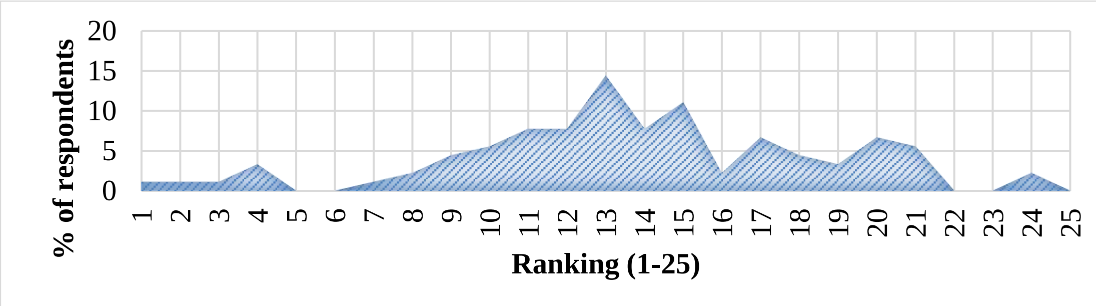
Graph 4.12 SF 12: Regular site visits / meetings (see Chapter 2: item 2.7.3 - f and j)



1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1.1%	-	2.2%	1.1%	1.1%	2.2%	2.2%	4.4%	6.7%	8.9%	7.8%	8.9%	4.4%
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
4.4%	6.7%	5.6%	6.7%	7.8%	3.3%	3.3%	3.3%	2.2%	2.2%	1.1%	2.2%	

Relatively flat dispersion, with majority of the participants (25.6%) ranking this as 9, 10 or 11 while 7.8% of the participants ranked it as 18.

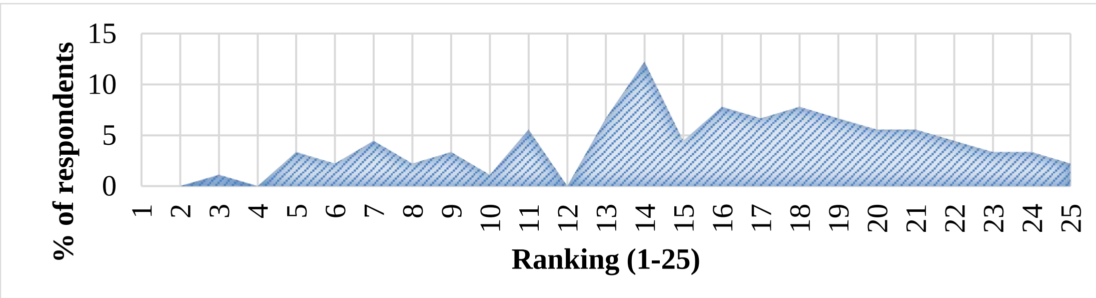
Graph 4.13 SF 13: Clearly defined and detailed contract procurement processes (see Chapter 2: item 2.6.5 to 2.6.5.5)



1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1.1%	1.1%	1.1%	3.3%	-	-	1.1%	2.2%	4.4%	5.6%	7.8%	7.8%	14.4%
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
7.8%	11.1%	2.2%	6.7%	4.4%	3.3%	6.7%	5.6%	-	-	2.2%	-	

33.3% of the participants ranked this as 13, 14 or 15 with the majority 14.4% ranking it as 13.

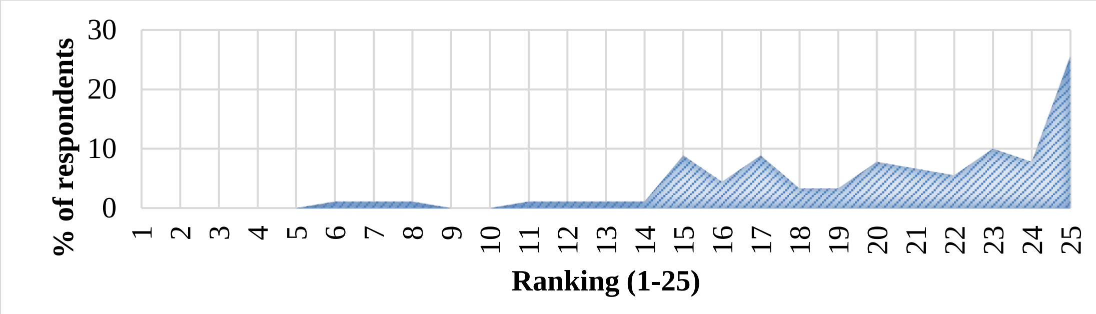
Graph 4.14 SF 14: Project risk management (see Chapter 2: item 2.7.3 (a)



1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
-	-	1.1%	-	3.3%	2.2%	4.4%	2.2%	3.3%	1.1%	5.6%	-	6.7%
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
12.2%	4.4%	7.8%	6.7%	7.8%	6.7%	5.6%	5.6%	4.4%	3.3%	3.3%	2.2%	

This was regarded a less important as the majority ranked it below 14.

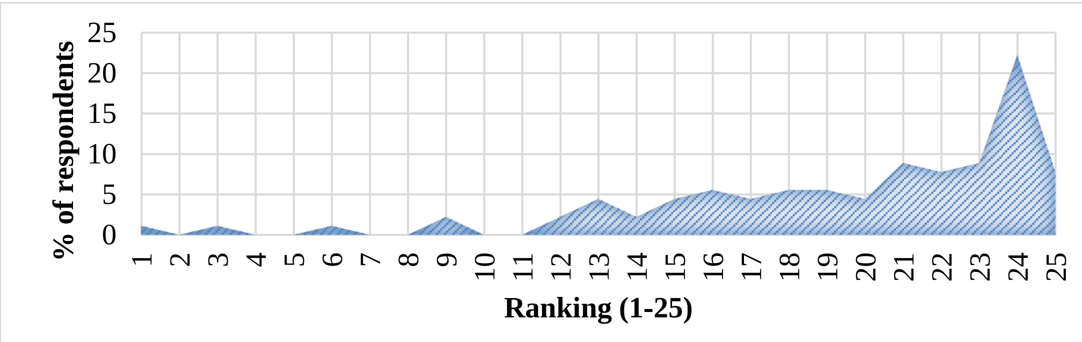
Graph 4.15 SF 15: Project variation orders (VOs') (see Chapter 2: item 2.6.5 to 2.6.5.6)



1	2	3	4	5	6	7	8	9	10	11	12	13
-	-	-	-	-	1.1 %	1.1 %	1.1 %	-	-	1.1 %	1.1%	1.1 %
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
1.1 %	8.9 %	4.4 %	8.9 %	3.3 %	3.3 %	7.8 %	6.7 %	5.6 %	10.0 %	7.8 %	25.6 %	

Regarded as unimportant as the majority of the participants (25.6%) ranked this as 25.

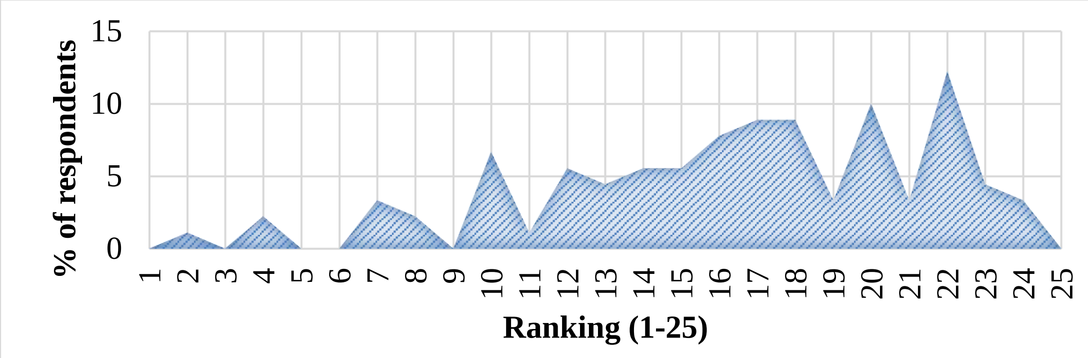
Graph 4.16 SF 16: Applicable training provision (see Chapter 2: item 2.6.3.2)



1	2	3	4	5	6	7	8	9	10	11	12	13
1.1 %	-	1.1 %	-	-	1.1 %	-	-	2.2 %	-	-	2.2 %	4.4 %
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
2.2 %	4.4 %	5.6 %	4.4 %	5.6 %	5.6 %	4.4 %	8.9 %	7.8 %	8.9 %	22.2 %	7.8 %	

Regarded as unimportant as the majority of the participants (22.2%) ranked this as 24.

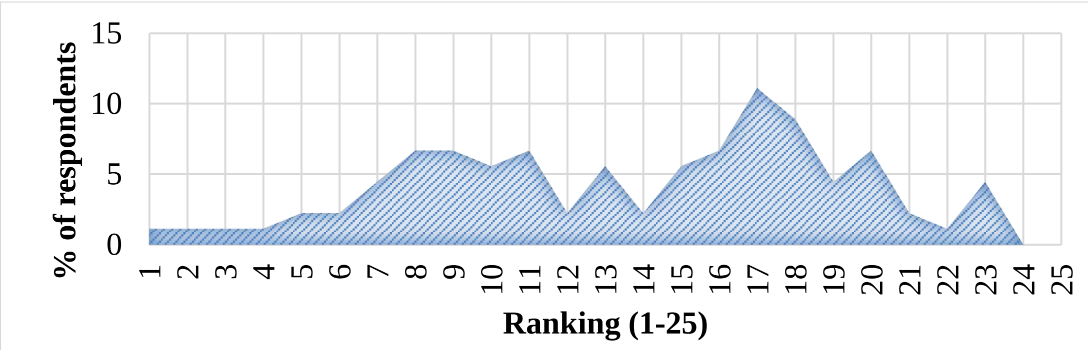
Graph 4.17 SF 17 Progress meetings (see Chapter 2: item 2.7.3 (e and j)



1	2	3	4	5	6	7	8	9	10	11	12	13
-	1.1 %	-	2.2 %	-	-	3.3%	2.2 %	-	6.7 %	1.1 %	5.6 %	4.4 %
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
5.6 %	5.6 %	7.8 %	8.9 %	8.9 %	3.3 %	10.0 %	3.3 %	12.2 %	4.4 %	3.3 %	-	

Regarded to be of lesser importance with the majority ranked below 16.

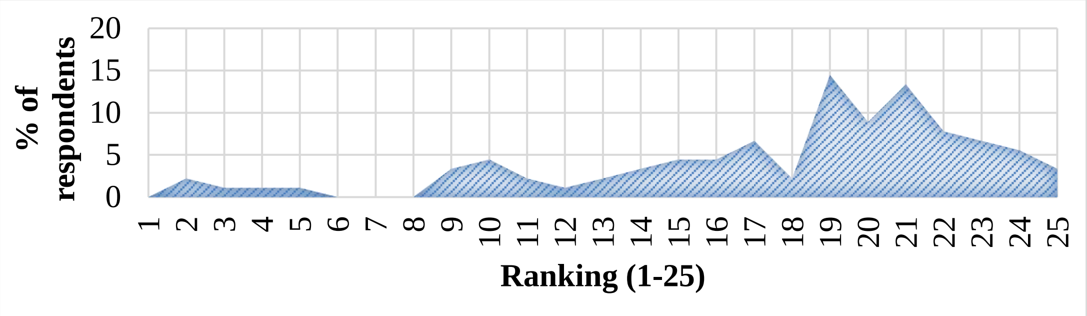
Graph 4.18 SF 18: Well defined specifications and technical drawings with BoQ (see Chapter 2: item 2.7.2 (c)



1	2	3	4	5	6	7	8	9	10	11	12	13
1.1 %	1.1 %	1.1 %	1.1%	2.2 %	2.2 %	4.4 %	6.7 %	6.7 %	5.6 %	6.7 %	2.2 %	5.6 %
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
2.2 %	5.6 %	6.7 %	11.1 %	8.9 %	4.4 %	6.7 %	2.2 %	1.1 %	4.4 %	-	-	

Importance ranking was spread relatively equally, but it was mainly ranked as 17.

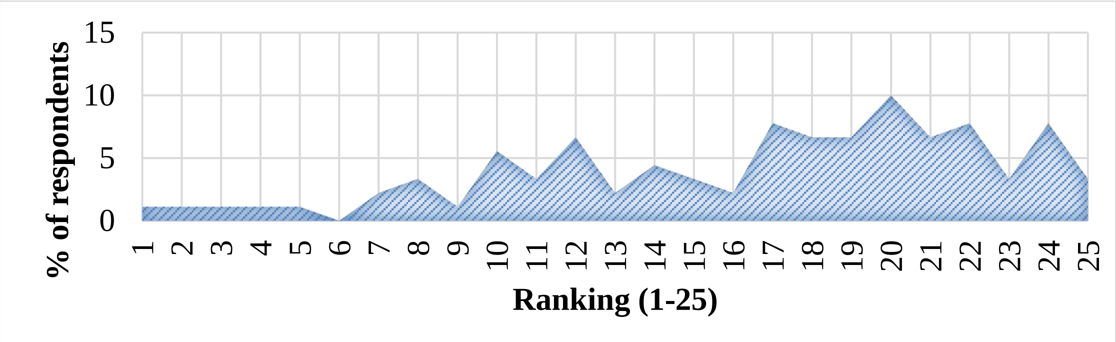
Graph 4.19 SF 19: Environmental studies (see Chapter 2: item 2.7.2 (d) and 2.7.2.2)



1	2	3	4	5	6	7	8	9	10	11	12	13
-	2.2 %	1.1 %	1.1 %	1.1 %	-	-	-	3.3 %	4.4 %	2.2 %	1.1 %	2.2 %
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
3.3 %	4.4 %	4.4 %	6.7 %	2.2 %	14.4 %	8.9 %	13.3 %	7.8 %	6.7 %	5.6 %	3.3 %	

Regarded to be of lesser importance with the majority (60%) ranking this 19 and lower.

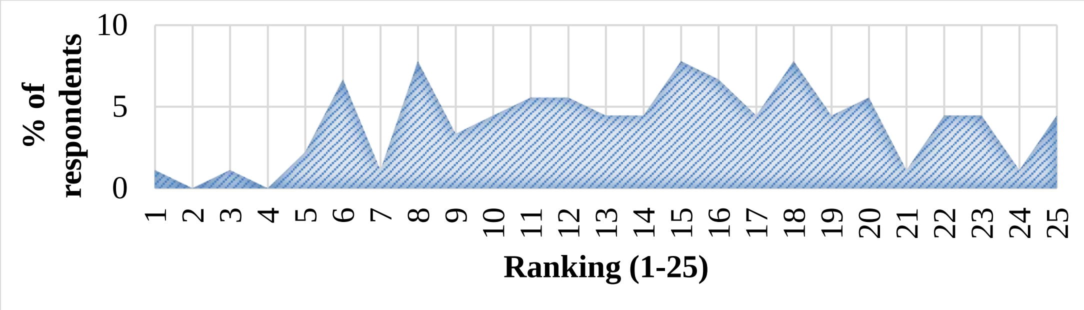
Graph 4.20 SF 20: Feasibility studies (see Chapter 2: item 2.7.1 and 2.7.2.1 and 2.7.2.2)



1	2	3	4	5	6	7	8	9	10	11	12	13
1.1 %	1.1 %	1.1 %	1.1 %	1.1 %	-	2.2 %	3.3 %	1.1 %	5.6 %	3.3 %	6.7 %	2.2 %
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
4.4 %	3.3 %	2.2 %	7.8 %	6.7 %	6.7 %	10.0 %	6.7 %	7.8 %	3.3 %	7.8 %	3.3 %	

Regarded to be of lesser importance with the majority (60%) ranking this 17 and lower.

Graph 4.21 SF 21: Adequate financial resources (see Chapter 2: item 2.7.1. and 2.7.1.4)

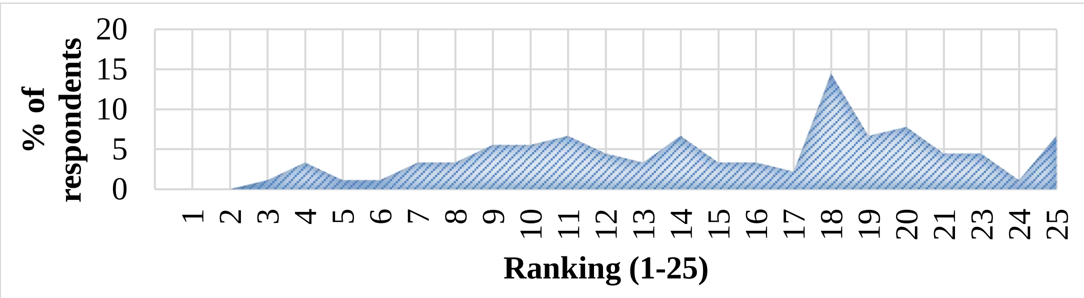


1	2	3	4	5	6	7	8	9	10	11	12	13
1.1 %	-	1.1 %	-	2.2 %	6.7 %	1.1 %	7.8 %	3.3 %	4.4 %	5.6 %	5.6 %	4.4 %
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
4.4 %	7.8 %	6.7 %	4.4 %	7.8 %	4.4 %	5.6 %	1.1 %	4.4 %	4.4%	1.1%	4.4%	

With a relatively flat and even dispersion (no clear opinion) emerged.

Graph 4.22 SF 22: Contractor performance on site management and supervision

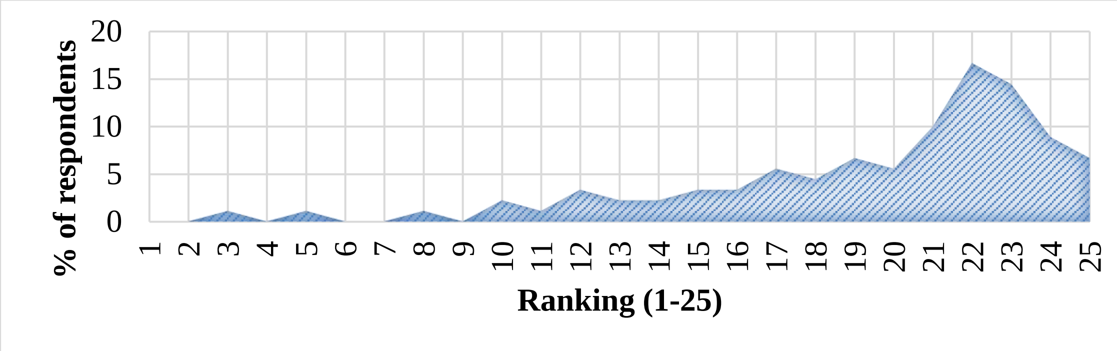
(see Chapter 2: (item 2.6.3.5; 2.6.5.1; 2.6.5.3 and 2.7.3 (f)



1	2	3	4	5	6	7	8	9	10	11	12	13
-	-	1.1 %	3.3 %	1.1%	1.1 %	3.3 %	3.3 %	5.6 %	5.6 %	6.7 %	4.4 %	3.3 %
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
6.7 %	3.3 %	3.3 %	2.2 %	14.4 %	6.7 %	7.8 %	4.4 %	4.4 %	1.1 %	6.7 %	1.1 %	

There is a relatively flat and even dispersion, but this factor seems to be regarded as less important as 14.4% of the participants ranked this as 18.

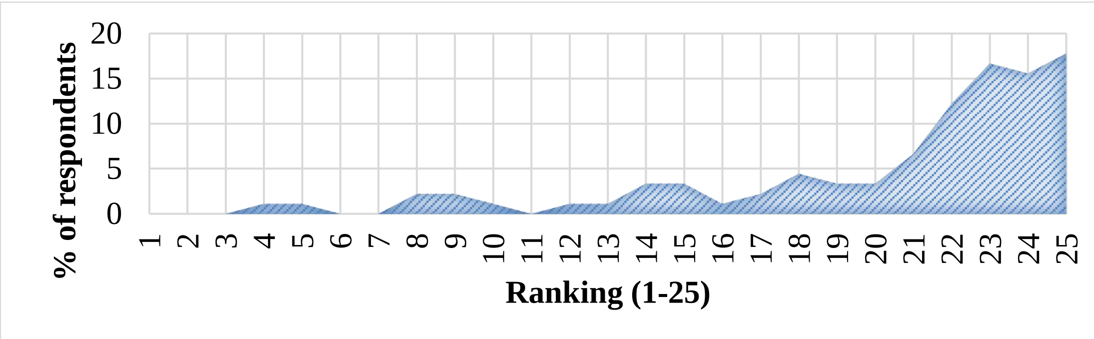
Graph 4.23 SF 23: Decision procedures or latent issues (see Chapter 2: item 2.7.3.9 (a) and 2.7.2 (e)



1	2	3	4	5	6	7	8	9	10	11	12	13
-	-	1.1%	-	1.1%	-	-	1.1%	-	2.2%	1.1%	3.3%	2.2%
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
2.2%	3.3%	3.3%	5.6%	4.4%	6.7%	5.6%	10.0%	16.7%	14.4%	8.9%	6.7%	

The success factor was deemed to be less important as the majority (56.7%) ranked it 21 and lower.

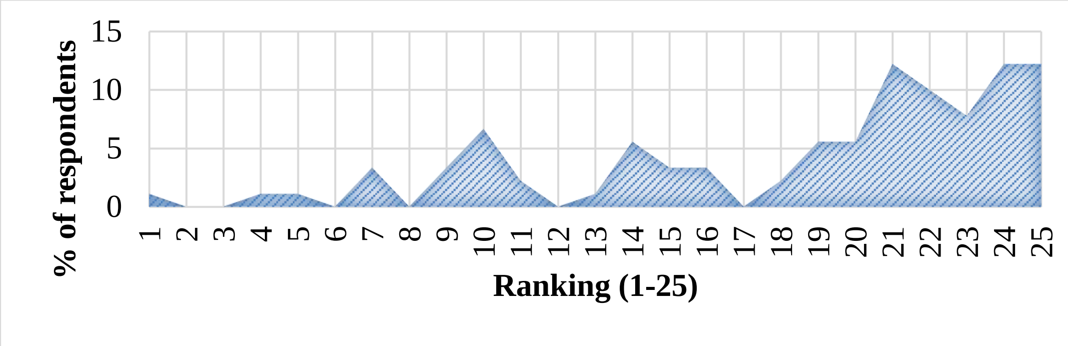
Graph 4.24 SF 24: Type and size of project (see Chapter 2: item 2.7.1 (a) and 2.7.1 b)



1	2	3	4	5	6	7	8	9	10	11	12	13
-	-	-	1.1 %	1.1 %	-	-	2.2 %	2.2%	1.1%	-	1.1%	1.1 %
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
3.3 %	3.3 %	1.1 %	2.2 %	4.4 %	3.3 %	3.3 %	6.7 %	12.2 %	16.7 %	15.6 %	17.8 %	

This success factor was also deemed less important with the majority (62.2%) ranking it as 22 and lower.

Graph 4.25 SF 25: Contract and dispute procedures (see Chapter 2: item 2.6.5 to 2.6.5.5)

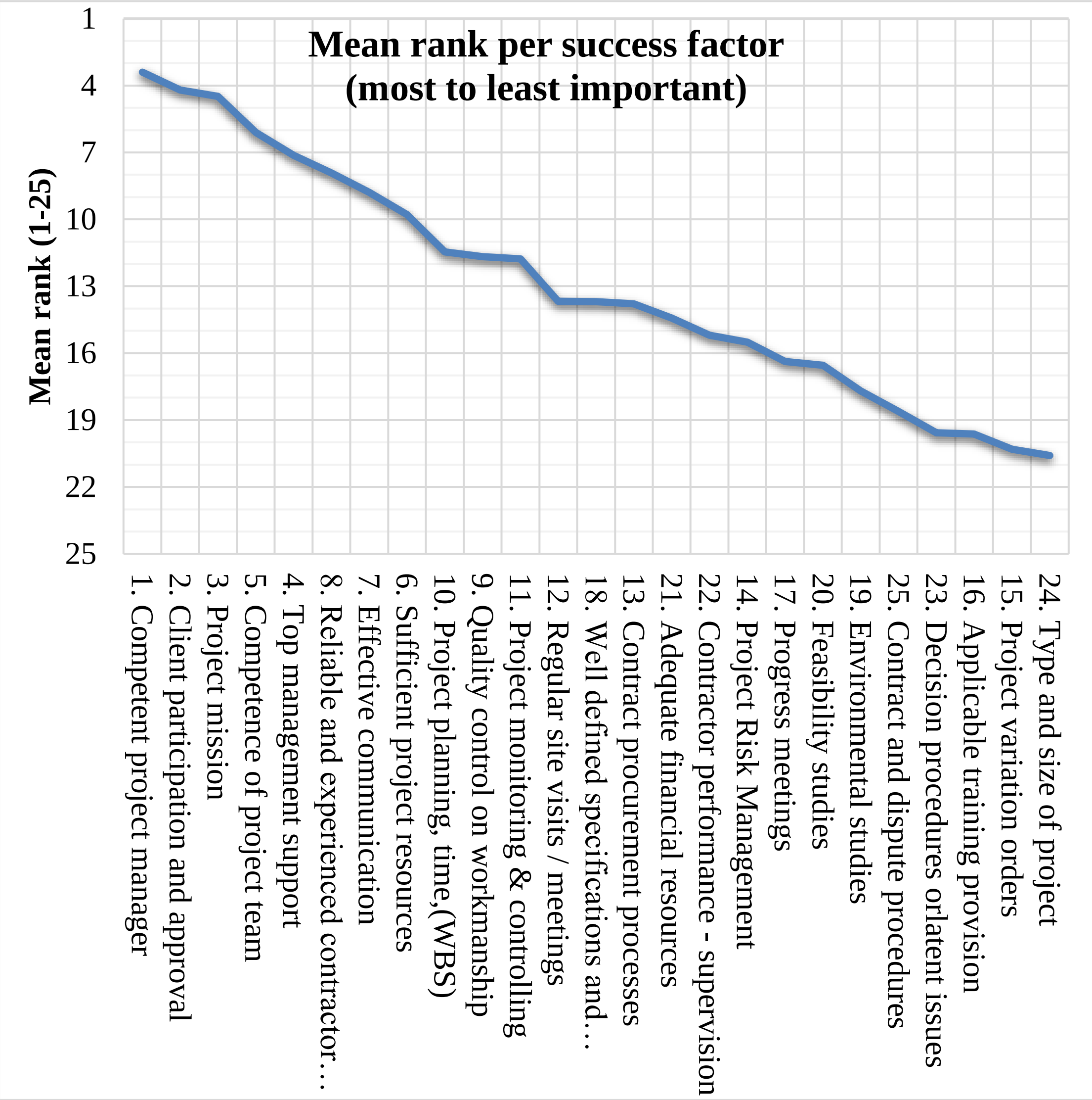


1	2	3	4	5	6	7	8	9	10	11	12	13
1.1 %	-	-	1.1 %	1.1 %	-	3.3 %	-	3.3%	6.7 %	2.2%	-	1.1 %
14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	
5.6 %	3.3 %	3.3 %	-	2.2 %	5.6 %	5.6 %	12.2 %	10.0 %	7.8 %	12.2 %	12.2 %	

Deemed of lesser importance with the majority (54.4%) ranking it as 21 and lower.

MEAN RANK PER SUCCESS FACTOR

- The success factors are listed from those ranked most important to those ranked least important (1-25).
- The majority of the participants ranked the following success factors above 5. (As the respective mean ranking is less than 5 it follows that these success factors were selected by most of the participants as among the top five:
  - Competent project manager (SF 1);
  - Client participation and approval on project, design – construction (SF2);
  - Project mission – clearly defined goals, objectives, scope of works (SF3).



Graph 4.26: Mean rank per success factor

Description and summary of SF rankings (mean and standard deviation of rankings)

Success Factor (SF) (numbering as in the questionnaire)		***Ranking of importance rating (Phase 5)***	**Mean ranking (1-25)**	**Standard deviation**
1	**Competent project manager**	**1**	**3.40**	**3.21**
2	**Client participation and approval on project, design – construction**	**2**	**4.20**	**4.12**
3	**Project mission – clearly defined goals, objectives, scope of works**	**3**	**4.49**	**4.58**
4	**Top management support**	**5**	**7.13**	**6.08**
5	**Competence of project team**	**4**	**6.11**	**4.32**
6	**Sufficient project resources**	**8**	**9.78**	**4.85**
7	**Effective communication between participants**	**7**	**8.79**	**4.64**
8	**Reliable and experienced contractor services**	**6**	**7.92**	**4.24**
9	**Quality control on workmanship**	**10**	**11.68**	**4.53**
10	**Project planning, time,(WBS)**	**9**	**11.46**	**4.75**
11	**Project monitoring and controlling**	**11**	**11.77**	**4.31**
12	**Regular site visits / meetings**	**12**	**13.68**	**5.28**
13	**Clearly defined and detailed contract procurement processes**	**14**	**13.79**	**4.75**
14	**Project risk management**	**17**	**15.51**	**5.31**
15	**Project variation orders (VOs')**	**24**	**20.31**	**4.59**
16	**Applicable training provision**	**23**	**19.62**	**5.10**
17	**Progress meetings**	**18**	**16.37**	**5.08**
18	**Well defined specifications and technical drawings with BoQ**	**13**	**13.69**	**5.38**
19	**Environmental studies**	**20**	**17.70**	**5.43**
20	**Feasibility studies**	**19**	**16.54**	**5.89**
21	**Adequate financial resources**	**15**	**14.43**	**5.81**
22	**Contractor performance on site management and supervision**	**16**	**15.20**	**5.77**
23	**Decision procedures or latent issues**	**22**	**19.57**	**4.67**
24	**Type and size of project**	**25**	**20.59**	**5.01**
25	**Contract and dispute procedures**	**21**	**18.62**	**6.02**

Table 4.4: Descriptive and summary of success factor rankings.

The above table defines the following:

1. Success factors in order of most importantly ranked to least importantly ranked (1 – 25).
2. Majority of participants ranked the following success factors above 5 as the respective mean ranking is less than 5 (therefore formed part of the top 5 success factors in most participants' views):
   - Competent project manager;
   - Client participation and approval on project, design – construction;
   - Project mission – clearly defined goals, objectives, scope of works.

Most important factors per phase <u>combined with respective overall rankings</u> of success factor (phases 1 to 4 and phase 5 of study) from Table 4.3.

By considering the factors indicated as the most important per phase by 60% or more of the participants the factors were limited to:

Phase 1 (7 success factors)

- SF 1 Competent project manager;
- SF 2 Client participation and approval on project, design – construction;
- SF 3 Project mission – clearly defined goals, objectives, scope of works;
- SF 4 Top management support;
- SF 5 Competence of project team;
- SF 7 Effective communication between participants;
- SF 20 Feasibility studies.

Phase 2 (14 success factors)

- SF 1 Competent project manager;
- SF 2 Client participation and approval on project, design – construction;
- SF 3 Project mission – clearly defined goals, objectives, scope of works;
- SF 4 Top management support;
- SF 5 Competence of project team;

- SF 6 Sufficient project resources;
- SF 7 Effective communication between participants;
- SF 10 Project planning, time (WBS);
- SF 11 Project monitoring and controlling;
- SF 13 Clearly defined and detailed contract procurement processes;
- SF 14 Project risk management;
- SF 18 Well defined specifications and technical drawings with BoQ;
- SF 19 Environmental studies;
- SF 20 Feasibility studies.

Phase 3 (20 success factors)

- SF 1 Competent project manager;
- SF 2 Client participation and approval on project, design – construction;
- SF 3 Project mission – clearly defined goals, objectives, scope of works;
- SF 4 Top management support;
- SF 5 Competence of project team;
- SF 6 Sufficient project resources;
- SF 7 Effective communication between participants;
- SF 8 Reliable and experienced contractor services;
- SF 9 Quality control on workmanship;
- SF 10 Project planning, time (WBS);
- SF 11 Project monitoring and controlling;.
- SF 12 Regular site visits / meetings;
- SF 13 Clearly defined and detailed contract procurement processes;
- SF 14 Project risk management;
- SF 15 Project variation orders (VOs');
- SF 17 Progress meetings;
- SF 18 Well defined specifications and technical drawings with BoQ;
- SF 21 Adequate financial resources;
- SF 22 Contractor performance on site management and supervision;
- SF 25 Contract and dispute procedures.

Phase 4 (5 success factors)

- SF 1 Competent project manager;
- SF 2 Client participation and approval on project, design – construction;
- SF 8 Reliable and experienced contractor services;
- SF 9 Quality control on workmanship;
- SF 25 Contract and dispute procedures.

Average across project: Phase 5 (7 success factors)

- SF 1 Competent project manager;
- SF 2 Client participation and approval on project, design – construction;
- SF 3 Project mission – clearly defined goals, objectives, scope of works;
- SF 4 Top management support;
- SF 5 Competence of project team;
- SF 7 Effective communication between participants;
- SF 10 Project planning, time (WBS);

ANNEXURE 3: CASE STUDIES AND ASSESSMENTS

CASE STUDY NO 1

Background: The property was one of a number of similar units in a cluster development.

1 This property consisted of a number of similar units in a cluster development in a suburban area.
2 A contractor was appointed to oversee the development.
3 The purchaser of one of the units (the employer) entered into a contract with the contractor of the development.
4 The contractor retained the services of the engineer to provide the necessary professional engineering services.
5 An investigation revealed that the quality of materials and workmanship produced by the contractor was substandard.
6 The substandard level of the workmanship in numerous activities which justified the purchaser's complaint to the architectural council.
7 Numerous additional faults and defects seemed to be of an engineering nature.
8 After the investigation it was noted that the dominant fault concerned the reduction in the floor to floor height between the ground and first floors. This fault involved the engineer.
9 When the owner/employer consulted with the engineer, the engineer made a written misrepresentation to the owner to cover up for the contractor.
10 It was found that the engineer violated the rules of conduct in that he had failed to base any decision, recommendation or opinion upon prevailing facts.

Details of the problem:

1 The units were designed not suitable for South African climate conditions.
2 Considerable modifications were therefore necessary, but these resulted in finishes which were Spartan and "cheap" and not according to the standards to which buyers were accustomed.

3 Another factor included inferior materials and poor workmanship from employing unskilled artisans.

4 Various disputes between the employer and contractor were caused by defects not being put right and also a failure to complete the project.

5 There were various unprofessional and unacceptable situations such as client and team participation, design, scope of work, quality control, risk management and contractor performance.

6 The main problem was that the contractor decided to reduce the height of the walls between the ground floor and first floor of the unit by at least 300mm. In this way he saved the labour and material not constructed of 360mm.

7 Because of this decision the contractor also used less plaster, Rhino-Lite plaster and paint on the walls of the ground floor of the unit. The owner queried this.

8 The door to a walk-in pantry below the stairs, which was supposed to have had a door frame of standard height (2.10m), had a frame of 1.91m, an unacceptable height.

9 The engineer and the designer discussed the reducing of the floor height with the client but the reasons were not valid.

10 The roof reduction was not necessary from a design perspective but was a blatant cost-cutting exercise.

11 Furthermore, the decision to reduce the height of the walls was made without informing the owner, which would have been the correct procedure.

12 The reduction could not be rectified as the matter was only investigated when the unit was nearly complete.

13 The following had lasting and negative effects on the value of the unit :

- The door to the pantry was too low and therefore hazardous.
- The loss of volume in the utility.
- The negative aesthetic effect of the loss in volume.
- Consequent market value loss of the unit.

Assessment: Case study 1

It is clear from the above case study analysis that the engineer/project manager did not utilise support, knowledge and expertise available to him/her when supervising the project. The engineer's misrepresentation to the owner to cover up for the contractor is a violation of the engineering code of conduct.

Neither the engineer nor the contractor should have allowed the use of substandard materials.

From the case study analysis it is evident that the engineer and the contractor abused the most critical success factors 1, 2, 3, 5, 7, 9, 14, 18, 22 and (25) as these neglected CSFs were the reason for failure to meet the client's expectations (see evaluator's assessment form pp. 244). They also failed to perform good project management and to deliver a quality project management service.

The analysis of this case study revealed that the engineer and contractor rendered a substandard service.

This conclusion is shown in merging graphs 6.1, 6.2, 6.3 and 6.4 (pp. 179 - 181) and Table 5.2 (pp. 170) which indicates high ratings in critical success factor (CSF) 5, Table 5.2: SF 5, competence of project team.

Phase 1 rated 23, phase 2 rated 39 and phase 3 rated 40, phase 4 rated 12 and Total Rating 114. The project ranking factor indicates that this was the second highest risk factor to deliver a successful project.

These CSFs were rated as very important in Chapter 4 when the engineer rated the CSF 5 at 72.2% in phase 1, 83.3% in phase two and 87.8% in phase 3.

There is no doubt that both the engineer and the contractor should take full responsibility for the financial loss (and its impact on the client's investment) caused by the reduction in the floor-to-floor height.

The project’s final rating was CSF 1 which indicated the lowest project service delivery out of 25 CSFs due to the incompetence and lack of experience on the part of the project manager (rating of 23).

The researcher’s point of view is that the engineer was not equipped with sufficient project experience or knowledge to oversee this project through its various phases.

Evaluator's assessment:

CASE STUDY NO: ......1..................

SUCCESS FACTORS Qualitative - Analysis SF NO SF CODING	Phase 1 Concept SF NO	Phase 2 Planning SF NO	Phase 3 Implementation Construction SF NO	Phase 4 Closeout SF NO	Success Factor Rating SF TOTALS
1. Competent project manager.	7	15	8	2	32
2. Client participation and approval on project, design – construction	4	7	8	6	25
3. Project mission – clearly defined goals, objectives, scope of works.	6	8	7	3	24
4. Top management support.	3	1	2	1	7
5. Competence of project team.	5	8	9	3	25
6. Sufficient project resources.	1	–	–	1	2
7. Effective communication between participants.	3	7	6	3	19
8. Reliable and experienced contractor services.	–	5	8	3	16
9. Quality control on workmanship.	1	6	10	6	23
10. Project planning, time, (WBS).	1	2	3	2	8
11. Project monitoring & controlling.	2	4	8	3	17
12. Regular site visits / meetings.	1	3	6	3	13
13. Cleardefined and detailed contract procurement processes.	2	6	7	1	16
14. Project Risk Management.	2	7	9	3	21
15. Project variation orders (VO').	–	0	1	–	1
16. Applicable training provision.	–	–	–	–	–
17. Progress meetings.	2	2	1	1	6
18. Well defined specifications and technical drawings with BoQ	1	6	9	3	19
19. Environmental studies.	2	4	6	2	14
20. Feasibility studies.	2	6	4	2	14
21. Adequate financial resources.	–	–	–	–	–
22. Contractor performance on site management and supervision.	2	4	16	3	25
23. Decision procedures orlatent issues	1	3	5	3	12
24. Type and size of project.	–	1	3	1	5
25. Contract and dispute procedures.	1	6	8	7	22

CASE STUDY NO 2

Background: Major structural engineering additions were carried out on an existing shopping mall.

1 Large scale additions involving major structural engineering elements were made to an existing shopping centre.

2 The owners of the shopping centre appointed a firm of consulting engineers to provide the structural engineering services required for these major structural additions.

3 A senior professional engineer of this firm was appointed to be in charge of the assignment.

4 The new structure included a steel lattice girder beam spanning an open area of 40m and supporting the ceiling and roof of this part of the building.

5 After the beam had been erected, a welded connection in the lattice beam failed.

6 This caused the beam to collapse and resulted in injuries to the people below as well as in some fatalities.

7 The designer contravened certain building rules of conduct.

Details of the problem:

1 The agreement between the client and consulting engineers provided *inter alia* for the "design and commissioning" of structural engineering services which involved reinforced concrete foundations and structures and a steel roof structure.

2 It was agreed that the engineering firm would not be responsible for the design elements of equipment supplied and installed by others. It was required that the consultants approve the structural designs.

3 The failure of the lattice beam was the failure of a welded joint between a diagonal member and the top chord of the lattice beam at the spot where it was supported on a concrete column.

4 The welded joint was unable to withstand the forces applied to it and the welds failed. It was found that the preparation of the steelwork for the

welding (chamfering) had not been done correctly and the welding itself was therefore suspect.

5 It was further revealed that the joint had not been welded with the beam on the ground. The steelwork subcontractor should have used a 25 ton crane to lift the completed lattice into position.

6 The investigation showed that the lattice was supported by scaffolding and was not welded on the ground. It was lifted to its position where the welding of the joint was done "up in the air".

7 During the investigation considerable emphasis was put on the culpability of the beam designer and steelwork subcontractor as they had not met their contractual obligations.

8 The competence and experience needed for the inspection and approval of the welding was beyond the competence of the average structural engineer.

9 The Department of Labour put considerable emphasis on the culpability of the beam designer and steelwork subcontractor in terms of the Occupational Health and Safety Act.

10 The responsibility of the design engineer included supervision of the construction as well as inspections by the engineer to verify the contractor's workmanship and materials complied with the contract specification.

11 The owner limited the engineer to approximately 4 hours per fortnight for site visits, inspections and site meetings.

12 The engineer therefore had to rely on the contractor and subcontractors to carry out inspections themselves and to fulfil their obligation to produce work which complied in all respects with the contract specifications and requirements.

13 This applied particularly to the welding of the lattice beam members and joints, and the contractor and subcontractors were supposed to have the necessary competence and expertise.

14 The design engineer had to ensure that the contractor and subcontractors were furnished with information and details necessary for the manufacturing and erection of all the elements of the work they were responsible for.

15 The design engineer was also responsible for checking and approving the shop drawings to ensure the design intent and requirements were clearly stated and fully comprehended by the contractor and subcontractor. It was particularly important that all necessary information and details required for the manufacture, erection or fabrication of all elements needed for the work were supplied to the contractor and subcontractors.

16 In the case of structural steelwork comprehensive "general arrangement" drawings had to be made by the engineer. They had to be sufficient for the steelwork subcontractor to be able to prepare the shop drawings, including all the necessary details for fabrication or manufacture, both in the shop and on the site.

17 It was also the design engineer's responsibility to check and approve the shop drawings to ensure that the design intent and requirements were clearly stated and could be fully complied with by the subcontractor.

18 The design required that the welds should be full penetration welds.

19 It was revealed in the investigation that the welding method was not clearly described to the subcontractor.

20 Examination of numerous welds in the joints of the collapsed beam revealed that the proper weld preparation was not done. It also revealed that the weld gaps were too wide and were filled by first welding in the round bars.

21 The welding of the joint which failed was complicated by the joint being too close to the support column.

22 The subcontractor's engineer inspected the welding after completion for visual defects, but he was unable to verify the number of weld runs because these were now covered and he could only rely on the word of the welding foreman.

23 Although the subcontractor had concerns about the lattice beam welding and suggested the addition of gusset plates at the joints, his suggestions were not acted upon.

24 A major reason for the collapse can be contributed to the fact that the engineer was limited by the owner regarding the number of his inspections.

He could not inspect the works or verify compliance to the instructions in the drawings sufficiently to be sure that there were no defects.

25 The engineer did have concerns when the welded lattice beams were erected in sections and joints were welded high off the ground.

26 The engineer requested a load test on this part of the structure but the owner refused his request. The engineer felt that the scope of the on-site welding added an unknown element to the design process and that that should have been checked for consistency.

The following conclusions were reached by the evaluator of this case study:

- The way in which the lattice beam members were fabricated resulted in significant unconventional behaviour. There were differences between member centrelines and central axes, causing secondary bending moments which had not been taken into account.
- Important and heavy connections, including weld specifications and test requirements, are normally specified by the engineer in the engineering drawings. These were omitted.
- The specific lattice beam was assembled in sections and then welded together. No design details were provided by the engineer for construction joints and this detail was left to the contractor to work out.
- The engineer was obligated to provide sufficient supervision to ensure that the structure that was built was safe for public use. The engineer had to sign the structural certificate of the local authority, thereby giving his assurance of the safety of the structure.
- The engineer contravened the building code of conduct because he did not discharge his duties with the necessary skill, efficiency, professionalism, knowledge, competence, due care and diligence. The engineer failed to adhere to acceptable practices.
- The engineer did not have regard for public health, safety and interest at all times. He did not provide work or services according to the accepted standards and practices of his profession.

Assessment: Case study no 2

This was a large project which required a high level of specialised professional engineering services. For this reason the client appointed a firm of consulting engineers to provide the required services and to execute the requirements in terms of the project scope of work. This type of project often contains latent defects, necessitating the knowledge and supervision of an experienced engineer/project manager.

An additional problem was the fact that the owner limited the engineer/project manager's site visits, something which later proved to has been crucial oversight.

The most important success factors defined in the survey research were SFs 1, 2, 3, 5, 7, 8, 9, 14, 18, 22, and 25 (see Table 4.3, pp. 136). These included the success factors listed in phases 2 and 3 (which are above 60%), but in this project they were ignored. As noted in Chapter 2 the project manager/engineer is supposed to take full responsibility of the project team. He should have taken the lead in advising the client, design team, contractors and other role players about the full scope of work and the complexity of the project.

The project manager failed to do the following:

- He did not formulate a full scope of work, something which would have identified the client's needs. There was no written project mission, no risk and project implementation, no testing of the reliability of work force, a lack of the experience and knowledge required for the specific design components of the project and no environmental and feasibility studies to assess latent factors.

Other success factors were also neglected.

- The project manager failed to take control and lead in managing, advising and overseeing the client's needs. This was probably because of his lack of managerial and leadership experience.
- The client limited the engineer's site inspections probably to cut costs. The project manager/engineer did not advise the owner of the risks inherent in

his decision, and this decision led to his violating the building code of conduct.

Evaluator’s case study analysis:

From the above analysis it is clear that the most important critical success factors were contravened indicating the following CSFs: 1, 2, 3, 5, 7, 8, 9, 14, 18, 22 and 25. This was illustrated in the evaluator’s case study assessment form below.

The above mentioned factors are shown in Graphs 6.1, 6.2, 6.3 and 6.4 where the four project phases were displayed.

Evaluator's assessment:

CASE STUDY NO: ……2……………

SUCCESS FACTORS Qualitative - Analysis		Phase 1 Concept	Phase 2 Planning	Phase 3 Implementation Construction	Phase 4 Closeout	Success Factor Rating
SF NO	SF CODING	SF NO	SF NO	SF NO	SF NO	SF TOTALS
1.	Competent project manager.	4	10	12	3	29
2.	Client participation and approval on project, design – construction	5	9	8	4	26
3.	Project mission – clearly defined goals, objectives, scope of works.	5	8	9	2	24
4.	Top management support.	2	4	2	3	11
5.	Competence of project team.	9	12	14	3	38
6.	Sufficient project resources.	–	–	–	–	–
7.	Effective communication between participants.	5	9	9	3	26
8.	Reliable and experienced contractor services.	4	6	11	2	23
9.	Quality control on workmanship.	3	12	10	3	28
10.	Project planning, time, (WBS).	1	3	2	1	7
11.	Project monitoring & controlling.	1	4	11	2	18
12.	Regular site visits / meetings.	1	2	4	3	10
13.	Cleardefined and detailed contract procurement processes.	2	4	4	–	10
14.	Project Risk Management.	3	9	7	2	21
15.	Project variation orders (VO').	–	–	1	–	1
16.	Applicable training provision.	–	–	–	–	–
17.	Progress meetings.	–	1	1	4	6
18.	Well defined specifications and technical drawings with BoQ	2	7	11	4	24
19.	Environmental studies.	1	8	5	0	14
20.	Feasibility studies.	1	4	4	2	11
21.	Adequate financial resources.	–	–	–	1	1
22.	Contractor performance on site management and supervision.	0	4	16	2	22
23.	Decision procedures orlatent issues	1	5	5	2	13
24.	Type and size of project.	1	1	–	1	3
25.	Contract and dispute procedures.	1	8	12	6	27

CASE STUDY NO. 3

Background: A four-story community centre constructed with a reinforced concrete structure, comprising of spread foundations, columns, floor slabs and a basement with retaining walls.

1 The building has a length and breadth of approximately 100m x 50m. It consists of a parking basement with two office floors above and a tiled roof supported by timber trusses and resting on external walls.

2 While the internal brick walls were being built and the roof tiles put in place, the concrete structure, more than half of the area of the building, collapsed.

3 Thirteen workers were injured, there was one fatality and one person could not be found in the rubble.

4 An investigation revealed that the probable cause of the collapse of the structure was the fact that the columns had been punched through the floor slab.

5 The design was carried out by the engineer concerned with the project.

7 The engineer designed the floor slab reinforcing but instead of issuing drawings or bending schedules, he only provided A4 sketches.

8 Calculations for the design of the structure could not be retrieved.

9 Openings in the floor slab were not taken into account in the design.

10 No geotechnical investigation was done for foundation design; a safe bearing pressure under the footings had been assumed and could have been insufficient.

11 The engineer relied on verbal instructions given on site, including increasing concrete strengths which indicated the reinforcement bar bending details.

12 Saw cuts in the ground floor suspended slab had been introduced, apparently to allow for the thermal movement.

13 The engineer took it upon himself to check his own calculations and details.

14 The floors were built without beams but the reinforcement for this was insufficient, particularly in the area of the columns.

Evaluator's case study analysis:

Assessment: Case study no 3

The assessment of this case study led to the conclusion that the engineer was not competent to design the structure. His method of executing the design and drawings showed that he did not take the complexity of the design into consideration and this affected the entire project.

Critical success factors 1, 2, 3, 5, 7, 8, 14, 18, 22 and 25 were shown to be relevant for this project's failure (as indicated in SF rating totals). This was illustrated in the evaluator's case study assessment form below.

The engineer/project manager maintained *inter alia* that the collapse was not caused solely by him, that he was not responsible for producing the structural design, that he did not err when reacting to the punching failure, that the design was altered without his knowledge and that his scope of work included only limited visits to the site. The engineer claimed that the design changes altered the loading on the structure, culminating in overloading during construction.

However, the engineer/project manager signed the local authority's form *A19 form,* confirming his appointment as the responsible person for the design and overseeing the project.

- He failed to discharge his duties to his client and the public with skill, efficiency, professionalism, knowledge, competence, due care and diligence.
- He undertook work of a nature for which his education, training and experience had not rendered him competent.
- He failed to engage in or adhere to acceptable practices (SFs 2, 3, 5, 7, 8, 9, 11, 12, 13, and 19).

- He did not have due regard for public health, safety and interest (SF 14).
- He did not provide work or services of quality and scope or on a level corresponding to accepted standards and practices in the profession (SF 9).

The engineer did not conform to the design and construction codes of conduct, and did not pay attention to the critical success factors. He also did not do soil analysis to ascertain the soil conditions of the site, something which is necessary when the foundation design loadings are calculated. The most important success factors as defined in the survey research (Table 4.3, pp 136) namely CSFs 1, 2, 3, 5, 7, 8, 14, 18, 22 and 25 as well as the success factors listed in phases 2 and 3 (which are above 60%) were ignored.

In the average across ranking (Table 4.3) CSFs 1, 2, 3, 4, 5, 7 and 10 were shown by the quantitative research to be regarded as very important. In this project they were all disregarded, leading to a negative outcome for the project.

Regarding phases 1, 2 and 3 scope of work (SF 3) the engineer and the contractor's competence to execute their duties, (SF 19) environmental studies, (SF 14) risk control and well defined specification and technical drawings were not listed as a high priority on this project.

The above mentioned success factors are illustrated in the merging graphs 6.1, 6.2, 6.3 and 6.4 (pp. 179 – 181) which display the four project phases.

Evaluator's assessment:

CASE STUDY NO: ...3...................

SUCCESS FACTORS Qualitative - Analysis SF NO / SF CODING	Phase 1 Concept SF NO	Phase 2 Planning SF NO	Phase 3 Implementation Construction SF NO	Phase 4 Closeout SF NO	Success Factor Rating SF TOTALS
1. Competent project manager.	4	11	6	3	24
2. Client participation and approval on project, design – construction	5	8	9	5	27
3. Project mission – clearly defined goals, objectives, scope of works.	6	11	8	3	28
4. Top management support.	1	2	1	1	5
5. Competence of project team.	4	11	8	4	27
6. Sufficient project resources.	–	1	1	–	2
7. Effective communication between participants.	3	6	9	4	22
8. Reliable and experienced contractor services.	3	7	7	2	19
9. Quality control on workmanship.	4	4	7	3	18
10. Project planning, time, (WBS).	–	1	2	1	4
11. Project monitoring & controlling.	1	3	9	2	15
12. Regular site visits / meetings.	–	2	6	2	10
13. Cleardefined and detailed contract procurement processes.	2	4	6	1	13
14. Project Risk Management.	1	6	9	3	19
15. Project variation orders (VO').	–	–	1	1	2
16. Applicable training provision.	–	–	–	–	–
17. Progress meetings.	2	2	3	2	9
18. Well defined specifications and technical drawings with BoQ	3	7	11	3	24
19. Environmental studies.	1	3	4	1	9
20. Feasibility studies.	1	3	4	2	10
21. Adequate financial resources.	–	–	1	–	1
22. Contractor performance on site management and supervision.	1	3	12	2	18
23. Decision procedures orlatent issues	–	4	5	3	12
24. Type and size of project.	–	1	2	–	3
25. Contract and dispute procedures.	–	6	10	5	21

CASE STUDY NO 4

Background: A double story block of flats above ground floor parking was constructed with reinforced concrete footings, columns and flat slabs and with load bearing brick walls.

1 The building in question was an apartment block with double storey flats above ground floor parking. It was constructed with reinforced concrete footings, columns and flat slabs and with load bearing brick walls.
2 A registered professional engineer was appointed to provide design and construction monitoring services for the proposed building.
3 An architect was also appointed.
4 The first floor flat slab was supported on columns on pad footings and in reinforced concrete.
5 The load bearing brick walls on this slab supported a second floor reinforced concrete slab also with load bearing walls to support a lightweight roof.
6 After the casting of the concrete, severe cracks at an early stage were noted in the first floor slab.

Details of the problem:

The findings during the investigation revealed the following:

1 The load bearing walls on the first and second floors did not correspond with the position of the columns below the first floor, i.e. the first floor slab functioned as a transfer slab.
2 The report revealed that the slab was a flat slab without beams.
3 The load on this slab was extremely heavy as it carried the load of the roof, the second floor slab and the two floors of brickwork.
4 It was noted that there were longitudinal top cracks over column lines, radial cracks around columns, longitudinal cracks on the soffit, and top cracks at the root of the cantilever slabs. This was all seen on the first floor slab.
5 It was further revealed that the slab was not designed as a flat slab capable of transferring this load to the columns and that this caused the slab to fail in

various ways. The failure of the slab was attributed to the following design faults:

- The slab was too thin and therefore needed compression reinforcement in places.
- The bottom slab reinforcement was insufficient.
- There was too little top slab reinforcement.
- There was inadequate reinforcement round the columns to withstand punching shear forces.
- There were also insufficient anchorage lengths of cantilever slab reinforcement.

6 The investigation also revealed other failing structural elements such as the column stirrup spacing and starter bar lengths as well as excessive bearing pressure below footings.

7 The lateral stability of the structure in withstanding wind loads had not been considered and would require shear walls.

8 The strength of the ready-mixed concrete had been questioned by the engineer after the casting of the slab.

9 Subsequent tests showed the strength to be marginal but not the cause of the slab failure.

10 The omission of a geotechnical investigation and reliance on information from a nearby site for foundation design was a risk that should not have been taken.

11 The investigation revealed that the slab could not be strengthened *in situ* and would have to be demolished.

12 The project manager/engineer had undertaken work of a nature which his education, training and experience had not rendered him competent to perform.

13 The project manager/engineer failed to engage in or adhere to acceptable practices. He accepted conditions and terms that compromised his ability to carry out his responsibilities in accordance with acceptable professional standards.

14 The engineer did not at all times have due regard for public health, safety and interest.

15 The project manager/engineer did not provide work or services corresponding to the standards and practices in his profession.

Evaluator’s case study analysis:

Assessment: Case study no 4

The developer commissioned a registered professional engineer to design and monitor the construction of this project. The client also employed the service of an architect and a contractor. The engineer as the civil designer worked in conjunction with the architect, contractor and the client, and they were known as ‘the project team’. The project manager/engineer was expected to have the required knowledge and experience to design and oversee a project of this size, and to act as the *de facto* project manager.

The case study analysis indicated that very little attention was paid to most of the important success factors (see Table 4.3, pp. 136). The comments in the case study report were in fact alarming given in the requirements for the job. The outcome of the project showed clearly that the engineer was not qualified to execute and oversee the project successfully.

The following critical success factors (CSFs) were disregarded: CSFs 1, 2, 3, 5, 7, 8, 9, 11, 13, 14, 17, 18, 22 and 25. It is clear that the violation of the standard design and practice code of conduct (Code of practice (2002) as well as inexperience and lack of knowledge regarding project management had serious implications for all the role players as well as the project as a whole. This was illustrated in the evaluator’s case study assessment form below.

The case study analysis indicated that very little attention was given to most of the important success factors quoted in Table: 5.2 (pp. 170).

In this fourth and last case study the assessment revealed that the CSFs as ranked in Table 5.2: ("Total of complete project – Ranking code") indicates a lack of knowledge and experience on the part of the engineer/project manager. The ranking codes 1, 3, 4, 2 and 5 are all applicable here and affect all four phases of the project.

Evaluator's assessment:

CASE STUDY NO: ....4..........

SUCCESS FACTORS Qualitative - Analysis SF NO / SF CODING	Phase 1 Concept SF NO	Phase 2 Planning SF NO	Phase 3 Implementation Construction SF NO	Phase 4 Closeout SF NO	Success Factor Rating SF TOTALS
1. Competent project manager.	5	13	10	4	32
2. Client participation and approval on project, design – construction	6	9	9	5	29
3. Project mission – clearly defined goals, objectives, scope of works.	5	9	7	4	25
4. Top management support.	2	2	2	2	8
5. Competence of project team.	5	8	9	2	24
6. Sufficient project resources.	1	–	–	1	2
7. Effective communication between participants.	3	8	9	3	23
8. Reliable and experienced contractor services.	4	8	8	4	24
9. Quality control on workmanship.	3	5	8	2	18
10. Project planning, time, (WBS).	–	2	2	1	5
11. Project monitoring & controlling.	1	4	9	2	16
12. Regular site visits / meetings.	1	2	5	1	9
13. Cleardefined and detailed contract procurement processes.	–	6	7	1	14
14. Project Risk Management.	2	6	8	4	20
15. Project variation orders (VO').	–	–	2	1	3
16. Applicable training provision.	–	–	–	–	0
17. Progress meetings.	2	5	8	3	18
18. Well defined specifications and technical drawings with BoQ	2	5	8	2	17
19. Environmental studies.	1	4	4	1	10
20. Feasibility studies.	1	5	6	1	13
21. Adequate financial resources.	–	–	–	1	1
22. Contractor performance on site management and supervision.	1	4	14	3	22
23. Decision procedures orlatent issues	1	3	4	2	10
24. Type and size of project.	–	–	2	1	3
25. Contract and dispute procedures.	1	5	8	6	20

In conclusion over all four case studies:

The final and total score of success factor 1 (competent project manager) showed a total rating of 117 (highest rating) and indicates the incompetency of the project manager, ranked as 1 in the total of complete project column (Table 5.2, pp. 170).

The relevance of this finding for this research is shown in the merging graphs 6.1 to 6.4 in Chapter 6, as the pattern-matching of all four phases illustrate the lack of knowledge and experience of the engineer when operating in the office of a project manager.

ANNEXURE 4: CASE STUDY ASSESSMENT FORM

SECTION C: CASE STUDY ANALYSIS

Based upon your overall experience in project management of design and construction projects, kindly review and evaluate the case study according to the explanation and guidance. See assessment protocol below. You are requested to code the literature of the case study and rate the success factors (SF) over the various phases. See example below.

The aim of this survey is to identify the most important success factors, which determine the success of the construction project. Dr Harry Visser is conducting this survey as part of the requirements for completion of a post-graduate research study at the University of the Witwatersrand.

Please be assured that your answers will be treated with confidentiality and that the case study assessment DOES NOT requests any identification from the evaluator. Your frank and honest opinion is sought and the information obtained will be strictly used for academic purposes and statistical analysis only. The identity of evaluator will not be revealed. Participation in this assessment is entirely voluntarily and there is no penalty if you do not participate. There is no risk associated with filling in the assessment form since the researcher guarantees anonymity of the responses.

Your cooperation is appreciated.

Harry Visser (PhD): hv@lpcmanagement.co.za. Cell: 083 2600 170

Study Leader, Prof Robert McCutcheon: robberttmccutcheon@gmail.com
011 717 7129

SF NO	SUCCESS FACTORS (SF) Case – Study No: Coding Analysis SF CODING	Phase 1 Concept Ranking SF NO	Phase 2 Planning Ranking SF NO	Phase 3 Implemen-tation Construc-tion Ranking SF NO	Phase 4 Closeout Ranking SF NO	Phase 5 Success Factor Rating SF TOTALS
1.	Competent project manager.	111(3)	____	111111 (6)	11(2)	**11**
2.	Client participation and approval on project, design – construction	1 (1)	111(3)	1111 (4)	11(2)	**10**
3.	Project mission – clearly defined goals, objectives, scope of works.	11 (2)	1	11 (2)	1	**6**

TABLE 5.1: Example of case study analysis

The assessment protocol was as follows:

The engineers remained anonymous and the case studies under review were not identified.

Each of the four engineers selected a case study (from the four already selected by the researcher) and was then shown how to apply the assessment questionnaire.

Remember that your rating on the Assessment form will identify to what degree the project manager has not applied to the standard code of practise.

- Every SF and coding incident as identified in the case study counts one point.

  Example: in coding case study 1: an investigation revealed that the quality of materials and workmanship produced by the contractor was substandard. **(1, 2, 5, 7, 8 and 11).**

  Explanation: this implied the following: The project manager did not approve the bill of quantities **(1).** The designer failed to provide the specification for materials **(2).** Lack of client participation **(5).** No effective communication **(7).** Lack of reliable contractor service **(8).** Project monitoring and controlling was not carried out **(11),** and so forth. **One statement in the case study addressed 6 SF items.**

- Read the case study through and prepare for unknown questions to be clarified before filling in your questionnaire which will then be discussed before dealing with the assessment review.
- Every item (failure or not according to the standard code of practice) on the case study should be identified and coded individually within its specific phase and the numbers added in the SF rating column.
- One incident of case activity may have numerous of the same SF applicable within the same criteria and context. The design engineer can be involved four or five times in the same paragraph depending on the area under question. **For example**: In question SF criteria 2, the design can have an impact on SF items 2, 6, 8, 16 and 20, and therefore your reply will be coded as '1' at each of those identified SF numbers i.e. 2(1 point), 6(1), 8(1), 16 (1), and 20 (1). A total of 5 points is then written in the Rating SF totals column.
- The assessment must be coded and include numbers 1 to 25 in the case study "Assessment Form" pp. 265.

ASSESSMENT FORM: CASE STUDY NO: …………………..

(Evaluator's assessment)

SUCCESS FACTORS Qualitative – Analysis SF NO & SF CODING	Phase 1 Concept SF NO	Phase 2 Planning SF NO	Phase 3 Implementation Construction SF NO	Phase 4 Closeout SF NO	Success Factor Rating SF TOTALS
1 Competent project manager.					
2 Client participation and approval on project, design – construction					
3 Project mission – clearly defined goals, objectives, scope of works.					
4 Top management support.					
5 Competence of project team.					
6 Sufficient project resources.					
7 Effective communication between participants.					
8 Reliable and experienced contractor services.					
9 Quality control on workmanship.					
10 Project planning, time, (WBS).					
11 Project monitoring & controlling.					
12 Regular site visits / meetings.					
13 Clear defined and detailed contract procurement processes.					
14 Project Risk Management.					
15 Project variation orders (VO').					
16 Applicable training provision.					
17 Progress meetings.					
18 Well defined specifications and technical drawings with BoQ					
19 Environmental studies.					
20 Feasibility studies.					
21 Adequate financial resources.					
22 Contractor performance on site management and supervision.					
23 Decision procedures or latent issues					
24 Type and size of project.					
25 Contract and dispute procedures.					