Total Quality Management in the civil engineering consultancy industry in South Africa.

by

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- **To my Heavenly Father – Soli Deo Gloria**

ABSTRACT

Consulting Engineers worldwide, and in South Africa, render a professional service to clients consisting of project feasibility studies, planning reports, design, documentation and construction monitoring for infrastructure projects.

In rendering this service, consulting engineers are subject to certain project risks that can have a huge influence on their company's success and hence their profitability. Quality Management is an instrument through which the risks associated with consulting engineering can be mitigated to a certain degree, if a Quality Management System (QMS) is successfully introduced and continuously managed.

The QMS must conform to the requirements of a recognized system like the International Organization for Standardization (ISO), and in this particular case ISO 9001, which is a model for quality assurance systems in design, development, production, installation and servicing. The quality system requirements of ISO 9001 are aimed at preventing nonconformity at all phases of the product life cycle from design and/or development to servicing.

The study was carried out by obtaining a convenience sample of qualitative questionnaires among professional civil engineers in consulting management positions, testing their experience of a QMS. This study has indicated that a QMS can only be successful in a company if the users have a positive attitude towards the system, and if they believe in the benefits thereof. It is therefore required that the system be launched and maintained in a user-friendly manner, with the emphasis on real risk-reducing aspects. As one of the requirements of ISO 9001 is continuous improvement of the system, recommendations are made in this study towards improving the QMS of the particular company.

The influence of a QMS on the frequency and extent of Professional Indemnity cases against a company was investigated and reported on by studying 20 case studies of projects that have experienced difficulties, and have resulted in lawsuits against the consulting engineer.

Keywords:

Quality management system, Consulting civil engineer, Project risk, Professional Indemnity

OPSOMMING

Raadgewende Ingenieurs wêreldwyd, en ook in Suid Afrika, lewer ‘n professionele diens aan kliënte wat insluit projekvatbaarheidstudies, beplanningsverslae, ontwerp-, dokumentasie en konstruksiemonitering van infrastruktuurprojekte.

Met die lewering van hierdie diens word raadgewende ingenieurs blootgestel aan sekere projekrisiko’s, wat ‘n groot invloed kan hê op ‘n firma se sukses en winsgewendheid. Kwaliteitsbestuur is ‘n instrument waardeur die risiko’s wat met die raadgewende ingenieursbedryf gepaardgaan tot ‘n sekere mate vookrom kan word indien ‘n kwaliteitsbestuurstelsel (KBS) gebruik en deurgaans onderhou word.

Die KBS moet voldoen aan die vereistes van ‘n erkende stelsel soos die Internasionale Organisasie vir Standaardisasie (ISO), en in die besonder ISO 9001, wat ‘n model is vir kwaliteitsbestuur in ontwerp, ontwikkeling, vervaardiging, installering en onderhoud. Die kwaliteitstelselvereistes van ISO 9001 is daarop gemik om nie-konformering op alle vlakke van die produk se lewensiklus uit te skakel.

Die studie is uitgevoer deur ‘n gerieflikheidsteekproef te doen onder professionele siviele ingenieurs by wyse van ‘n kwalitatiewe vraelys met die doel om hulle ervaring van ‘n kwaliteitsbestuurstelsel te toets. Hierdie studie het aangetoon dat ‘n KBS slegs in ‘n firma suksesvol kan wees indien die gebruikers ‘n positiewe gesindheid jeens die stelsel het, en indien hulle glo in die voordele daarvan. Dit is daarom belangrik dat die stelsel op ‘n gebruikersvriendelike wyse bekendgestel en bedryf moet word, met die klem op risikoreduserende aspekte. Aangesien een van die vereistes van ISO 9001 voortdurende verbetering is, word aanbevelings in hierdie studie gemaak t.o.v. die verbetering van die KBS in die betrokke firma.

Die invloed van ‘n KBS op die voorkoms en aard van professionele versekeringseise teen ingenieursfirmas is ook ondersoek by wyse van ‘n bestudering van 20 gevallestudies van projekte wat probleme ondervind het, en wat gelei het tot regsgedinge teen die raadgewende ingenieur.

Sleutelwoorde: Kwaliteitsbestuurstelsel (KBS), Raadgewende siviele ingenieur, Projekrisiko, Professionele aanspreeklikheid

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LIST OF ABBREVIATIONS

CESA	:	Consulting Engineers South Africa
ECSA	:	Engineering Council of South Africa
IEC	:	International Electro-technical Committee
ISO	:	International Organization for Standardization
ITU	:	International Telecommunication Union
PDCA	:	Plan-Do-Check-Act Methodology
PI	:	Professional Indemnity
QM	:	Quality Management
QMS	:	Quality Management System
SABS	:	South African Bureau of Standards
SANS	:	South African National Standards
SANAS	:	South African National Accreditation Service
TQM	:	Total Quality Management

LIST OF DEFINITIONS

Capability

Ability of an organization to realize a product

Competence

Demonstrated ability to apply knowledge and skills

Continual improvement

Recurring activity to increase the ability to fulfil requirements

Customer satisfaction

Degree to which the customer's requirements have been fulfilled

Effectiveness

Extent to which planned activities are realized and planned results achieved

Efficiency

Relationship between the results achieved and the resources used

Infrastructure

System of facilities, equipment and services needed for an organization's functioning

Management

Coordinated activities to direct and control an organization

Management system

System to establish policy and objectives and to achieve those objectives

Procedure

Specified way to carry out an activity or a process

Process

Set of interrelated or interacting activities which transform inputs into outputs

Product

Result of a process

Professional Indemnity

Insurance taken out against professional misconduct or errors made during the rendering of a professional service

Project

Unique process consisting of a set of coordinated and controlled activities with start and finish dates, undertaken to achieve an objective conforming to specific requirements including the constraints of time, cost and resources

Quality

Degree to which a set of inherent characteristics fulfils requirements

Quality assurance

Part of quality management focused on providing confidence that quality requirements will be fulfilled

Quality control

Part of quality management, focused on fulfilling quality requirements

Quality Management System

Management system to direct and control an organization with regard to quality

Quality objective

Something sought, or aimed at, related to quality

Quality planning

Part of quality management focused on setting quality objectives and specifying necessary operational processes and related resources to fulfil the quality objectives

Quality policy

Overall intentions and direction of an organization related to quality as formally expressed by top management

Requirements

Need or expectation that is stated, generally implied or obligatory

System

Set of interrelated or interacting elements

CHAPTER 1: INTRODUCTION AND PROBLEM STATEMENT

1.1 Introduction

The work of Consulting Engineering Companies involves a certain amount of risk when design projects are undertaken for buildings and other structures, as well as for other projects such as roads and runways, pipelines, sewerage- and water works and pump stations.

Accepted levels of risk for these companies when accepting a particular appointment from a client are not always adequately quantified at the beginning of the project. This puts the company in a position where it may be subject to professional indemnity claims from clients and from the public, should something go wrong during a particular project.

The risk taken by the consulting engineer can to a large extent be quantified, and timeous mitigation measures can be taken to prevent certain things from occurring that may pose a threat to the successful construction and later use of the facility. As it is, the civil and structural engineering industry has a reputation that many projects run late and are over budget, not to mention the technical difficulties that might arise during the course of the project. This situation can to some extent be avoided by the introduction of a Quality Management System (QMS), which, if implemented and used correctly, should be able to identify and mitigate most of the risks that might arise from any project.

Companies will therefore introduce a QMS into their company for this purpose, and will train their employees in the use of the QMS. This system must conform to the requirements of a recognised system like the International Organization for Standardization (ISO). In this particular case ISO 9001 will be discussed, which is a model for quality insurance systems in design, development, production, installation and servicing. The quality system requirements of ISO 9001 are aimed at preventing

non-conformity at all phases of the product life cycle from design and/or development to servicing.

The aim is further for a company's QMS to be assessed against ISO 9001 by an independent certification body, then for the quality system to be registered, and then be used as evidence of quality assurance in tendering for contracts. Quality systems produced in accordance with these quality system requirements are subject to regular third-party assessment based on documented, objective evidence and compliance (ISO 9001, 2008:iii).

1.2 Causal factors to this study

ISO 9001 was developed out of the British Standard of production line manufacturing quality (BS 5750), and has evolved considerably since 1987, when the BS 5750 name was dropped in favour of the international ISO standard. The use of the international standard then grew throughout many other industrialised countries, and was then also adopted by the civil engineering consultancy industry towards the end of the millennium. In its evolution over the last 20 years, the most recent update to ISO 9001 was in 2008, which is the current version (ISO 9001:2008) against which organizations are assessed (Mead, 2011:1, ISO 9001, 2008:vi).

Companies in manufacturing and service delivery have begun to realise that ISO certification was a necessity due to increasing demands by government departments and the private sector that their suppliers be ISO 9001 compliant and registered.

PQR CONSULTING ENGINEERS (Pty) Ltd. is a fictitious name given to the company that will be under discussion in this document, and will be referred as **PQR CONSULTING ENGINEERS.** The company will remain anonymous to protect its reputation. The company **PQR CONSULTING ENGINEERS** has previously made use of their own internal Company Excellence System (CES), which was used to ensure quality on design and research projects. This system was introduced in the early 1990s and consisted of a number of measures and checklists but was not adequate to satisfy the need of clients, and was furthermore not an accredited system (Piallat, 2012).

It was therefore an obvious choice to replace the CES with a new Quality Management System (QMS) in 2004, as the CES had the following limitations:

- The CES's provisions were limited to the management of projects only – there was no provision made for human resources and marketing, as is the case with the QMS.
- The CES was in other cases an over-interpretation of the provisions of ISO 9001, which resulted in expectations in excess of the actual requirements.
- There was a measure of antagonism in the company against the CES, as the system was difficult to use and required considerable paperwork.
- The document was all in text and difficult to read for engineers, who prefer a flow diagram approach (Piallat, 2012).

1.3 Problem statement

The ideal functioning of an engineering consultancy will be where no mistakes are made during project execution, and where clients are always 100% satisfied with the service they pay for. If these perfect situations had been possible, quality management would have been unnecessary (McNamara, 1989:29).

The reality is that projects often encounter difficulties, caused by design and documentation errors or project management oversights, resulting in project difficulties and hence dissatisfied clients. These errors and oversights can to a large extent be avoided by quality management if the systems are applied correctly. Although Quality Management Systems, conforming to ISO 9001 are introduced by consulting companies, and are subject to Quality Management audits by independent auditors, it is not clear how effectively the QMS can manage to reduce project difficulties due to quality inadequacies. It is furthermore not clear to what extent the QMS is used effectively within the company by its employees and how well it operates even after the company was accredited. It is also uncertain whether the introduction of a QMS has improved client satisfaction, or reduced the number of Professional Indemnity (PI) claims against the company.

The difference between the ideal functioning of a consulting civil engineering company regarding quality management, and the reality of how it actually functions, has given rise to this study.

1.4 Objectives

1.4.1 Primary Objective

The primary objective of this research can be formulated as follows:

- To evaluate the effectiveness of the current QMS as implemented for PQR Consulting Engineers.

1.4.2 Secondary Objectives

The secondary objectives were as follows:

- To determine the understanding of a QMS by senior managers as well as the attitude of the employees who use the system towards the functionality of the QMS and its benefits.
- To determine whether the introduction of a QMS has changed the way in which senior managers approach their duties in any way, as well as their perception of the cost/benefit ratio of the system.
- To determine whether client satisfaction has improved since the introduction of the QMS.
- To determine whether the QMS can serve as a training tool for new employees, or whether it serves any other purpose.
- To determine whether a QMS can prevent or reduce PI claims against consulting engineers.
- To recommend improvements to the company's QMS system.

1.5 Limitations of the Study

Companies are not willing to disclose information regarding PI claims against them, as these matters are usually based on sensitive information which is not readily revealed. Consulting Engineers South Africa, which is a voluntary association of consulting engineering companies, was approached for case studies of PI claims, and so were the Professional Indemnity insurance companies. It is true that PI

claims are a sensitive matter in all companies and therefore all cases were treated anonymously, i.e. the identities of the companies were not revealed in order to protect their interests.

The same applies to their existing QMS, of which they do not wish to reveal details, or possible shortcomings, as they do not wish this information to be in the public domain.

This study is a historical overview of quality management. The ideal situation would have been to compare the improvement in quality from a historical period before the introduction of ISO, with a later period after the introduction thereof.

1.6 Research methodology

1.6.1 Literature review

The following topics are covered in the literature study:

- Total Quality Management – early years and evolution, including Six Sigma and Lean, as quality management concepts.
- ISO and ISO 9001 accreditation.
- The different **ISO** codes which are referred to in **ISO 9001**, thereby contributing thereto. Main principles and concepts are explained in this section together with **QMS** and project interface.
- The nature of a consulting engineering company – the day-to-day functioning of a company, including liaison with clients, feasibility studies, appointment by the client, planning and design, and the remaining value chain of a project until project close-out.

1.6.2 Empirical investigation

The focus of the study is mainly of a **qualitative nature**, where questionnaires provided to role-players are used in applying the QM principles within **PQR Consulting Engineers,** and this is supplemented with information regarding historical Professional Indemnity claims in the wider industry**.** The research consists of the following elements:

- In-depth interviews with the companies' Quality Assurance Manager, to determine the current functioning of the QMS, the attitude of the personnel towards the system, the functionality of the system as well as the current compliance with the system by the company – the cost of the system will also be addressed to determine the success and to determine whether it made a significant contribution to profitability.
- Questionnaires to senior engineers who are users of the QMS to determine their attitude towards the system, their views regarding benefits and disadvantages, the functionality and shortfalls and how the system can be improved.
- An interview with the person in the company responsible for reporting and administrating PI claims.
- A study of previous PI claims in the industry, the circumstances giving rise to the claims and the outcomes thereof. It was furthermore determined whether the effective functioning of a QMS had made a difference since implementation.

1.7 Layout of the study

This study is divided into four chapters:

Chapter 1: Introduction and problem statement

This chapter discusses the context of the study, as well as the causal factors to the study, the problem statement, objectives, scope and limitations and the research methodology. The layout of the remaining chapters is also discussed in this chapter.

Chapter 2: Literature Review

The literature applicable to this study, mainly the **PQR QMS** and other sources on Quality Management, as well as the relevant **ISO** codes is reviewed in this chapter.

Chapter 3: Empirical Research

Qualitative questionnaires to managers in consulting engineering companies were distributed and are contained in this chapter, together with the analysis of case studies on Professional Indemnity cases against role players in the industry.

Chapter 4: Results and recommendations

The findings of the study have served as a base from which conclusions are drawn and recommendations made.

CHAPTER 2: LITERATURE REVIEW

2 The Quality Environment

2.1 The nature of Total Quality Management

2.1.1 Total Quality Management

The total quality movement was first documented by Frederick W. Taylor in the 1920s, in a book titled “The Principles of Scientific Management”. Walter A. Shewhart of Bell Laboratories followed in 1931 with statistical quality control in his book “Economic Control of Manufactured Products” (Evans, 2011:6) Total Quality Management (TQM) has since been recognized as a philosophy and has developed into various effective management tools, and even as a necessity for corporate survival, by quality strategists like:

- W. Edwards Deming, who assisted the U.S. Bureau of Census in applying statistical sampling techniques in 1940, and joined the U.S. War Department in 1941, to teach quality control techniques (Aguayo, 2008:23, Aikens, 2011:20).
- Joseph M. Juran, who published the *Quality Control Handbook* in 1951 (Juran, 1989:6).
- Philip Crosby, who introduced the concepts of “cost of quality” and “zero defects” in 1970 (Crosby, 1979:18, Goetsch, 2010:8).
- Armand Feigenbaum, who provided the foundations for what became total quality management in the 1980s (Feigenbaum, 1991:10).

Each of these individuals contributed towards the philosophy of Total Quality Management in a different way, and with a different focus. They all developed different tools for different quality purposes, but they all had one common philosophy, which was Total Quality. TQM gained popularity in Japan in the 1950s, at a time when products out of Japan were considered inferior, and most Japanese companies were unsuccessful in international markets. It was at the time a new

approach to the art of management and has further gained popularity in the west. “Made in Japan” remained synonymous with poor quality, as it had been before World War II. Around 1950, however, Japan decided to get serious about quality and ways to produce quality products (Aikens, 2011:23). Japanese manufacturers overcame a reputation for producing cheap products and developed a reputation as world leaders in the production of quality products. It was this effort that convinced the world to focus on quality. Western companies only responded when they finally realized that quality was the key factor in global competition. With this realization, the total quality movement began to gain momentum (Goetsch, 2010:9).

Total Quality for any company can be best described as the culture and attitude of the companies’ employees to continuously provide their clients with products and services to satisfy their needs. The culture that is required is quality in all the activities of the company, which must result in a “first time right” way of conducting their operations, with minimum or no wastage of resources. In a consulting engineering company, as opposed to a manufacturing company, wastage will be extra time spent on work that was previously carried out unsatisfactorily. The end purpose and highest company priority in mind is always the client, who must be satisfied that he has received value for money, and has confidence in the end product. The company must believe that they can only be successful when their clients are satisfied (Foster, 2010:160).

2.1.2 Six Sigma

A second quality management concept applied by many different organizations is Six Sigma, and whilst TQM is a much older concept, the two could actually complement each other, and can be very compatible in various business situations. TQM will facilitate quality improvement of processes, products and services, as applicable in the civil engineering consultancy industry, whilst Six Sigma will assist in giving the improvements an edge and keep them more focused. The question remains, as to whether both TQM and Six Sigma are aimed at improving quality, and if so, what the difference between them is. The answer lies in the following (Andersson, Eriksson & Torstensson, 2006:291):

- TQM is the overhead philosophy which includes various techniques to accomplish quality.
- Six Sigma is a methodology to achieve TQM (Stark, 1998:194).
- TQM existed well before Six Sigma, and as such, Six Sigma broadly inherited many of the TQM principles (Oakland, 2005:23).
- TQM has, like Six Sigma, elements of accomplishing a no-defect situation and eliminating waste, but the main objective is to increase external and internal customer satisfaction with a reduced amount of resources. Six Sigma focuses more on accomplishing no defects and to save money (George, 2010:3).
- Sig Sigma originated at Motorola as an approach to measuring product and service quality while in contrast, no single organization led to the origin of the term TQM, which originated in the quality evolution in Japan (Evans, 2011:84).
- The TQM methodology is Plan, Do, Check, Act, and that of Six Sigma, Define, Measure, Analyse, Improve, and Control (George, 2010:36).

2.1.3 Lean

The third concept closely associated with quality management applied by organizations is “lean”, or also known as “lean manufacturing”. Lean is about controlling the resources in accordance with the customer’s needs and to reduce unnecessary waste (including the waste of time). The concept was introduced on a larger scale by Toyota in the 1950s, but not labelled lean manufacturing until 1990. While there are many formal definitions of the lean concept, it is generally understood to represent a systematic approach to identifying and eliminating elements not adding value to the process. The National Institute of Standards and Technology has defined lean as “a systematic approach to identifying and eliminating waste through continuous improvement, following the product at the pull of the customer in pursuit of perfection.” (NIST 2000:110).

2.1.4 Why the focus is on TQM

Although TQM, Six Sigma and Lean have the same origins, the concepts have developed differently. TQM became a very popular notion in the beginning of the 1990s among researchers and practitioners in order to describe how organizations should work to obtain better performance and customer satisfaction. The success with Six Sigma at Motorola and with lean at Toyota is a main reason for these concepts to spread to other organizations (Andersson *et al.,* 2006:291).

Whereas TQM, with its emphasis on customer satisfaction, is more appropriate to the civil engineering consultancy industry, and whereas Six Sigma and lean are more appropriate for manufacturing processes (George, 2010:7), this study will focus on TQM as a quality concept, and more specifically Quality Management Systems, as applied by consulting civil engineers.

2.1.5 The difference between the traditional view of quality and total quality

The important differences between these two concepts are shown in Table 1:

Table 1: Differences between the traditional view of quality and Total Quality

Traditional view of quality	Total Quality
Productivity and quality are in conflict	Lasting productivity gains are made only as a result of quality improvements.
Only defined as meeting customer expectations.	Quality means satisfying customer needs and exceeding customer expectations.
Quality is measured by establishing an acceptable level of non-conformance, and measuring against that benchmark.	Quality is measured by establishing high-performance benchmarks for customer satisfaction, and continuing improving performance.
Quality is inspected into the product.	Quality is determined by product and process design, and achieved by effective control techniques.
Defects are an expected part of producing a product.	Defects are to be prevented using effective control systems.
Quality is a separate function.	Quality should be fully integrated throughout the organization.
Employees are blamed for poor quality.	At least 85% of quality problems are management's fault.
Supplier relationships are short term and cost driven.	Supplier relationships are long term and quality orientated.

(Source Goetsch, 2010:10)

2.2 Definitions of quality and Total Quality Management

ISO 8402 (1986) defines quality as "the totality of features and characteristics of a product or service that bears on its ability to meet a stated or implied need". Japanese companies have previously defined quality as "the degree of conformance to a standard", which was later replaced with "user satisfaction". ISO 9000 defines quality as the "degree to which a set of inherent characteristics fulfils requirements". There are also many definitions for TQM. Hongen and Xianwei described TQM as "a strategic approach to producing the best product and service possible through constant innovation (Hongen & Xianwei, 2006:11). Pfau defines TQM as "an approach for continuously improving the quality of goods and services through the participation of all levels and functions of the organization" (Hongen & Xianwei, 2006:13). Feigenbaum gives a more complete definition: "A total quality system is defined as one that embraces the whole cycle of customer satisfaction from the interpretation of his requirements prior to the ordering stage, through to the supply of

a product or service of an economical price and on to his perception of the product after he has used it over an appropriate period of time" (Feigenbaum, 1991:9).

The main focus in the above- and other definitions for quality is to satisfy the needs and expectations of customers. The most commonly accepted definition of quality as provided by ISO 9000 is: "The degree to which a set of inherent characteristics fulfils requirements" (Tricker, 2010:23).

2.3 ISO

There are three existing bodies responsible for the planning, development and adoption of International Standards, namely (EXALTA, 2010:6):

- The International Organization for Standardization (ISO) is responsible for all sectors excluding electro-technical and most of the telecommunications technologies.
- The International Electro-technical Committee (IEC)
- The International Telecommunication Union (ITU)

ISO, the world's largest developer and publisher of International Quality Standards, was first established as a United Nations Agency in 1947. ISO is a network of the national standards institutes of 163 countries – one member per country, with a central secretariat in Geneva, Switzerland which is responsible for coordinating the system. It is a non-governmental organization that forms a bridge between the public and private sectors. Many of the member institutes are part of the governmental structure of their countries, or are mandated by their government. Other members have their roots uniquely in the private sector, having been set up by national partnerships of industry associations. The first ISO standard was published in 1951 titled "Standard reference temperature for industrial length measurement" (Tricker, 2010:31).

ISO is not an acronym. The name of the International Organization for Standardization has different abbreviations in different languages – IOS in English, OIN in French etc. It was therefore decided to use a word derived from the Greek ISOS, meaning "Equal" – the short term for the organization is therefore always ISO.

ISO is responsible for providing standards documentation, but it is not a certification body. There are currently 7 accredited certification bodies in South Africa, who can offer certification services in certain fields where they have competent employees, namely:

- PriceWaterhouseCoopers (PWC)
- TUV Rheinland
- SA Bureau of Standards (SABS)
- SGS
- Dekra
- SAI Global
- Bureau Veritas

These bodies must be accredited by the South African National Accreditation Service **(SANAS)** before offering certification services to customers (EXALTA, 2010:8).

The ISO 9000 is a generic name given to a family of standards developed to provide a framework around which a QMS can effectively be implemented. The following volumes are applicable to a QMS (the year of latest revision is shown after the specification number):

- ISO 9000: 2005 – Vocabulary Standards
- ISO 9001: 2008 – Requirements
- ISO 9004: 2009 – Guidelines for improvement
- ISO 19011: 2002 – Auditing Standards (for external audits)

The South African Bureau of Standards (SABS) is a member of ISO, and is the ISO representative in SA. The SABS is the originator of Quality Standards in SA – the SANS series. The ISO Standards process was adopted by the SABS, who published it under the SANS banner and is typically known in SA with the prefix SANS – for example **SANS: ISO 9001: 2008** (EXALTA, 2010:13).

2.4 ISO 9000: 2005 – An Overview

2.4.1 Eight Quality Management Principles (ISO 9001, 2005:v)

This volume contains the fundamentals and vocabulary of the ISO Quality Management Systems, and focuses on eight Quality Management principles, to be used by the management of a company, to direct his employees towards a culture of quality. These principles are:

2.4.1.1 Top management participation, commitment and leadership

A QMS introduced in a company must enjoy the support and leadership of top management in a constructive way and not through mere lip service and delegation. The Quality Manager must preferably be a member of the board to ensure not only commitment and personal involvement, but also to deploy clear quality values and goals, consistent with the objectives of the company. Management will as a result be fully informed about the success of the company through performance measures, client satisfaction surveys, and will be in a better position to encourage participation by all employees. Employee performance and remuneration indicators can also be directly linked to customer requirements and satisfaction as a guide for management. The role of top management within the QMS can therefore be summarized as follows: (EXALTA, 2010:22-23).

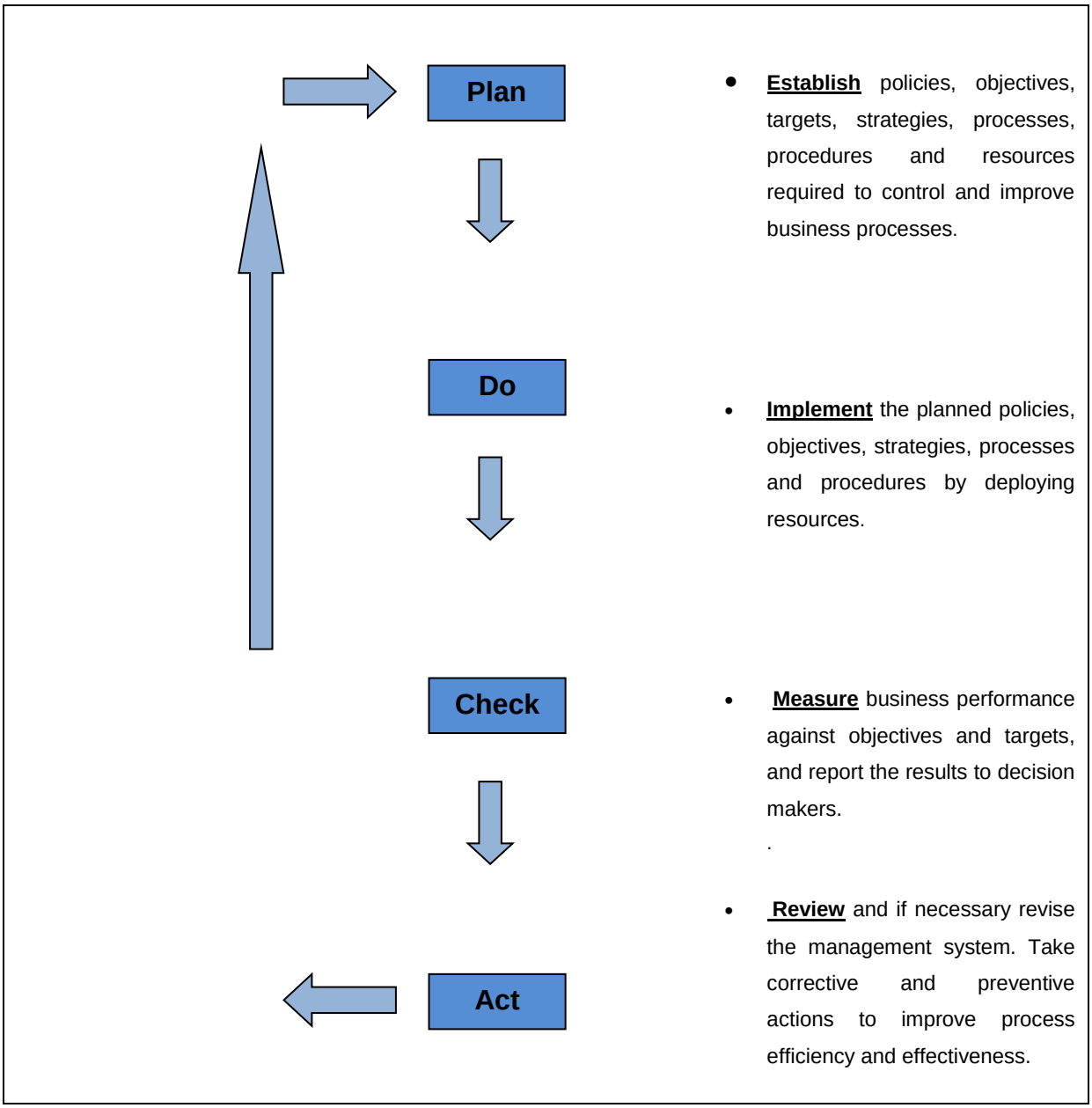
- To establish the quality policy and objectives of the company.
- To motivate and encourage personnel by increasing awareness of the quality policy and objectives.
- To emphasize and increase awareness of customer requirements.
- To ensure that the necessary quality procedures and processes are implemented to achieve the required quality objectives.
- To ensure that an effective and efficient QMS is established in the company, which can then be implemented and maintained.
- To provide the necessary resources to achieve the above-mentioned.
- To review the QMS periodically and to decide on actions to revise and improve the system.

2.4.1.2 Continuous improvement of the system

A high level of customer satisfaction can only be obtained through continuous improvement of the QMS. Improvement of the process quality will inevitably lead to increased product quality. It is therefore the biggest challenge for the QM Department to keep on refining and improving the system, and to keep employees on board regarding changes in documentation, and at the same time ensuring that management and employees remain positively committed to the use of the QMS. A strong emphasis needs to be placed on the prevention of errors, rather than the detection thereof when it is too late, wastage of time has already occurred. Discovering- and resolving difficulties at an early stage are ideally required during a project (Foster, 2010:129).

The PDCA cycle is useful when considering continual improvement and is illustrated in **Fig 2.1.**

Figure 2.1: The PDCA Model



(Source ISO 9001, 2005:vi, Foster, 2010:346))

2.4.1.3 Measures that ensure fast response when required

The consulting engineer must be in a position to provide a fast response system when required by a client in the event of project difficulties, be it during the design phase or during construction. The lack of a fast response system will decrease client confidence, but if functional it can contribute positively towards company processes,

and ultimately company success. The result can also be a dramatic improvement in the time it takes between preliminary- and final design (Botha & Jordaan, 2011:13).

2.4.1.4 Participation by all employees – involvement of people

The biggest challenge faced by the QM department in this regard is to convince employees of the benefits of the system. As employees will resist any change of procedure (more so with QM) the benefit might not always be tangible. Employees need to be accompanied through an extended period of training, during which the system is introduced and implemented. Employees are then subject to internal audits and issued with finding reports, indicating where the employee conforms to the requirements, and where improvement is necessary.

A successful Quality Management environment is one where management and employees are well-trained in the system, and committed to make a success thereof by fully participating in quality improvement activities. In time, committed participation can be rewarded and recognized after the outcome of the increased quality is realized, which will emphasize the achievement of the quality objectives. It is, however, important to maintain continuous education and training in order to keep the momentum of the quality drive alive. It is not surprising that Quality Managers report increased effectiveness, creativity and innovation as well as improved communication when a QMS is functioning successfully (Botha & Jordaan, 2011:15).

2.4.1.5 Customer focus

Total Quality Management has a customer-first orientation. Customer satisfaction is the company's highest priority. To achieve maximum customer satisfaction, the needs of clients demand constant sensitivity, as well as a fast response to their requirements. The QMS must therefore be structured such that the satisfaction of the customer is measurable and measured and documented on a regular basis (Chopra, 2010:105).

2.4.1.6 Actions based on data and analysis – process approach

At the heart of TQM in a civil engineering consultancy are facts, data and analysis, supporting the planning, review and tracking of performance, improvement of operations, and comparisons of quality performance with that of competitors. TQM is based on the use of objective data, and provides a rational rather than an emotional basis for decision-making. The approach ensures that data is collected and analysed by those best equipped, who will take the necessary action to reduce cost and to prevent non-conformance. If the right information cannot be made available for this purpose, the analysis cannot be carried out successfully, and non-conformances can therefore not be identified (Foster, 2012:38).

2.4.1.7 Mutually beneficial supplier relationship

Value is created only when a client and his suppliers have a mutually beneficial relationship, which can be created by a QMS if implemented correctly. It is important that both parties believe that they benefit from such a system, such that one party does not feel treated unfairly, by believing that they are paying for something they do not benefit from (Botha & Jordaan, 2011:16).

2.4.1.8 A Total Quality Culture

A Total Quality Culture ensures that employees “think” quality and apply the principles every day, and not only when approaching another quality audit. It furthermore means that employees are not excluded during the development of quality visions, strategies and plans, but that they fully participate to ensure their commitment (Tricker, 2010:68).

2.4.2 The Quality Management Systems Approach

The approach that needs to be followed by a civil engineering consultancy when introducing a QMS includes the following steps (Botha & Jordaan, 2011:9):

- Determine the needs of customers and the expectation they have when appointing a consulting engineer.
- Define the quality policy and the quality objectives of the company.

- Develop the processes to achieve the quality objectives and assign responsibilities to implement the processes.
- Provide the necessary resources to achieve the quality objectives.
- Develop procedures and methods to measure the efficiency and effectiveness of each process.
- Identify means of preventing non conformities and to eliminate their causes.
- Develop methods and apply a process to ensure continual improvement of the QMS.
- Buy-in from top management.
- Training of personnel in the use of the QMS.
- Benchmarking of the QMS against other similar companies.

Companies that adhere to this approach will ensure confidence in the capability of its processes and hence the quality of its products. This approach also provides a basis for continual improvement, and will lead to increased client satisfaction and to the overall success of the company. It will furthermore lead to a distinct competitive edge over other similar companies.

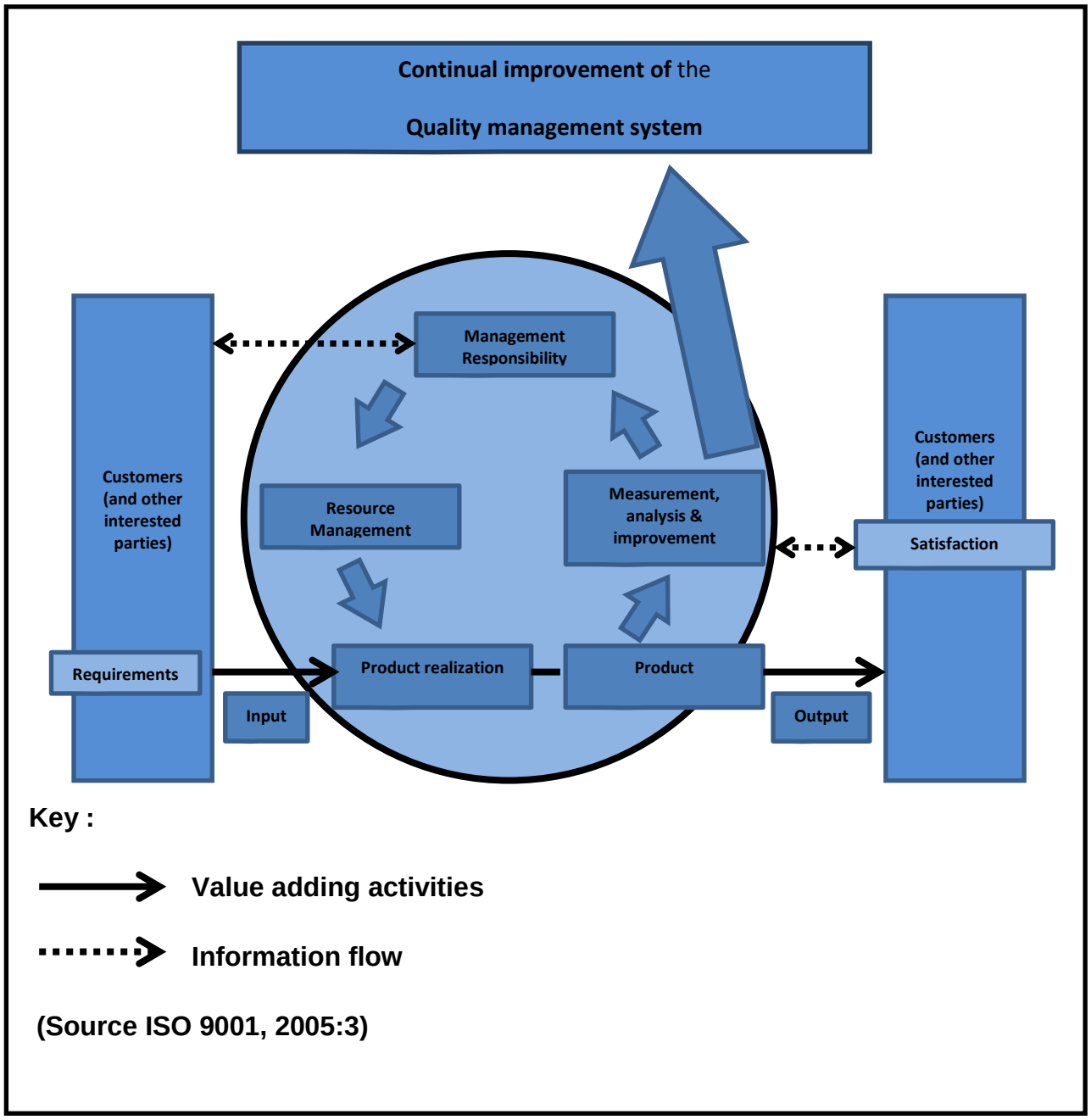
2.5 The process approach

A process is a set of activities that transforms inputs into outputs while using resources (ISO 9001, 2005:2). A successful organization must use and manage interrelated and interactive processes to conduct business effectively, where one output from one activity will serve as the input to the next activity. The systematic identification and management of processes employed and particularly the interactions between such processes is referred to as the “process approach”.

Figure 2.2 shows the process-based quality management system as described in the ISO 9000 standards. From this illustration it can be seen that the interested parties (clients) play a significant role in providing inputs into the organization, after which the product realization transforms the input into outputs, which are assessed by the client in order to provide feedback for a process of continual improvement. The product realization process is also subject to measurement, analysis and

improvement, supported by management, who in turn provide the necessary resources to conduct the process. This entire cycle also contributes towards the continual improvement of the different processes, aiming at a mutual beneficial relationship between management of the company and its clients.

Figure 2.2: Model of a process-based QMS



2.6 Documentation of a QMS

2.6.1 The value of documentation

The documentation of a QMS in a consultancy is the most important part of the system as it communicates to clients and personnel the intent of the system and ensures that the system is applied consistently. The documentation furthermore contributes towards (ISO 9001, 2005:4):

- The achievement of customer requirements and improvement of quality.
- Training for personnel in company procedures and company quality policies.
- The provision of evidence of the events that take place during a project.
- The evaluation of the QMS and the continual improvement thereof.

2.6.2 Types of documents of a QMS

The following document types are used in a QMS (ISO 9001, 2005:4):

- Quality manuals – documents that provide consistent information about the organization's QMS – quality manuals are also helpful in leading personnel in the right direction towards company procedures and quality policy.
- Quality plans – a quality plan indicates how a specific project is addressed regarding the company quality procedures – a quality plan is therefore uniquely drawn up for every new project.
- Quality specifications – a document that is also project-specific, and provides the specific quality requirements.
- Quality guidelines – documents containing quality recommendations or suggestions.
- Procedures, work instructions and drawings – documents that provide information about how to perform activities and processes consistently.
- Records – documents that provide objective evidence of activities performed or results achieved.

The difference between a document and a record is as follows (EXALTA, 2010:59-61):

- A document is always forward looking, contains information of what needs to be done, and how it must be done. A document can be changed and can have a revision status.
- A record is backward looking and a historical recording of events. A record contains information that cannot be changed, and cannot have a revision status.

Documents and records are both media independent, and can consist of video, audio, electronic format, colour coded or on hard paper copy.

2.7 ISO 9001: 2008 – An Overview

This ISO volume deals with the requirements of Quality Management Systems. The same terms and definitions as contained in ISO 9000, apply here. The focus in ISO 9001:2008 is on the following key aspects (IS O 9001, 2008:3-12):

- The QMS
- Management responsibility
- Resource management
- Product realization
- Measurement, analysis and improvement

2.7.1 The Quality Management System

The first requirement is that a company must establish a QMS, which needs to be documented, implemented and maintained, as well as continuously assessed and improved in accordance with the requirements of ISO 9001. In compiling the QMS, the processes used by the company to conduct its business must be identified, arranged in a logical order, and to determine the criteria and methods to ensure that the operation and control of these processes are effective. Furthermore the resources and information required to support the functionality of these processes

must be made available, as well as monitoring and measuring of the processes in order to be able to ensure that continuous improvement can be achieved.

This QMS must conform to the document requirements as stated by ISO 9001, including the companies' quality policy and quality objectives, a quality manual and documented procedures, and documents and records.

All the documents of a QMS shall be controlled, which means that all documents produced will be approved to be adequate for usage before issue, will be reviewed and updated as necessary – also to identify changes and update the revision status, and to ensure that the relevant versions of applicable documents are readily available to employees. Furthermore, documents must be legible and readily identifiable, the distribution must be controlled, and old or obsolete versions must be taken out of the system (EXALTA, 2010:59-61).

2.7.2 Management responsibility

A QMS introduced to a company, cannot be successfully implemented and maintained unless top management provides its undivided support and commitment to the system. Employees must receive and use the system as if it is an order from management, therefore it is required that the Quality Manager should be a member of the management team. Management must therefore provide assistance and the required budget to establish the quality policy and objectives, which must be appropriate to the purpose of the organization, and must ensure the availability of resources. The ultimate aim of customer requirements and customer satisfaction must always be the focus of management's involvement.

It is also management's duty, as required by ISO 9001, to ensure that the QMS is implemented, utilized and maintained. This will include the regular review of audit results, customer feedback, process performance and product conformity, the status of preventive and corrective actions, and recommendations for improvement (ISO 9001, 2008:3).

2.7.3 Resource management

The organization is responsible to provide all the resources required to realize the QMS, including human resources – the necessary personnel with the appropriate education, training, skills and experience, the required infrastructure – work space and utilities, hard- and software and other supporting services such as transport, communication or information systems (ISO 9001, 2008:6).

2.7.4 Product realization

Product realization means planning the processes which are required to deliver the product, with the focus on the company's quality plan and – objectives. The customer focus is important, together with his requirements, as well as good communication between company and client. The design and development process of the product, including functional, performance, statutory and regulatory requirements are further aspects covered by ISO 9001. There are further requirements like purchasing of products, production and service provision and product preservation, which are applicable to the manufacturing industry, rather than a service-orientated business (ISO 9001, 2008:7).

2.7.5 Measurement, analysis and improvement

Continual improvement can only be achieved if regular measurements are carried out. This is done to demonstrate conformance with the product requirements and to ensure conformity with the QMS. This must be realized by conducting regular internal audits, to test conformance of the QMS, to benchmark against other similar systems and to focus on the ultimate goal of customer satisfaction, by reviewing customer reports on the products and services they have received. Any non-conformances must be identified during these audits, and remedies must be proposed to prevent recurrence of these events. Corrective action and preventive action must be exercised, which will make continual improvement of the companies' processes a reality (ISO 9001, 2008:12).

2.8 The aims and benefits of ISO 9001: 2008

Tricker (2010:85) considers the main aims of ISO 9001: 2008 to be as follows:

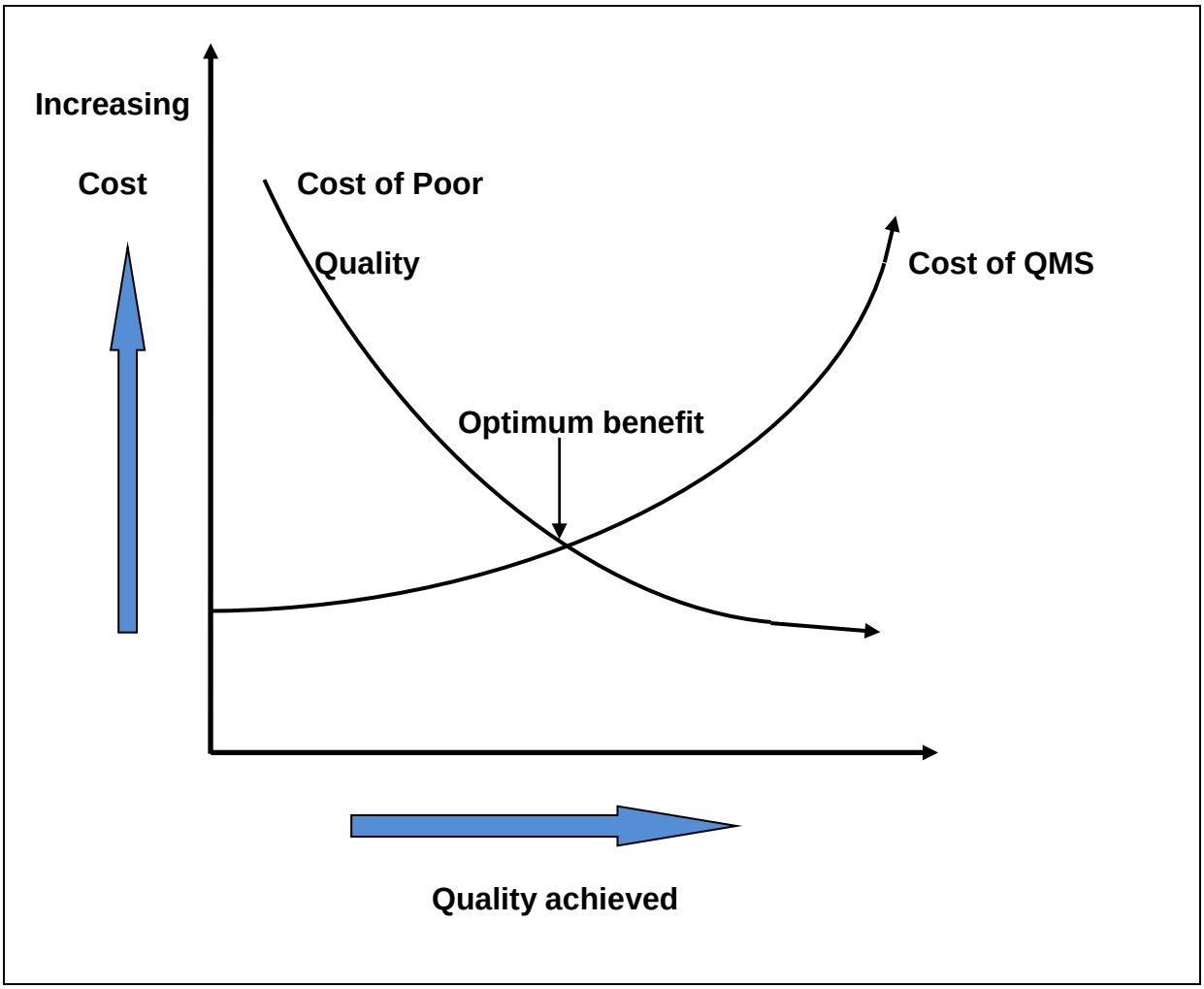
- To be flexible enough to be applicable to any organization including manufacturers or service providers.
- To introduce a simple structure for QMSs by implementing a Plan-Do-Check-Act process-based model. (see Fig. 2.1 on page 27)
- To place emphasis on determining and reviewing customer requirements, and verifying that they are met. Emphasis is also placed on measuring customer's satisfaction.
- To assert continual reviewing and – improvement of organizational processes, including the QMS.
- To define the responsibilities, authorities and resource requirements of the QMS.

The benefits of ISO 9001:2008 can be summarized as follows (Tricker, 2010:58):

- It proposes a QMS in a process-based format that follows the Plan-Do-Check-Act (PDCA) principle – see Fig. 2.1. This cycle supports the principle of continuous improvement, as it acts on something which is checked, but not found in a good working order, or deviates from the prescribed procedure. If the cycle is followed a second time, the deviation of non-conformance should be improved, and the continuous improvement principle can be considered successful, as it builds on the knowledge of previous cycles.
- The requirements of each process are determined after agreement with the client, fixed before commencement, and measured during and after completion of the product or service. Verification of the conformance is then done afterwards, which confirms that the requirements have been met, as proof of the quality of the product or service.
- The documentation of the QMS serves as proof that the quality standard was reached and can be presented to any auditor who inquires. The record furthermore shows management that the prescribed process was followed and serves to assist in improving the process by learning from past achievements and failures.

- The ISO 9001:2008 standard can be used by any organization irrespective of size or market they operate in, who can develop their own QMS, and get it certified by an accredited body.
- The standard was developed to be flexible in nature, such that it can be applied by any organization. It can therefore easily be incorporated in any business, as long as it is process-based. For this reason, organizations will not have to drastically change their operations to suit the standard, but can merely adjust their activities to fit, provided that their processes conform to quality requirements.
- The financial benefit of a QMS is difficult to quantify, as quality alone cannot be profitable. There is, however, an indirect financial benefit, as the organization will spend less time in fixing failures of non-quality products. Time is an expensive commodity, especially for professional engineers and technicians, and saving time can have a huge influence on profitability. There is another cost dimension, namely customer satisfaction, which will inevitably generate more work if the customer was satisfied with the previous project, carried out by the organization. The opposite is also true for an unsatisfied customer.
- Tricker proposed an optimum benefit point for increasing quality cost expended by the QMS versus the cost of poor quality. **Figure 2.3** indicates the optimum benefit point of the two curves, which indicate (1) the high cost with low quality, where the cost reduces as quality increases, and (2) the increasing cost of quality as it increases in magnitude. Every organization's challenge lies in determining where the optimum benefit point is, and to manage the processes of the business such that this point is reached and maintained (Tricker, 2010:20).

Figure 2.3: Tricker's model of the Cost of poor Quality versus QMS cost



(Source: Tricker, 2010:20)

2.9 Limitations of ISO 9001:2008 and ISO certification

There is a certain amount of vagueness in the ISO 9001 framework, according to which a company must develop its QMS. Therefore companies find it hard to comply with the requirements as they are only described in vague terms, difficult to relate to the activities of a service company.

- Management must first determine how each of the requirements of ISO 9001 relates to their organization and then develop the relevant processes required.
- As a result of the vagueness in the standard, it requires a bigger effort from companies to develop their QMS.
- The process of certification also presents some limitations. Some certifying bodies do not always have the specific knowledge to evaluate the output

of a specialist organization. In such an instance the auditor can only ensure that the company conforms to the provisions of the standard. Therefore an organization that has ISO 9001 certification merely proves that they have an operational QMS, but does not guarantee that they produce a high quality service.

- An organization can comply with the ISO standard, have a QMS in place, and achieve ISO 9001 accreditation, but still produce and deliver a poor quality service. The challenge for top management is therefore to keep focusing on the aim of the QMS, to continuously improve the system and to perform regular evaluations of the system, to assess whether it still achieves its quality objectives (Pitout, 2007:32).

2.10 Introduction to the civil engineering consultancy industry

Civil Engineering consultants are responsible for the planning and design of a wide range of infrastructure-related projects in the built and natural environment. Their role during the project life cycle is the effective planning, design and management of a project from the inception stage, through to the handover of the final functional product to the client. The essence of a good project is time, quality and budget, which are the main focus areas of a consulting engineer. Civil engineers are employed on a wide range of projects including roads and storm water, bridges, airports and harbours, buildings and stadiums, water- and wastewater structures and – reticulation, waste management and geotechnical engineering (Botha & Jordaan, 2011:4).

2.10.1 Governing bodies for engineers in South Africa

The **Engineering Council of South Africa (ECSA)** is a statutory body which was established in terms of the Engineering Profession Act, 2000 (Act No. 46 of 2000). The principal focus of this act, from which ECSA obtains its mandate, is to promote the interests of the public in relation the Engineering Profession. ECSA, who is in partnership with the state and with engineers, promotes a high level of education and training of practitioners in the engineering industry, ensuring full professionalism amongst its members. ECSA enjoys full autonomy, although it is accountable to the state, the profession and the public, in pursuit of their vision statement which is “to

ensure that South Africa enjoys all the benefits of a strong, competent, growing, sustainable and representative engineering profession, able to provide all the expertise necessary for the socio-economic needs of the country and to exert a positive influence in South Africa" (ECSA 1: 2012).

Consulting Engineers South Africa (CESA) is recognized by ECSA as a voluntary organization in terms of the Engineering Professions Act. Consulting companies, and not individuals, become members of CESA, which is a body that promotes the joint interests of their members, and provides quality assurance for clients of civil engineering consultants. CESA and their member firms are committed to continuous education and development for their personnel and upliftment of the communities they serve, improving the quality of life for all South Africans by the promotion of engineering excellence and serving their clients with professionalism, integrity and independence of judgment (CESA 1: 2012).

The **South African Institution of Civil Engineers (SAICE**) is the learned society and professional home for almost 8 000 civil engineers, technologists and technicians. The SAICE develops technical guidelines and documentation in the industry, assists with continuous professional development, and creates a networking opportunity for their members. The Institution is furthermore responsible for outreach programmes to society through career guidance and awareness campaigns, and for the support and input to central government regarding legislation concerning all aspects of civil engineering (SAICE 1:2012).

2.10.2 Obtaining projects in the civil engineering industry in South Africa

Civil Engineering consultancies obtain new project appointments from clients in the public or the private sector, by means of direct appointment through negotiation, or more recently also through a process of tendering. New innovation often determines whether a project is viable or not, and engineers are therefore required to provide solutions which are extraordinary, cost-effective and functional, in order for the project to proceed to design and construction. Expenditure on infrastructure by government and the private sector is of a cyclical nature which follows the local economic cycle, interest rates and the local and international markets. It is therefore expected that more will be spent on infrastructure when the economic cycle is in an

upward phase, interest rates are low and the market sentiment is positive. Alternatively, lower activity on infrastructure expenditure is expected when the economy is in a downwards trend, interest rates are rising and the markets in a declining phase (SAICE, 2012).

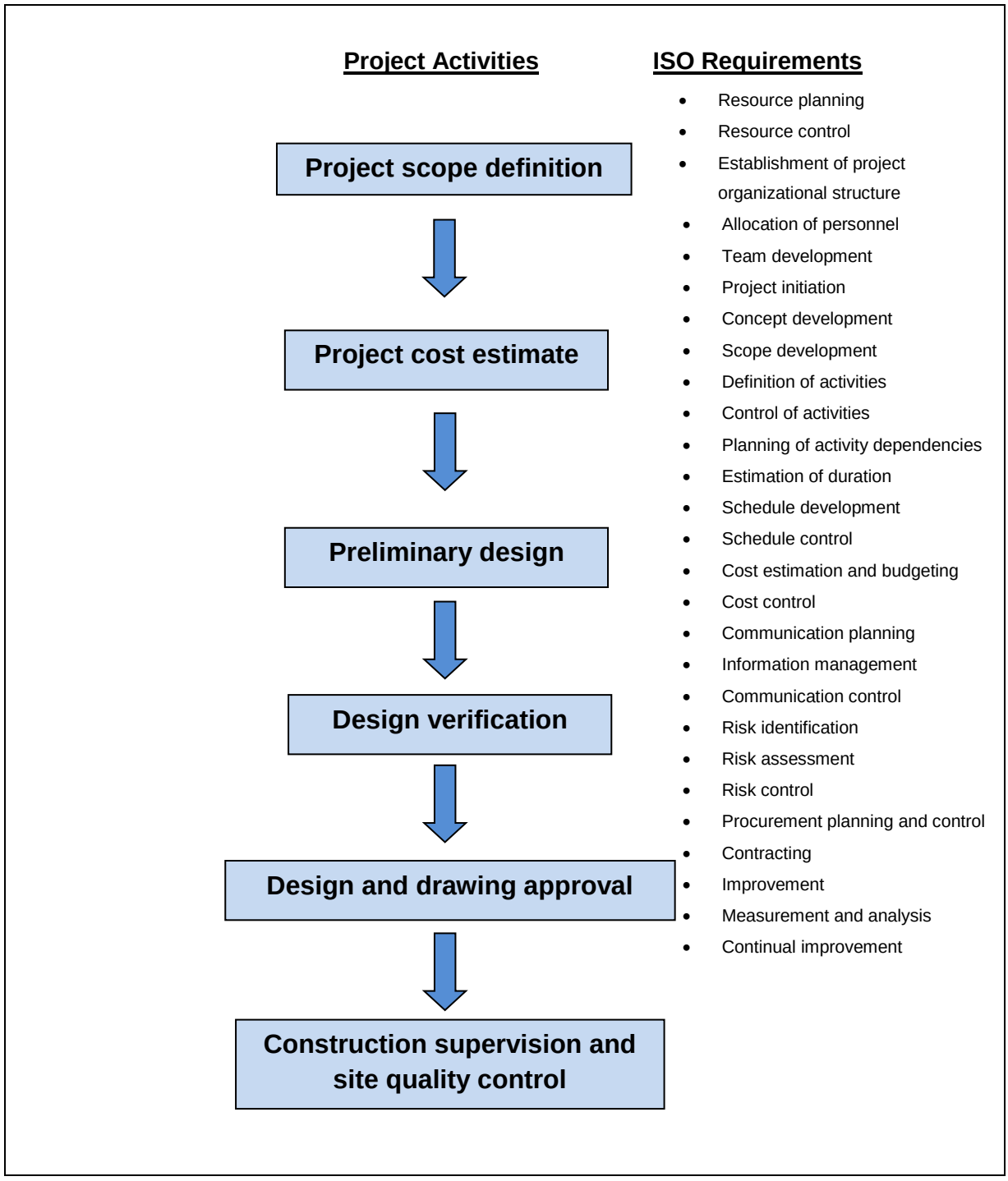
2.11 Marketing and business development

Marketing and business development are done by civil engineers mainly by ensuring that clients are satisfied with the projects that they entrust engineers with, as a good project will always ensure repeat business from the same client. It is therefore of utmost importance for an engineer to produce a service of satisfactory quality, not only to ensure that his client will return for the good experience with a particular project, but also to tell others about the exceptional quality that prevailed. By the same token, it is important for the engineer to create quality by means of a systematic approach, and to document this system such that a prospective client will be convinced of the positive outcome that can be expected (ISO 9001, 2008:6).

2.12 Project life cycle and –value chain

The stages of the value chain of a typical civil engineering design project are indicated in the schematic representation in Figure 2.4:

Figure 2.4: Value chain of a civil engineering project



Source: Botha & Jordaan: 2011

2.12.1 Project scope definition

The scope definition and agreement is one of the most important steps during a project. The detailed scope must be defined and submitted to the client for approval

to avoid later disputes or project inefficiencies. The project definition must therefore be one of the first requirements of the QMS - to compile a scope definition and to get it approved by the client, before the project proceeds (Heizer & Render, 2008:60).

2.12.2 Cost estimate

The cost estimate is the next logical step as the client must be confident that the budget for the project is in order and that the funding is available, failure of which will result in an incomplete project or non-payment to the consultant or the building contractor. Provision should also be made for price escalation, especially if the project runs over a few years, and for a contingency amount which will provide for design omissions and scope creep. “Scope creep” occurs when the scope of the initial project is increased incrementally during the project cycle due to increased needs and requirements from the client (Heizer & Render, 2008:37).

2.12.3 Preliminary design report

The Preliminary Design Report (PDR) indicates the project intentions, and is submitted to the client for his approval, before the detail design commences. This report can avoid misunderstandings regarding the project scope and measures if the client’s intentions correspond with the engineer’s interpretation thereof. The engineer’s Quality Management System can be very useful in getting the PDR compiled and approved by the client.

2.12.4 Design verification, final control and drawing approval

Final design approval also requires strict enforcement of Quality Management procedures during this stage of the project and is essential for reducing mistakes during the project, which will inevitably result in a cost implication for the engineer and the client.

2.12.5 Construction supervision and site quality control

Construction work which is carried out outside the specified quality can usually be attributed to inefficient site personnel, or the lack of site quality assurance. This leads to an inferior product which can cost huge amounts of money to rectify afterwards. By training the site personnel properly according to the engineer's company site quality assurance system and to conduct frequent audits on the use thereof, will ensure that the end product conforms to quality standards and the contract specifications (Heizer & Render, 2008:208).

2.13 Benefits of Quality Management and ISO certification

The five main steps of the project value chain as shown in Figure 2.4 are complemented by various other intermediate steps which are also an important part of the chain, and require quality management inputs during the course of the project. These intermediate steps are adding value to the project and include site investigations for the collection of site information, for example topographical and geotechnical surveys and a project feasibility study. As professional engineers and technicians are expensive commodities, it is of utmost importance to ensure that maximum value is added whilst employing them on projects. Any work that needs to be redone as a result of poor quality control, can affect the profitability of a project, and will determine the eventual success or failure thereof. Project difficulties including technical problems and time and cost overruns can usually be attributed to a certain stage, or various stages, when quality checks were omitted or overseen (Botha & Jordaan, 2011:17).

Further benefits of ISO 9001 certification are:

- A QMS or ISO 9001:2008 system implemented in a company is a prerequisite for membership of Consulting Engineers in South Africa (**CESA**) irrespective of the size of the company. (EXALTA, 2010:40)
- Large client bodies either require or recognize ISO 9001:2008 compliant firms in their procurement processes. As clients become more aware of the potential benefits to themselves and the associated reduction of risk, demand for compliant companies increases.

- Dealing with ISO-accredited suppliers provides clients with a sense of security, and reduces their effort to control their service provider's products.
- From the engineering company's point of view, ISO accreditation provides a quality image, client confidence and access to markets where quality certification is obligatory.
- Companies with a QMS approved by CESA can be entitled to a 15% discount on the deductible payable in the event of a claim brought against it. The onus and responsibility would, however, fall on the member company to prove that the QMS had been adhered to.
- Company activities can be more easily controlled with a QMS in place.
- Company risks can be better managed with a QMS in place and can have a major effect on internal performance (CESA 1: 2012).

Organizations must strive to demonstrate good corporate governance through sound business controls and active management of organizational performance. Clients expect consulting engineers to develop, implement and maintain a well-structured QMS, integrated with the overall management activity and addressing all aspects of desired organizational performance. There is at present worldwide attention on QMS in organizations which offer a structured and systematic method to incorporate quality in all aspects of organizational activities. The aim is not only to comply with regulations and minimize the risks of liabilities and costs, but also to improve the organizational performance continually in order to improve corporate image and gain competitive advantage (Young, 2006:4).

2.14 Chapter conclusion

If it is true that a QMS or ISO certification holds so many benefits for the civil engineering consultancy industry, the following questions come to mind and will be investigated in the empirical research in Chapter 3:

- Why are there still failures in the work of consulting civil engineers given that a project is documented and executed in accordance with the QMS?
- Why is it that QMS that are implemented and certified still seem to fail during the execution of projects, causing project difficulties?
- Why are clients sometimes dissatisfied with consulting engineers at the conclusion of a project, even with a fully operational QMS?
- Can the QMS be used for purposes other than quality?
- In what ways can the QMS be improved to better prevent project difficulties?

CHAPTER 3: EMPIRICAL RESEARCH

3.1 Introduction

The differences between quantitative and qualitative research are as shown in Table 2:

Table 2: Differences between quantitative and qualitative research

Quantitative research	Qualitative research
To evaluate **objective data** consisting of numbers.	Deals with **subjective data** produced by the minds of respondents or interviewees, presented in language.
Analysis process is based on **complex structured methods.**	Analysis process is based on **flexible and explorative methods.**
The purpose is not to deal with everyday life, but rather with an **extraction of reality.**	The constraints of day-to-day events are investigated and results are based on **daily events and behaviour of people**.
Researchers try to understand the facts from an **outsider's perspective** to get an objective view**.**	Researchers try to achieve an **insider's view** by talking or observing behaviour.
Researchers try to keep the research process as **stable** as possible.	Researchers work with the **dynamic and changeable** nature of reality.
Specific measurement instruments are used to collect data, therefore the approach is described as **particularistic.**	A wide array of data is collected, therefore the approach is described as **holistic.**
Focus is more on **reliability.**	Focus is more on **validity.**
Aims for **larger numbers,** and bases analysis on statistical significance**.**	Involves **small samples** of people, studied by means of in-depth methods.

(Source Welman, Kruger & Mitchell, 2010:9)

3.2 Why was qualitative research selected for this research?

Qualitative research is any research that relies primarily or exclusively on qualitative measures. Qualitative measures in turn are any measures where the data is not recorded in numerical form, but rather includes brief written responses on surveys, interviews, anthropological field research, video and audio data recording, all of which are characterized by a non-numerical format. Qualitative research is typically the approach of choice in circumstances that have one or more of the following four characteristics (Trochim, William & Donnelly, 2008:142):

- For generating new theories of hypotheses
- For achieving a deep understanding of the issues
- For developing detailed stories to describe a phenomenon
- For mixed methods surveys

Qualitative data can be collected in a few ways, including in-depth interviews, direct observations, questionnaires, written documents and case studies. This study will focus on qualitative questionnaires and case studies, as these are considered the most appropriate methods of achieving a deep understanding of the subject. The sample is a **non-probability convenience sample**, as it consists of engineers in management positions. The respondents were part of a closely-knit society of engineering professionals, who were selected by the author. The qualitative research consisted of the following 3 aspects:

- Open-ended questionnaires to engineering managers. It is perceived that in this instance open-ended questions give a more unbiased view of engineers' perception of value adding by a QMS (Botha & Jordaan, 2011:14).
- An in-depth interview with the company Quality Manager.
- Case studies on PI claims in the wider industry.

Each of these aspects is discussed in this chapter, followed by the analysis of the responses received from respondents.

3.3 Questionnaires

A qualitative questionnaire consisting of 21 questions was compiled and distributed to 45 participants, all of whom are managers in consulting engineering companies in South Africa.

The questions in the questionnaire were aimed at assessing engineering managers' perception of quality regarding the following aspects:

- Understanding of what quality means in their organization.
- What a QMS is and what ISO is.
- Whether the introduction of QMS has changed the way in which he/she approaches his/her duties in any way.
- The cost and benefits of a QMS in his/her company.
- The attitude of the respondent and of his/her subordinates towards the QMS in the company.
- The role of the external audits, and the attitudes of respondents and subordinates on the audits.
- Whether the use of the QMS has contributed towards improvement in client satisfaction.
- The respondents' experience regarding PI claims – if he/she has been involved in claims and whether they believe that the QMS has any influence in the occurrence of claims.
- Whether the QMS is useful in any capacity other than client satisfaction or the reduction of PI claims.

The complete questionnaire is attached as **Annexure 1.**

The questionnaire was distributed on **1 September 2012,** and the 45 participants were requested to respond by **15 September 2012**. Those identified as participants were encouraged to complete the questionnaires at distribution and again a few days before the target submission date. On **20 September 2012** the number of responses amounted to **22**, or **48.9%**, confirming that the qualitative approach was the most appropriate choice for this study. The following analysis was made from the responses:

3.4 An analysis of the responses received from questionnaire respondents

A summary was made of the responses received from those identified to participate in this study as follows:

3.4.1 Respondents' understanding of the term quality and what it means in their organization

- Doing your work at an acceptable standard of accuracy and correctness.
- Producing drawings with a distinctive style and without errors.
- A feeling of achievement, recognition and satisfaction.
- Peace of mind, pride, less re-work and more profit.
- Taking pride in what you do and deliver.
- Assuring clients of a good service, and meeting their expectations.
- Doing things right the first time using best practice, being accountable.
- Ensuring that engineering designs comply with agreed design specifications, meeting high technical and aesthetic standards.
- Not having to repeat any part of completed work.
- Meeting objectives and target dates, delivering on clients' expectations and needs.
- Providing accuracy, minimizing risk for the client.
- Achieving levels of excellence in rendering service to clients, and limiting your own risk.
- Obtaining a competitive edge over your competition.
- Complying with standard methods.

Discussion:

All 22 respondents displayed a reasonable understanding of quality in their organization. The reason for this question was to determine whether respondents understand the reasons for using quality principles, and not merely adhering to a set of quality rules without thinking about the benefits. It was clear that respondents understood the requirements and the benefits, although some were much more elaborate than others, and were more convincing in their understanding of the term. The responses are generally in agreement with the definitions of Quality Management as provided in the literature study in paragraph 2.2.

3.4.2 Has the introduction of a QMS changed the way in which they approach their duties in any way?

Positive comments:

- More checklist-oriented than before. The management process for project execution now follows a structured path with documentation of the steps to ensure that it is auditable.
- Very different to what it used to be, especially regarding drawings.
- Projects are now more defined and there is less risk of non-compliance with client requirements.
- QMS is quite thorough on initiating and closing projects, yet less focused on planning, executing and controlling.
- It is different now, but only administratively – technical detail is still as before.
- The most notable change is on documentation (record keeping).
- Filing and documentation are much more organized and uniform.

Negative comments:

- QMS has hardly had any impact on the way reports are produced technically, although large amounts of red tape were added administratively.
- Very little has changed during the construction phase of a project.
- The methodology is essentially the same, although there is more documentation.
- Project execution is now more expensive. There is more documentation than before.

Discussion:

From the 22 respondents, there were 6, or 27%, who indicated that they approached their duties in exactly the same way as before. The other 73% believed that the approach to projects was different from before, with emphasis placed on documentation and structured workflow and on a checklist approach which is now

used. It is evident that departments where technical report writing is focused on believe that there is no real difference in the way projects are executed. In departments where drawings are produced, on the other hand, the experience is quite different. Drawing production and drawing issue have become much more important activities, where procedures and checklists are now much better documented than before. There are also regular drawing audits where drawings and drawing registers are scrutinized for compliance.

3.4.3 Respondents' view on the cost and benefits of a QMS in their company, and the cost of quality failure

Positive comments:

- The cost of quality failure is very high in a design environment and can even lead to death and disability, apart from financial loss. Lawsuits and criminal prosecution can also occur as a result of quality failure.
- Quality failure results in the loss of clients and hence loss of a company's competitive edge.
- The cost of quality failure in bridge design can be huge if the technical quality assurance is not up to standard.
- The cost is more than financial – it also involves additional risk and a breakdown of trust between client and consultant, poor reputation and a loss of clients.
- Companies have closed down as a result of PI claims emanating from poor quality management.

Negative comments:

- It is doubtful whether the QMS can prevent quality failure.
- Design errors result in very expensive comebacks – the QMS is not, however, sufficiently focused to avoid that.
- The cost is minimal (this was the response of traffic engineers who produce traffic studies which normally do not have a high risk of failure costs).
- The cost of quality failure in project management is insignificant.

Discussion:

Where design work and drawings are concerned, the cost of failure can be catastrophic and can put the company in a position from which it cannot recover again. The same does not apply for technical or feasibility studies. Respondents feel, however, that the QMS is not focused on the right issues, as more emphasis is placed on the paper trail of procedures, rather than the design itself.

3.4.4 Respondents' view on whether the cost of QMS exceeds its benefits

Positive comments:

- The cost of the QMS can currently not exceed the benefit.
- The cost of QMS can be minimal if it forms a natural part of your working day, and should not exceed the benefit.
- The only additional cost for QMS should be in training and study groups.
- The benefits of QMS probably exceed the cost, although the cost is probably under-estimated.
- The benefits should exceed the cost, provided the QMS is focused on design- and documentation excellence, which is currently not the case.
- The benefit of QMS should outweigh the cost thereof in an industry where reputation or lives are at stake, provided it is appropriately applied.

Negative comments:

- The cost of the QMS can easily become a burden if the focus is not right and if “over-applied”, the cost will exceed the benefit.
- The benefits of QMS are very small and mostly a “waste of money”.
- It is unlikely that the benefits from QMS justify the cost as it is too complicated and a degree of duplication exists.

Discussion:

From the 22 respondents, there were 4, or 18%, who believe that the cost of the QMS exceeds the benefit, whereas the other 82% believe the opposite. It is clear that the actual cost of QMS is not known, as it is quite difficult to measure. There are 3 employees (not part of the respondent group), who are fully engaged on the successful implementation and maintenance of the QMS, the cost of which is known. However, the time spent by engineers on QMS cannot be measured. If the QMS can be applied during the normal time during which projects are executed, the cost can be kept at a minimum.

The cost awareness of the respondents regarding quality compares favourably with **Figure 2** in the literature study and with Figure 3 where Tricker (2010:20) proposed an optimal benefit point for increasing quality cost expended by the QMS vs the cost of poor quality. According to 82% of respondents, the optimum point in the figure regarding cost of quality has not been reached.

3.4.5 Respondents’ attitude towards the QMS in their company

Positive comments:

- It forces one to follow procedures which are beneficial in the long run.
- The system is well set up and operates well, although there are certain aspects that can be improved.
- One cannot work in a professional environment without a QMS.
- The QMS is easily accessible on the intranet and is helpful at project initiation stage.

- Training of the QMS should be a part of the system.

Negative comments:

- The system is over-complicated and guidelines used on the forms are generic and confusing. It is furthermore ever changing and requires of employees to keep abreast of the revisions.
- The QMS only consists of a set of policy and procedural documents primarily aimed at HR functions and project initiation.
- The QMS fails to address the heart of service delivery.
- There is a lack of “excellence” which was evident in the previous system.
- The QMS is uninspiring, without a clear purpose and vision for the employees in the “engine room”.
- The QMS has grown into a very large administrative animal, which takes up too much time, especially on small projects and tenders, where time is very limited.
- It measures unimportant matters and misses or overlooks the more important.

Discussion:

While some of the respondents see the QMS as a burden producing too much paperwork, a system that addresses the less important matters and omitting the more important, **all of the respondents** are positive about the QMS and believe in its benefits. It is evident that users feel safe to a certain extent, knowing that the system guides them into ensuring that certain activities and procedures are adhered to. There is, however, opportunity for improvement in certain areas of the QMS as suggested. Although employees realize the necessity of the QMS, it was not launched in a professional manner which employees could buy into. This has created resistance by employees since the inception of the QMS.

3.4.6 Respondents' view on the role of the audits

Positive comments:

- A daunting experience, but the value thereof is realized – a necessary and stressful evil.
- Perceived negatively at first, but more positive after realizing the benefits.
- Managers must set an example, motivate employees and show that they support the QMS.
- Fully supportive of the need for QMS; however, the audits and findings leave one demotivated.
- Positive – employees see it as a way of assistance to ensure compliance with procedures.
- Audits act to reinforce the necessity of implementing the QMS.

Negative comments:

- It is seen by personnel as a time to do some catching up on outstanding quality items.
- Employees show guilt when non-compliance is registered, and upset about employees who are frustrated and uncertain about goalposts recently moved.
- Audits are seen as a compulsory office cleaning exercise, tidying of files and quickly doing some paperwork to pass the audit.
- Negativity amongst employees – however, if your QMS is in place, it is easy to maintain.
- Time-consuming, even a waste of time, but necessary.
- Findings on insignificant items are very demoralizing.
- The system is being adhered to only in so far it is compulsory and enforced – therefore a special effort is put in to catch up when an audit is due.
- Perceived as a necessity performed by people not familiar with reality and the essence of service delivery.

- Employees see audits as a “test”, and can become confrontational or defensive.
- Grapevine talk is very negative. Prior to the audit, everything gets polished, but after the audit, it is business as usual.

Discussion:

From the 22 respondents, there were 18 or 82%, who experience the audits negatively, yet all agree that they are necessary. It even creates feelings amongst participants that they are subject to a “test”, which causes emotional stress. It is clear that last minute catching up on documentation is often done just before audits, and things revert back to business as usual afterwards. This means that they only adhere to the fact that it is compulsory and gets enforced – otherwise they will probably not bother, even knowing the benefits of the system. Employees are furthermore of the opinion that too often “petty findings” are made, which has a demoralizing effect and creates resistance against the QMS. There are, however, also positive attitudes where little audit findings are experienced – probably in a drawing-free environment.

3.4.7 Respondents’ opinion as to whether the use of the QMS has contributed towards improvement in client satisfaction

Positive comments:

- It creates comfort about company capacity and peace of mind to the client, but also higher expectations of the deliverables.
- Most clients expect a quality product or service without really caring how it is achieved.
- Clients will rather appoint a consultant with ISO certification than without.
- It does give some comfort; however, most clients believe that your work will be of a high standard, whether you are certified or not.

Negative comments:

- Some clients can get offended and it may be perceived as an aggressive act by the consulting engineer, rather than part of the QMS.
- It does not contribute to client satisfaction, as the quality of the work is demonstrated more by the quality of the end product than the QMS certification.

Discussion:

Respondents differed in opinion on this question**. From the 22 respondents, there were 6, or 27%,** who believe that the QMS has not improved client satisfaction, whereas the balance of 73% has a view to the contrary. Whilst it is believed that ISO certification is comforting to some clients, others believe that clients are not really bothered about certification, and expect high quality work anyway. Some clients will react offendedly if you request them to fill in a satisfaction form, whereas others will appreciate a call after completion of the assignment, which is aimed at getting the client's view on how the service was perceived. It is therefore important to know your client and to approach him in a manner most suitable to his liking.

Client satisfaction is, however, one of the cornerstones of ISO 9000 and should be companies' highest priority. To achieve maximum customer satisfaction, the needs of clients demand constant sensitivity, as well as a rapid response to their requirements. The QMS must therefore be structured in such a way that the satisfaction of the customer is measurable and measured and documented on a regular basis (Chopra & Meindl, 2010:105). Respondents have indicated that whilst the satisfaction surveys are helpful in most cases, the company should be cautious in its approach towards conducting these surveys, as it can create negative attitudes towards the service provider from certain personalities at client institutions .

3.4.8 The respondents experience regarding Professional Indemnity (PI) claims – whether they had been involved in claims, and whether they believe that the QMS has any influence in the incidence of claims

Positive comments:

- The QMS should prevent PI claims if applied correctly.
- The QMS should ensure that the risk of claims is lower and can be identified much earlier, which should result in fewer PI claims.
- The mere fact that the QMS provides for considered contracts must make a difference to the incidence of PI claims.
- It should, as it creates accountability amongst employees, and it requires examination of project risks before formalization of appointment conditions.

Negative comments:

- It is unlikely that the QMS will make any difference to PI claims.
- The QMS will not influence PI claims as it does not adequately address the vitally important design and documentation phases of a project.

Discussion:

The respondents did not have experience with PI claims, as is evident from the fact that only one **out of 22, or 4%,** had previously been involved in claims. The reason is that it is a specialized field, carried out by personnel knowledgeable and experienced in this field, not one of whom was part of the study. The general belief **(16 out of 22, or 72 % of respondents)** is that the QMS should reduce PI claims if applied correctly, as most of the risks should be mitigated during the application of the QMS procedures.

The above-mentioned opinion of the respondents is in agreement with the findings of the Professional Indemnity study, which follows below.

3.4.9 If the QMS is useful in any capacity other than client satisfaction or the reduction of PI claims. Does it enhance project performance or improve project execution?

- It is useful for standardization and guidance for junior staff – no-one needs to reinvent the wheel every time and it provides a good common basis to work from.
- The formalization of the project processes and procedures results in a more thorough approach to project execution.
- It ensures proper record-keeping of projects, and checklists during project execution.
- You do not have to wait until project completion to measure quality.
- It ensures improved planning and management of projects.
- It is comforting to know that company procedures are adhered to.
- Although a structured approach is ensured, it also discourages creativity and innovation which is essential for engineering.
- The standards and procedures are well-documented and can be used as a training manual for young engineers.

Discussion:

The general belief **(18 out of 22, or 82 % of respondents)** is that the QMS is quite useful other than for auditing purposes. The QMS is seen as a very useful training tool for new personnel. It is also comforting to know that you are adhering to procedures in a systematic way. The standard way in which a project is documented makes it easy to inspect the paper trail or to know exactly where to find specific information. An important aspect is that quality can be traced along the timeline of the project, and that there is no need to wait until completion to determine project quality and therefore project success.

The reactions of the respondents were in agreement with the aspects that were mentioned in paragraph 2.4.4.1 of the literature study regarding the use of the QMS as a training tool and the provision of evidence of project events during execution.

3.4.10 Any aspects that respondents considered limitations of the QMS?

- The fact that it is currently a “one system for all” and that it is not customized for a specific department. There is no appreciation for different needs in different departments.

- Too much emphasis on less important things.
- Too complicated and too much paperwork and time-consuming.
- Mega-projects should have more elaborate planning documentation than smaller projects as the requirements are different.
- It is developed for engineers, but not by engineers.
- It is cluttered by marketing efforts added on by third parties.
- It measures irrelevant aspects but does not address the core business of the company, which is to ensure that the engineering aspects are correct.
- There is too much focus on risk management as the driving force, instead of excellence as a way of service delivery.
- Quality of designs is not being audited. Instead it is considered that if drawing standards are audited, then designs must be good.

Discussion:

From the 22 respondents, there were only 2, or 9%, who indicated that they were satisfied that the system does not have any limitations. The other 91% believe that the system is not fit for its purpose, lacks diversification for different departments, does not measure the important aspects of consulting engineering, is too complicated, or is creating too much paperwork. The most important aspect that was identified by one respondent is the fact that mega-projects should have their own specialized QMS requirements, which must be different from small or medium projects.

The above-mentioned opinion of the respondents is in agreement with that of Tricker (2010:85), which states that a QMS must be flexible enough to be applicable to any organization including manufacturers or service providers. In addition, Tricker calls for a simple structure for a QMS by implementing a Plan-Do-Check-Act process-based model. (refer to fig. 2.1), which is not the way the current QMS is experienced by respondents, who refer to “an over-complicated system with too much paper work”.

3.4.11 What suggestions do respondents have that will improve the QMS?

- The problem is not about the QMS itself, but rather the way it is used.

- It should provide design procedures in the form of standard philosophies and checklists against which young engineers can check that they are following good practice before spending too much time on design.
- It should focus on excellence as a way of life and in your work – the ISO requirements will follow automatically.
- It should develop standard procedures for each product, which should make the system more user-friendly.
- It should provide continuous training on relevant QMS aspects.
- It should update policies and procedures less frequently, and concentrate on relevant quality issues.
- During an internal audit, findings should be made known immediately, instead of surprising the person audited with a number of written findings one week later.
- It should simplify or summarize requirements and provide standard check-lists and pro-formas.

Discussion:

From the 22 respondents, there were only 4, or 18%, who had no suggestions for improving the system. There is a clear call for standardizing procedures and check-lists, for continuous training and for simplifying the system. More than 50% of respondents also believe that the system is not user-friendly.

3.5 Interview with the company Quality Manager

Further to the questionnaire, an in-depth interview was conducted on 27 August 2012 with the Quality Manager of PQR Consulting Engineers, in which the following was found:

- The frequency of internal and external audits of offices and departments in the company.
- The most common non-conformances found during audits, and whether the same non-conformances are recurring again and again.
- The attitude of managers and personnel towards the QMS.

- The cost and benefits of QMS.
- Proposed improvements to the QMS.

The questions to the company quality manager are attached as **Annexure 2.**

3.5.1 An analysis of the responses obtained from the company Quality Manager

3.5.1.1 The frequency of internal - and external audits on offices and departments in the company

The general rule is that the bigger offices in the company (between 80 and 200 employees) are audited at least twice a year and all other offices are audited at least once per calendar year. All departments in an office are audited. There are also separate drawing audits carried out 5 times a year, during which all drawings produced over a certain time are checked for correctness. Corporate activities like human resources are audited at least once every 3 years – the frequency is based on the audit findings of the previous audits. In all cases, additional audits may be scheduled if the results of the previous audits are poor.

3.5.1.2 The most common non-conformances found during audits, and whether the same non-conformances are recurring again and again

There are certain elements in the QMS in which employees tend to do better than others. Repeat findings are, however, linked to specific offices or specific departments in an office. There are repeated non-conformances of certain elements, but the Quality Manager was not prepared to elaborate on this aspect, as she felt uncomfortable that this information might become public domain.

3.5.1.3 The attitude of managers and personnel towards the QMS

The attitudes are not different between managers and subordinates. As a general rule, if a manager supports the QMS, then the subordinates will support and implement the QMS, and will become involved in improving it. This correlates well

with the reaction of the respondents, where it was found that a manager with a positive attitude towards QM has equally positive subordinates and vice versa.

3.5.1.4 The main benefits of the QMS are as follows:

- It helps in managing the operational risks of the company.
- It improves efficiency in the company as many operations are standardized.
- It can be useful as a training tool.
- As activities are carried out in the same way in all the offices where the company operates, the relocation of employees between offices is made easier as the systems in place are the same irrespective of the geographical location.
- It assists with winning tenders or being considered for tenders as many client bodies give a score for a certified QMS.
- Without a QMS, membership of Consulting Engineers South Africa (CESA) would not be possible.

These benefits are in agreement with the benefits of ISO 9001:2008, as was summarized in paragraph 2.6 of the literature study (Tricker, 2010:58).

3.5.1.5 The cost of QMS to the company

The total cost associated with the QMS is difficult to assess. The salary costs of the employees who are involved full time are known; however, the time spent by other employees on QM activities is not recorded as such.

3.5.1.6 Has client satisfaction improved since implementation of the QMS?

There is no means of determining a direct correlation between the implementation of a QMS and the level of client satisfaction. The only thing known to the quality manager in this regard is that client satisfaction does get monitored.

3.5.1.7 What is the QM's perception on Professional Indemnity (PI) claims and the influence of QMS on that?

Once again it is difficult to have a direct correlation between a QMS and PI claims. Many other factors may contribute to PI claims e.g. abnormally high workloads, tight deadlines, low profit margins and the unwillingness of client bodies to allow full-time supervision.

3.5.1.8 Proposed improvements to the QMS

The Quality Manager was not willing to answer this, as she does not wish for this information to be in the public domain.

3.6 The study of a collection of case studies on Professional Indemnity claims

Case studies on professional indemnity claims in South Africa were studied to determine the causes of these cases and the possible contribution of Quality Management or a lack thereof. A total of 20 cases were assessed. The following tables contain a summary of this study. In the last column it is indicated whether a QMS could have prevented the circumstances leading to the project difficulties.

Case 1	Project	Background	Problem	Lessons learnt	Could this situation have been prevented by a QMS?
Cracks in a surface bed floor laid on a sub-grade built by others	Concrete surface beds in the floor of a controlled atmosphere storage building	During construction of the surface bed floors, cracks were observed in the completed floors. The cracks had to be repaired to maintain the required air tightness of the building. Temporary repairs were made with an epoxy resin sealant set in a groove above each crack, while the cause of the crack was investigated by the consulting engineer and permanent remedial measures capable of withstanding fork lift truck traffic were determined.	The consulting engineer's commission included construction monitoring by means of periodic inspection visits to the site. After commencement of the concrete floors, the consulting engineer noted omission of a 50 mm compacted sand layer, to have been placed by the building contractor on top of the sub-grade, which had been prepared by others. An expert investigation concluded that the absence of the sand layer was the main cause of the cracking. The engineer was found partially responsible and his insurance had to pay part of the cost of reparation.	In supervising a construction contractor, it is important for the consulting engineer to get confirmation from the contractor at the outset, of his acceptance of the site handed over, including the setting out and levelling of any prepared formations, foundations, and similar works constructed by others.	Probably not, especially by an inexperienced resident engineer, but if a well-experienced resident engineer was on site, he would have known that levels must be checked before any additional work is carried out.

Case 2	Project	Background	Problem	Lessons learnt	Could this situation have been prevented by a QMS?
Power line erected in incorrect position.	A 1.25 km long Medium Voltage (220 000 volts) supplying power to a township.	A consulting engineer was appointed by a municipality to upgrade its electrical infrastructure in an existing township. The new power line followed an existing road to the township, which was flanked by a Telkom line on the other side of the road. At design stage the new line was placed on the opposite side but during construction the resident engineer decided to move the electrical line to be on the same side as the Telkom line, as a result of obstructions on the other side.	As soon as the line was constructed, Telkom objected that the line was too close to their line and caused interference with its operation.	It is common practice in agreements between consulting engineers and their clients that the consulting engineer shall undertake the necessary liaison with relevant authorities and bodies who have the power of sanction , and this includes the obtaining the required approval of plans or proposals pertinent to the project, in terms of procedures laid down by the authority concerned.	No, this was a decision taken by the resident engineer. QMS would not have made any difference.

Case 3	Project	Background	Problem	Lessons learnt	Could this situation have been prevented by a QMS?
Correction of road levels at tie in.	Extension of roads at a major transport interchange, done by consulting engineers in joint venture.	A firm of consulting engineers was appointed by a public sector client to undertake the design and construction monitoring of extensions to the road system of a major transport interchange. A condition of the appointment was that the consulting engineer should form a joint venture with an emerging consultant, who should undertake at least 50% of the work.	When the construction of the work was well advanced, it was discovered that the tie-in levels between two of the contracts differed drastically from each other, by approximately 1.5m. (The two sections were designed by the different partners in the JV). Work was immediately halted, the affected portions were redesigned by the JV partners and remedial works were carried out by the contractor. The client held the JV responsible for the extra costs involved.	The duties of the lead firm in a joint venture should not be underestimated. This includes coordination of designs and drawings done by the JV firms for their portions of the work. It requires a proactive approach by the lead firm in the issue of information, and the checking of information received, for correctness.	Yes. The fact that a second party was involved made it more difficult. If the lead consultant and his JV partner had both applied their QMS, as a result of a clause in the JV agreement calling for the application of QMS, the level difference situation could have been picked up by one of the partners.

Case 4	Project	Background	Problem	Lessons learnt	Could this

					situation have been prevented by a QMS?
Foundations in a compacted fill material.	Foundations and superstructure for a residence erected on compacted fill.	A double-storey residence situated on a golf course estate where earthworks and terracing had been carried out prior to house construction. The residence was situated on a compacted fill 2-3m deep which was carried out before by others.	The consulting engineer noticed that the fill on an adjacent site was removed and replaced, when his construction was already at eaves level. He decided to do tests on the fill that he was building onto, and took some precautionary steps by underpinning part of the house after development of cracks on the patio perimeter due to differential settlement.	Where a building is to be founded on an area of previously compacted fill, the effectiveness of the compaction under the foot print of the building should not be taken for granted. A visual inspection of trial holes or test pits should be supported by a probe such as the Dynamic Cone Penetrometer, to confirm consistency of the compaction and indicate any area of weakness, prior to finalising the designs of the foundations.	No. This situation could only have been prevented if the tests to the fill had been carried out before that start of construction. An experienced consulting would know that no fill for which compaction results are not available can be trusted to build on.

Case 5	Project	Background	Problem	Lessons learnt	Could this situation have been prevented by a QMS?
Laying of storm water pipes in a dolomitic area.	A storm water drainage system for a new residential township.	A consulting engineer accepted an appointment from a Township Developer for the design and monitoring of construction of a piped storm water drainage system to serve a proposed new residential township in a dolomitic area. The consulting engineer specified by mistake the use of concrete storm water pipes with interlocking joints, instead of the Spigot-and-socket type storm water pipe joints, which are usually associated with dolomitic areas. These pipes were ordered by the Contractor before the municipality approved the drawings. The pipes were delivered to the site before the mistake was realised	Dolomitic areas are well-known for their potential subsurface instability under varying ground water conditions. The fact that these pipes were incorrectly delivered to site meant that they had to be returned and new pipes delivered. A claim of R 1.4m was instituted by the client against the consulting engineer.	It is essential that the design of engineering works takes the underlying geotechnical condition into account and that specifications and details appropriate to such conditions are used. Notwithstanding any pressure from a client to meet target dates, if the consulting engineer proceeds before any relevant geotechnical or environmental information becomes available, he does so at his own risk, which can have implications if the design must then be changed.	Yes, but only if the design and contract documentation were checked by an experienced engineer as prescribed by the QMS. If the person responsible for the design check had no experience of dolomitic conditions, the QMS would not have made any difference.

Case 6	Project	Background	Problem	Lessons learnt	Could this situation have been prevented by a QMS?
Design fault in a Joint Venture turnkey contract.	Design and construct contract in an irrigation scheme project.	A large agricultural undertaking appointed a consulting engineer and contractor in a joint venture on a large irrigation scheme. A performance specification was introduced to the project according to which a stated quantity of water was to be delivered to particular positions. However, on completion it was found that the actual quantity delivered was as much as 20% less than the specified quantity.	The consulting engineer admitted that his design was at fault. The rectification measures adopted by him comprised repositioning of the filters downstream of the booster pump and the installation of additional booster pump capacity.	While it is appropriate for a conceptual design by a consulting engineer to be undertaken by an experienced principle, it is essential for the detail design to be subjected to scrutiny, to ensure that the intent of the conceptual design is maintained, and that the finished product of the design complies with all requirements. This applies particularly in cases of designing to a performance specification.	Yes, it is clear that if this design which was carried out by an experienced engineer was not scrutinized by someone else. This case seems as if the mistake could have been identified quite easily which would have prevented the difficulty only if a QMS was applied.

Case 7	Project	Background	Problem	Lessons learnt	Could this situation have been prevented by a QMS?
Over-payment to a joint venture contractor.	Supply and installation of fittings in a petroleum industry project.	Civil and structural work comprising steel storage tanks, pipe work and fittings, was undertaken by a consulting engineer for the owner of a petroleum supply company. In preparing the final account, the consulting engineer discovered that an over-payment was made to the contractor to an amount of R 730 000. The contractor was liquidated at this same time. The client subsequently claimed this amount from the consulting engineer.	It was clear that the repeated payment of material on site was a mistake on the part of the resident engineer employed by the consultant. The client claimed the amount form the consultant on the basis that the consultant had not acted with due skill, care and diligence Faced with this the consulting engineer admitted he had acted incorrectly and advised his insurer accordingly.	A consulting engineer whose appointment includes certification of payment certificates, should always ensure that prior to preparation of a final account or final certificate, a comprehensive audit is carried out on all previous payments certified to ensure that no overpayments have been made. If there had been over-payments, it can generally be recovered before the final payment is certified.	It is doubtful that a QMS would made a difference in this instance. Normal payment certificate approval procedures call for the signature of the resident engineer as well as the Engineer, before any of the QMS requirements are applied. Not even the basic contract administration procedures were followed here, making it doubtful if they would have adhered to the QMS.

Case 8	Project	Background	Problem	Lessons learnt	Could this situation have been prevented by a QMS?
Defective design at anchorage ends of post-tensioned concrete beams.	Post-tensioned in-situ concrete beams in an industrial materials handling project.	A consulting engineer was commissioned to design and make drawings for precast beams At tender stage the consulting engineer prepared a preliminary design for pricing by a contractor. After casting of the beams at ground level, stressing commenced when the required concrete strength was reached. During stressing, cracks were observed at the live anchors and at least one anchor pulled into the concrete. After extensive investigation it was concluded that the design was deficient although this was aggravated by certain shortcomings in workmanship and concrete quality.	The root cause of the design deficiency lay in too low a concrete strength specified, inadequate provision of bursting steel, insufficient dimensions of reinforcement on drawings, omission of aggregate size in the specification. The remedial measures comprised breaking away the concrete in the cracked anchorage zones and reinstatement with strengthened spiral bars, added bar reinforcement accurate dimensions for fixing reinforcement, higher strength concrete and small size aggregate.	Where a specialist design involves construction techniques of a higher standard than those normally to be expected, the designer should take extra precautions in the provision of his specification and construction drawings and indicate clearly the standards of workmanship, setting out and materials required in order to ensure the integrity of his design.	Yes, it is clear that if this design which was carried out by an experienced engineer was not scrutinized by someone else. This case seems as if the mistake could have been identified quite easily which would have prevented the difficulty only if a QMS was applied.

Case 9	Project	Background	Problem	Lessons learnt	Could this situation have been prevented by a QMS?
Inadequate design of a concrete slab.	A reinforced concrete slab installed in an existing building as a mezzanine floor.	A consulting engineer undertook the design of a concrete slab for a mezzanine floor in a building used for religious education. After the concrete supports had been stripped, severe cracking of the soffit of the slab occurred. Investigation showed that the slab had been under-designed. The only remedy was to demolish the slab and replace it with a new one.	The consulting engineer's office was very busy at the time of the slab design and the work was assigned to a B Tech technologist working under supervision of a principal. Although it was specified for props to be stripped after 21 days, stripping started after 17 days. It also transpired that the slab design was based on incorrect assumptions.	In the design of large slab areas, it must always be remembered that the loads applied must be transferred to the supports, which was an oversight here. Notwithstanding pressures of work in a practice, the need for designs by a person working under supervision to be checked for structural integrity remains paramount.	Yes, this design was carried out by a person not qualified and his principal should have paid more attention to Quality Management. This situation could have prevented if QMS principles had bee- applied.

Case 10	Project	Background	Problem	Lessons learnt	Could this situation have been prevented by a QMS?
Failed connection between a column and a pre-stressed concrete slab.	Low rise multi-storey building constructed with reinforced concrete columns and pre stressed post tensioned concrete floor slabs.	A client appointed a consulting engineer for the design of this building consisting of pre-stressed floor slabs. After casting of the floor slabs and removal of formwork, cracks were observed in the top and slab soffit adjacent to certain columns, being most severe at the corners of large openings in the floor. Investigation into the cause of the cracking was done in order to determine the most appropriate remedial measures which were then implemented.	Preliminary investigations showed inadequate resistance to shear forces. Furthermore the slab was unable to withstand the tensile stresses in the area concerned due to a combination of shear and torsion. .	Where a design includes an element which is especially complex or unusual, the designer should take extra precautions or develop special design techniques to ensure the integrity of his design, even if this justifies additional fee compensation in order to meet his obligation to exercise the requisite duty of care towards his client.	Yes, although technically challenging, another expert engineer should have checked this design.

Case 11	Project	Background	Problem	Lessons learnt	Could this situation have been prevented by a QMS?
Defective design of concrete floor slabs and staircases, with remedial work by others.	Upgrading of public areas in a commuter transport facility, involving new structural concrete floors and staircases, with remedial work by others.	At conclusion of this contract the contractor claimed that he had been underpaid by amount of R 585 000. The Employer (who has appointed a consulting engineer) responded that payment had been withheld because certain floor slabs and staircases in the building were showing severe deflections and had accordingly not been accepted until repairs were done. The consulting engineer admitted that his design was defective, but queried the extent of the remedial works which had not been carried out under his supervision. The consulting engineer had also through an oversight not notified his insurers of a potential claim at the time of P.I policy renewal.	The engineer designed a system of precast concrete slabs 120 mm thick, with a 30mm structural screed topping placed on the slabs. The topping was envisaged to compositely link with the precast slabs. Shear links between the precast slabs and topping were intended but these were omitted through an oversight. The structural topping delaminated as a result of a differential in curing between the precast and in situ concrete. The cost of the remedial works amounted to R 378 000.	Omission of shear connectors in the floor slab constituted a clear design error. In any form of composite construction, it is essential that shear connectors between the 2 elements of the construction be provided. In this case study, it is conceivable that the omission of connectors would have been noticed on site by the engineer at the outset of the construction, which would have significantly mitigated the impact of the omission.	If a design check had been carried out by an experienced engineer, it is likely that he would have noticed the insufficient connection between concrete and screed. A QMS applied properly would have made a difference.

Case 12	Project	Background	Problem	Lessons learnt	Could this situation have been prevented by a QMS?
Ongoing deflections in a reinforced concrete office block structure.	A suburban office block complex, comprising two wings with central lobby, over a full basement parking area.	Shortly after completion of construction of the building, deflections were noted in certain suspended ground floor slabs and in cantilever slabs of one office wing. The consulting engineer investigated the cracking caused by the deflections and prepared a detailed report with recommendations for repairs. Remedial work was carried out at no cost to the client, however, cracking persisted and the owner commissioned another consulting engineer to investigate the position. The owner then informed the engineer that he had obtained a quotation for repairs and the engineer advised his insurers of a possible claim. Although the structure was considered safe and adequately reinforced, the consulting engineer accepted liability.	The various investigations done by the consulting engineer and the insurers' assessor were in general agreement that the cause of the cracking was due to excessive deflection in the building structure. This was a s a result of overloading of the slabs with extra heavy partitions, which exceeded the load for which the slab was designed.	In the design of floor areas, the designer needs to ensure an appropriate loading for partitions is adopted. This should be done in collaboration with the architect and the owner. Drawings for floor areas should indicate clearly the loading for which the floor has been designed, including the partition loading. Also, the application of superimposed dead loading should be delayed as long as possible, for the structure to gain sufficient strength.	Probably not, as the loading of the partitions was not known at the time of the briefing and the agreement with the consulting engineer.

Case 13	Project	Background	Problem	Lessons learnt	Could this situation have been prevented by a QMS?
Under-design of structural elements in a building, in exceptional circumstances.	Reinforced concrete framed double-storey office blocks with basement.	This building comprised four double-storey blocks, one of which contained a basement. When all the drawings were ready for plotting and making up of backups to a remote server the next day, the engineer's computer was stolen and all data was lost. The engineer had to introduce a fast-track redesign and drawing programme so as not to delay work on site. The redesign was completed timeously after a period of intensive work and the construction proceeded as planned. When the building was approaching completion, cracking was observed in a number of 8m span beams. The client appointed an independent consulting engineer to investigate and report on the cracking. It was found that some of the beams had been under-designed and were under-reinforced. Remedial measures were recommended and implemented amounting to R 380 000.	The root cause of the problem can be ascribed to the theft of the consulting engineer's computer and loss of data, causing a frantic programme of redesign and drawing to be instituted. The consulting engineer was not a large firm and a small team led by the consulting engineer regularly spent 100 hours per week on the job, to maintain the building programme. In such conditions the risk of work containing defects or omissions and risks of inadequate checking, can be very high.	The need for the computer-based work of the consulting engineer to be regularly and consistently backed up cannot be over-emphasised. The likelihood of losing all data on the eve of producing documents or drawings from that data may seem remote, but the event showed that this is entirely within the bounds of possibility, and a weekly or monthly backup may not be enough.	Theoretically yes, but in practice, no time would have been set aside for QMS, therefore QMS would not have made any difference whatsoever.

Case 14	Project	Background	Problem	Lessons learnt	Could this situation have been prevented by a QMS?
Cracking due to hoop tension in wall of a circular reinforced concrete tank.	A ground reinforced concrete reservoir structure to contain effluent within a treatment works.	One of the structures of a sewer treatment works was a circular roofed tank, set into the ground to store effluent. On filling the tank, vertical cracks appeared in the tank wall around its circumference. These widened as the tank was filled to capacity and allowed liquid to leak through the wall. Investigation showed that hoop tension in the wall had been insufficiently reinforced for. It was found to be a design error on the part of the consulting engineer. The wall was repaired by the installation of post-tensioned tendons fixed around the outside of the wall, covered with a granite layer. The consulting engineer's insurers met the cost of repair and reinstatement of the tank, amounting to R 870 000.	Cracking occurred while the tank was being filled. The tank was emptied and the cracking was investigated. It was found that the horizontal reinforcement provided was insufficient. Due to its circular nature, the tank generates significant hoop tensions, which need to be resisted by a high percentage of reinforcement, working at reduced stresses to minimise tension cracking and width of cracks in the concrete. The investigation found that for the design of the wall, a computer programme which was intended for linear retaining walls, not circular walls, had been used. i.e the programme did not take hoop tension into account..	In the design of a structure, it is vital that the choice of appropriate computer software to be used for the design be selected by a competent experienced person. When computer programmes are used for design, there is a tendency to simply accept the results as presented by the programme. Incorrect input gives incorrect output. This risk can be minimised by a rough parallel manual calculation, which although approximate, will give a result in order of magnitude.	Yes, although technically challenging, another expert engineer should have checked this design. In practice however, the use of a QMS would probably not have prevented these events.
Case 15	Project	Background	Problem	Lessons learnt	Could this

					situation have been prevented by a QMS?
Failed propped cantilever retaining wall.	A 5m high, 100m long reinforced retaining wall, facing an open parking area.	This retaining wall was part of a shopping centre complex and was along one side of the parking area, to be constructed in reinforced concrete. The wall was designed as a propped cantilever, utilising a slab at the top of the wall. During construction, the building was changed and the slab was omitted. The concrete layouts were changed but not the reinforcing drawings. As a result of the omission, the wall now functioned as an unrestrained vertical cantilever and deflected excessively when fill was placed behind the wall. To avoid further movement of the wall, the fill behind was removed to a depth of 2m below the top of the wall, while remedial measures were designed by others. The owner held the consulting engineer responsible for the cost of remedial work.	The problem arose simply from the engineer's omission to change the reinforcing details of the walls when the design changed from a propped to a full cantilever structure. In this condition the stresses at the foot of the wall were approximately 3 times the allowable design stresses, and severe deflections resulted.	The application of design checking procedures in a consulting engineer's office should not be confined to the original design, but applied throughout the design process – especially in case of changes to a structure's configuration. When layouts or dimensions are changed, it is essential to check the continued integrity of the structure.	No, it is unlikely that design checks are carried out more than once on the same project. Usually if a design audit is carried out, it is not done a second or third time, like it should be.

Case 16	Project	Background	Problem	Lessons learnt	Could this situation have been prevented by a QMS?
Construction of township roads in an incorrect position.	Construction of roads in a new residential township and need for partial realignment arising from incorrect setting out information.	A developer compiled a professional team for the planning, design, setting out and construction of roads and associated services in a new residential township. The town planners provided the consulting engineer with a roads layout plan, and steel pegs marking the stand boundaries were placed by the land surveyor. During this process the developer elected to alter the layout of certain stands to enhance their marketability. A new set of pegs was installed by the land surveyor and the amended survey plans were given to the engineer. The changes to the alignments of the roads were not realised by the engineer. Some of the roads had subsequently been halfway constructed in the wrong position	The problem was in the transmittal of information between members of the professional team. The altered and approved survey plans were sent to the engineer by the land surveyor without specific reference that the earlier layout had been changed. The surveyor installed a new set of pegs after the changes, but did not remove the incorrect pegs. Road construction proceeded in accordance with the coordinates of the original alignment. .	The negligence of a consulting engineer, in not exercising a duty of care can extend beyond normal design and supervision, into the transmittal and receipt of information. Incoming information in the firm needs to be checked carefully for the impact of changes affecting the engineer's design. This is notwithstanding the fact that the revision have not all been clearly shown, or that the sender or his covering note did not draw attention to the changes.	It is unlikely that this matter would have been avoided by a QMS. A new drawing issue is usually accompanied by an issue slip and the extent of changes should be indicated on the drawings itself. It still remains doubtful whether a QMS will identify changes, and act positively thereupon every time, as was in this case study.

Case 17	Project	Background	Problem	Lessons learnt	Could this situation have been prevented by a QMS?
Design shortcomings and omissions at the interface between civil structures and mechanical plant.	The construction of civil structures to accommodate mechanical plant at a mining operation..	The civil works comprised retaining walls, a receiving bin and plant support structures. After construction it was found that the specified rate of material flow through the conveyor system could not be achieved as a result of inadequate capacity design by the consulting engineer. The consulting engineer accepted responsibility for this, accepting there were deficiencies in his design.	After commissioning it was found that material was spilling over from the conveyors onto the works below, causing damage to the plant. This tended to block the passage of materials from behind and it also affected the operation of machines, reducing its capacity as a result. As remedial measures, modifications were made to the conveyor framework and chutes to avoid spillages. Further measures included containment of rock spillage and reduction of the discharge height onto the conveyor. Investigations into the problem concluded that there had been both shortcomings and omissions in the civil design and detailing.	Errors in design, which constitute a lack of the duty of care, can occur in at least two ways, i.e. shortcomings, where the design is deficient, and omissions, where the design is incomplete. Either of these can occur more than once in the same overall design. A combination of the above can create extreme difficulties for the consulting engineer especially in a civil/mechanical interface and special duty of care is required in such circumstances.	If the QMS calls for design interface testing between the civil – and mechanical works, and liaison is done between the two disciplines during the entire design phase, this situation can be avoided by the use of the QMS.

Case 18	Project	Background	Problem	Lessons learnt	Could this situation have been prevented by a QMS?
Runoff cover to the rescue of a retired consulting engineer.	House foundations constructed on a sloping site giving rise to movement, causing cracking in the superstructure.	While still in practice, a consulting engineer undertook the design of foundations for the front portion of a house, built on a sloping site. Within a year after construction, cracks throughout the house became evident. The owner held the engineer responsible for the cost of repair and reinstatement, arising from alleged inadequacy of the foundations. An expert appointed by insurers concluded that movement of the foundation was caused mainly by the builder using a strip footing and buried brick walls. Experts appointed by the owner and insurers differed in their opinions as to the nature of the foundation movements and causes of the cracking. The engineer's appointment was for the front foundation only and was made verbally.	The builder's action was taken without the engineer's knowledge who did not make a further inspection and assumed his instruction had been complied with. Although experts differed in opinion, it was generally accepted that forward movement of the buried walls was a major contributor to the cracking. The owner held that the engineer was responsible for all the foundations as constructed, that he was obliged to inspect work during construction and that he was at fault in allowing material deviation from plans.	A consulting engineer should always record his appointment in writing, including the scope and obligations to the appointment. Where the scope of the appointment includes design of foundations, the consulting engineer must be competent to evaluate the subsurface strata and adopt an appropriate solution, or appoint an competent experienced geotechnical practitioner if he is not qualified himself.	This is a clear case where a QMS would have ensured proper documentation of the engineer's appointment, as well as his rights and obligations. If proper site procedures had been imposed on the builder, he would only have reacted on written instructions from the engineer and would not have acted without the engineer's knowledge.

Case 19	Project	Background	Problem	Lessons learnt	Could this situation have been prevented by a QMS?
Claim in delict, arising from deficiencies in design and construction.	The foundations and internal floor and roof structures in a large new residential dwelling.	A building contracted with a private owner to construct a new home for the owner in a housing estate. Included in the arrangement was provision by the builder of architectural and engineering services as part of his contract and for this purpose an architect and engineer were retained. When construction had been completed and the house occupied, a number of defects manifested itself and the owner claimed damages from the builder for the cost of repairs. The consulting engineer's Professional Indemnity insurance policy provided for the insurer to bear the costs of defending a claim against the insured, and attorneys were appointed for this purpose. A long series of legal arguments and court actions ensued, lasting for more than four years.	The consulting engineer was commissioned to design the foundations, reinforced concrete floor slabs and staircases and to monitor their construction to ensure compliance with his design. To assess the extent of alleged deficient design, an expert structural engineer and an expert geotechnical engineer were engaged. The structural engineer considered all aspects of the building and found a number of shortcomings in the design, applying to timber rafters, floors and trusses and two brickwork arches showing signs of distress (these were not designed by the engineer in question).	In house construction on variable foundation strata there is typically a risk of differential settlement of the foundations, which can give rise to visible cracking in the rigid brickwork and masonry above, particularly if insufficient movement joints are provided. Where such variable strata are encountered, it is vital to design foundations which will settle evenly on the different strata, and in the case of a compacted fill as founding stratum, extreme care is needed	Yes, but only if the entire design had been audited by a competent engineer with adequate experience on foundations.

				to ensure compaction.	
Case 20	Project	Background	Problem	Lessons learnt	Could this situation have been prevented by a QMS?
Failure of a dam lining, under a limited liability.	The lining, applied in situ, in an earth dam constructed as an effluent retention pond, in an industrial undertaking.	A company in the food processing industry commissioned a consulting engineer to undertake the civil engineering design and construction supervision for extensions to the effluent disposal system at one of its factories. The works comprised a number of earth dams, forming large ponds, each lined with a proprietary lining compound. During commission of the works, problems of detachment of the linings arose on two occasions, from different events. The consulting engineer's agreement with his client limited his liability to twice his professional fees but decisions had to be made as to the causes of the failure. The matter was aggravated by the need for repairs to be done before the next operating season of the factory. Eventually the matter was settled with insurers bearing the cost of the remedial works, which was below the consulting engineer's limit of liability to his client.	After had been effluent disposal system was put into use, the first event indicating a fault was the discovery of portions of the liner floating on the water surface. The cause was attributed to faulty installation of aerators in the earth dam. The consulting engineer instructed the process designers to re-detail the aerator outlets and their contractor to effect repairs. The second event occurred some 4 months later when it was noted that in some areas the liner had ballooned and was standing proud of the water surface. It was concluded that the liner was not 100% watertight, and that the in situ subsurface material was of low permeability, allowing the accumulation of effluent material beneath the liner.	Where a consulting engineer's design places absolute reliance on the stated properties of a specialist material, as was the case here, he should verify these properties as far as possible, to avoid the risk of failure in the works, due to any deviation from the properties stated.	No, as this problem occurred mainly due to a misrepresentation of a supplier, it is unlikely that a QMS would have made any difference.

3.7 An analysis of the PI claim case studies

The question in the last column of the summary of the PI claim case studies is: Could this situation have been prevented by a QMS? From these cases, it is the opinion of the author that in 8 out of the 20 cases, a QMS could have prevented the difficulties of the project which is 40 % of the cases. The question is then asked why this percentage is not higher than 40%, if a QMS appears to solve all project difficulties before they occur. The answer lies in the qualifications which apply to this statement – the project difficulties could have been prevented by the QMS, only in the following circumstances:

- If the design was internally audited by a colleague.
- If the auditor is a specialist in this field, with knowledge and experience in this field, at least equal to that of the designer.
- If the site monitoring during construction was carried out in accordance with the QMS – i.e. the construction was exactly in accordance with the design.
- If all project documentation was in order and up to date.

In each of the case studies, which seemed could have been prevented if only QMS was applied, one or more of the above-mentioned aspects were absent due to personnel negligence or incompetence. Therefore, even if a QMS had been in force, the difficulties had arisen due to non-compliance of the system by workers on the project.

This is in agreement with the literature study where it was stated by Pitout that an organization can comply with the ISO standard, have a QMS in place, and achieve ISO 9001 accreditation, but still produce and deliver a poor quality service (Pitout, 2007:32).

Out of the 20 cases, there were 9 cases where it is considered that a QMS would not have made a difference to prevent the difficulties, or where the answer was that a QMS would “probably not” have made a difference. This represents 45% of the cases, and can be attributed to the following factors:

- inexperienced personnel
- incorrect decisions taken by site personnel
- an overextended design work force in times of abnormally high work-loads, tight deadlines and low profit margins
- the unwillingness of client bodies to allow full time supervision

There were 3 cases, or 15%, where the answer was “maybe”, and where a QMS could have made a difference under certain conditions, including:

- the design auditor is sufficiently experienced to identify specific technical difficulties.
- the site personnel are sufficiently qualified and experienced.

3.8 Chapter conclusion

This chapter explained the research methods that were adopted to identify difficulties with a QMS in a civil engineering consultancy company. The qualitative questionnaires were aimed at sourcing information from QMS users to assess the effectiveness of the system in order to identify aspects which can be improved upon. The interview with the quality manager of the company served to indicate what difficulties are experienced by the quality department with users of the system. The final part of the empirical study was the case studies of difficult civil engineering projects, where specific short comings were identified which can be addressed in the QMS in future to prevent recurrence of similar cases.

In chapter 4, conclusions will be made on the findings of this chapter and recommendations for an improved QMS will be identified.

CHAPTER 4: CONCLUSIONS AND RECOMMENDATIONS

4.1 Introduction

This chapter deals with the benefits of a QMS, the effect a QMS can have on the frequency on Professional Indemnity (PI) claims and the conclusions that can be drawn from the case studies of chapter 3. In addition, recommendations are made on improving the QMS and final conclusions are drawn from the study.

4.2 The benefits of a QMS

- QMS is a system which documents current practice, ensures that everybody does what he is supposed to do, and lifts the standard over a period of time.
- It is a tool for managers to rapidly assess whether the right procedures are followed, or had been followed in case of project difficulties.
- It is a valuable source of information for a new employee who needs to know how the company operates and therefore a handy training tool. In a time of expansion of the company (new employees and new managers), it should be a valuable asset to maintain the company standards.
- Moving between offices in a company is made much easier as the QMS standard procedures are the same everywhere in the company.

4.3 The effect of a QMS on Professional Indemnity Claims

Has the implementation of a QMS in PQR Consulting Engineers, and the subsequent ISO 9001 certification, made any difference to the frequency and the nature of Professional Indemnity claims against the company ?

It is expected that the answer to this question should be a definite “yes”, but the reality is that the answer is in fact “not really”. There are, however, a few reasons why an analysis of this question is rather difficult:

- The introduction of the QMS and the ISO certification was done over a time period of almost three years, and it is therefore difficult to assess whether a claim was made before or after the introduction.
- A PI claim is usually made as a result of a number of factors, and is quite complex.
- Claims are often not made directly after the error was made, but can take several years after occurrence for the claim to be tabled.
- Work pressure often causes workers to make mistakes, which lead to PI claims – one can conclude that work pressure is also the reason for not adhering to QMS requirements.
- Although a QMS provides for checking of designs, it cannot always detect design errors, which are usually the reasons for a PI claim.

Professional Indemnity Insurers hold that the largest claims that they have handled in recent years have arisen from firms with heavily advertised and externally audited quality management services and procedures.

So why does this happen? The problem, at least in part, would appear to be the fact that very often quality management procedures are only instigated once the fee and services have been agreed, the contract awarded and the project entered into a company's financial control system. Business development activities, or speculative work carried out "on risk" are infrequently catered for by QMS (Glenrand MIB, 2009:83).

In the case of speculative work – and therefore no fee – quality management may not be applied to the services rendered. The early information provided to contractors under design and build arrangements to support tenders is frequently provided on a speculative basis. In these particular circumstances it is often the early stage advice that brings with it the greatest potential liability, without the benefit of quality management and in return for little or no fee – far from the perfect combination.

Similar problems can occur when consultants are working to a client's brief that is inadequately defined in terms of its scope. By the time that the project definitions are agreed, unchallenged assumptions may have been incorporated into the design,

which are then carried forward into the detail. It is important, therefore, that quality procedures also apply to advice provided to help clients to develop their brief. If they do not, there is a real risk that the design developed from an inadequate brief will in itself, prove to have been inadequate.

Shying away from challenging assumptions can have very significant consequences. Consultants should not hesitate to question assumptions and formally record any reservations. This is particularly relevant when there is a temptation to avoid openly challenging clients' assumptions as a mechanism to win work.

4.4 What conclusions can be drawn from the case studies on PI claims?

The case studies as summarized in chapter 3 show that the cases can be divided into four distinctive groups as follows:

- Cases where a design oversight was not discovered until it was too late, and which could have been prevented if only a design check had been carried out. A QMS would definitely have made a difference in the outcome of these cases, if it had been applied properly – refer to cases 6, 8, 9, 10, 18 & 19.
- Cases where a design check was conducted, but that the responsible person was not experienced enough. The QMS was therefore applied but not strictly in accordance with requirements, and would therefore have made no difference to the outcome of the case – refer to cases14 & 19.
- Cases where difficulties occurred during construction, and where proper site control as prescribed by the QMS would have made a difference, if only they had been applied and documented – refer to cases 3, 5 & 11.
- Cases where the correct application of QMS would not have made a difference to the difficulties experienced – refer to cases 1, 2, 4, 7, 12, 13, 15, 16 & 20.

4.5 Recommendations: What improvements of the company's QMS can be proposed?

As one of the eight quality principles of ISO 9001 is continuous improvement, the challenge remains for the company to assess in what way the existing QMS can be improved to ascertain progress and to refine the system such that the functioning thereof keeps on improving. The following aspects were identified (Piallat, 2012):

- There is currently no provision made for the review of structural design – it is proposed that a compulsory design report be introduced, which must be countersigned by a co-author who will be responsible for the review. It is important that a design review should not only be a checklist, but that all design elements be addressed in this report, in order for the designer to have confidence that the design is correct.
- The QMS is furthermore not well-suited for structural site supervision – it is believed that the pro forma for structural inspections can be improved to not only assist construction supervisors in increasing the effectiveness of the inspections, but also to improve the associated documentation.
- Drawings must be countersigned by someone who has checked all aspects of the drawing.
- There must be a continuous move away from the day-to-day administrative non-conformances towards the management of risks for the company.
- Whereas the company performs environmental projects and assessments, they should consider seeking certification for ISO 14 001, which is the standard for the environment.
- The company must consider improving the QMS regarding Information Technology (IT), especially on business continuity and knowledge management.
- Employees must undergo a certain amount of training in the QMS and must especially be made aware that the system requires low maintenance once it is properly implemented and adhered to.
- Internal auditors must realize that so-called petty findings, or insignificant issues of compliance frustrate engineers and have a negative impact on their attitude towards the QMS. These findings should be avoided, and

more emphasis be placed on matter that really present a risk to the company.

- There must be flexibility in client satisfaction surveys and each client must be treated in accordance with his preferences. Some clients would prefer a phone call, rather than completing a questionnaire, and the QMS must make provision for different approaches.
- Consideration should be given to applying the QMS partially to smaller projects and not expect the same effort as is done for large projects. This will ensure that small projects can be completed at a higher profit percentage as there is a reduced amount of time spent on QMS-related matters. It is very difficult to maintain the entire system on a small project budget.
- Mega-projects in turn have other distinctive requirements, which are not applicable to medium and small projects. There should be a distinction made to apply QMS procedures differently to accommodate these projects in a special way.

4.6 Have the study objectives been reached?

The primary objective of the study was to evaluate the effectiveness of the QMS of PQR Consulting Engineers. This objective has been achieved as it was determined that the system is only partially effective and that there is ample room for improvement. The responses received from 22 senior personnel members on their experience of the QMS were instrumental in determining to what extent it is effective and how the system is perceived by personnel on a junior and senior level. The understanding of respondents of the system and the attitude of personnel provided a good indication of the functionality, as is reflected in the conclusions.

- Secondary objectives were to determine whether personnel have changed their modus operandi in fulfilling their duties and whether client satisfaction had increased since the introduction of the QMS. Although the responses were clear and concise, the opinions of respondents differ on these matters and indicated that duties are generally executed in the same manner as before and that client satisfaction had generally not improved since the

introduction of the QMS. This objective was partially reached – further investigation regarding these aspects of the study can be done.

- A further secondary objective was to determine whether the QMS can act as a training tool and what recommendations can be made to improve the system. An overwhelming 82% of respondents were of the opinion that it can act as a training tool. Furthermore there were numerous valid suggestions on how the system can be improved as contained in paragraph 4.4. These objectives were therefore reached successfully.
- The last secondary objective was to determine whether a QMS can prevent Professional Indemnity cases. The answer to this question was “not really”. It is the opinion of the author that this objective was only partially reached and that more research can be carried out in this regard. Due to a lack of information and unwillingness of companies to share project difficulties, this topic has potential for further research.

In summary, it is believed that the objectives of the study were achieved, some more than others. It furthermore indicated that there is ample opportunity for improvement to the Quality Management System of the company. The recommendations for improvement can serve as a guideline for the company when considering improvements to the system.

4.7 Final conclusion

A Quality Management System (QMS) in the consulting engineering industry is only as good as the people who use it and can only be effective if used strictly in accordance with the requirements, without any exception and without taking any shortcuts. If the conditions of a QMS are adhered to, it can prove to be a valuable tool in reducing the risks of a company and to ensure customer satisfaction and therefore a competitive edge in the market for the consulting engineer. It must be added that there are more and less important aspects of a QMS – more important where there is an actual risk involved for the company, and less important which are more cosmetic and not presenting a risk. Quality Managers must ensure that more emphasis is placed on real risks and that cosmetic requirements are neglected, as engineers who are responsible for upholding the QMS are more effective workers if they are not confronted by unnecessary and unimportant issues. The study

indicates that respondents understand the need for quality in consulting engineering and the requirements and the benefits of the system. While some see the QMS as a burden producing too much paper work, a system that addresses the less important matters and omitting the more important, most are positive about the QMS and believe in its benefits.

The introduction of a QMS does not mean that the Professional Indemnity claims against that company will be reduced or disappear overnight. There are too many factors that play a role and that can influence the successful execution of a project, or that may cause difficulties during the course of that project. The most important is to create a positive attitude amongst personnel to apply the principles of the QMS in a spontaneous manner, without having to enforce it. This means that managers and employees must buy into the system, believe in it and make it their own. The Quality department in turn must ensure that engineers are not subject to petty non-conformances, which are unimportant issues like the correct use of a font or a company logo, but that emphasis is placed on mitigating matters that can really create a risk for the company.

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ANNEXURE 1

QUALITATIVE QUESTIONNAIRE

Guidelines for completing this questionnaire:

- **Thank you very much for taking time to help me with this questionnaire. I appreciate your effort and will share my results with you after completion.**
- **This is a qualitative questionnaire which is distributed to only a few of my friends and colleagues, all of whom are in management positions in their companies.**
- **This is not a multiple choice questionnaire – I need to know what your opinion is on QMS, and how you perceive the system which you are using, or considering. I will therefore appreciate detailed answers.**
- **Please give your honest and considered opinion according to your experience – not what you think the answer should be.**
- **Please try to explain your answers where possible.**
- **Please do not Google the answers – I am interested in your understanding of the principles. Your response will remain anonymous.**
- **If you want to write more than the space provided, kindly carry on at the bottom of the questionnaire, referring to the specific question.**
- **My estimate is that this should not take more than 30 minutes to complete.**
- **The information provided by you will be treated in the strictest of confidence and will only be used for this specific research study without disclosure of any company and/or individuals details. The answering of the questionnaire is absolutely voluntary and you may withdraw at any time without any reason or consequence.**

INVESTIGATING THE EFFECTIVENESS OF THE QUALITY MANAGEMENT SYSTEM CURRENTLY USED IN YOUR COMPANY?

1. **What does the term quality mean to you in your everyday work activities?**

   _____

   _____

   _____

   _____

2. **What is your definition of quality in a service organization like yours?**

   _____

   _____

   _____

3. **Do you know what ISO is? And ISO 9001?**

   _____

   _____

   _____

   _____

4. **Remembering the pre-QMS era, is your methodology during project execution any different from what it used to be? If so, in what way?**

   _____

   _____

   _____

   _____

   _____

5. **What is your perception of the cost of quality failure in your work activities?**

   _____

   _____

   _____

   _____

6. **If you consider the cost of QMS for the company (your estimate thereof), do you think the benefits of QMS exceed the cost?**

_____

_____

_____

7. **What are, in your opinion the benefits of QMS in your business?**

_____

_____

_____

8. **How do you experience the QMS used in your company? Please elaborate.**

_____

_____

_____

9. **How do your subordinates react to the compulsory requirement of the QMS? And you?**

_____

_____

_____

_____

10. **How are the QMS audits perceived by you and your personnel?**

_____

_____

_____

_____

11. **Do your subordinates realize the benefits of QMS?**

_____

_____

_____

_____

12. **Why do you think are the same mistakes made by managers and employees leading to the same non-conformances of the QMS at every audit?**

_____

_____

_____

_____

13. **Do you think that the QMS and ISO certification contributes towards client satisfaction, more than before?**

_____

_____

_____

_____

14. **Have you ever been involved in a Professional Indemnity claim against your company? If yes, please provide a broad background at the bottom.**

_____

_____

15. **Do you think that the QMS contributes towards fewer PI claims in your company than before implementation?**

_____

_____

_____

16. **Is the QMS useful during project execution, other than for audit purposes?**

_____

_____

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_____

17. **Does it enhance project performance or make project execution any easier?**

_____

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18. **Can the QMS be considered a training tool in your department? If yes, in what way?**

_____

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_____

19. **What do you consider to be limitations of your company's QMS?**

_____

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_____

20. **How will you improve the current QMS in the company?**

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_____

21. **Do you have any other suggestions or contributions?**

_____

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_____

_____

Thanks again – much appreciated.

ANNEXURE 2

QUESTIONS RAISED DURING AN INTERVIEW WITH THE COMPANY QUALITY MANAGER

QUESTIONS FOR THE QMS MANAGER OF THE COMPANY

1. **How often are QMS audits undertaken in a certain office or department?**

   _____

   _____

   _____

   _____

2. **What are the most common non-conformances of the QMS found in your company?**

   _____

   _____

   _____

   _____

3. **Do you experience recurrences of the same non-conformances again and again? To what extent?**

   _____

   _____

   _____

   _____

4. **What are the attitudes of personnel members towards the QMS – is it different between managers and their subordinates?**

   _____

   _____

   _____

   _____

5. **What do you consider the main benefits of the QMS to be?**

_____

_____

_____

_____

6. **Is the cost of implementing and maintaining the QMS known to the company?**

_____

_____

_____

_____

7. **Do you believe client satisfaction has improved since implementation of the QMS?**

_____

_____

_____

_____

8. **What is your perception of PI claims – do you think the QMS has decreased or has the potential to decrease PI claims in future?**

_____

_____

_____

_____

9. **How can the QMS still be improved as required by ISO 9001 – in the near and the distant future?**

_____

_____

_____

_____

ANNEXURE 3

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Declaration

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Client: **D van R Botha**

This is to declare that I, Annette L Combrink, accredited translator/language editor of the South African Translators' Institute, have edited the study by

D van R Botha

With the title

AN INVESTIGATION INTO THE EFFECTIVENESS OF A QUALITY MANAGEMENT SYSTEM IN THE CIVIL ENGINEERING CONSULTANCY INDUSTRY IN SOUTH AFRICA

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South African Translators' Institute
Membership no. 1000356

Date: 1 November 2012