QUALITY MANAGEMENT AND SOCIO-ECONOMIC OBJECTIVES IN THE CONSTRUCTION OF THE GAUTRAIN

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A research report submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, Johannesburg, in partial fulfillment of the requirements for the degree of Master of Science in Engineering.

Johannesburg, 2010

DECLARATION

I declare that this research report is my own unaided work. It is being submitted for the degree of Masters of Science to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other university.

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(Signature of Candidate)

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ABSTRACT

Apartheid caused segregation and inequality in technical and managerial skills in all sectors in South Africa. Because of the unsatisfactory skills level in South Africa, the post-apartheid government decided to use the construction sector as one of the ways of providing development for sustainability and redistribution of wealth.

Job creation, one of the ways of alleviating poverty by the government, has been carried out effectively by employment-intensive methods of construction for small and technically simple projects. Gautrain is an exception because it is high standard infrastructure owned by the government and yet it has similar socio-economic goals attached to it. Despite the requirement of high quality in the Gautrain, these socio-economic development goals have been exceeded by the execution team without compromising the quality.

In this report, the method of quality management of Gautrain is explored to understand the reason for the success in the implementation of the two objectives that may conventionally seem difficult to reconcile in very large and traditionally equipment intensive projects – quality and socio-economic goals. The findings of this study are that the execution of major infrastructure projects can achieve significant socio-economic goals and high quality, which can be achieved by ensuring that the design team puts into place policies and executes the project to ensure that the objectives are met. These principles can be used to guide a wide range of infrastructure projects in the future.

The importance of training at all levels during the execution of projects is shown in this report. This report has shown the possibilities of integrating non-compliant small contractors into an ISO9000 compliant project in a supply chain management system where the main contractor is commercially and contractually driven to deliver.

ACKNOWLEDGEMENTS

Special thanks to Almighty God for pulling me through the entire thick and thin of another stage of education in my life. If it not for Your mercy and favour, where will I be at this moment?

I would like to express my deepest appreciation to my supervisor, Dr. Anne Fitchett, for her valuable contribution to this research, encouragements and time devotion during this research. Without her guidance and persistent help, this dissertation would not have been possible. I am grateful.

My in-depth appreciation goes to my Dad – Mr. M.O. Ayandibu, elder ones – Bimbo, Taiye, Kehinde, Shola and their spouses for their prayers, financial and moral support during this programme. You all stood by me in various capacities, may God bless the work of your hands and your nuclear families.

I want to say a big thank you to Mr. Henry for sparing so much time for me for discussions during my research. I would like to extend my thanks to Nare Marakalala, Innocent Zulu, Ravi Moodley, Alice Muller and Mark Scott of Bombela, Cuan Lynes of ARUP, Ingrid Jensen of Gautrain and Michael Baloyi of PRASA for sparing time during the course of my research and assisting with access to documentation. You guys are wonderful.

I will never forget to thank Mrs. Abidemi Dunmoye for all her care, support and advice. You have proved to be more than a sister to me. Big thanks to my friends – Mr. Edoghogho, Lunathi, Femi Omidosu, Kunle, Aby, Uno, Gideon, Okeke, Leon Bash, Terfa, Chris, Flow, Refiloe and Raakhee, for your unswerving care during this research. I will never forget to thank my family in RSA – GodFirst Wits, you guys made me feel at home despite the fact that I am thousands of kilometers away from home.

And to my friends back at home – Femi Afariogun, Tola Makanjuola, Seun Obasa, Abiodun Adedotun and Gift Watti, thanks for your calls and care.

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ANC	African National Congress
BEE	Black Economic Empowerment
BBBEE	Broad-Based Black Economic Empowerment
BOT	Build-Operate-Transfer
BOOT	Build-Own-Operate and Transfer
CETA	Construction Education and Training Authorities
CIP	Contractor Incubator Programme
CJV	Bombela Civil Joint Ventures
ECDP	Emerging Contractor Development Programme
EPWP	Expanded Public Works Programme
ESDS	Employment and Skills Development Services
GDP	Gross Domestic Product
GGP	Gross Geographic Product
HDI	Historically Disadvantaged Individuals
HRD	Human Resource Development
IC	Independent Certifiers
ILO	International Labour Organization
ISEM	Independent Socio-Economic Monitor
ISO	International Organization of Standardization
OHSAS	Occupational Health and Safety
PPP	Public Private Partnership
PRASA	Passenger Rail Agency of South Africa
RDP	Reconstruction and Development Programme
RIP	Review in Principle
SED	Socio-Economic Development
SETA	Sector Education and Training Authority
SMME	Small, Medium and Micro-Enterprises
TKC	Turnkey Contractor
TQM	Total Quality Management

1.0 INTRODUCTION

1.1 Background to the research

There is a need for developing countries to increase and improve infrastructure as a means to generating economic growth. According to the World Bank President, James D. Wolfenson, the World Bank is – and should be – playing a central role in the global fight against poverty (World Bank 2004: 4). He also states that the bank's strategy focuses on two pillars of poverty reduction: empowering people and improving the investment climate. Empowerment of people is achieved when jobs are created during increase and improvement of infrastructure in developing countries.

In many developing countries, major investments are not generating the quality or quantity of the services demanded (World Bank, 2004: 2). However, many of the infrastructure projects in these countries run over budget, take far longer than necessary to complete and are of unacceptable quality, from initial construction and through poor maintenance.

This research seeks to explore the possibility of combining Project Management best practice, specifically in the area of Quality Management, with socio-economic objectives in one of the most technically demanding of civil engineering projects in South Africa, namely the Gautrain Rapid Rail project, currently under construction.

Quality can be defined in different ways depending on the context in which it is needed. Asking people of their opinions, different definitions will be given. According to Duncan, Thorpe and Sunmer (1990: 15), 'some people will say *the best* others *value for money*, whilst some will offer the definition of *fitness for purpose*. Quality is the ability of the features of a project to meet the requirements needed by the final user.

Quality management is that aspect of the overall management function that determines and implements the quality policy and as such, is the responsibility of the top

management. Quality management refers to all activities that determine the quality policy, objectives, responsibilities and implementation by means such as quality planning, quality control, quality assurance and quality improvement within the quality system. Quality management is not separate from general management. When used effectively, it should be an integral part of an organization's overall management approach. (Zairi, 1991: 41)

The construction industry has heterogeneous products – in terms of inputs, technology, standards and end use, and this makes it very difficult to have a particular quality standard during construction. Due to the different uses of end products, quality varies and this means that different projects have different types and levels of quality that have to be met. For major projects, the responsibility for production is divided among a wide variety of participants - the client, the construction professionals, contractor and subcontractors, producers and suppliers of materials, plant, equipment, utilities and so on. This means that all participants have their various roles to play in assuring that the quality of the project is achieved, which may be complex in some projects because of the methods of construction and terms of contract.

In most cases, socio-economic objectives can be embedded in contract terms, stating the number of people to be employed, race or other demographics of people to be employed, and the number and type of employees to be trained. This is a common routine in developing communities where poverty, skills shortage and lack of employment, especially amongst the uneducated, are rife.

Many governments in developing countries have effectively employed the construction sector in alleviating poverty through job creation. One of the ways of doing this is by introducing employment-intensive construction methods for infrastructural projects owned by the government. This is an opportunity for the government to address poverty, provide a source of living to the poor, empower them and allow them to play an active part of the economy. This has yielded good results in many countries.

In the South African case, the post-apartheid government perceived the need to redress the injustice that has prevented the majority from playing a significant role in the economy. Several programmes and policies are being used by the South African government as instruments to empower Historically Disadvantaged Individuals. These will be discussed in other sections below.

Most government projects in South Africa are encouraged to have socio-economic objectives tied to them because of the high unemployment rate in the country. Since projects in developing countries tend to encourage labour-intensive methods, it is necessary to do a pre-feasibility study to know how efficient the options of available construction may be. If the quality of the end product of the labour-intensive method of construction can match up with conventional machine-intensive methods, considering that time and costs are also reasonable, it is preferable to go for the labour-intensive method of construction.

Introducing socio-economic objectives into an infrastructural project, for example, by executing a project using labour-intensive construction methods to solve the problem of employment, may cause a fall in quality of the infrastructure if care is not taken by the execution team. All project teams need to bear in mind that providing jobs is not the utmost aim for developmental projects but rather to provide infrastructure of reliable standard should be the major reason that the project is executed. Meeting these two sets of objectives, socio-economic objectives and quality of the project, seems divergent and unachievable because meeting one of the objectives may compromise the other.

The Gautrain is a major project in Gauteng Province that requires international quality standards to be able to meet its objectives of a safe and reliable rapid rail system. The Gauteng Provincial Government is the client, and the delivery mechanism is through Build-Operate-Transfer (BOT) with the Bombela Consortium heading up the construction process. Some of the major objectives of the Gautrain construction project include: job creation; investment in Black Economic Empowerment (BEE); and economic improvement. To ensure that Black Economic Empowerment is achieved, the

project has been encouraged to create a predefined number of jobs for targeted labour and support of small entrepreneurs is maximized bearing in mind that the project must be of world class standard.

Considering that some parts of the Gautrain project were planned to be ready before the 2010 Soccer World Cup, this time constraint may be viewed as a threat to the quality of the project if it is not managed optimally. Looking at the method of construction that will be considered by the contractor, because of the government policies that tends to encourage Black Economic Empowerment, emerging contractors and the economy as a whole, the socio-economic objectives would need to be considered by the main contractor during the planning phase, which may have adverse effects on the quality, time and cost.

Despite the fact that the Gautrain is an infrastructural project that must be of high standard, the government has attached some socio-economic goals to be accomplished while executing the project. For infrastructural projects with high level of quality like the Gautrain, it seems quite difficult to combine the technical and socio-economic objectives together during execution.

1.2 Problem statement

After apartheid, the South African government perceived the need for restoring equity among its citizens because of the pre-democratic policies governing the country, and negatively affecting Historically Disadvantaged Individuals (HDIs). These policies created inequality in skills levels, poverty and poor access to employment opportunities. The government from 1994 decided to roll out programmes to alleviate poverty and improve livelihoods. These programmes instituted by the government in the construction industry encouraged the use of more people in construction, creating more jobs for all levels of workers, particularly the marginalised ones in society.

Employment-intensive methods of construction have been used mostly on small projects so the question arises on how the government could justify the imposition of employment creating policies on a major project such as the Gautrain. “Can the demands of these socio-economic objectives be met on this project?” The Gautrain is the first project of such magnitude and complexity that has employment-creation policies attached to it by the government since the post-apartheid government came to power. “What is the possibility of achieving the goals of job creation and sustainable developments in a project that needs such high level of precision?”

1.3 Objectives of the research

The main objectives of this research are:

1. To study how quality is managed in the Gautrain, as a Government owned project.
2. To look at the ISO system in relation to a sample section of construction works in the Gautrain project.
3. To investigate the measures put in place for quality assurance for the emerging contractors and suppliers on the Gautrain project construction.
4. To briefly review the impact of the Gautrain project on the socio-economic development of South Africa.

1.4 Research questions

This research aims to answer the following questions:

1. Will the aim of job creation by the Government for this project be achieved? If not, what may be the possible causes or hindrance?
2. Is the project going to be of ISO 9000 standard? If not, what are the missing features of the project?
3. Will time limitations be a threat to the quality of the project?
4. Does the Gautrain quality management unit have a plan that is of world class standard and good enough to attain the required quality?

5. How is the quality of jobs being carried out by emerging contractors being assured to meet up with ISO 9000 standard?

1.5 Scope and Limitations of the research

1.5.1 Scope of the research

The focus of this study is on the documentation and organisational structure of the quality management unit and the socio-economic performance of the Gautrain project.

1.5.2 Limitations of the research

During the course of this research, efforts to interview the Chief Executive Officer of Bombela Concession Company were not successful. The research relied on interviews with other key project participants, site visits and a study of the relevant documents. Due to limited access to the day-to-day operations, it was not possible to verify how the socio-economic targets were carried out, i.e. the research relied on the documentation of these targets. For this reason, it has not been possible to determine whether activities were carried out using more labour wherever technically feasible, or whether there was merely a greater percentage of targeted labour than may have been used following conventional practice.

1.6 Composition of the research report

The first chapter of this report gives a brief overview, including the research question and methodology employed in the study. The second chapter reveals what authors have written on quality as a whole in industry, quality assurance in the construction industry, the effects of ISO9000 in the construction industry, the relationship between construction, infrastructure and economic growth, and government policies on the construction industry in South Africa.

The third chapter introduces the methodology and the case study while the fourth chapter reviews the quality management documents used in the construction of the Gautrain project. The socio-economic development achievements are discussed in the fifth chapter while the sixth chapter contains recommendations, conclusions and areas for future research.

2.0 LITERATURE REVIEW

2.1 Introduction

The purpose of this chapter is to introduce the concepts of quality, how quality is assured in construction, effects of construction on economic growth and the policies of the South African Government regarding construction. Literature has been written on quality management but there is a need to establish the relationship between quality management and how it is applied in South Africa, especially in Government projects.

Steyn et al (2004: 189) argue that quality never happens by itself: it is always an outcome of careful research into the requirements of the deliverables that will meet all the needs of the customers as well as expectations of the stakeholders involved. Quality is one of the major areas in the construction industry that has to be looked into critically before a project is initiated. Harris and McCaffer (1995: 362) also discuss that the quality of a project has to be guaranteed by a contractor to its client in order to compete effectively in the modern construction market and this is important nowadays because quality is becoming as discriminating a factor as price has traditionally been.

Zairi (1991: 16) notes that the Japanese were leading in the field of quality in the 1970s. This can be explained by the strong motivation to succeed, strong leadership, total commitment and belief in continuous improvement. This strong motivation is described by Ishikawa (1985: 58) as the "Japanese spirit". The western world has had the same opportunity as Japan, and in fact the major pioneers of the Quality Movement are Americans. However, the results of this opportunity were different because the Japanese utilized the opportunity to the full. Because of the humiliation suffered by the Japanese during the Second World War, they perceived the need to rebuild a new Japan which would be industrially strong and respected world wide. This consciousness brought about the level of enthusiasm, responsiveness and commitment in wanting to achieve high quality standards because Japanese products were suffering from poor quality and reliability standards.

> It has therefore got to be widely recognized that the prominence of TQM today is due to a small number of people without whose contribution businesses would have still perhaps carried on making same mistakes with the same level of ineffectiveness and with similar percentages of waste. (Zairi. 1991: 17)

Although few people worked on quality improvement and techniques, they have successfully changed people's view about quality. W E Deming was the first western scientist invited to give seminars to Japanese workers and managers on effective quality management (Zairi. 1991: 17). His main interest was in the application of statistical techniques. He came up with the Deming Cycle: Plan, Do, Check, Action (PDCA). Deming proposes that the purpose of using quality management techniques is to help companies stay in business and that quality improvement has to be led by management. He sees management responsibility in two main areas, namely:

- To create a positive climate for quality improvement: it is the responsibility of the management to make sure that work is rewarding and that workers must enjoy it;
- To place an emphasis on knowledge workers rather than rigid systems: many errors which occur in organizations are caused by existing systems which are impractical, too rigid and inaccurate rather than due to human error.

Deming came up with fourteen points for total transformation that is based on a company-wide quality improvement philosophy. Deming's fourteen points as summarised by Zairi (1991: 19) and Wadsworth, Stephens & Godfrey (1986: 42-44) are:

1. Create consistency of purpose toward improvement of product and service, with the aim of becoming competitive and thus to stay in business, and to provide jobs.
2. Adopt the new philosophy. 'We are in a new economic age. We no longer need to live with commonly accepted delays, mistakes, defective materials and defective workmanship.'
3. Cease dependence on mass inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place.
4. End the practice of awarding business using price tags. Instead, minimise total cost. Move toward a single supplier for any one item, on a long-term relationship of loyalty and trust.

5. Improve constantly and forever the system of production and service, to improve quality and productivity, and thus constantly decrease costs.
6. Institute modern methods of training and education on the job, including management.
7. Institute leadership. The aim of supervision should be to help people and machines and gadgets to do a better job.
8. Drive out fear, so that everyone may work effectively for the company.
9. Break down barriers between departments. People in research, design, sales and production must work as a team, to foresee problems of production and in use that may be encountered with the product service.
10. Eliminate slogans, exhortations and targets for the work force asking for zero defects and new levels of productivity. Such exhortations only create adversarial relationships, as the bulk of the causes of low quality and low productivity belong to the system and thus lie beyond the power of the work force.

11a. Eliminate work standards (quotas) on the factory floor,: substitute leadership.

11b. Eliminate management by objective. Eliminate management by numbers.

12a. Remove barriers that rob the hourly worker of the right to pride of workmanship. The responsibility must be changed from sheer numbers to quality.

12b. Remove barriers that rob people in management and in engineering of their right to pride of workmanship. This means, inter alia, abolishment of the annual or merit rating and management by objective.

13. Institute a vigorous program of education and self-development.

14. Put everybody in the company to work to accomplish the transformation. The transformation is everybody's job (through company-wide improvement).

Deming's 'fourteen points' highlight the need for a change in approach in terms of quality management from the aims (point 1), to thoughts (point 2), to action (points 3 and 4), improving (point 5), incorporating new approach (points 6,7,13 and 14) and eliminating acts that negatively affect quality (points 8 to 12). Building quality into the product in the first place (point 3) has significant implications on the operational costs of

projects. There will be a reduction in the cost of maintenance if the product is produced to the required quality.

Deming's approach to quality management emphasises that the purpose of using quality management techniques is to help companies stay in business. This can be achieved when there is quality improvement which leads to higher productivity and this lowers costs. The prices will be lower because of lower production costs and this invariably attracts more customers to the product with good quality and reduced price – getting value for their money. When there is an increase in the number of customers for a product at a reasonable profit for the producer, the producing company stays in business.

Deming's approach to total quality management is quite different from *management by objectives* because he argues that the management has two main areas of responsibilities, as mentioned earlier, and quality management is a duty of everyone in the organisation. Meanwhile, the *management by objectives* concept requires all managers to participate in strategic planning processes and implement performance systems to help the organisation back on track. Managerial focus of *management by objectives* is the final result and not the set of activities that produce the result while Deming's approach encourages the definition of a detailed roadmap for implementation.

Howard and Shelly Gitlow (1987: 8) note that Deming's quality philosophy highlights the continuous improvement of the process for which management is responsible. They also state that there are three types of quality that management must understand. These include:

1. Quality of design/redesign;
2. Quality of conformance; and
3. Quality of performance.

According to Zairi (1991: 21), Joseph M Juran contributed as much to total quality as Deming did. Juran was invited to speak to Japanese senior managers in 1954 on the

importance of planning, organising and managing quality programmes (Zairi, 1991: 21; Ishikawa, 1885: 19). Juran's approach to quality control and management was twofold:

- Company's mission; and
- Senior manager's role.

Juran proposed that quality has to be controlled at each stage of the process and should be aimed at controlling:

- Sporadic problems/avoidable costs (defects and product failure, scrapped materials, labour wasted usage for re-work, repair, dealing with customer complaints);
- Unavoidable costs dealing with chronic problems (prevention and control).

Sporadic problems can be solved easily using quality control techniques such as standard statistical techniques, charts and diagrams; while unavoidable costs require introduction of a new culture which is intended to change attitudes and increase company wide knowledge. Planning, implementing and controlling quality according to the mission of a business determines how lasting a business will be. Juran also argues that managerial processes are necessary for the structured implementation of a total quality programme: planning, control and improvement. He argues that 'the planning process is crucial for improvement to become a continuous activity' (Zairi, 1991: 23). Planning therefore has to be conducted with a long term view rather than on a project by project basis.

According to Zairi (1991: 23) and Wadsworth, Stephens and Godfrey (1986: 19), Philip B Crosby's quality drive is prevention and he argues that quality is free. The costs are only related to the various obstacles for the first time. According to Crosby, the major objectives of organizations implementing total quality should be Zero Defect. He proposes that acceptable quality levels should be forbidden because they compromise the commitment towards the achievement of Zero Defect. He also identifies that there are two major problems which are causes of poor quality in the industry which are:

- Those which are due to employees' poor awareness and knowledge; and
- Others which are due to carelessness and lack of attention.

The first problem can be easily identified, measured and solved but the second needs a long term management effort in changing culture and attitude. Crosby argues that if a company is serious about achieving Zero Defect, they have to be serious about prevention. He also proposes four steps for managers and fourteen steps to improve quality. Crosby's fourteen steps differ from Deming's because they facilitate the introduction of continuous improvement. Crosby's approach to total quality is to change the culture and attitudes within the organizations to implement continuous improvement. This approach is more management oriented since it does not refer to the control of quality predominantly by the use of various statistical techniques.

These three 'pioneers' of quality have their different approaches to quality. Deming's approach is more of transformation, based on a company-wide quality improvement philosophy; Juran's approach is the company's mission in relation to the customer's specification and the role of senior managers in providing leadership and resources in awareness of developing systems for quality; and Crosby's approach produces guidelines for managers and gives room for corrective actions despite the fact that he preached 'zero defect'.

Zairi (1991: 32) concludes that there is no doubt that total quality management ideas and concepts will be developed in the future to facilitate meeting the requirements of a business market which is always changing. Despite the constant change in the construction industry, total quality management approach allows flexibility in the achievement of quality on projects.

2.2 Definitions

2.2.1 Quality

According to Duncan, Thorpe and Sunmer (1990), quality refers to standards and the ways and means by which those standards are achieved, maintained and improved upon. The term quality is often misused, especially when associated with prestigious products.

Although quality is applicable to those products, it does not necessarily refer to their prestigious attributes, but merely to the fitness of purpose to the customer's requirements. Harris and McCaffer (1995: 364) emphasize that quality is meeting the requirements of the customer. Looking at quality from the fitness for purpose perspective, Duncan, Thorpe and Sunmer (1990: 15) states that before we can say whether fitness for purpose has been achieved, we need to know what exactly the purpose is and how fitness in terms of factors such as performance, duration, reliability, accuracy and so on is to be defined and measured.

According to International Organization for Standardization (1994: 19), quality is: "the totality of characteristics of an entity that bear on its ability to meet stated or implied needs." Harris and McCaffer (1995: 362) state that the modern concept of quality is considered to have evolved through four major stages. These stages are:

- Inspection, the principal method of quality control in the traditional approach to construction projects;
- Quality control;
- Quality assurance; and
- Total quality management.

2.2.2 Quality Control

Quality control entails checking that all the various stages of the process of serving the customer have been conducted correctly and any defects identified have been corrected. According to Zairi (1991: 37), quality control can be defined as: "operational techniques and activities aimed both at monitoring a process and eliminating causes of unsatisfactory performance of relevant stages of the quality loop (quality spiral) in order to result in economic effectiveness."

Zairi (1991: 37) also defines quality control as "the use of techniques (mainly statistical) to achieve, maintain and try to improve on quality standards of products and services." Quality control is significant because:

- it helps to follow the path of specification required;
- it helps in the design of the product required;
- it helps to inspect the product during manufacture or production to determine if it is in conformance to the customer's specification; and
- it helps to monitor the use of products and gives a feedback if there is a necessity for improvement.

Zairi (1991: 38) identifies that there are three types of quality control. These include;

1. Irregular control: This is the type of control applied when a customer complains about the product.
2. Routine control: This type of control is regular control taken at different stages of production/construction.
3. Scientific control: This is control through measurement and it is analysed using statistical sampling theory.

These three types of quality control are all relatively effective but irregular quality control tends to make a customer lose confidence in the quality of goods produced. Routine and scientific controls are very good approaches to quality control because the product is still in the production process when they are carried out. They make the quality of the finished product conform to the specified requirements in the long run. The scientific control measures specifically the degree of conformance of raw materials, processes and products to the agreed specification.

Burke (2007: 260) also defines quality control as: "the process companies go through to confirm that the product has reached the required condition as determined by the specifications, build-method and the contract." Quality control defines the method of inspection (testing), in-process inspection, and final inspection to confirm the product has met the required condition. Quality control means monitoring whether specific project results comply with relevant quality standard and identify causes of unsatisfactory results. The method of testing should be outlined in the project quality plan. This could involve checklists, inspections, reviews, verification and validation against standards and

requirements. The project quality plan should also give a definition of deviation and state how to approach deviation.

Harris and McCaffer (1995: 362) note that quality control introduced inspection to stages in the development of goods and services to ensure that they are carried out to specified requirements. Inspection is the process of checking or confirming that what is produced is what is required. They also discuss that quality control is done on a sampling basis dictated by statistical methods. An example in the construction industry is making of concrete and sampling cube tests.

Quality control is the earliest and most basic form of Quality Management, primarily concerned with defect detection. Quality control is a very useful tool that helps to detect defects early enough during execution and provides for correction to make the product meet the quality specification. Harris and McCaffer (1995: 364) point out that the major objectives of quality control can be defined as follows:

- To ensure the completed work meets the specification;
- To reduce customers' or clients' complaints;
- To improve the reliability of products or work produced;
- To increase customers' or clients' confidence; and
- To reduce production costs.

Harris and McCaffer (1995: 367) define inspection by activities such as measuring, examining, testing, gauging one or more characteristics of a product or service and comparing these with specified requirements to determine conformity. Once inspection proves a low level of conformity, this activates the need to improve on the quality standards and, depending on the context, corrections may be made before moving on. Inspection in construction can take two forms as discussed by Harris and McCaffer (1995: 364). These are:

1. Quantifiable: examples are lines, levels, verticality and dimensions;
2. That which is open to inspector's interpretation: examples are cleanliness, fit, tolerances and visual checks.

Strength tests on materials such as concrete, in construction, can be categorized under ‘specific quantifiable’. Quality control concerns the operational techniques and activities that are used to fulfill requirements for quality.

According to Harris and McCaffer, there are five stages of approach to quality control. These are:

1. Set the quality standard or quality of design, required by the customer;
2. Plan to achieve the required quality;
3. Manufacture right first time;
4. Correct any quality deficiencies, i.e. defective work; and
5. Provide for long term quality control and planning.

As noted above, authors have different ideas when it comes to quality control, but their major goal in quality control is to derive a method of detecting and documenting defects and devise means of correction before the product is completed. This has particular significance to the present research, in that projects are unique, so that there is no possibility of ‘returning’ a defective final product. Moreover, the products of construction have high value (cost) and are expected to have long duration, so that investment in quality at all steps of the process are rewarded by reduced maintenance, longer life of the infrastructure and reduced risk of failure, with the possible negative consequences to public health and safety.

2.2.3 Quality Assurance

Authors have different approaches to the understanding of quality assurance, which is reflected in the diversity of their definitions.

Duncan, Thorpe and Sunmer (1990: 16) defines quality assurance as a structured approach to business management and control, which enhances the ability to provide products and services consistently to specification, programme and cost. This is a

structured procedure put in place to help prevent, manage and control so that the products being produced satisfy requirements, meet up with time objectives and are cost effective.

Harris and McCaffer (1995: 366) state that quality assurance emphasizes defect prevention, unlike quality control which focuses on defect detection once the item is produced or constructed. Quality assurance concentrates on the production or construction management methods and procedural approaches to ensure that quality is built into the production system. Broadly, it is the prevention of quality problems through planned and systematic activities (including documentation). Quality assurance can be considered as all those planned and systematic actions planned to provide adequate confidence that a product or service will satisfy given requirement for quality.

British Standards (BSI) is the United Kingdom's national standards organisation that produces standards and information products that promote and share best practice (Distributing BSI British Standards 2009). British Standards started as early as 1900 when Sir John Wolfe-Barry, the man who designed London's Tower Bridge, instigated the Council of the Institution of Civil Engineers to form a committee to consider standardizing iron and steel sections on 22 January 1901 (History of BSI group 2009). The evolution of International Organization of Standardization came from the first Commonwealth Standards conference organised by British Standards in London in 1946. The world's first management systems quality standard, BS 5750, was published by BSI in 1979. In 1987, it was superseded by the ISO 9000 series of international standards which BS 5750 inspired.

Oliver (1992: 18) refers to BS4778: Part 1 to define quality assurance as: "all those planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality". From this context, quality assurance documents build confidence to both purchaser or client (customer) and the management. The client has assurance that the product will meet his quality requirements while management is assured that the product meets up with their own requirements, that of the client or customer and those of society. The group of activities aimed at providing

confidence to a purchaser is called external quality assurance, while internal quality assurance comprises the activities aimed at providing confidence to the management of an organization.

Zairi (1991: 40) argues that quality assurance means that quality control is conducted in a systematic manner. He also notes that quality assurance means that the process of checking, correcting and controlling is conducted in such a manner that the manufacturer or service provider is aware that all stages of the process are being conducted correctly (with the set quality standards in operation) and what is planned is what is expected in terms of output. Quality assurance also means that there is a set of documentation (a system) which demonstrates the existing standards of quality and reliability. Zairi (1991: 40) also explains that quality management uses what is referred to as "death certificate approach", which means that it rejects inspection as the answer to quality problems and encourages the implementation of procedures in order to comply with standards. He also argues that to make sure that products and services are in compliance with set standards, quality assurance relies on the use of Statistical Process Control techniques.

According to Burke (2007: 255), quality assurance is defined as: "a systematic process of defining, planning, implementing and reviewing the management processes within a company in order to provide adequate confidence that the product will be consistently manufactured to the required condition". The Project Management Body of Knowledge defines quality assurance as: "the planned and systematic activities implemented within the quality system to provide confidence that the project will satisfy the relevant quality standards." (Project Management Institute 2000)

It is evident that quality assurance emanated from and is dependent on quality control. Quality assurance builds confidence in the client and the supplier that steps have been taken to ensure that the specified requirements needed by the client have been followed by the supplier during production or execution.

2.2.4 Quality Management

As defined by Zairi (1991: 41), quality management is: “that aspect of the overall management function that determines and implements the quality policy and as such, is the responsibility of the top management.” Quality management refers to all activities of the overall management function that determine the quality policy, objectives and responsibilities, and the implementation of these by means such as quality planning, quality control, quality assurance and quality improvement within the quality system (ISO 9000 handbook, 1994: 19). The ISO handbook also states that quality management is not separate from general management. When used effectively, quality management should be an integral part of an organisation’s overall management approach**.**

Abdul-Rahman (1995: 23) states that the management of quality in construction is related to time and cost management and vice-versa. He also notes that a poorly managed project may lead to extra cost and time extensions and that a poor time and cost controlled project can affect conformance with a client’s requirements, a crucial aspect of project quality management. Poor quality management causes re-work in construction projects, when the quality of a project does not meet the required specification, satisfy the needs of the customer or the outcome of the project is not fit for the purpose it is needed for. The effects of re-work on projects are time and cost overruns.

According to Love and Li (2000: 479), quality failures have become an epidemic of the procurement process in construction and invariably lead to time and cost overruns in projects. The procurement system adopted for projects can be a major determinant in the achievement of quality in construction projects. Love and Li (2000: 479) argue that in order to improve the performance of projects, it is necessary to identify the causes and costs of re-work. It is recommended by Love and Li (2000: 479) that construction companies and consultant firms (particularly design consultants) implement quality management practices as well as placing emphasis on coordinating project documentation during the design development process so that the amount of rework in projects can be reduced or even eliminated. Re-work can be reduced from the development stage of a

project when the design and planning for the project is in progress. Love and Li (2000: 489) state that if the construction industry is to improve its performance, all organisations involved in the project supply chain should implement quality management practices. They also note that in order to ensure quality in design documentation, construction companies and consulting firms should give greater attention to the following quality management practices:

(a) the requirements of the clients and end users;
(b) producing correct and complete drawings and specifications;
(c) coordinating and checking design documentation (including inter-organisational coordination);
(d) conducting design verification through design analysis reviews;
(e) controlling changes e.g. scope freezing; and
(f) committing to providing a quality service.

It is evident that there is a need for the management of the executing company to be involved with the suppliers' organisation to plan on how quality is to be achieved in all projects they execute.

Cain (2004: 59) defines a supply chain as: "the integrated structure of activities that procure, produce and deliver products and services to customers. The chain can be said to start with the suppliers of your suppliers and ends with the customers of your customer."

The chain refers to all players in the implementation of a project ranging from the sub-contractors, to the design team and so on. Participants in the execution of a project must be committed to the supply chain in order to realise the expected quality of the project. A proper co-ordination of the supply chain results in a higher tendency of quality actualisation and effective results. One of the barriers to the actualisation of good co-ordination in the construction supply chain is the traditional separation of design and construction. It is easier for a compact team handling both design and construction to be more co-ordinated because there will be a faster response when attending to matters and lower cost of communication.

Vrijhoef and Koskela (2000: 169) argue that the traditional approach to the control of the construction supply chain is not adequate any more, and a shift of methods for managing the supply chain is needed. Deming's point number four suggests that a single supplier should be approached for any one item on a long term relationship of trust and loyalty, instead of awarding business on price tag, with the result that cost can be minimised.

Vrijhoef and Koskela (2000: 170) also define supply chain as the network of organisations that are involved through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of ultimate customer. Vrijhoef and Koskela (2000: 171) discuss the characteristics of construction supply chain as follows:

- It is a converging supply chain directing all materials to the construction site where the object is assembled from incoming materials. The "construction factory" is set up around the single product, in contrast to manufacturing systems where multiple products pass through the factory, and are distributed to many customers.
- It is, apart from rare exceptions, a temporary supply chain producing one-off construction projects through repeated reconfiguration of project organisations. As a result, the construction supply chain is typified by instability, fragmentation, and especially by the separation between the design and the construction of the built object.
- It is a typical make-to-order supply chain, with every project creating a new product or prototype. There is little repetition, again with minor exceptions. The process can be very similar, however, for projects of a particular kind.

It is evident from above that construction supply chain directs all the materials to one point – the site, with a single product to be produced. Because the supply chain is working on a single product which is rarely continuous, the construction supply chain has a tendency to be unstable, disunited particularly when there is a separation between the design and construction of the construction project. Quality management concepts ensure

that all components of the supply chain meet the quality specification. Quality management is the basic tool that must be effectively used for the successful realisation of all projects because the management has a great input in the outcome of the quality of any project. For these reasons, better results are achieved when there is a good co-ordination and commitment in the supply chain players.

Four major roles of supply chain management in construction are identified by Vrijhoef and Koskela (2000: 171) depending on whether the focus is on the supply, the construction site or both. These are summarised follows:

- Impacts of the supply chain on site activities and the goal is to reduce costs and duration of the of site activities. The contractor is in the best position to adopt this and it is best achieved focusing on the relationship between the site and direct suppliers.
- Focusing on the direct chain itself with the aim of reducing costs. This focus can be adopted by material and component suppliers.
- Focusing on transferring activities from site to the earlier stages of the supply chain. This focus can be adopted by the suppliers and contractors and the aim is to reduce the total costs and duration.
- The focus may be on the integrated management and improvement of the supply chain and then site production. Clients, suppliers and contractors may adopt this focus.

It is obvious from the four roles of supply chain management that the major aim of these roles is reduction in costs and time of construction projects. The importance of an understanding of the supply chain in the context of the Gautrain lies in the dynamics of the main contractor, directly responsible for the quality of the final product, and the necessity of meeting the project's socio-economic objectives, especially with regard to small contractors and suppliers.

2.2.5 Total Quality management

Total quality management as the name implies, is the management of all aspects of quality (Zairi, 1991: 41). Zairi argues that total quality management can be defined by several parameters, such as leadership, attitudes, systems, continuous improvement and customer supply chains. He explains that leadership is perhaps the most important ingredient in the total quality management philosophy, as has been addressed by pioneers such as Deming, Juran and Crosby. A company's ambitions and desire to succeed is a reflection of the company's leadership which is implemented through a series of actions and initiatives. Total quality management is not about achieving certain standards of competitiveness or introducing new techniques, concepts, methodologies and technologies. It is about changing attitudes and behaviour towards doing business where parameters are set by the customer or negotiated with the customer. Zairi (1991: 42) also argues that total quality management looks for continual improvement in the areas of cost, reliability, quality, innovation, efficiency and business effectiveness.

Zairi (1991:49) describes a model that shows that Total Quality Management depends on some building blocks which influence the strength of the organization. The building blocks are summarized below:

1. The foundation: For a successful TQM programme, improvement, introduction of change, flexibility and adaptability should be the basics of the organization. People should be rightly nurtured, provided with right tools, right working environment, and given flexibility to take part in the continuous improvement by contributing to their own tasks and solving problems.
2. The pillars: These are the various ways and processes (quality systems) by which human inputs are conveyed to output, to benefit the end user. These include procedure, documentation, recording and analysis, workplace design, and technological innovation, amongst others. The strength of the whole organization is dependent on the strength of each pillar, thus management should increase the strength of each pillar and add more where applicable.

3. The top: Just like the roof of a building, this part should be weather resistant because it covers the whole organization. This part represents the senior management and they should have vision for the future of their organization when planning for quality.

The figure below shows the proposed model by Zairi, looking at the three levels of total quality management; the top, the pillars and the foundation.

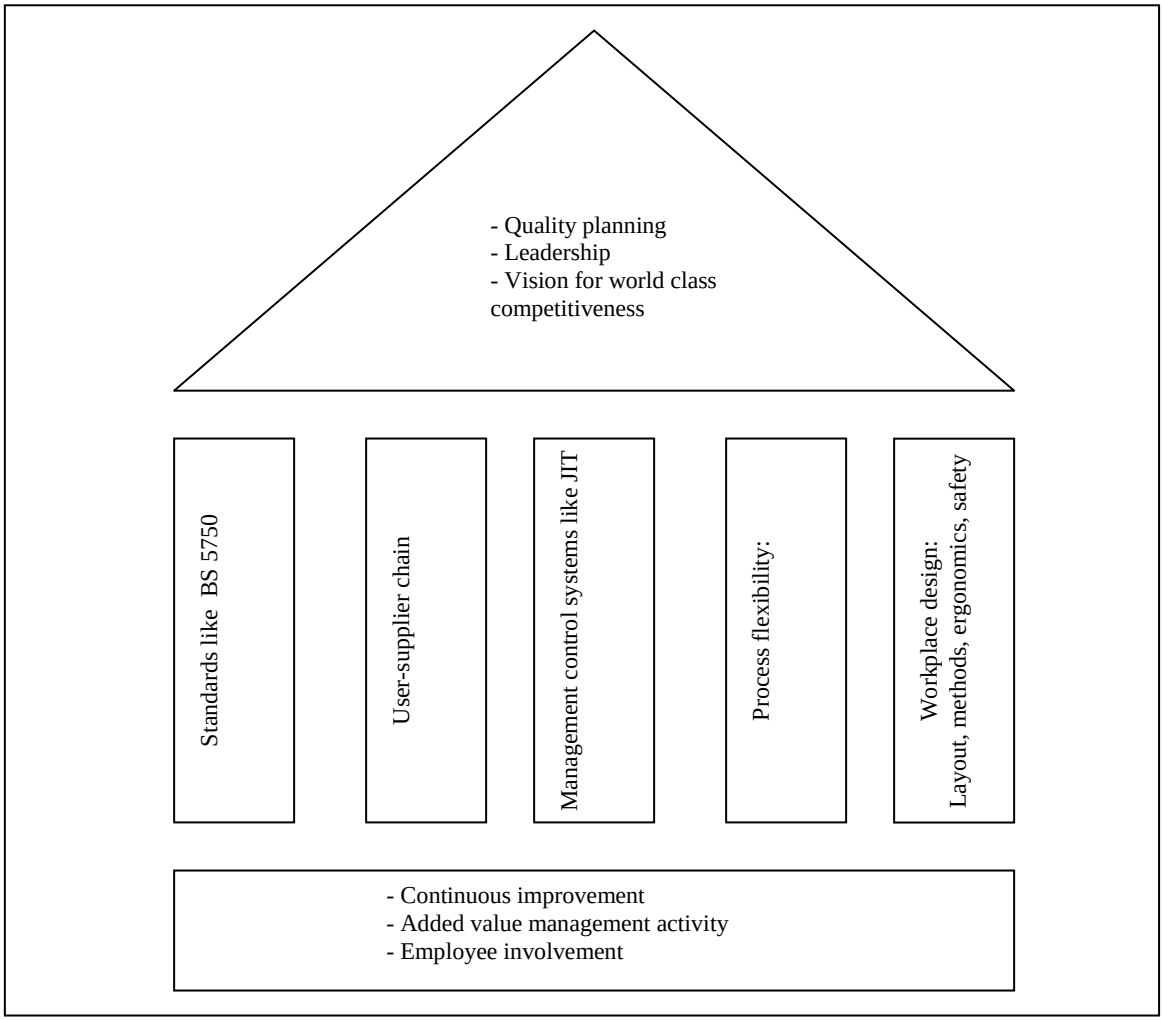


Figure 2.1: Total quality management: Building blocks. (Source: Zairi 1991: 49)

Harris and McCaffer (1995: 374) highlight two total quality management principles:

a) Commitment to quality

The top management of companies needs to initiate and demonstrate commitment to quality. To demonstrate their own level of commitment to quality, the middle management must also grasp and explain the principles of total quality management to those they are responsible for. Total quality management will spread effectively throughout the organization if this level of commitment to quality is achieved. Employees who are committed to quality, taking pride in their work, has the result of successful total quality management implementation. 'TQM is therefore not a set of procedures to achieve quality, but is instead a state of mind, based on the pride of the job'. (Harris and McCaffer 1995: 374)

b) Quality Chains

The responsibility of each individual to the person they are linked with is one of the fundamental concepts of total quality management. Each process is formed by a number of operations and if any of the operations in a process is faulty, the effectiveness of the whole process compromised. A chain of responsibility is formed with the people involved in operations which constitute a process, each success relying on successive success. "The concept of a quality chain provides an easily understandable concept to aid the adoption of TQM philosophy." (Harris and McCaffer 1995: 374)

When management are quality oriented and are committed to the realisation of quality, they need to lead by example so that other employees look up to them and become committed to achieving quality. The total quality management philosophy on the quality chains, as a supplier to a next operative, shows that each person is responsible to the people they deal with. Harris and McCaffer (1995) argue that these two principles will really improve the realisation of quality in products and this will have an effect on the maintenance cost of the product during operation.

Development of total quality management in an organization

There is no particular model that fits all companies when it comes to total quality management. A company adapts the model to suit the activities being carried out by the company. There are numerous models already developed to represent a total quality

culture and its development processes. An example of the model is Deming's 14 points that can be used in the development process of total quality management. Deming's model approaches total quality management from the management perspective i.e. the actions must be taken by the management.

Harris and McCaffer (1995: 369) talk about developing and implementing a quality system in an organisation. They mention four stages in the implementation of the quality assurance system which are summarised below:

- Establish awareness;
- Develop quality manuals;
- Introduce the system; and
- System evaluation.

Establish awareness: The top management introduces quality assurance into a system in order to make their organisation remain competitive. It requires having the understanding and commitment of the top management and it is necessary to explain the potential benefits to gain wide spread support for quality assurance. There is also a necessity for senior and middle management to support and understand the quality assurance approach. Short periods of quality assurance training are the best way to achieve this.

Develop quality manuals: The quality manual is the basis of any quality assurance system which comprises the company profile, amendments record, policy statement, quality standards, organisational structure, procedures and work instructions.

Introduce the system: After a draft of the quality system has been developed, it undergoes the trial period so that it can be debugged, understood and accepted. It is introduced to the system over a period of about three to six months, depending on the management. The major problems will be identified by the employees and corrections are made either immediately or after the trial period, depending on the type of errors. The quality system is now introduced formally after the trial period.

System evaluation: There are two methods of evaluating quality a system:

1. Management review: It 'requires managers to periodically review the quality system in their area of responsibility to ensure that it is still satisfactory'. (Harris and McCaffer 1995: 369)
2. Internal audits: Audit results should be documented and where there is non-conformance, notice should be issued and suitable corrective action taken, with the timing and the person responsible for the corrective action included in the notice. The audit should be undertaken by a trained person, who should report to the senior management.

Following the four stages mentioned above, there seems to be a systematic approach towards the introduction and adaptation of quality system in an organisation. For organisations where there are no quality management systems, an approach like this can be used for introduction and adaptation of the system. Also, where there is an existing quality management system and a change needs to be made, this approach can also be introduced to the system for the new approach to be tried.

The ISO system is a more rigid system when compared to Deming's total quality management model because there are some guidelines that must be used as standard documents and procedures by quality assurance departments in companies. This complexity makes it more difficult for smaller companies to be ISO compliant. ISO certifies companies that are compliant to their standards and audits them from time to time. When audited companies do not meet up with the standards, ISO retrieves the compliance certificate. Customers value competency of a company with the ISO certification but lose confidence in a company that has its certificate withdrawn.

2.3 Quality assurance in construction

Harris and McCaffer (1995: 371) state that the construction process involves three parties; the client, the design consultants and the contractors. Depending on the type of contract, each of the parties has different quality actions. For example a contract may

have an independent designer or it may be a ‘design and build’ contract. In a design and build contract, there is a higher probability that the client transfers some major risks to the design and build team whereby the team will take responsibility for failure to meet with the requirements.

Build-operate and transfer (BOT) or build-own-operate and transfer (BOOT) projects are types of design and build projects where the client transfers the risks of operating the project for a period to the design and build team to ensure that the project meets the requirements specified by the client. Here the agreement states the period of operation and transfer which is usually determined by the client.

When clients use a procurement system that encourages fragmentation in a project (design team different from execution team), it is unlikely to harness the skills and knowledge of the specialist suppliers during the design development because the suppliers will not be appointed until the design is complete. Cain (2003:14) argues that it is impossible to inject buildability and ‘right first time’ or greater standardisation of components into the developing design. Fragmentation also discourages continuity in skills and knowledge transfer, and there is a need to skills improvement over time during the project life cycle.

The quality assurance approach used in a build-operate and transfer project depends mainly on the construction team because the client has transferred a greater risk to the team to develop the design and build the project. This gives a degree of freedom to the executors to operate because the client, depending on capabilities, either gets an in-house monitoring team or hires separate consultants to monitor the design and the execution procedure for conformity.

Quality assurance in construction differs from that of manufacturing companies in that the client is not buying a finished product, so everything is done on trust that it will be completed on time, within budget and according to specification. If these are not met, the client has to pick up (pay for) the shortfall or end up with an incomplete or inadequate

result. In manufacturing, by contrast, the market dries up through customer resistance or profits are cut by dropping the price for inferior goods. Discussions on the need for quality assurance in construction will be discussed in this sub-section.

Need for quality assurance in construction

Duncan, Thorpe and Sunmer (1990: 12) proposes the need for quality assurance in construction because about 90% of cost related error has its source either in the design or construction management team. These cost related errors are due to:

- Inadequate training and management of the designers responsible for producing calculations and drawings, which makes for constant changes in the details throughout construction period and negatively affects the construction costs;
- Inadequate or incorrect specification at tender;
- Inadequate definition of responsibility within both management groups – in the office and on site;
- Poor communication between principal parties in the contract which leads to confusion and cost related delays;
- Inadequate training and management of labour on site;
- Inadequate verification routines to ensure that design, materials and workmanship meet specific requirements. (Duncan, Thorpe and Sunmer 1990: 12)

The lack of effective communication is the major cause of error in all professions. Instructions must be clearly given and understood; calculations must be accurate; and working drawings must be very easy to interpret.

> When dealing with a complex and varied industry, within which numerous professionals and artisans operate, whose background training and professional development are entirely different from each other, the most effective way to achieve good communication is to formalize it. (Duncan, Thorpe and Sunmer 1990: 12)

The biggest enemy to achieving success is the inability to communicate effectively. Effective communication keeps everyone supplied with the information they need and a continuous communication is needed for the success of a project. Formalizing communication in an organisation defines the medium in which to communicate and whom to communicate with.

Duncan, Thorpe and Sunmer (1990: 13) indicates that training at different levels in the construction industry has been neglected and it has caused disaster because those responsible for key activities lack sufficient expertise. Formal quality assurance requires that training policies for all staff are implemented. Each member of the team must know where he fits in terms of responsibility through clear definition and understanding of responsibility, because often people take decisions that they are not qualified to take. In addition to knowing where they fit, they must also understand how to relate with fellow team members. Training of workers to produce better quality workmanship can also help to produce long term capacity building for the unemployed in a developing country.

Time is another factor that may affect quality standards. Duncan, Thorpe and Sunmer (1990: 13) states that in the process of undertaking work within a tight programme, there never seems to be sufficient time or money to ensure that results are correct. This means that time and cost performance are affected negatively during the execution of projects. However, on discovery of a major error or fault, the resources to put it right are limitless. Therefore, proper time management during in projects eliminates or reduces project delays even in tight time schedules. Excellent time management requires proper planning by the project team.

Often a client may press on a project for unrealistic time and cost. Such projects may end up in disasters, not meeting the quality because the contractor may resort to unsafe practices to make up time and use materials of low quality to reduce costs, resulting in costs for rework. The British Standard design sector assessment schedule requires that, at commencement of each project, a project quality plan is prepared, detailing all the information that is essential in order to proceed in a satisfactory manner (Duncan, Thorpe

and Sunmer 1990: 14). Clients need to view the project quality plan before pressing for time and cost reduction because proper procedure should be followed in terms of the project quality realisation. The project quality plan shows the roles and responsibilities, policies, strategies, project management system structure, and management plans. Project quality planning will be discussed in section 4.2.1.

Duncan, Thorpe and Sunmer (1990: 14) also argues that quality assurance requires that formal records are kept throughout the period of design and construction as well as in the inception phase, and archived following completion. This keeps a track of the reviews made on the project during the construction period and helps in the final accounts of the project.

In project execution, it is preferable to build quality into the procedure as this reduces the number of defects that will occur during this phase. Building quality into the system is the responsibility of the three parties - the client, the design consultants and the contractors. Each one of them has their role to play in quality management.

Errors occurring during construction are mainly caused by the management team, which calls for a need in quality assurance in construction. The causes of error in construction have been highlighted, as has the difference between quality management in the manufacturing and construction industries. The causes of these errors need to be addressed in the construction industry in order to achieve specified quality in projects using effective quality management skills.

2.4 ISO 9000 in the Construction Industry

To establish compliance during the execution of a project, there should be a benchmark that must be used in comparing the main output of the product to the expected output specified. For the specified standard to be acceptable, the standard must be globally recognised and accepted. The International Organization for Standardization (ISO) is a network of the national standards institutes of about 160 countries, on the basis of one

member per country, with a central secretariat in Geneva, Switzerland, that coordinates the system. ISO9000 family is one of the ISO's best known standards (International Organization of Standardization, 2009). It is an international reference for quality management requirements which also provides a manual for companies to:

- Fulfill the customer's quality requirements,
- Meet applicable regulatory requirements, while aiming to enhance customer satisfaction, and
- Achieve continual improvement of its performance in pursuit of these objectives.

There are eight quality management principles on which the ISO 9000:2000 and ISO 9000:2008 series are based. These principles are summarised as;

- Principle 1: Customer focus: Organizations depend on their customers and therefore should understand current and future customer needs, should meet customer requirements and strive to exceed customer expectations.
- Principle 2: Leadership: Leaders establish unity of purpose and direction of the organization. They should create and maintain the internal environment in which people can become fully involved in achieving the organization's objectives.
- Principle 3: Involvement of people: People at all levels are the essence of an organization and their full involvement enables their abilities to be used for the organization's benefit.
- Principle 4: Process approach: A desired result is achieved more efficiently when activities and related resources are managed as a process.
- Principle 5: System approach to management: Identifying, understanding and managing interrelated processes as a system contributes to the organization's effectiveness and efficiency in achieving its objectives.
- Principle 6: Continual improvement: Continual improvement of the organization's overall performance should be a permanent objective of the organization.
- Principle 7: Factual approach to decision making : Effective decisions are based on the analysis of data and information.

- Principle 8: Mutually beneficial supplier relationships: An organization and its suppliers are interdependent and a mutually beneficial relationship enhances the ability of both to create value. (International Organization of Standardization 2009)

The requirements of a project need to be set out by the customer (client) and the executor of the project needs to stick to the specified requirements of the client. Leadership is the direction taken, to drive the whole organisation towards the required pre-determined goals. All people in an organisation have their role to play in the successful implementation of the required objectives. ISO 9000 recognises the involvement of everyone in the organisation in the realisation of quality in products and services. In this way, quality is built at each level of the organisation.

ISO 9000 proposes that it is easier to achieve the desired results when the procedures of carrying out activities are developed as a process to follow. A process approach should be presented and audited during the planning stages of a project. Organisations should always give room for a continual improvement in performance because opportunities to improve will materialise and if continual improvement is not considered as an objective, these opportunities will be lost. Correct and precise data makes decision making more effective because decisions are made based on the data and information available. It is easier to achieve the specifications of a project when there is a good relationship throughout the supply chain in the entire project. The beneficial relationship enables the players involved to have reasonable concern for the project objectives and work hand-in-hand to realise them. These principles are reasonable in the actualisation of project quality.

Low, Tan and Ang (1999: 89) state that it is frequently claimed that the achievement of ISO 9000 certification in the Singapore construction industry gives rise to unnecessary bureaucracy, additional paperwork as well as costs. These are the disadvantages that are found associated with the implementation of ISO 9000 in the construction industry. Summarizing an interview with the managing director of a company cited by these

authors (1999: 98), the managing director suggested that the following practices adopted in his organization have helped them to achieve high quality standards:

1. Only experienced supervisory staff, including the *kepalas* (or labour-only subcontractors), are assigned on site.
2. Subcontractors are selected based on their good track records in their own trades. Smaller jobs are first assigned to test them prior to giving them bigger jobs. An experienced representative of the subcontractor must be on site full-time.
3. The company adopts a "right first time" approach.
4. The managing director spends a lot of time on site in the company's projects. This has helped to assist site supervisory staff in their work and ensure that they do not overlook any area of work.
5. The managing director makes sure that the materials used meet specifications and that both supervisory staff and workers are instructed correctly in meeting these requirements.

The listed practice above – experienced supervisors, good records of subcontractors, companies' right first time approach, leadership and making specifications the goals of companies are best practice that can be integrated into construction companies' culture to enhance productivity in the aspect of quality. All the practices mentioned by the interviewed managing director are covered in the eight principles of ISO 9000 above.

Low, Tan and Ang (1999) analyze the effectiveness of ISO 9000 in raising construction quality standards in the Singapore construction industry (a developing country like South Africa) and they concluded that;

1. The construction firms certified by the ISO 9000 quality standards achieved higher Construction Quality Assessment System (CONQUAS) scores than non-certified firms.
2. However, the implementation of the ISO 9000 quality management system has not improved the Construction Quality Assessment System scores of those construction firms that have adopted the system.

The Construction Quality Assessment System was introduced by the Singapore Construction Industry Development Board (CIDB) in 1989 to evaluate the quality performance of building contractors using numerical scores. Some construction companies adopted ISO 9000 in Singapore and it was observed by Low, Tan and Ang that these companies had higher Construction Quality Assessment System scores than the non-certified companies. From the second conclusion, it can be assumed that the companies implementing ISO 9000 quality management system had in-built quality management policies in their system that were part of their organizational structure.

Deficiencies in three organisational sub-systems, namely Technical, Human Resource and Management, were found to cause defects in buildings (Low and Darren 2001: 6). Construction defects are not only caused by poor design or lack of use of specified materials. In their report, Low and Darren (2001: 9) state the factors that may cause failure to realise quality under the sub-systems mentioned above. These factors are summarised below as;

Technical Sub-system

1. Defective materials: Choice of materials to be used on site must meet the fitness of purpose on that site because some materials may be suitable for use in some sites and the characteristics may not make it permissible to be used on some other sites.
2. Design too difficult to build well: The quality and availability of resources used by the contractor dictates the ease of execution of projects.
3. Over-emphasis on first cost: Quality may be compromised when the client pressurises the contractor on costs, trying to reduce initial costs, by making the contractor use cheap and non-durable materials, which can be prone to failure, during execution.
4. Overlooked site conditions: There are some site conditions that should not be overlooked during planning because they may have adverse effects on the finished quality of the product. These conditions include soil conditions, weather and available space on site.

5. Poor site practices and supervision: Poor construction practices on site are a major cause of defects. Some of these practices include: inadequate curing; usage of damaged formwork and early removal; and poor materials storage, among other practices. This is caused by poor supervision.

Human Resource Sub-system

1. Ignorance and lack of knowledge: The construction industry needs to educate its players on the introduction of new materials, equipment and techniques on their characteristics and proper use to avoid defects. Some players in the construction industries are ignorant of why some things are done in the manner they are done. They could be more creative in doing things if they know the reasons behind doing things the way they are done.
2. Lack of training and skills: The operational competency of operatives is evidence of lack of lack of training and skills development. The specialists may have the technical skills to execute the project appropriately, but their employees on site should also have adequate training and skills because the employees are the ones to execute the project on site.
3. Lack of motivation and care: Motivation of employees has a direct impact on their performance which can reduce or eliminate lack of care towards their job.

Management Sub-system

1. Defective documentation: Defective documentation is caused either by inaccurate, insufficient or missing information. A major source of defective documentation is inaccurate or incomplete working drawings.
2. Poor communication: One party's assumption of knowledge and experience of another, and failure to draw sufficient attention to certain details can be a source of poor communication. This may have adverse effect on the performance of the project team.
3. Unanticipated consequence of change: Some changes are usually made quickly not to delay work or reduce the amount of rework to be done. This can invariably have undesirable effects on the project.

The table below shows the relationship between the causes of defects and ISO 9001 clauses.

Table 2.1: Relationship between causes of defects, ISO9001 clauses and defects reduction strategies

	CAUSES OF DEFECTS											
		Technical Sub-system					Human Resources Sub-system			Management Sub-system		
		Defective material	Design too difficult to build well	Over emphasis on first costs	Overlooked site conditions	Poor site practices and supervision	Lack of knowledge	Lack of training and skills	Lack of motivation and care	Defective documentation	Poor communication	Unanticipated consequences of change
ISO 9001 Clauses	4.1							**	/		**	
	4.2				**	**	**		/		**	
	4.3	**	**		**				/	**	**	
	4.4	**	**	**					/		**	**
	4.5								/	**	**	**
	4.6			**		**		**	/		*	
	4.7								/		*	
	4.8								/		**	
	4.9					**			/		**	
	4.10					**			/		*	
	4.11								/		*	
	4.12					**			/		*	
	4.13					**			/		**	
	4.14	**	**	*	*	**	*	*	/	**	**	*
	4.15					**			/		*	
	4.16	**	**	*	*	*	**		/	**	**	*
	4.17								/		*	
	4.18						**	**	/		*	
	4.19								/		*	
	4.20								/		*	
		Proper design and materials specification		Emphasis on value not cost	Comprehensive assessment of site before construction	Proper planning, execution and close process control	Effective proliferation of knowledge	Human resource planning and development	Staff support and motivation	Proper documentation and document control	Effective communication	Effective management of change
		Technical Sub-system					Human Resources Sub-system			Management Sub-system		
	DEFECT REDUCTION STRATEGIES											

Legend: ** Strong relationship; * Weak relationship; / Unsure/No detected relationship

(Source: Low and Darren, 2001 p.21)

The ISO 9001 clauses seen in Table 2.1 are listed below:

Clause 4.1 – Management Responsibility

Clause 4.2 – Quality system

Clause 4.3 – Contract Review

Clause 4.4 – Design control

Clause 4.5 – Document and data control

Clause 4.6 – Purchasing

Clause 4.7 – Control of customer-supplied products

Clause 4.8 – Product identification and traceability

Clause 4.9 – Process control

Clause 4.10 – Inspection and testing

Clause 4.11 – Control of inspection, measuring and test equipment

Clause 4.12 – Inspection and test status

Clause 4.13 – Control of non-conforming material

Clause 4.14 – Corrective and preventive action

Clause 4.15 – Handling, storage, packaging, preservation and delivery

Clause 4.16 – Control of quality records

Clause 4.17 – Internal quality audits

Clause 4.18 – Training

Clause 4.19 – Servicing

Clause 4.20 – Statistical techniques.

It can be seen from the table above that ISO 9000 can provide mechanisms to address causes of defects in construction. Each defect cause is monitored by at least four ISO 9000 clauses. It has presented an effective way of reducing, eliminating and monitoring defective quality of construction projects. Understanding and following the guidelines of ISO 9000 gives a systematic approach to achieve and improve quality at the same time.

Low and Darren (2001: 7) cited authors that critiqued ISO 9000, stating that the construction industry does not lend itself to the successful implementation of a formal quality management system like the ISO9000. They contend that it leads to a stifling of

initiative, increased confrontation and excessive cost and paperwork, which ultimately reduce rather than enhance quality. Low and Darren (2001: 7) also state that, according to some surveys conducted in the United Kingdom construction industry, implementation of ISO 9000 had contributed to some improvement for firms by increasing their management efficiencies and overall image of the company, but has also brought them increased bureaucracy, paperwork cost and time consumption. The reason behind the negative outcome associated with the improvement in the management efficiencies and overall image of companies is that there is always a price to pay for every effective procedure developed. Every procedure has advantages and disadvantages, and if the advantages weigh more than the disadvantages, it is logical to adopt the procedures. These are the strength and weaknesses of the implementation of ISO 9000.

The proper interpretation and reorganisation in line with the ISO 9000 quality assurance standards may lead to avoidance, reduction and prevention of defects in construction projects. A conceptual model may be developed based on the ISO 9000 quality management system through which construction defects can be avoided, reduced and prevented.

2.5 Construction, infrastructure and socio-economic growth

> The products of the construction sector differ widely in terms of size, appearance, location and in terms of end use. In many of the least developed countries, as much as one half of the total construction output may be in civil engineering projects (roads, railways, ports, dams, power stations, drainage projects or water supplies) forming the basic infrastructure that is so vital to all other forms of economic and social activity (Wells 1986: 3).

The finished products (infrastructure) from the construction industry differ in terms of the available resources (which include labour, materials, machines and money), skills, and purpose for usage, among other factors. There is a high flexibility in technology adoption

in the construction industry which is dependent on the available resources and the required purpose of the product (Wells, 1986). Within the single category of railway construction, a rapid rail project like Gautrain and a coal train are different products. This has a variation in terms of techniques and materials used in production and standards of the finished product.

The products in the construction industry are heterogeneous in terms of the standard, technological input and the end use. Wells (1986: 4) argues that the construction sector is different from other economic sectors in terms of the heterogeneity of the products and variety of end uses, which is perhaps part of the explanation for the wide-spread failure of economists and others concerned with development issues to grasp the concept of construction as a clearly identifiable economic sector in its own right. Wells also argues that there is no such thing as a standard construction product. From the author's argument, it is obvious that the quality of infrastructure differs in the construction industry and it is difficult to define what quality is in general: the achievement of a standard quality for each new product seems difficult. Each product has a unique specification and thus is difficult to generate standards and monitor these regularly.

Other characteristics of the construction industry are that: the finished products of the industry are immovable although some parts of the product can be produced elsewhere, transported and assembled on site; and infrastructure cannot be produced in advance.

> …the fact that construction products are site-specific, i.e. they are produced where they are to be consumed and cannot afterwards be transported, means that in general, the final products of the construction industry cannot be produced in advance of demand but rather have to be sold before they are produced or made to order. (Wells 1986: 5)

These characteristics distinguish a manufacturing company and a construction company in the sense that the management approach in terms of quality will be different in the two cases (construction and manufacturing companies). The customers may reject the

produced goods by the manufacturing company and there may not be market for the product causing price reduction which reduces profit for the company in the long run. By contrast, in construction "products", the client commits to the project before it has been produced, requiring a situation of trust between the key players of the project. The client prescribes the requirements he needs to the design team or specialist which may be in-house or hired, and also monitors the execution despite the trust he has for the contractor. The contractor monitors the project because uncompleted construction projects have no (or negative) value to the client until it is completed to specification. This is the reason why clients are always pushing on the execution time of projects in the construction phase – trying to avoid long duration of the execution.

According to Development Bank of South Africa's report (1998: 4), infrastructure can be viewed from two perspectives which are

1. Economic infrastructure: is that part of an economy's capital stock that produces services to facilitate economic production or serves as input to production (e.g. electricity roads and ports) or are consumed by households (e.g. water, sanitation and electricity)
2. Social infrastructure: provides services such as health, education and recreation and has both a direct and indirect impact on the quality of life

Good infrastructure raises productivity and lowers production costs, but it has to expand fast enough to accommodate growth (World Bank 1994: 2). Many developing countries do not produce the quantity and quality of the infrastructure needed. Growth in countries is encouraged when demand is met efficiently by the services provided. Improved infrastructure reduces costs in various ways like communication and transportation, increasing access to decent social amenities. The causes of past poor performance, and the source of improved performance, lie in the incentives facing providers (World Bank 1994: 2).

> The kind of infrastructure put in place also determines whether growth does all that it can to reduce poverty. Most of the poor are in rural areas,

> and the growth of farm productivity and non-farm rural employment is linked closely to infrastructure provision (World Bank 1994: 3).

There is direct link between construction and infrastructure within a country because without infrastructural development, the construction industry will be inactive. In a country with an active construction sector, employment opportunities are always available for the citizens. This is because as more construction jobs are embarked upon in a country, there are more opportunities to employ people. A country's investment in infrastructure contributes to socio-economic growth especially in job creation. Infrastructure can be referred to as the basic facilities and capital equipment needed for the functioning of a country.

Construction has the ability to "absorb the excluded" (ILO 2001: 12). The construction industry provides jobs that can be done without much education. There are different levels of work opportunities within the construction industry ranging from unskilled to semi-skilled to skilled and professional jobs. Most of the employment in the lower level is casual, often characterized by frequent changes in job which are short-term. In many countries, most construction workers are men but some countries are encouraging more women in the construction industry at all levels of employment. ILO (2001: 14) noted that "in India it is estimated that up to 30 per cent of the construction workforce are women." For the purpose of this research, the roles of women in construction are not specifically discussed.

According to the International Labour Organization (ILO 2001: 15), in different developing countries in the world, recruiting labour (unskilled) through subcontractors has been long established; creating a multi-layer contracting system in large construction projects and those who recruit and control the labour are the intermediaries who are at the bottom of the system. They have different local names, but have the same function: "They are known as *mistris*, *jamadars* or *mukadams* in India, *oyaji* in the Republic of Korea, *kepala* in Malaysia, *gatos* in Brazil and *maestros* in Mexico" (ILO 2001: 15). In developing countries, the construction industry has the ability to absorb unskilled labour

into the industry, providing jobs as a source of income to them. According to the ILO (2001:17), there is an evidence of increase in the use of casual labour for some decades. This shows the increase in job creation in the construction sector of most developing countries. Nonetheless when the supply of unskilled labour is far more than required in developing countries, the wages of construction employees often drop below the minimum wage.

In multi-layer contracting, workers are vulnerable to: no wage bargaining power; lack of access to medical and pension benefits; and lack of legal recourse. In terms of quality, the responsibility for training devolves to the lowest layer of this complex hiring system, which is the opposite of the best practice outlined above, generally resulting in a significantly under-qualified site workforce. Workers themselves seldom engage in training during periods when they are not employed in construction, as their low wages and lack of job security tends to force them to seek employment in other sectors during this 'down time'.

Wells (1986) identifies a close relationship between construction activity and economic growth. Anaman and Osei-Amponsah (2007: 951) state that "The construction industry plays an important role in the economy, and the activities of the industry are also vital to the achievement of national socio-economic development goals of providing shelter, infrastructure and employment". They also state that "A vibrant construction industry in a developing country, that mobilizes human and local material resources in the development and maintenance of buildings, housing and physical infrastructure, is an important means to promote increased local employment and accelerate economic growth". The construction industry is often seen as a driver of economic growth especially in developing countries because the industry can mobilize and effectively utilize local human and material resources in the development and maintenance of housing and infrastructure to provide local employment and improve economic efficiency (Anaman and Osei-Amponsah 2007: 952).

Ofori (1988: 59) highlights that Strassman (1970) studied the construction industries of all countries with a population of over 1 million for 10 years and concluded that in the initial period of any country's development, manufacturing is given a major boost for about two decades, after which construction catches up and becomes the major contributor to economic growth. Strassman also stated that construction's role in the economy declines after a country reaches middle-income stage, owing to the industry's relatively high wages and low productivity.

When there are well pronounced construction activities in a developing country, jobs will be created at all levels ranging from the unskilled labour to the specialists. Increase in employment in a country boosts the Gross Domestic Product (GDP) of the country because the people employed add to the active workforce that contributes to the Gross Domestic Product. For a developing country like South Africa, the construction industry can be a major way of alleviating poverty especially among the previously disadvantaged citizens.

Infrastructure services that help the poor also contribute to environmental sustainability (World Bank 1994: 3). All income groups benefit from infrastructure services like proper and safe disposal of solid waste, clean water and sanitation, better management of traffic in urban areas and environmentally safe sources of power supply. In developing countries, provision of infrastructure can be linked to one of the ways by which the government eradicates poverty. Embarking on developmental projects by governments of developing countries, where policies that supports the use of labour-intensive construction methods to create jobs and empower the citizens to create sustainable growth in the country, is a strategy to alleviate poverty. ILO (2001: 14) states that "people work in construction out of necessity and not out of choice. Almost universally they wish for better things for their children."

There are some problems in the achievement of quality in developing countries. When the purpose is not achieved at the end of a project, there is a high probability that the operational costs of the project will be higher because of the maintenance during use.

This is a factor that should be considered during the development phase or when there is a deviation that needs to be effected in a project.

The figure below shows the percentage composition of infrastructure changes with country income level. From this diagram, about 60% of total infrastructure within a low income country is basic (i.e. sanitation, water, railways and irrigation) while basic infrastructure is about 20% in high income countries.

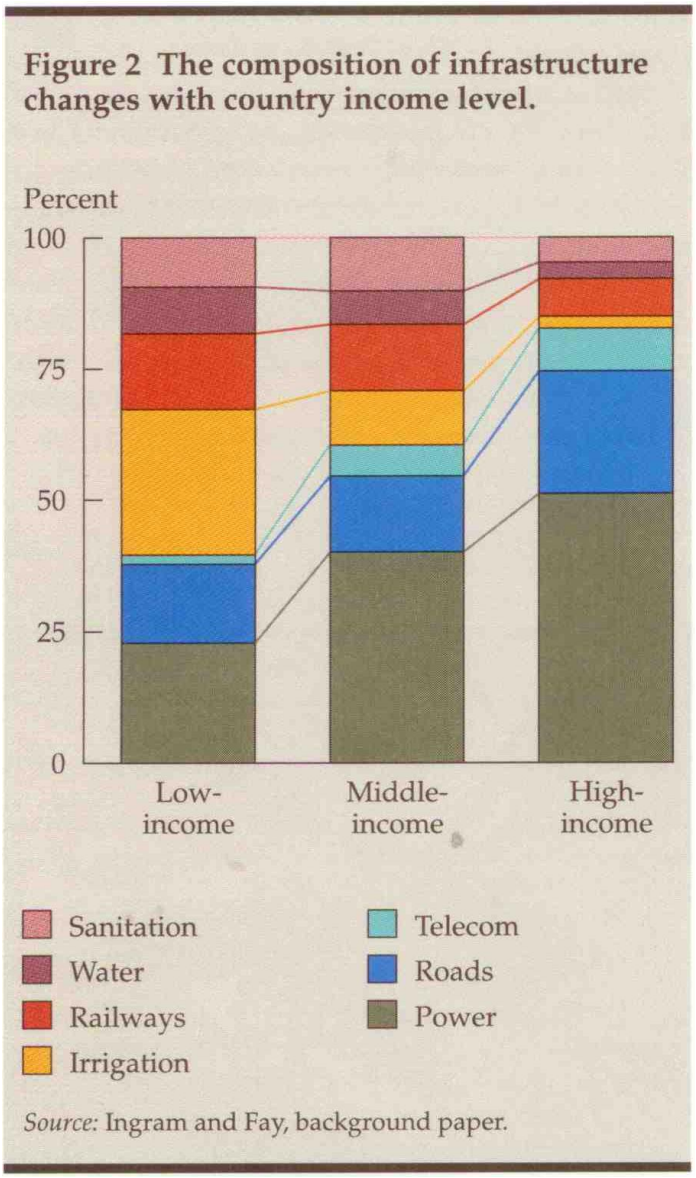


Figure: 2.2 The composition of infrastructure changes with country income level (World Bank Report 1994: 4)

In conclusion, Infrastructure represents if not the engine, then the "wheels" of economic activity (World Bank 1994: 14). The buoyancy of an economy can be easily spotted from the activities of the construction sector. Infrastructure's impact on development can be linked to economic growth, the quality of the environment and poverty.

2.6 South African policies on construction

After apartheid, the South African Government put programmes in place to empower previously marginalised citizens and improve the economy. This has given rise to several pieces of legislation and policy documents that can be grouped under the heading of "Black Economic Empowerment". In response to a history dominated by colonialism, racism, apartheid, sexism and repressive labour policies, the South African government came up with a programme - the Reconstruction and Development Programme (RDP).

McCutcheon and Taylor Parkins (2003: 16) noted six aspects of employment that have been disturbing in South Africa. These are summarised below:

1. The unemployment level is high and rising – from both formal and informal sectors, unemployment grew from 7% in 1980 to between 27% and 37% in 2001.
2. The formal employment sector was able to absorb 81% annual net additions to the labour force in 1960s but this shrank to under 10% in 1990s.
3. Unemployment varies geographically – some villages may have over 70% while others may be about 30%.
4. The level of unemployment amongst the uneducated between the ages of 16-19 is about 70%.
5. There are deleterious effects on people who are unemployed which lead to violence and extreme stress.
6. Because the South African economy has become more capital intensive, less than half the additional employment was created between 1986 and 1990 compared to 1971 and 1980.

The country's major policy document- the Reconstruction and Development Programme (RDP) was drawn up by the ANC and the key objectives were: meeting basic needs; developing human resources; building the economy; democratising the state and society; and implementing the Reconstruction and Development Programme (ANC 1994). The Reconstruction and Development Programme is an integral, coherent socio-economic policy framework that seeks to mobilize South Africans and the nation's resources towards the final eradication of apartheid and the building of a democratic, non-racial and non-sexist future.

Developing human resources as defined by the African National Congress (ANC) means involving South Africans in decision-making processes, in implementation, in new job opportunities requiring new skills, and in managing and governing the society (ANC 1994).

This gave birth to the Expanded Public Works Programme (EPWP) which is aimed at providing poverty and income relief through temporary work for the unemployed to carry out socially useful activities. The immediate goal of the Expanded Public Works Programme Phase 1 was to help alleviate unemployment by creating at least 1 million work opportunities, of which at least 40% of beneficiaries would be women, 30% youth and 2% people with disabilities (Expanded Public Works Programme).

> The Expanded Public Works Programme Phase 2 was launched in April 2009 at the University of the Western Cape. The goal of EPWP phase 2 is to create 2 million full time equivalent (FTE) jobs for poor and unemployed people in South Africa so as to contribute to halving unemployment by 2014, through the delivery of public and community services (Expanded Public Works Programme).

The Expanded Public Works Programme (EPWP) has exceeded its aimed target that was set when the programme was launched in May 1994. According to the South African

Government Information, at the end of April 2008, the programme (EPWP) had already created 1 077 801 job opportunities, ahead of its scheduled 31 March 2009 time limit.

The Expanded Public Works Programme (EPWP) is managed by Department of Public Works, which manages and provides accommodation, housing, land and infrastructure needs of national departments. The Expanded Public Works Programme optimizes employment, growth and transformation in the construction and property industries (South African Government Information 2009).

Two fundamental strategies underpin the government's approach to reducing unemployment: firstly, to increase economic growth so that the number of net new jobs being created starts to exceed the number of new entrants into the labour market; and secondly to improve the education system such that the workforce is able to take up largely skilled work opportunities which economic growth will generate. Short- to medium-term strategies have been put in place to contribute towards these strategies, of which the Expanded Public Works Programme is one (Expanded Public Works Programme). This has required the various tiers and departments of Government to embark on labour-intensive projects and insist that labour-intensive methods be considered on the major projects.

Not only does the Department of Public Works take steps to reduce unemployment in the country, they also support and empower women-owned construction enterprises through contractor development programmes such as the Emerging Contractor Development Programme (ECDP). As part of the Emerging Contractor Development Programme, the Contractor Incubator Programme (CIP) was inaugurated with the intention of providing support to existing small- to medium-size construction enterprises to enable them to become sustainable. By August 2008, a total of 136 contractors were registered on the CIP, of whom 62 were women-owned contracting businesses (South African Government Information). The figures show that the women contractors owned about 46% of the total local companies in South Africa. This is a great performance of the Emerging Contractor Development Programme.

Another state entity that has contributed to the reduction in unemployment, poverty and inequality through policies and programmes is the Department of Labour. The policies and programmes of the Department of Labour are aimed at:

- Improved economic efficiency and productivity;
- Skills development and employment creation;
- Sound labour relations;
- Eliminating inequality and discrimination in the workplace;
- Alleviating poverty in employment;
- Enhancing occupational health and safety awareness and compliance in the workplace;
- Nurturing the culture of acceptance that worker rights are human rights. (South African Government Information 2009)

The Employment and Skills Development Services (ESDS) is a unit under the Department of Labour that helps to achieve one of the focuses of the South African Government – skills development. There is also Human Resource Development strategy, which has given rise to a framework that stands on four pillars of strategic intervention:

- capacity-development initiatives: developing human capital for high performance and enhanced service delivery;
- organisational support initiatives: enhancing organisational capacity and support to maximise the productivity of human capital;
- governance and institutional support initiatives: ensuring that the Human Resource Development in the Public Service is effective;
- economic growth and development initiatives: ensuring that the Human Resource Development plans, strategies and activities seek to integrate, promote and respond to the economic growth and development initiatives of government. (South African Government Information 2009)

The Human Resource Development strategy helps in increasing the sustainable capacity development for the low income level citizens of South Africa.

The Sector Education and Training Authority (SETA) is another sub-department under the Department of Labour that contributes to the raising of skills, to bring skills to the employed, and assisting those wanting to be employed in their sector. They help to implement the National Skills Development Strategy through ensuring that people learn the skills that are needed by communities and employers. In most developing countries construction skills are still mainly acquired through an informal apprenticeship system (ILO 2001: 38). The Expanded Public Works Programme encourages formal training for all levels of the employees working under the programme. This assists in ensuring that things are done right the first time to reduce price and costs during execution.

Aggressive Affirmative Action (AA) policies were the first step taken to move black employees quickly into the corporate ranks where they can be trained and developed. Two basic arguments have been made in favour of such aggressive strategies (McFarlin, Coster and Mogale-Pretorius 1999: 65). The first is that the positive effects of economic growth will take too long to filter down to affect corporate practices. If South Africa fails to redress apartheid's inequalities quickly, it risks a level of racial polarization that could tear the country apart. The second argument is that aggressive Affirmative Action is simply good business since black consumers will dominate the South African economy in the future. Moreover, Affirmative Action will help the business environment by lowering unemployment and crime (McFarlin, Coster and Mogale-Pretorius 1999: 65).

> However, despite the large government programmes since 1994 to eradicate the inequalities of apartheid, almost 50% of the country's population lives under the poverty line defined as R1400 or US$140). In South Africa, the poorest 10% of the population receives only 1.4% of the total income, while the richest 10% receives 47.3% of the total income (du Plessis, Irurah and Scholes 2003: 242).

The poverty level in South Africa has induced the government to embark on development projects with all forms of programmes and policies to ensure that the there is poverty reduction, growth and development in South Africa. These programmes have been quite effective in growing the economy of this developing country.

2.7 Summary of Literature Review

In summary, this chapter has reviewed the history of quality management and the perceptions of some quality pioneers about quality. Various quality parameters were defined and discussed in this chapter, including quality; quality control; quality assurance; quality management; and total quality management. To develop total quality management in an organisation, the workers in the organisation must be aware of the quality system, quality manuals must be developed, the system must be introduced to the organisation for a trial period which is determined and finally, there needs to be an evaluation of the system by reviews and audits.

Quality assurance in construction involves three parties – the client, the design consultants and the contractor. The role of each party is dependent on the procurement system chosen for the project. The need of quality assurance in construction was also reviewed and it was discovered that high percentage of errors that lead to the non-achievement of quality in construction is caused by either the design or the construction management team, or by breakdown in communication between them.

The International Organization of Standardization – international standards Body of Knowledge - has contributed to quality achievement in the construction industry by laying principles down and certifying the International Organization of Standardization compliant companies, showing that they meet up with international standards. These help clients to build up confidence in their International Organization of Standardization compliant contractors and consultants. A comparison between the causes of defects and the International Organization of Standardization clauses was reviewed, i.e. how the ISO9001 clauses manage each cause of defects in projects. This chapter has also reviewed some critiques of the International Organization of Standardization, stating that implementation of ISO leads to uncreative initiatives, excessive costs and additional paperwork.

The relationship between the construction industry, infrastructure and economic growth was established in this chapter. The literature showed that developing countries with a booming construction industry tend to embark on infrastructural projects, which create jobs for citizens and eventually have a positive impact on the economic growth of the country. The policies of the South African government on the construction industry were reviewed since 1994 (post apartheid) and it was found that the performance of the policies has been quite encouraging in meeting the targets specified.

The aim of this research is to explore the possibilities of a developing country to embark on an International Organization of Standardization compliant project by involving local industries in the execution phase of projects, meanwhile International Organization of Standardization requires compliant players in the supply chain.

The next chapter presents the research methodology, conventional rail infrastructure projects in South Africa and the case study.

3.0 METHODOLOGY AND CASE STUDY

3.1 Research Methodology

This research investigates the quality management of the Gautrain project which demands a high level of quality. Therefore, the approach to this research is descriptive. The major players in the supply chain were interviewed in order to have access to data and information for perusal and analysis. These data include the quality management plan, method statement and other quality assurance documents. Interviews were conducted with some of the key staff involved in the quality procedure, on the relationship between Black Economic Empowerment policies and the achievement of them in the Gautrain project.

3.2 Conventional rail infrastructure projects in South Africa

According to the Passenger Rail Agency of South Africa (PRASA), before 1990, the road and rail based passenger services in South Africa were provided by the South African Transport Services (SATS) – a state-owned entity.

Transnet Limited and the South African Rail Commuter Corporation Limited (SARCC), companies created in terms of the Legal Succession to the South African Transport Services Act, (Act 9 of 1989) took over this responsibility from April 1990. Commuter rail services were transferred to the SARCC but long distance (both road and rail) passenger services continued to be provided by Transnet, which created a number of operating divisions including Spoornet and Autonet, the forerunner of Autopax.

In 1992, a subsidiary company, Intersite Property Management Services (Pty) Ltd (IPMS), was formed to manage and develop the newly transferred property portfolio which was a part of the services allocated to the SARCC. Transnet ran the commuter rail

assets on behalf of the SARCC through Metrorail – an operating unit of Spoornet – until 1996 when Metrorail became a business unit of Transnet.

According to the head of stations and facilities development, Passenger Rail Agency of South Africa (PRASA) is the mother company for Metrorail, Shosholoza Meyl, and Autopax. The primary objectives of PRASA include:

1. Ensuring that, at the request of the Department of Transport, rail commuter services are provided within, to and from the Republic in the public interest; and
2. Providing, in consultation with the Department of Transport, for long haul passenger rail and bus services within, to and from the Republic in terms of the principles set out in section 4 of the National Land Transport Transition Act, 2000 (act No. 22 of 2000). (PRASA)

According to the head of stations and facilities development, PRASA was created by the Government to advance its agenda for the transformation of the public transport system into a vibrant and efficient one. PRASA is responsible for ensuring that passenger rail in South Africa is efficient and properly run in the country.

PRASA is currently playing a major role in the development of social and economic infrastructure in the environments that new railway lines are being run. These objectives are monitored through monthly progress reports and weekly meetings. There are clauses in the contracts used by PRASA to ensure that the contractors comply with the specifications, such as job specifications and employment of local contractors. Employment of local contractors is a way of ensuring that people around the communities where projects are carried out benefit from the project by empowering them through employment. The penalties in the contracts are as severe as termination of the contract when the contractors do not comply with specifications. Also, PRASA appoints a professional team and one of their tasks is to monitor the socio-economic objectives and give a report to PRASA at the end of each month.

PRASA embarks on new projects when there is a need for an extension of rail services in developing areas around the country. Presently, PRASA is executing an extension in the

rail system in Kwazulu-Natal (Bridge City Rail Link) which is about 3.2 kilometers. The contract types used are Joint Building Contracts Committee (JBCC) and Fédération Internationale Des Ingénieurs-Conseils (FIDIC) for station buildings and SPK5 for the rails. The SPK5 contracts can only be found in the rail industry because they are specific to rail contracts. The maintenance of the existing rail system is also done by PRASA.

To ensure that quality, safety and health are excellent on PRASA projects, PRASA appoints a professional team that brings a resident engineer full time on site and who also have quality inspectors to supervise and monitor activities.

This is the environment within which the Gautrain was conceived – where the conventional construction practice where there is a division of design and construction (phases and teams), no indication of specific commitment to training, conventional contract types, management of quality through the contract provisions (inspection by the consultant team and resident engineer). By contrast, analysis of the Gautrain project shows the level of integration and dedication to quality management principles and processes needed to achieve the joint objectives of quality and socio-economic development.

The information gathered from the visits and interviews are discussed from chapter 3.3 to chapter 5.

3.3 The Gautrain Project

3.3.1 Introduction

The Gautrain Rapid rail link is a rail network project in Gauteng presently in the execution stage. The project client, the Gauteng Provincial Government, went into a Public-Private Partnership with Bombela Concession Company (Pty) Ltd to execute the project. The project is a design, build, operate and transfer (BOT) project, which will be finally handed over to the Government after 15 years.

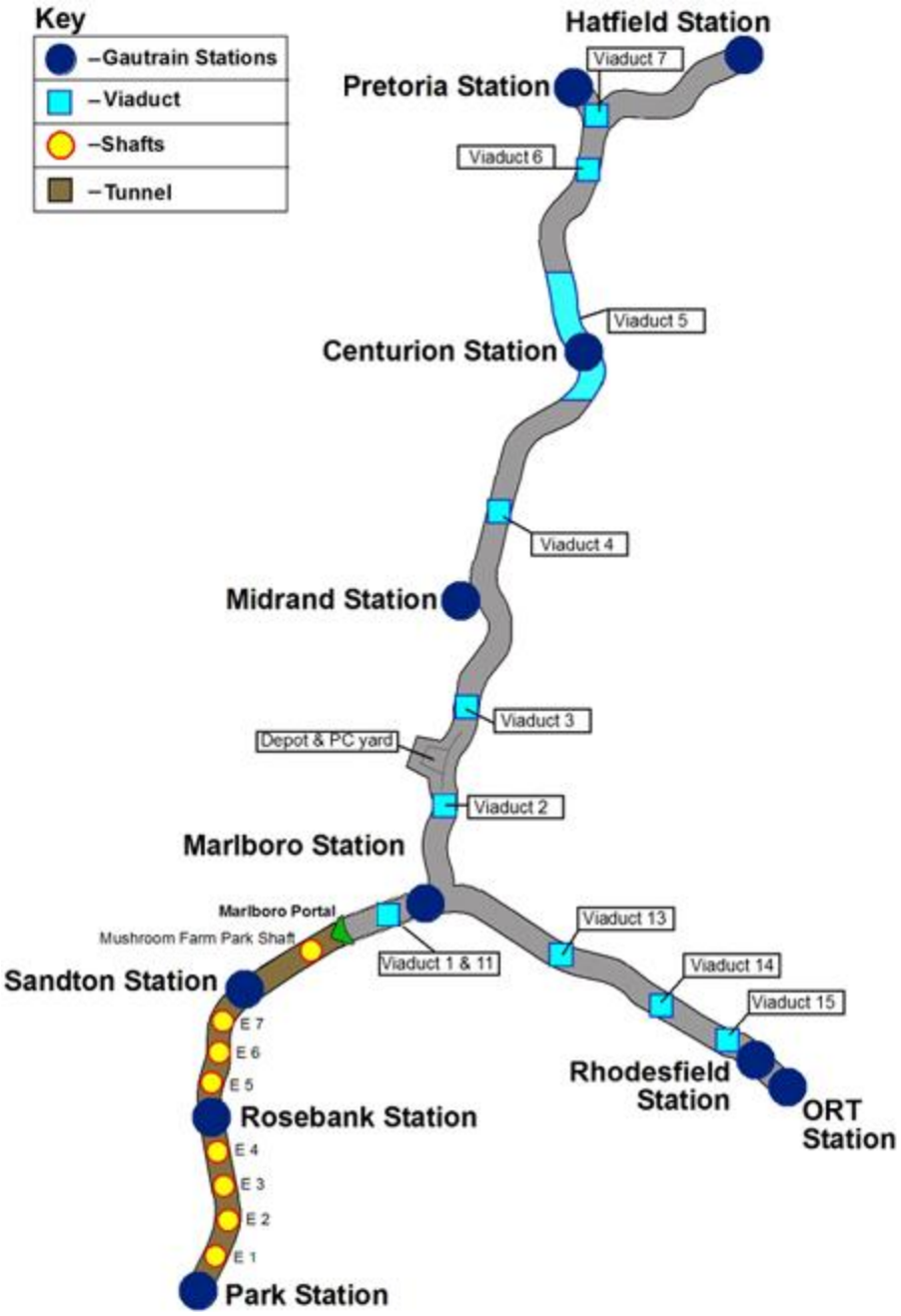


Figure 3.1: The Gautrain routes showing stations, viaducts, shafts and tunnel. (Source: www.gautrain.com)

The Gautrain consists of two links - Pretoria (Tshwane) to Johannesburg and Sandton to OR Tambo International Airport. The total length of the two links is about 80km. Gautrain has three anchor stations which are located at OR Tambo International Airport, Pretoria and Johannesburg. There are seven other stations located along the rail tracks.

The train is expected to deliver internationally recognised standard of transportation in terms of predictability, reliability, safety and comfort (Gautrain).

At the inception of the Gautrain project, the client – the Gauteng Province - engaged consultants to make a conceptual proposal for how the overall Gautrain rail system would work. Two potential bidders were employed to put bids together which explored the feasibility of the concept. The two bidders did the feasibility study and the selection of the bidder was primarily based on the functionality of their proposal. Bombela Consortium was the selected bidder for the Gautrain project. When Bombela came in to being, they already had an overview design that had to be fine-tuned to produce the detailed design. Bombela as a company was not appointed to execute the actual design, but rather to manage the design.

Bombela Consortium is made up of three companies – Bombela Civil Works, Bombela Electro-Mechanical and Bombela Operator. The contribution of the three companies towards the Gautrain project needs to be synchronised. Whatever the civil company builds, they need to provide exactly what suits the electro-mechanical company to enable them fit their components on the Gautrain project in order for the operating company to get an end product that meets the client's requirements and is profitable to operate.

The Gautrain project is split into 10 packages. The first package (DP1) is for the alignment, the geometry, station locations, and the geometry of the tracks. The second package (DP2) consists of the geotechnical aspects which includes the geotechnical surveys. The third package (DP3) is for the underground area, which is the tunnel section from Park Station in Johannesburg to Sandton. The fourth package (DP4) is the airport link from OR Tambo to Sandton.

The fifth package (DP5) is split into two: DP5A is the depot area around Midrand; and DP5B is from Marlboro station to Midrand station. The sixth package (DP6) starts from the Midrand station and runs through to Pretoria. The seventh package (DP7) is the Pretoria area and Hatfield. The eighth package (DP8) is the safety design including the

safety concept of how people will evacuate. Each of these packages was contracted to different consultants. The Bombela design team had to manage the entire programme scheduling and delivery by all of the consultants so that all of the packages could be integrated so that when the construction phase started, all the designs were ready.

Some of the factors that might have influenced the programme of works negatively on the Gautrain project were delays in execution, as has been experienced in many other projects of similar complexity. However, the major factor that has been experienced as a threat to the programme of works for the Gautrain project is the availability of land and the transfer of land parcels by the client to the contracting consortium.

3.3.2 The need for the Gautrain Project

For several decades, Gauteng, the economic heartbeat of South Africa, has experienced intense traffic congestion on its major roads during peak hours. The Gautrain has been designed in such a way as to encourage private car owners to use this new rail system to reduce the traffic congestion on the major roads. The train has been designed to be environmentally friendly, economical for users, less time consuming, safe and comfortable for users (Gautrain). In terms of conventional objectives, Gautrain is expected to impact the following:

- Personal travel time;
- Government revenue;
- Health care and environmental costs, including reduction in automobile accidents;
- Pollution - Gautrain will contribute to improved air quality due to fewer movements of motor vehicles. (Gautrain)

The Gautrain is estimated to provide a number of substantial economic benefits to Gauteng. It is to contribute between 0.7% and 1% to the GGP (Gross Geographic Product) of Gauteng (Gautrain). The impact of the Gautrain's construction on industrial sectors would lead to an increase in business sales by about R3 615 million. Additional business sales of R327 million per annum would be the result of operational and

maintenance expenditure and up to R3 600 million due to economic activities in and around the stations.

The Provincial Government has made the Gautrain project a developmental project in order to empower the people in the community. This was planned by structuring the concession agreement to meet certain socio-economic development goals, despite the high level of quality and precision required for the project. In relation to this policy, the Gautrain project is expected to contribute to accelerated economic growth, development and infrastructure delivery, with emphasis on:

- job creation;
- quality service delivery;
- good governance;
- SME development;
- investment in black economic empowerment;
- convergence of Public-Private Partnerships; and
- promotion of tourism. (Gautrain)

3.4 Management Structure of the Gautrain Project

The major Gautrain project players include the client (Gauteng Provincial Government), the main contractor (Bombela) and the certifiers (Independent Certifiers – IC, and Independent Socio-Economic Monitor – ISEM). The Bombela Consortium has a Concession Agreement with the Gauteng Province for the Gautrain Project.

The Independent Certifiers certify the civil works carried out on site. They are employed by both Bombela Joint Venture and the Gauteng Provincial Government. Both of the parties pay an equal share for these services in order to make the Certifiers unbiased towards either of the parties (client and contractor) throughout the project execution.

The Independent Certifiers must certify all milestones every month as a continuous process. Bombela submits their milestone statements monthly and IC goes to site to verify what milestones have been achieved and send reports back to both Bombela and

the client. At regular intervals they meet to discuss the progress of the project. When there are problems on the structures, such as when the constructed structure does not conform to the requirements, IC only gives their opinion to the parties. The IC is managed by a neutral reputable engineering company, ARUP.

The electro-mechanical unit takes care of the co-ordination of the electrical and mechanical aspects of the Gautrain project, the design of which is subdivided with different designers for the track, the overhead switches electrification, functionality of the stations and security. The Turnkey Contractor (TKC) is the project management consultant for the Gautrain project, playing a pivotal role in fusing all the components together to make the project a success.

Due to the scale of the project, the Independent Certifiers have to be rational about the quality checks on site, which they do by prioritising what will be checked because checking the quality at each stage will need the same resources that the execution team has, thereby making more extensive checking uneconomical for the client. The Independent Certifiers do not only monitor the quality; they also monitor the cost of the Gautrain project for the client.

Bombela Concessionaire has to certify itself because of the nature of the project – build-operate-transfer – in which their ability to run the Gautrain at a profit for the operational period is significantly influenced by maintenance and repair costs that would result from an inferior construction phase. Within Bombela, there is a quality assurance department that looks out for quality and certifies the works internally. Also, within Turnkey Contractors, there is a quality department that performs internal checks. These different quality assurance departments serve as levels of certification up to the overall certifiers that certify payment when satisfied. The client also has a representative on site similar in function to a resident engineer who monitors the quality of the work executed on site. The representative has the authority to stop work on site if the execution of the project is not according to the drawings or specifications.

The structure of the quality management system in terms of quality personnel is explained below. There is a project quality manager, who is at the head office, and on each section of the project, there are section quality managers or quality engineers. The quality management team is integrated with the execution team to implement the quality system.

A quality manager ensures that the execution team gives the client a quality product which should last about 50 years, in line with the concession agreement. The quality manager carries out quality control and quality assurance in the tunneling works, civil works and road works – basically all the works on his section. The quality manager has inspectors that work for him. The quality manager and inspectors do the inspections on site together with other members of the execution team, ensuring that the correct materials are used and the correct testing is done. This is achieved with the aid of planned documentation.

The quality manager liaises directly with the client, Gauteng province, to make sure that they are satisfied with the works on site. If there are queries on site, the quality manager discusses them with the client. The quality manager also interacts with the designers to ensure that the design is ready on time and is done properly. Any correspondence from the site to the design team goes via the quality manager, using the system that was set up for this purpose. The co-ordination of testing on site is done by the quality manager to ensure that the structures meet the specifications and requirements from the client.

One of the most important policies of the Gauteng Provincial Government is the socio-economic policy, namely job creation, skills acquisition and small contractors/suppliers development. To achieve this, the Gauteng Provincial Government employed the Independent Socio-Economic Monitor, ISEM, to monitor the socio-economic development goals of the project. At the end of each month, the Independent Socio-Economic Monitor reports back to the project team, giving the figures pertaining to the socio-economic development goals. From the Independent Socio-Economic Monitor's reports, it can be easily seen whether the objectives are being achieved or not.

This political commitment to the Gautrain has encouraged the Gauteng Provincial Government to support the project with about half of the cost of the project. The contractual structure of the Gautrain project comprises ten main parties. This is simplified in the table below:

Table 3.1: Contractual interrelationship in Gautrain Rapid Rail Project.

S/N	Party	In contract with the	Type of contract
1	The Gauteng Provincial Government	Bombela Concession Company	Concession Agreement
2	The Bombela Concession Company	Gauteng Provincial Government, lenders, shareholders, Bombela Turnkey Contractor, Bombela Operating Company	Concession agreement, shareholders agreement, financing agreements, turnkey contracts and O&M contract.
3	The Shareholders	Bombela Concession Company	Shareholders agreement
4	The Lenders	Bombela Concession Company	Financing agreements
5	The Bombela Turnkey Contractor	Bombela Concession Company	Turnkey contracts
6	The Bombela Operating Company	Bombela Concession Company	O&M contract
7	The Bombela Civil Joint Venture	Bombela Turnkey Contractor	Civil contract
8	Bombela Electrical & Mechanical Works	Bombela Turnkey Contractor	Electrical & Mechanical contract
9	Bombela Maintainer	Bombela Operating Company	Electrical & Mechanical maintenance contract
10	The Bus operator	Bombela Operating Company	

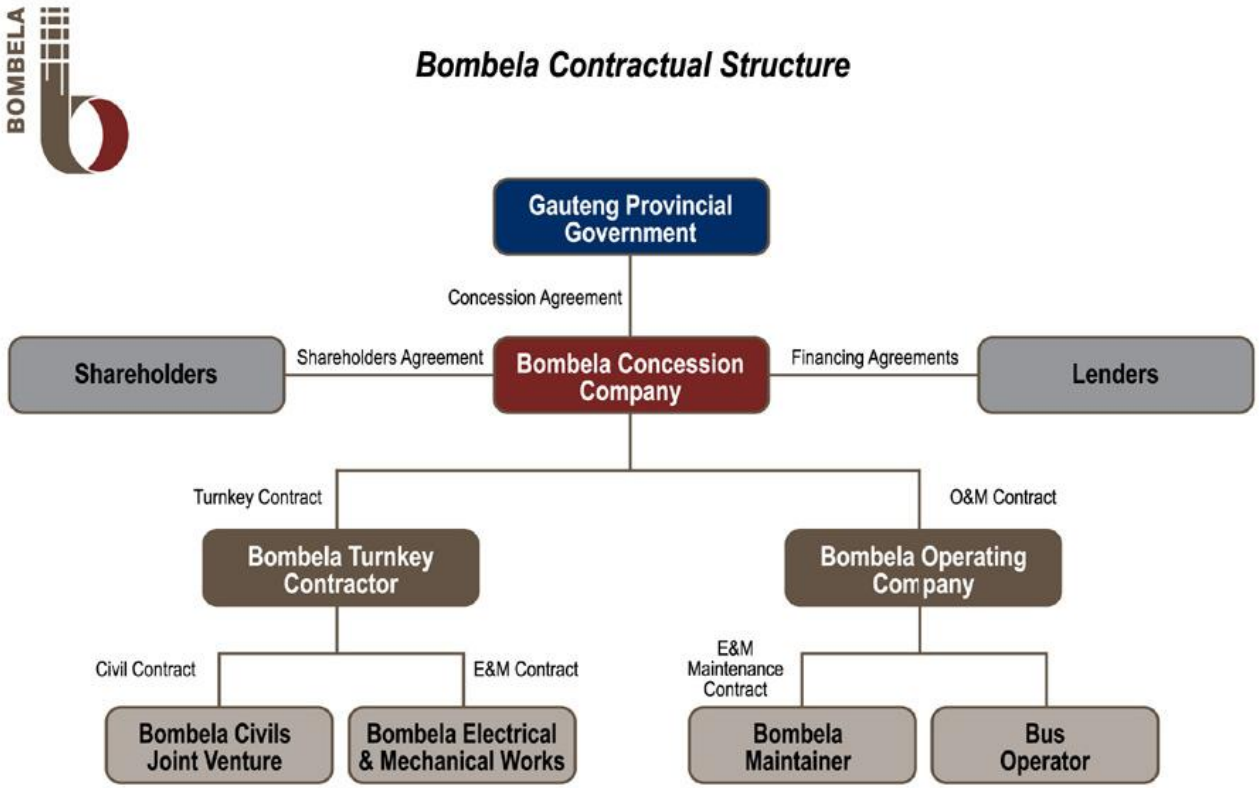


Figure 3.2: Bombela Contractual structure. (Source: Bombela Civil Joint Venture's Quality Management Plan, 2007)

4.0 QUALITY MANAGEMENT IN THE CONSTRUCTION OF THE GAUTRAIN PROJECT

4.1 Introduction

The basic concepts of quality have been discussed in chapter 2. This chapter looks at the practical quality management techniques adopted for the Gautrain Rapid Rail project by the players of the project.

Quality management is an integral part of the overall management of the 80 km rail link project between the OR Tambo Airport to Sandton and Johannesburg to Pretoria. The quality management in the Gautrain project focuses on delivering the Gauteng Provincial Government's requirement which was stated in the concession agreement. Despite the fact that the Provincial Government had extensive socio-economic development goals in the Gautrain project, the quality aspect of the project was also planned extensively. Quality was planned into the project from the inception stage to the last phase of the project. As earlier stated, to certify the quality of work, the Gauteng Province and Bombela jointly appointed a neutral body, Independent Certifiers (IC), to certify the quality and milestones of the project. In order to be unbiased, the Independent Certifiers is paid jointly by the Provincial Government and Bombela in a ratio of 50:50.

They carry out inspection and testing to confirm that the structure or product conforms to requirements. The project quality management plan designed for the Gautrain by Bombela views and implements the achievement of quality from three different angles or approaches;

- Process quality;
- Product quality; and
- Workmanship quality.

The process quality is the approach to quality during the execution stage. The plan which details process quality is called the execution quality plan, which details the method,

procedure, types of tests and documents that are needed for the execution of the Gautrain project. This gives detailed explanation of the whole quality process.

The project quality was defined from the inception stage of Gautrain and is incorporated in the design of the project. This required quality was defined initially by the Gauteng Provincial Government because they are the client of the project. Quality is first defined at this stage; therefore we can assume that the quality vision for the Gautrain project started at this stage. The set quality acts as the standard that the project's deliverables are to meet, which is the basis of quality incorporated into the design and the execution quality plan.

The workmanship quality deals with the skills of the people performing the work. The project team players improve the style and character of the work to be performed by sending different levels of workers for training as mentioned above. Despite the number of people specified for training, Bombela perceived the need to train more people in order to improve the quality of work during the project life cycle.

It will be seen that the Gautrain project is in conformance with the three approaches from the project quality management plan which will be reviewed later on in this chapter. Bombela's Quality Management system follows the Deming approach:
PLAN → DO → CHECK → ACT.

The Deming approach assures that good planning will secure quality. The quality procedures of the Gautrain rail link project were developed from the planning stage to specify the quality requirements from the client. The execution quality plan of Bombela Civil Joint Ventures is based: on ISO 9000; previous experience; and the Gautrain project requirements. The major principle for the quality execution is that all activities must be carried out in a controlled and verifiable manner by working as a team.

ISO9000 is the baseline of the quality management procedure for the Gautrain project. The quality management approach follows the ISO9000 system closely, while the

procedures were fine-tuned to suite the Gautrain project which introduces additional processes to accommodate the complexities of its objectives. For ease of reference, Bombela has embedded all the quality management systems into the quality management processes and procedures for their subcontractors. This facilitates the wide range of capacity of the smaller players, in that the contractors do not need to reference the ISO9000 documents once they have the contract documents. In this way, there is an avoidance of conflicting documents in cases where the contract may contradict or create ambiguity with the ISO9000 documents, leading to the possibility of unresolved issues. There needs to be a hierarchy of applicability of documents when there is more than one document to be used in projects to avoid such issues.

The quality management team uses a deviation reporting policy which is similar to ISO9001 in that it uses nonconformance reports, field change requests, and so on., all of which will be discussed later in this chapter. It is a process that is carried out on site in order to record and handle problems that are encountered during construction or mistakes that are made; ensuring that the right response is given and involving the right people in sorting out the problems. The quality management system is basically a reporting system which includes deviations and which record mistakes on site.

This type of project (build-operate-transfer) is a fairly new concept in South Africa which is not suited to a traditional type of contract. In traditional contracts, the contract designer will be appointed by the client to develop the project and prepare the contract documentation. The contractor will be selected, generally through a tender process, to carry out the construction in compliance with the contract documents.

The approach to quality control in conventional construction projects as dictated by the General Conditions of Contracts (GCC) requires the separation of the design and the construction of projects. The duties and authorities of the site agent and resident engineer are clearly stated in the contract. The authority of the engineer's representative is stated in section 2.5.2 of the GCC while he "observes the execution of works, examine the test materials and workmanship, and receive from the contractor such information that he

shall reasonably require" (GCC 2004: 4). In summary, the resident engineer and site agent ensure that correct procedures are followed and that cover-up work meets specifications. The Project Engineer inspects the works for compliance with the contract and certifies payments on the basis of this.

There has been extensive criticism of this approach, dating to the Banwell Report to the UK government in 1964, as it has been associated with projects running far over time and budget, and being one of the major sources of dispute, especially in larger and more complex projects. The Gautrain builds on these processes by introducing a higher level of Quality Management (ISO 9000) and through greater integration of the design and construction functions, both being responsible directly to Bombela rather than to the client, creating a single point of responsibility for meeting the client's requirements and to ensure that Bombela has a quality product that will be viable for them to operate for the period of their concession agreement.

By contrast, the design and construct approach is a concept that is used more often in Europe. In the Gautrain project, the client appointed Bombela Consortium, who then appointed the design team. The designers are directly responsible to Bombela Consortium while the contractor works on site for Bombela Consortium in a similarly direct relationship. If the design does not meet client requirements or there are problems of constructability, the Bombela Consortium representative goes back to the designer for a redesign stating the reasons. On a big project like this, it is impossible to design everything perfectly; there are changes on site always, which is what the quality system is designed to accommodate. All these changes are recorded through a system that includes the designer, with copies to the client. The record keeping on the site is extensive. Generally, for everything the Bombela Consortium representatives do, there is a paper trail because at the handover stage all this documentation, including all testing procedures and results, forms part of handover to the client to show the quality of the product that was built.

The sub-contractors must follow Bombela's system for activities during the execution of the project i.e. carrying out all activities in a verifiable manner. In realizing a successful project, communication is one of the major factors that influence the success. The communication for technical matters in this project ensures that the sub-contractors and suppliers have a direct link to the site agents working for Bombela.

The site agents communicate directly with the contract managers and the contract managers relate directly to the construction managers, other production teams and other departments. The construction managers report directly to the construction director, other joint venture parties and interested parties. The project director liaises directly only with the construction director. The Province relates directly to the other joint venture partner, Bombela, only. These lines of communication are quite direct and not too complex, making communication from any angle very effective, with direct lines to the source.

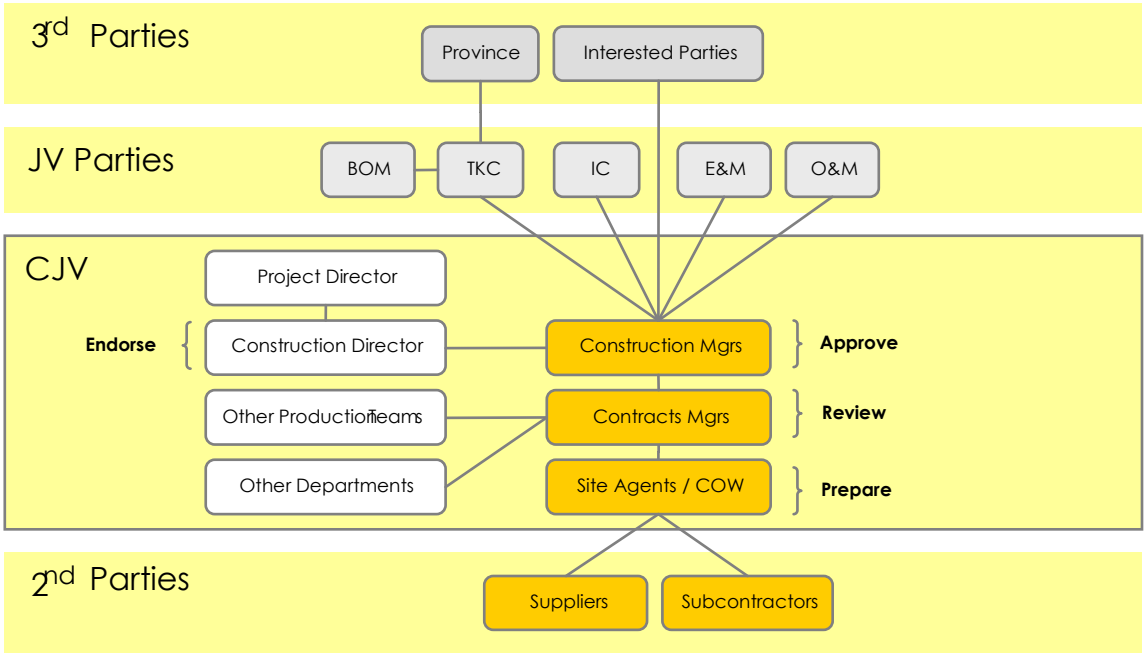


Figure: 4.1 Communication relationship of the team players of Gautrain (source: Bombela Civil Joint Venture's Management Plan, 2007)

As with many other projects, disputes are ongoing in the Gautrain project. There is a legal/commercial department that takes care of the disputes in the Gautrain project.

During an interview with one of the design team members, he stated that time and cost are major reasons for dispute in the project. The biggest dispute he identified from the Gautrain project is on the viaduct section. The electro-mechanical company did not give sufficient input from the inception (calculations for the train, the actual train load, equipment that is needed and the train dynamics), and when the civil company started the execution of the project, the omitted items started springing up. The items that were later brought up by the electro-mechanical company induced redesign; putting a strain on the scope of work, the programme and the quality of the product. On the other hand, the electro-mechanical company, although they had problems in terms of finalizing some parts of their design, are also claiming for delays in terms of handovers.

There is no contractual document that states what the electro-mechanical company can claim in terms of delays and handover but it can be quantified in terms of costs. When disputes arise in the Gautrain project, the first step is negotiations between the parties involved, but when there is no progress, then the case may proceed to the highest level – the arbitrators.

One of the quality managers also made reference to a dispute with the subcontractor in relation to the Sandton station when the contract was accelerated. The contractor put in an additional claim which was regarded by Bombela as being excessive. The basis of the dispute was that the subcontractor was not getting design information on time, which went down the legal route. There are also safety related disputes, with some of the subcontractors having their contracts terminated because of poor safety standards, causing fatalities on the job.

The delays in the programme of works for the Gautrain project have been associated with:

1. expropriation and delayed delivery of land parcels;
2. unforeseen circumstances.

The Gautrain route passes through some portions of land in private ownership as residences or businesses and the Government needs to take possession and compensate the land owners – expropriation. The expropriation process takes time in the Gautrain project and causes delay for the execution team in the programme of works. Unforeseen circumstances, such as the geology of some areas, may cause delay if there needs to be a redesign.

When there are safety disputes, the job continues without interruption until the dispute is resolved. In terms of time and quality, the job does not get stopped although if the subcontractor decides to stop the job; it will be to his own detriment.

There are different contract types used in the construction of the Gautrain project, depending on the type of work to be done. There are specific contracts that were written by the Gautrain legal unit at the inception of the Gautrain project and these are combination of different contracts. FIDIC is one of the contracts used as the basis for the customized contracts for the project. For construction, the Gautrain project team also uses an adaptation of the South African standard building contract, the JBCC. The standard Civil Engineering contract, the GCC, is the model for the civil engineering infrastructure of the Gautrain project. These specific contracts are not used in their original format, but are adapted to suit the project and co-ordinate with each other.

For instance, if there is a need to write a contract for one package to build a station, it will be difficult because the station comprises the civil and the electro-mechanical aspects. At the inception of the preliminary design, lawyers were contracted to develop the contracts that are applicable specifically for the Gautrain project that cover all project players. Each discipline also has its own sets of contract conditions and legal requirements that are put into place to contract all the services. The contract type used for the Gautrain project therefore draws on a combination of existing standard documents and not specifically on one type of contract.

Audit checks are monitoring tools used to ensure that the project plan is being followed during the execution phase of the Gautrain project. If the output is deficient, there is a plan for deviations. There are a number of documents being used to monitor conformance during the execution stage. Some of these documents include:

- Work plan: This defines the organizational solution and this applies to a team;
- Method statement: This defines the technical solution when there is a risk to manage;
- Inspection and test plan: Checking arrangements when conformity needs to be demonstrated;
- Work instruction: This specifies tasks or instruction;
- Approval of materials: This is for materials that are not fully specified;
- Standard forms: They promote consistency in the recording of information
- Methods drawings: These drawings support method description.

These documents have significant contributions to the monitoring of the quality of Gautrain.

Method statement requests are made by Bombela from their sub-contractors before awarding contracts to them, to ensure that the quality of the structure matches up with the requirements of the client. The method statements also include the health and safety control aspects to the staff and the environment.

4.2 The Project Management Plan

The Project Management Body of Knowledge defines a project management plan as a formal, approved document that defines how the project is executed, monitored and controlled (PMI 2000: 205). It may be in summary form or detailed and may be composed of one or more subsidiary management plans and other planning documents.

The project management plan defines the ideas or actions intended to approach the delivery of the project management scope of a project by the project team. During the course of interviews with key staff members involved in the quality management of the

Gautrain project, it was discovered that the project management plan comprised two types of documents: the project quality plan and the execution quality plan.

From discussion with a design team member for the Gautrain project, a design management plan shows how the flow of the design works. For instance, the process starts with the conceptual design and from the concept, the design is developed. When there is a need for change in design, the developed design gets reviewed through the review process. At the initial stage it is called review in principle (RIP). When there is a proposal for change in design, a report follows the working drawing, justifying the reasons for opting for that design, showing the standard requirements, standards applicable, if the requirements are met or not and this document is reviewed.

The review process involves the electro-mechanical consultants also having an opportunity to review the design as well as the client, the Gauteng province. After the review in principle is finalized, the construction design is prepared. The construction design stage is where the detail drawings are done. There is a review process during or after the construction design. Soon after all the comments and disputes are settled on the construction design, the as-built drawings are issued. When there are items or situations on site that may bring in constraints during the construction process, changes can be proposed to the design. These changes are referred to as deviations.

The quality management plan lists the detailed processes linked to the design plan which allows for deviation in the Gautrain project. The deviation reports are either generated by the construction team or generated by design team. The types of deviation reports include:

1. the field change request (FCR);
2. the non-conformance report (NCR); and
3. the materials record sheet (IOM) .

All these reports are explained to detail in the next sections of this chapter.

4.2.1 The Project Quality Plan

The project quality plan identifies the procedures and activities that a project team defines, plans, and executes to assure the quality of the project deliverables and project management. The purpose of the Project Quality Plan is to define the activities and tasks that are required to deliver products while focusing on achieving customer's quality expectations (Visitask, 2009).

According to Visitask (2009), a detailed Project Quality Plan should contain the following: management responsibility; documented quality management system; design control; purchasing; inspection testing; non-conformance; corrective actions; quality records; quality audits; and training.

The Project Quality Plan for Bombela Civil Joint Venture consists of the following sections: the preliminaries; the introduction to the Gautrain Project; Project Organisation; Bombela Civil Joint Venture Policy; Objectives and Strategies; and the Project Management System.

Preliminaries

The preliminaries section of the Project Quality Plan of Bombela Civil Joint Venture highlights the purpose of the project quality plan, the scope, the references and requirements, responsibilities towards the Project Management Plan and definitions. The purpose of Bombela's Project Quality Plan is basically the introduction of the project; contractual and team organisation; Bombela Civil Joint Venture's management policies, objectives and strategies; and the Civil Joint Venture's project management system.

The scope of the Project Quality Plan includes the design and execution of permanent and temporary works within the civil works scope; and related activities such as procurement, document control, non-conformity management and others. The scope excludes partner company internal processes; the preferred bidder period; and the defect liability period.

The references and requirements include the Statutory and Regulatory requirements, Concession Agreement, the Project Management Manual and the Project Quality Plan. The responsibilities towards the Project Management Plan are stated and the sources of their definitions are also stated for the purpose of clarity.

Introduction to the Gautrain Project

The second section of the Project Quality Plan introduces the different aspects of the Gautrain project. The aspects discussed include the location; project objectives; the programme; some facts about the economy, civil works and operation; and schematics of the station and alignment. It is stated in the introduction that the rail system will be designed, constructed, partly financed and operated by a private sector party through a Public Private Partnership (PPP) Concession. A sketched map of the route of the Rapid Rail Project is included in this document, showing the location of the stations.

The project objectives are listed as a reminder of the requirements of the client – the Provincial Government. The definitions of the programme period are stated and the timeframe for each of the periods is also clearly outlined. As stated above, the facts observed in this document are under the headings of economy, civil works and operations. The economic facts include the estimated project cost, economic growth and estimated job opportunities. The civil works data include the length of the rail, volume of earthworks, different civil structures and their sizes/volume, types of station and so on. The operation section includes speed, analysed distances, analysed time, amongst other operational values.

Project Organisation

This section under the Project Quality Plan describes the organisations' structure and the type of agreement that exists between the players. The formal agreements are strictly marked out, the result of a liaison agreement, with a diagram showing the relationships between the players involved in the project. The roles and responsibilities of the

Province's representative organisation, the Independent Certifier and Bombela are clearly stated during the project development and execution period. The Bombela Civil Joint Venture organogram is shown in the Project Quality Plan, highlighting the main departments and reporting structure.

Each production team in the Gautrain project comprises quality, safety and environmental staff to provide effective support to the line management by being close to the personnel, activities and works. All of these staff members have to make reports to their respective managers to ensure that the management system is complied with. The functions of each level of worker are defined diagrammatically, simplified as endorse; approve; review; prepare/do.

Bombela Civil Joint Venture Policy, Objectives and Strategies

The policy of the Bombela Civil Joint Venture is clearly stated in this section of the Project Quality Plan. This policy covers their commitment to design, execute and deliver the civil works of Gautrain project to the Turnkey Contractor (TKC). The policy is to meet and enhance the stakeholder objectives. The stakeholder objectives are distinctly stated in a legible manner under this section in this document. The policy covers the staff's responsibility to follow the management system in their work and support its continuous improvement in accordance with stated values.

The strategies to be used in the achievement of the stated objectives and policy are to be realised through Bombela Civil Joint Venture's project management system and they are clearly stated as:

- Activities to be performed in a "controlled and verifiable manner";
- One project, one system; and
- Civil Joint Venture is responsible.

These will be clearly explained in the discussion chapter. The management representative responsibilities are enumerated in more detail in the concluding part of this section.

Civil Joint Venture Project Management System

The overall requirements for the management systems of the Turnkey Contractor, Bombela Civil Joint Venture, Electrical and Mechanical, and Operation and Maintenance are defined in Bombela's Quality Manual, which requires compliance with ISO9001 and OHSAS18001 for quality, and health and safety management systems respectively. Bombela Civil Joint Venture's project management structure consists of input from:

- Government – Statutory;
- Project – Manual;
- Organisation – Management plans;
- Process – Procedures; and
- Activity – Instructions.

The different forms of statutory documents used by the government, province and authorities that are recognised by the Civil Joint Venture Quality Manual include Laws, Acts, Standards, Codes and Permits. The concession agreement is also a product of statutory documents that serves as an understanding between the client and contractor on the project. The Quality Manual of Bombela Civil Joint Venture is a document that is produced specifically for the Gautrain project.

There are 16 management plans under the Civil Joint Venture's project management systems that are used to improve coherence and assist in implementation and maintenance of the Gautrain project. These include:

1. The Project Quality Plan: This document introduces the project, the contractual and team organisation, Bombela Civil Joint Venture's management policy, objectives and strategies, and the Civil Joint Venture's project management system.
2. The Risk Management Plan: This explicates the how the process described in the Bombela Project Risk Procedure is implemented in Bombela Civil Joint Venture. Two categories or risks are analysed, and these are:

- Technical Risks – those that have impact on time, cost and technical requirements; and
- Legal Risks – those that have impact on health and safety and environmental requirements.

Three major stages of risk management are identified by the Risk Management Plan which include: Analysis; Control; and Report.

3. The Safety Management Plan: This explains how the execution activities are achieved with regards to safeguarding health and safety. Included in the Safety Management Plan are statutory requirements of the Occupational Health and Safety Act, the Mine Health and Safety Act, OHSAS 18001 amongst other documents.
4. The Environment System Plan: This document consists of four principal divisions which include:
   - Framework – details the overall strategy for environmental management on the Project;
   - Issues during construction – provides the specific mitigation plans linked to environmental impacts, aspects, activities and facilities;
   - Design requirements and criteria – provides specific requirements to be addressed during the design;
   - Checking and corrective action – details the monitoring programme for environmental compliance and management process for deviations.
5. The Management System Plan: This describes how the Civil Joint Venture's project management system is to be grounded, executed and maintained according to ISO9000 standard. This document addresses customer focus, management system planning, management review, audits, deviations and improvement.
6. The Organisation Plan: This shows how Bombela Civil Joint Venture provides resources needs. It shows the roles and responsibilities, authorities, and reporting relationships; recruitment of competent personnel; training to ensure competence and planning of suitable means and work environment.
7. The Internal Communication Plan: This document ensures that the correct information gets to the point of use. This document shows the interfaces and lines

of communication; how meetings are structured; document control; and reporting. The summary of the internal document control flow is sketched in the document.

8. The Design Quality Plan: This gives the detailed design process implemented by the design team and their sub-consultants. It is made up of the planning, organisation, risk management, document control, design process, changes, as-built design, design review, design verification and approbation.
9. The Execution Quality Plan: The aim of this document is to define the process of execution of the Gautrain project in a "controlled and verifiable manner". This document will be examined critically into in the next section.
10. The Procurement Plan: This shows Bombela Civil Joint Venture's procurement process to ensure requirements are clearly defined; vendors' ability to fulfill these requirements is assessed prior their engagement; and the agreement, including specification, is reviewed and approved before it is issued. The Procurement Plan describes two types of risks which are the 'significant risk' and the 'low risk'. A schematic diagram showing a summary of the procurement process is included under this subsection.
11. The Subcontractor Plan: This document serves as an "Information Document" for subcontractors and is presented according to the ISO9001 structure. It informs them about Bombela Civil Joint Venture's management system.
12. The Plant and Equipment Plan: This document shows how Bombela Civil Joint Venture carries out maintenance and required checks for their plant and equipment.
13. The Completion Plan: This shows how the Civil Joint Venture intends to progressively agree practical completion of the works with Turnkey Contractor, Bombela and the Province as civil structures are completed.
14. The Socio-Economic Development Plan: This shows the organisation set up for achieving the targets for recruitment of "historically disadvantaged individuals", local procurement, black economic empowerment and other related aspects.
15. The Admin Finance Plan: This describes the organisation of the Administration / Finance department, outlines its functions and introduces the subordinate procedures relating to each.

16. The Enabling Works Contract Plan: This document was established as a stand-alone system for certain “enabling works” recognised by the Province.

This research only investigates the documents that deal directly with quality management, namely the Project Quality Plan and Execution Quality Plan.

4.2.2 Execution Quality Plan

As the name implies, Execution Quality Plan is a quality management document used to plan the execution of a project by the project team. The purpose of this Execution Quality Plan document is to define how Bombela Civil Works plans its construction processes and controls their execution. The execution quality plan also covers plant and equipment, stating that the plant and equipment must be in safe and proper working condition. This is different from the Project Quality Plan because it describes the overall general aspects of quality in the system, documents used in the method stage and documents used in the realisation stage. Bombela Civil Joint Venture’s Execution Quality Plan has the following sections: preliminaries; introduction; general aspects; methods stage and realisation stage.

Preliminaries

This section of Bombela Civil Joint Venture’s Execution Quality Plan describes the purpose of the document, scope of the document, the references and requirements, responsibilities towards the Execution Quality Plan and terms and definitions. The scope of the Execution Quality Plan covers the civil engineering aspects of the Gautrain project, specifically the execution phase processes; permanent works; temporary works; and subcontractors. The only part excluded from the scope is the permanent works design, which is the subject of the Design Plan. The Concession Agreement and the Project Management Plan are the two references stated in this document. The Quality Manager prepares and maintains this plan while the construction staff is responsible for the implementation.

Introduction

The Civil Joint Venture's principle – *all activities must be carried out in a controlled and verifiable manner* - is introduced as the basic principle of the project management system especially for the construction stage. This means that what and how things are done in the execution phase should be defined in advance and must carried out in a way that demonstrates that the design and method planning were followed throughout the construction process.

Since there is a variety of large civil structures to construct in the Gautrain project, various teams are involved in the construction process and the need for consistent management arises: this is where the Execution Quality Plan approach takes over. The Execution Quality Plan is based on three major principles: activities shall be performed in a controlled and verifiable manner; one project, one system; and Bombela Civil Joint Venture is responsible. The Execution Quality Plan encourages the project team to "say what they do" and "do what they say". Saying what they do can be attached to planning phase of the project while doing what they say can be linked to the execution phase of the Gautrain project.

The set up of the execution plan is highlighted in the introduction part of the document which includes the general aspects, methods stage and the realisation stage.

General Aspects

The general aspects of the Execution Quality Plan refer to the aspects common to the methods and realisation stages of the execution phases. These are management system; organisation; communication; procurement; plant and equipment; survey; planning; and document control.

The Execution Quality Plan is an integral part of the Civil Joint Venture's project management system. The processes that are general to the project are defined in the

documents established at the start of the project while processes specific to design and work packages are established during the project according to the programme. Examples of the general management plan include the risk management plan, health and safety plan, environmental plan, management system plan, and organisation plan.

The organisation aspect clearly highlights the organisational structure with roles and responsibilities. The execution of Gautrain project is divided into two main departments, which are responsible for the north and south areas of the project and are controlled by a Construction Director, each reporting directly to the Project Manager. In each of the main departments major sections are managed by Construction Managers and sub-sections by Contract Managers, backed up by Site Agents. A simple table showing the organisational structure is shown in the document.

As earlier stated, the quality management of the Gautrain follows the Deming Cycle and the roles and responsibilities (as defined by Deming Cycle) can be mutually related to the job titles and levels in the Civil Joint Venture's execution team. The table below summarises the relationship between the quality management approach and the job titles / levels.

Table 4.1: Relationship between the quality management approach and the job titles

Responsibilities	Section level	Sub-section level	Work package level
Plan (prepare)	Contracts Manager	Site Agent / Subcontractor	Supervisor
Do	Contracts Manager	Site Agent / Subcontractor	Supervisor / Gang leader / Workers
Check	Construction Manager	Contracts Manager	Site Agent
Act (approve/improve)	Construction Director	Construction Manager	Contracts Manager

(Source: Bombela Civil Joint Venture's Execution Quality Plan, 2007)

An amplified table summarising the interrelationship is also shown, highlighting the general aspects, method stage and realisation stage. Each execution team is independent and has its supporting functions like quality, safety, environment, survey, planning,

procurement and cost control. This allows clear communication of the requirements for the specific work section.

Figure 4.1 shows the interfaces and line of communication between the key players in Gautrain and key positions in Bombela Civil Joint Venture. The figure makes the communication clear and precise and shows that communication follows the chain of responsibility. The Execution Quality Plan acknowledges that most day to day communication is informal – this includes email and faxes, however, only formal documented communication is recognised. A table showing the sources / causes of communication, with the means of communication and control is shown in the Execution Quality Plan. The document control department maintains each category of the communication control whereas the originator is responsible for the quality of the document.

Shared understanding is essential to communicate effectively, therefore meetings are necessary to raise issues and reach agreement. Meetings are an essential form of communication that has a goal of resolving issues. Bombela Civil Joint Venture have structured their meetings to be hierarchical so that matters arising beyond the scope or authority of attendees can be transferred to an appropriate meeting for follow up, therefore making sure that the meeting remains efficient. Meetings for the Gautrain project are planned to be properly conducted, led by a chairman, remain on time, and have formal minutes dispatched in a timely manner.

The diagram below shows the type of meetings, frequency of meetings, the chairman of meetings and the attendees in the Gautrain project.

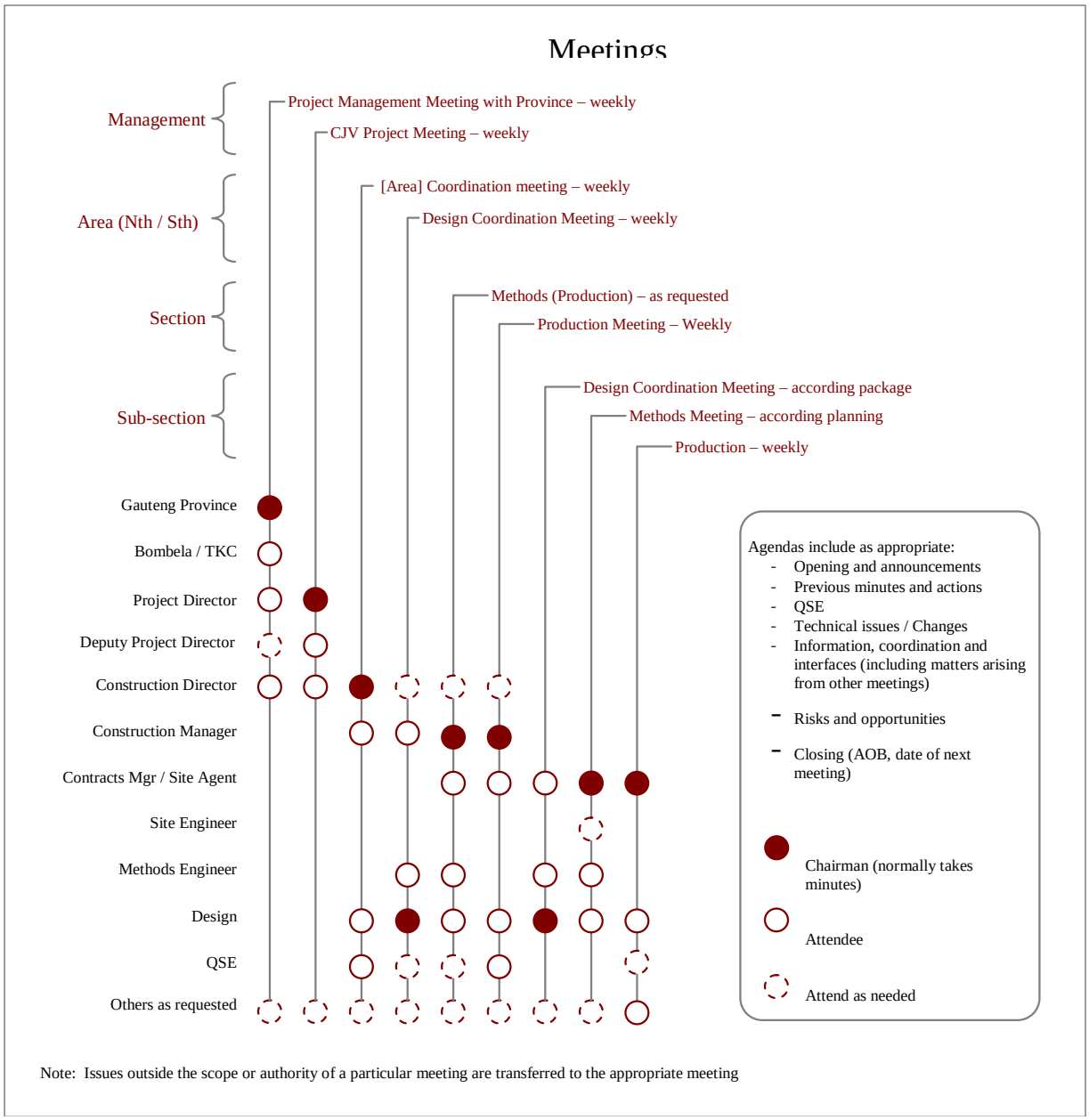


Figure 4.2: Schedule of meetings (Source: Bombela Civil Joint Venture's Quality Management Plan, 2007)

Bombela Civil Joint Venture's Procurement Plan specifies the procurement processes to ensure that requirements are clearly specified; assessment of vendor ability before appointment; review and approval of agreement including specification. Two procurement processes are identified, depending on the risk to the project objectives, in the Procurement Plan. These are:

- Contracting: This is done through subcontracts, supply contracts, rental contracts and service agreements. This is particular to work with significant risk.
- Purchasing: This is done through purchase, work and rental orders. This is common to works with low risk.

The level of risk is determined by the Construction Directors and Construction Managers. As purchases are for specifically lower value items, the purchasing process is shorter (particularly for sites where rates are established) and the review process is also shorter. Purchasing is supported by software which allows staff to initiate, review and track orders from their computer stations. A flowchart showing a summary of the procurement system is included in Execution Quality Plan.

The plant and equipment departments manage preventive maintenance and required checks, including safety checks and equipment calibration as defined by the Plant and Equipment Plan. The Plant and Equipment Plant states that: “only plant and equipment that is in safe and proper working conditions may be used for construction works”. The accuracy of the equipment used to report conformity of works must be known. The Plant and Equipment Plan states that: “the subcontractors and suppliers must demonstrate the same to Civil Joint Venture for their plant and equipment upon request”.

A description of the survey practice, organisation and processes applied by Civil Joint Venture can be found in the Survey Work Plan, which was prepared and maintained by the Chief Surveyors. Where specialised survey methods are needed such as the Viaducts, segment casting and tunneling, survey method statements are made. For specific survey tasks that require clear instructions such as settlement monitoring and calibration, work procedures are made. The survey organisational structure is described in the Execution Quality Plan, showing the lines of responsibilities of the workers in the department.

The Planning Procedure shows how Bombela Civil Joint Venture’s activities are programmed and monitored. The planning procedure defines the types of programmes and the frequency with which they must be issued; the frequency, manner and format in

which the various programmes are issued; the planners to update the programme; the manner in which changes can be made and controlled; and the manner in which variance must be reported and managed. Planning software is used to maintain the overall programme of the Civil Joint Venture activities, using network precedence and critical path method.

The Internal Communication Plan describes the Civil Joint Venture's document control procedures, and the aspects covered are preparation, registration, dispatch, filing and changes. The quality of the documents that are prepared is the responsibility of the originator, and must also be reviewed, approved and issued according to the Internal Communication Plan. A pattern of registration of documents is followed at Bombela Civil Joint Venture, monitored by the Document Control Department. Documents are registered in a unique pattern that shows the project structure, discipline or type of documents according to the communication plan.

To encourage document registration, only documents that appear in the Civil Joint Venture's master register exist in the project, and must have passed through the Document Control Department. The master file contains documents in the master register, which are maintained by the Document Control Department according to the filing plan. Changes to technical documents are highlighted according to the Internal Communication Plan. Suspended or cancelled documents are to be discarded except those to be kept in the master files, and if they are retained, they must be clearly identified.

Methods Stage

The methods stage details the planning of "how" to execute the project and show how work is to be properly realised and verified. The following aspects are described under this section: method planning, methods process, risk management, work plan, method statement, inspection and test plan, work procedure, approval of materials, standard forms, toolbox training, method drawings, temporary works and methods review.

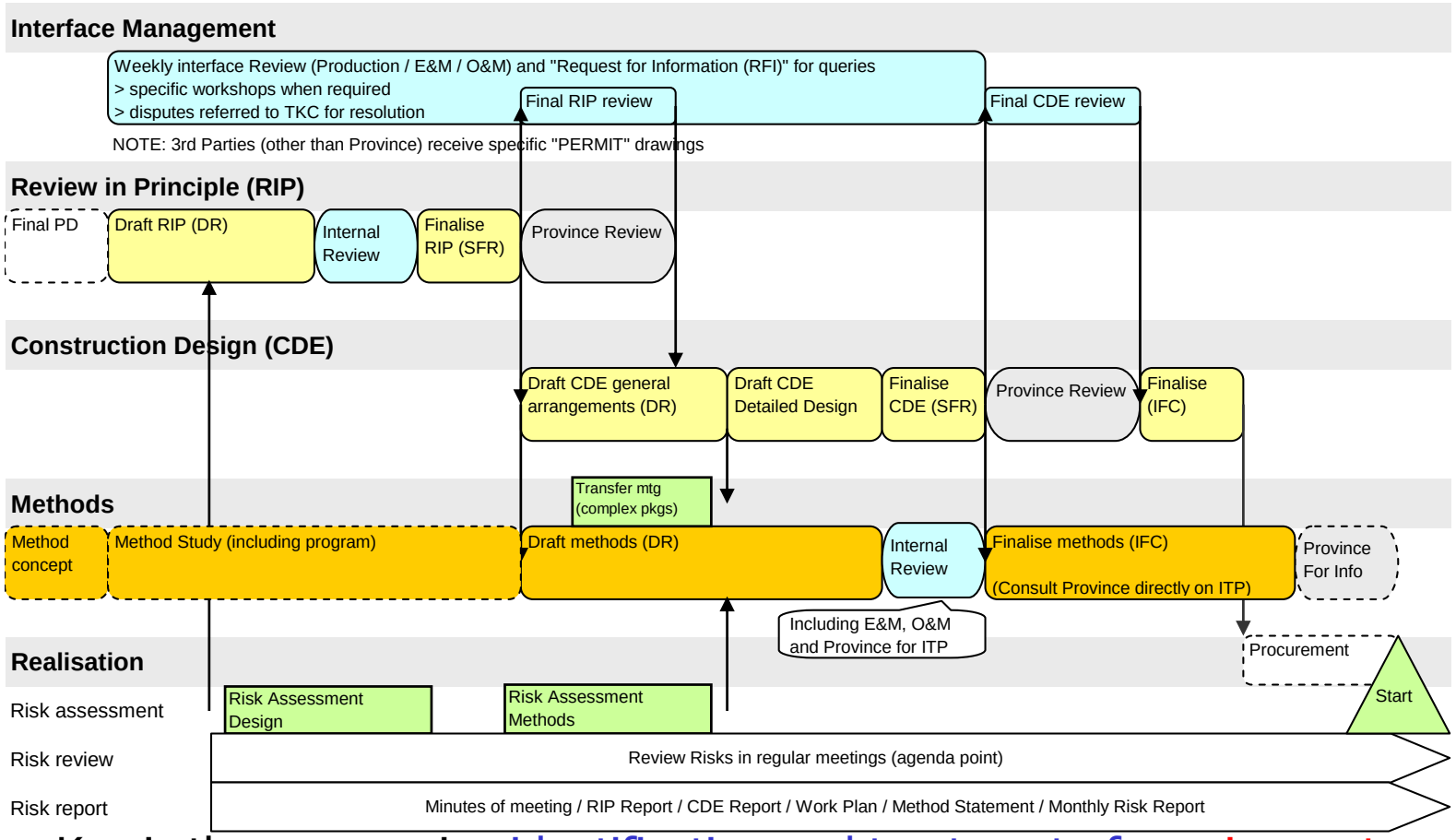
All construction processes are planned prior to execution which includes safety and temporary works which can affect permanent works. The level of planning depends on the risk of achieving and verifying the requirements. Following some guidelines, the Construction and Contracts Managers decide the degree of planning required. The Contracts Manager maintains methods planning which defines the breakdown of works scope, the associated method documents planned, the person or subcontractor responsible to prepare them and the target date to complete preparation.

The "Methods" specify the planned arrangements for execution and can be viewed in terms of the technical and organisational solution. The method statements and drawings define the technical solution which starts once the design is advanced. The methods process is started during the bid period where concept methods are prepared as part of the preliminary design. Detailed design is prepared in packages at the development stage firstly by review in principle (RIP) which specifies the design input and the construction design which defines design output. The other processes of the methods process are described from the general arrangement drawings to the detailed drawings and the risk assessment. The organisational solution is also described under this section.

The Risk Management Plan describes the risk management system of analysis, control and reporting, which is supported by Bombela Civil Joint Venture's Risk Manager and software that allows risk owners to populate and update their risks themselves. Risk analysis involves risk identification and evaluation as described in the Risk Management Plan. This is an exercise that can be done as a desktop study or through a meeting organised by the risk owner and other involved parties. Risk control involves developing measures to avoid or mitigate the impact of risks and monitoring their implementation. The implementation of the mitigation measure is taken up where necessary in the method planning so that it becomes built-in. The party responsible for the implementation of risk mitigation reports the status to the risk owner on a regular basis. Therefore, risks are managed through Civil Joint Venture's system, led by risk owners.

Methods Process

Refer 2000-8009 Execution Plan



- Key is the progressive identification and treatment of requirements

Figure 4.3 : Methods Process (Source: Bombela Civil Joint Venture's Quality Management Plan, 2007)

The Work Plan shows the planned organisational arrangements for a team, defined separately from method statements. Work Plans may include technical arrangements, often for manufacturing process where there is a close integration between the organisational and the technical aspects. It is not necessary for Work Plans to follow a standard format but the Civil Joint Venture suggests a model that can be followed.

The Method Statement serves as the technical solution in executing a work product. Method Statements are prepared by the production team and focus on the explanation of how applicable requirements are to be addressed rather than the process steps. There are two types of method statements – the Method Statement and the Simplified Method Statement. The templates of these two types of Method Statements are given under this subsection.

To ensure that all activities are carried out in a controlled and verifiable manner, Inspection and Test Plans plan the arrangements to verify conformity of materials and works during execution. This gives the opportunity to check, and make corrections where necessary in order to meet up with conformance and demonstrate conformance. This is produced in tabular form showing: item – for reference; what – the characteristic to be checked; how – the method used to check the characteristics; when – during process checks should be made available to detect deviation at early stage; who – a competent person to perform the check; point – allows other parties to participate in the check realisation; criteria – the standard to judge conformance; record – demonstrate conformity with specified requirements; why – provides traceability to the requirement for the check; legend and notes – to explain the abbreviations used.

Work Procedures are produced when required and they describe specific management systems used at the general project level. Work Procedures are similar and are based on a type of standard form which may be altered to suit the intended use.

Where there is no full specification of materials to be used by the design party and the full specification is only known when production starts, Approval of Materials is needed.

Therefore the materials that will be used for permanent works and those that can affect permanent works must be approved before use. When an approved design fully specifies materials, no further approval is necessary. Approval of Materials is a type of Standard Form.

Where certain document formats are used repetitively, standard forms are used to ensure consistency in the information captured. The quality department can help in the preparation and they are mostly created during execution for records of repetitive works. The standard form should contain the following: standard header; standard footer; content – to suit purpose; and result.

Method Drawings show the technical solution of the execution method, and often include details of plant and equipment used. They are produced using computer aided design and serve to formalize the construction method and supported as applicable by calculation. They are produced by Method Engineers working in construction teams and are issued as technical documents.

The production team is responsible for the design of temporary works required for executing the design. The Temporary Works Procedure defines the temporary works which requires that the each Construction Manager maintains a temporary works register for their section.

The preparers of method documents are the first to review the documents, followed by concerned departments and parties. The originator self-checks that the requirements are fulfilled. Once the documents are reviewed by the departments and parties involved, the document may be issued for construction and work may start on site.

Realisation Stage

Once the design and method documents have been issued for construction, works may start. The production team does not rely on other parties such as Province and authorities

to check for their quality compliance during production but the quality department provides surveillance checks and audits. The following aspects are discussed under this section: inspection and testing, control points and notification, sampling and testing, deviations, records, inspection and test status, use of inspection, measuring and test equipment, identification and traceability, protection of materials and works, completion, improvement, and emergency event (technical).

To demonstrate conformity, site supervisions that are defined in the Inspection and Test Plan are recorded whereas informal checks are regularly made (daily) which are not recorded. The Inspection and Test Plan covers the following stages: Approvals – they must be obtained before the process starts; Receiving – before incorporation of materials into works; In process – creates opportunities to check the conformance during the production process and rectify deviation cases as defined in the Inspection and Test Plan; Final – this ensures that the final acceptability is verified.

The Inspection and Test Plan creates opportunities for other parties to participate in controlling the continuity through the release of Hold and Witness points. For Hold Points, work can only continue if the parties shown in the Inspection and Test Plan have released the check by signing the record and attending at the specified time. For Witness Points, work process continues even when participating parties have not attended at the specified time provided that the conformity has been verified by the responsible person for the check. Participating parties may not attend registration points but they are informed of the results. The person responsible for the check informs the participating parties at the agreed period showing the work element, activity, location, type of check, date and time.

Only ISO17025 compliant laboratories carry out testing for this project, including internal laboratories set up by Bombela Civil Joint Ventures. Process testing can be carried out in non-accredited laboratories but not for acceptance tests. The methods described in the Inspection and Test Plan are used for sampling of materials, but if done internally, work procedure defines the sampling procedure and training is given as

appropriate. A request for a testing form is issued when testing instructions are not clearly defined, showing the test method to be performed and the identification and traceability details on the test report.

Deviations occur when the work does not meet up with the requirements and when detected, they are first recorded on the applicable check record by the responsible person. The deviation procedure is as follows: Identify – identify a deviation; Corrective action – action to rectify deviation; Preventive action – action to avoid recurrence; Review and approval; Implement / close – verify deviation is resolved and that corrective action is effective; and Evaluate – periodic analysis for learning and improvement.

Different documents are used in the deviation procedure. These include: Field changes request – used to obtain permission to deviate; Non conformance report – used to manage deviation in materials and works; Corrective action report – used to manage deviations in process (not strictly to ISO 9000); and Preventive action report – used to manage potential deviation (more related to risk management although this is central to quality management 'best practice' as outlined in the literature review).

The document control section under the Internal Communication Plan specifies that records should be "properly completed, collected, registered and filed in a manner which protects them from loss, damage or deterioration, and ensures they are readily retrievable". Quality records are documents that show conformity of processes, materials and work. Any deficiency found is recorded as a defect on the completion inspection record and followed up by the responsible person. Once deficiencies are settled, the final quality records are passed to the document control department for archiving. Quality records contain the following information:

- Unique reference number obtained from a record register;
- The part of the project that it refers to i.e. area, section, element and activity;
- Who has carried out the check (name and signature);
- The date of check; and
- The results against the requirements.

To ensure that a defective project is not handed over at project completion, the conformity of works and materials must be known at all times. The Inspection and Test Status must be known by the executing team at all times to know what has been checked and what has not, what has passed and what has failed. The Inspection and Test Status indicates the conformity of materials; if rejected on delivery, materials are not unloaded; materials are marked “rejected” if retained on site; materials not yet checked are identified as “on hold” materials. Conformity of works is demonstrated by inspection, test or survey records; and deviating works are identified by ‘traceability to record and record register’, and ‘deviation register’ if applicable.

According to the Execution Plan, equipment for the use of inspection, measuring and testing of works and materials must be:

- Suitable for the conditions under which the check is being made;
- Capable of checking to the required tolerance;
- Used by a competent operator; and
- Of a known reporting accuracy.

Where such equipment is used by subcontractors, they are to provide Civil Joint Venture copies of valid calibration records on requests where applicable. The management and use of this equipment is detailed in the Plant and Equipment Plan.

To know the conformity of materials, there is a need for identification and traceability centres. Delivery of materials needs to be identifiable in order to be verifiable against the order and traceable to supporting records. According to the Execution Plan, works must be traceable to their associated records which must clearly show the location of the project, the element to which they relate, and the characteristic checked.

In order for materials, equipment and works that conform to quality not to be damaged, deteriorated or lost, they must be adequately protected. When there are possibilities of that happening, protective measures must be planned in the method stage. For works,

protective measures when needed are defined in the method statement. For materials and equipment, necessary preventive measures should be taken on handling, storage, packaging, and delivery. When received on site, the suppliers' recommendations should be followed on handling, storage and transportation.

The Completion Plan defines the management of the following parts of the project completion: Completion planning – formal completion processes and key dates at project completion; Handovers – including land handovers and handovers of areas between Bombela Civil Joint Ventures and subcontractors; Practical completion inspections – including defect follow up; Testing and commissioning – of plant and equipment; As-built drawings and operating and maintenance manuals; Documents to deliver to Bombela, Province and authorities at project completion; Archiving – documents to be retained after operating commencement date by Bombela Civil Joint Venture; End of site report; and Defect liability period.

It is important that improvements are identified and capitalised back into the management system and this can be achieved through risk management, audits, deviations, repeat methods, and management review. Risk assessment helps to identify potential deviations and audits verify the performance of the management system. Whenever deviations occur, the cause is analysed to determine if it is structural and if a change in the management system is required. Reference documents from previous projects are available from Bombela Civil Joint Venture.

For emergency events, the responsible Contract Manager calls for a meeting at short notice with all concerned parties including the Province, to inform them of the event, examine the cause, review risks and agree on remedial actions, responsibilities and target days. If the remedial actions do not work and other actions are required, another meeting is held as before.

4.3 Method Statement

This document gives technical instruction on how to execute a work related task. The Method Statement for Bombela Civil Joint Venture comprises the following sections: Preliminaries, Introduction, Method, Means, Responsibilities and Appendices. The Method Statement that was made available for the present study is a draft and not completed. Only the sections with quality information in this document are reviewed here.

Preliminaries

Under this section, the following subsections were defined: the purpose and scope; reference and requirements; responsibilities; and definitions. Other documents stated to be related to the Method statement include: standard and codes; design package; specifications; work plans; method statements; inspection and test plans; work instructions; programme; risk management; safety – general; environment – general; and quality – general. The responsibilities lie on the contracts manager to establish, maintain and implement this document. Terms and abbreviations unique to this document are defined and abbreviations are not used unnecessarily.

Introduction

This section introduces the basic method of execution. The general method is briefly summarised, stating the steps that will be expounded in the next section – method section.

Method

The key requirements, difficulties, constraints and risks to be managed in the execution are highlighted in this section. The execution procedure is described in sequence and under the conditions that it must be performed – size and type of plant, special tools needed, required skills, knowledge, experience, qualification, working environments, specialist subcontractors, and so on. Management of the applicable requirements –

technical, is described at each step in the process including safety and environment risks, which is important for safe and proper execution. The methods of protection or preservation of the quality of the materials until they are used and of works till they are handed over are considered in the methods.

Means

This section is related to the necessary plant, equipment, skills, knowledge, materials, subcontractors, specialists and working environment. The permanent materials and those important to the process are listed in relation to the specification in the design drawing and approval of materials. Important items are identified with their capacity, attaching data sheet or drawings as an appendix. The second party – services and subcontractors are identified in all aspects, for example, concrete supply, laboratory services, main subcontractors and suppliers involved and so on.

Responsibilities

Main tasks and responsibilities of the execution methods are included in this document. For simple activities, a table can suffice, but for complex works, an organisational chart can be used. An example of a table of responsibilities is shown below.

Table 4.2: Table of responsibilities

Task	Perform	Check	Approve
Setting out			
Reinforcement			
Formworks			
Concrete supply			
Concrete placing			
Concrete finishing			
Control deviations			
Defining corrective actions			
Safety			
Environment			

(Source: Bombela Civil Joint Venture's Method Statement, 2007)

Note: checks are performed according to the Inspection and Test plan; general roles and responsibilities are given in the referenced Works Plan

Appendices

This section describes the documents needed to ensure safe and proper execution according to the Method Statement. Sections here include the technical risk (against the contract: quality, time, cost), safety, environment, inspection and test plan, method drawings, and data sheets.

The technical risk management, as earlier stated, involves risk identification; evaluation of their impact against time, money, quality, health & safety, and environment; and risk control by developing a mitigation strategy and monitoring the implementation of the strategy. The risk assessment model is included in this document. If there are important safety issues, they are briefly highlighted under the safety appendix. Approximately 60 hazards were listed to help all departments identify those that they are prone to. Risk assessment is carried out for each department on safety to mitigate the risks they are likely to encounter.

The important environmental issues are also listed under the environmental appendix and risk assessment is carried out to know the actions to be taken and who is responsible for each action and at what time. The most important checks / requirements are highlighted under the inspection and test appendix. There are the General Inspection and Test Plan and Specific Inspection and Test Plan. The Specific Inspection and Test Plan is in tabular form and shows what type of inspection or test being carried out – approvals, receiving checks, process checks, and final checks; how to inspect or test; when to inspect or test; who is responsible; the point of inspection or testing; the criteria; record; and why.

4.4 Approval of Materials

This is a document that shows the conformity of materials to be used to the requirements stated in the specification. This document consists of the following sections: Purpose; Scope; Type; Requirements & Substantiation; Supplier; Additional Remarks and Attachments.

The Purpose shows the material description while the Scope shows the location of use in the works. The Type section gives space to identify the material to be used by its specific designation, make, model, class, mix design and so on. The Requirements & Substantiation section is for identification of applicable requirements and explanation of how they are addressed.

The name, location and contact address of the supplier is taken down under the Supplier section if known. If there are additional comments to be taken down, the Additional Remarks section is the right place to put the comments. If there are Attachments in the document, the number of pages should be mentioned so that it is clear that nothing is missing.

4.5 Inspection and Test Plan (Concrete Works)

The Inspection and Test Plan is a document that defines the type and procedure of inspection and testing of materials and work throughout the project execution. Bombela Civil Joint Venture's Inspection and Test Plan consists of the following: Scope; Reference and Inspection and Test Plan.

The section of the Inspection and Test Plan that I had access to applies to general concrete for small works and excludes associated works such as road works. The reference documents include drawings, specifications, method statements and work instructions. Notification to the Province is made using logbooks in site offices or otherwise by fax, and where possible to be done the day before the inspection. The Civil Joint Venture accepts that the Province may audit their test results and have full access to quality records on demand. A prototype of the Inspection and Test Plan is shown in the table below

Table 4.3: Inspection and test plan

Item	What	How	When	Who	SC	CJV	Other	Criteria	Record	Why?
A	**Approvals**									
1										
B	**Receiving checks**									
1										
C	**Process checks**									
1										
D	**Final checks**									
1										

(Source: Inspection and test plans for concrete work, Bombela Civil Joint Venture's Inspection and Test Plan, 2007)

The “item” column shows the identification of the document while the “what” column shows the exact material or works being inspected or tested e.g. approval of formwork design. The “how” shows the method to be used for the inspection or testing, an example is visual / check delivery notes. “When” refers to the time the inspection and testing should take place which may be at each delivery for materials or prior to an activity for works. “Who” means the person responsible for the check and this includes the name or initials and signature.

The next three columns show the responsibilities of the parties involved, either Hold Point (H) – the party must formally release the check before works can proceed; or Witness Point (W) – if the party does not attend, works may continue. The “criteria” column shows the exact activity to be inspected and the degree of conformance can be determined from there. The “record” column shows the type of record to be kept and the “why” column shows the reason for the process i.e. clauses in specifications or standards.

4.6 Work Procedure – Main Laboratory interface with Bombela Civil Joint Venture

This document describes the process to be followed in requesting laboratory acceptance testing and the receiving of test results. This document has four major sections: preliminaries – purpose, scope, responsible, reference and requirements, and terms; organisation; instruction – concrete testing and other testing; and appendices.

The purpose of this document is clearly stated, showing the intention of the document. The scope of this document covers all types of acceptance testing on earthworks and concrete works to be performed by Bombela Civil Joint Venture and excludes process control testing and testing of sewer and water lines. The deputy quality manager is responsible for establishing and maintaining this document while the contracts manager / site managers / agents implement the contents of this document. The references and requirements are clearly stated, and also stated are the terms.

In the organisation section, the contacts – physical address, cell number, fax, and e-mail, of the laboratory manager and Bombela Civil Joint Ventures laboratory representative are given.

The concrete testing methods are explained, and the means of carrying out each type of test is also stated. A table showing method, means and additional information is used to simplify the process of testing and recording. Another table describing each task, who to perform, who to check and who to approve is given. The tasks to be performed in this table include: notification of test; take slump and make cubes; strip and transport of cubes; testing of cubes (process control); testing of cubes (acceptance control), results evaluation; deviations control; and defining corrective actions. People responsible to perform, check and approve each of these tasks are clearly stated. Same is done for other testing.

The appendices shows the list of each test to be carried out, method of testing and the reporting times, flowchart for site lab interface, notification of inspection and laboratory test request.

4.7 Deviation Management

This document shows how Bombela Civil Joint Ventures manages deviation in their materials, works and processes. This document also has four major sections: preliminaries, introduction, procedure, and appendices.

Like the other documents, the purpose of the document is clearly stated. The scope includes quality related deviations and excludes health and safety deviations, environmental deviations and quality advisory notices. The quality manager is responsible for establishing and maintaining this procedure, while all staff are responsible for managing quality deviations. The following definitions were given in the document:

- Deviation: failure to fulfill a formal requirement concerning execution of the Works.

- Deviation Report – refers to Field Change Request, Non Conformance Report, Corrective Action Report, Preventive Action Report (see below).
- Requirement – an obligation Bombela Civil Joint Ventures must comply with.
- Corrective Action – action necessary to resolve an existing deviation*.
- Preventive Action – action necessary to avoid a deviation from occurring or reoccurring*.
- Field Change Request – form used to request "Permission to Deviate"
- Non Conformance Report – report used in the management of deviations in Materials and Works. The material records sheet is a type of non-conformance report.
- Corrective Action Report – report used in the management of deviations in Formal Processes.
- Preventive Action Report – report used in the management of "Potential Deviations".
- A Quality Advisory Notice is a notice issued by the Province Site Monitoring Team to identify and inform CJV of a deviation or potential deviation.

*Note: this definition does not follow the definition in ISO9000 however it is considered more understandable for users.

The materials record sheet is not design related, but it is used as a proposal for the use of a different material. This is done by getting a specification for the material and proposing it. The proposal will be accepted if the materials' specification meets up with what is required. This occurs mostly when there is a scarcity of the materials specified.

The aim of deviations management is to discover deviations and eliminate their cause to avoid recurrence before they are passed to the operator in the delivered works. Those responsible for detecting deviations are the people responsible for works and processes. They should control further processing, resolve the deviation and eliminate the cause in a timely manner. The following are the steps to manage deviations: detection; identification; review and approval; implementation and closure; and evaluation. A

flowchart showing the relationship between deviation process and inspection and testing is shown in this document.

Briefly going through the procedures, deviation is detected through required checks defined in inspection and test plan and may be found through site supervision, audit and data analysis. If anyone detects a deviation, Bombela Civil Joint Ventures' intention is that the responsible person formalises and manages the deviation. "Works may not proceed beyond the point at which deviations can no longer be detected and optimum repair carried out – to be ensured by the person responsible for the whole process of works" (deviation management plan: 7).

Identification of deviation starts by formalising deviations by informing concerned people. The deviation should be recorded appropriately according to the type of deviation. Depending on the type of deviation, physical identification is the next to be carried out, for example, if deviating work is pre-cast concrete, it can be physically identified by marking, signage or segregation to prevent accidental use. To ensure that concerned persons / parties are informed, a deviation report is opened, where the deviation is described under the description section in the deviation report.

The deviation report is a standard form that is used for Field Change Request, Non Conformance Report, Corrective Action Report, and Preventive Action Report. Bombela Civil Joint Ventures opens and manages the deviation report. If the deviation is detected by a subcontractor, Bombela Civil Joint Venture's representative responsible for the work opens the deviation register and manages it until it is resolved. The deviation report has some features that make it easy to manage the deviation in a controlled and verifiable manner such as:

- Identification (header) – provides traceability within the project;
- Numbering – shows the type of document it is;
- Type categorisation – used to indicate what type of deviation document it is;
- Prepare and approval – shows the issue date, revision, purpose of issue, originator, and authority (approver);

- Review – corrective and preventive actions must be reviewed by competent persons before implementation.
- Dispatch – deviation reports are issued through document control after being signed off.
- Subject (title) – briefly describes the deviations in registers;
- Description – full and clear description of needed change and sketches or other information inclusive if possible.
- Requirements / documents affected – shows requirements and documents affected by the deviation;
- Reasons for change – motivation required why change is being demanded;
- Cause of deviation – to discuss the underlying cause of deviation;
- Corrective action – needed actions to resolve the deviation;
- Preventive action – needed to prevent deviation from reoccurring or taking place the first time;
- Further remarks / risks / consequences;
- Attachments – reports may include other essential information to further describe the deviation, actions or provide evidence that deviation has been rectified; and
- Closure – activities to be carried out as defined after review and approval.

The field change request is the most common deviation report and it is used each time irregularities are picked up on site that require change or when the specification from the design could not be found. The approval of the field change request goes through a process of its own; signatures are required from:

1. the design team;
2. the construction team;
3. the quality department; and in some cases,
4. the electro-mechanical team if it is related to the system they will be working on.

The operator is also expected to review the change if the change in design relates to the operational aspect of the system. The client eventually sees the copy of the field change request after all the project players have finished their review.

The non-conformance report is used when the construction team does not execute the project according to the drawing or specification. It also goes through the same process as field change request. When the process is completed, it is closed out. Once the non-conformance report procedures and the design are complete, then the as-built drawings are developed based on the design and all the deviation reports. Most document updates in the Gautrain project follow this procedure. The whole review process has an effect on the time of completion negatively although review processes are managed within the programme because the programme has already allowed for it. The review process is allowed to take place three weeks after the submission for the review is received but it is not always adhered to according to one of the interviewees. When document review time frame is not adhered to, it creates a negative effect on the programme schedule of the project. In order not to allow this regular occurrence of time consuming acts, the procedure should be strictly adhered to.

Accumulated deviations are analysed periodically to observe underlying causes / improvements when each was observed in isolation. Two approaches are used and these are: against quality system – deviation in terms of overall quality system; and against the type of work process – deviation in terms of specific work processes categorising their causes.

The appendix of the document shows a prototype of the deviation report form and the process flow chat for deviation management.

Deviations Principle

- "All activities to be performed according approved requirements"
  - Laws, Regulations, Standards, Permits, Design and Methods

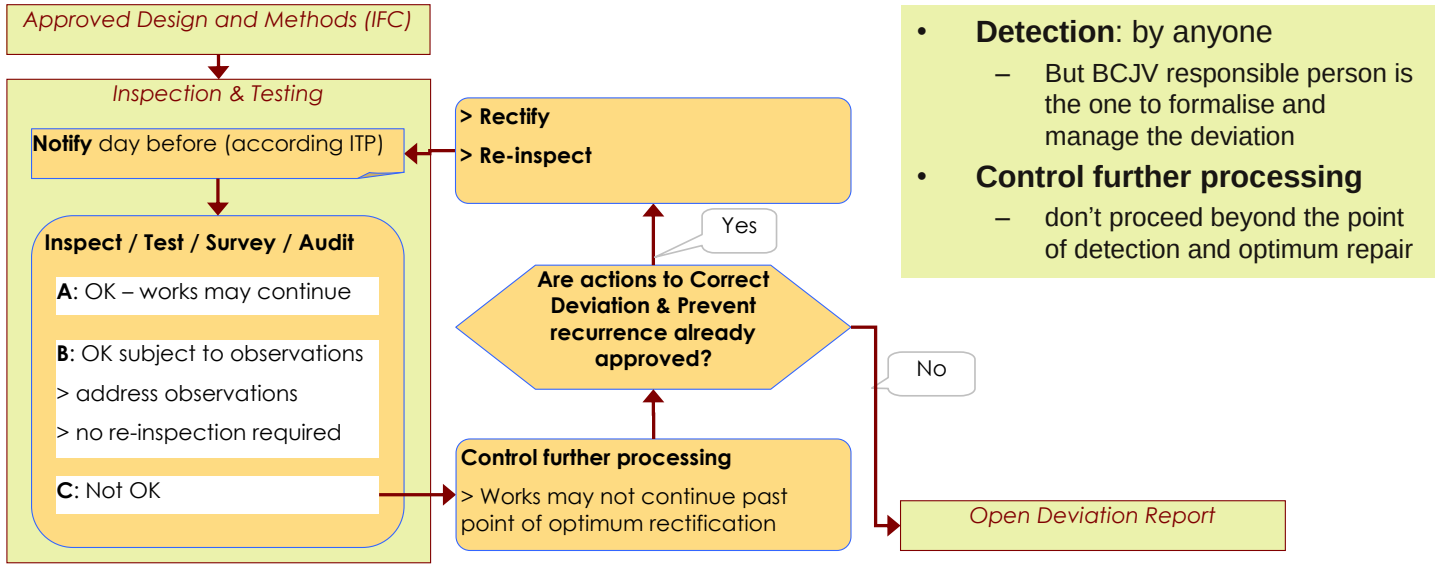


Figure 4.4: Deviations principle flow chart (Source: Bombela Civil Joint Venture's Quality Management Plan, 2007)

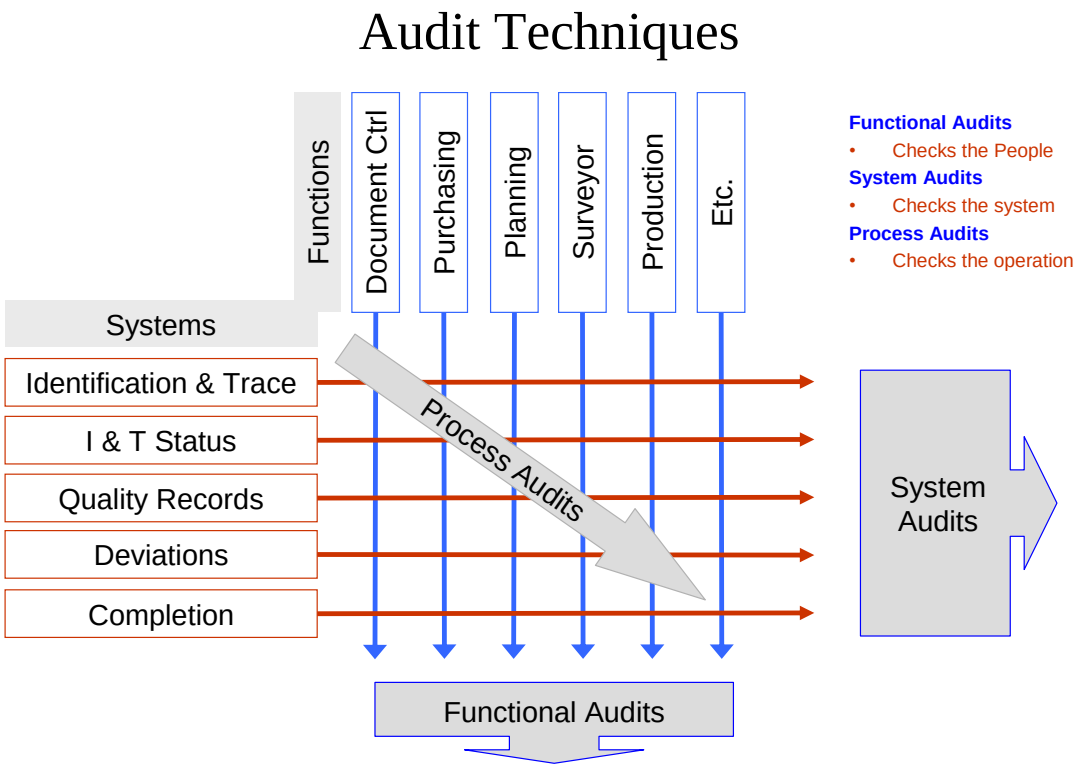


Figure 4.5: Diagrammatic Representation of Audit Techniques in the Gautrain Project (Source: Bombela Civil Joint Venture's Quality Management Plan, 2007)

During an interview with one of the design team members, he explained the quality management of the Gautrain project as follows:

> If you are to draw a graph, it is going to be the normal parabolic graph going up. I think now we are on the up side. At the beginning, the type of flow of how the designs go through all the stages is not standard traditional ones where you have consultants that do the design and manage the contractors, it's slightly different. There were a lot of items of how construction will meet the requirements and there are a whole lot of standards that are applicable to this. For instance there are tunnels which have their own specification, there are bridges, there are earthworks, and there are electro-mechanical items which have higher requirements in terms of specification. At the beginning it was almost like a learning curve and then eventually took up. I will say that efficiency will be around 80% maybe and there are some items they need to go back and redo. And the good thing about it is that the system is that it is well implemented

> because people actually did raise NCRs (non-conformance reports). It's not a common thing for someone to say 'I'm wrong, I'll do this rectification' and they were processes. It started up slowly and now people are more open to say 'I've done this'. There are also consequential effects for not reporting, for instance there is a scenario, probably it's one of the biggest deviations we have so far whereby it's related to survey. When the drilling of the single track tunnel which is coming from Rosebank started … because it is underground you set all your control points up from a central point. It actually gets transferred from top-down, and then they relied that it was correct and transferred it along. The transfer from up to down had an error of probably a micro millimeter when they started. When the drilling of the tunnel started, the error grew. Eventually when it was picked up, the tunnel was 1.8m out of line. The works had to stop and we had to redesign the whole alignment…. And the other thing was that the drilling was happening from both ends. We had to redesign (and) go through the whole process of review and changing of drawings and design and going through all approvals…

It was observed from his statements above that at the beginning the quality management procedure was quite new to the project players, but their performance in the beginning never discouraged them. The project players took their time to learn the quality management procedure of the Gautrain project. Although there are still some items that need rework, the contractors will raise reports against themselves to build things right – taking responsibilities for construction errors especially. This is quite untypical in normal traditional contracts. The instance cited above – the realignment of the tunnel - is proof that the quality management system in the construction of the Gautrain project allows for redesign of structures with checks and audits to ensure that whatever is executed on site is checked systematically.

Site conditions were highlighted by one of the quality managers as a key reason for change in design. The execution team needs to report the cause for change in design using the field change request to the design team for approval before any change can be

effected on site. The changes are recorded and these upgraded drawings are referred to as as-built drawings to show how the structure is eventually built for future reference.

The contractors get frustrated and unhappy when there is a change in the design of the Gautrain project. Most design changes are effected by the design team members, meaning that they redesign what they have already done before. At the inception of design for the Gautrain project, the construction team was involved with the review of the design so that the unexecutable designs are reviewed on time. Not all the information needed was captured in the design though because of the complexity of the project. When other information surfaced after design, it brought about delay and frustration because work might have started promptly on site thereby putting a hold on work on site in some cases. Change in design is not for quality purposes only; it might be for major omissions in the design and for simplicity or constructability. If the change in design is for quality purposes, it needs to improve the quality of the whole system. Even when a design is changed for simplicity, it does affect the quality positively too because it will be easier for the construction team to execute.

Quality, costs, availability of materials and buildability are other reasons for change in design as stated by the quality engineer. A cheaper option may be found that will give same quality of the product which has a positive effect on the completion cost of the Gautrain project. There are instances where the construction method and design are unpractical because the design team may over-design especially on concrete works – overdesigning the reinforcement and not considering space for concrete during execution. There are instances where the materials specified are not available, which may require a change in design in the project.

From a quality managers' perspective, there are different types of errors in the Gautrain project. These are

1. the construction error
2. the unforeseen error

As the name implies, construction errors are made during construction. For errors in construction, the Bombela Consortium is responsible, but for unforeseen errors the client is responsible for the cost. An example of unforeseen error was a report that the geology of a certain area is made up of rocks: a certain type of construction method was implemented, but it was later discovered that the geology was not rock, but mud. Such costs are covered by the client – the Gauteng Province. The bearer of cost of errors on site depends on the type of error.

In conclusion, the whole process of quality management in Gautrain as seen in this chapter looks quite complex and typical of "best quality management practice" (with regard to ISO), although there are a few modifications in the documents to suit this particular project. The quality management procedure is planned in an exemplary way at the highest level, but with a degree of flexibility, covered by Bombela's chain of responsibility and the use of method statement by the subcontractors and suppliers. This allows for different approaches without compromising the quality of the whole project or any part of it.

This sophistication exists at the higher levels, with the more highly qualified staff, while the procedures and forms at site level are very easy to follow and use. This shows an adaptation of sophisticated processes to ensure delivery of sophisticated infrastructure, yet formulated into simple elements to cater for less-skilled operatives. It is also important to note that, throughout the entire project cycle, Bombela explicitly takes the final responsibility for the quality of the entire project. This provides incentive for the lead contractor to ensure that all the other project participants are suitably briefed, trained and monitored to be able to interface with and use the quality mechanisms that have been put in place.

In this respect, the project also serves as an example of 'best practice' as described in the literature on supply chain management, as discussed in chapter 2. This provides a useful model to replace the conventional approaches to mentorship that have been used in other

public projects that have attempted to include similar socio-economic objectives to those of the Gautrain project.

After a review of the quality management documents used and the management structure of the Gautrain project, some inferences can be drawn as seen below with respect to table 2.1.

Clause 4.1 – Management Responsibility: Table 2.1 shows that management's responsibility may cause defects through lack of training and skills and poor communication. From the findings of this report, the organisation plan of the Gautrain project shows that training ensures competence (see chapter 4.21). Also, the project team ensures that training is given to workers in the Gautrain project at all levels (see chapters 5.1 and 5.2). The communication chart can also be seen to be simple and clear in figure 4.1.

Clause 4.2 – Quality system: The quality management system used in the Gautrain project ensures that site conditions are considered before the design starts; encourages excellent site practices (like safety) and supervision of works; encourages knowledge of the procedure to all participants in the project and has a good communication system in place for the project.

Clause 4.3 – Contract Review: Organisations need to review contracts to determine if the requirements are adequately defined, agree with the bid, and can be implemented. There are different types of contract used in the Gautrain project and these contracts are reviewed to suit the project.

Clause 4.4 – Design control: The design team of the Gautrain project is integrated with the execution team and members of each team are easily accessible to one another. According to table 2.1, the following causes of defects are related to design control;

1. Defective material: Defective materials can be easily spotted with the inspection and test plans and when materials are not available, approval of materials to be

used is documented by the use of approval of materials (see approval of materials and inspection and test plan).

2. Design too difficult to build: When there are complex designs for the execution team, the execution team gets back to the design team and the design team redesigns to ensure that the design is simplified.
3. Overlooked site conditions: Site conditions are checked before design starts (see clause 4.2).
4. Defective documentation: To avoid defective documentation, all updated documents are renamed and old documents are retrieved to avoid accidental usage.
5. Poor communication: The communication link between the design team and the execution team is quite direct. According to a quality manager, all design related problems are sent to the design team by the quality manager of that section.

Clause 4.5 – Document and data control: Table 2.1 shows that defective documentation, poor communication and unanticipated consequences of change are the anticipated causes of defects associated with ISO9001 clauses. The documents used and data collected in the Gautrain project are well kept and updated.

Clause 4.6 – Purchasing: the procurement system of the Gautrain project is quite direct. The material values are the primary focus of the execution team and there are documents used to monitor the purchased items in the Gautrain project.

Clause 4.7 – Control of customer-supplied products: In the Gautrain project, there are characteristics that are used by the execution team to appoint and control the supply chain participants. According to a quality manager, suppliers in the supply chain must meet the requirements set by the project team before they can be appointed.

Clause 4.8 – Product identification and traceability: The management of the Gautrain project put in place efficient communication and monitoring plans to ensure effective

control of supplied products. One of documents used for this control is the approval of materials (AOM) – see chapter 4.4.

Clause 4.9 – Process control: The methods process (figure 4.3) shows the adopted process control for the Gautrain project. This method process includes interface management, review in principle, construction design, methods and realisation. This process is adhered to by the Gautrain project team (design and execution).

Clause 4.10 – Inspection and testing: The inspection and testing plan adopted for the Gautrain project is described in Chapter 4.5 of this report. This takes care of the inspection and testing done across the project.

Clause 4.11 – Control of inspection, measuring and test equipment: The Gautrain project's plants and equipment plan takes care of the equipments used for testing and they must be in good conditions (see chapter 4.2.1).

Clause 4.12 – Inspection and test status: The inspection and test plan used for the Gautrain project has a column for the inspection and test status (see table 4.3).

Clause 4.13 – Control of non-conforming material: The non-conforming materials are controlled under deviations in the Gautrain project (see chapter 4.7)

Clause 4.14 – Corrective and preventive action: The Gautrain project team uses the corrective action report (CAR) and preventive action report (PAR) during the execution of this project (see deviation management in chapter 4.7). These documents are used to manage deviations in formal processes and used to manage potential deviations respectively in the Gautrain project.

Clause 4.15 – Handling, storage, packaging, preservation and delivery: Bombela's major principle for the quality execution – all activities must be carried out in a controlled and

verifiable manner ensures that handling, storage packaging, preservation and delivery of materials and the project are approached from a reasonable angle.

Clause 4.16 – Control of quality records: All records (including deviation records) are kept according to the type of information to be recorded (see chapter 4.1 and 4.7). Standard forms are also used in the Gautrain project to promote consistency in the recording of information.

Clause 4.17 – Internal quality audits: Figure 4.5 shows the audit techniques in the Gautrain project. Audit checks are used in the Gautrain project to ensure that the project plan is followed during execution (see chapter 4.).

Clause 4.18 – Training: The client of the Gautrain project included training of workers as one of the objectives of the project. This has been well achieved in this project (see chapter 5) and can be seen stated in the organisation plan (see chapter 4.2.1)

Clause 4.19 – Servicing: This is related to repairs, maintenance and other services specified in the contract. This requires an organisation to perform servicing activities when such activities are part of a specified requirement. An example can be seen in the Gautrain project as the plant and equipment plan which shows how Bombela carries out maintenance and required checks of their plants and equipments.

Clause 4.20 – Statistical techniques: Adequate statistical techniques must be identified by organisations and use them to verify the acceptability of process capability and product characteristics. The Gautrain project management team uses the Deming cycle (PLAN → DO → CHECK → ACT) to ensure that quality is met. The verification of the acceptability of the quality of work is done at the "check" stage where various measures are taken with respect to the type of work to be measured.

It can be seen from this analysis that the Gautrain is well aligned with the ISO principles and process, adapted as contemplated by ISO to meet the unique context of the project. It can therefore be seen to comply with “best practice” in the management of quality.

Process Summary for the Gautrain Project

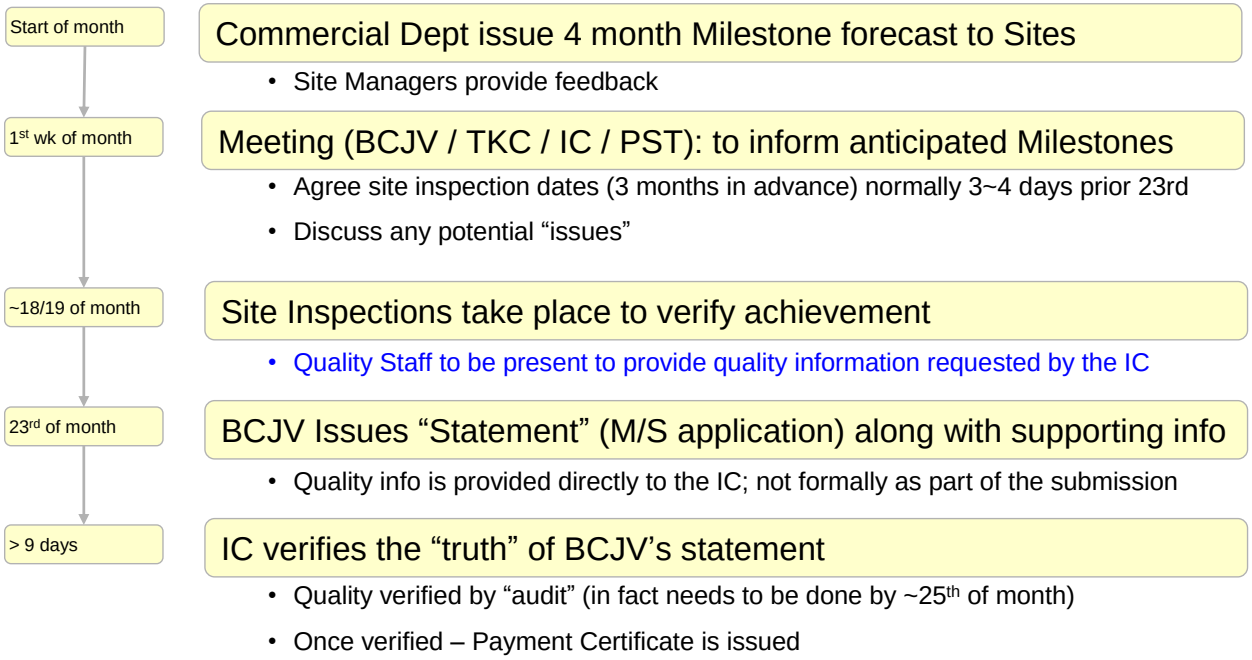


Figure 4.6: Process Summary in the Gautrain Project(Source: Bombela Civil Joint Venture's Quality Management Plan, 2007)

5.0 SOCIO-ECONOMIC DEVELOPMENT IN THE CONSTRUCTION OF THE GAUTRAIN

5.1 Introduction

The 1994 World Development Report (World Bank 1994: 2) states that: "infrastructure can deliver major benefits in economic growth, poverty alleviation, and environmental sustainability – but only when it provides services that respond to effective demand and does so efficiently." Provision of infrastructure in developing countries enhances job creation and improves productivity thereby encouraging the economic growth of the country. Also when more jobs are created, the level of poverty drops. Governments in developing countries put programmes in place to create jobs for their citizens and improve their economies (Wells, 1986). The South African government is not an exception to this because they have inaugurated several bodies and programmes not just to create meaningful jobs but also sustainable employment, in order to achieve and sustain economic growth and aspire towards the standards of developed countries.

To be able to target as many people as possible, programmes such as the Expanded Public Works Programme are seen as "stepping stones" into more sustainable employment – improving people's "employment prospects" in the medium to long term. For this reason, most of the general labourers on the programme are only employed for a few months, in which the training is aimed at increasing awareness of the world of work, employment opportunities, job seeking skills and sustainability.

Unemployment and scarcity of marketable skills became an issue of concern to the South African government immediately after the election of Nelson Mandela in May, 1994. The post-apartheid South African government decided to embark on these projects by involving the historically disadvantaged South Africans, thereby creating jobs and training programmes. Statistics have shown that the unemployment rate in the working-age population (15-64 years) decreased from 23.3% in year 2000 to 21.0% in year 2007

(Statistics South Africa, 2009: 8). This shows that the programmes have had an impact on the employment rate in the country.

There is shortage of technical skills in South Africa (Fitchett, 2009) and this is affecting the country's ability to meet development targets because of the technical void. In past years during apartheid, workers in the construction industry learnt skills informally by watching and doing without any evaluation or accreditation. Fitchett and McCutcheon (2005:8) state that "a web of race laws was brought in to prevent blacks from operating in any capacity beyond that of menial worker for a white employer." This prevented a growth in professional and high level managerial skills. Fitchett and McCutcheon (2005:8) also noted that additional burdens on meeting the skills void ware created by the inadequate schooling for the majority and the results of this legacy are:

- Massive skills and education inadequacy at all levels;
- Skills and knowledge are not market oriented; and
- The skills profile is distorted in terms of both race and gender.

Informal training, which was more pronounced in the construction industry after apartheid, needed to be enhanced because most of the learning is from "masters" who have equally learnt the trade incompletely because of the unavailability of stable employment and the collapse of the apprenticeship system. This made the skills level drop because in the construction industry, projects are finished once off and no project is a typical replica of another. Although there are advantages of learning through the "leadership by example" approach because physical and cognitive skills are fully integrated in apprenticeship training and management tasks such as care of tools, safety and so on become habitual to the learners. Workplace learning is also important because during periods of technological change, learners continue to learn in the process and adapt to the system of change which shows that there is constant learning and practice.

After apartheid, a need for new training approach was perceived and adopted by the post-apartheid government. An example is the Construction Education and Training Authority (CETA) which was established in April 2000 after the promulgation of the Skills

Development Act, No.97 of 1998 which aims to develop and improve the skills of South African workforce. The Construction Education and Training Authority (CETA) supports and develops small, medium and micro-enterprises (SMMEs) and individual skills through learnerships, focusing on workplace learning.

Despite the high failure rate of the small entrepreneurs world-wide (Fitchett and McCutcheon, 2005: 6&7), the South African policy makers decided to encourage emerging contractors by putting in place policies to favour the locally owned small, medium and micro-enterprises because it was considered to be a significant factor in employment creation. The high failure rate can be attached to the great variation in demand of the construction industry which makes it difficult for emerging small contractors and suppliers to survive. This failure rate is particularly high in the construction sector, for the reason given, but is high throughout all industries.

However, Fitchett and McCutcheon (2005) note that the Norwegians view the small entrepreneur not just as an important element in decentralized economies but as the principal providers of innovation. The South African government puts much emphasis on small business development as it is seen as a way of directing the project expenditure to less wealthy individuals (business owners) and that the small operator will be more likely to do things labour-intensively, as he or she will not have much capital to buy expensive machinery. This encourages wealth redistribution in the South African context.

The Expanded Public Works Programme is another approach demonstrated by the post-apartheid South African government to education and training. This programme was formally announced by President Mbeki in 2003 in his State of the Nation address (EPWP, 2005). The creation of the EPWP by the South African government is a strategy to reduce the inequality between the rich and poor, skilled and unskilled by making it a training programme for employment-intensive construction, focusing on vocational trade training and support for emerging contractors and other small enterprises. The aim of the EPWP is to address unemployment by increasing economic growth, improving skills

levels through education and training, and improving an enabling environment for industry to flourish.

The EPWP is managed by the Department of Public Works. In order for the EPWP to meet its aims, employment-intensive construction methods were introduced to create additional work opportunities on the basis that with well trained supervisory staff and appropriate institutional frameworks, employment-intensive methods can be used successfully for infrastructure projects involving low-volume roads and sidewalks, stormwater drains, and trenches (EPWP, 2005). These are the types of projects that EPWP has been using as a tool to achieve their aims. In the context of this research, the term 'employment-intensive construction method' is referred to, rather than labour-intensive construction.

> Labour-intensive construction methods involve the use of an appropriate mix of labour and machines, with a preference for labour where technically and economically feasible, without compromising the quality of the product (EPWP, 2005).

Although the execution of the Gautrain project is not labour-intensive, there is a need to compare socio-economic development objectives and labour-intensive construction methods because both aim at job creation in the construction industry. Labour-intensive construction is an extreme case of job creation during the execution of construction projects, while in the case of the Gautrain project, the client – the Gauteng Provincial Government - attached some socio-economic development goals to the project.

Because of the ability of the construction industry to "absorb the excluded" (those with little or no formal trade or education), the need for formal training was perceived, which allows quality performance to be more achievable. Formal training is very important especially where technical expertise is required in jobs because it improves the productivity of workers. (Productivity and quality are also improved through management training at all levels of the workforce, as well as occupational health and

safety, thereby minimising down-time that results from injuries on site.) Quality jobs are produced when the required skills are used in the production of the job and these skills can be effectively acquired by efficient training of workers.

Experience has shown that various problems can be faced during training programmes, especially the retention of trainees and the quality of training and trainers. The retention of trained workers is a problem for the private sector, as they have invested in the training, and the trained person may join a competitor company. The quality of trainers in South Africa is a serious problem, as there is such great demand for them, especially since the inception of the EPWP. The most suitable people for trainers come from disciplines in which there are critical shortages such as professional engineers.

Training of workers provides sustainability for them because once a skill is learned, it can be used at other places which makes the worker more easily employable, while on the other hand, improving the economy of the country. Most trained workers may decide to leave and search for greener pastures after training. To retain trained staff, the private sector has to raise wages and salaries, so productivity has to be even greater to achieve the needed output to cost ratio. It can be assumed that most companies in the private sector will want to operate at a good profit margin thereby viewing some costs as unnecessary e.g. costs of training, which is contrary to the Government's objectives.

5.2 Socio-Economic Development Strategy

Achievement of Socio-Economic Development goals by the Gautrain project

The Gautrain project is a government owned project which has several socio-economic development goals attached to the execution of the project. This section of the chapter looks into the policies put in place by the government and the statistics of performance of the executor – Bombela Civil Joint Venture - to achieve sustainable empowerment of the people.

The socio-economic development objectives address Broad-Based Black Economic Empowerment (BBBEE); development of small, medium and micro enterprises; sustainable development of underprivileged societies and maximisation of local content (SED progress summary, 2008). These principles have been adhered to by the execution company and the performance according to these principles is explored in this chapter.

According to the Gautrain Management's Socio-Economic Development (SED) progress summary, the socio-economic development remains a cornerstone of the Gautrain project. The socio-economic development strategy focuses on two concepts:

- Local skills development and capacity building, and
- Job creation.

By October 2008, reports show that Gautrain has been able to create approximately:

- 11 700 direct jobs,
- 63 200 direct, indirect and induced jobs combined,
- Companies that have benefited include:
    - 260 BEE companies (R1900 million)
    - 90 New BEE companies (R800million)
    - 230 SMMEs (R600 million)

During the course of this project, the Gautrain has trained its employees in all levels and disciplines. About 10 400 courses have been provided for unskilled and semi skilled staff and 1 250 for management staff. This indicates that the Gautrain project is not neglecting the fact that quality in the project should be a priority despite the fact that human resources will be used instead of machine technology wherever it is technically feasible. Training is very important in this project because it aids getting things right "first time" which has a positive impact on the overall cost, time and quality of the project. The socio-economic development implementation strategy, with respect to skills development and capacity building, has embraced Broad-Based Black Economic Empowerment (BBBEE) and the development of Small, Medium and Micro Enterprises (SMMEs). The

strategic objectives include the sustainable development of underprivileged communities and the maximization of local content.

The socio-economic development implementation strategy pertaining to job creation focuses on commitment to progress towards employment equity in various areas like employment of Historically Disadvantaged Individuals (HDI), people with disabilities, women, and the participation of HDIs and women in management positions. The Gauteng Provincial Government signed an agreement with the contractor to establish the purpose and objectives for the project, including these socio-economic targets. This concession agreement is somewhat unusual in that the socio-economic elements are seen as being as important to the client as the delivery of high-standard infrastructure rather that stated as an addendum. This filters through to the concessionaire's project planning documents, as has been discussed in the previous chapter, thereby indicating that the achievement of technical and socio-economic goals are not mutually exclusive. This said, there are numerous ways in which Bombela has adapted processes and documents to allow for these aspects to be achieved successfully, for example by embedding the ISO9000 quality requirements into the conditions of contract for subcontractors and suppliers.

To ensure strict adherence to the objectives, the concession agreement provided for the appointment of the Independent Socio-Economic Monitor (ISEM) to monitor the activities of the project execution in terms of the socio-economic development objectives. The Independent Socio-Economic Monitor is appointed jointly by the Gauteng Province and the Bombela Concession Company. The socio-economic development progress brochure states that the Independent Socio-Economic Monitor's core responsibilities are the performance and verification aimed at validating compliance by the Concessionaire particularly with its contracted socio-economic development obligations through all the phases of the project.

Also, to ensure that the emerging contractors follow the Bombela Consortium's quality system for all works, a good method statement is always required from the contractors for every piece of work. As explained in section 4.3, the method statement highlights the

procedure to follow and also serves as a planning tool. The use of method statements is a way of encouraging the subcontractors to think and plan ahead before they move on site to execute the job. Planning in this type of project is very important because it averts the occurrence of problems that can be predetermined and avoided, which makes a positive impact on the time and costs of the Gautrain project.

The method statement also contains risk assessments to analyse potential risks, such as environmental, work and quality. Bombela Consortium representatives review the method statements with the subcontractors to ensure that the subcontractors know what they are doing. Another document used by the execution team is the inspection and test plan – a summary of all the tests that are needed to be done in terms of specification. The testing laboratories are under Bombela Consortium's control: the subcontractor does the testing but it goes via Bombela's laboratory so that everything can be monitored.

If the subcontractors want to use their own private testing laboratory, Bombela insists that they are South African National Accreditation System (SANAS) accredited. All these are procedures that serve as guides for the subcontractors in training them in best practice on the project. It can be argued that this is a far more effective method of empowering small contractors than those used in other government driven programmes that use mentorship or joint ventures. In the Gautrain project, small contractors are integrated into a supply chain where the performance of any one entity potentially harms or contributes to the whole. This is a far less artificial scenario than formalized mentorship, in that all parties have incentives to follow best practice to meet the requirements of cost, time, scope, and especially quality.

At the end of each month, Bombela submits a detailed report on its socio-economic development performance to the Independent Socio-Economic Monitor and Provincial Support Team, which are in turn verified by Independent Socio-Economic Monitor. If Bombela does not meet up with its socio-economic development obligations within a quarter, there is a robust, fair and equitable penalty for the Concessionaire, but if they exceed their socio-economic development obligations, this could be used to offset a

possible under-performance in future quarters. So far, reports have shown that Bombela has made an effort to ensure that the socio-economic development goals are exceeded which is a sign that Bombela is committed to the socio-economic development objectives of the Gauteng Provincial Government.

At the end of October 2008, it was reported that:

- 10 517 HDIs were employed, compared with an obligation of 4 898;
- 834 Women were employed, compared with 369; and
- 63 People with disabilities were employed compared with an obligation of 49.

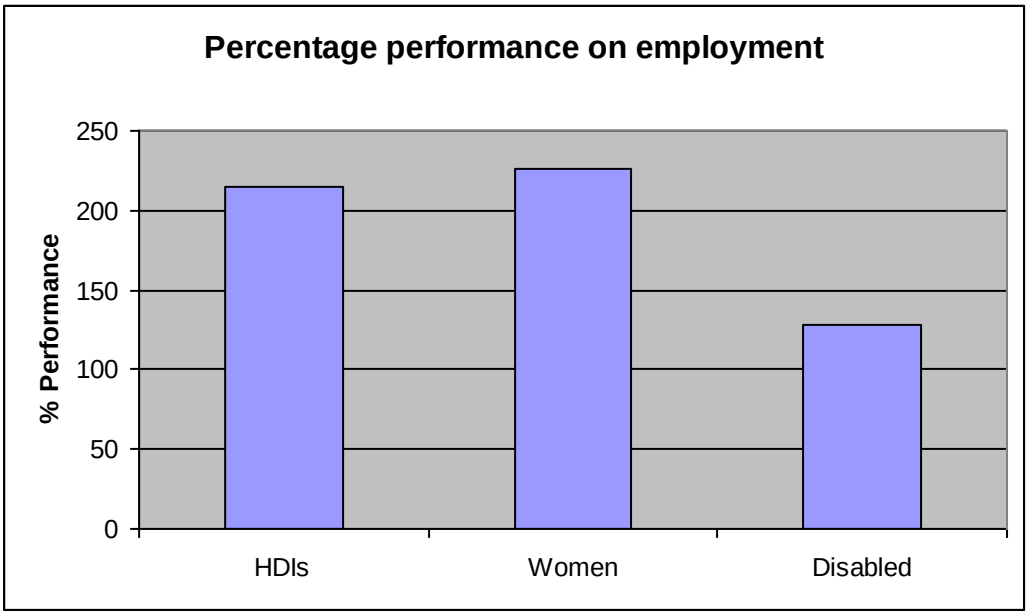


Figure 5.1: Bar chart showing the percentage performance of Gautrain on employment

Apart from job creation and local skills development, the Gautrain's socio-economic development strategy also ensures that Bombela optimally utilizes local resources. At the end of September 2008, Bombela had:

- Procured South African materials, plant and equipment worth more than R1 210 million
  compared with an obligation of R980 million;
- Employed more than 11 540 local people, compared with an obligation of 6 641.

It was also reported that the number of persons specified for training in the original plan has been exceeded in the Gautrain project. This shows that the Gautrain has performed exceedingly well compared to the expectation in making a significant contribution to the socio-economic development of Gauteng Province and South Africa as a whole. Some examples of Black Empowerment Entities (BEE) can be seen in companies such as Isithimela Rail Services (Pty) Ltd, where 50% of the shareholding is owned by a local BEE company (Strategic Partners Group). These companies act as sub-contractors in the Gautrain project and have rendered varieties of services to the project, such as:

- Construction activities
- Supply of construction materials, plant and equipment
- Supply of general office equipment and consumables
- Consultancy services
- Health and safety services
- Security services
- Transport services
- Office support services
- Human resource development support
- Marketing support

In terms of awarding contracts out to suppliers, there is a Black Empowerment Entities (BEE) policy that the Bombela Consortium follows. All the subcontractors, suppliers and whoever Bombela Consortium appoint on this project have to prove to Bombela Consortium that they fall within the Black Empowerment Entities criteria – that is, they need to employ people predominantly from *previously disadvantaged* groups of South Africans. That is a part of the contract that was signed and this has to be produced to the client and obviously the subcontractors and suppliers must ensure that they follow the procedure, otherwise they will not be appointed.

The Black Empowerment Entities process for selection is very important in this project because this project is also about improving skills in the country. Bombela Consortium itself tries to employ local, previously disadvantaged people and people with disabilities.

It is the first project in the Republic of South Africa with such a wide variety of criteria in terms of employment and training. The subcontractors have to prove to Bombela Consortium that their complement of staff is previously disadvantaged, as well as what training and other empowerment activities they are implementing to improve their staff's knowledge when they submit an invoice for payment. This is what the payment is based on. This project is not a window dressing type of a project; it has proved to be effective from the results above. There are small, medium and micro-enterprises (SMMEs) contractors working on site regularly and this has shown that the Gautrain project is helping to improve the country's employment, resources and skills.

According to one of the quality managers, the performance of the subcontractors is not always of the highest standard. This is one of the main purposes of the Gautrain project – training and development of local small, medium and micro-enterprises. For this reason, the Bombela Consortium appoints and helps these subcontractors to improve their skills to perform better. The Consortium tries to improve the subcontractors' performance because the quality management system is founded on the principle of continuous improvement. The Bombela Consortium insists that all the subcontractors and suppliers follow the quality management system established for the Gautrain project.

The subcontractors may have their own quality management systems but they are required to follow Bombela Consortium's because it may be confusing and difficult to co-ordinate if every company comes with its own system. This is in line with 'best practice' in supply chain management, as discussed above. When subcontractors follow Bombela Consortium's quality management system, it helps the subcontractors to improve themselves. Bombela Consortium uses ISO9001 system for quality management and ISO14000 in terms of environmental practices. Safety is a big concern on this project; therefore Bombela Consortium follows all relevant ISO standards – safety issues inclusive: for instance, Bombela Consortium follows the mining legislation for the underground works section.

Despite the policies laid down by South African policy makers having focused on executing low-volume roads and sidewalks, stormwater drains, and trenches, the government attached policies that encourage employment creation for the people of the community on the much higher standard Gautrain project. This significantly expands on the scope of project that Government has been using to create employment opportunities through programmes like the Expanded Public Works Programme. The Gautrain project has also been used to develop and empower emerging companies – contractors and suppliers - with the policies creating a strong and effective local supply chain.

Training of workers at all levels is a proof that no one is above training in organisations, especially those committed to quality. The achievements seen in the Gautrain project can be partly related to the training because once effective training is received by employees; there is an increase in performance of the employees. From the supply chain management perspective, training of each person in the supply chain gives them a clear sense of personal responsibility, as well as an understanding of how their contribution acts in the larger picture. This sense of "ownership" of their part of the process contributes both to productivity in not slowing down the process, and in quality in that the interface points are well understood, as is personal responsibility in meeting the specifications and other quality targets.

This quality management structure for the Gautrain project has enhanced the achievement of BEE objectives laid down by the client as seen from the results above.

5.3 Economic Effects of Gautrain

Since the inception of Gautrain, sustainable jobs have been created and employers have been trained to meet up with their job expectations. As at 1 December 2008, the Gautrain project had already created or sustained more than 29 400 jobs which was expected to increase to about 33 000 at the end of 2009 (Gautrain). The Gautrain hopes to create directly or indirectly an additional two million jobs by the end of 2025.

Training that has been given to the employees in Gautrain since inception has been quite well aligned with generating sustainable employment for them in the future: with their training, they can move and get jobs from different organisations because of their experience and competence. The training given to the employees is directly linked to achieving the performance demanded by the project. The integration of technical and management training is also valuable – many other construction projects will only have training for the specific task, so it is difficult to apply what has been learned to new contexts. Networking and other forms of business associations within the supply chain can carry on into future projects.

The World Development Report of 1994 has established the association between the increase in infrastructure stocks and the increase in GDP per capita. There is also robust literature on increase in productivity and the growth of an economy. Both of these need to be viewed from a medium to long term perspective, especially in the current global economic climate. These other studies suggest that the Gautrain project, by meeting its dual sets of objectives, will certainly have played a part in the future economic growth of the country, and possibly of the region.

This study has shown the possibility of combining two apparently diverging objectives (socio-economic development and excellent quality management) successfully provided that the project management is of a very high standard and scarce skills are strategically utilised. Secondly, this study has also shown the positive effects of using a supply-chain type of skills transfer rather than mere mentorship for small contractors. The suppliers have been built into the quality management chain from the inception of the project – project plan. This is run on business lines, for example by getting the contractors to provide method statements as part of the contract and tendering process, and this shows that the relationship is performance oriented and not a dependency relationship that characterizes most emerging contractor programmes in South Africa.

Thirdly, the project team came up with techniques used to assist small contractors in the Gautrain project (such as building the quality processes into the contract documents

simplifies the application of these processes without compromising them). Furthermore, the structure of the training and quality monitoring avoids some conflict scenarios recorded in many of the small contractor programmes in South Africa. The psychological characteristics of an entrepreneur are different from that of an employee, a contractor as an entrepreneur may find it difficult to subject him or herself to being controlled by his 'mentor' (Egbeonu, 2004).

One can also assume that the experience of being part of the Gautrain project gives credibility to these contractors (and other directly employed people to meet the job creation objective) because they were brought in on board and they did prove their ability to operate at high levels required, and were not just window-dressing to make the project look good from a socio-economic perspective.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

From this research a number of conclusions can be drawn. These include the possibilities of including socio-economic development goals for complex projects like the Gautrain and the conditions needed for their successful achievement. The Gautrain project gives an example of good practice in this regard, as the socio-economic goals are met and even exceeded in some instances. The project also demonstrates the possibilities of executing an ISO 9000 compliant project even though parts of the supply chain are non-compliant. It provides a model for the successful implementation of government policies on job creation in South Africa by showing the level of quality management and the approach used in its execution, including the assurance of the execution procedures needed for the emerging contractors.

South African policy makers have shown their commitment to job creation through their understanding that infrastructure projects involving low volume roads and sidewalks, stormwater drains, and trenches can be executed labour intensively. However a huge infrastructure project such as Gautrain has required a new level of commitment and trust that it can be executed with the aim of providing jobs for the people in the country without compromising the high level of quality demanded by this type of infrastructure. The manner in which this was carried out was analyzed in chapter 5 where the government entered a concession agreement with Bombela Civil Joint Venture to provide sustainable jobs for the Historically Disadvantaged Individuals, empowering the Small Medium Micro Enterprises, and procurement of South African materials, plant and equipment.

The results show that the Gautrain project has exceeded the targets agreed upon and this should give confidence to future project planners for even more ambitious socio-economic targets, including employment-intensive construction in many more aspects of a project providing that it is technically and economically competitive in terms of time,

quality and cost. It also indicates that a far wider range of projects can successfully include socio-economic objectives than has previously been accepted, for example the limited range of 'low-key' tasks considered in the South African Expanded Public Works Programme.

McCutcheon and Taylor Parkins (2003: 44) argue that experience has shown that good quality, low-cost, low-volume rural roads may be constructed and maintained by highly employment-intensive methods, and argue further that these methods can be extended into higher standard infrastructure, as shown in the example of the N1 freeway between Matoks and Louis Trichardt. However, the Provincial government's decision to embark on Gautrain with the inclusion of a number of socio-economic development goals takes this line of argument to a new level of scale and complexity. This is a proof that if proper plans are made from the inception of a project by the project players, these two objectives can be achieved even in the execution of extremely high standard infrastructure.

As explained earlier in this document, the International Organization of Standardization's (ISO's) policy encourages the whole supply chain of a project to be ISO certified to ensure that quality is embedded in the whole project from inception stage to the final completion of the project. In the case of Gautrain, most subcontractors who are members of the supply chain system do not have the capacity to be ISO 9000 compliant because they are emerging contractors that the government is trying to empower so they do not have the financial resources or management capacity.

Since the major contractor, Bombela Civil Joint Venture, is ISO certified, this company ensures that all activities carried out by the other supply chain members follow the ISO standards. This enables the "uncertified" ISO supply chain members to learn the procedures followed by the certified ISO members and use them effectively so that at the time of certification, it will be easier for them to follow the ISO procedures on quality management in their organization even if they are not certified. This can be viewed as a type of mentorship in the project, at the same time ensuring that the recognised standard is followed.

What is also worthy of note is that Bombela's commitment to quality, through its needing to retain ISO certification, gives a commercial incentive to ensure that their mentorship is fully effective. This can be contrasted with the systems of mentorship previously used in South Africa to support emerging contractors, where the mentor is employed by the client as a consultant and paid a certain percentage of the contract sum (Egbeonu, 2004: 56).

Bombela Civil Joint Venture requests method statements from subcontractors before awarding them jobs. This is a way of evaluating the subcontractor's methods of execution and to know if it follows the best technical practice. The quality management procedure, method statement, health, safety and environmental impacts of the subcontractors are the major documents that are reviewed by Bombela Civil Joint Venture to ensure that correct procedures are followed to meet the client's requirements. The use of method statements in this project can be seen in two ways as: a basis for planning the mentorship programmes and a pre-selection method for eliminating subcontractors who have too little experience to be able to meet the demands of the project.

One of the cornerstones of the approach to quality management is in carrying out all activities in a *controlled and verifiable manner*. Bombela Civil Joint Venture's policy on execution is a way of examining all the processes and stages of each aspect of the Gautrain project. This is an approach to determining defects and errors in each stage of every process and not after the completion of the whole project. This saves time and costs on rework if defects are detected early and ensures that hidden defects are avoided. Therefore Bombela Civil Joint Venture has adopted a time and cost effective culture to exhibit good practice in project management. This has shown that the Quality Management Unit of this project has a world class standard approach and the approach is good enough to attain the required quality.

Looking at the time management of the project, the project is still meeting the programme milestones. Despite the fact that there is a deadline for the completion of some aspects of the project before the 2010 Soccer World Cup, the programme allows for

the completion before then. This means that there is less threat posed on achieving quality in Gautrain by the June 2010 deadline.

Considering that ISO has a specifically outlined procedure, the quality management department of Bombela Civil Joint Venture has customized the quality procedures to suit the Gautrain project. Bombela Civil Joint Venture has a generic approach that they use on all of their projects, and since no two projects can be the same, they have to customize their approach to suit any project they are executing. It can be concluded that despite the ISO certification, there is a flexibility of customizing procedures to suit any project to be executed by ISO compliant companies for better results. This aspect of customization is not well understood in many developing countries, which acts as a barrier to the adoption of formal quality management systems that are externally monitored.

Due to the concession requirements, training was made mandatory by the government for Bombela Civil Joint Venture. This falls under the socio-economic development requirements for this project, and it is important to note that this was a condition of contract rather than a vague target that could be undermined by the other objectives, significantly the strict deadline and the high technical performance demands. The Gautrain project is quite different from the other high standard developmental projects the government has been embarking on like the Constitutional Hill project between Braamfontein and Hillbrow in Johannesburg (Ali, 2003)

In this example, the government wanted to create jobs for people but during the planning and execution, there was no real commitment to this goal, resulting in the project being machine intensive. This was a failure in meeting the client's socio-economic objectives of creating and generating employment and supporting small emerging firms during execution. If the government had included the socio-economic goals as one of the terms in the agreement that was signed by the project players for the Constitutional Hill project, the method of execution would have been more likely to have been employment intensive based.

During the course of this research, it was discovered that Bombela Civil Joint Venture spends 3% of the payroll on training. This training ranges from the very basic skills training of the general worker to internship, mentorship and sponsorships for university study in the professional and higher management levels. This shows how much attention should be put to training to realize better quality management in projects and make the jobs sustainable while trying to reduce cost related errors.

For the Gautrain project, most risks are borne by Bombela Civil Joint Venture because they are responsible for the design, which prompted the client to give them a high degree of freedom of operation. This has forced Bombela Civil Joint Venture to look for the best methods of executing the project efficiently, which were introduced into the system design by the professionals in the field, thereby reducing the responsibility for the selection of execution method by the client.

The client confirms the design and methods of buildability of the project, allowing higher degree of professionalism to come from the contractor. This encourages continuity and consistency in the people handling the project for better results because it is easy to harness the skills and knowledge of the specialist suppliers during the design development and also inject buildability and 'right first time' into the design development. For the Gautrain project, the higher level of integration of design, management and construction is a means of quality management, especially in relation to the concept of "right first time".

This research has shown that Bombela Civil Joint Venture has taken several steps to reduce cost related errors. Good and clear communication interface was defined in the quality management document to reduce confusion and cost related delays; there is a clear definition of responsibilities for all workers from the top management staff to the workers on site; and there is an adequate verification routine to ensure that design, materials and workmanship meet specified requirements.

There is an effective communication system in the Gautrain project which is described in the Internal Communication Plan. This clearly shows how the parties involved in the project are meant to relate to one another, and the means and medium of communication. The communication system adopted by Gautrain is effective for such a large project because every one gets the right information at the time needed. This has aided the achievement of required quality in the Gautrain project.

Finally, it has been revealed that ISO standard projects can be executed using *non-ISO certified* project players effectively; and capital intensive projects like Gautrain can be executed having in mind labour-intensive methods without compromising the quality required. Gautrain serves as an exemplar to large-scale and complex infrastructural projects that have traditionally been carried out capital intensively by the South African government.

In brief, listed below are some reasons Gautrain project has been a success in the achievement of socio-economic and quality standards without compromising one another:

- The project is a long term project and the policy makers understand the concept of job creation in the project;
- There was an in-depth assessment of the technical feasibility and economic efficiency of job creation and the job creation principles were incorporated into the daily work;
- During the preliminary work, concentrated attention was given to the technical, institutional, organisational, managerial and socio-economic aspects, which continued through other project phases;
- Training was extensive for all levels of employees;
- The government – client, has been supporting the project since the inception of the project financially; and
- There is good co-ordination between the parties involved.

According to one of the quality managers, the quality management system has been successful for the Gautrain project. Traceability is extensive, people think and plan more, and the end product is the proof.

The Gautrain project should serve as an exemplar to future public sector projects.

6.2 Recommendations

This research has shown that socio-economic goals can be successfully included in high standard infrastructure like the Gautrain with good planning, procurement system and project structure. Firstly, for projects like the Gautrain, the design and execution team should be introduced from the inception of the project so that their technical expertise can be exploited and the buildability of the execution methods can be questioned and adapted where this would enhance the project's deliverables. This will have a positive effect on the project by:

- Reducing the cost of rework;
- Reducing the time of completion;
- Building quality into the whole execution system;
- Improving the quality of occupational health and safety;
- Reducing in wasted materials; and
- Encouraging the efficient use of labour.

Secondly, when the government wants to embark on such large and complex infrastructural projects such as Gautrain, they should ensure that training of workers should be emphasized, as happened on the Gautrain project, because training makes the execution team get things right the first time easily and more frequently, and creates sustainable jobs for individuals, there by reducing the skills shortage in the country. In contrast to many of the labour-intensive projects carried out throughout the developing world, where training is fairly limited and project specific, the training model used for the Gautrain, because of its focus on international best practice, can be adapted by the employee to a wider set of circumstances in future projects.

Thirdly, the construction industry should encourage more projects to be designed and built by the same company. This encourages continuity and the quality of the project is attained with greater assurance. When the quality of a project is achieved, the cost of maintenance and latent defects are minimised, and the project lifecycle is improved.

Lastly, whenever the government or a client feels the need to improve the labour productivity for high standard infrastructure, the literature indicates that this can be achieved by:

- Improving the organisation and management of the construction programme;
- Introduction of improved tools and equipment;
- Health and nutritional conditions of the labour force

6.3 Areas for future research

Firstly, the role of women in quality assurance in the construction industry in developing countries is an area recommended for future research. Secondly, the advantages of using build-operate and transfer procurement systems in the construction industry is another recommended area of research in the future. Thirdly, the success of implementing the South African government policies on the youth and disabled in the construction industry is another area for future research. Also, the barriers to achieving successful project implementation using recognised quality management systems is another area for future research.

This work has been limited to the study of a single project, selected because of its complexity and its apparent success in meeting world class standards. It should become part of a far larger study of the different approaches to quality management in both the public and private sector in Southern Africa as a basis for a comprehensive set of guidelines.

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