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MAIN CONTRACTORS' DESIGN CONTRIBUTION TO THE DELIVERY OF GREEN BUILDINGS



Submitted by:

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A dissertation is submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, in fulfilment of the requirements for the degree of Master of Science in Building.

Supervisor: Professor David Root

Johannesburg, June 2016

Declaration

I declare that this dissertation is my own unaided work. It has been submitted for the Degree of **Master of Science (Building)** at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University

.

……

(Signature of Candidate)

29th day of June, 2016

(day) (month) (year)

Abstract

This study set out to establish the extent to which South African contractors are seen as capable of engaging and contributing towards the designs of green buildings. The study further examines how the traditional procurement path, which is dominant in delivery of construction projects, affects a contractor's contribution towards green buildings.

The problem that exists is the exclusion of contractors at the design stage of a project through the use of the traditional procurement path. This exclusion potentially leads to clients not getting the full benefits of green practices in the delivery of their projects.

The research adopted a positivist methodology collecting quantitative data using a questionnaire surveying construction professionals that are registered with the Green Building Council of South Africa (GBCSA).The construction professionals that were surveyed include construction managers, project managers, architects, quantity surveyors and engineers who have direct experience and knowledge of green buildings

Findings from the research reveals that there is a perception that the lack of awareness of green buildings in South Africa leads to certain clients, most notably government and parastatals, to invest less in green buildings. The use of the traditional procurement path is perceived to be inappropriate in the delivery of green buildings. This is due to the fact that the traditional procurement path excludes involvement by contractors at the early stages of the project therefore they do not contribute to the design of green buildings. The clients are therefore advised to plan and strategise procurement plans so that contractors can be involved early during the design stages, so that they can provide input so as to improve the buildability of projects and prepare proper health and safety plans.

Key Words: *Green Construction, Early Contractor Involvement, Supply Chain, Procurement*

Dedication

I dedicate this dissertation to my family, especially my mother, Evelyn Nthepha Mothobiso for the support and encouragement they have shown throughout my entire studies for this degree.

Acknowledgements

I would like to acknowledge the Industry sample for taking part in the research, and also acknowledge my supervisor, Professor Dave Root for his mentorship and guidance in my research career. Mangosuthu University of Technology is thanked for financial support that enabled me to complete my studies, and all thanks to God.

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List of acronyms

GBCSA: Green Building Council of South Africa

SCM: Supply Chain Management

ECI: Early Contractor Involvement

GSCM: Green Supply Chain Management

SSCM: Sustainable Supply Chain Management

CIDB: Construction Industry Development Board

SACQSP: South African Council of the Quantity Surveying Proffession

SACPCMP: South African Council for the Project and Construction Management Proffesions

SACAP: South African Council for the Archiectural Profession

1 Introduction

1.1 Context of the Study

This study examines the extent to which South African contractors are experienced and knowledgeable about contributing towards green buildings designs. It further examines how the current traditional procurement path limits and prohibits contractors to significantly contribute design input towards the design of green buildings.

This chapter sets the background to the current situation within the South African construction sector regarding green construction. The current existing trends of green construction are briefly discussed to set the context of the problem. Procurement is also discussed to show its potential relationship to green initiatives of the project. The chapter thus builds a justification for the research and articulates the problem to be studied and the primary and secondary research questions. The hypothesis and sub-hypothesis is stated, research aims and objectives are identified and the research design is briefly described.

1.2 Background for the research

In the traditional procurement path, which is the dominant form of procuring buildings in South Africa, the contractor is appointed after the design concepts and ideas have been finalised by the design team and the client, and after the production of information in terms of drawings, specifications and bills of quantities are prepared for tendering purposes. The dominance of this procurement path dates back decades and it is evident from Bowen *et al.,* (1999) that the most preferred procurement was the traditional procurement method. . The preference was mainly expressed by the clients and the design team whilst the contractors ranked this procurement path as the least preferred. More recently it was emphasised by Tomilson (2011), that for example, in the housing sector, the guidelines of appointing contractors documented in National Housing Code (DoH, 2000) explicitly sets out tender procedures that should be followed which still favour the adoption of a traditional procurement path. A similar bias is also evident in the CIDB documentation which shows best practices for awarding tenders.

Contractors, under this system, are invited to bid on a project, by pricing the tender documents compiled by the design team and to provide a lump-sum price for the project

(Pesämaa *et al*., 2009). Typically, the lowest priced bidder is appointed (Kadefors, 2004) although in South Africa, preferential procurement may have also be considered, but even then price counts for 80-90% of the weighting of the tender (Mathonsi and Thwala, 2012). Further evidence of the dominance of the traditional procurement path is in the way the fees tariffs by different built environment councils (e.g. SACAP, SACQSP, SACPCMP etc.) which also reflect the traditional procurement path in their description of the professional's duties.

This procurement process, which separates the delivery of the building into the three stages of design, bid and build, consciously excludes the contractors from any involvement before the design is complete, since the price submitted by the contractor is expected to be on a completed design communicated by the drawings, specifications and bills of quantities. This approach of separating the designers from those who build has been challenged by Riley *et al.*, (2003), and has been seen as problematic because the contractors are not able to contribute towards designs e.g. by suggesting alternative designs based on previous experience, or giving input on a selection of materials and identifying construction methods that can deliver the project by the expected time and save costs; reflected in ideas such as constructability or buildability (Trigunarsyah, 2007), as well as practices such as Early Contractor Involvement (Bryde and Robinson, 2005) and Value Management and Value Engineering (VM/VE) (Salvatierra-Garrido and Pasquire, 2011, and Emuze *et al.*, 2014)

The early involvement of contractors has been shown to assist in improved planning which can lead to savings of time, the addressing of health and safety issues in advance before the commencement of works on site and improved quality onsite (Song *et al*., 2009). Riemanm and Spang (2014) argue that early involvement by the contractors can help the design team to achieve constructability, design assistance, scheduling, identifying site issues and the maintenance and life cycle of the building.

Constructability is affected when using a traditional procurement path and the end products normally become expensive to build. Constructability is defined by Trigunarsyah (2007) as the degree of enhancing cost efficiency of the project by integrating the past knowledge and experience of the contractor to the design process so

that the construction process can be of ease and allows the achievement of project goals.

Whilst there are potential benefits to all construction projects by gaining access to the knowledge of contractors, in the case of green buildings there is recognition that the early involvement of the supply chain, including the contractor is vital (Song *et al*., 2009). Yet, evidence suggests that green buildings in South Africa continue to be predominantly delivered using the traditional procurement path (Rose, 2014). Green buildings are defined by U.S Environmental Protection Agency as "*a practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction."* They are constructed with the aim of using less natural resources and less energy in order to minimise environmental depletion but whilst still attaining the social and economic stature of the building (Yudelson, 2008). These types of structures are becoming increasingly adopted as countries and economies move towards minimising the depletion of environmental resources and as well as minimising energy consumption and water usage.

The consequences of this failure to facilitate the contribution of contractors to the design of green buildings is that the South African clients may not be achieving the full benefits of these projects as contractors are not actively engaged at a stage where they are capable of adding value (Rose, 2014). As a consequence, the construction sector as a whole is not getting full access or exposure to the potential benefits of green technologies and practices and the benefits of green designs as the potential contribution of contractors is not recognised nor facilitated by the procurement practices adopted. Thus it is likely that the procurement practices are acting as a brake on the adoption of some green building technologies and practices.

Thus the purpose of this research is to explore views on green construction in South Africa and to establish whether the contractors have the expertise to contribute to improving green buildings in either the design and construction phases and whether their ability to contribute towards green construction is hindered by the continued selection of traditional procurement practices, and whether their exclusion at the

conceptual and detailed design stages affect their willingness and ability to promote and adopt green building practices.

1.3 The role of contractors and green design

Contractors play a vital role within the built environment as they execute the scope of work as set by the design team. Construction as an economic activity contributes significantly towards Gross Domestic Products (GDP). In South Africa the construction industry contributes approximately five percent (5%) towards GDP and the industry provided more than 1.18 million jobs in 2014 (Statistics South Africa, 2014). The construction industry is used as a catalyst in economies to provide employment and produce different buildings needed for social and economic services (Zuo *et al*., 2012). As these services are provided by the construction industry, a lot of environmental issues arise as there is a depletion of natural resources, emission of gases on site and pollution to the environment arising from their activities (Tan *et al*., 2011). With all these activities the public, governments, legislatures and environmentalists scrutinise the industry and push it to come up with sustainable methods to minimise negative environmental impacts. Zuo *et al.,* (2012) states that there needs to be strong integration and emphasis on how interventions can be carried out through all the stages of a project which are: briefing, design, construction and operation.

Construction activities by nature intensively consume natural resources and emit carbon in its various forms (Lam *et al*., 2010). Findings by the World Business Council for Sustainable Development (WBCSD) state that the construction industry consumes 40%, 25% and 16% of stone, timber and water respectively, globally, per annum and at the same time Yan *et al.,* (2010) reveal that carbon emissions arise due to the use of fuel and electricity during the construction process. Wong *et al*., (2012) argue that increasingly more responsibilities are being imposed on contractors by society through regulations etc., to control these emissions during construction, minimise the use of natural resources and reduce wastes. Yet despite this growing and increasingly intensive need to make construction activities sustainable, contractors are excluded during the inception stages of projects where the key design decisions are made, and where they can get the opportunity to reduce the impact of construction activities.

Yet in most projects in South Africa contractors are appointed after drawings and specifications have been finalised by the design team and client (Mathonsi and Thwala, 2012). Even in the case of green buildings, this late appointment of contractors applies despite the recognition of the benefits of contractor involvement (Rose, 2014). The basis of their selection remains largely dependent on their response to the design information in the form of tenders to provide prices (*ibid*.).

The construction industry, like other industries, is faced with the challenge of the current paradigm shift towards the implementation and adaptation of green design principles. South Africa, like other developing countries, is also moving in line with implementing green designs and non-governmental bodies, such as Green Building Council of South Africa (GBCSA), have been established to award ratings to green buildings and promote green design and construction practices.

Globally, the construction industry has made this development a priority to meet the standards of achieving sustainability (Holton *et al.*, 2010). The principles of green design requires the meeting of social needs without affecting future generations, by attaining budgeted costs of the projects and expected quality whilst minimising environmental depletion and complying with legislature (Abidin, 2010). All these fundamental project needs should be met without compromising one another. These pillars are the governing mechanisms of green construction, namely; environmental protection, social well-being and economic prosperity (Addis and Talbot, 2001; Brownhill and Rao, 2002.)

During the construction phase there tends to be many activities that adversely affect the environment including air, water and noise pollution. Some of these activities are directly under the control of the contractor whereas others are the function of the design of the building. Whilst the contractor can take independent steps to reduce environmental impacts during the construction phase, the major impacts are likely to be derived by the operation of the building, hence the importance of design in mitigating these impacts. The actions taken by the contractor are therefore constrained by the design decisions of the design team, of which they are not part under the traditional procurement path.

Some construction waste is also hazardous to the environment thus affecting the eco-system (Majdalani *et al*., 2006). With these problematic issues the industry needs to come up with strategic and innovative ways to reduce these environmentally adverse attributes (Yitmen, 2007). Some governments have positively responded to these problems and come up with policies and regulations to control construction activities (Shen and Yao, 2006).

1.4 Factors affecting green construction

Even though green construction is perceived to be of growing importance within the construction industry there are challenges that hinder the implementation and adoption of initiatives in support of green construction (Meryman and Silman, 2004). There remains a lack of awareness and knowledge from investors and clients as how these designs will influence cost reduction (Qian *et al.,* 2013), despite the fact that adapting these designs in actual fact depends on the knowledge and understanding of overall concepts **(**Abidin, 2010). Some surveys done reveal that managerial skill was a concern as adaptation to these initiatives needs skill and knowledge by contractors (Qi *et al*., 2010).

With cost being a matter of concern, particularly in a low growth environment, as being experienced by countries such as South Africa, implementation comes at a price. Therefore clients may be reluctant to adopt green designs (Kunzlik, 2003). It is evidently highlighted by Ofori and Kien (2004) that costs act as the main barrier to implement the designs as clients have limited budgets, for example water and energy savings equipment have high capital costs and in most cases this tends to be problematic during cost control (Qian *et al*., 2013). Other issues of concern are the integration of green designs with other components of the building. Ofori and Kien (2004) state that designers spend time on integrating different elements which end up affecting the progress of works, and at the end construction teams revert back to traditional methods of construction because the new products proposed might not be compatible with other elements or components of the structure (Qian *et al*., 2013). If contractors were involved at the design phase they could potentially add value by resolving these problems by using previous experience from other projects because they are the ones affected by ease of building in respect of time, cost and quality to a specific form of constructability that incorporates ease of achieving green outcomes.

1.5 Construction Procurement Methods

The construction industry by nature has a variety of strategies to procure construction projects, this includes a traditional procurement path, design and build, construction management etc, and the choice of which one is suitable depends on many variables (Khalfan *et al.*, 2012). Projects differ in nature in terms of clients, scope, quality and time constraints, so these factors influence decisions over what possible procurement methods are appropriate in any given situation (Wolf and Seuring, 2010).

Within the context of South Africa, the construction industry implemented hybrid, conventional methods of procurement during the years when the country was colonised (Mathonsi and Thwala, 2012). South African procurement is based on the British model and has been re-engineered due to the political uncertainty that took place during the 80s and late 90s. Since 1994 new policies were developed to foster socio-economic diversification to create new, sustainable development and redress the past (Department of Public Works, 1999). The procurement options mentioned by Mathonsi and Thwala (2012) as being available within the South African context are open tender, selective tendering, negotiated tendering, management procurement and collaborative procurement systems. However, open tender continues to dominate due to concerns to avoid the racially exclusionary practices prior to 1994 and to demonstrate fairness and transparency (*ibid.*).

1.6 Problem Statement

In the traditional procurement path that dominates the South African construction industry the contractor is appointed after the design concepts and ideas have been finalised by the design team and the client. The contractor is only appointed to execute what is designed and finalised in the drawings and specifications. Consequently, the exclusion of the contractor during the design stages of the project is encouraged by the current, traditional procurement methods adopted in the construction industry. Thus, South African clients may not be getting the full benefit of green projects as contractors are not actively engaged at a stage where they are capable of adding value and, as a consequence, the construction sector as a whole is not getting full access or exposure to the potential of green technologies and practices and the benefits of green designs. Thus

is it likely that the procurement practices are preventing the adoption of green building technologies.

1.7 The Rationale of the Study

The rationale for the study is to find out how to maximise green construction within the built environment and how to close the gaps that have been created by the existing procurement methods. If the contractor is involved during the inception and briefing stages of the project there would be an increase in the attainment of green construction and maximum lean efficiency in the project. The study also researches from literature how other countries are involving contractors to take part in green implementation, and how their systems can benefit the South African context.

1.8 Research Question

Thus the primary research question can be stated as:

- *To what extent are South African contractors contributing to and promoting green building practices?*

1.8.1 Sub-Question

From this the following sub questions are:

Sub-question 1: *Are South African contractors able to contribute and promote green building practices?*

Sub-question 2: *Do South African contractors have the necessary capacity, knowledge and experience to contribute and promote green building practices?*

Sub-question 3: *Is the use of the traditional procurement path allowing South African contractors to contribute and promote green building practices?*

1.9 The Aim of the Study

The aim of the study is to establish the extent to which South African contractors are seen as capable of engaging and contributing towards the designs of green buildings.

1.10 Objectives of the Study

The objectives of the study can be described as being:

- To find the stance of green construction in South Africa;
- To identify the role contractors play within the traditional procurement;
- To identify the role that contractors are willing to play in order to contribute in the design of green buildings;
- To identify existing practices that can involve contractors during the design process;
- To identify the most dominant project delivery process;
- To identify the most ideal procurement method for green buildings;
- To find out green practices and challenges of countries with the same economic scale as South Africa;
- To find out how the supply chain is affected by the current procurement methods *with respect to* green construction; and,
- To identify how the supply chain can be integrated in order to get the full benefits of green designs.

1.11 Research Methodology

Contractors' input on green construction is affected by many variables and factors. In order to thoroughly investigate the problem statement the research approach chosen was the quantitative technique. The choice of the research approach was due to the fact that data was primarily collected by the use of questionnaires. The philosophical orientation will be a positivist approach because it is useful for testing a hypothesis, and the research is trying to find the causes that lead to contractors not actively being involved during the design stages of projects. Data was collected from a sample of individuals who are construction professionals that have been involved in green projects and they are registered members, trained by the Green Building Council South Africa (GBCSA). The primary source of data is literature reading and the secondary source of data is by questionnaires.

Collection of data was in the form of a census survey specifically on individuals as per the green project(s) they have worked on. A set of questionnaires was sent to participants. An email was sent through online link (Qualtrics) which lead to

questionnaires that needed to be answered by construction professionals. The construction professionals that took part in the survey are architects, construction managers and construction project managers, quantity surveyors and engineers.

Data collection was carried out as a single stage process whereby the questionnaire was sent to participants. The design of the questionnaire was to establish perceptions and attitudes of green building in South Africa and experiences of professionals within the South African set up. Different statistical methods were used to analyse qualitative data while thorough analysis and discussion was used to analyse quantitative data.

1.12 Hypothesis

Since a positivist research design has been adopted, the following hypothesis and sub-hypothesis is posed based on the primary research question and the sub-questions:

H_0 *: Contractors' willingness to contribute and promote green building practices is negatively affected by their exclusion from design stage of project delivery process.*
H_1 *: Contractors' willingness to contribute and promote green building practices is not affected by their exclusion from design stage of project delivery process.*

1.12.1 Sub-hypothesis:

From this the following sub hypothesis is:

Sub- hypothesis 1:

H_0: *The South African contractors have the necessary capacity, knowledge and experience to contribute and promote green building practices*

H_1: *The South African contractors do not have the necessary capacity, knowledge and experience to contribute and promote green building practices*

Sub-hypothesis 2:

H_0:*The South African contractors have the necessary capacity, knowledge and experience to contribute and promote green building practices*

H_1:*The South African contractors do not have the necessary capacity, knowledge and experience to contribute and promote green building practices*

Sub-hypothesis 3:

H_0*The use of a traditional procurement path is allowing the South African contractors to contribute and promote green building practices*

H_1*The use of a traditional procurement path disallowing the South African contractors to contribute and promote green building practices*

1.13 Ethical Considerations

Ethical clearance was obtained for this research. Anonymity was not avoided when collecting the data, as individuals were identified that have worked in green buildings. However, when analysing, presenting and reporting the data it was done on an aggregated basis, so individual participants and projects are not identifiable. There were no specific ethical risks related to this investigation.

1.14 Limitations of research

The research will only be carried out and limited to the following parameters:

- Only construction professionals that have been accredited by GBCSA were sent questionnaires
- Only construction professionals that have been involved in green projects that have only been rated by GBCSA participated in the survey.
- The research was within the South African context, predominantly green projects rated by GBCSA.
- The research is looking at perceptions about contractors' expertise and knowledge, not if they actually have the expertise and knowledge.
- Time frames to collect data were limited to two months so that submission dates could be met.
- The research was not focusing on incomplete projects

1.15 Assumptions of the study

The following was assumed during the duration of the research:

- The sample as accredited by GBCSA has the necessary knowledge and expertise as deemed by the organisation.

1.16 Structure of discourse

The research report is structured in the following chapters:

Chapter 1: This chapter introduces the topic and gives a brief background about the study. The rationale of the study is also explained together with the objectives that the research has to meet.

Chapter 2: The second chapter of the research unfolds the current literature on the subject matter and looks at any existing theories that may help to explain certain concepts. The literature mainly looks at the South African context about green construction in South African and other countries on the same economic scale as South Africa. Other comparisons are made with developed countries within the context of green projects and how procurement has influenced their delivery as have contributions by the contractor.

Chapter 3: This section details how the research has been designed and the methods that were used for data collection (Research Methodology).

Chapter 4: This chapter presents the research findings and the results are analysed and discussed

Chapter 5: This chapter gives a holistic summary of the research projects. Main findings are summarised and presented. There are also recommendations based on the findings.

1.17 Definitions of Terms

1.17.1 Sustainable Construction:

The concept of ‘sustainable construction’ is widely adopted within the research due to the impact that the construction industry is having on the depletion of national resources and a negative impact on the environment, it is defined by the University of Southampton as:

> *"The need to find a balance between economic, environmental and social factors in the design, construction and use of buildings".(http://www.southampton.ac.uk/susdev/documents/sustainable_construction.pdf)*

These principles of sustainable construction are derived from the world concepts of **Sustainable development** which was defined by the World Commission on Environment and Development as:

> *"Development which meets the needs of the present without compromising the ability of future generations to meet their own needs". (International Institute for Sustainable Development (IISD, 2010).*

1.17.2 Green designs:

The concepts of green design as adapted by the construction industry embed the principles of sustainable development. It is described as:

> *"Designs that incorporate saving energies, resources, recycling materials and buildings adapting to locational climate and its contemporary approaches environmentally responsible and resource efficient decision making by accounting for requirements throughout a building life cycle i.e. considering entire cycle from design, construction, operation, maintenance, renovation, and demolition". (Liu and London, 2013)*

1.17.3 Procurement:

Systems of sourcing work is termed 'procurement' and is defined as:

> *"Mechanism for linking and coordinating members of the building team throughout the building process in a unique systematic structure, both functionally and contractually. Functionally via roles, authority and power, contractually via responsibilities and risks. The main aim is to deliver a project that meets its objectives and fulfils the client's criteria and expectations. (Naoum and Egbu 2015)*

1.17.4 Supply Chain:

Supply chain (SC), which is an integrated system that connects activities in construction is defined as:

> *"An integrated network of facilities, transportation options for the supply, manufacture, storage and distribution of materials and products and its standards comprises of suppliers, manufactures and distributors". (Garcia and You 2015)*

1.17.5 Early Contract Involvement (ECI):

Procurement methods are urged to be flexible and innovative in order to attain value for money. One of concepts is EIC, is which is defined as:

> *"An approach to contracting that supports improved team working, innovation and planning to deliver value for money. It involves an integrated contractor and designer team, appointed under an incentivised, two-stage contract consisting of involving design development and construction planning, which is aimed at meeting the objectives and which leads to the agreement of a target price and later covers the period of detailed design and construction"*https://www.gov.uk/.../Early-contractor-involvement/ECI/guidance**.**

1.17.6 Buildability:

This is defined as:

> *"The extent to which a building design facilitates ease of construction, subject to the overall requirements of the completed building." (CIRIA, 1983*)

2 Literature Review

2.1 Introduction to Literature Review

This part of the report covers research that has already been published in the domain of green construction, specifically on the subject matter of the contractors' role in influencing green designs within the construction project. This chapter of research covers existing literature on the subject matter in order to validate the problem statement. The use of theories is also used to substantiate certain ideas and concepts. Information on this chapter is gathered from publications, journals, text books, and engineering newsletters and government and parastatal publication reports. There is also use made of models and theories from different researchers.

2.2 Objectives of Literature Review

The objectives of the literature review for the purpose of this research are as follows;

- To gather information about the subject matter, i.e. to discover the stance of the construction industry with regard to green designs implementation and adaptation by contractors;
- To unfold the construction project setup and the influence of the design team on delivery of the project;
- To identify the stance of green construction initiatives in the South African context;
- To support and backup with evidence the issues that are being argued and raised;
- To compare findings from developed countries and developing countries about green construction;
- To analyse the information collected by researchers and apply it to the problem statement;
- To answer questions raised as literature questions;
- To benchmark theories and models and come up with alternative suggestions to help the construction industry to achieve green initiatives; and,
- To gather information that will be able to solve the research questions.

2.3 Literature Framework

The literature review covers the general concepts of green construction and its implementation in South Africa. The South African construction industry is discussed in detail on its current stance with regards to green initiatives that are in place. Current design processes will be analysed to determine where the design teams provide green designs and where alternative design solutions can be introduced and considered.

The role of contractors is discussed as to how they potentially and in practice contribute towards green initiatives. The initiatives will be based on how they implement and monitor greening on sites and possible barriers they experience while implementing these initiatives. The current construction procurement practices will be discussed along with a discussion of how they may affect implementation of sustainable designs. Discussions will be done on different types of clients and how they adopt green buildings and practices and what influence their decisions have on procurement strategies and the delivery methods of projects.

The latter part of the chapter focuses on the traditional procurement path that is currently used for most projects so as to seek evidence of, and develop a logical argument for how its selection hinders and limits contractors in fully engaging and contributing to achieving green construction outcomes. Furthermore literature will be used to find out what is done in countries with the same economic level as South Africa.

Promotions and initiatives set by clients and government will also be reviewed to see how they have been implemented to promote greening the construction industry. Literature in the field of Early Contractor Involvement (ECI) and Supply Chain Management (SCM) will be unpacked and its correlation with the problem statement discussed.

2.4 The Context of the South African Construction Industry

The South African construction industry contributes on average five (5) % towards the Gross Domestic Product (GDP) of the country, therefore the construction industry plays a vital role in economic development (Statistics South Africa, 2014). While it

contributes this significant proportion to the economy it has to meet legislative obligations and meet international norms.

Contractors in South Africa are largely governed by the Construction Industry Development Board (CIDB), which governs the registration of contractors who work with the public sector and their development. Other parties involved in the construction projects are governed by different bodies such as Engineering Council of South Africa (ECSA), South African Council of Quantity Surveying Profession (SAQSP), South African Council of Architectural Profession (SACAP), South African Council for the Project and Construction Management Professions (SACPCMP), South African Council for the Property Valuers Profession (SACPVP) and South African Council for the Landscape Architectural Profession (SACLAP). All these councils fall under the main umbrella of the Built Environment (CBE), which oversees all the built environment councils who have a mandate with respect to the professionals who are required to register with their respective councils in order to be allowed to practice in South Africa. All the above-mentioned bodies are legislated entities that ensure that the built environment professionals are monitored in terms of academic qualifications, registration as professionals and that they maintain professionalism and adhere to standards in the industry.

There are other bodies of significance such as voluntary associations, including an independent and non-profit entity; the Green Building Council of South Africa (GBCSA). Its mandate is to promote green initiatives within the construction industry; to promote that designs, construction and the maintenance of buildings are environmentally sustainable. (GBCSA, *n.d*). The GBCSA provide tool for training to the industry about different technologies and innovative methods that can be used to green projects, as well as methodologies for the rating of buildings in terms of their greenness (GBCSA, *n.d*).

The South African construction industry has experienced major changes over the past two decades that parallel the changes in the wider South African economy and society (Emuze and Smallwood, 2014). These changes include new models of financing of projects in a form of partnerships between the private sector and the government. The

changes to the industry have been catalysed by the adoption of flexible contracting arrangements between clients and contractors (*ibid*).

Shakantu *et al*., (2007) claim that the new phenomenon and changes have led to the contractors' share on site being reduced and replaced by many subcontractors' works. They furtherly suggest that this situation has caused more fragmentation in the industry that previously existed. All these trends follow global phenomena of fragmentation of the construction industry (Masrom *et al*., 2013)

2.5 The construction project team

Construction projects are made up of a team of professionals comprising of the design team and the main contractor, who typically engages specialist and sub-contractors for specific trades and activities. The design team execute professional duties on behalf of the client. Oloufa *et al*., (2004) defines the design team as individuals from different domains, companies and different geographical locations who innovatively produce a competitive product. Where use is made of traditional procurement, the design team provides complementary skills and experience to achieve project objectives and have accountability and an obligation to deliver as per contractual arrangements (Senaratne and Hapuarachchi, 2009). When the client uses the traditional procurement path, it tends to lead to fragmentation in terms of project deliverables and these perpetuate the design team to tackle tasks independent from one another throughout all stages, from design to production (Mitchell *et al*., 2011).

Otter and Emmitt (2007) argue that construction projects are becoming more complex and diversified due to the increase in the project organisational setup .The design team have different unique needs and thus a lot of thought has to be given to the effective communication by the team members (Emmitt and Gorse, 2007). This is due to the fact that the construction project team is temporary and it is made up of different organisations which have different work cultures, personal attributes, expertise and professional systems (Gorse, 2002). With all the above-mentioned issues, construction project teams have been perceived as performing badly, in terms of project delivery, due to the fact of non-cohesion resulting from the fragmented characteristics of the industry. (Evbuonwan and Anumba ,1998)

2.5.1 The construction design team

The design team within a construction project are involved at the early stages of the project in order to determine the shape, aesthetics and performance of the building, and these teams have a direct influence on the choice and selection of materials, construction methods and the facilities management state during the life of the building (Sacks *et al*., 2015). During the design phase, the designers have the responsibility for the safety of activities during the construction and whole life of the building (Brace *et al*., 2009).

Within the South African context it is also explicit in the Occupational Health and Safety Act (OHS) and Building Regulations of 2014 that safety must be prioritised and that it is the responsibility of both the client and the contractor to have health and safety representatives on site at all times (Windapo and Goulding, 2015). However, most designers lack site experience and this makes it difficult for them to actually identify and plan health and safety related issues (Raviv *et al*., 2012). However, legislation allows them to delegate authority to competent parties to make up for this lack of expertise (National Building Regulations, 2014).

Riemanm and Spang (2014) find the design phase too theoretical as there is no input from the practical side of the project - from the contractor - which could maximise the efficiency and performance of delivery of the project. Therefore there is a suggestion that there should be inclusiveness of the technical construction professionals during the design stage because they have execution experience and they would be able to identify proper construction methods, good choice of specification and proper health and safety planning for site problem-solving activities (Sacks *et al*., 2015).

The construction design team is faced with challenges and they can be exposed to the following risks as depicted by the figure below.

Design team's ability to perform	Unsuitability of Design Team
	Poor performance by design team
	Inferior initial design
	Inheritance of design team error
	Unfamiliar with statutory design requirements

Figure 2.1: Risk elements pertinent to design team's ability to perform adopted from Ng et al., (2002)

As depicted in the figure above the design team poses some difficulties which could lead to an inability to perform to the expected level. Assaf and Alli-Heiji (2006) in Saudi Arabia observed problems on projects that affected the time performance of the projects due to the design team's performance as categorised in the figure above. The problems included the following:

- Errors in documentation;
- Late production of designs;
- Ambiguity in designs;
- Unclear briefing from the client;
- Lack of adequate experience within the design team; and,
- Complex designs.

The same problems as mention above have been highlighted by (Mitchell *et al*., 2011) where major setbacks have occurred because the design team were unable to meet their objectives.

2.5.2 The role of the main contractor

Contractors are appointed by the client on a project in order for them to execute duties of construction as per contracts, and their selection is based on the criterion set and evaluated by the client with the assistance of the design team. The appointment of contractors should include screening in order to eliminate inefficient and incompetent contractors, these screening methods guard the interests of the clients and for the

contractor acts as an auditing mechanism on its ability to perform (Russel and Skibniewskin ,(1990) cited by Sönmez *et al*., 2002).

Thus, during the pre-qualification of contractors the following points should be critically evaluated (Holt *et al*., 1994):

- Contractors' organisational structure;
- Financial stance of the company;
- Resources available for management;
- Previous project experience; and,
- Previous project performance

Contractors are responsible for converting the designs into the physical state of a building (Wong *et al*., 2012). In the current paradigm shift contractors are obligated to uphold sustainability in terms of being carrying out environmentally friendly activities (Robin and Poon, 2009).

2.5.3 Construction clients identity

Construction clients vary in nature and have different objectives and the need to build. Higgin and Jessop (1965) found it difficult to classify clients into specific definitions because they claim each design brief process should follow a certain procedure to meet the desired needs of the client. However, Bowen (1990) classified construction clients as private individuals, governments or state clients and property investors. All these client identities have different objectives when it comes to the need to build. Yet the crucial aspect about clients is their experience in construction and these affect the level at which the client can be actively involved at design stages of the projects (Bowen, 1990). Bowen further categorises client experience as follows:

- Inexperienced clients;
- Moderately experienced clients; and,
- Experienced clients

With all these categories some clients may have knowledge of construction and therefore end up actively involved in all stages of the project leading to project success,

while some have no experience and will rely on outsourcing representatives to partake in the project (Love, 2001)

Murray *et al*., (1990) also ascertain that relatively few clients understand construction processes and issues relating to procurement methodologies and how they can influence and impact on the delivery of the construction project. Because the experience of the clients varies, those with limited experience employ advisers that are equipped with the knowledge and experience of building projects (Love, 2001). Spencer and Winch (2002) suggest that clients should be more participative in construction processes so that they gain more knowledge on how to achieve successful projects, so that they can use this knowledge and experience in future projects to determine procurement strategies and planning of the works.

The level of client involvement is perceived to be of high importance so that they can carefully evaluate the choice of procurement strategies and the project management of construction processes (Errikson and Laan, 2007). Ideally it is an innovative stance on a project for a client to be the pivotal driver during the design phase of the project, however commitment for change is not easily implemented (Bresnen *et al*., 2000). Research (Venstroom, 2008; Psilander, 2004; Kadefors *et al*., 2007) reveals that active involvement of clients on projects tends to improve the performance of projects as they bring previous knowledge from past projects, and they have the power to influence the choice of suppliers and thereby the end product is significantly improved

In most countries the government as a client represents a major share of the fixed infrastructure development, and in cases like Singapore, public infrastructure accounts for about 60% of the construction projects (BCA, 2012). Where the government is a client there tend to be problems of performance satisfaction as the projects are not finished on time and within the expected budgets (Ning and Ling, 2013). There tends to be many procedures to follow when doing projects for governments. These affect the decision-making process leading to poor performances of the projects (Puerto *et al*., 2008). Most of the time public infrastructure projects are run by governments and these projects are governed by complex policies and regulations (Rahman and Kumaraswamy, 2004a). It is a fact that public agencies have what Crowely and Karim (1995) define as "*Well defined jurisdictions, responsibilities and hierarchy of*

authority". These regulations tend to affect the delivery of projects under governments and can lead to poor delivery. Ning and Ling (2013) suggest that these regulations and codes of practice are put in place in order to regulate and facilitate fair and unbiased procurement practices, however Rose *et al*., (2002) argue that these non-flexible polices tend to disadvantage projects in terms of collaborative relationships.

2.6 Design Processes in the Construction Industry

The design process is defined by Bowen (1993) as "*continuous process encompassing all activities associated with design decision-making*", and that it is used to facilitate a process to solve a client's needs with creativity (design) skill that is relevant to that problem. Gerth *et al*., (2013) state that the design process determines how the building is going to perform in terms of its function and will also determine if it will yield some profit. This process involves intense decision-making processes and requires great knowledge and experience.

Chen and Mohammed (2007) reveal that the processes from previous projects can be remodelled and be improved in the design of a new project and while adopting these historical data, the process should be inclusive of everyone including the non-white collar professionals (Dai et al., 2007). Lam and Wong (2009) suggest that there should be consideration to maximise constructability when carrying out design decisions and these can also be learnt from previous projects and be incorporated within the designs.

The design process is crucial because it is here where most of the unwanted waste can be identified and reduced for the whole life cycle of the building (Okadiri *et al*., 2012). Some waste arises from "design defects" (Josephan et al., 2005), but Bakti *et al* (2011) suggest that if early construction expertise is involved at the design phase these design defects can be reduced significantly to achieve better 'constructability'. The design team should invest their creativity and decision-making at this stage because it will affect the life cycle of the structure and the process should have different options to allow the client to choose in order to maximise the performance of the building (Schade *et al*., 2011).

Current literature reveals that the design phase should also cater for health and safety for the physical state of the building and the construction activities. This gives the design team the opportunity to identify hazards and reduce the chances of unsafe

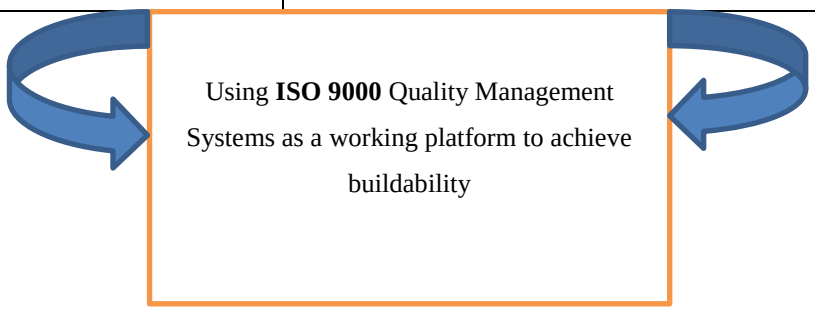
activities during the execution of the works (Sacks *et al*., 2015). Furthermore the design team should aim at reducing the reworks that arise due to improper decision-making and incorrect implementation (Love *et al*., 2000). They ascertain that it will ease the constructability of the projects. Constructability aims at connecting the design phase with the construction phase (Trigunarsyah, 2007), and moreover by doing so delivers benefits to the project by saving on costs and completing the projects within the required time frame. Thus there is a strong argument for making the design process flexible so that other parties as end users - sub-contractors and suppliers - can be accommodated during the design phase so as to maximise the economics of design of the buildings (Fabricio et al., 1999).

2.6.1 Buildability and Constructability concepts during the design phase

The concepts of buildability and constructability are said to require crucial attention during the design phase, therefore designers should be sensitised to maximise attaining the buildability of structures (Lam *et al*., 2006). The concepts of buildability as explained by Wong *et al*., (2006) are encompassed within the design phase of the project and they focus mainly on the optimal use of resources and safe construction activities.

Table 2.1: Buildability principles and ISO 9000 Quality alignment as adapted from Phen et al., (2001)

Buildability Principles	**ISO 9000 Quality Systems**
Investigate thoroughly	Management responsibility
Consider access at the design stage	Quality system
Consider storage at the design stage	Contract review
Design for minimum time below ground	Design Control
Design for early enclosure	Document and data control
Use suitable materials	Purchasing
Design for the skills available	Control of Customer-supplied product
Design for simple assembly	Product Identification and traceability
Plan for maximum repetition and standardization	Process control
Maximise use of plant	Inspection and testing
Allow for sensible tolerances	Control and Nonconforming product
Allow for practical sequence of operations	Corrective and preventative action
Avoid return visits by trades	Handling, storage, packaging, preservation and delivery
Plan to avoid damage to work by subsequent operations	Control of quality records
Design for safe construction	Internal quality audits
Communicate Clearly	Training
	Servicing
	Statistical Techniques



Turner (1995), Moore (1996), Henriques (2001), and Mbamali (2002) debate that there is a significant role played and value added by the construction expertise if they are involved during the design phase of the projects to contribute on the buildability of the

project. If the construction expertise is involved at the design phase it is shown that there will be an ease of buildability of the infrastructure (Mabamali *et al*., 2005).

Pheng *et al*., (2001) find a correlation between the implementation ISO 9000 quality management principles and an increase in buildability of designs. This is based on the fact that there are policies in place that guide contractors on how to monitor quality, and there are remedial reviews that can be used to correct any deviations from quality protocol, hence this method will maximise the attainment of buildability.

The model depicted by Pheng *et al*., (2001) above, shows how buildability can be achieved through its alignment to ISO 9000 quality Systems. The buildability principles identified by Pheng *et al*., (2001) are more similar to the buildability attributes identified by Wong *et al*., (2006) which include;

- Construction activities below ground level;
- Weather conditions;
- Innovations;
- Rationale and coordination of designs;
- Type and choice of site;
- Plant and Equipment;
- Materials and resource usage;
- Flexible designs and standardization options, and;
- Specifications and material systems.

In order to achieve this "intelligent system" as termed by Gray (1986), the contractor has be actively involved at the early stages of the design so as to provide input into the design process on how to innovatively implement the concepts of constructability than using past experience from other projects. However, in most construction projects where the traditional procurement path is adopted the contractor is excluded from contributing to the designs where they may have insights in respect to cost saving construction methods and technologies (CIRC, 2001).

Buildability issues should be addressed at the design stage in order to minimise quality failures and project cost overruns related to designs (Mydin *et al*., 2011). If issues of buildability are not implemented at the design phase the project is prone to experience

re-works, claim disputes, time adjustments, redesigns and endless contract adjustments (Madelsohn, 1997)

The idea of Constructability is aimed at involving the construction team at the design phase in order to ease the construction phase of the project so that they can share the experience and the knowledge (Song and Chua, 2006). Wong *et al*., (2006) argues that the principles of constructability and buildability are aimed at an efficient design phase by involving the contractors to use the resources efficiently and to achieve ease of construction , they further lament that the constructability concepts are not only focused at the design phase unlike buildability , they span the project development phases. It is evident that constructability should be assessed first so that the goals for a project can be achieved, and assessment should span the phases of design, fabrication, construction and project management (Ugwu *et al*., 2004).

This assessment during design can give the designers potential problems that might be experienced during construction and ideal methods of how to avoid or minimise the problem can be implemented. In order to asses constructability the design team should be analytical, creative and strategise on how to maximise the overall execution of the project to be a success (Kannan, and Knight, 2012). Kannan and Santhi (2013) argue that in order to asses and survey the feasibility of constructability an individual should have adequate knowledge and "*hands-on experience*" in carrying out similar work over a period of time.

The Construction Industry Institute (CII) which is an organisation based at University of Texas and made up to clients, contractors and suppliers describes the main purpose of constructability as being to plan the execution of construction works by using experience and knowledge of engineering and the ideal procurement so that project objectives can be fulfilled. Further studies by the CII reveal that projects experience savings on cost construction of about 6% to 10% if constructability principles are implemented in a project (Gugel, 1994). As mentioned by Yustisia (2014), the principles of constructability have evolved over years and have influenced the planning team to incorporate health and safety issues because of the many accidents experienced on site due to improper planning and communication breakdown.

Song *et al*., (2009) suggest that there can be various ways of bringing constructability concepts at the design stages. These include the following:

- Confirm checklists
- Reviewing Constructability
- Designs Reviews
- Placing construction experts in the design team to add value

With all the mentioned constructability concepts they are argued to maximised and fully attained if be applied at the early stages of the project (Pocock *et al*., 2006). While embedding the concepts of constructability at the design phase Song *et al*., (2009) argue that value engineering can be attained where the whole life cost of the building is taken into consideration and high cost areas and alternative construction methods be identified to maximise the value for money concept within a project investment.

2.7 Parties involved during the design process

During the design phase of projects there are various professionals making up the design team, and it mainly depends on the procurement strategy adopted by the client because when using traditional procurement the parties in the design teams exclude the contractor and the contractor is only appointed after the designs have been finalised, and many construction projects are carried out with this procurement package (Yustisia, 2014).

As stated by Griffiths (1992) and Watson (1994) the procurement strategy adopted by the client will influence the composition of the design team because in situations of partnering procurement the client, together with the contractor, contribute towards designs, and the contractor is appointed at an early stage of the design phase in betterment of a relationship to achieve mutual objectives of the project.

2.7.1 Traditional design process

The traditional design process is depicted by Riemanmn and Spang (2014) as planning stages, in Table 2.2 below. All the stages of planning are executed by the client and the contractor is only featured during construction.

Table 2.2: Planning steps and responsibilities adopted from Riemann and Spang, (2014)

Planning Step	**Responsibility**
Initial Assessment	Client
Conceptual Design stage	Client
Basic Engineering stage	Client
Approval Planning stage	Client
Detail Engineering stage	Client

Evident in the table above is the lack of emphasis in trying to integrate the design activities with construction activities. Most of the aspects emphasised at these stages include aesthetics, spatial designs and functionality of the building (Griffith and Sidwell, 1995). The disintegration between design and construction activities lead to contractors having problems on site trying to replicate activities shown on the designs which are not viable to carry out and thus, buildability and constructability is intensely affected. These problems are claimed to arise due to the lack of incorporating the buildability concepts during the design phase of a building (Lam *et al*., 2006).

2.8 Green designs

Green Buildings are a fairly new phenomenon within the construction industry and they are slowly gaining momentum (Edwin *et al*., 2009). Green buildings are designed to use fewer resources, be more economical to manage and healthier (U.S Green Building Council, 2007).

2.8.1 Green Initiatives and Implementation Concepts

Since the mid-80s the concept of green building design emerged and broadened globally (Bassam and Michael, 2006) and this concept widened to include the protection of the environment while meeting the needs and wellbeing of the society, without compromising future needs. These concepts were widely adapted by different industries including the construction industry because it uses a lot of natural resources and hence it contributes significantly towards economic development. Worldwide many

entities, including governments and organisations, have considered and accepted the challenge to move towards being environmentally conscious (Ofori *et al*., 2000)

The main philosophy of green construction is to meet the clients' requirement within the budgeted costs and the wise use of natural resources. Bassam and Michael (2006) identify two issues of priority during construction, namely; energy efficiency during the manufacturing of construction materials and the consumed energies during construction and after construction. All of this energy consumption should be maximised to allow the efficient use of buildings and less depletion of natural resources. Innovative methods should then be implemented during the design of buildings when coming up with specifications and construction methods. Designers should promote re-using and recycling materials on site and at the same time there will be a reduction of waste on sites, hence providing a safe working environment.

In order to come up with a holistic approach in implementing and developing sustainable construction there needs to be a strategic approach, irrespective of whether it is in a developed or developing country (Ofori, 1990). James *et al*., (2010) calls for "urgent *strategic planning*" by different governments in order to uphold and continue the sustenance of the construction industry despite the rareness of strategic planning at macro level. One cited example of strategic planning is of the Construction 2020 in Australia. Hampson and Brandon (2004), focused on extrapolating the future of the industry within and the drivers of change, furthermore they urged that long term visions, missions and policies should be positioned and realigned.

In order to sustain the construction industry and to attain efficient growth there needs to be active government participation and intervention to support the private sector (Wells, 1986). There should be active boards set up to identify key issues, industry markets and drivers of change within the industry, and this is evident in both developed and developing countries like South Africa (James *et al*., 2010). Lopes (1998) suggest that there should be active, centralised bodies at macro level to plan and coordinate industry initiatives. In support of this suggestion, Ofori and Hugo (1996) state that good outcomes of such bodies have been experienced in Japan and Singapore.

Due to the criticalness of the issues there have been suggestions to incorporate principles and requirements of sustainable designs within specifications and contract

documents (Hill and Bowen, 1997) however, Meryman and Silman (2004) argue that economic factors will always act as a barrier.

2.8.2 Adoption of Green Design in South Africa

In South Africa there are mechanisms and polices in place that try to address the issues of green initiatives (Goulding and Windapo, 2015). This is evidenced by the legislation policies at national and provincial level, which are aimed at governing environmental issues. For example:, the National Environmental act and the National Building regulations acts. There are other interventions at provincial level such as that by the City of Cape Town which has the Green Building Guidelines (City of Cape Town, 2008). In the South African context there tend to be some polices and guidelines that are controlling the design and construction of green buildings (Naidoo, 2008). These policies and guidelines tend to have some gaps as shown in the table 2.3. None of the policies identified in the table cover extensively on issues on quality and standards of green materials. There is also a gap at national level on policies covering soil conservation and treatment.

Table 2.3: Green initiatives in South Africa (Goulding and Windapo, 2015)

Green requirements/issues covered				
	City of Cape Town Green Building Guidelines 20028	Waste Act 59 of 2008	National and Building Regulations & Building standards Act Part XA	National Environmental Management Act (NEMA) 107 of 1988
Soil conservation and treatment	X			
Waste management	X	X		X
use of sustainable materials and products	X		X	
Quality and standards of building materials				
Minimising the consumption of natural resources		X		
Prevent pollution and environmental degradation		X	X	
Type of legislation	P	N	N	N

In the South African perspective, polices of green initiatives documented by government are mainly at the production phase of the project. Green initiatives as highlighted by Goulding and Windapo (2015) are tabulated in the table above.

The Government Gazette (2009) indicates the inclusion of environmental guidelines can lead to minimising wastes incurred and it also promotes the re-use and recycling of materials. However, the City of Cape Town manual on green initiatives details the design phase and the production phase of construction activities (City of Cape Town, 2008). Furthermore, it is evidenced that the SANS 1024 document promotes the use of sustainable and green materials and how waste can be managed and recycled. Private consulting firms also have their sustainable publications that are promoting green initiatives on construction projects (Aurecon, 2010). It is evident that none of the legislature covers quality and standards of building materials for green construction.

2.8.3 How green features in buildings are measured

Globally there is an increase in the pace at which buildings are rated in terms of green design and how it satisfies environmental compliance (Wood *et al*., 2015). The rating of buildings and construction projects is due to the fact that there is a greater concern about how the construction industry and its production activities are contributing to the depletion of natural resources, uses of energy and waste disposal from sites (Aliagha *et al*.,2013). There is a need to control this so that there can be environmental compliance. There are different rating mechanisms in places for construction projects; however, these mechanisms have common features.

Table 2.4: Green Rating tools and Model by different countries

Country	**Green Rating Tool**
USA	Leadership in Energy and Environmental Design (LEED)
UK	Building Research Establishment Environmental Assessment Method (BREEAM)
Singapore	BCA Green Mark
Australia	NABERS rating system and Green Star rating system
Malaysia	Green Building Index (GBI)

Wood *et al*., (2015) identify different green rating tools with respective countries and these are summarised in the table 2.4.The Green rating tools have a common objective to identify buildings that incorporate saving energy and re-using and recycling materials. The assessment of rating is mainly based on the conceptual framework of the projects including design, construction and demolition of buildings (Liu and London, 2013). Chen and Lu (2015) state that the green rating tools have been collectively designed by construction professionals, researchers and clients and they are mainly designed to address the design of structures which will in turn affect the construction process and the utility of the building. All of this will have a great influence and impact on the end-users. They further ascertain that the main attribute of the green tool is focused on energy consumption and usage within structures

There are different methods that can be used to asses if the project conforms and adapts to green initiatives. Tam *et al*., (2003) identify different construction activities: are they eco-friendly and how environmentally sensitive are the methodologies implemented on site? They further categorise environmental issues based on the following indicators:

- Management of the works;
- Community involvement and consultation;
- Financial viability;
- Conformity to norms;
- Material availability;
- Energy consumption;
- Pollution prevention measures and control;
- Training and development,and ;
- Environmental controls.

Rikhardsson (1996) argues that environmental performance should be assessed based on how effective and efficient the methods are on production, and that they should be aligned to products and services, and that the policies implemented should conform to the legal regulations. Vivian *et al*., (2005) adapt the method of the corporate environmental performance pentagon (Rikhardsson, 1996) which focuses on "*management, operation, finance, products and effects*". All these assessment tools cover crucial aspects which should be balanced in order to achieve a well-balanced tool.

In a nutshell, all models should have a formal auditing format so that they can be adapted to different projects depending on the magnitude of the project and its scope.

Vatalis *et al*., (2012) strengthen the philosophy of green construction and attest that it should be better understood and not constrained to time quality and cost so as to best indicate the performance, inclusive of environmental and social indictors that can be aligned properly.

2.8.4 Problems associated with green buildings

Adaptation and implementation of green buildings is still facing challenges because of the perception that they have high design and construction costs as compared to normal buildings(OEDC 2003;). Yudelson (2008) argues the same point - that green buildings tend to be expensive to construct as compared to normal buildings and these costs tend to escalate when time is spent finding alternative designs and trying to maximise the rating of the buildings. These high escalating costs range from initial design to the integration of energy systems and mechanical components of the buildings. However, Edwin *et al*., (2009) argues that even though the initial cost of the project may be perceived to be high, during the life of the building the maintenance costs tend to be lower compared to conventional buildings. He further urges that the perceived high costs will be reduced when the industry brings innovative new practices and methods into play that are accepted and adopted by it. Dewlaney and Hallowell (2012) claim that current research reveals that LEED buildings experience high accident rates and injuries on site as compared to non-LEED buildings. Hwang and Tan (2012) summarise the problems of green buildings being caused by the following factors:

- High costs premiums;
- Unequal distribution of benefits;
- Lack of green product information;
- Lack of awareness in clients,and ;
- Complex legislature requirements

2.8.5 Promotion of Green Initiatives

Even though the concept is fairly new, it needs to be promoted so that the industry can adopt it and enjoy its full benefits. In countries like Hong Kong researchers Varone and Aebischer (2001) feel that the government has to play a significant role in the

construction industry to transform and adopt these innovative initiatives. Furthermore, there should be buy-in from the other stakeholders. Qian and Chan (2008) reveal that there are currently movements in place that promote Green buildings; these include the GBCSA in South Africa, and internationally the LEED initiatives or Energy Star. Promotion of green during designs can be improved by governments providing incentives to the clients that are complicit, this is evident in the Western Cape where the Provincial government provide tax deductions and rebates to promote adherence to the initiatives (Windapo and Goulding, 2015). These initiatives are aided by the GBCSA which facilitates evaluation and rating of green projects (GBCSA, *n.d*)

2.8.6 Factors affecting green construction

Even though green designs are perceived to be of high importance within the construction industry there tends to be problems that hinder implementation and adaptation of these initiatives (Meryman and Silman, 2004). There is still a lack of awareness and knowledge from investors and clients as how these designs will influence cost reduction (Qian *et al.*, 2013) despite the fact that adapting these designs in actual fact depends on the knowledge and understanding of the overall concepts (Abidin 2010). Some surveys done by Shen *et al*., (2010) reveal that managerial skill was a concern as adaptation to these initiatives needs skill by contractors.

Cost being a matter of concern, implementation comes with a price; therefore many clients are reluctant to adopt green designs (Kunzlik, 2003). It is evidently highlighted by Ofori and Kien (2004) that cost acts as the main barrier to implement the designs as clients have limited budgets. For example, water and energy savings equipment are costly and in most cases this tends to be problematic when doing cost control (Qian *et al*., 2013). Other issue of concern are the integration of sustainable designs with other components of the building. Qian *et al.,* (2013) states that designers spend time on integrating different elements which end up affecting the progress of works, and in the end the construction team ends up going back to traditional methods of construction because the new products may not be compatible with other elements or components of the structure.

2.9 Procurement methods in construction

Selection of appropriate procurement method is one of the important processes within the construction project management principles (Ruparathna and Hewage, 2015). How it affects the success and performance of the project is substantiated by many authors (Preus, 2009). Procurement is explained by Martins (2009) and Sears *et al*., (2008) as a systematic process within a construction project that coordinates the acquisition of goods and services in order to meet the client's needs.

Construction projects are commonly appointed on a competitive basis using the traditional procurement path, a process that separates the design team and contractor appointments (Trigunarsyah, 2007). Usually the contractor is appointed after the designs have been completed by the design team. Wells (1986) argues that this method has led to the isolation of certain construction teams from providing input in the technical documentation of the crucial specifications and processes. It has been identified by the Australian Construction Institute (1992) that this method leads to cost overruns and quality issues within projects. Clients' needs are becoming more complex and sophisticated and therefore the industry needs procurement methods that will improve the performance and delivery of projects (Yu *et al*., 2010). There are a number of problems that need to be properly addressed by the choice of procurement and these include limited resources, constrained budgets, expected times of delivery, planning and scope of the work with the required quality (Yu and Shen, 2013). Oyegoke *et al*., (2009) ascertain that procurements used in construction have evolved from the traditional set-up where considerations were based on the lowest bids but that rather the best value for money and problem solving orientation should be taken into consideration.

2.9.1 Common procurement methods

There are different procurement systems within the construction industry. Naoum and Egbu (2015) identify different procurement methods used in the construction industry such as:

- Traditional Procurement systems;
- Design and Build;
- Project Management,and;

- Management Contracting.

Research has been focusing on how these packages affect the delivery of projects in terms of quality, cost and time. Tuomela-Pyykkönen *et al*., (2015) argue that there are four essential strategic thrusts that should be taken into consideration when selecting an appropriate procurement package, namely: risk management, relationship management, knowledge sharing and coordination of the project activities. Client diversity, complex clients' needs and demands are creating an environment where construction projects are becoming more complicated and not easy to solve (Riemanm and Spang, 2014). This complexity leads to construction projects not being completed on time or within budget and leads to compromised quality. Spang (2009) and Gimscheid (2005) have identified the following key problems which are perpetuated by the procurement methods chosen for particular projects:

- Increase in disputes between construction team;
- Compromised quality leading to dissatisfaction of clients;
- Insufficient returns on investment by clients;
- Risk business opportunities for contractors;
- Lowest price principle compromising knowledge generation and innovation on construction projects,and;
- Improper claim management by both contractors and the client.

The problems mentioned above were also identified by Lathan (1994) who suggested that there should be a relational improvement between clients and contractors rather than only contractual partners (Black *et al*., 2000). Lathan (1994) suggests re-engineering the tendering methods where the lowest price bid is not given automatic priority over other bids, and that additionally there should be qualitative criterion embedded in the systems in order to choose the best contractor.

In the South African context the adoption of different procurement methods depends on different client entities. The guidelines for tendering purpose by the CIDB are depicted in the tables below. The guidelines are best practices to be adopted in governments' projects when evaluating tenders. The CIDB criterion explicitly shows that there

allowance is made for functionality, but may not always be used or may be used as a threshold above which cost is a primary criterion.

Table 2.5: Standard tender evaluations as adopted by CIDB

Method	**Description**
Method 1: Price and preference	1) Score tender evaluation points for price
2) Score points for B-BBEE contribution	
3) Add the points scored for price and B-BBEE	
Method 2: Functionality, Price and Preference	1) Score functionality, rejecting all tender offers that fail to score the minimum number of points for functionality stated in the Tender data.
2) No tender must be regarded as an acceptable tender if it fails to achieve the minimum qualifying score for functionality as indicated in the tender invitation.	
3) Tenders that have achieved the minimum qualification score for functionality must be evaluated further in terms of the preference points system prescribed in paragraphs 4	

2.9.2 Traditional procurement Path

During the traditional procurement path the "*design phase*" activities are separated from the construction phase and there is a team solely responsible for the designs (Lam *et al*., 2006). This system involves tendering systems where contractors bid based on the drawings and specifications documented by the design team, based on the client s brief. Other design team members are quantity surveyors who are responsible for compiling bills of quantity that will be priced by the contractors on competitive bids (Babatunde *et al*., 2010). Following the sequence of traditional steps this method is termed Design-Bid-Build (Daniel, 2006).One of the high priority factors when choosing the traditional procurement method is for delivery of the project to be completed on time, while other methods are focus more on quality assurance objects.

It is been argued that the traditional procurement method needs to be thoroughly re-engineered because its procedures cause an adverse impact on the relationships between a construction project team, and many problems are experienced at all buying stages (Cheung *et al*., 2003). This evidently shows that the traditional procurement path does not integrate construction activities to its maximum to attain the best delivery of projects, and as argued by Wardani *et al*., (2006) it needs to be tailored in order to suit different project objectives. The reason why traditional procurement is common is because clients tend to only choose and adopt the procurement methods that they are familiar and comfortable with (Erickson, 2008a). Tysseland (2008) claims that for clients to choose a different procurement they have to be aware of its positive outcomes and be confident about its delivery of the project. Errickson and Westerberg (2011) argue that traditional procurement paths where design is divorced from construction leads to projects not being finished on time. This is due to the fact that the planning at the design stages is not integrated with the construction activities (Dubois and Gadde, 2002). The method is said to be starving innovation to the entire project as there is no collaborative problem-solving (Korczynski, 1996).

2.9.3 Design and Build

The design and build package is defined by Wardani *et al*., (2006) as a procurement system where the clients appoint the contractor who becomes responsible for designing and carrying out the site production activities. It will be up to the main contractor to carry out all the activities as an entity, or subcontract some of the tasks. Previous studies (Konchar and Sanvido 1998) reveal that the design and build packages as compared to procurements methods like conventional methods and construction management, yields better performance of project delivery, especially in the cost expenditure and time overruns of a project. Good returns and value for money have been achieved in the use of Design and Build and the projects span are reportedly reduced compared to the traditional procurement path (Tam, 2000). The Design and Build method tends to build long partnerships between the construction project team ranging from clients, sub-contractors, suppliers, contractors and the consulting team. In doing so it integrates the construction supply chain (Jergeas and Put, 2001). Despite the credentials about the Design and Build, it is complex to implement compared to other methods (Palaneeswaran and Kumaraswamy, 2000). Beard *et al*., (2001) suggest that

due to the complexity of the Design and Build it should be categorised in sub-types depending on the project it is best suited to address. He further suggests that the design team should be chosen fairly and on a reasonable basis taking into consideration their past experience, the competency of the contractors and their financial viability to secure the completion of the works.

Types of Design-Build Procurement Methods		
Price Based Procurement	**Best Value Procurement**	**Subjective & Qualitative Procurement**

Selection Factors	Quantitative cost factors	Subjective, qualitative and quantitative factors	Subjective and qualitative factors
Procurement Method Examples	Low Bid, Two step sealed Bidding	Competitive Negotiation, Weighted Criteria, Fixed Budget/Best Design	Sole Source, Qualification Based

Figure 2.2: Types of Design and Build as adapted from Beard et al., (2001)

Within the Design and Build procurement set up there is another sub method that derives from it and is termed Design Novate and Construction. The only difference between the two methods is the "*Novation process*", which allows for the replacement of the initial obligations with the current obligation (Ng and Skitmore, 2002). The method is argued to be one of the most flexible innovative procurement systems. This procurement method allows the parties to completely review and replace the old contracts and even update the teams. Ng and Skitmore (2002) states that through the novation process the clients' duties and its design team are transferred to the contractor after initial and sketches have been completed. The method is argued to be giving the

contractor clear details about the contract and therefore realistic and competitive bids can be made.

2.9.4 Project Management

Project management is one of the procurement methods that take into consideration the performance of the project, so there needs to be a proper process and systems need to be put in place for the delivery of projects (Pheng and Chuan, 2006). There are different packages and methodologies that can be adopted by project managers in order to deliver a successful project. Some of the tools guide the project management team to use suitable project management practices as well as risk management tools (Rolstadås *et al*., 2014). Project success is said to be determined by the experience of the project manager and the proper communication put in place to disseminate project information (Christenson and Walker, 2008).

In order for the project management approach to be successful, the project manager should take different project approaches per specific project, depending on the scope and complexity of the project (Shenhar *et al*., 2002). Projects differ in different scopes, complexities, the industry and the project manager handling the project (Muller and Turner, 2007). Despite the fact that some researchers' find that projects are different and they should be treated differently Bredillet (2007) believes that projects are homogeneous but they have distinct differences which need to be profiled and planned for. Fortune and White (2006) identify different factors that can affect the success of a project when it is delivered through project management principles. They believe that for the success of a project there should be enough communication amongst the project team members, there should be support from executive members of management as well as detailed plans kept and tracked by a competent project manager.

2.9.5 Public Private Partnerships

The Public Private Partnership (PPP) is a commonly used delivery system applicable to most types of infrastructure developments, and its wide adoption around the world has shown that it is able to yield value for money in projects where it has been applied (Ke *et al*., 2010). Chowdhury *et al*., (2011) argue that most developing countries are adopting this procurement method because of deficit budget constraints and its innovative strategies in delivering projects. Hwang (2013) state that the PPP

procurement package is risk-cushioned and the objectives of the arrangements of these contracts are to properly manage risks strategically.

Recent literature promotes collaborations and working relationships between the clients and contractors to be more than simply contractual obligations (Suprapto *et al*., 2015). These relationships have an influence on the overall performance of the project (Meng *et al*., 2011). If there is high collaboration and improved working relationships there can be fewer disputes in projects and there can be successful integration of problem-solving mechanics which can lead to smooth operations and the enhanced performance of the project (Black *et al*., 2000).

2.10 Early Contractor Involvement

The concept of Early Contractor Involvement (ECI) is when the contractor is involved in the project in the early stages with the design team and the contractor is allowed to be actively involved at the design stage of the project by sharing previous experience and knowledge (Song *et al*., 2009). This method is said to improve the co-operation between the design team and the contractor and tends to add value to the progress of the project from conceptual stage until construction stages (Jergeas and Put, 2001).

Akintoye *et al*., (2000) ascertain success and efficiency have been achieved in the delivery of projects in the United Kingdom (UK) government for the Public-Private Partnerships (PPP) projects when there was design and build contracts where the contractor was involved at the inception stages of the project. The success of ECI evidently dates back by the reports documented by Egan (1997) and Lathan (1994) that in order to maximise efficiency there has to be a re-engineering of the procurement strategies that were in place, and integration of the supply chain within the construction industry. Even though much is emphasised on partnering Eriksson (2010) claims that the benefits of partnering are often not attained due to a lack of common understanding of the whole concept of partnering and its implementation.

Based on the fact that involving contractors at an early stage saves on the overall cost and shortens the project span (Errasti *et al*., 2009 and Song *et al*., 2009) and there is evidence that buildability is maximised (Rahman and Kumaraswamy, 2004b). At the same time there is the attainment of client satisfaction (Ericksson, 2008b) as well the

contractor carrying out safe construction activities (Cameron and Duff, 2007). It has been therefore proposed by Errickson and Westerberg (2011) for the following;

- Integration of client and contractor at the design stages of the project;
- Fewer number of contractors invited to bid on the selected tendering;
- More focus on soft parameters when carrying out tender adjudication;
- Incentivising project performance;
- Independence and self-control of the contractor;
- Maximum communication using collaborative tools ,and;
- Collaborative climate as a moderator and mediator on relationships.

All the above-mentioned proposals are claimed to improve the performance of the project in terms of innovation, time, cost, quality and work environment.

2.10.1 Benefits of ECI

Early Contract Involvement (ECI) can benefit the client as the contractors are able to offer reasonable prices, as they will be involved in the process and will know where they can eliminate and reduce waste (Lahdenpera, 2010). Chan *et al*., (2003) suggest that when there is a partnership there is improved quality, fewer disputes and innovation tends to evolve with a project set-up. Riemanm and Spang (2014) strongly make the case that contractors' knowledge can be used in the early stages of construction and can benefit in the planning phase of the project and this is complemented by research showing that some projects yielded good outcomes after involving contractors at an early stage of the project. This is revealed by Rooney (2006) where it was applied in Andwers project in the UK. Another form of ECI termed Alliance Contracting has also been applied in Australia since 2005. Swainston (2006). Gil *et al*., (2004); Jergeas and Put (2001) strengthen the idea that the benefits of ECI to the clients include but are not limited to:

- Improved quality on the overall standards of project delivery;
- Improved time delivery;
- Balanced and proper trace of costs and control measures, and;
- Safe construction activities.

All the above mentioned will enable the contractor to be fully engaged at early stages of the project and add value to the designs

2.10.2 Resistance to ECI

Even though there is a drive to move towards involving contractors at early stages, these methods tend to disturb the traditional business practices within the built environment (Song *et al*., 2009). There tends to be resistance and many challenges when contractors are involved at the early stages, which act as barriers in adopting ECI. O'Conner and Miller (1994) identify teamwork, contractual agreements and construction industry culture as the main barriers in moving towards early contractor involvement. All of these barriers are perpetuated by a lack of understanding, the importance of the method and how it can add value to the delivery of projects. Song *et al*., (2009) still find that there is less research in the field which will make practitioners, clients and contractors aware and fully benefit from engaging in this form of partnership at an early stage of the project.

2.11 Supply chain Management (SCM) in Construction

Supply chain management (SCM) is defined by Meng *et al*., (2011) as "*integrated process that manages and ties relationship between customers and clients"*. The process is highly adapted by other industries such as manufacturing and retailers which leads to significant improvement of performance and delivery of services (Briscoe and Dainty, 2005). The main focus on Integration of supply chain is "*partnering and collaboration*" which will significantly increase processes in terms of the quality and delivery efficiency of projects (Bygeballe *et al*., 2010 and Meng *et al*., 2011). Research shows that quality and efficiency increases when supply chain partnering is embedded in projects and this can be traced back decades and evidenced in the Dutch Housing delivery (Venseler *et al*., 2014). There are five (5) main concepts that make up the conceptual framework deduced by Maqsood *et al*., (2002) and they include:

- Outsourcing;
- Supply management;
- Chain Management;
- Relation Management, and;

- Power Management.

The main objective of integrating supply chain management in construction is to properly align upstream and downstream activities and to establish sustainable relationships between parties for the success of the project and its yielding maximum performance (Bresnen and Marshall, 2000). In order to benefit from an effective system of integrated supply chain management it is argued that partnering development should be utilised. In the consideration of partnering more focus should be on the social aspects such as commitment, strategic leadership, efficient communication and trust, so that supply chain management can be well integrated (Kim, 2010). However, there is still a lack of literature as to how these aspects and principles can be embedded in daily construction activities (Kadefors, 2004 and Kim *et al*., 2010).

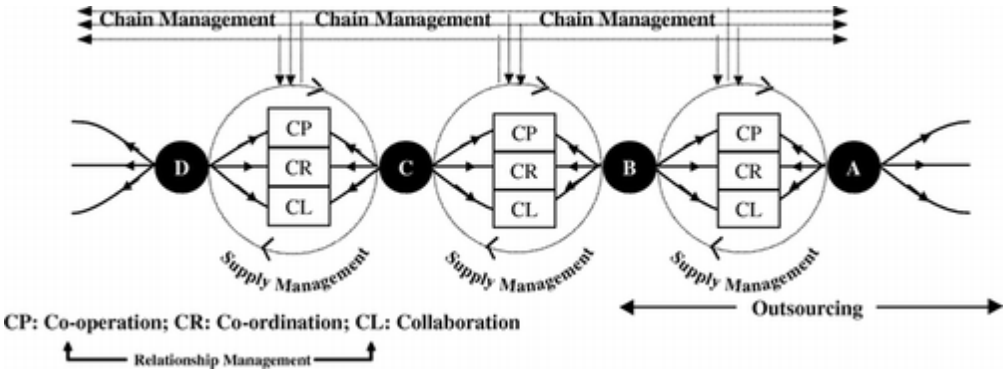


Figure 2.3: Conceptualisation of generic integrated supply chain management model as adapted from Khalfan and Maqsood (2012)

The construction industry is slowly adapting principles of supply chain management (Love, 2000), and this slack pace is due to the fact that construction projects consist of temporary project teams (Akintoye *et al*., 2000). Saad *et al*., (2002) claim that research in the field of construction supply chain management is growing, however, the existing literature focuses on the relationship sphere (Meng *et al*., 2011).

As depicted in Figure 2.2 above, there is supply management and chain management. Khalfan and Maqsood, (2012) argue that the two components are the one that constitutes the integral part of SCM while outsourcing is the bond or link that connects the chains together. Furthermore, they urge that there should be strong collaboration, coordination and cooperation.

2.11.1 Integrating the Construction Supply Chain Management

When integrating supply chain management in the construction industry all aspects of the project should be considered from a project management view, as this will help to reduce uncertainties and risks and resources will be well distributed (Winch, 2003). Emphasis should be on the role played by other parties within the supply chain such as suppliers and distributors, on how they can be integrated during the production phase of the project. Vollman *et al*., (1998) suggest that in order to achieve full benefit and integration of supply chain management there should be management and integration of all allied activities from raw materials until end users. All these initiatives can be achieved and the industry at large can embrace collaborations and partnerships (Barker *et al*., 2000). A report that was carried by Person (1999) revealed that in the U.K, initially when the concept of SCM started, only a few participants in the construction sector adopted it as a strategic goal of their business.

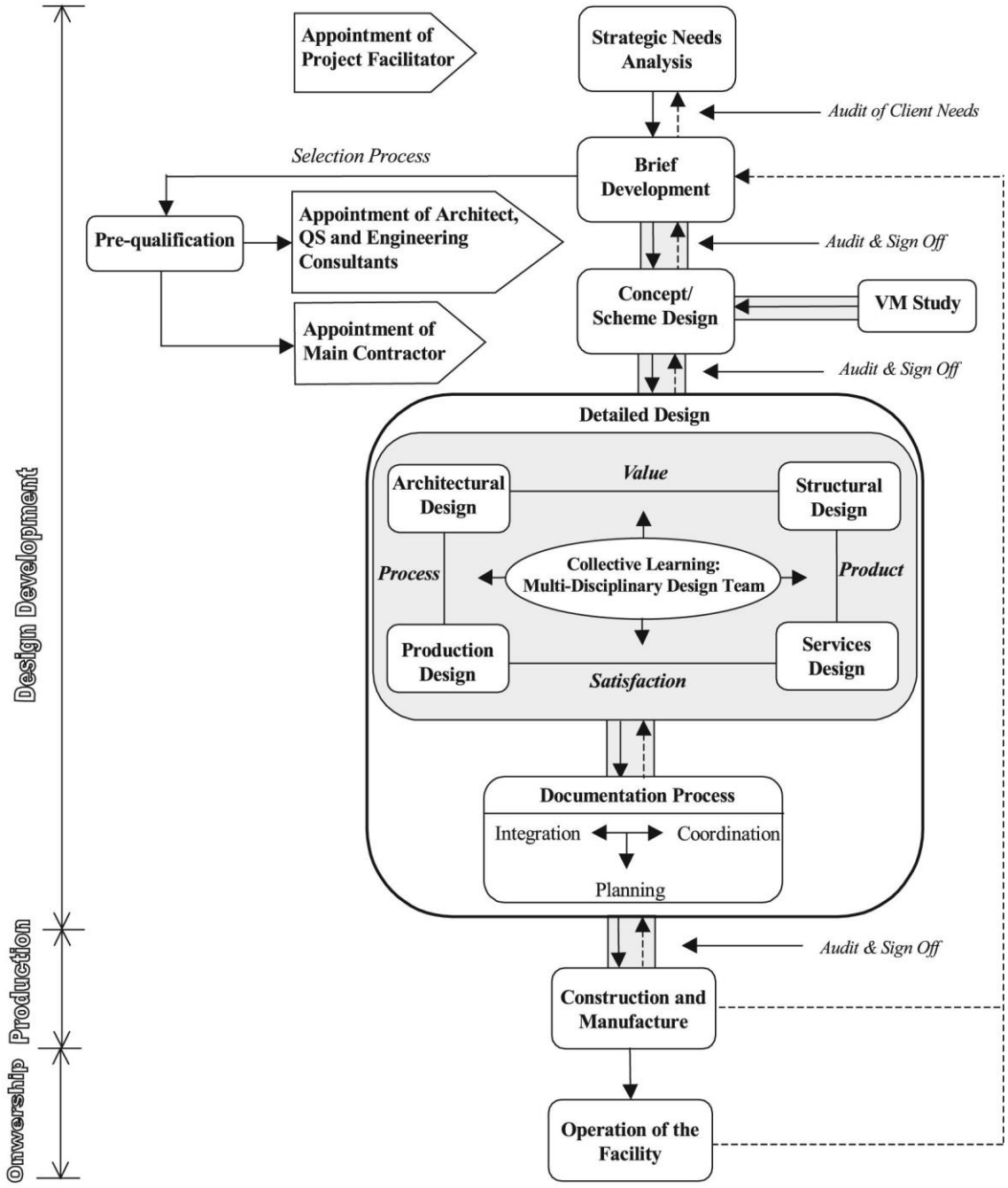


Figure 2.4: Seamless supply chain management for construction as adapted from Love et al., (2004).

Love (2000) argues that the traditional procurement path that separates design from construction activities perpetuates the disintegration of the supply chain management, because the project life cycle stages are broken. Love *et al*., (2004) ascertains that there is reciprocity in the "customer- supplier" because each entity in the project neither fit to be called either a customer or a supplier, therefore all the parties all add value to the supply chain management.

As depicted in the model above by Love *et al*., (2004) are the integrated, inclusive planning activities for proper supply chain management and all stakeholders should be included at all stages of the project in order to add value. With all the team members included and sharing responsibility performance will be high on the project (Nesan and Holt 1999).

The construction industry has to learn from the manufacturing industry on how to adapt the principles of supply chain management, but they have consider its nature and not translate all the principles as they are compatible to manufacturing (Skitmore and Smyth, 2009). This is due to the fact that supply chain management in construction is more complex and consists of diverse participants (Meng, 2010). Supply chain management in construction is vast and it differs in nature. Different organisations add different values through the value chain, some add value by producing products from raw materials, some add value by knowledge and sometimes it is in the form of processes (Khalfan and Maqsood, 2012).

2.11.2 Problems within the Construction Supply Chain

The current problems in the construction supply chain are not fully addressed because of limited literature, and within limited literature there is robust use of terminologies which are not consistent and lead to confusion (New, 1999). As mentioned by Akintoye *et al*., (2000) most of the research is focused on the technical and operational aspects of the relationship between clients and contractors and their subcontractors.

The built environment has been battling with adapting SCM principles to integrate them in the production phase of the project (Briscoe and Dainty, 2005). Different researchers have multiple reasons why the industry cannot integrate the activities, some claim it is because there is high dominance in concentration in the construction phase of the project (Dubbois and Gadde, 2000). Dainty *et al* (2005) claims that the fragmented state of the industry puts more disintegration on SCM. The divorce of design from production phase is also identified as a factor (Egan 1998 and Love *et al*., 2004).

When root cause analysis was evaluated by Cox and Ireland (2002) they identified problems such as communication, inefficient use of technology, contractual arrangements and a lack of proper coordination to be the factors putting strain on the strategies of SCM implementation. The other issues raised by Ankitote *et al*., (2000)

and Chen & Li (2001) are that builders often concentrate on the demand tier of supply chain management and less effort is invested in understating the suppliers who are deemed to be in the lower tier of the supply chain, and this limits the innovation and sustainability concepts that these entities can add value to the entire supply chain structure. However, this tendency is perpetuated by the fact that suppliers do not want to be transparent about their supply strategies (Pala *et al*, 2014).

2.11.3 Green Supply Chain Management and its initiatives

There is a drive to strategise the implementation of supply chain management that has led to the new paradigm of Green Supply Chain Management (GSCM) which is aiming at recognising and seeking environmental performance (Dadhich *et al*, 2015). This phenomenon is due to the fact that business communities and government entities are faced with challenges of limited resources, increased carbon emissions, climate change, and waste management. As mentioned by Dadhich *et al*., (2015) these initiatives are social aspects and business needs to be clear about their ethical standing on environmental issues as it can give them a competitive edge over their counterparts. There are different stages of GSCM and Srivastava (2007) and Zhu *et al*., (2008) summarise them as:

- Environment risk management systems;
- Occupational Health and Safety systems;
- Waste management systems;
- Pollution prevention and management;
- Resource conservation strategies, and;
- Product safety.

Each stage and elevation of supply chain needs to be fully assessed if there is an environmental impact then re-engineered so that it fully complies with set carbon emission, elimination of waste or energy usages (Koh and Aoshima, 2001). All these stages give the company time to redesign or remodel the product so that it is in compliance and thus they are able to identify ways to reduce the costs while being competitive (Dadhich, 2015; Zhu and Sarkrs, 2004)

The principles of GSCM are in line with what academics term Sustainable Supply Chain Management (SSCM). Linton *et al*., (2007) describe the SSCM as a methodology

where, within the supply chain, there are eco-friendly mechanisms considered in procedures of product or service delivery ranging from the product design, production, utility and all stakeholders should be environmentally conscious in their input or value added services. These can be designers, fabricators, transporters and users. However, there is complexity and dynamics in attaining the ideal model when facing real practical situations (Bettencourt *et al*., 2007).

2.12 Summary

Literature review is designed to cover domain of green construction, early contractor involvement, supply chain management and procurement. In the South African construction it is evident that the insutry is dominated by the traditional procurement path. Despite the populality of these procurement paths, there are other packages that can be used to deliver construction projects. Thecontractor s role under traditional procurement path is to replicate what the design team has finalised. Theories urge the contractors to be involved at early stages of the projects so that buidabuilt can be maximised. Green consruction is fairly new in the South African market and there are challenges in adopting the new paridim, these include issues of supply chain intergration and lack of experienced designed team.

3 Research Methodology

3.1 Introduction

This section details the research process that was followed in order to answer the research question, sub-questions and to test the validity of the hypotheses and sub-hypothesis. Reasons and justifications are also given for the choice of the research methods used and the overall research design. The research methodology chosen is shown to be appropriate for achieving the aims and objectives of the research and answering the research questions posed.

In this chapter, the research philosophy is thoroughly explained and also the strategies that have been used are explained and their importance and the reason why they have been adopted detailed. The other source of information that is used is the literature review. Other approaches of data collection such as questionnaires are also explained in detail.

The research's intent is to find out how the traditional procurement path limits contractors in engaging and adding value to the designs of green buildings.

The main purpose of the research methodology is to give a systematic approach and guide that assists in achieving the aims and objectives of the research derived from the problem statement. The research methodology acts as a mechanism framework that is utilised to answer the research question or test the hypothesis and validate its nullity or validity. It also allows the researcher to be able to identify the approaches for the appropriate collection of data and to analyse the data based on the nature of the data depending on whether it is either qualitative or quantitative.

3.2 Type of Research used in the study

The epistemology of research is positivist because the presentation of the problem statement is an objective phenomenon. The research follows a logical scientific process where a problem statement is stated and there are research questions which need to be answered and a hypothesis which needs to be tested for validity. Carson *et al*., (2001) describes that a positivist research seeks to address a problem statement logically and rationally by being objective and often use is made of statistical methods to analyse the data

Contractors' input on green construction is affected by many variables and factors so in order to thoroughly investigate the problem statement the researcher opted to use the quantitative approach. Quantitative research is defined by Aliaga and Gunderson (2002) as "*explaining phenomena by gathering numerical data that are analysed and presented using mathematically based methods and in particular the use of statistics*". The quantitative method assisted in easing the process of analysing and presenting the data properly. Statistical and mathematical applications were used to determine relationships between variables and also compare trends in terms of fluctuations, and as well as behaviour patterns of data. The quantitative approach was used mainly because of the use of questionnaires to collect data.

The data that was collected was in the form of quantitative and qualitative data. The qualitative data was aimed at understanding the knowledge and perceptions of the subject matter more in a qualitative manner (Creswell, 2003).The other purpose of using qualitative data was that it assisted in resurfacing the underlying concepts on the subject of study and also tends to find the relationship between concepts (Hyde, 2000). The qualitative data assisted in understanding the existing trends of green construction and initiatives in the construction and expanding more on how the use of a traditional procurement path affects the implementation and full benefit derived from green initiatives. This was attained by analysing the experiences and knowledge of construction professionals that have been involved in green projects, and it gives the researcher a good understanding of the subject matter (Cao *et al*., 2006). Quantitative data was used to find the most occurring trends, variation of variables and measures of central location of the data.

3.2.1 Construction of the instrument (Questionnaire design)

The primary instrument used to collect data for this research is by use of questionnaires. The research instrument consisted of 94 items, with a level of measurement at a nominal, scale or an ordinal level.

The questionnaire was divided into 38 questions. The questionnaires structure is divided into three parts. The first part of research requires general information of the respondents including their background and exposure to green building projects. It is

intended to enable the researcher to compare the profile of respondents with the known profiles of built environment professionals.

The second section focuses on the knowledge and experience in the delivery of green buildings. Green buildings under consideration are in the scope of the research and refer to buildings rated by GBCSA, and it includes any buildings that individuals have worked on that were designed and built around green principles.

The third section of the questionnaire focuses on the most recent green building project that individuals have been involved in, and that project should have reached completion. The design of research questions includes questions with options to choose from. Some of the questions have been summarised from perceptions of green buildings gathered from literature, these questions are designed to find if the same perception also exists in the South African context.

At the end of the questionnaire there are open end questions which allow participants to add value on issues that have not been raised in the questionnaires. Whilst this is qualitative data the majority of the questions were quantitative data.

The entire survey is designed to be answered in fifteen (15) to twenty (20) minutes. The participants were given the option to answer certain questions and leave to finish it later before the due date. The participants were given eight (8) weeks to return the completed questionnaires. Table 3.1 summarises the literature that informed the design of questions.

Table 3.1 Questionnaire design

Question	**Source**
Gender	Rose, (2014)
In which year were first involved in the delivery of green buildings projects?	GBCSA,(2012), Rose, (2014)
Before you were involved in the delivery of green building, how would you rate the level of knowledge and awareness of green building practices and principles?	Qian *et al* ,(2013)
How would you rate your current the level of knowledge and awareness after being involved in the green building projects?	Qian *et al* , (2013)
The following have been identified in research as barriers to the implementation of Green building practices in South Africa. How would you rate their significance to the contractor.	Shakantu *et al*. (2007)
The use of correct procurement strategy	Errikson and Laan (2007)
Cost of the green projects compared to normal buildings	Kunzlik,(2003) Ofori and Kien, (2004)
Lack of awareness by client of green practices and principles	Qian (2013),and Abidin ,(2010)
Expertise and management of green projects by contractors.	Qi, Shen *et al*.(2010)
In your opinion, which type of client is more respective to the idea of green buildings?	Rose, (2014), Venstroom, (2008), Psilander (2004) and Kadefors *et al*. (2007)
Overall, South African contractors are knowledgeable about the benefits of adopting green buildings practices.	Qian (2013) and Abidin (2010).
Overall, South African contractors have the necessary skills to construct green buildings.	Riley *et al*. (2003)
Overall, the following client types are knowledgeable about benefits of adopting green buildings practices.	Rose, (2014), Venstroom, (2008), Psilander (2004) and Kadefors *et al*. (2007)
Private Sector	Riley *et al*. (2003), Goulding and Windapo (2015)
State Sector (Central, Provincial and local Government)	Riley *et al*., (2003), Goulding and Windapo,(2015)
Parastatals and other Government agencies	Riley *et al*., (2003), Goulding and Windapo (2015)
Overall, the following clients are "greening" their construction projects.	
Private Sector	Rose (2014), Bowen (1990), Spencer and Winch (2002) and Chen and Lu (2015)
State Sector (Central, Provincial and local Government)	Rose (2014), Bowen ,(1990), and Spencer and Winch, (2002)
Parastatals and other Government agencies	Rose, (2014), Bowen, (1990), and Spencer and Winch (2002)
Overall the South African construction supply chain (e.g. specialist contractors and specialist suppliers) are ready to adopt green practices.	Linton et al. (2007), Dadhich, (2015), and Zhu and Sarkrs, (2004)
Contractors are able to provide input into green aspects of buildings projects to assist in achieving the green outcomes of the projects.	Dadhich, (2015

Question	**Source**
Based on your experience of green construction rank in order the procurement that is commonly used.	Mathonsi and Thwala (2012) Babatunde, et al. (2010), Wolf and Seuring (2010)
Design and Build Path	Wardani et al. (2006), Brace et al. (2009)
Traditional Paths(Open Tender)	Dubois and Gadde (2002) Cheung et al. (2003), Daniel, (2006)
Management Path	Pheng and Chuan (2006)
Public-Private Partnership	Wardani,et al. (2006)
1. Based on your experience of green construction rank which method of procurement you perceive as the most appropriate for delivering green buildings.	
Design and Build Path	Riley et al.(2003)
Traditional Paths(Open Tender)	Riley et al. (2003)
Management Path	Riley et al. (2003)
Public-Private Partnership	Riley *et al*. (2003)
Based on your experience of green construction rank in order the commonly used method to appoint the main contractor.	Riley *et al*., (2003) Meryman and Silman (2004)
Based on your experience of green construction rank which method of appoint of main contractor you perceive as the most appropriate for delivering green buildings.	Riley *et al*. (2003) Mathonsi. and Thwala (2012) Wardani, *et al*. (2006)
Rate the frequency of problems when using traditional procurement path (separating design from construction) in any projects irrespective if its green project or not	Mathonsi. and Thwala (2012) Wardani, *et al*. (2006)
Rate the frequency you have experienced of the problems on green building	
Poor specification detailing	Yan *et al*. (2010), Ning and Ling (2013) and Raviv *et. al*. (2012)
Availability of suppliers of green materials	Briscoe and Dainty (2005), Love (2000), Pala *et al*. (2014) Dadhich *et al*. (2014)
Compliance with Health & Safety	Yan et al., (2010), and Raviv *et al*., (2012)
Disputes and conflicts	Yan *et al*., (2010), and Raviv *et al*., (2012)
Lack of technical expertise	Qian *et al*., (2013)

Question	Source
Lack of managerial Expertise	Qi, Shen *et al.,(* 2010)
What was the value of the construction work (Value of the construction exc VAT)?	CIDB
What was the procurement path used in the project to appoint the contractor?	Mathonsi and Thwala (2012), Bowen, Pearl, and Ewards (1999)
How was the main contractor appointed?	Bowen, Pearl and Ewards (1999)
What was the contract conditions used in the project for the main construction?	JBCC, CIDB
In your estimation how complete (%) was the design when the contractor was formally appointed on the project? (e.g if there were substantially amount of provisional sums , it would indicate some areas of design were still to be finalised.	K & L GATES (*n.d*) and Song *et al*. (2009).
At what stages of the project was the contractor involved in design meetings of the green project?	JBCC, CIDB
At which stage was the contractor formally appointed?	CIDB
What is your evaluation on the level of success in the green project based on the criteria below	Riley *et al*., (2003), Yitmen (2007), Lam and Wong (2009), and Liu and London (2013)
In your own words what do you consider as the client's priorities in terms of green project?	Majdalani *et al*., (2006)

3.2.2 Population and Sampling

The target population is construction professionals such as project managers, construction managers, architects, quantity surveyors and engineers that have worked in green buildings in South Africa. Green buildings that are rated by GBCSA were identified in the website for GBCSA and the professionals that were involved in the green projects were identified and listed in an excel spread sheet detailing their email addresses, companies and contact numbers. The entire population of the professionals accredited by GBCSA is 1110. Their membership includes clients, contractors and design team professionals. The sampling techniques used to choose the sample was *Purpose Sampling Technique*; this was because it was intended to select professionals that influence design decisions. The supplier and specialist subcontractors were not part of the survey.

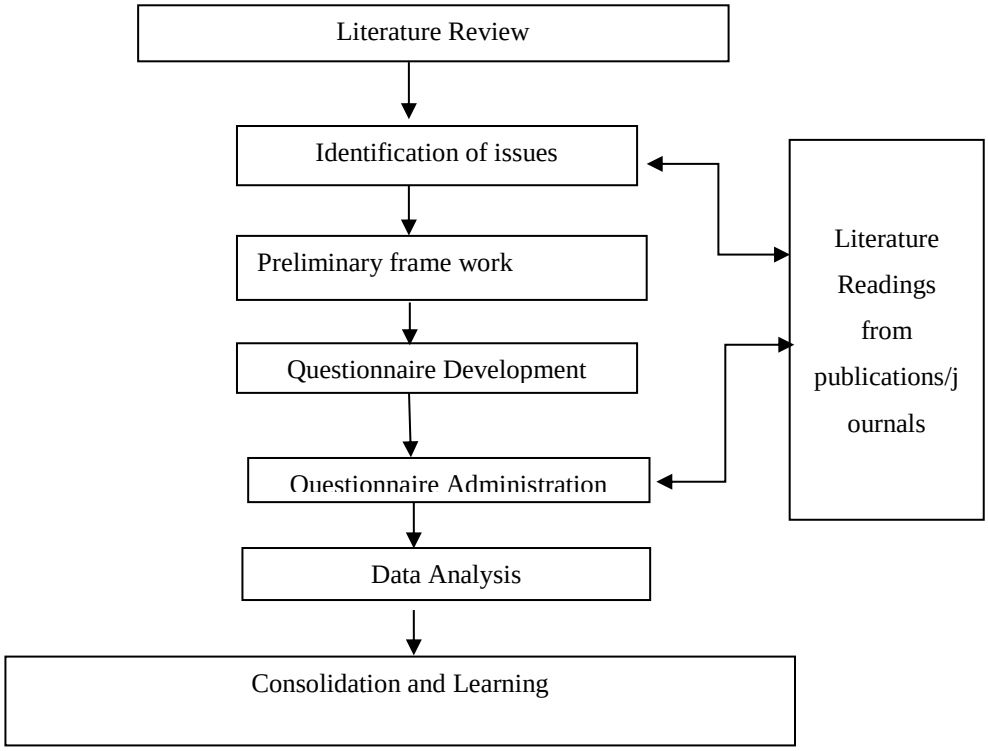


Figure 3.1: Methodological flow diagram

The construction professionals that participated in the project were approached by email for their willingness to share their knowledge, experiences and perceptions on green buildings. The choice of GBCSA professional database was because the organisation registers individuals and companies that have knowledge, training and experience in the field of green buildings; their input is valuable and can add value to the research and resurface the existing trends in green construction.

The figure above summarises the flow of methodological approach that was applied in the research. Literature was read on the topic area and issues were identified. For the purpose of this research traditional procurement was identified as a problem area in green design contribution, especially for buildability and constructability related issues.

3.3 Data collection strategies

The primary source of data was in the form of a questionnaire distributed as an on-line survey, specifically to individuals as per green project(s) they have worked on. The secondary collection of data was by means of literature readings on the themes of green

construction, procurement methods, supply chain management and early contractor involvement, amongst others.

3.3.1 Questionnaires

Green rated projects in South Africa acted as a source of data as they are the subject matter in the problem statement. The questionnaire was loaded on an online platform (Qualtrics), which sends an email to the participant to follow and start the questionnaire. The questionnaire was loaded onto the qualtrics software and distributed to construction professionals that are registered with the GBCSA. Email addresses of the participants were obtained from the GBCSA database, and some participants were followed up because their companies were identifiable enabling the researcher to do follow up calls.

Qualtrics is survey software used by the department of construction economics and management for research purposes. The software is designed to load and distribute questionnaires to an identified sample. The data collected is then organised and presented in an easy manner for analysis and interpretation.

There were strategic measures put in place that increased the response rate of the questionnaires and these included:

- Addressing the questionnaire to individuals. This led to some professionals undertaking email dialogue communications to comment and discuss some of the issues;
- Design of questionnaire made sure that individuals did not take long to finish the survey. On average it approximately took individuals 15-20 minutes to complete the survey;
- The sample was of individuals who are on GBCSA therefore there had a professional interest in the subject;
- There was a lot of follow-up on individuals through social media like LinkedIn and Facebook. The same strategy is mentioned by Nicholas and Rowlands (2011) on how powerful social media assists academics to conduct successful surveys due to an increase in the response rate,and ;

- Reminder emails and telephone calls were done to an extent where some professionals enquired if the period of the survey could end in January because of busy schedules.

3.4 Validity of sampling technique

The sampling was done on the data base of the GBCSA, which lists registered professionals with training, experience and a passion for green buildings. All individuals had valuable information to add to the survey.

There was a standardised confidence interval for the questions chosen. The percentage of targeted confidence Interval (CI) was in the range of 95 %. The chosen CI was because it is the commonly used in other similar studies such as Rose (2014).

3.5 Research Limitations

Research will be only carried out and limited to the following parameters; only construction professionals accredited by the GBCSA were sent questionnaires to find out about their involvement in green projects. The questionnaire is intended for green projects carried out in South Africa as rated by the GBCSA. Due to the limited literature in the South African context because it is a fairly new phenomenon in the construction industry, the literature used is broad in spectrum in such a way that it covered countries that have already established the adaptation of green buildings. Time frames to carry research on the planned schedules in order to submit within the planned dates.

3.6 Research Ethics

Ethical clearance has been granted by the University for the purpose of this research. There are no major ethical risks in this research. Individuals are identifiable therefore anonymity was not avoided in collecting the data. However, when analysing, presenting and reporting the data it was done on an aggregated basis so individual participants and projects are not identifiable. The information collected from the survey will be stored for the next five years, and the data will be shared and used in future publications.

3.7 Summary

The research epistemology adopted is positivist research, because there is use of an hypothesis which needs to be tested. The research method adopted is a quantitative

approach because of the use of questionnaires to collect data. The primary source of data was collected through questionnaires. A set of questionnaires was sent to construction professionals that have worked on green projects registered and rated by GBCSA. The secondary source of data was from readings from literature.

Data collection in the field was carried out as a one stage process. An online survey was used to send questionnaires to participants' emails. The intent of the questionnaire was to gather information pertaining to perceptions, attitudes, exposure and knowledge about green construction in South Africa. The data collected was both qualitative and quantitative. The research was limited to projects carried out in South Africa. Different statistical methods will be used to analyse the data with the use of SSPS software package. Different statistical measures were calculated such as variances and correlations of variables.

4 Data Presentation and Analysis

4.1 Introduction

This chapter deals with the presentation of the collected data, its analysis and interpretation. The data collected from the responses was analysed with SPSS version 23.0. The results will present the descriptive statistics in the form of graphs, cross tabulations and other figures for the quantitative data that was collected. Inferential techniques include the use of correlations and chi square test values; which are interpreted using the p-values Findings are made and compared against the literature previously reviewed.

The questionnaire was delivered using the qualtrics software application so that respondents could access it via a URL link. The link was distributed to construction professionals that are registered with the Green Building Council of South Africa. The database of GBCSA was used as the population and from this the sample was drawn. The professionals that were sent questionnaires ranged from construction project managers, construction managers, quantity surveyors, architects, and engineers.

The construction professional emails were identified by the GBCSA website. The study was conducted over a period of eight (8) weeks. Initially it was allowed for six (6) weeks then extended for a period of two (2) weeks because it was sent towards the end of the year when most of the participants in the built environment were preparing for closure for builders holidays.

The choice of using an online survey was due to the fact it could reach the sample in different locations. Before using online surveys there was sensitivity on issues identified by Lefever *et al*., (2007) that the response rates may be low compared to face-to-face paper surveys, however, online surveys are cheaper to administer.

A total number of 420 emails were sent. Of these 123 out of 420 - twenty nine percent (29%) were opened by recipients. There are a few reasons why some of the sample did not open their emails: some may have identified the email as spam and blocked it, while some might have been on leave or may have ignored it because of their busy schedules. Alternatively, some may have resigned from the companies and their emails no longer existed. Of the 123 emails opened there were seventy two (72) responses which

accounted for an approximate seventeen percent (17%) response rate of the entire population. The rate of response was fifty nine percent (59%) based on respondents that opened the emails. The response rate from participants who opened their emails shows a good success rate especially after follow-ups were done to remind them to respond to the survey. During the first week of distribution of the survey the response rate was less than five percent (5%). This was due to the fact that the email was generic and sent to all participants. During the second week a reminder email was sent but it was addressed to individuals. This impacted hugely on the response rate, as it grew exponentially.

Even though seventy two (72) participants started the survey some did not complete the entire survey. However, partly answered questions were still taken into consideration when analysing the data because their participation contributed and added value to the survey. The dropout rate with the incomplete survey was four percent (4%).

Table 4.1:1 Distribution responses

Emails sent	420/420	100%
Emails opened	123/420	29%
Total responses based on the entire population	72/420	17%
Total responses based on opened emails	72/123	59%
Dropout rate	3/72	4%

Addressing surveys to individuals made a big impact on the response rate which reached 36.11%. The response rate was within the normal range of online surveys which was depicted by Nulty, (2008). He ascertains that the response rates of online surveys are in the range of thirty percent 30% to forty five percent (45%). The rest of the participants finished the survey after the last reminder and it reached fifty nine percent (59%). The table above summarises the distribution responses for the survey.

4.2 Survey Statistics

It is evident that most of the participants took part during working hours (6am- 9pm). The majority of respondents took part towards the end of the working day around 3pm. These times may have an impact on the concentration level and attention levels that were given to the questionnaire. The modal time of survey duration is approximately sixteen (16) minutes. Some respondents took longer because they had the option to pause and continue later. The minimum time taken was eight (8) minutes while the longest time taken was approximately three (3) hours. The survey date is from the 16th November 2015 until the 4th January 2016. The majority of individuals attempted the survey on the 26th November after personalised reminder emails were sent. Question response rate is within the range of ninety five percent (95%) to hundred percent (100%) for those who attempted to complete the survey. There were participants that partially answered the questions and their responses were taken into consideration when doing data analysis.

4.3 Reliability Statistics

The two most important aspects of precision are **reliability** and **validity**. Reliability is computed by taking several measurements on the same subjects. A reliability coefficient of 0.70 or higher is considered as "acceptable".

The table below reflects the Cronbach's alpha score for all the items that constituted the questionnaire.

Table 4.3.1: Reliability Statistics

Question		Number of Items	Cronbach's Alpha
Q11	Barriers to the implementation of Green building practices in South Africa	3 of 4	0.483
Q15	Client types are knowledgeable about benefits of adopting green buildings practices	3 of 3	0.784
Q16	Clients who are "greening" their construction projects	2 of 3	0.687
Q23	Frequency of problems experienced when using traditional procurement path	7 of 7	0.799
Q24	Frequency of problems experienced on green buildings delivery	6 of 6	0.813
Q35	Evaluation on the level of success in the green project	5 of 5	0.810

The reliability scores for all sections exceed the recommended Cronbach's alpha value of 0.600 for a newly developed construct, and is in fact greater than the recommended 0.700 for developed constructs. This indicates a degree of acceptable, consistent scoring for these sections of the research. Only Question 11 had a lower than acceptable value. This is primarily due to the interpretations by the respondents in this section.

4.4 Data Analysis of the questionnaire

A discussion of questions will be done on significant questions and their relevance to the study so not all questions will be discussed in detail. The questionnaire was divided into three sections, focusing on the following:

1. General information of the participants including their background and exposure to green building projects. It was intended to enable the researcher to compare the profile of respondents with the known profiles of the built environment professionals;
2. Knowledge, exposure, perspective and the experience in the delivery of green buildings in the South African construction industry, and;
3. Most recent green building that participants have been involved in and that has reached completion in South Africa.

4.4.1 General background information of respondents

The section for general information was developed to collect descriptive statistics of the sample and the participants' backgrounds and experience with green buildings.

Question 1: What is your gender?

The question was developed to find out the gender distribution of the participants. This was mainly to find if gender still plays a role in the construction industry as it is perceived to be male dominated. A study that was done by English (2002) revealed that women were highly unrepresented in construction activities and their numbers were very low compared to men. A reason given was that women had a low educational background as compared to men which made them less competitive. The statistics SA data of 1999 revealed the same figures where fewer females were represented.

It was cited by Haupt and Fester (2012) that as a result of similar figures trending generally in most industries, government initiatives were introduced aiming at women

empowerment such as the Gender Policy Framework (2008) which aims at reducing gender discrimination. Based on the results of this research it is evident that a significant growth in the representation of women in the construction industry has taken place over the past two (2) decades.

Table 4.4.1: Gender of participants

Gender	*Response*	*Percentage (%)*
Male	41	57%
Female	31	43%
Total	72	100%

The table reveal a slight gap which may mean women are more interest and involved in green construction. A similar trend of women representation was revealed in Rose (2014) study on client satisfaction: a proportion of about thirty five percent (35%) of women took part in the study. It emerged that the majority of the respondents were male, accounting for fifty seven percent (57%) of the total respondents and forty three percent (43%) were female. The construction industry is perceived to be male dominated and this is still evident in this research as most of respondents are males. However, the margin of gap between gender participation is not big as it is only fourteen percent (14%).

Question 2: What is your age group?

The question on age was formulated to find out the age group of professionals that are involved in green buildings: whether it's a group of older, mature professionals or young emerging professionals. The intention of the question is also because green buildings exhibit innovative new trends in construction and need highly innovative minds to execute a successful green project. The age as a factor was to determine which professionals are involved in green building.

Table 4.4.2: Age group of participants

Age group	*Percentage (%)*
20-30	26%
31-40	35%
41-50	24%
51 and above	15%
Total	100%

The majority of participants, accounting for thirty six percent(36%), are in the age group of 31-40 years, followed by the 20-30 age group (twenty seven percent (27%) and 41-50 years with twenty three percent(23%). The least participation was from the age 51 years and above which accounted for fourteen percent (14%). There might be possible reasons why the majority of the respondents are in the middle age group (31-40). These are professionals that have computer literacy and can easily respond to online surveys. Green construction is a fairly new shift in the construction industry and they might have chosen a career path to specialise in these new building technologies.

Question 3: What is your professional background?

The intention of this question was to discover which professions are the most involved in contributing towards the design of green buildings. The professionals that took part in the survey were mainly architects - thirty seven percent (37%). Their high participation made a significant contribution because they are responsible for the overall design of buildings and therefore influence specifications and the choice of materials. This was followed by other professionals - thirty percent (30%) - who were not categorised in the list of commonly known built environment professionals. Interestingly, there seems to be a new title where some professionals identify themselves as ‘green building consultant’ or ‘sustainability consultant’ who are appointed by the clients to review the green building concepts and interests during the design and construction of green projects. These professionals form part of other professions. Some other professions included interior designers and specialist engineers such as mechanical engineers. Other participants of the survey included construction project managers which accounted for sixteen percent (16 %); construction managers with thirteen percent (13%); quantity surveyors at eleven percent (11%) and civil

engineers at three percent (3%). It was evident from sending the survey that most of the professionals that were based full-time on site did not manage to respond on time during the distribution of the survey as many took a long time to respond and had to be tracked down and reminded to complete the survey. Most of these professionals were construction managers and project managers. However, the office-based professionals managed to respond on time, such as architects and green building consultants.

Question 4: How many years have been working in the construction industry?

The question was intended to gather information as to whether the professionals who are actively involved in green building have a lot or less experience in the construction industry, and if this experience plays a significant role in the delivery of green projects.

Table 4.4.3: Experiences of participants

Experience	*Percentage (%)*
> 5 years	18%
6-10 years	29%
11-15 years	15%
<15 years	38%
Total	100%

The majority of respondents indicated that they had more than 15 years' experience in the construction industry accounting for thirty eight percent (38%) of the total respondents. This figure correlates with the combination of the age group of participants of 41- 50 and 50 years and above. About fifteen percent (15%) of participants have 11-15 years of construction experience while twenty nine percent (29%) have 6-10 years' experience. About eighteen percent (18%) of participants have less than five (5) years construction experience.

Question 5: What is your highest qualification?

The question was intended to profile the qualifications of participants in order to inform the researcher if the experience gained is backed up with educational qualifications. Most of the participants have post matric qualifications. About thirty percent (30%) of the participants hold masters' degrees followed by twenty seven percent (27%) with

bachelor degrees and twenty one percent (21%) with honours degrees. Some are doctoral degrees and advanced certificates account for three percent (3%) with a post graduate diploma accounting for one percent (1%). Generally most of the participants are well educated.

Question 6: In which year were you first involved in delivery of green buildings projects?

This question was intended to find out when green buildings were first introduced into the country. Different professionals started the exposure of green buildings at different times, few individuals started exposing green buildings in the 90s. On average most of the participants started getting exposure to green buildings in South Africa in the mid 2000's.

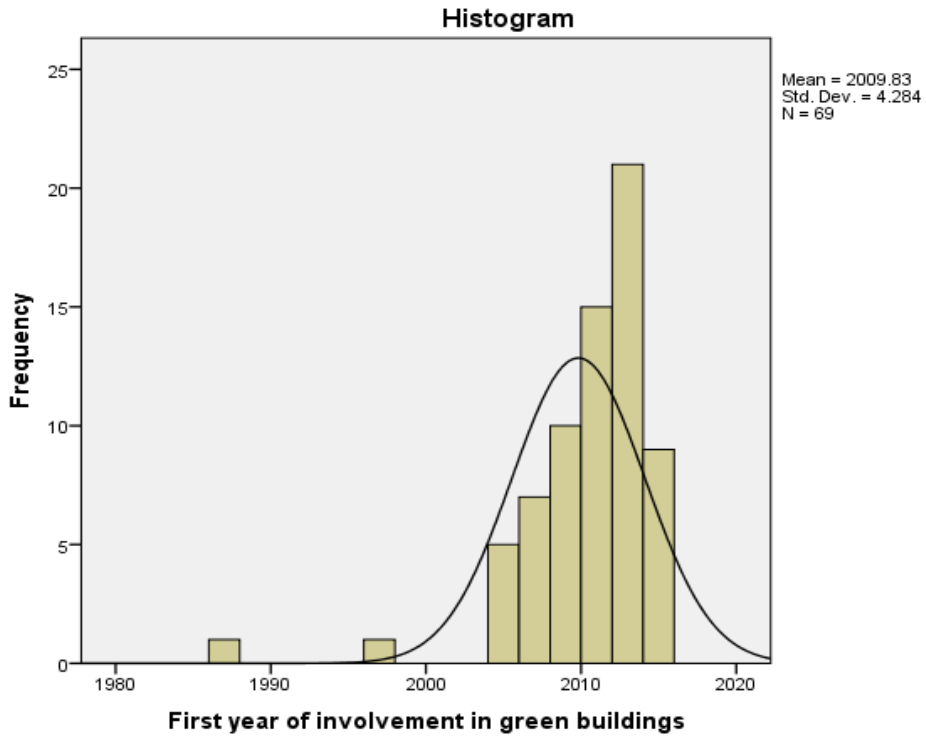


Figure 4.4.1: First year of involvement in green buildings

The histogram below shows a peak after 2010. This peak is around the time when South Africa was hosting the 2010 World Cup. The increase is experienced towards the host year and declines slowly thereafter. The data reveals a modal peak of about 13 individual buildings in a normal distribution exposed to projects. The establishment of

the Green Building Council of South Africa coincides with the data below because the council was established in 2007 (GBCSA). The council was established due to the growth and need for the construction sector to venture into innovative green initiatives.

Question 7: How many green buildings have you been involved in (including current projects) during your career?

The question on the number of green projects was developed to determine the rate of exposure to green projects so that the momentum of adaptation can be determined.

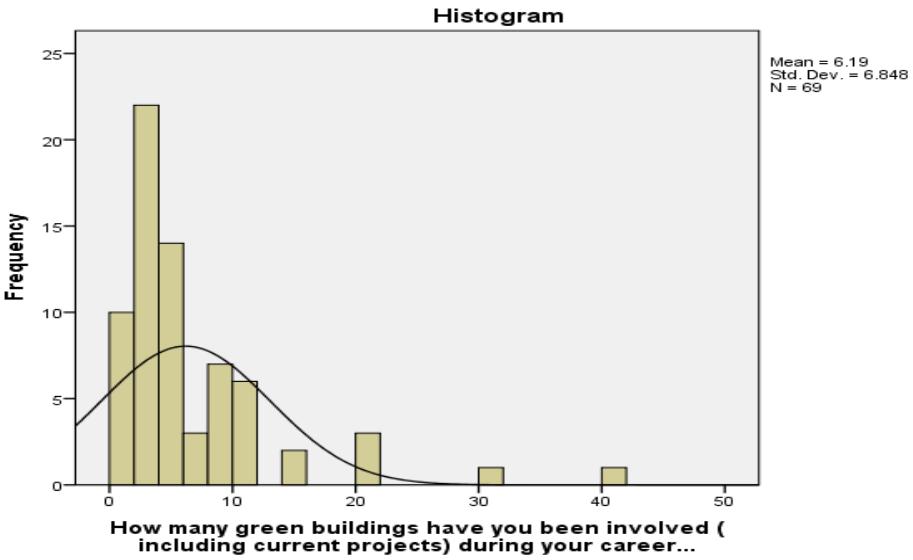


Figure 4.4.2: Number of green buildings for participants

The histogram above reveals that the majority of participants have been involved in at least five (5) projects of green buildings. The data reveals some outliers that have done about forty (40) projects. These may be individuals who started being exposed to green buildings in the 1980s.

Question 8: How many years of experience would you say you have had in working on green buildings?

The majority of participants, sixty five percent (65%), have less than five (5) years' experience in green building and about ten percent (10%) have more than ten (10) years' experience of green buildings. This table shows that the South African construction industry is still young in the delivery of green projects.

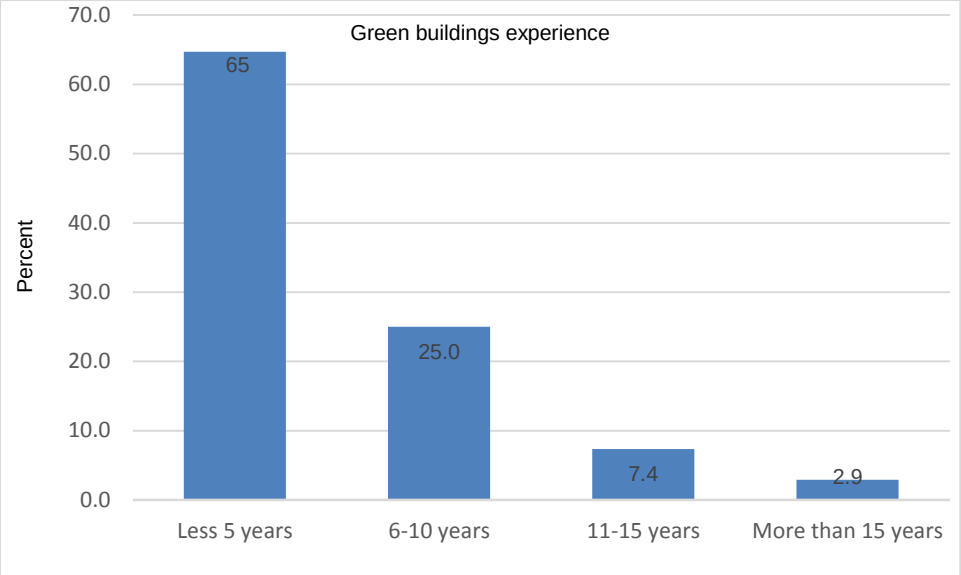


Figure 4.4.3: Experience in green buildings by participants

The pattern indicates that the phenomenon is fairly recent as most respondents have been involved for a short period of time.

Question 9: Before you were involved in the delivery of green building, how would you rate the level of knowledge and awareness of green building practices and principles?

Question 9 was designed to gauge the level of knowledge and awareness that the professionals had before they were involved in the delivery of green projects. The intent of the question was to compare the results with question 10 below which asks the same question but focuses on the knowledge and experience after involvement in delivery of green projects. In terms of knowledge and awareness the majority of participants indicate that they had a low to moderate experience before they were involved in green projects

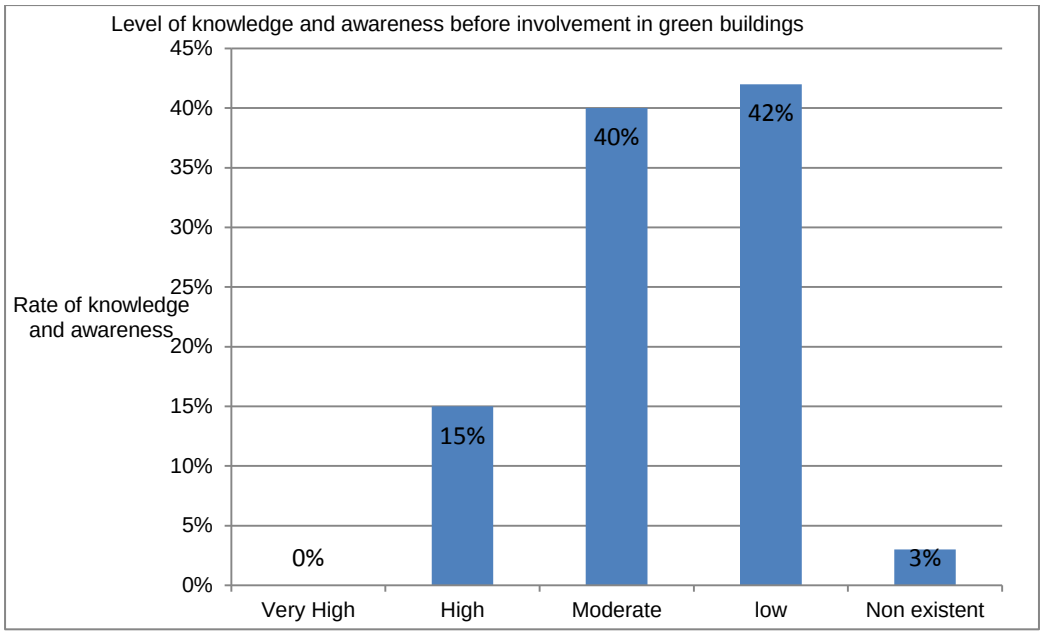


Figure 4.4.4 Rate of knowledge and awareness

Question 10: How would you rate your current level of knowledge and awareness after being involved in green building projects?

The data in the graph below reveals that after involvement on green project(s) their level of knowledge and awareness was classified as high and very high with proportions of fifty five percent (55%) and thirty three percent (33%) respectively. This is depicted in the graph below. This implies that the participants gained significant knowledge after they had been involved in green buildings. This is depicted in comparisons between the graphs in question 9 and 10.Therefore, site experience has a huge impact in knowledge transfer because the data reveals that the majority of individuals have at least a qualification higher than matric.

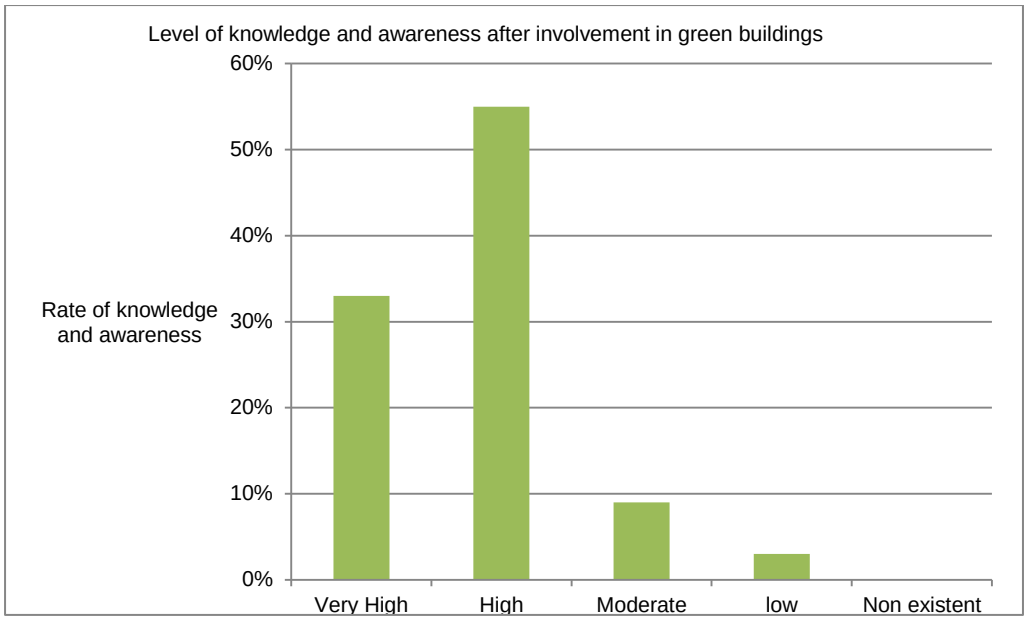


Figure 4.4.5: Rate of knowledge and awareness

Question 11: The following have been identified in research as barriers to the implementation of Green building practices in South Africa. How would you rate their significance to the contractor?

This question was developed on literature findings of different barriers that are said to be affecting the implementation of green practices. These barriers are to be matched against the South African construction to check if they are applicable in the local context. The purpose of the question was to find the extent to which the factors are affecting the South African construction industry. Each problem was ranked for the participants to state how problematic it is in the industry.

Question 11.1 Lack of awareness by the clients on green practices and principles

A lack of awareness by clients on green practices and principles was a highly ranked factor. It seems most of the participants find this to be the major factor in the South African construction clientele. About six eight percent (68%) of the participants finds it is a problem. This means that the initiators of projects (clients) are not familiar with the full benefits of green buildings. These findings tie in with the current research that was done by Windapo and Goulding (2015), which revealed that there are many South

African construction clients who are unaware of green practices and their benefits and there seems to be a huge gap in the legislation requirements and building practices.

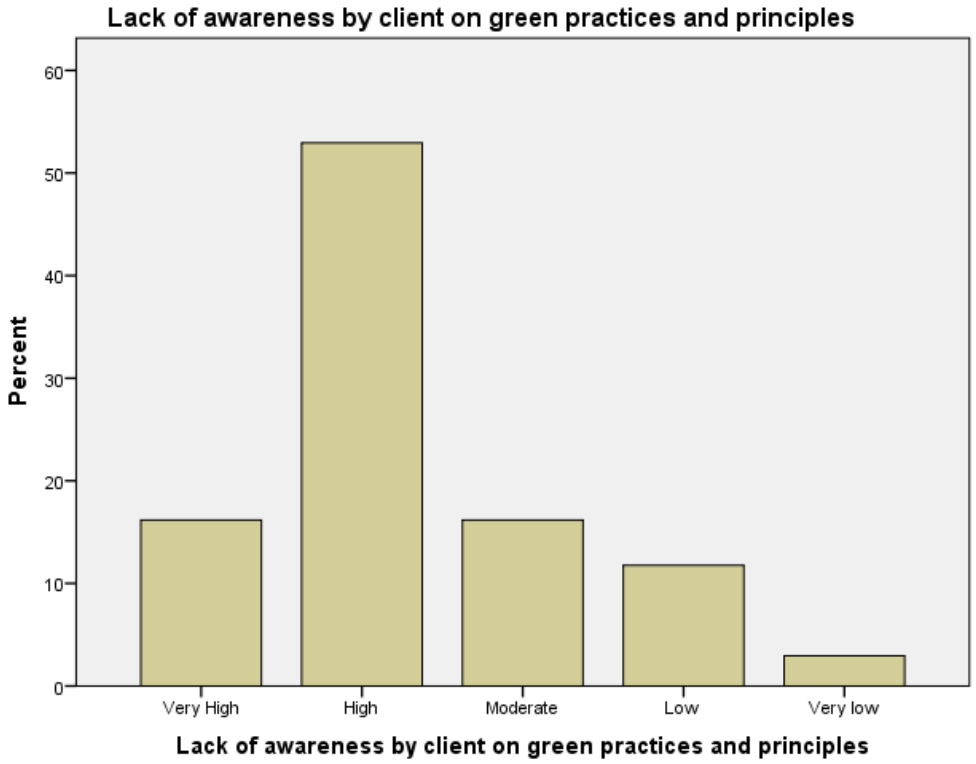


Figure: 4.4.6.1: Lack of awareness by clients on green principles

Question 11.2 Expertise and management of green projects by contractors

Expertise and experienced management was ranked number two (2), but it was still perceived to be highly problematic. About sixty five percent (65%) of participants perceive it to be a problem because there seems to be a lack of green building experience. The same factor was revealed in the findings by Liu *et al*., (2013) that there is a lack of experienced professionals in the field of green construction. Despite a lack of experienced professionals in the green fields, Shi *et al*., (2013) argue that there are sometimes sufficient personnel but senior management is reluctant and do not pursue and implement the agenda of green construction and environmental issues.



Figure 4.4.6.2. Expertise and management of green projects by contractors

Question 11.3 The use of procurement

The use of the correct procurement methods was identified as one of the factors that impede implementation of green practices and it is ranked as the third problem. About sixty four percent (64%) believe that procurement strategies can be a hindrance in implementing green practices and initiatives. It is clear that the current, commonly used, traditional procurement method is not yielding best results for project delivery. The study by Mathonsi and Thwala (2012) revealed that other procurements packages are not given recognition in the South African construction industry, unlike in the United Kingdom (UK). They further recommended that there should be thorough analysis of external and internal factors of the project so that a proper strategic procurement can be adopted. Findings on these CIDB paper 13 (2012) revealed that the clients' needs must be thoroughly understood, a clear strategy of approach should be in place and some contingency cushions should be detailed. The findings still tie in with Ann and Shen (2013) findings on traditional procurement shortcomings. They identified that the model cannot suit all construction projects because when meeting complex

clients' organisations with a multitude of needs, the models lack a comprehensive framework which is versatile to changes. Ann and Shen (2013) recommend diversifying procurement strategies by the inclusion of partnerships and the appointment of project managers to control communication disparities.

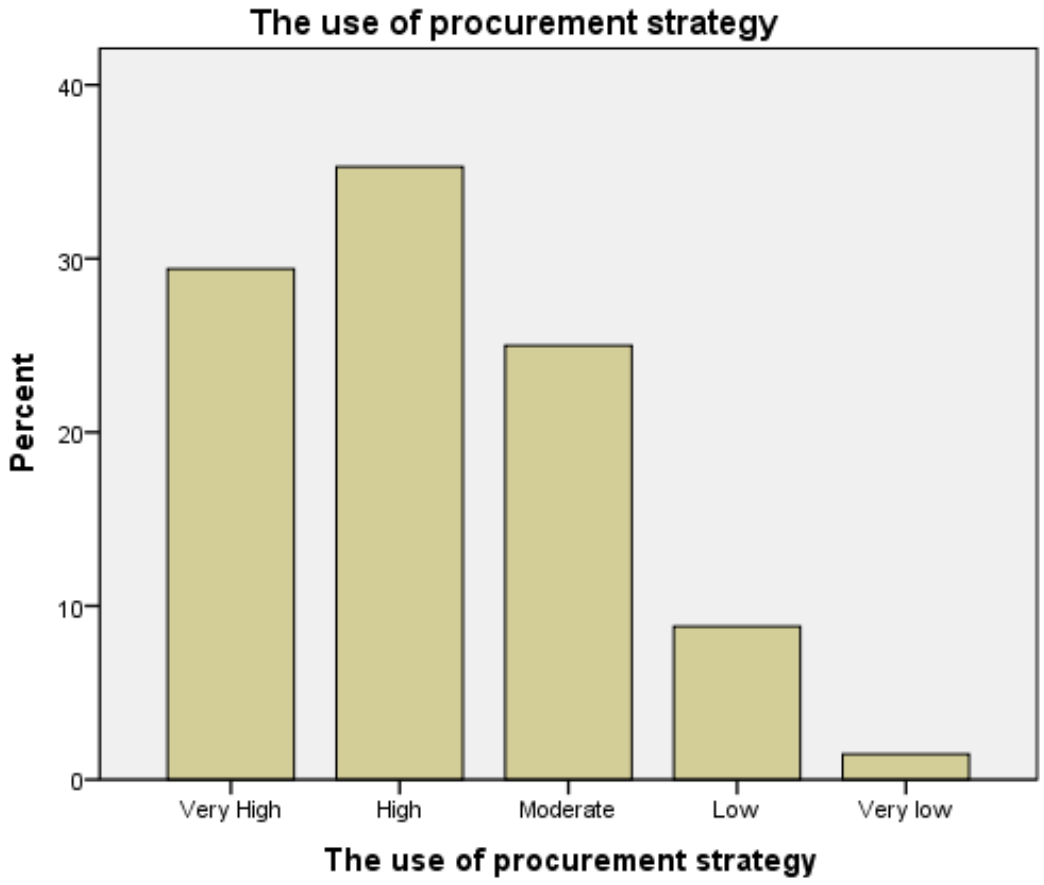


Figure 4.4.6.3: The use of procurement strategy

Question 11.4 Cost of green projects

Green buildings are perceived to be costly as compared to conventional buildings. The data reveals that the cost of green buildings is highly rated as a barrier to implementation. Cost ranked number four (4) as one of the impediments in the South African context. About sixty two percent (62%) perceived it to be a problematic factor. The cost was also identified as a major impediment in growing economies such as China. Liu *et al*., (2013) revealed that the Chinese construction industry still finds the fabrication costs of green buildings to be a major hindrance in adopting the buildings. They also revealed that carrying costs control measures within green projects was a

major problem. On the same sentiment, the additional costs expense, as compared to conventional buildings, acts as a major barrier to the implementation of green buildings (Ofori and Kien, 2004).

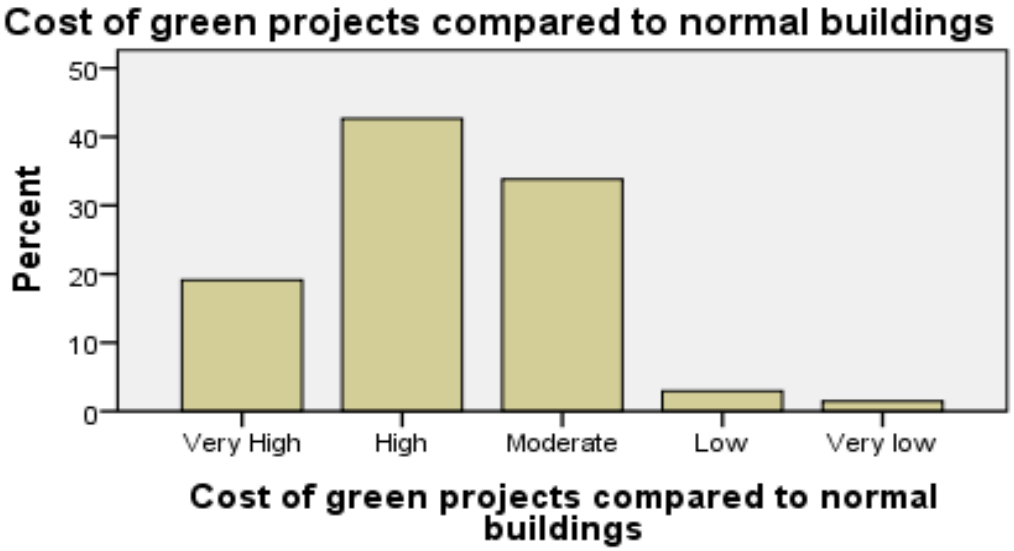


Figure 4.4.6.4: Cost of green projects compared to normal buildings

Question 11.5 Summary of problems experienced in green buildings as compared to conventional buildings

The identified problems have resurfaced in literature as problematic areas also experienced in other countries. These same problems are also perceived to be problematic in the South African construction industry. In the South African context it seems there is a high level of unawareness about the benefits and a lack of knowledge about green buildings. Green buildings are perceived to be expensive compared to normal buildings therefore they are adopted less often. The perceived high cost has shown a different client spending priority where private clients are more susceptible to investing in them compared to the government and other state entities. The use of the correct procurement strategy also act as barrier to their implantation as the clients use the commonly used procurement packages that are used to deliver normal buildings. Another crucial aspect is the lack of proper expertise and managerial skill in the field of green construction. This may be due to the fact that the adoption of green buildings only increased a decade ago and therefore there are fewer experienced individuals in the field.

Question 12: In your opinion, which type of client is more receptive to the idea of green buildings?

This question was to find out which clients adopt more use of green buildings compared to others. This may be used for future research to assist clients who have less or no knowledge about green buildings. It also enables the researcher to gather more information by doing follow-up interviews with clients who have adopted green building practices. From the pie chart below it is evident that private clients are more receptive to the green building ideology compared to the state and parastatal sectors which are almost identical in their share. This means that these buildings require more promotion and their benefits need to be shared with government and parastatal entities. The reason for this is because the state is the biggest client in the construction industry and it can also benefit from adopting this type of building.

The pie chart below summarises the ratios of adoption of green practices and designs by different clients.

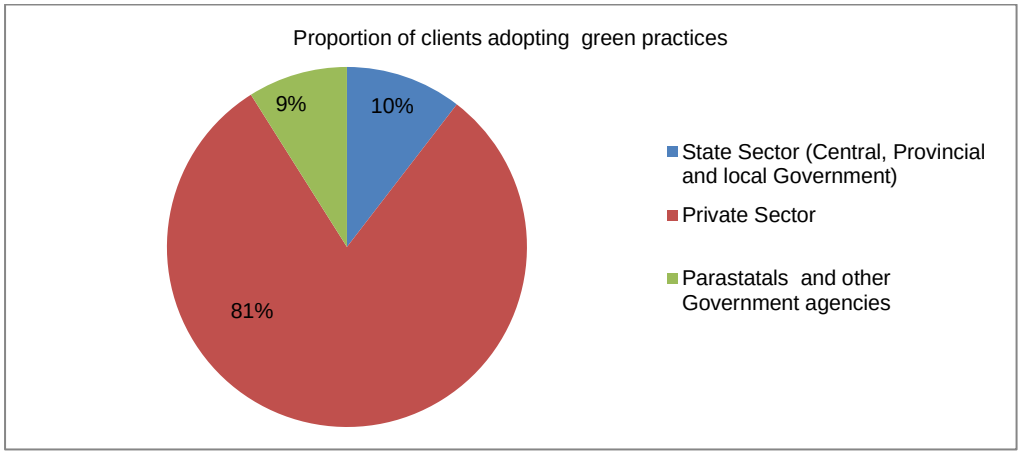


Figure 4.4.7: Pie chart summarising proportion of clients as per adoption of green buildings

The pie chart above reveals that eighty one percent (81%) of the participants perceive that a majority of private clients adopt green buildings and practices. The government and parastatal sector shares almost half the proportion of the remaining nineteen percent (19%). The state is ranked lowest as a client that uses and adopts green building practices in South Africa despite the findings of Windapo and Goulding (2015) who state that there are some legislative measures in place for the South African construction industry to follow in green implementation and compliance. Another

reason why the public sector shows a low rate might be because the public sector is said to have a shortage of skills in construction project delivery as identified by Bowen *et al*., (2007).

4.4.2 General perspectives of the South African contractors

Question 13-18 are summarised below with graphs. It depicts the perspective held by the respondents of South African contractors. The questions were formulated to understand the state and the contribution of contractors in terms of green buildings. This is also tied in with the hypothesis as it claims that contractors are not contributing to the use of traditional procurement.

Question 13: "Overall, South African contractors are knowledgeable about the benefits of adopting green buildings practices".

The intent of the statement was for the participants to state if contractors have knowledge about the benefits of adopting green building practices and to discover if the contractors are contributing towards green initiatives. This may assist in developing experience for the contractors.

Table 4.4.4: Knowledge of South African contractors on benefits of green initiatives

Answer	*Percentage (%)*
Strongly Agree	1%
Agree	28%
Neutral	31%
Disagree	36%
Strongly Disagree	3%
Total	100%

Based on the graph above, approximately one third (1/3) of the participants (thirty six percent (36%) believe that South African contractors are not knowledgeable about the benefits of using green practices. About thirty one (31%) are indecisive as to whether they are knowledgeable or not and about twenty eight percent (28 %) believe that they are knowledgeable. In a nutshell, there is still no clear indication whether they are knowledgeable or not. This might be due to the fact that green building is a new trend in the construction industry in South Africa. A clearer indication will be possible once the

industry has familiarised and gained experience itself with the concepts of green buildings.

Question 14: "Overall, South African contractors have the necessary skills to construct green buildings".

The question was designed to discover whether the current projects that have been done satisfactorily meet the skills requirement to state that contractors can diligently carry out green projects. The intent was to match skill with awareness and find if there are positive correlations. Based on the graph below, it seems respondents are both agreeing and disagreeing. An equal proportion of respondents believe that South African contractors do not have the necessary skills while the same proportion disagrees with the statement. However, a combination of strongly agree and agree accounts for forty two percent (42%), therefore one can deduce that South African contractors do have the necessary skills to construct green buildings. However, the study done by Windapo and Goulding (2015) reveals that there is a high non-compliance of activities on site when it comes to green building legislature. This was on the claim that contractors are not finding the true benefits of adopting these practices.

Table 4.4.5: Perception of contractors' skill on green buildings

Answer	*Percentage (%)*
Strongly Agree	6%
Agree	36%
Neutral	22%
Disagree	36%
Strongly Disagree	0%
Total	100%

Question 15: "Overall, the following client types are knowledgeable about benefits of adopting green buildings practices".

The question was designed to find the stance of clients as compared to contractors as to whether they are knowledgeable about the benefits of adopting green building practices. A comparison will also be made in Question 12 that intends finding which clients adopt green buildings.

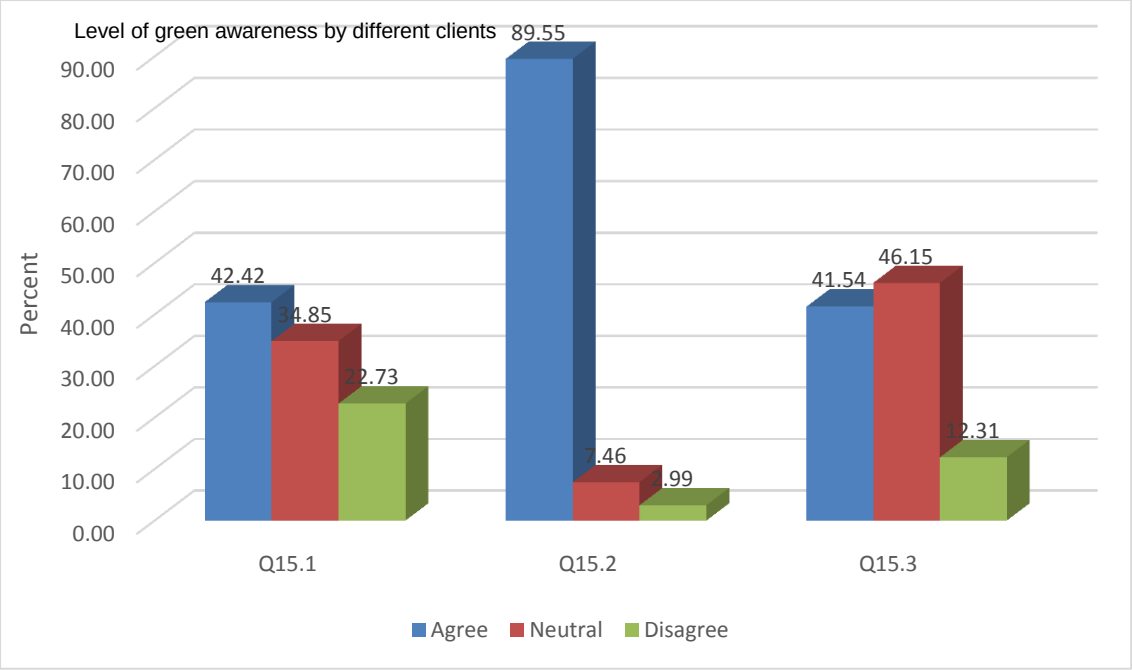


Figure 4.4.8: Level of awareness by clients on green initiatives

The figures still correlate with the data from Question12, that there is clear evidence that the private sector is the lead client compared to government and parastatal entities. Figures reveal that private clients are knowledgeable about the benefits of adopting green building practices which lead them to investing more in green buildings than other clients. It would therefore seem that there are low levels of awareness on the full benefits of green buildings initiatives, as revealed in the findings by Shi *et al*., (2013), who suggested that clients, contactors and policymakers should be made more knowledgeable and become more skilled and aware of the field of green construction.

Table 4.4.6: Chi-Test Results: Level of clients awareness on green buildings

		Chi-Square	df	Asymp. Sig.
Q15.1	Private Sector	95.493[g]	2	.000
Q15.2	Parastatals and other Government agencies	13.138[i]	2	.001
Q15.3	State Sector (Central, Provincial and local Government)	12.030[g]	2	.002

In the chi square tests are shown above, it is noted that the scoring patterns per question per option was significantly different.

Question 16: "Overall, the following clients are "greening" their construction projects".

There is still a high correlation between Questions 12, 15 and 16. The private sector is said to be greening their projects, this is because it is agreed that they are knowledgeable about the benefits of green buildings hence their adoption of them. It evidently shows that state projects are also on the move to green some of its projects. It is agreed that most private clients are greening their projects. Similar trends and patterns have been identified in Rose (2014).

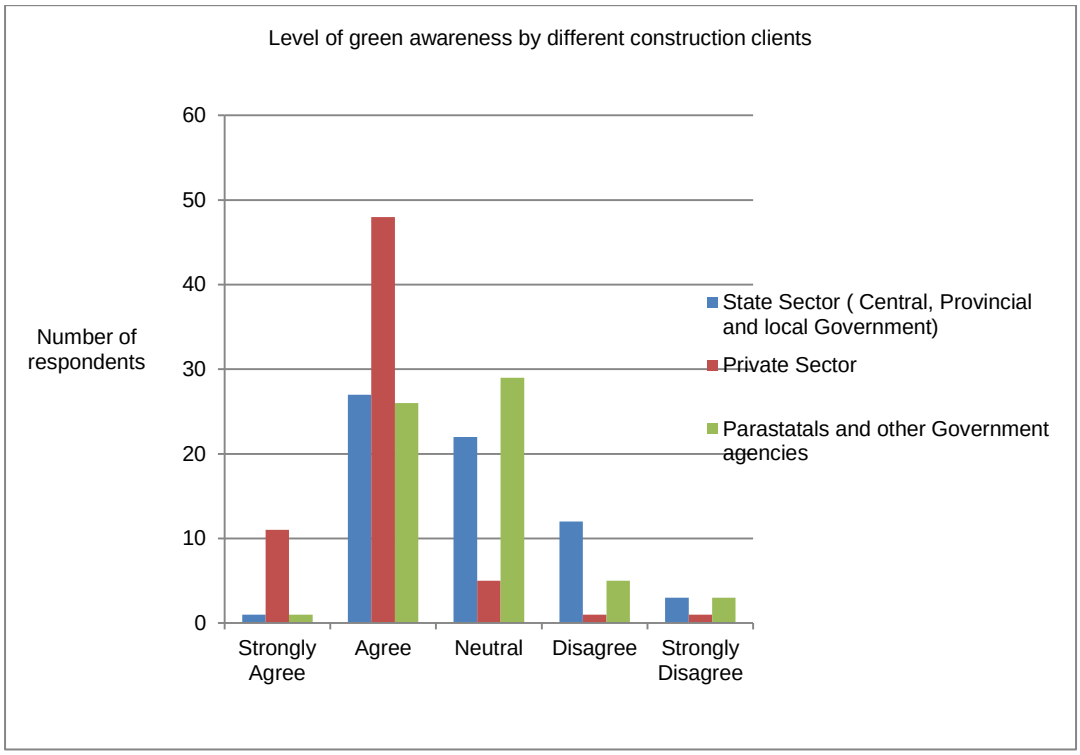


Figure 4.4.9: Clients that are greening projects

Question 17: "Overall the South African construction supply chain (e.g. specialist contractors and specialist suppliers) are ready to adopt green practices".

The statement was designed to discover if other construction supply chains are also knowledgeable and if they blend with the new technologies of green buildings. The statement intended to find out if the supply of materials is readily available and how the markets are responding to these new technologies. The participants perceive that the supply chain in South Africa is ready to adopt green practices. This is revealed by above fifty percent (50%) of participants agreeing with the statement. Only about

thirteen percent (13%) of the participants disagreed with the statement. This clearly shows that other parties within the construction industry are ready for the developments and technologies of green construction.

Table 4.4.7: Readiness of South African supply chain in construction

Answer	*Percentage (%)*
Strongly Agree	7%
Agree	49%
Neutral	30%
Disagree	12%
Strongly Disagree	1%
Total	100%

Question 18: "Contractors are able to provide input into green aspects of buildings projects to assist in achieving the green outcomes of the projects".

The statement was designed to find out if the contractors are capable and are adding value to construction processes in order to achieve the greening of projects. This is a crucial aspect because it determines the input at which contractors are able to add to projects. As mentioned by Wang *et al*., (2010), the design of green, sustainable buildings should reduce the harmful effects to the environment and still provide the design purpose to the owner; consideration should be made to the whole life cycle of the buildings. Wang et al., (2010) mentions six (6) essential aspects being:

- Site design and layout;
- Material outsourcing;
- Water efficiency;
- Energy consumption and efficiency;
- Innovative design,and;
- Quality of indoor environment.

All the above-mentioned aspects should balance in order for the success of green building to be maximised. Contractors' input can be maximised in selecting materials

for construction purposes and designing an efficient site lay out and as well as coming up with green initiatives to promote sustainable construction.

As found in Question 14 that South African contractors have the necessary skills to construct green buildings, it is again evident that the contractors provide valuable input in projects in achieving green outcomes. The table below clearly favours contractors that provide inputs to projects. About forty one percent (41%) agree with the statement and thirty five percent (35 %) of respondents are neutral about the statement. Only twenty five percent (25%) disagree with the statement.

Table 4.4.8: Contractors' skills on green designs and initiatives

Answer	*Percentage (%)*
Strongly Agree	3%
Agree	38%
Neutral	35%
Disagree	23%
Strongly Disagree	2%
Total	100%

Question 19: Based on your experience of green construction rank in order the procurement that is commonly used.

The question was formulated to find out the most used procurements and its effectiveness on the delivery of projects. It was also formulated to be compared to Question 21, which looks at the perceived and most appropriate method of appointment in green buildings. The procurements selected were identified in literature as those commonly used in South Africa. The question will also assist in answering the problem statement where procurement is perceived to be the one thing disadvantaging contractors for fully engaging and contributing to green buildings. The data reveals that the most commonly used procurement is the traditional procurement. This procurement method involves competitive bidding where the different contractors submit offers to the invited bid. The adoption of this method may be perpetuated by the points mentioned by Walters and Cloete (2008) that most government policies require competitive bidding. It is also explicit in the CIDB tendering procedures. As cited by

Walters and Cloete, (2008) the policy of 1996 white paper also detailed that all tenders should be in a competitive bid manner, and it was later amended after further consulting to allow other forms of procurements.

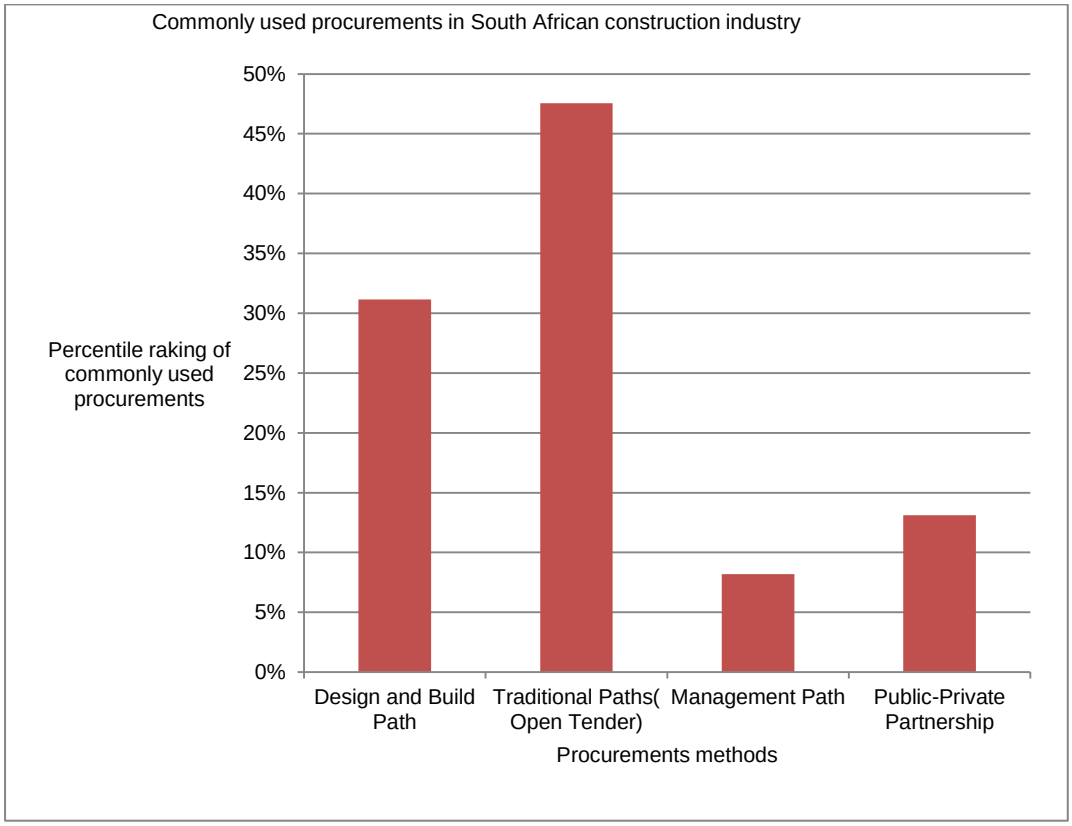


Figure 4.4.10: Commonly used procurements in South African construction industry

From the data above it can be shown that the traditional procurement path is still the most commonly preferred path by the construction industry. By preference it is followed by the Design and Build path.

Question 20: Based on your experience of green construction rank which method of procurement you perceive as the most appropriate for delivering green buildings.

The question was formulated to be matched against the commonly used procurement which is found in Question19 above. Comparisons will be made with the ideal procurement and the one preferred by clients. The table below reveals that the most appropriate method of procurement for green buildings is design and build path. This is also revealed by literature because of its benefits compared to other building

procurement methods. Design and Build is highly ranked followed by public-private partnerships, traditional procurement is then the lowest ranked is management path. The design and build method is said to be taking a lead in specialised projects (Akintoye, 1994). The contractors who carry out the design also have the necessary skills and experience to do the construction that was documented (Rowlison, 1997).

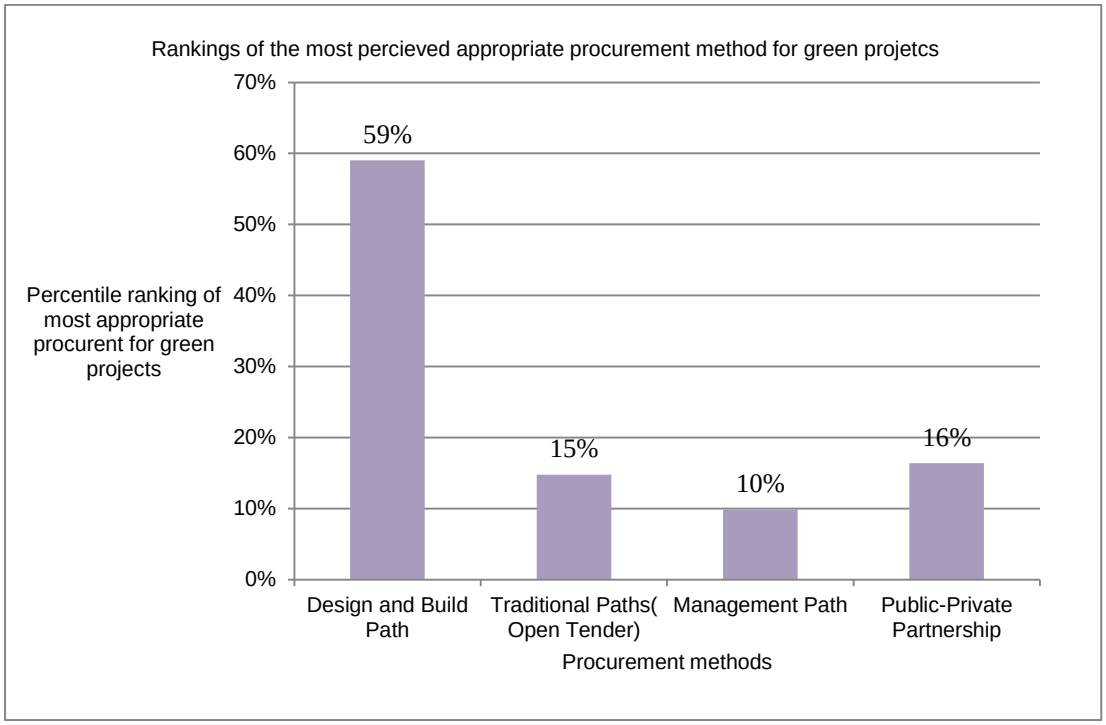


Figure 4.4.11: Perceived procurements for green buildings

Question 21: Based on your experience of green construction rank in order the commonly used method to appoint the main contractor.

The method of appointment of a contractor plays a big role in the contractual arrangement and the delivery of projects. There are different ways that contractors can be appointed. They can either be selected (closed) to tender for the works, or it can be open where every contractor can tender or it can be negotiated' depending on the client-contractor relationship or the nature of the work to be done. This question was formulated for participants to indicate which method of appointment they have experienced in green construction. It seems the commonly used method of contractor appointment for green buildings is through selected tendering method. This might be due to the fact that green construction is a new phenomenon in construction, so only contractors that are experienced in the field may be invited to tender. Selective

tendering is defined by Odedokum *et al*., (2015) as selecting a few contractors at least three (3) who are deemed to be equipped to carry a certain task through to completion. The number may vary to six (6) if the job is deemed to have a larger scope (Aje, 2012). Selective tendering can be carried out in different ways. The client can draw up the tenders from its own supply database, or may ask the consultants to determine them from an *ad hoc* list and alternatively, an advertisement can be posted (Odedokum et al., 2015).

The data reveals that open tenders still have preference as it falls in the second place as the most preferred method to appoint a contractor.

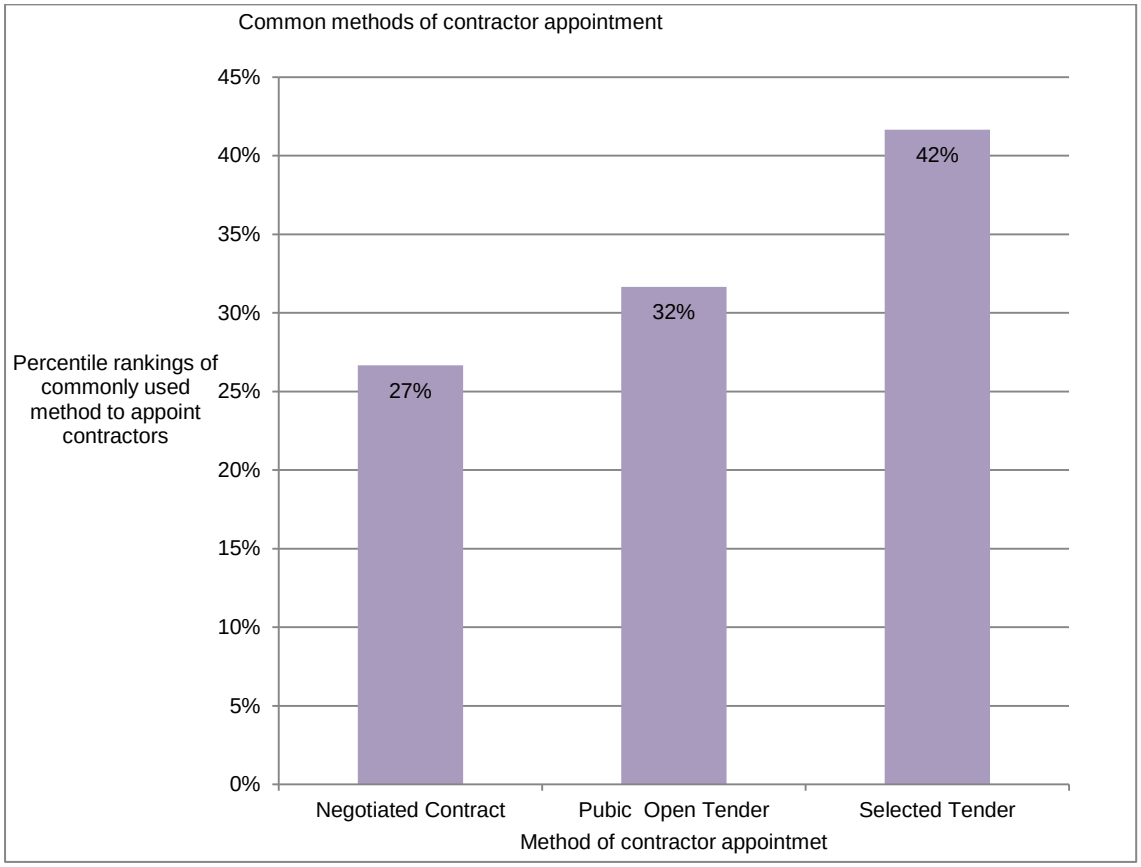


Figure 4.4.12: Method of contractor appointment

Question 22: Based on your experience of green construction, rank which method of appointing the main contractor you perceive as the most appropriate for delivering green buildings?

This question was formulated to be compared with Question 21 above. It was formulated to find out if what is actually happening with respect to the appointment of contractors is the ideal method. Based on the experience of the participants they had a different viewpoint when compared to the actual practice when it comes to the appointment of contractors on green projects. The most ideal method of appointment is perceived to be a negotiated contract as compared to the commonly used selected tendering..

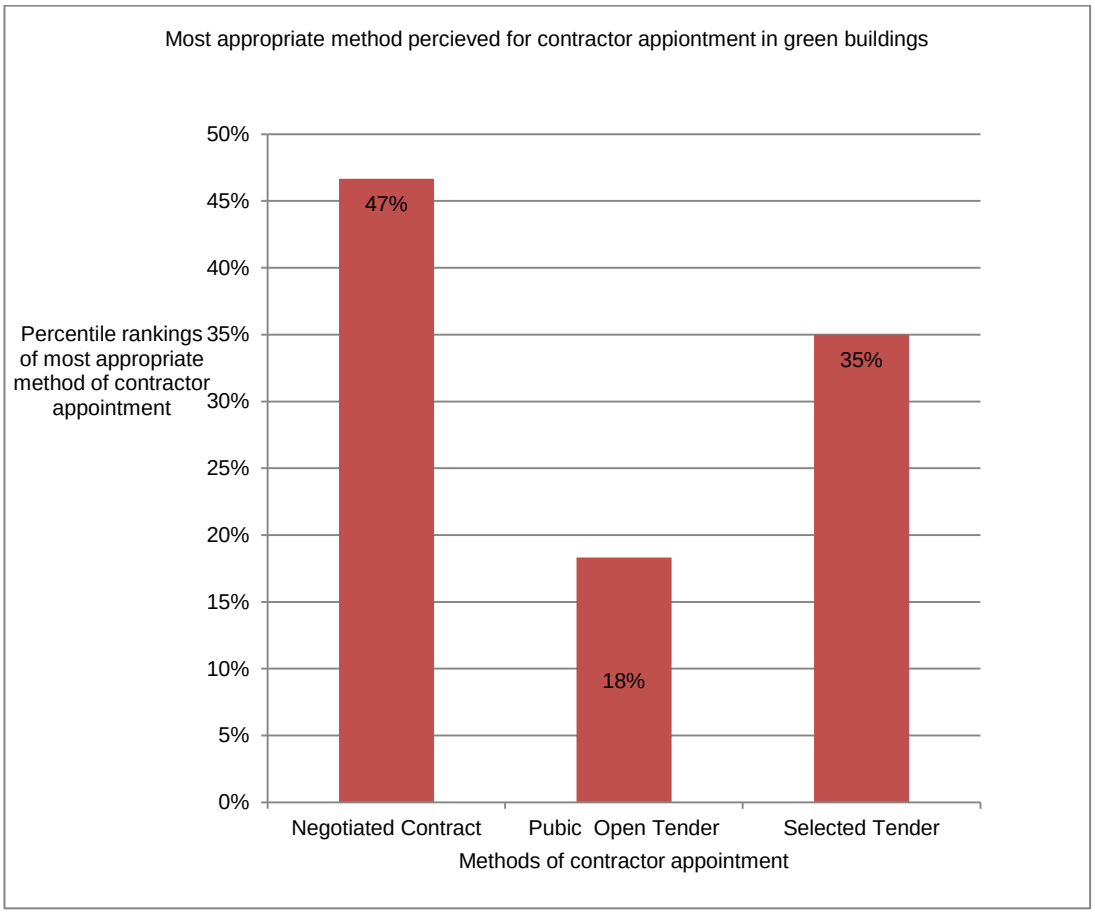


Figure 4.4.13 : Perceived method of contractor appointment in green buildings

Walters and Cloete (2008) describe negotiated contracts as a form of partnering as contracts are flexible and they can be continuously updated to carter for variations that they may be exposed to. The second most preferred method is selected tendering and

open tendering is ranked lowest. Common practice shows the opposite of these results which may be a factor leading to the unsuccessful delivery of projects.

Question 23: Rate the frequency of problems when using a traditional procurement path (separating design from construction) in any projects irrespective of whether it is a green project or not.

This question was formulated on problems associated with using a traditional procurement path. These problems were identified from literature. The question was mainly designed to focus on traditional procurement so that some problem statement can be proved and for the researcher to be able to answer the research sub question. The identified tabled problems that are commonly experienced when using a traditional procurement path are contract experience and the high cost of over runs. This is evidenced as about sixty seven percent (67%) of participants believe it to be a major problem. The other high ranking problems include time delays and contractual disputes. The least experienced problems are health and safety related issues.

Problem 23.1: Time delays

The majority of respondents, about sixty five percent (65%), believe that when using the traditional procurement path they experience time delays. It is evident, globally, that construction activities never finish by the anticipated time (Zidanea *et al*., 2015). These delays have become part of the normal construction process and have led to project management teams allowing for these delays in the main construction programme (Sweis *et al*., 2008). Some of the time delays identified by Zidanea *et al*.,(2015) are caused by a change of scope and material outsourcing problems. By its nature traditional procurement excludes contractors at the planning stage where issues such as material sourcing could be identified early and ordered. If there was early contractor involvement as well, there would be fewer changes to designs during the construction phase as the contractors would add value to designs by using previous experience.

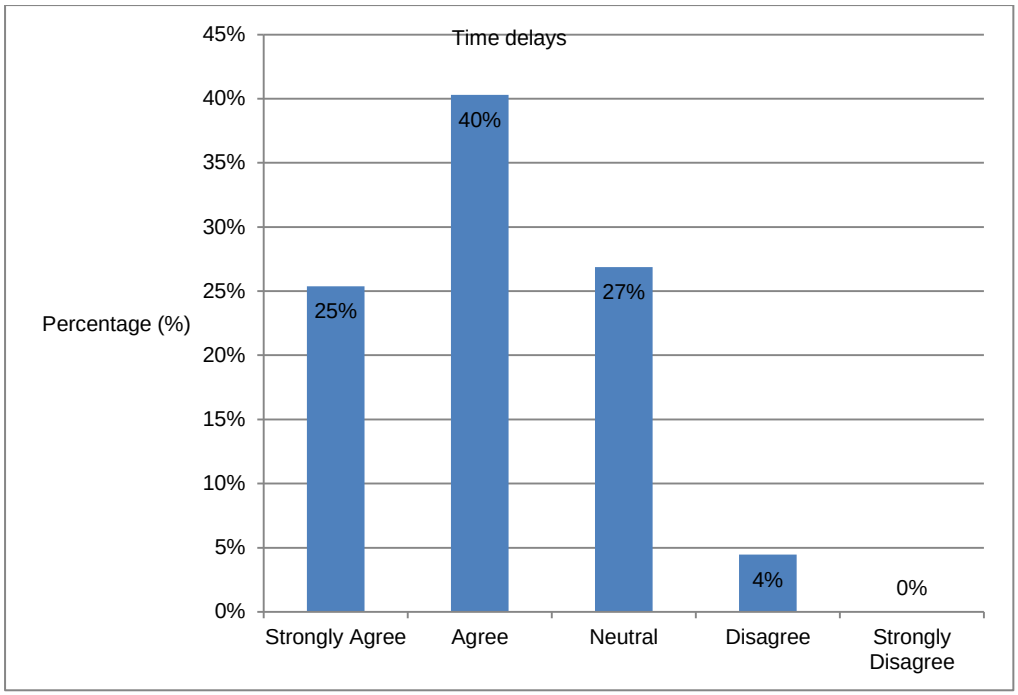


Figure 4.4.14: Time delays

Problem 23.2: Cost overruns

Cost over runs are said to be problematic when using a traditional procurement path. About sixty nine percent (69%) of the participants believe projects do no finish within the agreed budget. Cost overruns are also dependent on time extensions. Once the contract is not finished on time, it is prone to experience cost overruns. This may be caused by changes to the design, the late arrival of materials or communication problems.

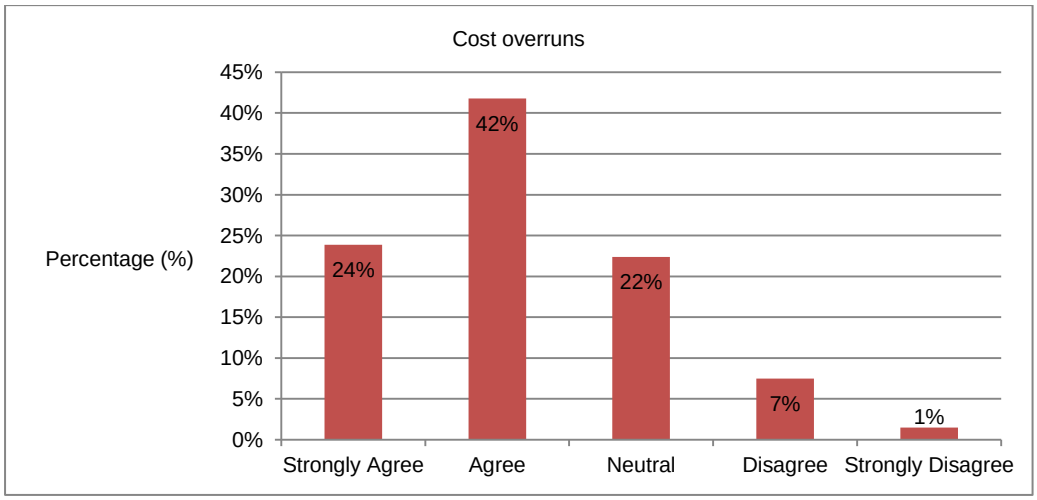


Figure 4.4.15 : Costs overruns

Problem 23.3 Contractual disputes

There seems to be a balance on the issue of contractual disputes. About forty seven percent (47%) agree that they experience some disputes when using the traditional procurement path. It seems about twelve percent (12%)disagrees with the matter that the traditional procurement path is prone to contractual disputes.

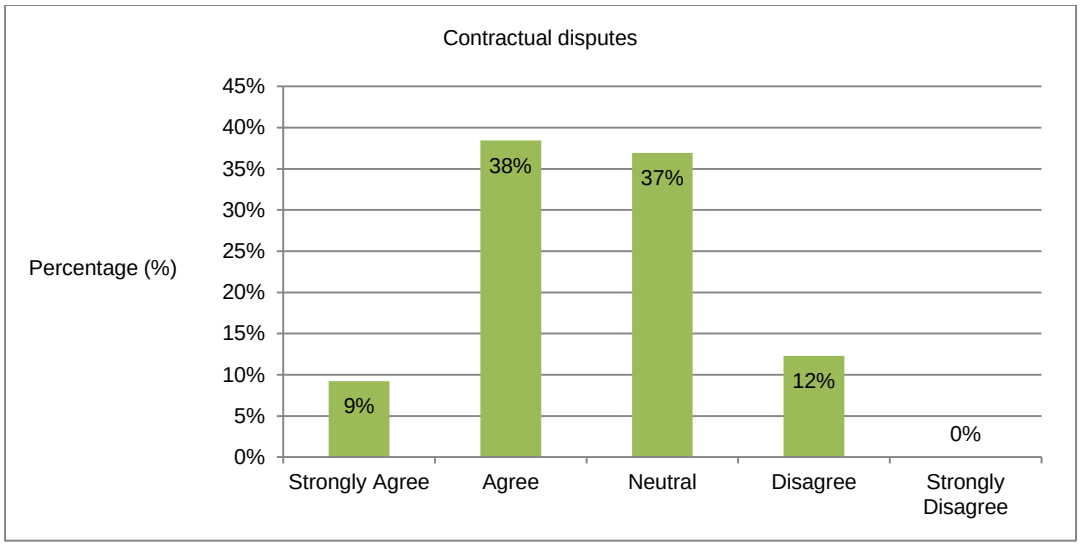


Figure 4.4.16 : Contractual disputes

Problem 23.4 Poor quality

About forty one percent (41%) of the participants believe that the traditional procurement path leads to poor quality when utilised. About thirty six percent (36%) are not sure and only twenty percent (20%) of the participants disagree that poor quality is attained when using traditional procurement.

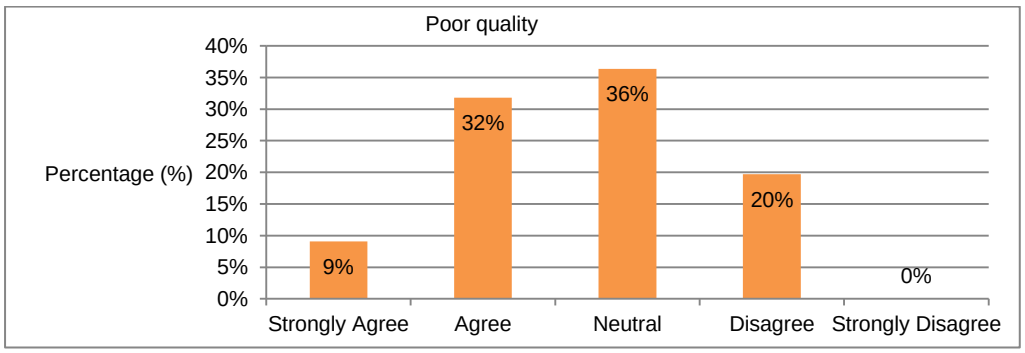


Figure 4.4.17: Poor quality

Problem 23.5 Non- compliance health and safety

Health and safety is being sensitised on construction sites by the ministry of labour and home affairs. The new construction regulations require that the employer should have health and safety personnel on site. The figures below show that there is a high compliance to the health and safety aspect. About forty four percent (44%) of the participants disagree that there is non-compliance when using the traditional procurement path. Only sixteen percent (16%) of the participants believe there is non-compliance.

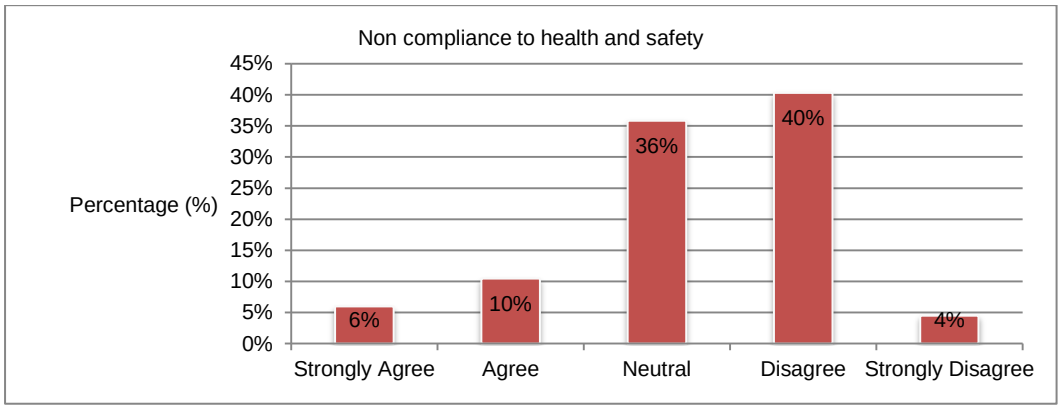


Figure 4.4.18: Non-compliance to health and safety

Problem 23.6 High maintenance and life cycle costs

There is a high proportion of forty nine percent (49%) of the participants indicating a neutral position when it comes to high maintenance and life cycle costs. It means that participants perceive that using the traditional procurement path is not directly linked to the life cycle costs of buildings

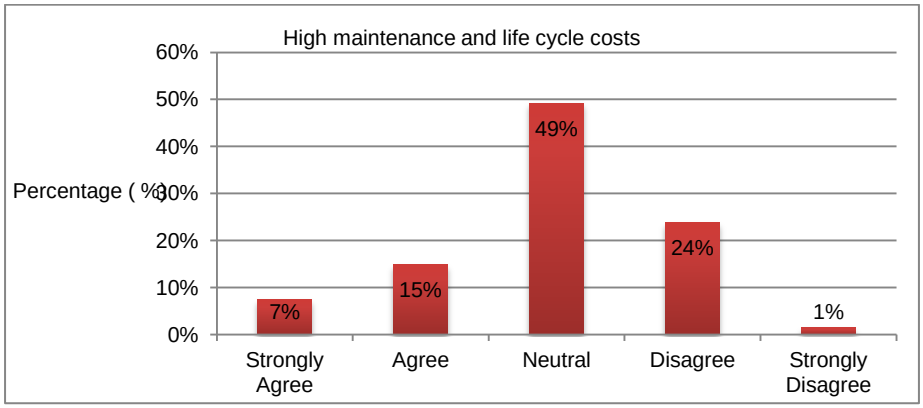


Figure 4.4.19: High maintenance and cycle costs

Problem 23.7 Constructability issues

The relationship between the use of a traditional procurement path is not clearly identified as the majority of participants are neither agreeing nor accepting. However, a proportion of forty one percent (41%) believe that the use of a traditional path has an impact on the constructability of the projects. This is due to the fact that the contractor is appointed only after the designs have been done. If there was early involvement by the contractor there could have been greater added value by ensuring that the contractor's previous experience was transferred to the new designs.

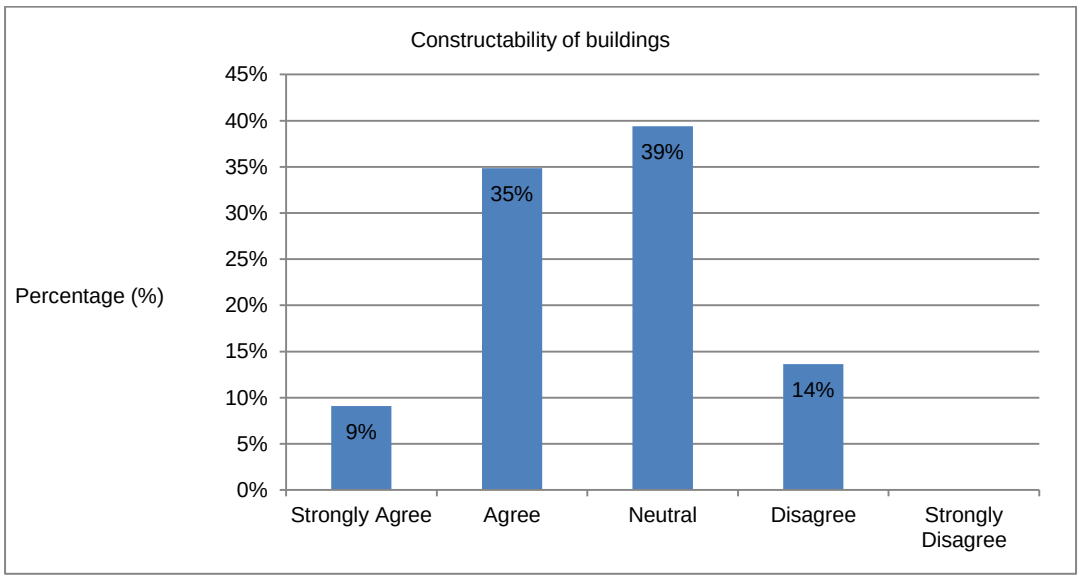


Figure 4.4.20: Constructability of buildings

Question 24: Rate the frequency you have experienced of the problems on green building

Problems that are normally experienced in green buildings were also identified from literature then tabled for participants to rate them according to the South African context. Even though there was agreement with question 17 that the green supply chain is ready to adopt green practices, response from the table below contradicts that statement, as the availability of green materials is posed as a problem. The other highly ranked problems include a lack of technical and managerial expertise as well as poor specification detailing.

Table 4.4.9: Frequency table showing problems experienced in green buildings

		Agree		Neutral		Disagree	
		Count	Row N %	Count	Row N %	Count	Row N %
Poor specification detailing	Q24.1	36	57.1%	14	22.2%	13	20.6%
Availability of suppliers of green materials	Q24.2	45	70.3%	9	14.1%	10	15.6%
Compliance with Health & Safety	Q24.3	15	23.4%	24	37.5%	25	39.1%
Disputes and conflicts	Q24.4	11	17.2%	37	57.8%	16	25.0%
Lack of technical expertise	Q24.5	42	66.7%	11	17.5%	10	15.9%
Lack of managerial Expertise	Q24.6	37	58.7%	14	22.2%	12	19.0%

The results in the table there is a problem of availability of green materials. Therefore the supply chain of green buildings is not integrated as there tends to be no availability of green materials. It is followed by lack of expertise in the field of green construction. This is evident with the list of scare skills released by ministry of home affairs which classifies most of construction professions as scare skills (Government Gazette, 2014). The other factor of concern is that there is lack of managerial skill of green construction.

Table 4.4.10: Chi-Test Results

		Chi-Square	df	Asymp. Sig.
Q24.1	Poor specification detailing	16.095[s]	2	.000
Q24.2	Availability of suppliers of green materials	39.406[r]	2	.000
Q24.3	Compliance with Health & Safety	2.844[r]	2	.241
Q24.4	Disputes and conflicts	17.844[r]	2	.000
Q24.5	Lack of technical expertise	31.524[s]	2	.000
Q24.6	Lack of managerial Expertise	18.381[s]	2	.000

4.4 Project based analysis

The next set of questions was project based. Participants were asked to answer the questionnaire based on one of the recent green projects, in which they were involved, that has reached completion. The purpose for this section was to identify how similar projects are in terms or technical, managerial and contractual matters.

Question 25: In which province was the project located?

This question was designed to find if green development preferences differ according to location and which province is leading with the investment of green projects. This can also assist with future research in order to find ways to encourage the development of green buildings. According to the graph below, Gauteng province is leading by sixty four percent (64%) of developments of green buildings, followed by Western Cape which has a portion of twenty eight percent (28%). Gauteng is leading because of its economic hub and high density which perpetuates to more development. According to the data, provinces such as North West and Mpumalanga show a non-existence of green projects. Other influencing factors may be because of investment decisions by the private sector in that they expect to get a greater rate of return on their investment since the data revealed that the most receptive clients to green buildings are private clients.

Table 4.4.11: Location of projects

Province	*Percentage (%)*
Gauteng	64%
Western Cape	28%
Kwa Zulu Natal	8%
Eastern Cape	3%
Limpopo	3%
Norther Cape	2%
Free State	2%
North West	0%
Mpumalanga	0%

Question 26: What was the type client for the project?

Data under individual projects still reveal that the majority of projects are being carried out by private clients which accounts for eighty four percent (84%). The state is still the lowest contributor to the idea of adopting green buildings.

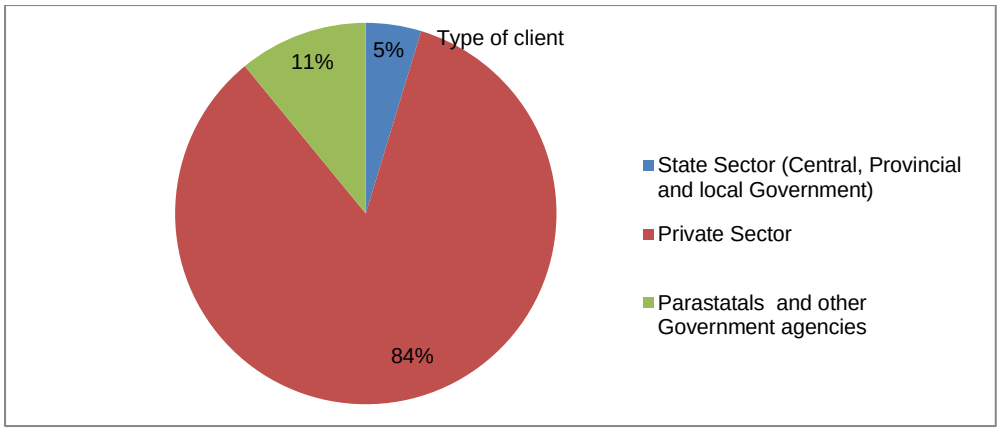


Figure 4.4.21; Clients of projects

Question 27: What was the type of the project?

This question was designed to find out the type of infrastructure that mainly adopts green principles. The data reveals that seventy eight percent (78%) of development in green construction is for office developments. This means that most private clients, as perceived by research, are investing in office developments with green features. This might be because they want to improve staff performance and morale in the workplace. Other reasons may be to reduce maintenance and operational costs for the buildings. Other green developments, that account for thirteen percent (13%), mentioned by participants include mixed developments and public and educational infrastructures amongst others. Industrial and retail accounts for a small proportion of two percent (2%).

Table 4.4.12: Type of project

Answer	*Percentage (%)*
Residential/ Housing	6%
Retail Development	2%
Offices	78%
Industrial	2%
Other (Please specify)	13%
Total	100%

Question 28: What was the value of the construction work i.e Value of the construction excl (VAT)?

This question was developed based on the price grading of CIDB. This was done to discover whether cost plays a significant role for contractors qualifying to carry out the majority of green construction. About forty one percent (41%) of the works are greater than R 130 000 000, which means that these works will be carried by grade 9 as per CIDB grading, if it was a government works. A cost bracket of
R 40 000 000-R 130 000 000 also accounts for a significant proportion of about thirty one percent (31%). About eight percent (8%) of projects cost less than R 6 500 000.

Table 4.4.13 : Value of construction work

Answer	*Percentage (%)*
Below R 2000000	3%
R2 000 000 - R4 000 000	2%
R4000 000 -R6 500 000	3%
R65000 00 -R13 000 000	9%
R13 000 000 -R40 000 000	11%
R40 000 000 -R130 000 000	31%
Above R130 000 000	41%
Total	100%

Question 29: What was the procurement path used in the project to appoint the contractor?

The question was designed to be matched with the perceived and ideal procurement as discussed above in questions 18 and 19. It is evident that the traditional procurement path is still the most preferred. The majority of projects investigated opted to use a traditional procurement path despite the problems that have been discussed above in question 23. The second preferred procurement path is design and build, despite the perception that it is the most ideal method for green construction as discussed in question 20. The least used methods that account for two percent (2%) usage are management contracting and Public-Private-Partnership.

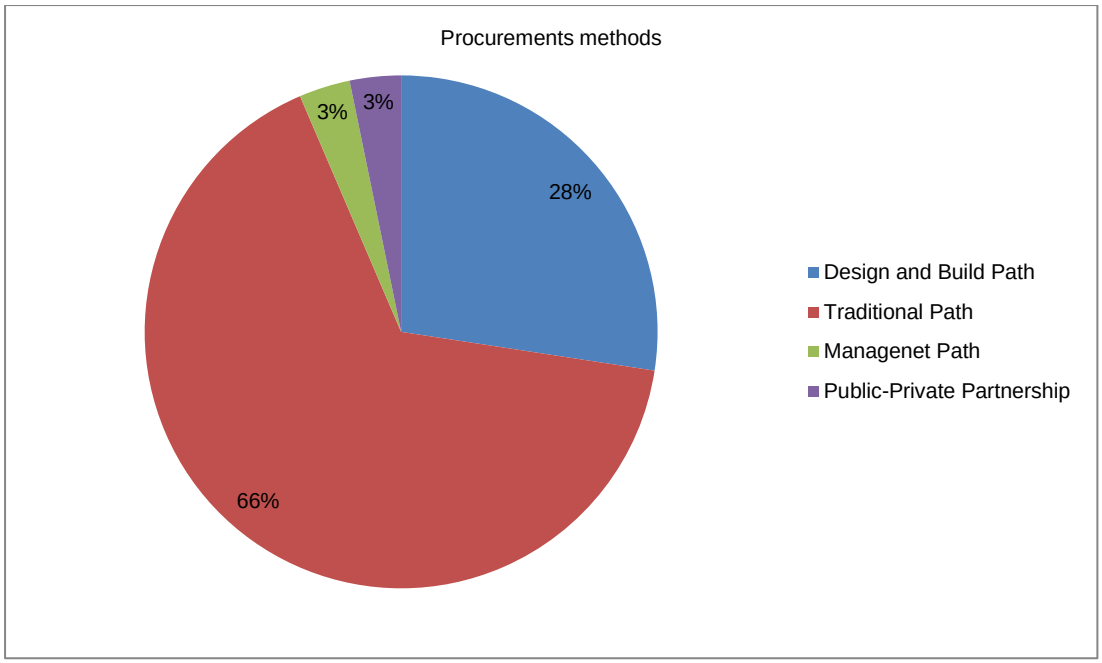


Figure 4.4.22: Procurement path

Question 30: How was the main contractor appointed?

The question was developed to find the common method used to appoint contractors for green buildings and compare this with the perceived method as the ideal method. The data reveals that most of the projects, accounting for forty seven percent (47%) use selected tendering to appoint contractors. The method of appointment is against that perceived as the ideal method in question 22, which is negotiated tendering, and while it ranks in the second preferred method followed by public tendering.

Table 4.4.14: Method of contractor appointment

Answer	*Percentage (%)*
Negotiated Contract	27%
Pubic Open Tender	23%
Selected Tender	47%
Other(Please specify)	3%
Total	100%

Question 31: What were the contract conditions used in the project for the main construction?

Contracts play a big role in the delivery of projects. The question was designed to find the most commonly used contract packages for green buildings and match this with a question whether contracts do impact on delivering green buildings. The most used contract for green buildings is the popularly known local contract of JBCC. It accounts for seventy nine percent (79%) usage as compared to other contracts. This might be due to the fact that it is commonly used and local clients and contractors are familiar with it.

Table 4.4.15: Type of contract used in projects

Answer	*Percentage (%)*
JBCC	79%
NEC	5%
FIDIC	3%
GCC	3%
Other(Please specify)	10%
Total	100%

Question 32: In your estimation how complete percentage (%) was the design when the contractor was formally appointed on the project? (e.g. if there were substantially amount of provisional sums, it would indicate some areas of design were still to be finalised.

From Figure 4.4.22, tt seems the in most contracts the contractor was appointed when the design have already started. This still is because the traditional procurement was used.In some instances it seems there was partial designes and the contractor had to excute other designs. This still reflect the use of JBCC as it supports traditional procurement path.

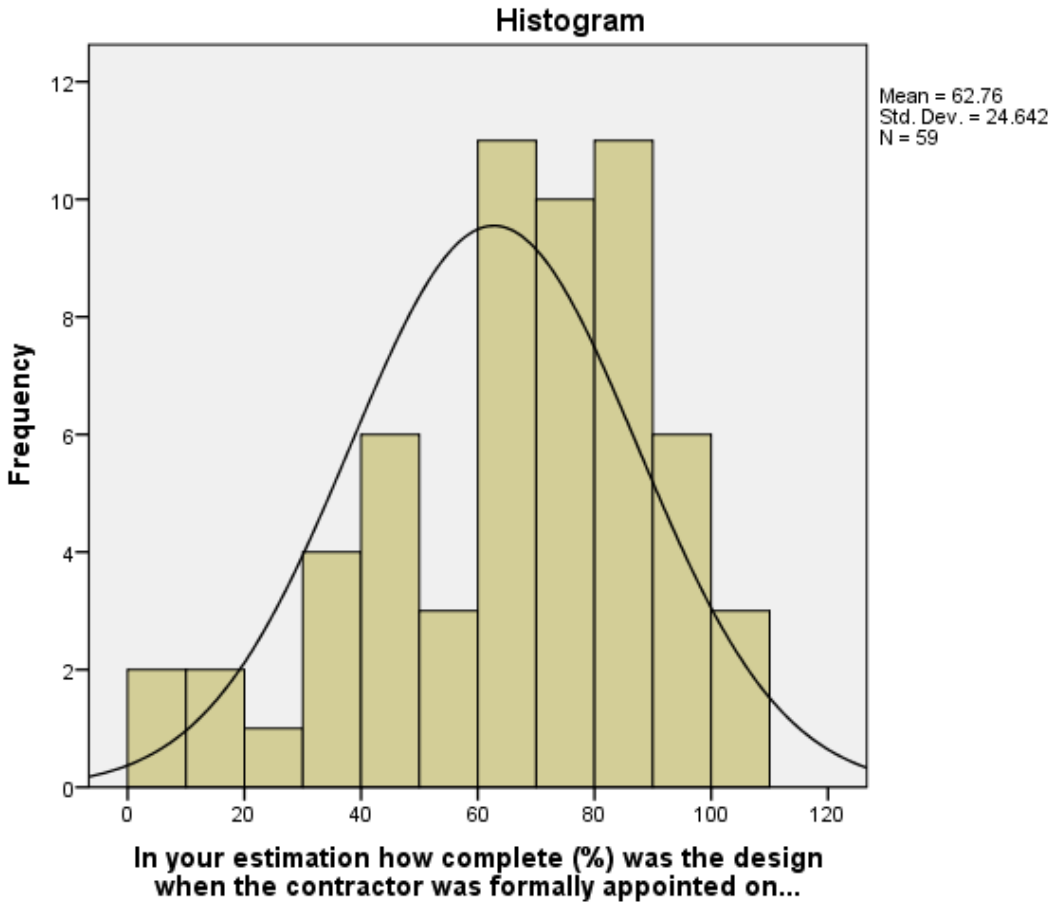


Figure 4.4.23: Formal appointment of the contractor

Question 33: At what stages of the project was the contractor involved in design meetings of the green project?

Table 4.4.16: Contractor's involvement during project delivery

Answer	*Percentage (%)*
None	8%
Inception Stage	8%
Concept and Viability	8%
Design Development	23%
Documentation and Procuremen	44%
Construction	63%
Close out	38%

The question was designed to find out if contractors are actively involved during design stages of projects. The data reveal that most of contractors, about sixty three percent (63%), are engaged only during construction. This indicates that most are appointed by the traditional procurement path as depicted in question 29. Therefore the majority can only contribute towards green initiatives during the construction phase.

Question 34: At which stage was the contractor formally appointed?

This question was designed to overlap with question 33 above, to find out at which stage the contractor is appointed. It is clear that most contractors are not involved at the inception of projects..

Table 4.4.17: Formal appointment of contractor

Answer	*Percentage (%)*
Inception Stage	8%
Concept and Viability	2%
Design Development	25%
Documentation and Procurement	42%
Construction	23%
Close out	0%
Total	100%

Only about eight percent (8%) of contractors in this study were involved at the beginning of the project before the design started. The majority of contractors, about forty two percent (42%), were involved during the documentation and procurement stage, after the design development had already commenced. However, there were about twenty five percent (25%) of contractors involved during design. These are the contractors that were involved in design and build contracts

Question 35: What is your evaluation on the level of success in the green project based on the criteria below?

This question was formulated so that the results could be compared to normal buildings, and to measure the level of success in comparison with green buildings.

Table 4.4.18 : The level of success in green projects

		Successful		Average		Unsuccessful	
		Count	Row N %	Count	Row N %	Count	Row N %
Achieve Expected Quality	Q35.1	53	81.5%	12	18.5%	0	0.0%
Cost Management	Q35.2	45	70.3%	14	21.9%	5	7.8%
Compliance with Health & Safety	Q35.3	49	75.4%	14	21.5%	2	3.1%
Minimise Dispute Resolutions	Q35.4	36	55.4%	28	43.1%	1	1.5%
Expected Time Delivery	Q35.5	36	55.4%	16	24.6%	13	20.0%

It appears that participants achieved the expected quality in the projects that they were exposed to. This information coincides with the information that the industry has the necessary skills to build green buildings. Cost was also managed efficiently since the majority of participants believe that cost management was successful. The data reveals a success in compliance with health and safety as well as dispute management.

Question 36: In your own words what do you consider as the client's priorities in terms of a green project?

This question was designed to get a qualitative perspective in terms of items that the client normally prioritises in terms of green initiatives. This question was developed in order to widen and discover other drivers on greening clients in terms of a client's viewpoint.

This was an open-end question therefore the feedback was drawn in different fields. Some respondents revealed that clients were mainly aiming at minimising energy consumption and usage of buildings. It was clear that most clients wanted buildings that have clean energies and mainly wanted buildings with recyclable energies. Some statements included "*To minimise energy usage costs and to increase the interior comfort without resorting to extreme energy usage*" and "*energy efficiency getting a green star rated building*". It is evident that some clients are aware of green principles and would like to save operating costs of building, by investing in cleaner energies.

Operating costs were also identified as one of the priorities that the clients wanted to lower. There was a mention of "*The client wants a Green Building Project to lower operational costs and to use it as a marketing tool. Issues such as Indoor*

Environmental Quality are not of top concern to clients but once they are aware of the differences Green Buildings make to Office Spaces they become more aware of the benefits". Kim et al., (2010) ascertain that operational costs are said to be greatly reduced in green buildings as compared to conventional buildings - this study was done on different properties such as retail, residential and offices spaces. The study done by Jong and Arkesteijn(2014) revealed that life cycle costs of buildings, especially schools which were their field of study, can be drastically reduced if clients invest in green building as compared to conventional buildings.

Another interesting driver of clients that was mentioned by numerous participants was for the client to have a green rated building for marketing purposes and to increase the value of the property. It was noted that "*Getting to the targeted Green Star score"* Some aligned star rating with returns because the rents are presumed to be high, i.e. "*only the star rating to charge tenants more*". The star rating was also aligned with internationalism, i.e. "*achieving a minimum of a 4 Star Green Star Office v1 Design + As Built building - to comply with their internal international goals*." It seems that the star rated buildings are more expensive in terms of rent as compared to conventional buildings as the other participants mention that "*to enable a client to increase the rental he could possibly charge for a Green Building*".

Other issues include the comfort that green buildings create. The occupants are said to be provided with comfort as compared to conventional buildings. One participant believed that clients prioritise on factors of "*pleasing aesthetics in combination with comfort of inhabitants and saving of energy costs*" as well as there being a perception of "*healthy office building they and their staff could be proud of*".

Question 37: Did the contractor have different priorities to what they might normally have on a construction of a similar type or familiar client, and did the contractor do anything different as a result?

This question was designed to gather qualitative opinions and experiences of contractors and if they have different priorities when compared to the client's priorities. An approximate percentage of forty four percent (44%) answered "No" to the question. Basically they did not see the contractor having different priorities to the client. The remainder of the participants noticed some differences. Some of the comments include:

"*The contractor has to implement waste management practices during construction as well as environmental management monitoring which is unusual to ordinary projects. Issues such as Volatile Organic Compounds are also new to contractors where all adhesives, sealants and paints used need to be low VOC".* This clearly shows that the contractor had to adjust to the new challenges and come up with ways to deal with unusual practices as identified by the participant.

The other comments state that "*To achieve some of the green points, the contractor had to adjust some of their standard practices, i.e. procurement of material, adjusting programming to lead times, etc*". It means that contractors in these situations also had to adjust in order to deliver green initiatives. All these points mentioned clearly show how important it is for the contractor to be involved early in the project so that they can plan things like waste management practices procurement and proper programming of the works.

There is a mention of "the *contractor was more focused on green compliance, and they assisted in ensuring compliance. They tracked the green items using their convectional systems*" .Clearly this shows that there was commitment from the contractor's side.

There is an interesting statement from one participant that mentions that "*Priorities for the contractor involved the procurement of materials from suppliers and manufacturers using methods compliant with the Green codes. This proved to be difficult in some cases, due to the extra effort in finding materials that complied and the frequently increasing costs of such materials and the delivery periods. Therefore the contractor needed to take more care and time in locating some of the specified products to ensure that orders were placed timeously to avoid delay to the contract programme".* It still appears that procurement of green materials prove to be problematic to acquire. The same issues still back up the idea of early contractor involvement so that materials can be ordered earlier and be available when they are needed.

One participant revealed that they handled and managed tasks as priorities. It is revealed that "Priority *1 was Green Star Education & Awareness - We incorporated of Green Star education into the Tool Box talks for EVERYONE on site - from labour to management. Prior to subcontractors being allowed on site, full Quality Control, Green Star & Safety Files were to be submitted with all technical data sheets etc. of*

materials to be used. In Safety Meetings, Green Star was on the agenda...heavy fines issued due to non-conformance of any Green Star Credit that was being targeted (especially Waste Management, IEQ-13 etc.). Policing everyone on site and constant education is really worked! Priority 2 - Waste Management - A cleaning crew with waste separation station and waste education (plastic burn test etc.). Diversion from landfill became a priority. Priority 3 was Specifications & Quality control - More attention paid to subbies - programme/procurement/workmanship etc. Priority 3 was the achievement & policing of IEQ-13 - Low VOC Credit - Working closely with the Safety Department - the use of all adhesives, sealants, paints etc was monitored very closely (actually policed on site)"

It is clear they have enough experience in handling green projects as they first tackled awareness and education which is identified in this research as the main hindrance on implementation of green practices.

Question 37: In your opinion what could have been done differently in this project in order to improve the green outcomes of the project?

The question was designed to get opinions and experiences on how projects could have been handled better in order to improve the performance and outcomes of the project, if it was unsatisfactory. There were different suggestions differing with projects and some felt that, "*A green coordinator role could have been created to maintain oversight of design features and site execution*". This was evident during the collection of data as some participants are designated as green building consultants, sustainable design consultants or Green star accredited professionals. With the new trend of green buildings there are new professions emerging as well which can provide advice on the green designs of buildings. Some participants still felt there was a lack of awareness on site so they thought "*Better training and awareness of contractor to understand EXACTLY what is required on site, how to PROPERLY monitor and how to PROPERLY Report upon. It is of utmost importance for all specifications to be run through the green building consultant before implementation on site*".Some felt " *A bit longer planning stage - as we had massive amounts of changes in the construction stage due to the credits we were targeting . (From the client side the changes were made)."* It is evident that scope changes a lot during construction and if the contractor was

involved early there would be ease of buildability and fewer changes would need to be made during the construction phase as the contractor will be using previous experience to solve current construction problems. This is evident as some participants suggest "*Earlier involvement of the Contractor*" would have made things different. Issues of supply chain are also mentioned as they suggest *"specialist green subcontractor being more knowledgeable about the main contractor s programme*". On the same note of supply chain it is pointed out that "*Green building materials and concepts have changed dramatically over the part number of years with numerous technical and innovative ideas and products entering the market. Better understanding at the onset in terms of design and different options".* It can be deduced from the above that there are still some areas that can be improved upon in order to achieve the benefits of green buildings, and it is evident that the contractor can be of great assistance if he/she was involved in the early stages of construction.

4.5 Summary

The data was collected from construction professionals that are registered and accredited by GBCSA; therefore the individuals have knowledge and skill about green construction. The gender of particpants represented fair representation noting that construction industry is male dominated.The particants age ranges from 31-40 with majority having less than five (5) years experience on green buildings. The trends of adopting green buildings reflect that it's a farily new concept in the South African construction industry. It seems green building are mainly adopted by private cclients as compared to government and parastatals, and the private clients are pervieved to be aware and knolegeabble about the benefits of green buildings The commonly used contract to deliver these projects is perceived to be JBCC and there procurement method tend to follow the traditional procurement path. Cost of gren buildings are perceived to be braking the adoption of these buildings. There is lack of supplies of mnaterials of green buildings in the South African market. It is still not clear if South African contractors are knowlwgeable abputh the benefits of green construction, however they are perceived to be skilled about green buildings

5 Conclusion and Recommendations

5.1 Introduction

This chapter develops a summary of the entire research and conclusions are drawn from the primary and secondary source of data. When conclusions are drawn, research objectives mentioned in chapter one (1) are met and this is done through cross-referencing to the findings from literature and questionnaires. Hypothesis and sub-hypothesis is later tested against H1 and H0. The testing of hypothesis is done using both literature and the questionnaire. The last task is giving recommendations based on the findings of the research.

5.2 Summary of key findings

The following are the objectives of the research with the key findings identified. The key findings are matched with the respective objectives and it is explained how they were achieved.

1. Finding the stance of green construction in South Africa from the construction professional's viewpoint. The data reveals that South African contractors have enough knowledge, exposure and experience with regards to green buildings based on their current experience.
2. Identifying the role contractors' play within the traditional procurement path. It appears that in the traditional procurement path contractors are limited to only the construction phase of the project. This is revealed in the data and the literature.
3. Identifying the role that contractors are willing to play in order to contribute in the design of green buildings. Literature reveals that contractors are willing to actively be involved during initial and design phases of projects so as to add value to designs by bringing previous experience to projects, carry out health and safety plans, contribute to buildability concepts of the project and be able to order materials on time to avoid delays..
4. Identifying existing practices that can involve contractors during the design process. The data reveals that adoption of Early Contractor Involvemen (ECI) such as design and build and any form of partnership such as Public-Private-

Partnership practices can allow the contractor to be involved at the initial stages of the project.

5. Identifying the most dominant project delivery process. The traditional procurement method is identified as the most dominant delivery process
6. Identifying the most ideal procurement method for green buildings. The selected tendering method is perceived to be the ideal procurement method to be used for delivering green buildings.
7. To find out practices of countries with similar economies as South Africa in the context of level and adoption of green construction practices as most countries with the same economics of scale are experiencing the same problems in terms of adoption of green buildings
8. To find out how supply chain is affected by the current procurement methods *with respect to* green construction. There is high disintegration in the supply chain which leads to the late delivery of materials
9. Identify how supply chain can be integrated in order to get the full benefit of green design. Supply chain can be integrated by strategic planning which includes the involvement of parties at all stages of project delivery.

5.3 Revisiting Problem Statement and Research Question

In the traditional procurement path that dominates the South African construction industry the contractor is appointed after the design concepts and ideas have been finalised by the design team and the client. The appointment of the contractor is only done to execute what is designed and finalised in the drawings and specifications. Consequently, the exclusion of the contractor during the design stages of the project is encouraged by the current traditional procurement methods adopted in the construction industry. Thus, South African clients may not be getting the full benefits of green projects as contractors are not actively engaged at a stage where they are capable of adding value and as a consequence the construction sector as a whole is not getting full access or exposure to the potential of green technologies and practices and the benefits of green designs. Thus is it likely that the procurement practices are serving as a brake to the adoption of green building technologies.

The main aim of the research undertaken was to find the extent to which South African contractors are engaging and contributing to the design of green buildings. The research question and sub question were as follows:

5.3.1 Research question

To what extent are the South African contractors contributing and promoting green building practices?

5.3.2 Sub-questions

The sub-questions that were identified were as follows:

Sub-question 1: *Are the South African contractors able to contribute and promote green building practices?*

Sub-question 2: *Are the South African contractors having the necessary capacity, knowledge and experience to contribute and promote green building practices?*

Sub-question 3: *Is the use of traditional procurement path allowing the South African contractors to contribute and promote green building practices?*

5.3.3 Hypothesis

The hypothesis that was posed was:

H_0 *: Contractors willingness to contribute and promote green building practices is negatively affected by their exclusion from design stage of project delivery process.*
H_1 *: Contractors willingness to contribute and promote green building practices is not affected by their exclusion from design stage of project delivery process.*
The research was aimed at meeting the following objectives:

- To find the stance of green construction in South Africa from the contractor's viewpoint.
- To identify the role contractors play within traditional procurement.
- To identify the role that contractors are willing to play in order to contribute to the design of green buildings.

- To identify existing practices that can involve contractors during the design process.
- To identify the most dominant project delivery process.
- To identify the most ideal procurement method for green buildings.
- To find out the practices of countries with similar economies to South Africa in the context of level and adoption of green construction practices.
- To find out how supply chain is affected by the current procurement methods with respect to green construction.
- To identify how supply chain can be integrated in order to get the full benefits of green designs.

5.4 Key Findings

The study has revealed vast scope of findings in the field of green buildings in South Africa. The general stance and adoption of green building in South Africa has resurfaced. In the South African context it is very clear that there is a high level of unawareness and knowledge about the importance of green buildings. It is revealed by the data that the drivers of green buildings are clients that are aware of the benefits of adopting green initiatives. In most cases private clients are the ones that are more engaged in green building. After criticall analysis, findings have been clustered in the following themes:

5.4.1 Ability of the design team to perform

It is revealed by literature that the design team is responsible for determining how the building is going to perform in relation to external and internal environment. The team is also responsible for the aesthetic and the shape of the building. All these attributes of buildings are also influenced by the choice of materials and construction methods. The construction methods and techniques should encapsulate proper health and safety procedures and they should also adhere to the national building regulations. Even though the designers are tasked with producing safe designs they normally battle with health and safety planning because they tend to lack site experience. . Some consider the design phase being too theoretical as compared to the actual site activities. With these incompatible processes it is therefore suggested that the contractor be involved during the design phase so that he/she can add value to the process by sharing his/her

practical experience. With the contractor involved from the outset the efficiency of the project could be improved and there would be less chance of changes being made to the design scope; there would be proper health and safety planning and a supply chain strategy could be identified during the early stages of the contract.

5.4.2 Role played by the contractor in the traditional procurement path

The traditional procurement path involves active participation of the contractor at the construction stage. The contractor is appointed after a successful bid based on drawings, specifications and bills of quantities. The contractors are appointed as per clients' contracts to carry out duties of construction under instruction from the client's representative. The contractors are selected based on many variables which may include the financial standing of the contractor, availability of resources, previous experience and the bid price, amongst others. The contractor's role in this procurement path is to duly convert the designs into a physical state.

Joint Built Contracts Committee (JBCC) have been identified as the most used contracts in South Africa. The contract is designed especially to suit a traditional procurement path. Even in the delivery of green buildings the data reveals that the most used contract was JBCC, therefore the projects followed a traditional procurement path.

5.4.3 Role played by clients in construction projects

Clients play different roles in construction projects depending on the identity of the client. Clients can be categorised as state or government entity, private individuals and investors. These clients have different needs in property therefore their participation and role in construction projects will differ. The other factor that determines the role played by the client is their knowledge of construction, which may in turn make them actively involved or they employ agents to work on their behalf if they lack knowledge. The client's role at the design stage is to unfold the brief to the design team so that they can produce sketches, budgets and feasibility plans of the works. The client's other role is to determine the procurement strategy that will be used to deliver the project and also to determine the project management of the works. Active participation of clients tends to improve the performance of projects. However, overall, when state projects are compared to private projects there tends to be less performance with regards to project

delivery schedules and budgets even though the state is perceived to be the highest contributor to infrastructure development.

The findings from collected data reveal that the most receptive clients to green building are private clients as compared to state and other parastatal organs. Most of these clients are involved in the development of green buildings for office space. These clients are undertaking projects in major economic provinces such as Gauteng.

5.4.4 Buildability and Constructability During Design

Buildability and constructability plays a significant role during the design phase of the project. The design process is taken to be continuous and flexible so that the facilitation of any problem-solving can be achieved. The process can involve a totally new task or can incorporate principles of previous projects. When carrying out the design process it is therefore advisable to include all project stakeholders so that they can add value to the process. Involvement of all project participants, including the contractor, can therefore improve the constructability of the project because previous experience can be incorporated into the new project. Inclusiveness of all project participants is crucial as unwanted waste caused by design defects can be identified and reduced. The main aim of constructability is to connect the design phase to the construction phase by breaking the perceived, theoretical disparity between the two processes. This is achieved by bringing the contractor on board early in the design phase. Findings from Lean Engineering tend to reduce waste at the design phase maximising productivity of the process. The same applies to buildability concepts, which focuses on optimum use of resources and easy and safe construction procedures. Construction expertise at an early stage can assist in achieving these concepts. However, due to the current set up where traditional procurement is used there is less chance of finding contractors being involved at early stages so that constructability and buildability of projects can be improved. The data reveals that most of the contractors were appointed after drawings and specifications were completed, therefore there was no contribution of contractors at the design stage.

5.4.5 Adoption of greening initiatives

Green buildings are globally gaining momentum as governments and private investors become sensitive to environmental impacts of global warning. The phenomenon of

green building is slowly gaining pace in developing economies like South Africa. Globally it was initiated around the mid-80s and in South Africa the trend of green buildings started picking up around the mid-2000s. A lot of green developments were popular after 2010. There was the establishment of GBCSA in 2009 which focused on training and grading projects and buildings in terms of greenness.

The construction industry was tasked with adopting these building so that they can save energies because, by nature, the construction sector consumes a lot of energies during construction and during the life of buildings. Qualitative data collected revealed that clients adopted these buildings because they are perceived to be saving energies and thus saving on the operating costs of the buildings. The buildings are perceived to be environmentally friendly in terms of the construction processes and the materials used. In South Africa grading of these buildings is done by GBCSA. The clients are said to be developing these buildings because they are perceived to have higher returns as compared to normal buildings and they are said to be more marketable as compared to conventional buildings. This is due to the fact that the buildings are designed to be more comfortable. Research reveals that these buildings increase the productivity of workers. The findings correlate with the data collected because the majority of participants were involved in projects for office developments.

There is clear evidence that the South African construction industry is aiming at adopting these initiatives of green buildings as there are some policies and regulations covering the environmental and waste management of green buildings within local government and national building standards.

Green buildings have different tools used to measure their greenness. The tool are used to measure the extent to which the designs are green and comply with environmental requirements, either in material selection or construction processes and waste management systems on site. Other variables are energy consumption and usage of the building, recycling and re-use of materials.

Despite the paradigm of adaptation of these buildings, there are some problems experienced by the construction industry. There is a perception that the buildings are costly to build and this acts as a hindrance for clients to adopt this type of building. It has been revealed in the data that high costs are identified as a factor that prevents

clients to invest in green buildings. The high costs are said to be experienced at the design phases until installation of the energy system. Despite the perceived high costs, literature points out that there are huge savings in the life cycle costs of building when using green designs. Maintenance and energy consumptions are said to be lower when compared to conventional buildings.

Another problem that slows adoption of these buildings is a lack of knowledge and awareness. This is the highest ranking factor among South African construction clients. The clients are not knowledgeable about the full benefits of green designs. Other problems that have been identified in this study include a lack of expertise and management of green buildings, the improper use of procurement packages and problems with supply chain integration.

Despite the hindrances some promotion is being done by GBCSA to train clients on the usefulness of green initiatives.

5.4.6 Influence of procurements on projects

Procurement plays a crucial role in project delivery. The client has to decide on a suitable procurement strategy that can delivery and meet project objectives. The most commonly used procurement method in construction is competitive packages of a traditional procurement path, where design is separated from construction. The data reveals that the South African construction industry uses the method more than any other procurement method in the delivery of both green buildings and conventional buildings. Amongst other procurement methods the sample perceives the most appropriate procurement method for green buildings would be design and build. These findings tie in with the ECI concept that it is ideal to involve the contractor at an early stage during design so that buildability and constructability can be attained. When it comes to the method of appointment of a contractor it appears selective tendering is used a lot on green buildings in South Africa. The most appropriate perceived method of appointment is a negotiated contract.

5.4.7 Concepts of ECI

Early Contracts Involvements are the scenarios where the contractor is actively involved at the initial phases of the contract. The contractor is actively engaged with the design team. The main reason for this is for the contractor to share previous experience.

There is evidence from literature that when the contractor is actively involved at the initial stages there is a high level of success on the project. There are many varied forms of ECI like PPP, design and build and partnerships. There are savings in the overall time schedules when the contractor is involved early and buildability of the project is maximised as well. When the contractors are bought forward they can also give reasonable prices because they know where they can cut costs and eliminate waste. However, construction culture tends to act as a barrier to utilising this form of partnership. Findings from qualitative data reveals that some participants suggested that project performance could have been enhanced if there was active involvement of contractors at early stages of construction.

5.4.8 Supply chain integration

Supply chain integration in construction plays a crucial role in project success. If all the parties of supply chain are actively involved in the project there is a good chance of delivering the project within the stipulated time. Supply disintegration normally leads to late finishing times because of poor communication and poor planning systems. The integration of supply chain assists in avoiding uncertainties and reduces the chances of reworks. Findings reveal that the highly regarded problem in green buildings is a lack of supply of green materials. This is because the suppliers are engaged late in the project, whereas they could have been invited early so that they could also have provided input of alternative specifications.

5.4.9 The role played by contractors in green buildings

Contractors play a crucial role in green buildings even though most the time they are appointed after the designs and specifications have been finalised. The contractors are responsible to carry out works as per design, and sometime s there are penalty clauses in contracts which force them to perform according to contracts. The contractors' role in green construction are to meet the desired needs of the clients such as delivering the green building according to design and delivering the project within the agreed times and agreed budget. But with regards to green buildings there are usually delays because the contractors have to have compatible green methods of handling waste on site. There are also delays caused by the late arrival or non-availability of green building materials from suppliers. There is a perception that if contractors are to be actively engaged during the design phase of projects they will contribute to the design of green building

using previous knowledge and they will be able to reduce delays by outsourcing materials early and planning and preparing health and safety files timeously while identifying hazards and risk activities. The data reveals that South African contractors are knowledgeable about green buildings.

5.5 Testing the hypothesis

The following hypothesis and its null value is stated in Chapter One:

H_0 *: Contractors willingness to contribute and promote green building practices is negatively affected by their exclusion from design stage of project delivery process.*
H_1 *: Contractors willingness to contribute and promote green building practices is not affected by their exclusion from design stage of project delivery process.*

The data was collected, analysed and presented. Based on the results the H_0 test positive therefore it was found that contractors' willingness to contribute and promote green building practices is negatively affected by their exclusion from the design stage of the project delivery process.

The tests for sub-hypothesis were as follows:

Sub- hypothesis 1:

H_0: *The South African contractors have the necessary capacity, knowledge and experience to contribute and promote green building practices*

H_1: *The South African contractors are do not have the necessary capacity, knowledge and experience to contribute and promote green building practices*

The test reveals that H_0 is positive so therefore South African contractors have the necessary capacity, knowledge and experience to contribute and promote green building practices.

Sub-hypothesis 2:

H_0: *South African contractors do not have the necessary capacity, knowledge and experience to contribute to and promote green building practices*

H_1: *South African contractors do have the necessary capacity, knowledge and experience to contribute and promote green building practices*

The test reveals that H_0 is negative so therefore South African contractors do have the necessary capacity, knowledge and experience to contribute and promote green building practices

Sub-hypothesis 3:

H_0: *The use of a traditional procurement path is allowing South African contractors to contribute and promote green building practices*

H_1*: The use of a traditional procurement path is not allowing South African contractors to contribute and promote green building practices*

The test reveals that H_0 is negative so therefore the use of a traditional procurement path is not allowing South African contractors to contribute and promote green building practices.

5.6 Conclusions

The key finds reveal that the main objectives of the research have been met and the research questions and sub questions have been answered. The testing of the hypothesis and sub-hypothesis has been done, and indeed the *contractors' willingness to contribute and promote green building practices is negatively affected by their exclusion from the design stage of the project delivery process.*There have been suggestions that the contractors should be involved early in the design stage so that they can contribute to the buildability of the project. The early involvement of contractors will also assist them to plan for health and safety issues and for them to be able to make arrangements with supply chain management for the timeous delivery of construction materials. South African contrators are perceived as having the necessary capacity, knowledge and experience to contribute and promote green building practices. There are perceptions as well that the traditional procurement path prohibits these contractors from significantly contributing to green design and this has been tested and found to be true.

The role played by the client in green buildings and traditional buildings has been identified. The procurement strategy has been identified as an important factor that the

client should consider because it affects the performance and delivery of projects. The role played by traditional procurement has been identified and it can be concluded that it is the most favoured delivery mode for projects of either green or traditional buildings. Green buildings as a trend in South Africa have been identified and it is clear that private clients are greening and are more knowledgeable about green buildings. GBCSA was established in 2007 and the adoption of green buildings was initiated in South Africa in the early 2000s. Greening initiatives as preferred by client are due to the benefits of saving on the overall use of energies thus lowering the operational and life cycle costs of the buildings. Other clients invest in green building for higher rentals and the perception that investing in a green building as office space provides employees with greater comfort.

Supply chain management has also been identified as problematic as there seems to be late delivery or unavailability of some of the required green materials. The role played by contractors in the delivery of green buildings has also been identified as they produce the buildings that are supposed to meet the client's needs.

All these findings have been achieved by the use of literature and data gathered by means of online questionnaires.

5.7 Recommendation and suggestions for future research

Based on this entire process I would recommend doing case studies in the same field because I realised that projects differ in scope and have different targets. Therefore, it would be ideal to analyse induvial projects rather than collecting data from an entire population that have worked on green projects

5.8 Reflection on research

The entire research has been an interesting journey. There are a few steps that have been identified which lead to a good research output. There has to be a clear research methodology. One has to understand the research process and hope to choose the correct research approach. The research needs realistic time frames so that good results can be achieved and it needs continuous engagement with the supervisor to provide guidance.

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Appendices

Default Question Block

Q1. **This section collects general information of the respondents including their background and exposure in green building projects. It is intended to enable the researches to compare the profile of respondents with the known profiles of the built environment professionals**

Gender

- Male
- Female

Q2. **Age**

- 20-30
- 31-40
- 41-50
- 51 and above

Q3.
What is your professional background?

- Construction Project Manager
- Construction Manager
- Quantity Surveyor
- Architect
- Civil Engineer
- Other (Please specify)

Q4. **How many years have you been working in the construction industry?**

- Less than 5 years
- 6-10 years
- 11-15 years
- More than 15 years

Q5.
What is your highest academic qualification?

- Doctor of Philosophy Degree
- Masters Degree
- Post Graduate Diploma
- Honours Degree
- Bachelors Degree
- National Diploma
- Advanced Certificate
- Matric

Other (Please specify)

Q6. **The next set of questions will focus on your knowledge and the experience in the delivery of green buildings. Green buildings under consideration do not necessarily refer to buildings rated by GBCSA, but should include any buildings that you have worked on that were designed and built around green principles.**

In which year were you first involved in the delivery of green buildings projects

Q7.
How many green buildings have you been involved (including current projects) during your career ?

Q8.
How many years of experience would say you have had in working on green buildings?

- Less 5 years
- 6-10 years
- 11-15 years
- More than 15 years

Q9.
Before you were involved in the delivery of green building, how would you rate the level of knowledge and awareness of green building practices and principles?

Very High	High	Moderate	low	Non existent
○	○	○	○	○

Q10.
How would you rate your current the level of knowledge and awareness after being involved in the green building projects?

Very High	High	Moderate	low	Non existent
○	○	○	○	○

Q11.
The next questions ask about your perceptions of the knowledge and the experiences of green buildings of the South African construction industry.

The following have been identified in research as barriers to the implementation of Green building practices in South Africa. How would you rate their significance to the contractor.

	Very High	High	Moderate	Low	Very low
The use of correct procurement strategy	○	○	○	○	○
Cost of the green projects compared to normal buildings	○	○	○	○	○
Lack of awareness by client of green practices and principles	○	○	○	○	○
Expertise and management of green projects by contractors.	○	○	○	○	○

Q12.
In your opinion, which type of client is more receptive to the idea of green buildings?

- State Sector (Central, Provincial and local Government)
- Private Sector
- Parastatals and other Government agencies

Q13.
Overall, South African contractors are knowledgeable about the benefits of adopting green buildings practices.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
○	○	○	○	○

Q14.
Overall, South African contractors have the necessary skills to construct green buildings.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
○	○	○	○	○

Q15. **Overall, the following client types are knowledgeable about benefits of adopting green buildings practices**

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
State Sector (Central, Provincial and local Government)	○	○	○	○	○
Private Sector	○	○	○	○	○
Parastatals and other Government agencies	○	○	○	○	○

Q16.
Overall, the following clients are "greening" their construction projects.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
State Sector (Central, Provincial and local Government)	○	○	○	○	○
Private Sector	○	○	○	○	○
Parastatals and other Government agencies	○	○	○	○	○

Q17.
Overall the South African construction supply chain (e.g. specialist contractors and specialist suppliers) are ready to adopt green practices.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
○	○	○	○	○

Q18. **Contractors are able to provide input into green aspects of buildings projects to assist in achieving the green outcomes of the projects**

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
○	○	○	○	○

Q19. **Based on your experience of green construction rank in order the procurement that is commonly used (PLEASE NOTE: 1= most commonly used and 4=less commonly used)**

	1	2	3	4
Design and Build Path	○	○	○	○
Traditional Paths(Open Tender)	○	○	○	○
Management Path	○	○	○	○
Public-Private Partnership	○	○	○	○

Q20.

Based on your experience of green construction rank which method of procurement you perceive as the most appropriate for delivering green buildings. (PLEASE NOTE: 1= most appropriate used and 4=less appropriate)

	1	2	3	4
Design and Build Path	○	○	○	○
Traditional Paths(Open Tender)	○	○	○	○
Management Path	○	○	○	○
Public-Private Partnership	○	○	○	○

Q21.

Based on your experience of green construction rank in order the commonly used method to appoint the main contractor. (PLEASE NOTE: 1= most commonly used and 3=less commonly used

	1	2	3
Negotiated Contract	○	○	○
Pubic Open Tender	○	○	○
Selected Tender	○	○	○

Q22.

Based on your experience of green construction rank which method of appoint of main contractor you perceive as the most appropriate for delivering green buildings. (PLEASE NOTE: 1= most appropriate and 3=less appropriate)

	1	2	3
Negotiated Contract	○	○	○
Pubic Open Tender	○	○	○
Selected Tender	○	○	○

Q23.

Rate the frequency of problems experienced when using traditional procurement path (i.e separating design from construction) in any projects irrespective if its green project or not.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Time Delays	○	○	○	○	○
Cost Overruns	○	○	○	○	○
Contractual Disputes	○	○	○	○	○
Poor Quality	○	○	○	○	○
Non-compliance to Health and Safety	○	○	○	○	○
High maintenance and life cycle costs	○	○	○	○	○
Constructability issues	○	○	○	○	○

Q24.

Rate the frequency of problems you have experienced on green buildings delivery .

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Poor specification detailing	○	○	○	○	○
Availability of suppliers of green materials	○	○	○	○	○
Compliance with Health & Safety	○	○	○	○	○
Disputes and conflicts	○	○	○	○	○
Lack of technical expertise	○	○	○	○	○

Lack of managerial Expertise	○	○	○	○	○

Q25.

Pleaseanswer the following questions based on the most recent green building you havebeen involved in and that has reachedcompletion.

In which Province was the project located

Kwa Zulu Natal	Western Cape	Northern Cape	North West	Eastern Cape	Limpopo	Free State	Gauteng	Mpumalanga
☐	☐	☐	☐	☐	☐	☐	☐	☐

Q26.

What was the type client for the project?

- ○ State Sector (Central, Provincial and local Government)
- ○ Private Sector
- ○ Parastatals and other Government agencies

Q27.

What was the type of the project?

- ○ Residential/ Housing
- ○ Retail Development
- ○ Offices
- ○ Industrial
- ○ Other (Please specify)

Q28. **What was the value ofthe construction work (Value of the construction excl VAT**

- ○ Below R 2000000
- ○ R2 000 000 - R4 000 000
- ○ R4000 000 -R6 500 000
- ○ R65000 00 -R13 000 000
- ○ R13 000 000 -R40 000 000
- ○ R40 000 000 -R130 000 000
- ○ Above R130 000 000

Q29.

What was the procurement path used in the project to appoint the contractor?

- ○ Design and Build Path
- ○ Traditional Paths
- ○ Management Path
- ○ Public-Private Partnership

Q30.

How was the main contractor appointed?

- ○ Negotiated Contract

- Pubic Open Tender
- Selected Tender
- Other(Please specify)

Q31.
What was the contract conditions used in the project for the main construction?

- JBCC
- NEC
- FIDIC
- GCC
- Other(Please specify)

Q32.
In your estimation how complete (%) was the design when the contractor was formally appointed on the project? (e.g. if there were substantially amount of provisional sums, it would indicate some areas of design were still to be finalised.

Q33.
At what stages of the project were the contractor involved in design meetings of the green project? (NB: Tick all relevant stages)

- None
- Inception Stage
- Concept and Viability
- Design Development
- Documentation and Procurement
- Construction
- Close out

Q34. **At which stage was the contractor formally appointed?**

- Inception Stage
- Concept and Viability
- Design Development
- Documentation and Procurement
- Construction
- Close out

Q35.
What is your evaluation on the level of success in the green project based on the criteria below

	Extremely successful	Successful	average	unsuccessful	Very unsuccessful
Achieve Expected Quality					
Cost Management					
Compliance with Health &					

Safety					
Minimise Dispute Resolutions	○	○	○	○	○
Expected Time Delivery	○	○	○	○	○

Q36.
In your own words what do you consider as the client's priorities in terms of green project?

Q37.
Did the contractor have different priorities to what they might normally have on a construction of a similar type or familiar client, and did the contractor do anything different as a result?

Q38.
In your opinion what could have been done differently in this project in order to improve the green outcomes of the project?

Q39.
Whilst we will treat this information in confidence, if you feel you would like to discuss some of these issues in more detail, please provide your contact details below. The questionnaire is deliberately set up in such a way that the researcher is unable to identifying who answers the questionnaire. By providing contact details below, you are indicating you are willing to talk direct to the researchers. Your answers to this questionnaire will still be reported anonymously and the data will remain aggregated with other respondents' responses

Company (Optional)	
Position	
Please furnish mode of communication	