PERCEPTIONS ON THE USE OF LIGHT STEEL FRAME CONSTRUCTION METHODS FOR PRIMARY SCHOOLS.

By:
Nyiko Gift Michavi – 0605436W

Supervisor:
Prof. David Root

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

School of Construction Economics and Management

University of Witwatersrand

Johannesburg

2017

Declaration

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

_____

Nyiko Gift Michavi

____ day of _____ _____

Abstract

In 2012, the Gauteng Department of Education and the Gauteng Department of Infrastructure Development jointly embarked on a construction innovation journey. Due to pressed delivery time, the two institutions deviated from the normal building methods to using light steel frame building for a more rapid construction period to deliver school infrastructure. This method came highly recommended, but after delivering the schools, the building method was never heard of again. The Gauteng Department of Education and the Gauteng Department of Infrastructure Development are jointly responsible for delivering educational buildings, as the client department and the implementing agent respectively. To date, the institutions have not adopted and implemented this method as an alternative building method. This study aims to understand the factors that influenced the discontinuation of this building technology. The study examines the impact of innovation in the construction industry as a whole before focusing on light steel frame building as an alternative building technology. It covers both the benefits and the challenges of using this building technology. Further, the South African regulations and green aspects with regard to the technology are studied. Questionnaires were sent out to the two departments to establish perceptions of construction professionals in both organisations that could have contributed to the decision not to adopt the technology. The key findings were that the technology is perceived to be a threat to the established contractors and suppliers to the traditional building sector. The survey findings indicate a level of resistance within the South African construction industry to accommodate innovative initiatives despite their potential and demonstrated benefits. It was therefore concluded that the client department together with the implementing agent department should revisit this building method as specifications for building primary schools for South Africa.

Dedication

I dedicate this report to my sisters: Mildred Nonhlanhla Hlungwani, Khanyisa Precious Michavi, Mikhenso Noble Michavi and our very special brother, Rinoko Adiel Michavi.

Acknowledgement

I wish to sincerely thank the following persons for their selfless contributions towards the completion of this report:

My supervisor, Professor David Root, thank you very much for your priceless contribution and assistance from inception through to completion. Ms Mantiseng Sithole, you ensured and pushed for the smooth running of this report, I am very grateful. Thank you.

My parents, Mhani na Papa, your support through it all is what kept me going. My siblings (Tati, Khanyie, Khenso na Noko), you are all totally amazing. Given another chance to make a family choice in life, I would beg God for us all to be just as we are. I pushed myself because I knew you had so much faith in me than I had for myself. Thank you. I love you oh so dearly.

My lovelies: Hillary (our igwe), Ntsako (our most selfless queen) and my fellow kingdom residents, Indira, Njeri and my beloved Nkaya. Your selflessness carried me throughout the entire program, I am so grateful, thank you.

Thulani Comfort Nxumalo, I owe it all to you. Thank you very much. Your drive and push made it much easier from the very start. I am still amazed at how much you believe in me, in everything I attempt. I wish nothing but the greatest for you. You are totally amazing.

Tati Celiwe Mtebula (my dancing shoes), I am yet to meet a human being with your heart. I will forever be grateful for your presence in my life. You are totally amazing. May God continue being super amazing in your life.

The respondents from the Gauteng Department of Education and Gauteng Department of Infrastructure Development, thank you for taking your most valued time to assist me in getting this report completed. Your responses made this report.

A very big thank you to Isaac Simelane from Marley Building Systems for the tour and detailed workshop about the light steel frame building method, the tour gave birth to this research report. I am exceedingly grateful.

To God who above everything gave me the strength and proper support to get this done. For the wisdom, knowledge and understanding granted during this period, for the mercy and undeserved grace, I am eternally grateful.

May my gracious Lord bless you all.

Contents

List of Figures

List of Tables

Glossary of Concepts

Building method - Refers to the planned method of construction, taking into account all contractual and legal requirements, construction constraints, risks, and opportunities.

Innovation - A new method, idea, product, etc.

Light Steel frame buildings - A building constructed by steel frame.

School - An institution for educating children.

Standards - A document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose

Steel Frame - A building technique with a "skeleton frame" of vertical steel columns and horizontal I-beams, constructed in a rectangular grid to support the floors, roof and walls of a building which are all attached to the frame.

Traditional building method - Traditional construction will be taken as cavity brick and block walls, roofs with slates or tiles on timber trusses.

List of Acronyms

ABT - Alternative Building Technology

CAD - Computer Aided Design software

CIOB - The Chartered Institute of Building

GDE - Gauteng Department of Education

GDID - Gauteng Department of Infrastructure Development

EPS - Expanded Polystyrene

LSF - Light Steel Frame

NHBRC - National Home Builders registration Council

RSA - Republic of South Africa

SABS - South African Bureau of Standards

SANS - South African National Standards

SASFA - The Southern African Light Steel Frame Association

SCM - Supply Chain Management

SIP - Structural Insulated Panels

1 Introduction

According to the Chartered Institute of Building (CIOB), the construction industry is not widely perceived as offering an environment that nurtures creativity. Construction is a unique environment and by definition is a creative industry. No single project is the same as another and that diversity breeds innovation and innovative problem solving at the practical level, CIOB (2007).

Murray (2015) stated that the US academics Wesley Cohen and Daniel Levinthal have argued that a company's innovative capabilities depend on its ability to recognise valuable new ideas and absorb them. He further stated that professionals are essential for maintaining standards of practice. According to Murray (2015), the evolution of the construction professions has produced many skilled and motivated people. They are open to new ideas within their own fields but often fail to continuously implement those ideas that could lead to new ways of doing things. Innovations take many years to mature and result from the collisions between the hunches of people working in related but different fields. The more connected you are the more likely you are to nurture an innovation (Murray, 2015).

The Gauteng Department of Education (GDE) is responsible for all education related matters within the Gauteng province, and that includes infrastructure development. The constructing and maintaining of these educational facilities all falls under GDE's to do list. In constructing and maintaining these educational facilities, GDE issues the Gauteng Department of Infrastructure Development (GDID) with mandates to construct and maintain both primary and high schools. The GDID then operates as an implementing agent for the Gauteng department of Education.

Marley building systems offered a fully detailed tour on behalf of GDID and demonstrated how a light steel frame structure is erected. They demonstrated from foundations all through to roof coverings by a means of site samples and videos. It was through this presentation that enlightened and disclosed that not all primary school building structures have to be built with bricks and mortar, and hence gave birth to this study. There is a global trend towards environment-friendly practices related building methods (Marley, 2015). Marley building systems further illustrated that light steel frame (LSF) building has been around for more than 50

years. This alternative building method is extensively used in the USA, Europe and Australia (Slaughter, 2010).

Slaughter (2010) mentioned that the technology has become available to the South African market for the past 10 years it. Light Steel Frame Building offers quality, cost efficiency and speed of erection for low-rise residential and non-residential buildings (Marley, 2015). It is put together by using rivets or self-tapping screws to form the structural wall and roof panels, which are erected on slabs. Once erected, the walls are cladded externally with fibre cement boards and internally, with either fibre cement or plaster boards (Marley, 2015)

Light Steel frame buildings are produced in strict accordance with national standards with no regional variations (Marley, 2015). It dictates a high degree of accuracy of building dimensions by being computer designed and rolled –tolerances are minute ensuring consistent material and element quality every time. (Marley, 2015) All designs are certified by an engineer to ensure that the built is according to specification and industry standards.

Marley (2015) explained the process of constructing a light steel frame building in the following manner, that standard architectural building plans are copied into a CAD system which is linked with the roll-forming machine, to produces the exact sections required. Each section is marked for ease of assembly. Rational plans must be approved where-after National Home Builders registration Council (NHBRC), local authorities and concerned financial institutions will allow commencement of project. Light steel frame is flexible enough to facilitate from the most modest to complex shapes, whilst providing a secure and strong structure. This method allows for extra floor space due to the reduced thickness of external walls compared with brick walls (approximately 6% difference) (Marley. 2015).

The Gauteng department of Education and the Gauteng department of Infrastructure Development indicated that they have previously attempted to implement the new technology (light steel frame construction). The Olivenhoutbosch Primary School is one of the projects that are considered being the most successful due to quite a number of reasons. The project was monitored by GDID as the custodian for GDE. The school is located at Olivehoutbosch area and is now called Orefile Primary School. The project was considered a success due to the following

reasons: it was built within a period of six months with no exceeded budget, the quality of the building was assured and the building costs were minimised.

Average expenditure for a primary school was about R56 million however with the new building method, the total cost of the building was only R36 million. GDID saw this technology as a fast mechanism to minimise costs and time constraints in terms of delivery timeframes. GDID mentioned also that this method somewhat also improves site cleanliness and safety, however that was the first and the last time this technology was ever used in these two departments. This technology has not been adopted as a matter of policy and is not being implemented as an alternative building method for primary schools despite government policy supporting the use of Alternative Building Technologies (ABT).

Figure 1: Orefile Primary school

1.1 Problem statement

Alternative Building Technologies such as light steel frame building have been demonstrated internationally to be robust and appropriate construction methods. Demonstration projects locally have shown then to be applicable in South Africa, however despite this they have not become established as a solution for the GDE and GDID. This suggests that perceptions around the technology of professionals in the GDE and GDID may be inhibiting the adoption of LSF….

1.2 Objectives

The specific objectives of the study are as follows;

- To establish the perceptions of LSF.
- To investigate the effects of light steel frame innovation in the construction industry.
- To identify the barriers to innovation within the construction industry.
- To investigate the disadvantages associated with light steel frame as a new technology within the South African construction industry.
- To investigate the benefits offered by the light steel frame construction.

1.3 Aim of the study

The aim of the research is to develop a better understanding of the significant factors constraining the adoption and implementation of light steel frame construction as an alternative building method for primary schools in Gauteng. The study will further investigate how implementing light steel frame construction will have an impact on the construction innovation process, and understand the influences and barriers of innovation within the industry, focusing on light steel frame construction as a new technology.

1.4 Research question

The purpose of this research is to conduct an in-depth investigation into the following main question:

> *What factors are perceived to be hindering the selection of light steel frame as a construction technology for the delivery of primary schools in the Gauteng region?*

The following sub-questions have been formulated to help address the specific objectives relating to the research question;

- What are the perceptions associated to LSF?
- What are the barriers to innovation?
- What disadvantages does the light steel frame technology currently have?

- What benefits does light steel frame construction offer to industry?
- What are the South African regulations around light steel frame construction?

1.5 Hypothesis

Lack of awareness and exposure to light steel frame methods gives rise to incorrect perceptions about its implementation. These incorrect perceptions act as a barrier to LSF adoption

1.6 Limitations

The key limitation to this research is that it focuses on only the Gauteng Department of Education and the Gauteng Department of Health. It will not say anything about any perceptions from the construction private sector or any other department.

It will also be focused only on professionals from the two departments.

1.7 Assumptions

The following assumptions were made during the research:

1. Sample surveyed is a true representation of the South African construction industry.
2. Information and findings gathered in the Gauteng Province will remain true and valid for the rest of South Africa.
3. Innovation literature obtained will be deemed to be the latest applicable due to the very limited construction innovation literature available.
4. The Gauteng department of Education and the Gauteng department of Infrastructure Development will be deemed to be a single unit as the Infrastructure Development department carries out mandates from the department of Education, which makes the two department operate as a single unit.

1.8 Research Methodology

This is a positivist study that will seek to measure the perceptions of professionals in the GDE and GDID towards LSF construction methods. The study was conducted through a form of

questionnaires, and journals were reviewed and analysed; also a series of other published literature were consulted and reviewed. The sample was drawn from the population of the Gauteng department of Education and the Gauteng department of Infrastructure Development.

1.9 Research Report Structure

The research report is structured into the following five chapters;

Chapter 1 introduces the background of the research report which built up to the research problem, the objectives and also outlines the significance of the research report.

Chapter 2 covers literature on innovation in the construction industry and further narrowly focuses on light steel frame construction. Authenticated journals, academic books and various published materials were reviewed.

Chapter 3 describes the methodology that was adopted in order to attain objectives of the research report. The quantitative method was selected and a questionnaire was chosen to be the instrument for gathering data. The reasons for choosing this methodology and research design are explained and the choice of research design defended.

Chapter 4 presents the data from the survey and analysis of it. The main findings of the study, which seek to address the research question and hypothesis statement, are presented.

Chapter 5 revisits the research questions and objectives and in the light of the findings, assesses if these have been answered and achieved. Conclusions are drawn from the findings and recommendations are made.

2 Literature Review

This chapter is aimed at reviewing existing literature relevant to this study. It is set out to examine the theory of innovation in the construction industry through different implementation stages. It explores the key influences on construction industry. Barriers to innovation within the construction industry are also explored.

It further narrows down from general innovation literature to focusing on the direct technology this study is aimed at: light steel frame construction. South African regulation and procurement issues are explored with regard to LSF. The benefits, challenges and the green aspects of this technology is also explored. This chapter is summed up by a case study about an existing structure that outlines the process throughout its construction and the lesson learned through this innovation.

2.1 Innovation in the construction industry

"*Innovation is the key to the future success of construction, using technology as the enabler. The industry needs to embrace a complete technology and innovation culture change so that research and development is seen as the core value for the future of construction and essential to business success.*" (Davies, 2006)

Slaughter (1998) stated that, while an innovation could also be an invention, an invention is not an innovation unless it has actually been used. New markets can also emerge based upon innovations, in particular, , innovations in construction technology often increase the technical feasibility of construction undertakings. Projects or facilities that may appear to be beyond the current technological frontier can become possible.

Innovations may also provide significant benefits that cannot be adequately measured in direct monetary savings and gain, but can, nonetheless, add to a company's competitive position (Davies, 2006).

For both the innovators and the early users of the innovations, certain intangible benefits can be obtained from innovations, such as improved reputation, ease of work, and attraction of promising new hires. These intangible benefits can often be more important for the early use of

innovations than the expected rand savings, as examined in the adoption of new information technologies for construction (Slaughter, 1998).

2.1.1 Implementation of Construction innovation

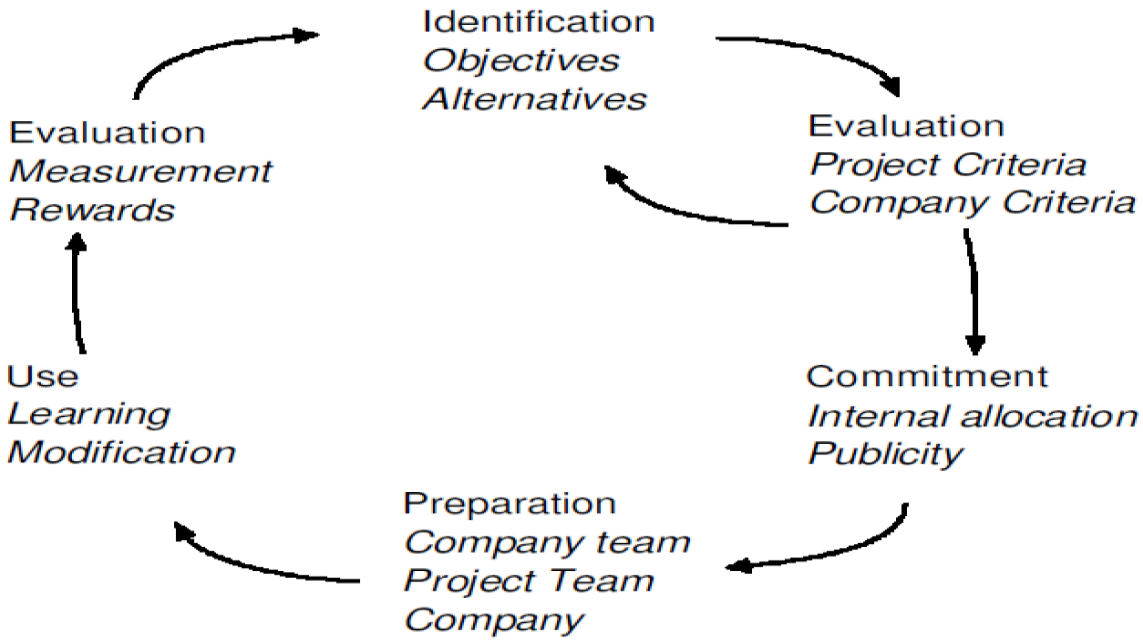

Figure 2: Implementation stages for innovations (Slaughter, 2010)

Slaughter (2010) stated that the effective use of construction innovations can be planned through a cycle of implementation stages and activities (Meyer and Goes, 1988; Goodman and Griffith, 1991; von Hippel and Tyre, 1995). The six stages often identified in the theoretical literature and empirical studies are: 1) identification; 2) evaluation; 3) commitment; 4) detailed preparation; 5) actual use; and 6) post-use evaluation. Below, Slaughter (2010) intensively explains the six stages of construction innovation.

2.1.2 Identification of potential alternatives

The first stage of the implementation cycle according to Slaughter (2010) is the clear specification of the objectives associated with the project and organization(s), and the identification of potential alternatives to achieve those objectives. Often alternatives are identified within the firms involved from the set of known means to achieve familiar objectives. For innovations, however, the sources to identify and/or develop the innovations are often more

widely spread throughout the value chain, and the general industrial environment (Nelson and Winter, 1977; Dosi, 1982).

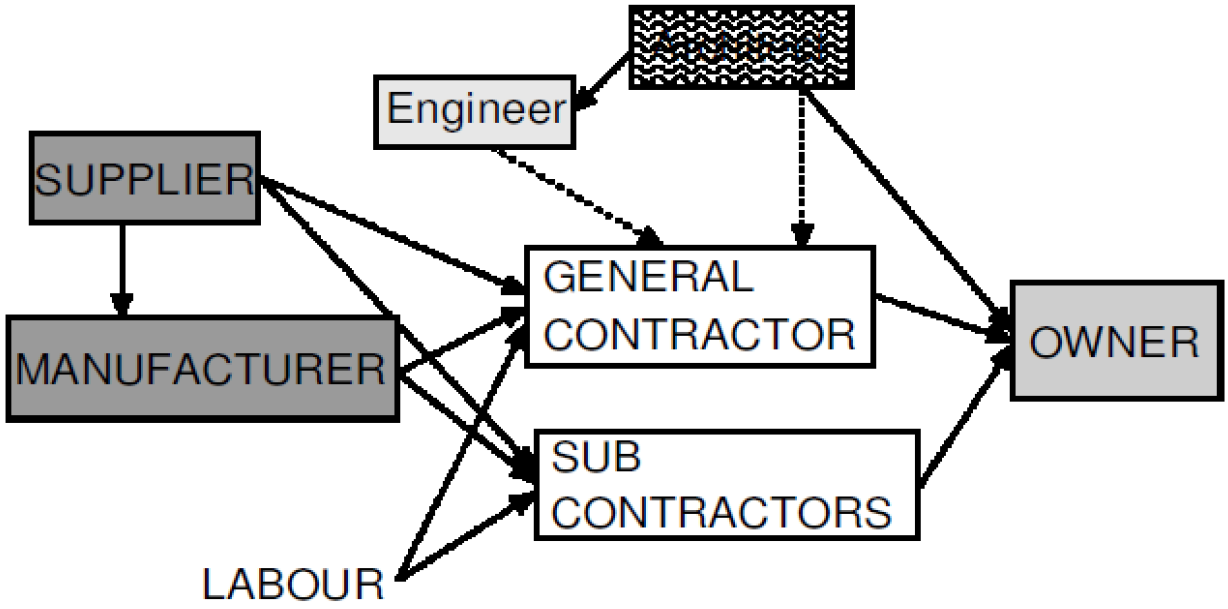

Figure 3: Value-added chain in construction as sources of innovation (Slaughter, 2010).

Traditionally, manufacturers and suppliers have been viewed as the primary source for construction-related innovations (Pries and Janszen, 1995). However, recent research has demonstrated that general and specialist contractors can be a significant source of construction related innovations (Slaughter, 1993a; Semlies, 1999), particularly for innovations which involve The integration and interaction among systems, such as with architectural and system innovations. Designers, including both architects and structural engineers, can also be significant sources of innovations, particularly during the early stages of a project conceptualization in response to strong client requirements (Semlies, 1999).

2.1.3 Evaluation of innovative alternatives

Slaughter (2010) mentioned that once the preliminary set of alternatives has been identified, they are evaluated with respect to the project objectives, in particular to measure the performance of the alternatives on key criteria. Given the cost-competitive nature of the construction industry in most markets, the common expectation is that reducing design and construction-related costs is

the main focus of most innovative activity (Duke, 1988). However, recent research indicates that a large portion of the innovations suggested and accepted within the construction industry actually improve the performance of either the design/construction process or the performance of the completed facility itself (Johnson and Tatum, 1993).The key point is that evaluating innovative alternatives only with respect to current known alternatives and especially without explicit consideration of potential improvements in other aspects, such as performance, worker safety and technical feasibility, may not reveal the full range of benefits which could be expected from innovations.

2.1.4 Commitment to innovations

In the third implementation phase, the construction company commits to the innovation(s) selected after evaluation. The company's commitment is demonstrated through its internal allocation of resources to the implementation of the innovation (Johnson and Tatum, 1993) and often through public announcement and acknowledgement of its decision to use the innovation. The irrevocability of publicly announced commitments to innovations can often provide the internal impulse to overcome problems as they occur, and to drive the implementation to completion (Goodman and Griffith, 1991).

2.1.5 Preparation of implementation

Slaughter (2010) further stated that a critical, but often neglected stage in the implementation process is to actually prepare for the implementation. The units that need to be prepared include the people within the company who will implement the innovation, the project team (e.g. owner, designer, general contractor, specialist contractors) in which the innovation will be implemented and the construction company as a whole (Slaughter, 2010). During this preparation stage, the construction team needs to be able to accomplish two key activities: 1) to actually obtain the resources; and, since most construction processes are labour-intensive, 2) to develop and train the personnel who will be involved. (Slaughter, 2010)

2.1.6 Use and accommodate the innovation

Slaughter (1993b) stated that typically, construction innovations are changes introduced into large, complex systems. As a result, the use stage itself is often a time in which adjustments and

changes are made on-site to obtain the expected benefits, or to take advantage of opportunities to increase the level of benefits obtained (Slaughter, 1993b). These modifications can include changes to the processes or systems to most effectively use and accommodate the innovation, and also changes to the innovation itself to better fit the complex set of systems (Fleck, 1994)

2.1.7 Post-use evaluation of the innovation

Slaughter (2010) mentioned that even though project teams usually disperse quickly after the end of the project, certain information about the innovation implementation should be collected immediately. The data can be used to evaluate the organization processes as well as the specific innovation use (Slaughter, 2010). The first element in the evaluation is to compare the original expectations of benefits and costs to the actual outcomes.

2.1.8 Overview of the stages

The overview on Slaughter's stages provides a useful model to understand construction innovation. It assists in proper identification and the evaluation the innovative alternative. After the evaluation, committing to the alternative leads to preparation and then the usage and accommodating of the innovation takes place. It is during the use of the innovation that will lead all involved stakeholders to provide proper post-use evaluation of the technology for amendments and further referrals. The cycle then repeats itself. It is a never ending process.

2.2 Key influences on construction innovation

The higher the levels of innovation in the construction industry, the greater the likelihood that it will increase its contribution to economic growth. Unfortunately, in most countries, there is a perception that the industry is not generally innovative, and that there is much room for improvement (Blayse and Manley, 2004).

Innovation in the construction industry can take many forms. Slaughter (1998) characterizes such innovation according to whether it is 'incremental' (small, and based on existing experience and knowledge), 'radical' (a breakthrough in science or technology), 'modular' (a change in concept within a component only), 'architectural' (a change in links to other components or systems), or 'system' (multiple, integrated innovations).Blayse and Manley (2004) describes innovation as

being either ‘technical’ or ‘organizational’. Technical innovation involves either ‘product’ or ‘process’ innovation, whereas organizational innovation includes changes to organizational structure, introduction of advanced management techniques, and implementation of new corporate strategic orientations (Anderson and Manseau, 1999).

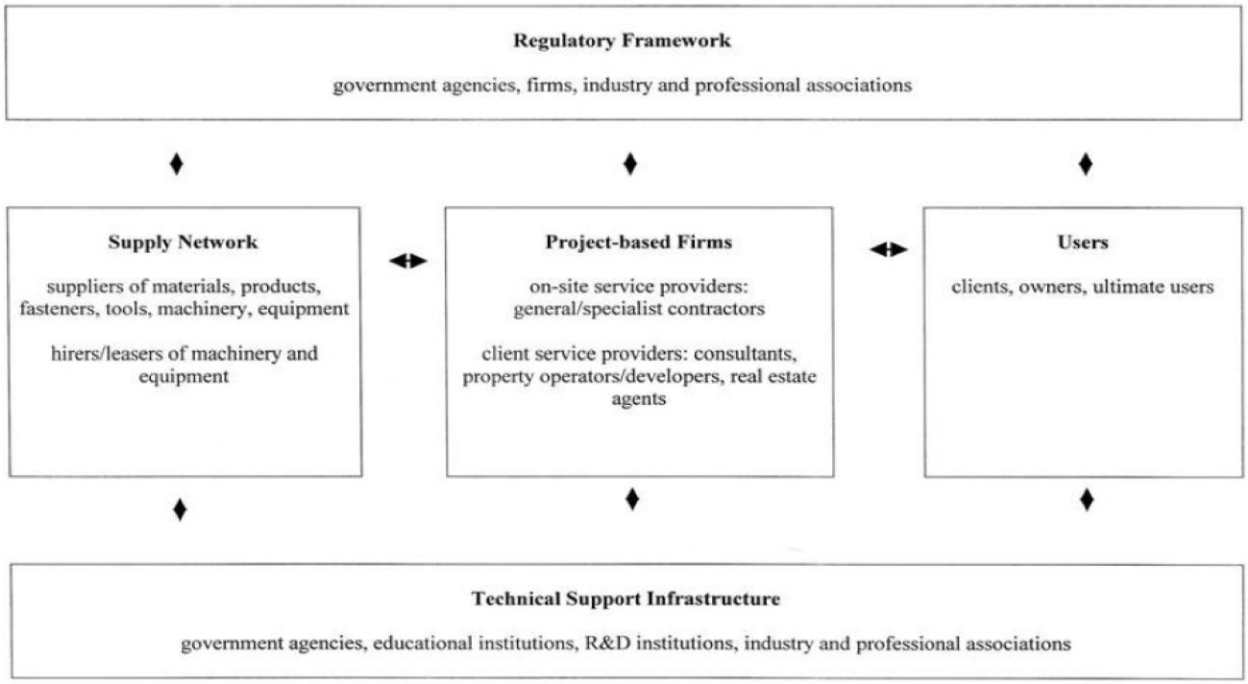

Figure 4: Participants in the building and construction project system (based on Gann and Salter, 1998

2.2.1 Clients and manufacturing firms

Clients and manufacturing firms are key industry participants in terms of driving innovation. Clients are commonly considered to have enormous capacity to exert influence on firms and individuals involved in construction in a way that fosters innovation (Barlow, 2000; Gann and Salter, 2000; Kumaraswamy and Dulaimi, 2001; Nam and Tatum, 1997; Seaden and Manseau, 2001).Clients are able to enhance innovation in construction in a number of ways.

They can identify specific novel requirements to be supplied by developers, building product suppliers, contractors, and operators (Seaden and Manseau, 2001); exert pressure on project participants to improve buildings’ lifecycle performance, overall characteristics, and project flexibility to cope with unforeseen changes (Gann and Salter, 2000); and generally demand

higher standards of work (Barlow, 2000). The more ‘demanding’ and experienced the client, the more likely it is to stimulate innovation in projects it commissions (Barlow, 2000).

2.2.2 Structure of production

One of the features of production said to be most difficult is the temporary or one-off nature of construction projects. This is associated with discontinuities in knowledge development and in transfer of knowledge within and between organizations, and restraints on the development of an ‘organizational memory’ (Dubois and Gadde, 2002). The one-off nature of most building projects limits the degree to which a given innovation will be applicable to other situations, reducing the benefits of innovation and therefore incentives to innovate.

It also tends to have the effect that different solutions to similar or identical client requirements are developed time after time, meaning that organizational learning is hindered (Barlow, 2000). Traditional approaches to the management of construction projects have also been criticized as tending to dampen conditions for innovation. For example, Koskela and Vrijhoef (2001) call for a complete revision of the theory of construction management, which they see as currently deficient.

A number of researchers have elaborated on the problems caused by traditional management approaches. For example, Winch (2000) has suggested that the allocation of hierarchical roles has important consequences for innovation.

2.2.3 Industry relationships

Industry relationships have an extremely significant influence on construction innovation (Anderson and Manseau, 1999). The importance of relationships lies in their capacity to facilitate knowledge flows through interactions and transactions between individuals and firms. These interactions and transactions can include processes related to product integration (between manufacturers and assemblers and installers of construction products), processes related to project organization and coordination, diffusion of technologies and practices, flow of labour, and information flow from various sources (Anderson and Manseau, 1999).

In a complex systems industry such as construction, firms must rely on the capabilities of other firms to produce innovations and this is facilitated by some degree of continuing cooperation between those concerned with the development of products, processes and designs (Anderson and Manseau, 1999).

The structure of production in the construction industry involves challenges that can be met through the existence of robust industry relationships that can enhance knowledge flows. Innovation brokers, especially those with a multi-industry focus, can assist in maximizing knowledge flows, helping to overcome the limitations of 'technology watch' in the industry (Anderson and Manseau, 1999).

2.2.4 Procurement systems

Procurement systems that tend to discourage construction firms from risking the adoption of nontraditional processes and products are most injurious to innovation. These systems include those that place a premium on speed and urgency or on competition on the basis of price alone, establish rigid role responsibilities, or promote adversarial and self-protective behavior (Kumaraswamy and Dulaimi, 2001).

A number of procurement systems are available to construction clients, including traditional lump-sum (fixed price), design-build, construction management, project management, on-call multi-task contracting, guaranteed maximum price, full cost reimbursable, and BOOT (build, own, operate, transfer). The traditional lump-sum contract is the most conservative, and the most detrimental to innovation, drawing the most criticism in the literature (Walker and Hampson, 2003). It involves the highest cost risk for contractors, the highest incidence of adversarial relationships, the lowest level of integration across the supply chain, and the poorest innovation outcomes (Kumaraswamy and Dulaimi, 2001).

Higher levels of innovation arise when a more innovative procurement method is chosen. From an innovation perspective, it is the presence of a well-integrated team that is of most importance, as this aspect of a procurement system is key in driving innovation (Walker *et al*., 2003). This might involve partnering alongside fixed cost contracts to improve communication, learning, and

innovation outcomes on straightforward projects. For more complex projects, a design-build, construction management or project management can have good innovation outcomes.

These approaches integrate design and construction functions (and sometimes financing and operation), leading to improved design constructability and economy, through innovation. Communication, learning, and innovation are also improved across the supply chain through management by a single entity. Further, incentives for innovation are enhanced as there is greater scope for capturing benefits (Kumaraswamy and Dulaimi, 2001; Walker *et al*., 2003).

2.2.5 Regulations/standards

Gann and Salter (2000) argue that government regulatory policies exert a strong influence on demand and play an important part in shaping the direction of technological change. According to Dubois and Gadde (2002), this has generally been a negative influence internationally, with many government regulations and industry standards hampering innovation. Although performance approaches are often seen to promote innovation more vigorously than prescriptive approaches, the ultimate impact of any regulation or industry standard depends on the capabilities of the regulators (Gann *et al*., 1998)

The process of developing regulations is complex, relying upon the knowledge of key players. The extent to which technical change is encouraged depends on the availability of new knowledge, together with the development of appropriate mechanisms. If the design of regulations and standards is approached strategically, positive innovation outcomes may be expected through the codification of existing technology and the creation of demand for new practices and technologies (Gann *et al.*, 1998).

2.2.6 Barriers to innovation within the construction sector

Benmansour and Hogg (2002) stated that innovation within the construction sector is occurring and evidence of this can be found in the list of issues and activities that has emerged in recent years. However, notwithstanding such developments, within the context of the framework outlined above, evidence of the existence of barriers to innovation can be identified within the construction industry. They further stated that construction literature is full of explanations of barriers to innovation. Winch (1999) considers the project-based nature of the construction

industry as a significant barrier to innovation. Egan (1998) reports that the fragmentation of the construction industry inhibits performance improvement while Morledge (2000) points to the supply-side reluctance to embrace new ideas and the weak demand-side in terms of number of clients who have access to innovative or improved techniques. In the report 'Value for Money' (Gray 1996) underlines the problem of the need for bespoke designs with the design of highly engineered and non-standardised buildings and suggests that the production-oriented approach to building design and construction common in other countries should be extended to greater use in the UK.

Hogg (2000) stated that the tendency in construction toward the production of unique, non-standard products leading to buildings that are complex to construct, with each building requiring a new learning experience, may be regarded as a fundamental aspect of the industry's culture that, at the level of the firm, may be a significant barrier to innovation. Likewise, resistance to the adoption of recognised and proven methods of improving the service given to clients, be it from contractors or consultants must be regarded as damaging and examples appear to be common in construction. One such example relates to the extent of use of the practice of Value Management. Despite the level of recognition and promotion given to this activity, there appears to be a hesitance by many practitioners to embrace the opportunity Value Management provides (Hogg, 2000).

2.3 Light steel frame construction

"*As pressure comes to bear in the construction industry, to supply alternatives to the more traditional methods of construction, light weight steel framing exhibits many attractive features for the Designer, Builder and Owner. It offers quality, cost efficiency and speed of erection for low-rise residential and non-residential buildings*". (Barnard, 2010)

Lately a lot of building technologies have been introduced and these include Light Steel frame System, Vela Steel Building System and IMSION Building System.

2.3.1.1 Vela Steel Building System

The Vela Steel Building System according to the Agrèment South Africa's certificate is based on the Structural Insulated Panels (SIP) incorporating a steel frame which enhances the structural integrity of the system. The steel frame is designed in accordance with the requirements of SANS 517. The composite wall panels comprise Autoclaved Magnesium Oxide board encapsulating polyurethane core and polystyrene blanks between panel cavities.

The Agrèment certificate also states that the walls are finished with armour coat waterproof paint. Where required, the panels are delivered on site with factory fitted window and door frames. For the certificate to be issued after the completion of the project, the foundation and floor slab are conventional and are always the responsibility of a competent person. The roof is described as constructed of standard lightweight steel trusses clad with metal sheeting, concrete roof tiles or Agrément approved cladding. The plumbing and electrical conduits are pre-fixed into the composite panels. These systems must comply with SABS, NHBRC & Agrèment SA for the certificate to be issued (www.quantumconstuction.co.za).

2.3.1.2 IMISON Building System

The Council for Scientific and Industrial Research (CSIR) illustrate the Imison walling system as comprising mainly of a series of interlocking wall panels, made from Neopor. Imison wall panels are manufactured in licensed manufacturing plants across the globe under strict quality control guidelines, to ensure a consistent standard (CSIR).

The council further states that the panels contain an in situ light gauge steel or concrete substructure wall panel that can be installed on to any type of foundation or floor slab. The process is explained as follows: once erected, the Imison wall panels are sprayed on both sides with a high density, fiber-cement technology, called Fibrecote.

The combination of Neopor, the in situ reinforced substructure and Fibrecote acts as a composite member, providing load bearing or non-load bearing Imison walls with unparalleled strength with the look, feel, and durability of masonry construction, whilst offering far superior insulation and STC values, reduced construction time and at an affordable cost. This system complies to SABS/SANS, NHBRC & Agreement SA Standards (www.imison.com).

2.3.1.3 Light Steel Frame System

In the construction of the Olivenhoutbosch Primary School by the Gauteng department of Infrastructure Development in carrying out a mandate from the Gauteng department of Education, the light steel frame System was used. This method came highly recommended as it was seen as the fast mechanism to minimise costs and time constraints in terms of delivery timeframes. This system is compliant to international building standards and meets the testing requirements of SABS/SANS. Additionally it is accredited by the NHBRC.

This study will focus only on light steel frame building, which is a building method, and should not be confused with prefabricated or 'kit' buildings. It has been described as 'off-site' building, as a lot of the manufacturing takes place in factories, and the components are assembled on site (Barnard, 2010). It consists of structural wall panels and/or trusses, assembled using cold formed steel sections made from thin gauge high strength galvanized steel sheets. Sections are joined together, typically in a factory, using rivets or self-tapping screws, to form structural wall panels and/or roof trusses which are transported to site for erection on foundations and floor slabs (Barnard, 2010).

The South African Treasury (2015) states that infrastructure in South Africa is foundational to a better life for all. However, as stated by the National Treasury, investment in economic infrastructure will not necessarily lead to economic growth. Infrastructure which provides improvements or efficiencies in services, production or export capabilities, and which is delivered and maintained in a manner that minimises waste of materials, time and effort in order to generate the maximum possible amount of value, is most likely to contribute to economic growth

2.3.2 LSF South African Regulations

SANS 517 (2013) offers strict requirements that need to be satisfied in order to obtain access to municipal approvals. It covers everything from foundations to roof structures of the light steel frame structure. In addition external cladding (fibre cement) must adhere to SANS 803 (2005) and SANS 10409 (2005). In addition the light steel must comply with regulations as set out by South African Steel and Iron Association.

SASFA (Southern African Light Steel Frame Association) is tasked to regulate the industry standard, develop and test the system and train contractors (Barnard, 2008), Every LSF project requires an engineer to sign off a rational design as per Act 14 of 1990 declaring that the building is "deemed to satisfy" above-mentioned act. SANS 10400 allows for an Agreement Certificate that declares a project "fit for purpose" (Barnard, 2008),

SASFA is the Southern African Steel Frame Association formed to collectively launch and regulate Light Steel Frame industry in Southern Africa made up of the major raw material suppliers for Light steel frame (Barnard, 2008),

2.3.3 Benefits of using LSF

In anything new, the recipient needs to have some benefit before fully committing and adapting to the idea. Light steel frame construction offers some benefits to the owner and the client.

Barnard (2008), the director of SASFA, stated that light steel frame buildings appear no different to 'conventionally' built structures, except that the quality of finishes is typically better. He further stated that it is finding acceptance for 'affordable' as well as up-market buildings in South Africa. He emphasised that it is a cost-effective building method, with financial savings emanating mainly from significant time savings to complete building projects, less rework, reduced logistical costs (which is of growing importance due to the escalation of fuel prices) and a drastic reduction of rubble on building sites, when compared with the brick-and-mortar alternative (Barnard, 2008).

Clotan Steel (being one of the leading steel suppliers in South Africa) further emphasised the cost effectiveness of this technology by stating that the construction method is very cost effective, as the light steel frames will be supplied according to the necessary specifications and requirements. There is very little material wastage when the steel frames are supplied in this manner. This method also somewhat improves safety (www.clotansteel.co.za).

The client (being the Gauteng Department of Education) mostly occupy theirs school structures way after the anticipated completion date due to prolonged construction duration caused by different factors. Due to the quicker construction of steel frame building methods, the client

department would enjoy earlier occupation of up to 50% quicker than conventional building methods.

There is a very high safety element associated to light steel frames buildings as steel is resistant to fire, meaning that it will not aid in the spread of fire if burnt. The Council for Scientific and Industrial Research (CSIR) emphasised that it is also ideal for houses or structures built in areas that are prone to strong winds and earthquakes. Steel frame structures also offer the benefit of being environmentally friendly, as steel is fully recyclable, and less material will be wasted as stated by Clotan steel. Clotan steel also stated that steel frames structures are ideal for South African home owners, as it is resistant to pests like termites (www.clotansteel.co.za).

Figure 5: Picture of a school in construction in Tsakane (East rand)

2.3.4 Challenges associated with LSF

All new ideas have both positive and negative sides and a few challenges associated with the proposed building method are highlighted as well. Barnard (2010) compared America or Australia to South Africa and, mentioned that SA has a limited history of lightweight primary school construction. He further elaborated by stating that limited availability and expense has made masonry construction a first preference, and that major investment in the education of the industry in the use of this new technology will be necessary. This task should not be underestimated, as conservatism resists change, especially when there is the perception that current building methods are as good as anyone needs (Barnard, 2010):

Most challenges as stated by Barnard (2010) included general perceptions relating lightweight construction to temporary structures such as site offices and temporary accommodation. He further illustrated that local authorities are not familiar with the technology. This could imply that there might be delays and disputes during the process of drafting new building regulations and agreement certificates. This could further imply that established contractors and suppliers to the traditional building sector may see the technology as a threat to their building as stated by Barnard (2010). Builders will need to familiarize themselves with the new technology. Will LSF building work in the African climate?

This building method has been successfully used in the harsh climates of Australia, the United Kingdom, Canada, New Zealand and the United States of America as stated by The Council for Scientific and Industrial Research (CSIR). The lifespan of steel is 40+ years. The council illustrated that fiber cement cladding can be installed without the curing limitations of bricks and mortar. (CSIR) mentioned that South Africa has seen approximately 450 000 square meters of LSF buildings completed in 2013/2014, from approximately 300 000 square meters in 2012/2013 (Barnard, 2010).

2.3.5 Green Credentials of LSF

The field of "green technology" encompasses a continuously evolving group of methods and materials, from techniques for generating energy to non-toxic cleaning products. Perhaps the most urgent issue for green technology, this includes the development of alternative fuels, new means of generating energy and energy efficiency.

Green building encompasses everything from the choice of building materials to where a building is located. This government innovation involves the search for products whose contents and methods of production have the smallest possible impact on the environment, and mandates that these be the preferred products for government purchasing (www.green-technology.org).

Over its life span, a LSF building, offers superior energy efficiency because it can be optimally insulated for each type of building and climate (SANS 517: 2013). Following the insulation regulations a LSF building offers excellent thermal performance compared with conventional building, keeping the interior of a building cooler during the summer months and significantly

warmer during the winter months (SANS 517: 2013). According to the Council for Scientific and Industrial Research (CSIR), LSF buildings require as little as half of the electrical energy needed to heat and cool a masonry house!

As energy efficiency requirements become more stringent in South Africa, LSF buildings are already able to offer a fully SANS 517-compliant solution (unlike masonry buildings, where additional measures have to be applied).

2.4 Written Case Study- Stand 47

The case study below was prepared and elaborated by Ms Edna Peres (2004).The main purpose of this case study is to illustrate the probability and possibility of a successful light steel frame building. The case study illustrates the general and specific lessons learned during the construction of this house.

Peres (2004) stated that the property is located in Monaghan Farm, an eco-estate near Lanseria Airport just north of Johannesburg. It was completed in September 2014. Stand 47 is located on a North facing plot, predominantly covered by veld grasses and indigenous aloes. She illustrated further that the house is sunk into a gently sloping site that falls 3m toward the East with extensive views toward the Magaliesberg valleys. Framed on the South by a line of mature trees, the site plan is defined by strict architectural guidelines set up by the estate aesthetics committee. With a maximum coverage of 1298 square meters, Stand 47 may not exceed one storey and 1000 square meter in size, and has 'earthy' external walls and roofs that do not increase visual bulk, but blend into the landscape.

The stand is 3766 m2 in size and the size of the house is 333m2 and a 41m2 enclosed carport. The size of the open plan living room and dining room is 68m2 and it has 4 bedrooms with 3 bathrooms.

Peres (2004) indicated that stand 47 as a case study project aimed to test the hypothesis that a luxury house can be built just the same if not better, using contemporary building systems rather than a masonry house. In testing this hypothesis, it has proven that it is not only possible but that

by following a clear process the results can out-perform what we expect from housing in South Africa: better performance, better comfort, better safety and better health.

General lessons as illustrated by Peres (2004) included:

- A good process and concept: Undertaking an innovative experiment like a case study requires a lot of pre-planning based on a good architectural design to develop detailed documentation for construction.
- Training: The need to 'train' the local municipal councils of the benefits and properties of light-steel construction with drywall systems from Saint-Gobain was necessary in order to get building plans approvals. A workshop with local plans officials demonstrated to them the technical quality, performance and energy benefits of this construction system.
- Contractor selection: Having a main contractor that understands the construction contracts and can manage all the sub-contractors on site becomes very important. In Stand 47, it was essential to determine whether subcontractors had the capacity and expertise to execute their contracts within the prescribed timeframes. A good main contractor and suppliers are essential to the success of a project.
- Delays: A number of delays can wreak havoc with the construction process and sequence of activities on site. It is important to provide for a few scenarios within the extended timelines where realistic delays due to climate, industrial action, product research or supplier related delays might significantly prolong the progress of key aspects of construction work.

2.4.1 Specific lessons learned:

Many of the systems, materials, technologies and products were used for the first time in such an integrated manner in South Africa. This requires a great deal of research and at times decisions had to happen quickly. The cost (in delays and budget) of this type of pioneering activity can be higher than using standard systems, and must be considered early on in the project through some form of buffer.

The collaborative process is essential to the design and realisation of a case study house but there are implications that might slow down the process when too many people get involved and there are no clear structures for communication and decision-making.

Figure 6: Stand 47
www.stand47.co.za

2.5 Summary of literature

The chapter aimed to understand fully the impact of innovation in the construction industry and the further understand light steel frame as an alternative building method in the construction industry. The stages of innovation were explored, together with challenges and barriers to innovation within the construction industry. Further light steel frame was studied. To close it off, the case study of stand 47 was highlighted which indicated lessons learned during the construction of the house. This was to indicate that successful projects have been undertaken and can be properly managed. Lessons highlighted could be highly valuable in planning and constructing primary schools in the Gauteng province.

3 Research Method and Design

The purpose of this chapter is to discuss research methods designed and selected to investigate the perceptions of GDE and GDHS professionals around the adoption and implementation of light steel frame construction as alternative construction method for primary schools in South Africa. The first section of this chapter is an introduction that highlights the research question to be answered. The research question describes the research design and data collection methods used and why they are appropriate to answer the research question.

A review of the different types of data methods is reviewed, followed by a classification of the nature of the research. These data are important as it will give a framework to the research methods available and will thus allow an informed selection. The research strategies are then discussed, discussing the type of data collection techniques selected and ensuring a suitable strategy selected. This is then followed by a discussion on the types of data collection techniques that may be applicable to this research as well as their assessing the validity of the collected for each technique. Having outlined the different methods and strategies, the selection for this research is justified (Maroge, 2012).

3.1 Introduction

Chapter 2 provided a background study and comprehensively reviewed existing literature on innovation in the construction industry through different implementation stages. It explored the key influences on construction industry. Barriers to innovation within the construction industry were also explored.

It further narrowed down from general innovation literature to focusing on the direct technology this study is aimed at: light steel frame construction. South African regulation and procurement issues were explored with regard to LSF. The benefits, challenges and the green aspects of this technology are also explored. This chapter is summed up by a case study about an existing structure that outlines the process throughout its construction and the lesson learned through this innovation. Having reviewed existing literature, enough background was provided to design data collection method and execute the research. The selection of appropriate methodology in order to gather information proved to be challenging because of the vast geographical area of South

Africa. As a result the Gauteng area was studied and assumptions were made that results will represent the country as a whole.

Questionnaires were developed to answer the research question and distributed to the department of Infrastructure Development (as an implementing agent) and the department of Education (as the client department) in the Gauteng province. As stated in chapter one, findings conducted in the Gauteng province will be deemed true for the rest of South Africa and due to the nature in which the two departments operate, they will be deemed to be a single unit.

3.2 Method Selection

Saunders *et.al* (2012) defines research design as the general plan mapping out details of how research questions will be answered. This is the first step to consider when designing the way the data will be collected in order to address the research questions. The steps of designing the research data collection is discussed below (Maroge, 2012). The first methodological choice to be made when doing research design is to determine whether the research will be quantitative or qualitative. Saunders *et.al* (2012) go on to define the two methods and state that although the definitions distinguish the two, in reality many business and management research designs are likely to have a combination of both methods (Maroge, 2012).

3.2.1 Quantitative Research

According to Saunders *et.al* (2012) quantitative research is used where any data collection technique, such as questionnaire, or data analysis procedure, such as graphs are employed to gather numerical data. This is 'objective' in nature. Creswell (1994, cited by Naoum, 2007; p.39) define quantitative research as "an inquiry into a social or human problem, based on testing a hypothesis or a theory composed of variables, with measured numbers and analyzed with structural procedures". This type of research aims to prove the hypothesis to be true or not. Saunders *et. al* (2012) further stated that the characteristic of quantitative data is that it examines relationships between variables, which are measured numerically and analysed through multiple statistical techniques. This type of method is usually associated with experimental or survey research strategies which will be fully explained in the following section of this chapter. The

survey research strategy is usually conducted through the use of questionnaires or structured interviews (Saunders *et.al,* 2012).

3.2.2 Qualitative Research

The application of this method is used alongside any data collection technique such as interviews, or any data analysis procedure, such as categorising data, that generates or uses non-numerical data (Saunders *et.al,* 2012). This type of research is 'subjective' in nature (Naoum, 2007). It deals with putting across the meanings, experiences, (often verbally described) and description of the subject being investigated. According to English *et.al* (2003) qualitative data are confirmed to be based on opinions and perceptions. (Maroge, 2012)

Collecting data for this type of research method is not standardised, it depends on the design of the technique used to gather data to answer the research questions. Furthermore, non- probability sampling techniques are most likely used to gather data (Saunders *et.al,* 2012).

3.2.3 Combination of the Methods of Research Design

It is important to highlight that the methods, as mentioned could be combined in order to answer research questions. Saunders *et.al* (2012) gave an example using the type of sampled data collection technique, stating that if a researcher uses questionnaire to explain a quantitative research the respondents may be requested to answer some open questions in their own words as opposed to ticking a box. Another example given is that it may be necessary to follow up questionnaires with interviews to seek explanations from the questionnaire. Therefore qualitative data may be analysed quantitatively and vice versa (Maroge, 2012).

3.3 The Nature of the Research Design

The way in which the research question is asked will involve exploratory, descriptive or explanatory answers (Saunders *et.al,* 2012). These are further discussed in this section to assist in method selection appropriate for this type of research.

3.3.1 Exploratory Studies

This type of study is a way to ask open questions in order to discover what is happening in the industry and to gain insight about the topic of the research (Saunders *et.al*, 2012). This definition is supported by (Thames Valley University, 2009), stating that exploratory research occurs when there are no previous studies to refer to for information. It focuses in gaining insight on a research area where vigorous research is required to be carried out. To conduct exploratory studies interviewing 'experts' can be conducted, these interviews will most likely be unstructured as the researcher has to allow flexibility and the ability to adapt to the change in the direction of the research (Saunders *et.al*, 2012).

3.3.2 Explanatory Studies

This type of research is commonly used where there is a limited amount of knowledge about the subject under study. According to Naoum (2007), in this instance an interview is usually selected as a method of data collection. The main purpose of this type of study is to bring forward a recognised problem in that area of study. Saunders *et.al* (2012) further stated that explanatory studies emphasize on studying a situation or a problem in order to explain the relationships between variables.

Naoum (2007) stated that explanatory research is conducted for three interrelated reasons: to diagnose a problem, to explore alternatives and to discover new ideas on how to solve that problem.

3.3.3 Descriptive Studies

"The objective is to gain an accurate profile of events, persons or situations" (Saunders *et.al*, 2012). This is to an extent, an extension of explanatory research as it is important for the researcher to have knowledge on the research topic prior to collecting data.

3.4 Research Strategies

In general terms Saunders *et.al* (2012) defines a strategy as a plan to achieve a goal. As a result a research strategy can be defined as a plan of how the researcher will execute the research so that

the research questions can be answered and objectives achieved. In selecting a research strategy the methods selected for the design, whether quantitative or qualitative have a limited influence on the type of strategy selected. For example an experimental strategy is linked with quantitative methods, while survey is linked with qualitative. However, Saunders *et.al* (2012) stated that the choice of a suitable qualitative research method causes the greatest confusion due to the diversity of the research. Naoum (2007) defines the research strategy as "the way in which the research objectives can be questioned". Different research strategies are discussed in detail in this section.

3.4.1 Experiments

This type of strategy is based on the natural science research. Saunders et.al (2012) defines experiment as "the study of probability of a change in an independent variable causing a change in another dependent variable". Experiments use hypothesis rather than research questions to anticipate whether or not the relationship between the variables will exist. The hypothesis will have one of two outcomes, either it is a null hypothesis; predicting that there will be no relationship between variables; and alternative hypothesis, predicting that there may be a relationship between the variables (Saunders et.al 2012).

3.4.2 Surveys

This type of strategy is common in management researches and is most frequently used. It is used to answer the 'what', 'who', 'where', 'how much' and 'how many' questions (Saunders *et.al*, 2012). There are different methods that can be used for collecting data in this type of strategy, the most popular being questionnaires (this is the research strategy adopted for this research) as they allow collection from a sizeable population. This is supported by Naoum (2007) who states that when gathering data from a relatively large number of respondents within a limited time frame, surveys are recommended (Maroge, 2012).

Another advantage of surveys as stated by Saunders *et.al* (2012) is that it enables the researcher to compare the data collected and analyze accordingly. The type of data collection techniques belonging to the survey strategies are discussed later in this chapter, drawing out the advantages and disadvantages of selecting any particular data collection technique. These data collection techniques include, but not limited to interviews, questionnaires, semi structured interviews and

so forth. The above mentioned are the most popularly employed techniques for research (Maroge, 2012).

3.4.3 Case Study

Naoum (2007) defines the case study approach as the researcher's intent to support his/ her argument by an in-depth analysis of a group of persons, an organization or a particular project. This is supported by Fellows and Liu (2003) who state that a case study is used when the research needs to back up their study by researching on previous data that has been published on the particular topic at hand. This type of research is undertaken in context, to gain a rich understanding of the research topic at hand (Maroge, 2012).

According to Saunders *et.al* (2012) the case study strategy can also answer the questions 'why', 'what' and 'how'. It can be used as an explanatory or exploratory study using qualitative or quantitative methods. The data collection techniques used may include interviews, observation and questionnaires.

3.4.4 Other Research Strategies

Maroge (2012) stated that the three research strategies discussed are not exhausted; there are several more research strategies that will be touched on briefly. These strategies are not applicable to this research paper but will be explained briefly. The archival research strategy is employed in instances that make use of administrative records and documents as a principal source of data (Maroge, 2012). This type of strategy is not limited to recent data only; it also makes use of historical data that is studied. It allows for research questions that focus upon the past and changes over time (Saunders *et.al,* 2012). Another research strategy is the use of Ethnography; developed to study cultures historical societies that had been brought under rule of colonial power. (Maroge, 2012)

3.5 Data Collection Techniques

This section aims to touch on the data collection techniques available. The different types of collection techniques and the application have already been mentioned in sections above (Maroge, 2012). The techniques applicable to this research are discussed and the selection

technique justified. The purpose is to shortlist the techniques that could be used so as to serve as a comparison (Saunders *et.al,* 2012).

3.5.1 Interviews

This is a form of dialogue between two people where the researcher (interviewer) engages a research subject (interviewee) on the research topic (Gillham, 2000). The interviewing technique is most suitable to be used in the following situations;

- When the people being interviewed share the same characteristics
- When the interviewer has knowledge of the interviewee so only the important questions are tactically addressed.
- When interpersonal interaction is necessary to highlight and explain the questions and responses.
- When details of the questions need to be given to address the how and why questions
- When the responses are more that yes and no, or agree or disagree, following with an explanation as to why the responses are as they are.
- When time and cost permit
- When observation of behaviour is important
- When the sample size allows it

The following instances prompt the use of interviews in order to gather data for a research. However it must be brought to light that there are several ways for interviewing, which is discussed below. Open- ended or Unstructured Interviews "The interviewee gets to practice a greater amount of flexibility to answering questions" (Naoum, 2007). Although there is a great deal of flexibility, the interviewer prepared questions in advance and are asked in a way that permits the interviewer to guide the interview.

According to Nachimas and Nachimas (1996) typically the interviewer will develop new questions as the interview progresses and continues to say that this type of interviewing is adopted in situations where information is obtained which cannot be predicted. However, the amount of information to be provided during the interview may be large, and therefore may not be covered due to time constraints (Naoum, 2007). These types of interviews are best suited at

the beginning of any research (explanatory interviews) when the research has little knowledge about the topic at hand. At this stage a clear research outline is necessary to carry the general points across to the interviewee. (Maroge, 2012).

3.5.1.1 Structured Interviews

"The interviewer has full control of the questionnaire throughout the entire process of the interview" (Naoum, 2009, p.57). This type of interviews has a considerable formal nature to them. With this technique, the questioning may start with some 'open' questions but the questions become more structured and specific as the interview is defined further. Unlike the 'open' question interviews, the respondent is allowed a choice of answers to select from. Nachimas and Nachimas (1996) as cited in Naoum (2007), listed the following assumptions of the structured interview;

- The respondents have a sufficiently common vocabulary to ensure that the questions asked have the same meaning for each of them

That it is possible to phrase all questions in a way that all the respondents will find the same meaning.The three main advantages of a structured interview are; the answers are more accurate, the response rate can be high, especially if the respondents have been contacted directly and the answers can be explored by finding out 'why' the particular answers are given by interviewees.

3.5.1.2 Semi- Structured Interviews

Although there is a fair amount of structure according to Gillham (2000), semi structured interviews are a combination of closed questions and open questions. The interviewer arranges the questions in a way that obtain the respondent's answers on a certain topic as opposed to "leading the interviewee toward a preconceived choice" (Naoum, 2007). Naoum (2007) goes on to cite Merton and Kendal (1946) who outlined characteristics on semi-structured interviews;

- It takes place with respondents known to have been involved in a particular experience.
- It refers to situations that have been looked at prior the interview
- An interview guide is usually set out before hand to steer the interview in a certain direction

- It is focused on the respondents' experiences regarding the situation under study.

According to Naoum (2007), semi- structured interviews start by asking indirect questions in order to gain understanding of the respondent and then to explore the specific issues that are too concerned with the particular research. Gillham (2000) stated that this kind of data collection method is ideal to gather a wide- range of information on a particular topic and continued to state the underlying principles pertaining to semi- structured interviews; the interviewer should avoid leading the interview and should create a relaxed and comfortable conversation

These above mentioned principles will allow the interviewer to get the interviewee to relax and make it easy for them to provide useful information that will add to the research at hand. (Maroge, 2012)

The interview approach is for various approaches, the most frequent match is the use of structured questionnaire for a descriptive study, the use of semi- structured for an explanatory study and the use of unstructured interview when one is looking to explore the core issues of the topic of interest (exploratory). (Maroge, 2012)

3.5.1.3 Limitations of Interview Approach

Having highlighted the purpose and strengths of the different above mentioned interview methods, it must be noted that there are limitations with interviews as a form of gathering primary data. In order to make sure that the questions asked in the interviews are specific to the subject being researched, it is up to the interviewer to ensure that an investigation into the subject matter is carried out prior to designing the data collection method. The investigation for this particular research is carried out in Chapter two, being the literature review and introduced in Chapter One. (Maroge, 2012)

According to Naoum (2007), conducting an interview is a complex and demanding technique Naoum (2007) further justifies this statement by highlighting the three main challenges of conducting interviews, especially if it is an unstructured interview. The first challenge faced when conducting an interview is that it is a time consuming exercise. Naturally unstructured interviews would take longer than structured or semi- structured interviews. The second

challenge is that in an unstructured and semi- structured interviews is for the interviewer to able to take control of the direction and pace of the interview. (Maroge, 2012)

The other challenge experienced with adopting interviews as a data collection method is that it is challenging to examine the data ones collected. The interviewer must have the ability to ensure that the respondent's answers are accurate and complete, which is a challenge as people do not often provide accurate information as they can harbor feelings of embarrassment, nervousness, extreme bias opinion and sometimes lack of knowledge on the topic (Fellows and Liu, 2003).

Fellows and Liu (2003) further on stated that respondent's answers can be highly influenced by personal opinion and may not completely relate to the facts. Therefore the interviewer must be careful in accepting all information and thus must have some knowledge on the topic at hand so as to validate and make sense of the data gathered. (Maroge, 2012)

3.5.1.4 Validity and Quality issues of data collected

The findings derived from using in- depth or semi- structured interviews are not meant to be repeated as they are applicable to a time when they were collected in a situation that maybe subject to change (Marshall and Rossman, 2006). The assumption behind this type of data collection technique is that the type of research is complex and dynamic; therefore, semi-structured interview is adopted to explore the complexity of the matter.

The interviewee has a challenge to make sure they remain impartial throughout the interview phase. This refers to the preparation of the interview as well as conducting the interview. The interviewee has to ensure that they have gained knowledge about the content of the organization and culture, select an appropriate location, ensure they are appropriately presentable for the interview, ensure the nature of the opening comments are neutral, approach to questioning should also remain neutral and must show the ability to listen intently. (Saunders et.al, 2012)

3.5.2 Questionnaires

A questionnaire is a structured technique that is used as a primary data collection method, where each respondent is asked to respond to the same set of questions (Saunders *et.al*, 2012). This is confirmed by Fellow and Liu (2003) who state that it involves a series of written questions to

which the respondents provide the answers to. Fellow and Liu (2003) define a questionnaire as a "research instrument that entails a series of questions for the purpose of gathering data". This type of data gathering method is best suited for the use of statistical analysis. Questionnaires are better suited to be used for the explanatory and descriptive approach where relationships can be examined between variables. Questionnaires are often not used as the only technique for collecting data (Saunders *et.al.* 2012).

The use of questionnaires is advantageous when compared to other methods of data collection as it is an affordable method and does not require much effort from the respondents (Naoum, 2007). This is for the reasons that questionnaires usually have a listed set of options that the respondent can select from, if conducted verbally or by telephone then it is comprised of frequently standardised answers which in turn make it easier to compile the results, compare them and analyses them.

The questionnaire requires the respondent to fully understand the questions being asked, if they do not understand then this method of data collection is impractical to apply (Fellow and Liu, 2003). It is therefore important for the person conducting the research to ensure that the questions are clear and their use is clearly explained and attached to the questionnaire.

Questionnaires have been selected as appropriate for application in this particular type of research, for the reason that the target sample are professionals in the construction industry, therefore interpersonal contact is not essential to explain and break down language barriers. This type of technique is used to explain and answer the question behind the lack of adoption and implementation of light steel frame as an alternative building method for primary schools in South Africa. (Maroge, 2012).

3.5.2.1 Validity and Quality issues of data collected

According to Saunders *et.al* (2012) one of the major challenges on the quality issues of the data collected is to ensure that the data will enable research questions to be answered. The recommended method in ensuring data validity and quality is to create a data requirements table, where the outcome is summarized. The table will help ascertain the level of detail that is

required, the variables for which data are to be collected and thus to develop the questions. (Maroge, 2012).

3.6 Justification for the selection and application of strategy

The methods, approach, strategies and the different data collection techniques that can be used to collect data for this research have been explored above. After having done research and a review of the different methods, the method that is suitable for this research is the Quantitative method. This is primarily due to the numerical nature of the data collected.

Having reviewed the three different types of approach, this was the most appropriate as there is a limited amount of literature pertaining to the topic at hand that has already been studied and reviewed in the literature review chapter. The main purpose is to bring about an identified problem in the industry as per the research problem outlined (Maroge, 2012).

The type of data collection chosen for this research is a questionnaire. The research adopted two different types of questions. This was dictated by the type of questionnaire sent out, which was self- completed by respondents. Questionnaires are relatively structured as stated above. The respondent follows the questions outlined by the researcher in order to gather research related data.

The main advantage of this type of data collection method is that when compared to other methods, questionnaires do not require too much time and effort from the respondents. This was important for the reasons that when interviewing working professionals during working hours, time is a major factor (Maroge, 2012).

Saunders *et.al,* (2012) stated that questionnaires are standardized questions with several options for answers, which make it easier to compile results, compare and analyze the output. As stated above, this method was selected looking at the sample subjects targeted. Inter personal contact is not essential for project managers as they are professionals and the questions asked are clear and the questionnaire will be effective for data gathering, this is emphasised by Maroge (2012).

In order to make sure that the questions formulated for the questionnaires are specific to the subject at hand, research was done on the literature review outlined in Chapter 2. The review of

existing literature concerning the light steel frame construction is helpful as it allows for a more in- depth approach when drafting the questionnaires (Maroge, 2012).

Questionnaire technique was selected based on a study conducted on the type of data collection methods available and their limitations outlined above. In order to ensure that the most effective type of data collection is selected, the other methods had to be fully explored in order to choose a specific type of data collection method for this particular study. Explanatory research projects are usually conducted using interviews. However, this type of method proved to be challenging. It is for the reasons that apart from the fact that it is relatively time consuming for the respondents, it proved to be a risk to lose direction of the interview in that the interviewer needs to be experienced in conducting interviews. (Maroge, 2012)

Maroge (2012) motivated that the choice of a questionnaire technique was influenced by the fact that professionals are targeted and thus a properly designed questionnaire would attain the information required in the appropriate time. There was a confidence that the right person would respond, this was assured by preceding the questionnaires with an email to the respondents to explain the purpose of the questionnaire and request a response. (Maroge, 2012)

3.6.1 The design of the questionnaire

When designing the questionnaire the flow and layout of the questionnaire was determined before designing the actual question content. The intention was to make sure that there is logical flow of the questionnaire and to minimise the risk of respondents skipping questions as they find them ‘annoying’, this was emphasised by Maroge (2012). The length of the questionnaire was kept manageable for a busy professional to get through and easy to complete. Covering the questionnaire was a letter to explain the purpose of the questionnaire. This was done primarily to get permission from the respondents to email questionnaires and to clarify the purpose of the questionnaire.

The first section of the questionnaire set out to profile the respondents of their professional state and the experience they have in the construction industry as a whole and of light steel frame construction. This was a section entailing short questions accompanied by a list of possible answers which were split into ranges to select from. This was done to understand the background

of the respondents and to assess the level of knowledge/experience and understanding with regard to LSF.

The second section of the questionnaire included 'multiple choice' questions. This section set out to answer the research question, which was to find out the reason behind the lack of adoption and implementation of light steel frame as an alternative building method for primary schools in South Africa. The last section of this questionnaire was semi- structured; where respondents were asked to give opinions as to what could be done for the technology to be implemented in the South African construction industry, and this was for recommendation purposes to the two departments in queston.

The table below illustrates the factors most perceived to be the main cause of lack of adoption and implementation of light steel frame as an alternative building method for primary schools in South Africa.

Table 1: Questions outlined in questionnaire

Perception questions outlined in questionnaire	Source
Limitation of job creations in communities.	Marley, 2015
Perceived as a temporary accommodation solution. Perceived as an overseas construction method only. Strength outlook. Accreditation. Perceived as a threat to the industry rather than innovation. High expenditure in familiarizing builders with the technology.	Barnard, 2010
Failed attempt High educational costs	GDID, 2013; stand 47
South African construction industry inhibits new technologies.	Murray, 2015
Reluctance in embracing new ideas. Weak demand-side in terms of number of clients who have access to innovative techniques	Morledge (2000)
Hesitant decision making bodies in embracing the new technology.	Gann and Salter (2000)

3.6.2 Validity of the data collection technique selected

The validity of the data collection technique was taken into consideration when designing the questionnaire to ensure that the data collected represented the reality of what is going on in the construction industry. The questions were designed to ensure that they cover all aspects of the

research study. The literature was extensively reviewed and applied when designing the questions used to collect data. Another validity measure considered is called predictive validity. This refers to the ability of the questionnaires to make accurate predictions (Maroge, 2012).

The questions had to be clear and precise so that they remain consistent and are not misinterpreted by the respondents. The way in which the questionnaire is structured was to give the respondent a clear indication of what information is required, so as to produce consistent findings. Validity of the questionnaire was carried out by comparing the data with the existing literature on the topic. The data collected were compared to test the consistency and the reliability of the responses. (Maroge, 2012).

Appendix C shows the questionnaire circulated to the two departments mentioned above sampled for the purpose of this research and was done to respect the respondents' time and to keep them interested in completing the questionnaire. When designing the questionnaire, research was done on the previous studies carried out to adopt questions where necessary. This measure was taken as a reliability assessment step, as it has allowed data findings to be compared for correlation with previous studies (Maroge, 2012).

3.7 Sample Size and selection

Having selected a questionnaire as a data collection technique, data sampling and generalizing of results was possible. The sample size in this case was directly influenced by the research questions and objectives, in that what is needed to be found out and useful to answer the research questions was from credible sources thus generalizing from the responses would render the data valid. The Gauteng department of Education and Gauteng department of Infrastructure Development have been targeted for this study, for the reason that they have relatively more experience and influence with regard to the topic in hand as they plan and construct the educational facilities.

As stated in the assumptions in Chapter 1, the Gauteng department of Education and the Gauteng department of Infrastructure Development are deemed to be a single unit due to the manner in which the two departments operate jointly. The Gauteng department of Infrastructure

Development carries out mandate from the Gauteng department of Education, which makes the two department work together to produce a united product.

From the two departments, professionals from the construction industry were chosen to be respondents for this study (Architects, Project Managers, Quantity Surveyors, Electrical Engineers, Civil & Structural Engineers, Health & Safety Representatives, Foreman and Mechanical Engineers). From the selected population, a total of 105 research questionnaires were distributed to the Gauteng department of Education and Gauteng department of Infrastructure Development. Fifty five (55) questionnaires were sent to GDE, and fifty (50) were distributed at GDID. The 55 GDE questionnaires were sent electronically whereas the other 50 to GDID were hand delivered, this represents that 52% of questionnaires were electronically mailed and 48% were hand delivered.

Out of the 105 questionnaires distributed, a total of 52 responses were received from the two departments mentioned above. The overall response rate was 49.5%, which was found satisfactory for the study.

3.8 Analysing Data Collected

Due to the nature of the research method selected, the best suited approach to analyze the quantitative data collected is through the use of the deductive approach (Saunders *et.al,* 2012). This has been described by Lyn (2009) as the type of approach adopted where existing theory has been made use of to formulate research questions and objectives. This is applicable to this type of research and as a result the use of the framework reviewed will be helpful to organise and analyse the data collected. (Maroge, 2012)

The data display and analysis were done through data reduction, where the data were summarised and simplified by displaying the collected data in the form of tables and graphs. The reason for using graphs is that they are easy and quick to read and interpret. They allow for comparison between responses so as to draw a relationship in the responses given to answer the research question (Maroge, 2012).

3.9 Ethical Statement

To ensure that this research adhered to the School of Construction Economics and Management policy regarding research ethics, ethical challenges that might arise during this research were considered.

The questionnaires sent out to the two departments had a full disclaimer explaining what the purpose of the research is so as to notify the recipients that they are used as a subject for research. The disclaimer also ensured the participants that the Data Protection Act is followed, for example their particulars will not be distributed for any purpose and that the information provided will be treated with confidence. This gave way to a formal form of consent.

The key issues that may have ethical issues in the research are underlined below:

Collection of data (Population identification and access to information): Private respondent's information was not required, however, all information was treated with high confidentiality. This research treated the Gauteng department of Education and the Gauteng department of Infrastructure Development as a joint entity because of the manner in which the two departments operates jointly. The two Gauteng departments are used as a single population.

Analysis of data: Data was handled in a cautious way even without any personal information from the respondents.

Presentation and Dissemination of data: If the findings of this research were to somehow affect the reputation of the Gauteng department of Education and the Gauteng department of Infrastructure Development, a decision can be made as to whether such information can be disseminated or not. All these underlying issues have been thoroughly thought of, and a mechanism to mitigate the risk will be put in place in the course of the research.

Anonymity: A letter with the university logo accompanied every questionnaire to make the respondents feel safe, and to realize their importance in partaking in the research. The letter ensured that anonymity was guaranteed for all respondents, none of the respondents were requested to issue any personal details (*i.e*., names, age, residential address, *etc*.)

During data collection, the participants providing data were not less than the age of sixteen (16) years and had the right to discontinue participation should they wish to without reason. The data collected and analysed during this research are made available to all participants who participated on request.

4 Data Presentation and Analysis

4.1 Introduction

In this chapter the main findings of the study, which seek to address the research question and hypothesis statement, are presented. The objectives of the research are also discussed. These findings are based on information provided by survey results and literature review. The responses are presented in three segments: first segment profiled the respondents, second segment answered the research question and the third segment are views from the respondents as to how and what could be done for LSF building to be adopted and implemented as an alternative building method for primary schools in South Africa.

4.2 Response to Questionnaires

Table 2 below illustrates the number of questionnaires that were distributed to the Gauteng department of education and Gauteng department of Infrastructure Development, and the response received.

Table 2: Questionnaire Response Rate

Organisation	Questionnaire Distributed	Questionnaire Received	Response Rate (%)
Gauteng department of education	50	14	13.33
Gauteng department of Infrastructure Development	55	38	36.19
Total	105	52	49.52

Maroge (2012) stated that for results to be generalised the sample should be a true representative of the population it comes from (Welman, Kruger and Mitchell, 2005). This means that the sample to be used to arrive at a conclusion should not be too big or too small but large enough for the researcher to make a decisive conclusion about the population. Sorinolu (2008) echoed this concept by claiming that when a research is being undertaken, it is important that the researcher have a sample that will represent the population that is being investigated because investigating the whole population is not always feasible due to time and financial constraints.

Therefore it is crucial to have sufficient response in order to make an inference decision when conducting a research survey. Sidumedi (2009, p.48) summarizes the importance of enough response and claim that higher response rate helps to reduce the problem associated with non-response biasness. As already mentioned, the response rate of forty nine percent (49.52%) for the study was found satisfactory.

4.3 Profile of the Respondents

4.3.1 Position in the Organisation

The question sought to understand the influence individual respondents may have in the organisations they represent and projects they work on. This was found to be invaluable information that would benefit the study in that the information obtained is from individuals with enough influence and power, and this was to help in establishing the most probable reasons behind the lack of adoption and implementation of light steel frame constriction in the South African construction industry. From the respondents: 12% were architects, 28% were project managers, 24% were quantity surveyors, 9% were electrical engineers, 6% were civil and structural engineers, 3% were health and safety representatives, 6% were mechanical engineers and 12% were interior designers.

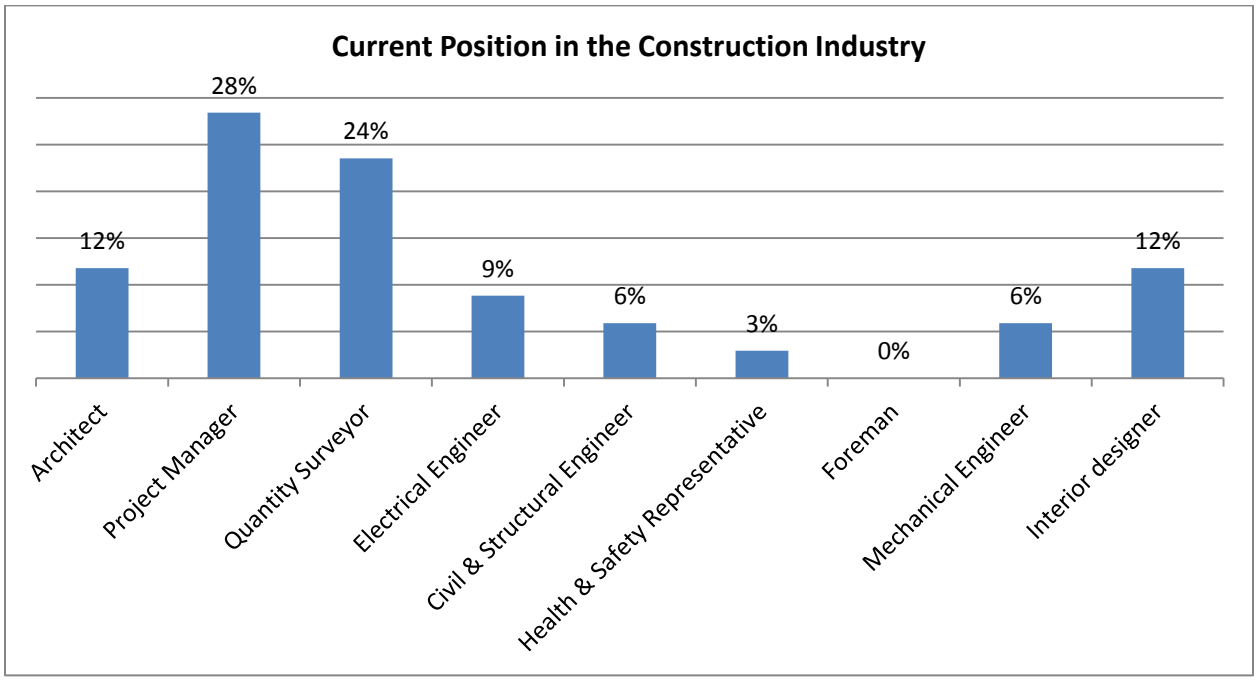

Figure 7: Position in the organisation

4.3.2 Experience in the construction industry

This question was to find out the number or years each respondent has in the construction industry. This was to understand the experience each one has which would be of high importance in understanding the intensity of the responses to be received. The survey showed that 50% of the respondents have been in the construction industry for less than 5 years, 27% are between 5 & 10 years and only 23% percent of the respondents have been in the construction industry for more than 10 years. This is an indication that between the two departments in question, the majority is young people compared to older people. The experience within the construction industry between the two departments is not as vast and broad as compared to the industry as a whole.

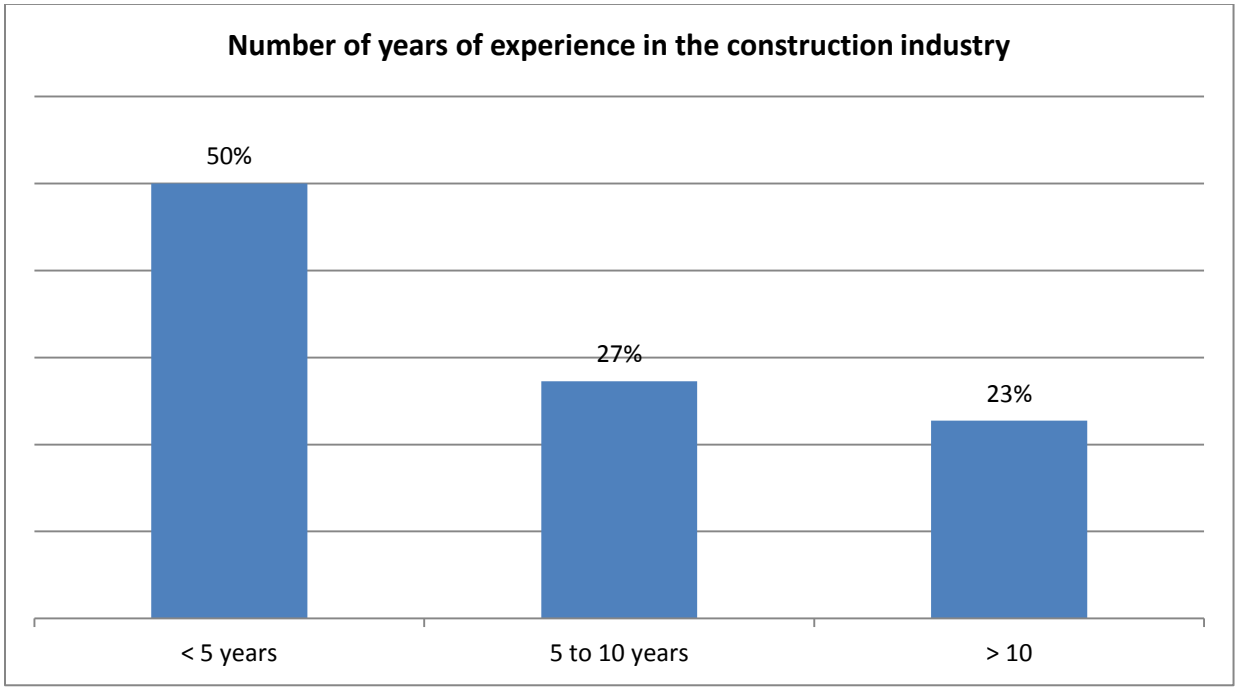

Figure 8: Experience in the construction industry

4.3.3 Number of construction projects involved in

It was discovered in the previous question that the majority of the respondents have less than 5 years in the construction industry. The question in hand is adjoined with the previous one in finding out the number of construction projects each respondent has been exposed to or involved in, in the number of years each respondent has been in the construction industry for. The survey reveals that 32% of the respondents have been involved in less than 5 construction projects between the two departments, 18% of the respondents have been involved in 5 to 10 construction projects within the two departments in question and 50% have been involved in more than 10 construction projects.

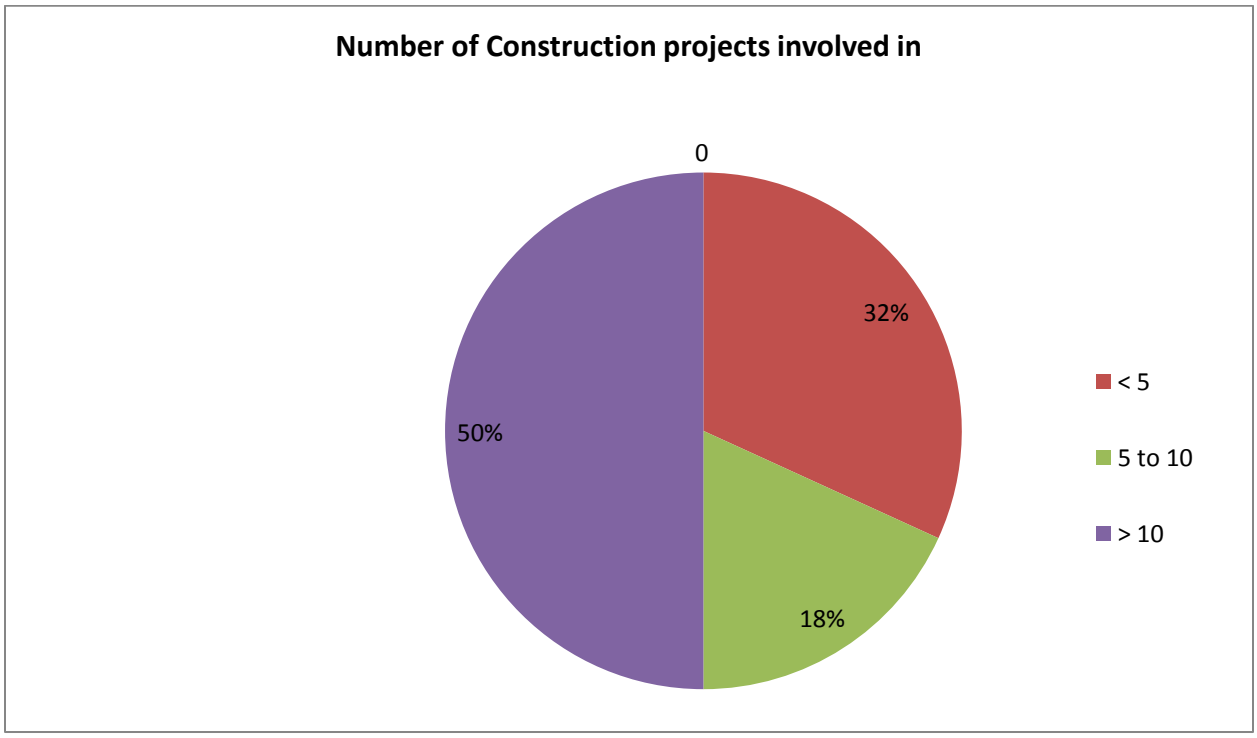

Figure 9: Number of construction projects involved in

4.3.4 Experience Light Steel Frame Projects

In understanding the main reason behind the lack adopting and implementing light steel frame building as an alternative building method in South Africa, respondents were asked if they have ever worked on any light steel frame project in the Gauteng region. The survey showed that only 25% of the respondents have worked on a light steel project and the majority of 75% have never worked on any light steel frame project. This is an indication that majority of the respondents in the South African construction industry have never been exposed to this technology and therefore have no experience with regard to light steel frame construction.

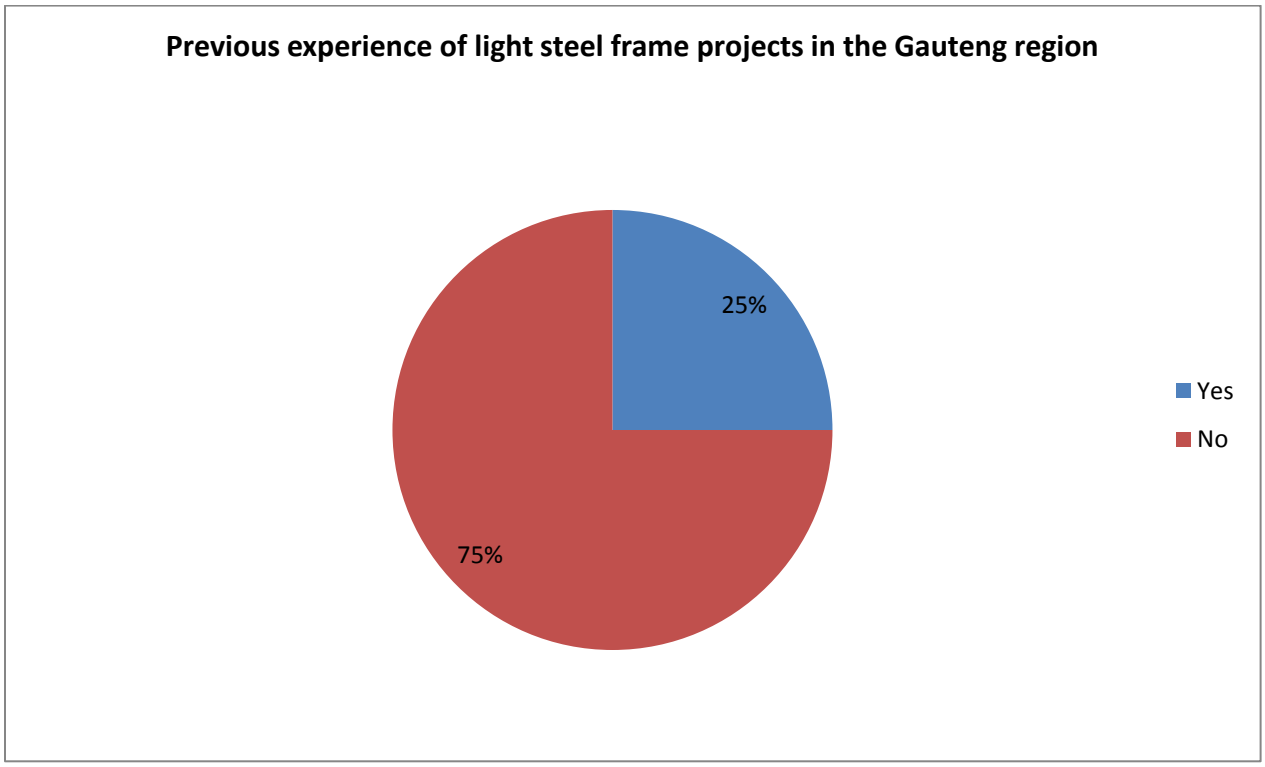

Figure 10: Experience with regard to light steel frame projects in Gauteng

4.4 Perception of light steel frames as a building solution

In order to find out and understand the possible reasons why light steel frame is not considered as an alternative building method for primary schools in South Africa, respondents were requested to rank the most probable factors that could be most applicable to the possibility of the lack of adopting and implementing light steel frame construction as an alternative building method in South Africa. A three-point multiple choice option was used to measure the respondent's knowledge as identified in the literature review: least applicable, neutral and highly applicable.

4.4.1 Limitation of jobs creation in communities

The traditional brick and mortar building method has proved to be associated with a huge turnout for temporary employment for the local communities where the construction project would be at. It has also been established in the literature review that the light steel frame building method has a very low construction period turnaround. It is again a mandate for government to create jobs for the citizens of South Africa, be it temporary or permanent. Respondents were asked if the limitation of job creation would be one of the reasons behind the adoption and implementation of the light steel frame building as an alternative building method in the South African construction industry. The survey indicated that 22% of the respondents thought that this could not be one of the reasons behind the lack of interest, 23% of the respondents showed uncertainty and 55% responded by showing that the limitation of jobs could be one of the reasons why the South African construction industry is not entirely showing interest in adopting this new technology.

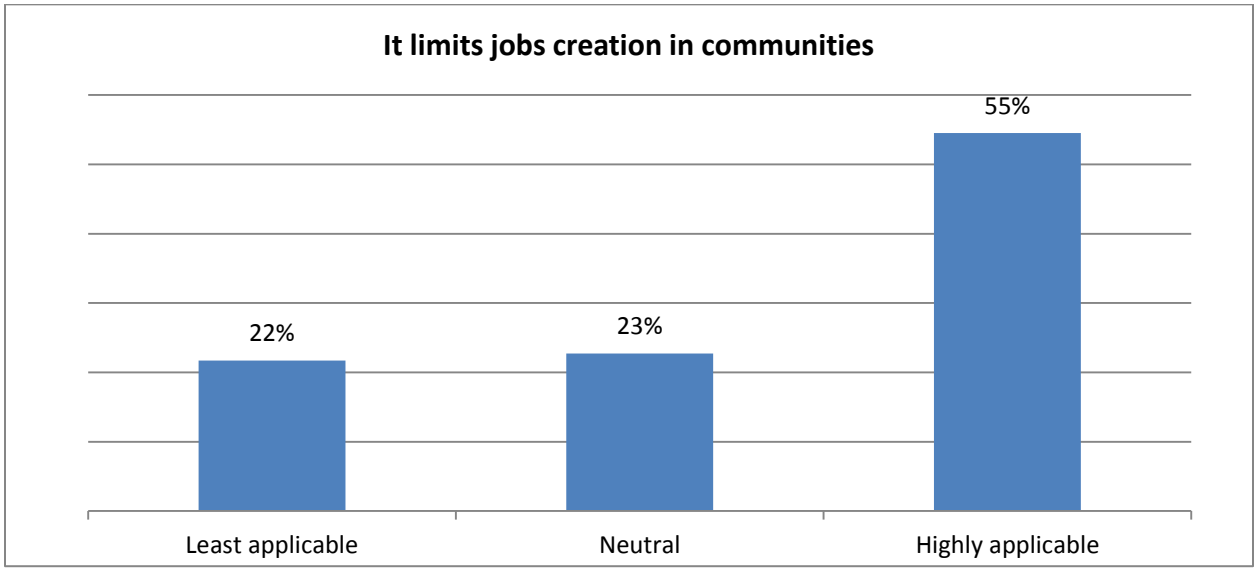

Figure 11: Limitation of jobs creation in communities

4.4.2 Temporary accommodation solution

In the history of restorative/alteration construction projects in primary schools, the temporary accommodation solution is always the hired mobile classrooms (modular buildings). These temporary classrooms are erected over the shortest space of time and allow renovations on existing classrooms to commence. The respondents were asked if perceiving the light steel frame buildings as a temporary accommodation solution could be one of the possibilities that the South African construction industry does not entertain this building method as an alternative building method. The survey indicated that 26% of the respondents thought that the light steel frame building method being perceived as a temporary accommodation solution could not be the reason behind the lack of adoption and implementation of this technology. 13% of the respondents were uncertain and 61% of the respondents showed that perceiving light steel frame building method as a temporary accommodation solution could be one of the factors behind the lack of adoption and implementation of this building method.

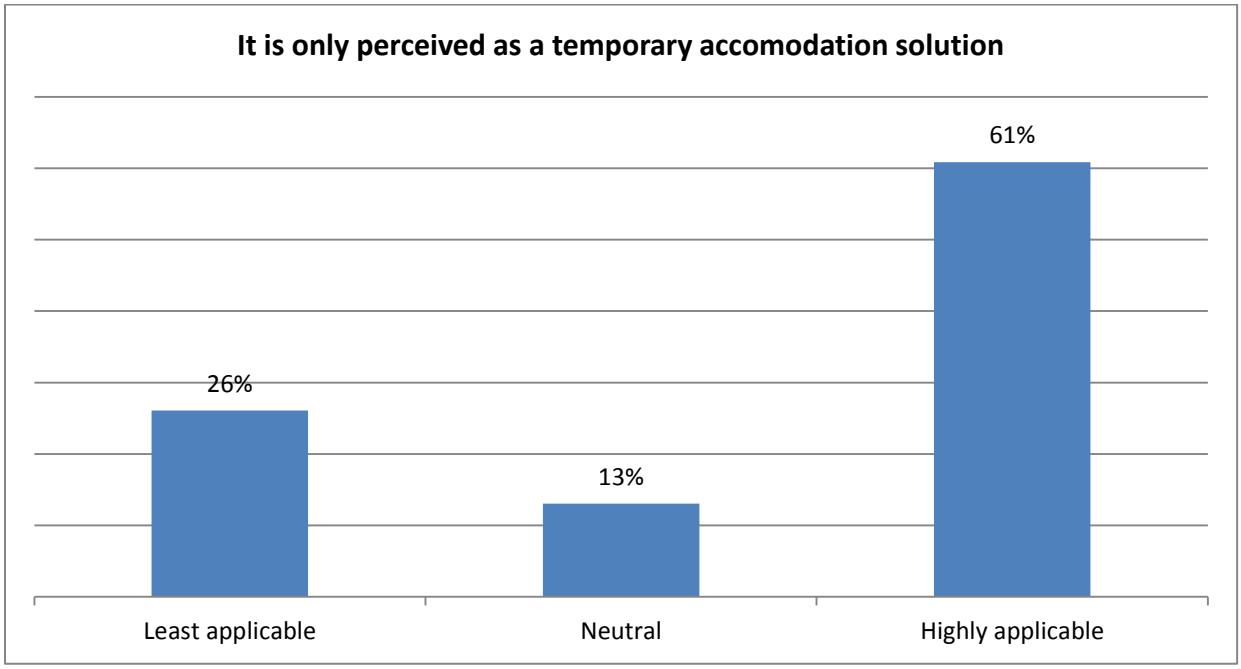

Figure 12: Temporary accommodation solution

4.4.3 Overseas method

It was discussed in the literature review that the light steel frame building method has been extensively used in the USA, Europe and Australia. It also has been established that in the last 10 years this building method has been introduced in the South African construction industry. The respondents were asked if they thought that perceiving light steel frame building as an overseas construction method could be one of the reasons behind the lack of adoption and implementing this technology within the South African construction industry. The survey indicated that 30% of the respondents did not think that perceiving this technology as an overseas construction method could be the reason behind the lack of adoption and implementing this technology within the industry. 13% of the respondents were uncertain. 57% of the respondents thought that perceiving this technology as an alternative building method in South Africa could be one of the reasons behind the lack of adoption and implementation of light steel frame building as an alternative building method in South Africa.

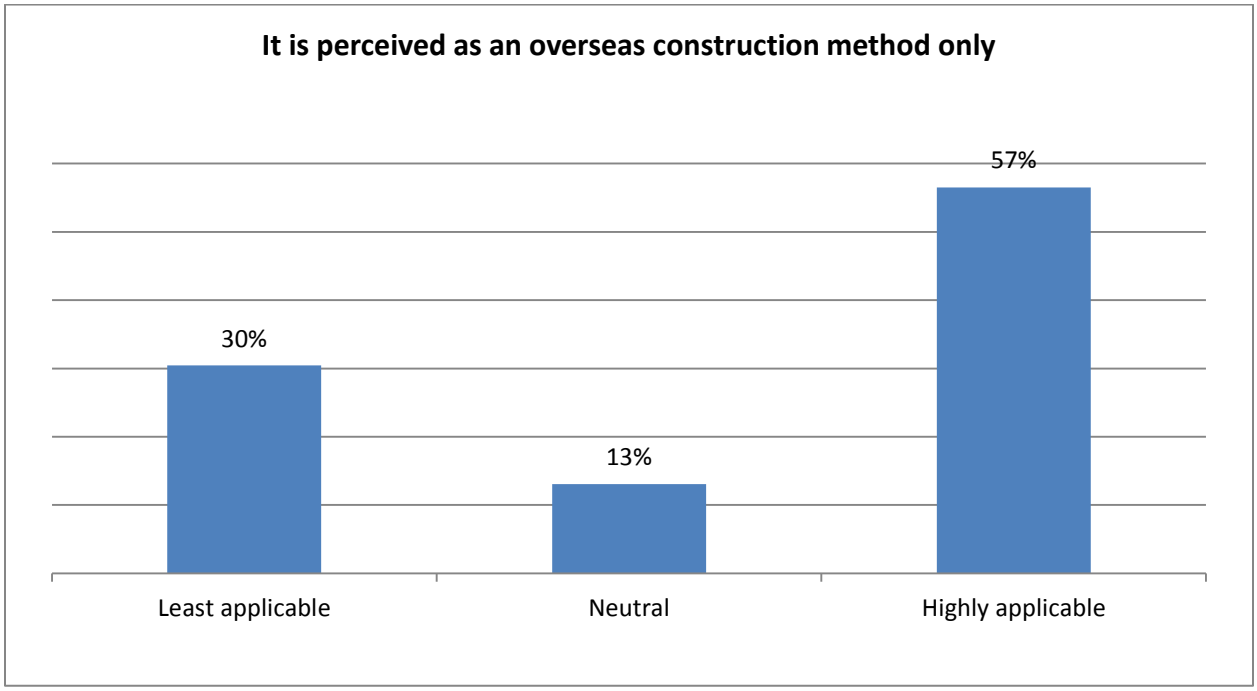

Figure 13: Perception as an Overseas Method

4.4.4 Strength outlook

The human mind believes what it sees every day and get used to the idea that a certain something is done or conducted in a certain manner. Anything that looks or feels unfamiliar to the known becomes either rejected, questionable or criticized. The traditional brick and mortar method assures the end users that they are getting a final product of a great quality because of the known combination of materials. The respondents were asked if the light steel frame does not look strong, and if that is one of the reasons behind the lack of adoption and implementation of this technology in the South African construction industry. 33% of the respondents responded by indicating that the appearance of the end product could not be the reason behind the lack of interest. 14% of the respondents were uncertain. 53% thought that the appearance of the structure could be one of the reasons behind the lack of adoption and implementing this technology. People could just see boards and assume that the structure is not strong without learning about the complete structure itself and the qualities of all its components.

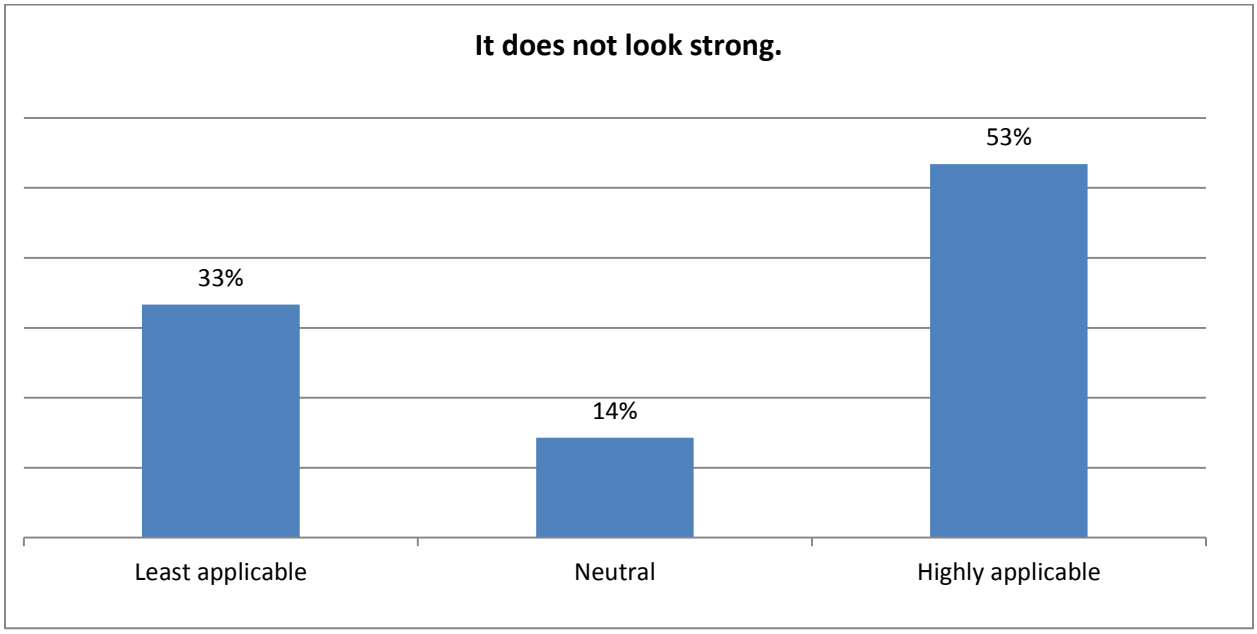

Figure 14: Perception of Strength

4.4.5 Lack of skilled contractors in South Africa

South African construction industry is known for the bricks and mortar building method and that method is the mostly used one. Contractors within the construction industry in South Africa have experience, knowledge and understanding of the brick and mortar method. The respondents were asked if the lack of skilled contractors when it comes to light steel frame construction could be one of the reasons behind the lack of adopting and implementing this technology. 30% of the respondents thought that the lack of skilled contractors could not be the reason. 35% of the respondents were uncertain. The remaining 35% of the respondents thought that the lack of skilled contractors in the South African construction industry could be one of the reasons why the industry is not adopting and implementing light steel frame construction as an alternative construction method.

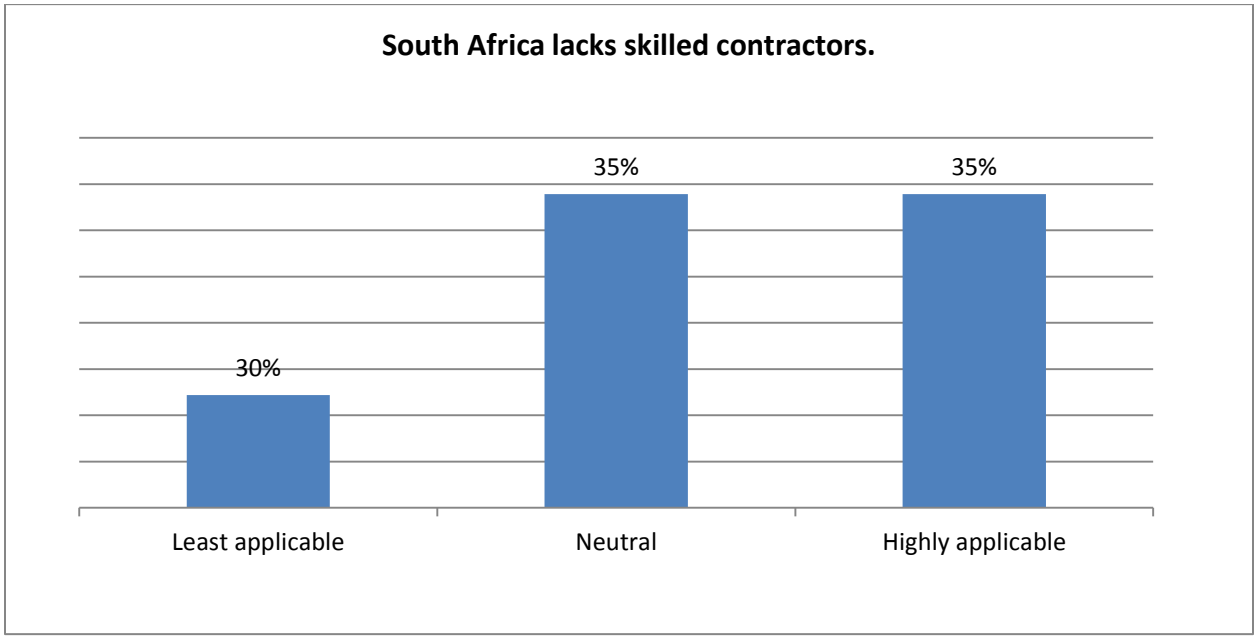

Figure 15: Lack of skilled SA contractors

4.4.6 Cost Implications

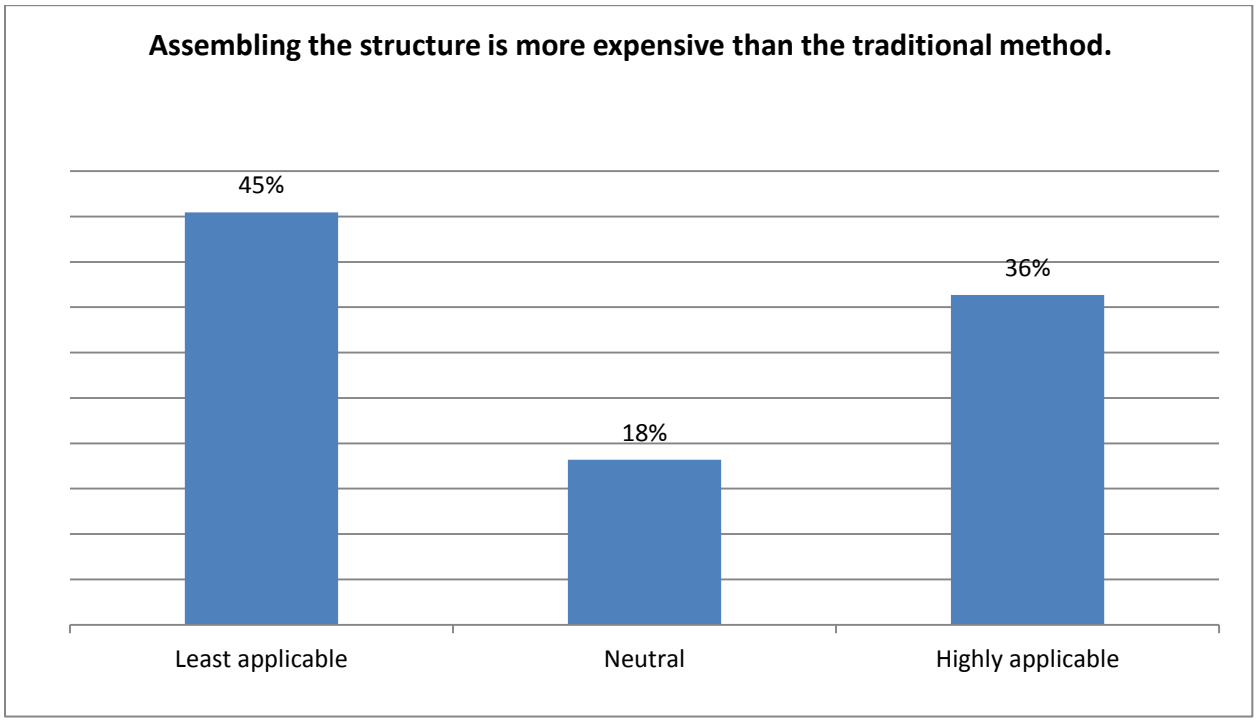

Figure 16: Perceptions over Cost of Assembly

It was discovered that light Steel Frame Buildings offer quality, cost efficiency and speed of erection. The respondents were asked about the cost comparisons between the light steel frame construction and the traditional brick mortar, if the possibility of the new technology's cost being higher than the traditional method, being one of the reasons behind the non-adoption and non-implementation of the new technology. The majority of 45% thought that that could not be the reason behind the lack of adoption and implementation of this technology. 18% of the respondents were uncertain. 36% of the respondents thought that could be one of the reasons behind the lack of adoption and implementation of the new technology.

4.4.7 Failed attempt

Respondents were asked if the previous attempt had an effect on the lack of adoption and implementation of the new technology. The majority of 59% thought that the previous attempt could not be the reason behind the lack of interest in adopting and implementing the light steel frame as an alternative construction method. 36% were uncertain and the minority of 5% thought that the reason stated could be one of the hindrances in the adoption and implementation of the technology. We have learnt of the success story of a primary school constructed through this technology.

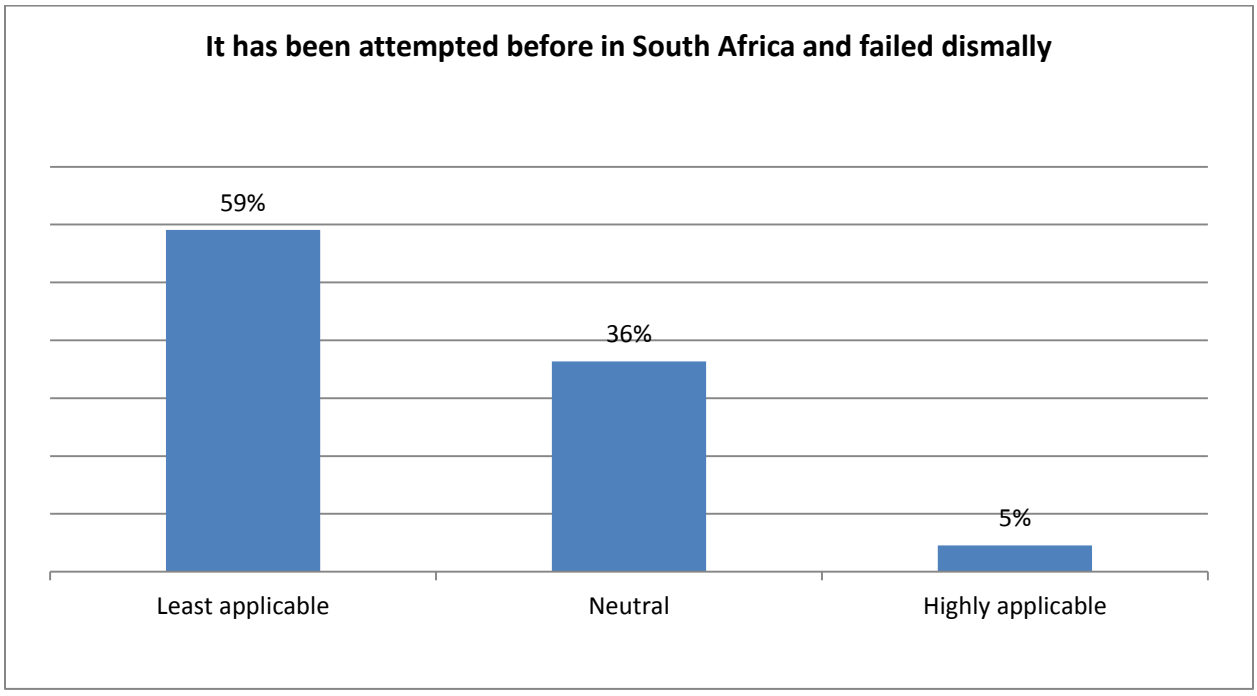

Figure 17: Perceptions of Historical Failure in Application

4.4.8 Accreditation

The literature review revealed that the entire building is regulated, all materials that form part of the building are regulated and the quality of the building itself. It was learnt that **SANS 517** offers strict requirements that need to be satisfied in order to obtain access to municipal approvals. It covers everything from foundations to roof structures of the light steel frame structure. In addition external cladding (fibre cement) must adhere to **SANS 803** and **SANS 10409**. Further more, the light steel must comply with regulations as set out by South African Steel and Iron Association.

SASFA (South African Light Steel Frame Association) is task to regulate the industry standard, develop and test the system and train contractors. Every LSF projects require an engineer to sign off a rational design as per Act 14 of 1990 declaring that the building is "deemed to satisfy" above-mentioned act. **SANS 10400** allows for an Agreement Certificate that declares a project "fit for purpose".

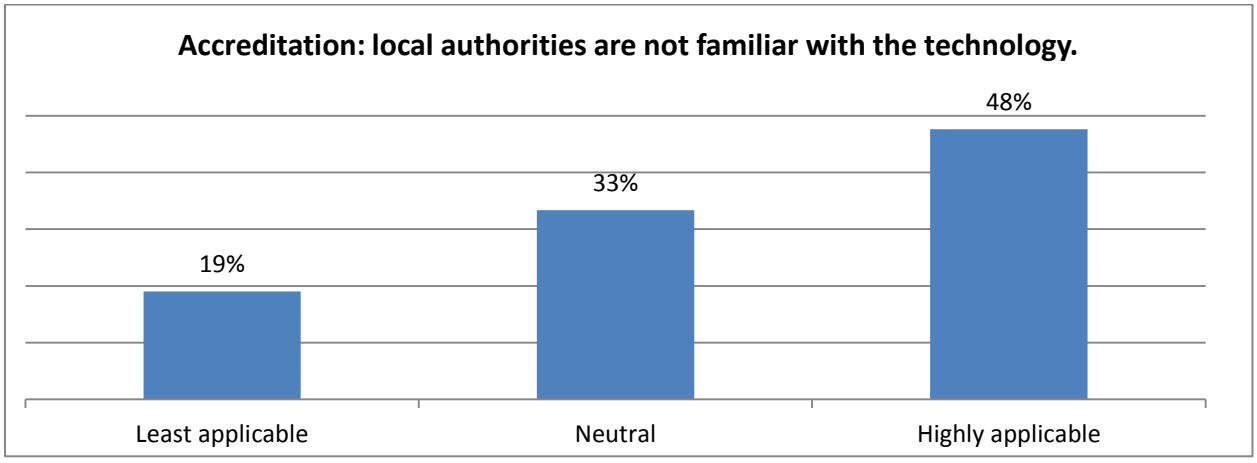

Figure 18: Local Authorities Familiarity with the Technology

Respondents were asked if accreditation in South Africa could be the reason behind the lack of adoption and implementation of the technology. 19% of the respondents did not think that accreditation could be one of the hindrances behind the adoption of this technology. 33% of the respondents were uncertain. The majority of 48% of the respondents thought that accreditation could be one of the reasons behind the lack of adoption and implementation of the light steel frame construction

4.4.9 Threat to the industry

A new idea or change comes with fear; it could be fear of the unknown or due to past experiences. Contractors and suppliers who are already established in the South African construction industry could see this technology as a huge threat. This technology could be a threat to their already known ways. 14% of the correspondents disagreed with the thought that the technology's lack of adoption and implementation could be due to contractors and suppliers seeing this technology as a threat to their businesses. 9% of the correspondents were uncertain. A majority of 77% of the respondents thought that this could be a major reason behind the lack of adoption and implementation of this technology.

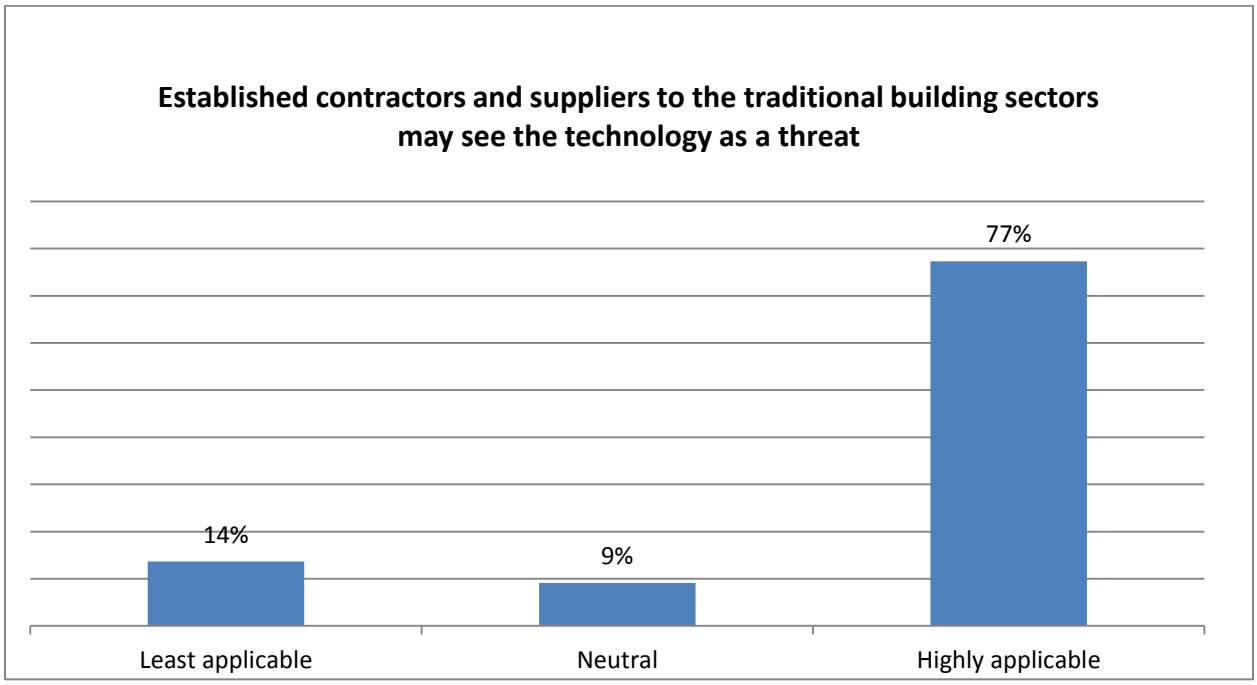

Figure 19: Perceived Threat to Traditional Building Sectors

4.4.10 Educational costs

One of the challenges that come with new technologies in the South African construction industry is the education that comes with the implementation. The technology needs to be introduced to the stakeholders through extensive workshops and practical work, and all this could be a bit heavy on the pocket. Could the high expenditure associated with introduction of the technology be a hindrance to the adoption and implementation of this technology? 22% of the respondents thought that the expenditure could not be a reason behind. 17% of the respondents were uncertain. The majority of 61% thought that expenditure could definitely be the reason behind the lack of adoption and implementation of the technology.

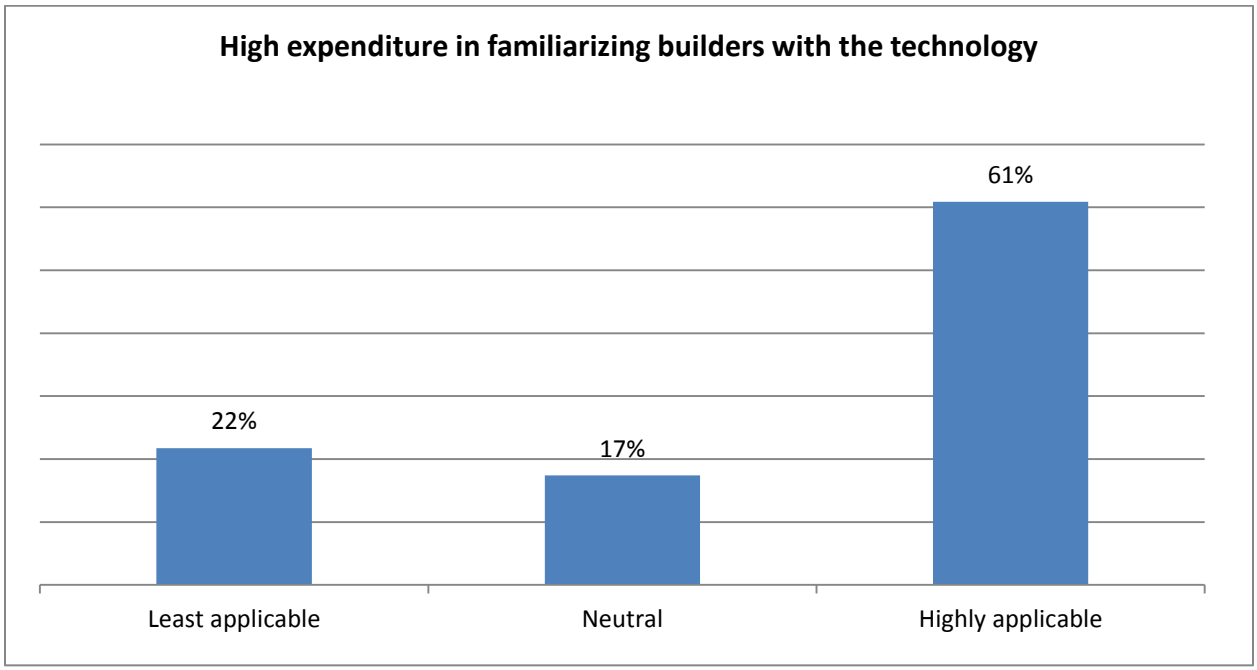

Figure 20: Perceived high educational costs

4.4.11 Inhibition over new technologies

It was discovered in the introduction of this study that this technology has been tried before by the client department and the implementing department, but was never continued with. Could it be that the South African construction industry inhibits new technology? The question was posed to the respondents. 32% of the respondents did not agree with the question and that it could be one of the reasons behind the lack of adoption and implementation of the technology. 27% of the respondents were uncertain. 41% of the respondents thought that the chances of the South African construction industry inhibiting the technology could be one of the reasons behind the lack of adoption and implementation of the technology.

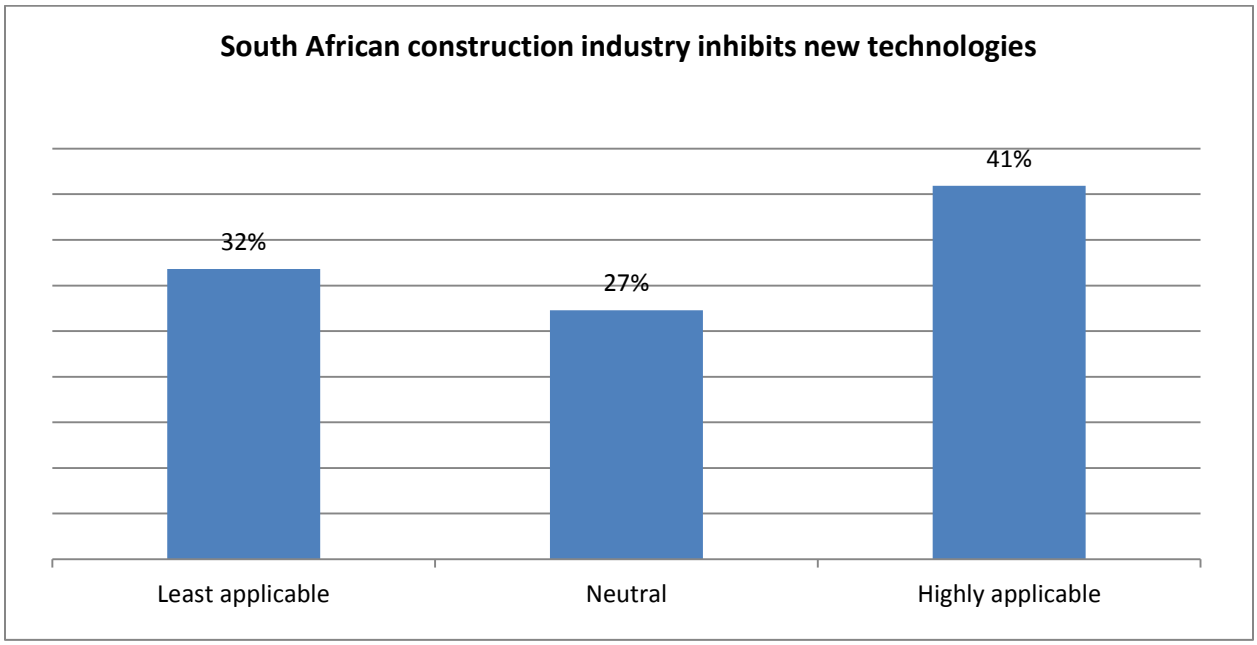

Figure 21: Perceived inhibition over new technology

4.4.12 Supply reluctance

The supply side of the construction industry could be reluctant to supply the industry game players with the necessary tools for light steel frame to be adopted and implemented, but were the suppliers ever tried and tested? The respondents were asked if one of the reasons for the lack of interest in adopting and implementing light steel frame as an alternative method could be a result of the reluctance from the suppliers in the construction industry. 22% of the respondents did not support or agree with the question. 35% of the respondents were uncertain. 43% of the respondents agreed with the question and thought that the reluctance to embrace new idea from the suppliers could be one of the reasons behind the lack of interest or hindrance in the adoption and implementation of light steel frame as an alternative construction method in the South African construction industry.

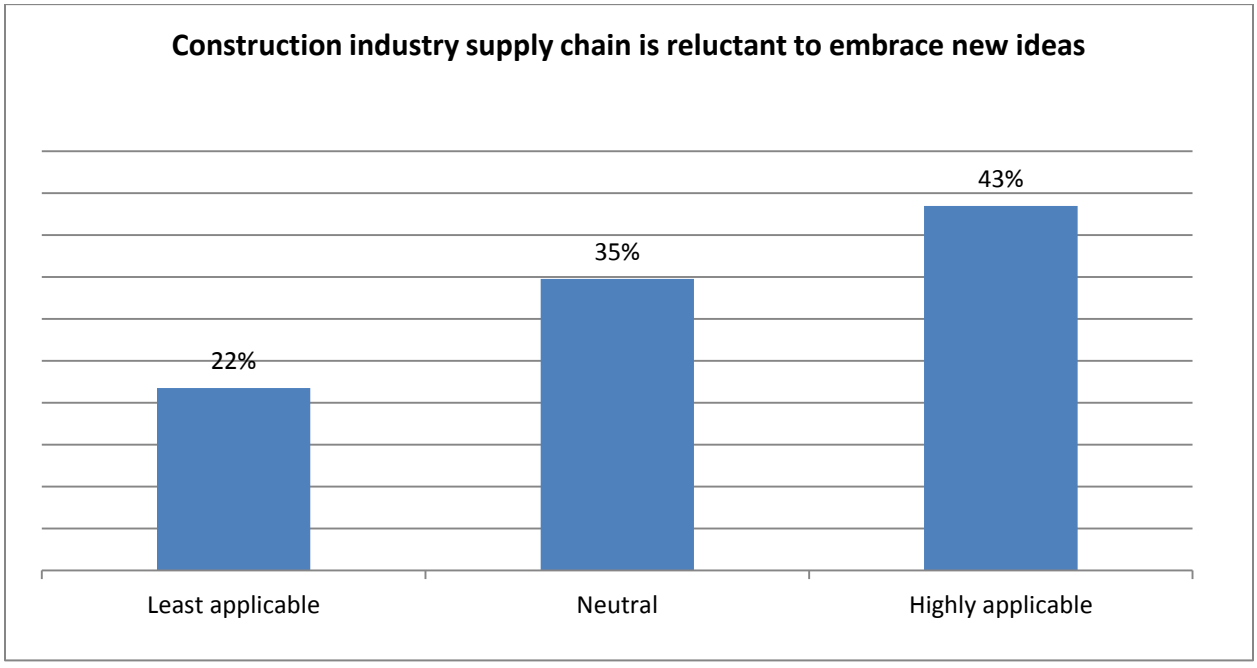

Figure 22: Perception on supply reluctance

4.4.13 Weak demand

It was discovered in the literature review that the demand side in terms of number of clients who have access to innovative techniques is weak. Debate would be clients would not demand a product they are not familiar with; they will always go for the known. Are the innovative techniques exposed to every game player, or is it assumed that since they do not demand anything to do with innovative techniques (which they might not be exposed to), there is no high demand. From the respondents, 18% did not think that there is a weak demand side, hence the lack of adoption and implementation of light steel frame as an alternative construction method. 27% of the respondents were uncertain. 55% of the respondents thought that there is a weak demand side in terms of number of clients who have access to innovative techniques hence the lack of adoption and implementation of light steel frame as an alternative construction method in the South African construction industry

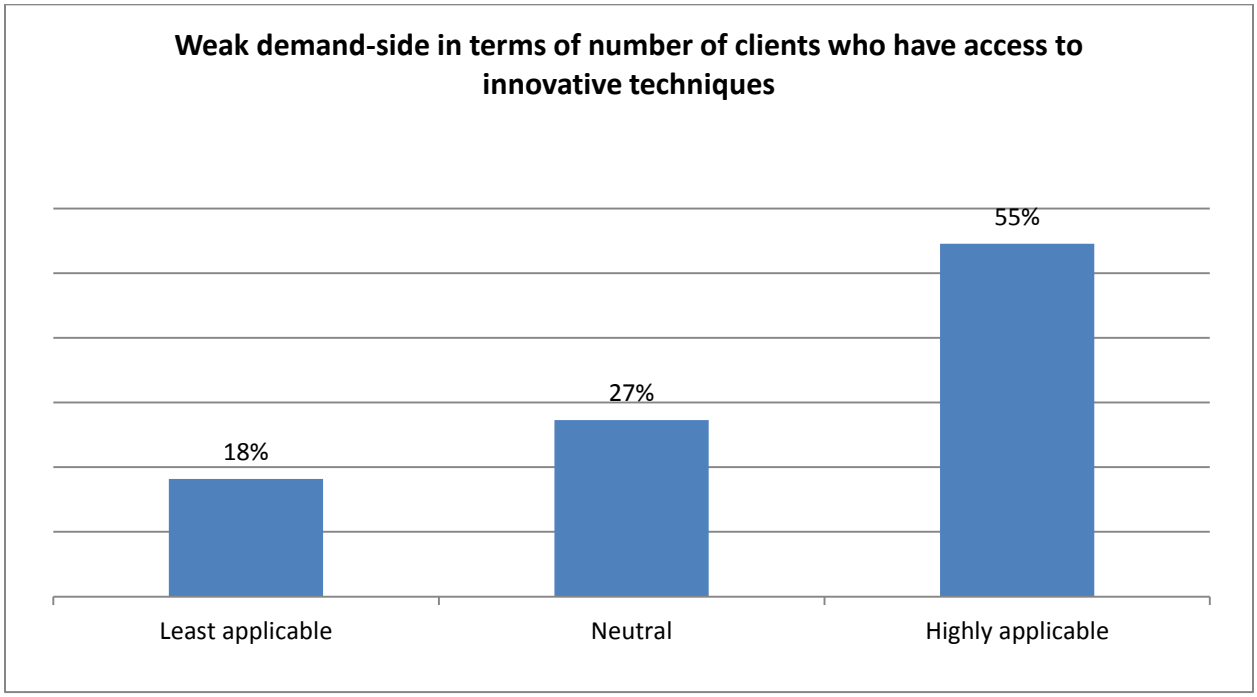

Figure 23: Perception on weak demand

4.4.14 Hesitance by Decision-making Bodies

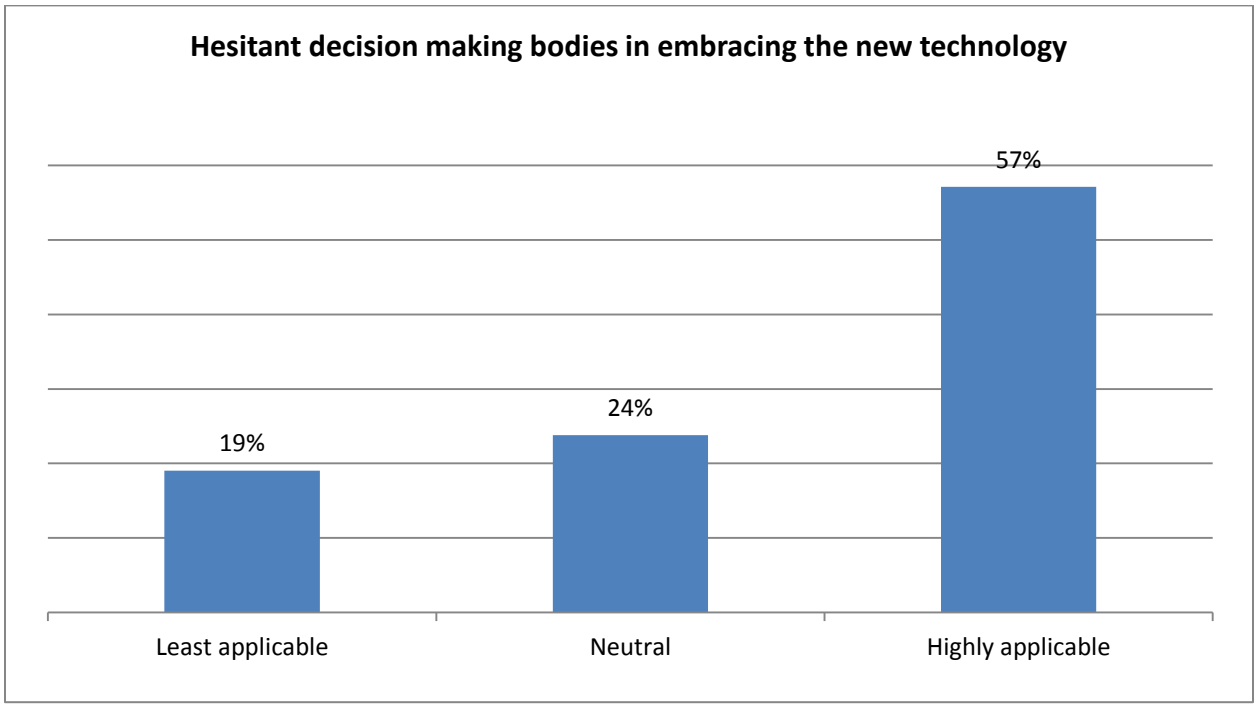

Figure 24: Perception on hesitant making bodies

Decision-making bodies in the South African construction industry could be hesitant in making decisions that embrace the light steel frame as an alternative construction method. The respondents gave their thoughts and views in the matter. 19% of the respondents thought that the hesitant decision making bodies in embracing the new technology could not be one of the reasons for the lack of adopting and implementing light steel frame as an alternative construction method. 24% of the respondents were uncertain and 57% of the respondents thought that hesitant decision making bodies in embracing the light steel frame as an alternative construction method in the South African construction industry.

4.5 Questionnaire overview

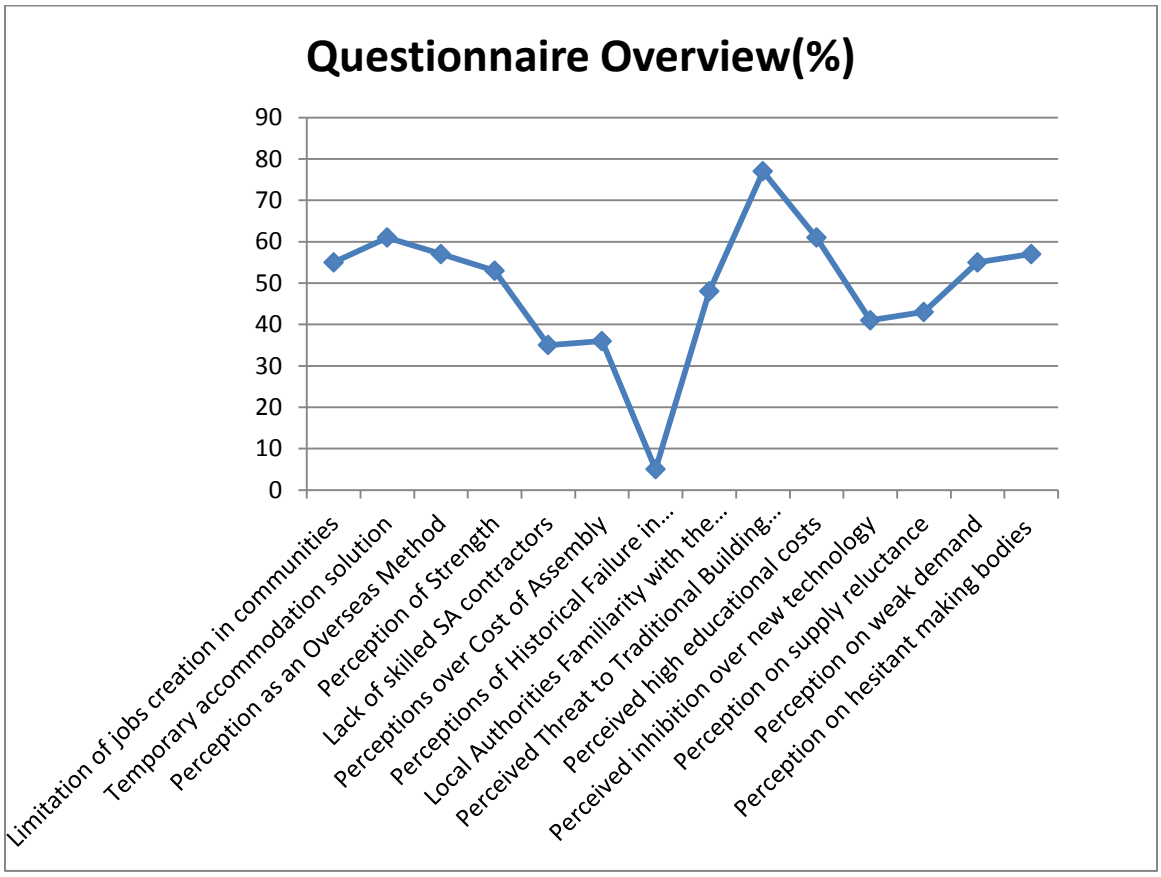

Figure 25: Questionnaire overview

From the graph indicated above, majority of the most perceived factors are between the 50% and 60% range. These factors include the limitation of job creation in communities due to the implementation of this technology. Another factor within this bracket is that the technology is perceived as a temporary accommodation. It is also perceived as an overseas method and also that it does not look strong, to the public, hence the strength outlook of the results of this technology is a concern.

Further more, the weak demand for this technology is a concerning factor and that the decision making bodies are hesitant to vote on this technology. The perceived high educational costs associated with this technology is another popular factor. These highlighted factors seem to be the most popular, but are not the highly perceived factor.

The mainly concerning perception with regard to this technology is that it is a perceived as a threat to the traditional building sectors.

4.6 Summary of Key Findings

The respondents were profiled and the following results were established:

- Majority of the responses received were from project managers who are involved from planning to close out of all the construction projects. The rest of the respondents were from other technical members (quantity surveyors, architects, structural engineers, mechanical engineers, etc.)
- The majority of the respondents from the two institutions used for this research have less than 5 years' experience in the construction industry. More than 50% of the respondents have been involved in 10 or more construction projects.
- More than 50% of the respondents have been involved in more than 10 construction projects.
- Only 25% of the respondents have been involved in light steel frame construction projects, and the majority of 75% have never been exposed to the technology.

Respondents were questioned about what could be the most likely reason for the lack of adoption and implementation of light steel frame as an alternative construction method for primary schools. From the highest most perceived factors to the less perceived, the factors are highlighted below:

The most perceived factor for the lack of adoption and implementation of the technology is that the technology is perceived as a threat in the South African construction industry. Second to that is the high expenses perceived to be associated with the familiarizing of the technology to all the affected stakeholders. In most renovation works to existing primary schools, alternative accommodation provided to the learners are the mobile containers, and this could be confused with light steel frame structure in being temporary accommodation solutions.

South Africa has witnessed very few projects made of light steel frame, hence the technology could be perceived as an overseas construction method. The South African construction industry decision making bodies are seen as hesitant.

The least perceived factor that has very minor effect is the factor that the technology was attempted in the South African construction industry and failed. It was illustrated that the two Departments have attempted this technology and have a successful story to tell. The case study of stand 47 proves the success of this technology.

Furthermore, respondents were again requested to give suggestions as to what could be done to ensure adoption and implementation of this technology in the South African construction industry, and the following suggestions were given:

- Conduct well informative workshops for all stakeholders in the South African construction industry to expose them to the technology.
- Department of education should make it mandatory in their planning stages.
- Though the market for these building methods has not fully developed, perhaps in tender specifications for the building of primary schools, this can be gradually inserted as the building method required.
- Consultative meetings to introduce this technology to the general public will be required to ensure they adopt it and familiarise themselves.
- The building materials should easily be accessible and readily available for supply.
- Need to ensure that the technology is fully accredited.

5 Conclusion and Recommendations

5.1 Revisiting the Aims and Objectives

5.1.1 Research Problem

This research report sought to address the research problem that after having learnt that light steel frame has been used previously to construct a primary school in the Gauteng region and the benefits thereof associated with the technology, the Gauteng department of Education and the Gauteng department of Infrastructure Development are still not implementing the technology for future use.

5.1.2 Hypothesis

Lack of awareness and exposure to light steel frame methods gives rise to incorrect perceptions about its implementation. These incorrect perceptions act as a barrier to LSF The above hypothesis was proved incorrect through the data collected and alaysed. It was rather discovered that the South African construction industry is not very welcoming to alternative methods of building.

Research objectives

The specific objectives of the study were as follows;

- To establish the perceptions of LSF and then evaluate whether these perceptions may be acting as barriers to the use of LSF for primary schools in Gauteng.
- To investigate the effects of innovation in the construction industry.
- To understand the barriers to innovation within the construction industry.
- To investigate the disadvantages associated with light steel frame as a new technology within the South African construction industry.
- To investigate the benefits offered by the light steel frame construction

The above objectives were achieved through literature review and the data collected.

5.2 Conclusions

Innovative ideas can make an enormous difference in the South African construction industry. This alternative building method is sustainable and with more buildings going green it would be wise to use this alternative building method as it is cost effective and can be maintained for primary schools in the Gauteng region and the entire country overall.

The most apparent reason behind the lack of adoption and implementation of light steel frame based on the findings from the study is that the technology is perceived as a threat to the established contractors and suppliers to the traditional building sector. The least apparent reason behind the lack of adoption and implementation is the previous attempt of the technology. This shows that the results from the previous attempt of the technology are not the main reason behind the discontinuation of this technology for building of primary schools in South Africa.

The survey findings indicate a level of resistance within the South African construction industry to accommodate innovative initiatives which could have economic benefits.

5.3 Recommendation

Though the market for this building method has not fully developed, perhaps in tender specifications for the building of primary schools, these can be gradually inserted as building methods required.

At the time of writing this research report the most recent statistics report on innovation and light steel frame construction were way more than five years old. As a result this study recommends that the South African government should play an essential role in publishing reports on different construction technologies/innovation for exposure to the public and all construction related stakeholders.

Based on the literature review and survey results that were discussed above, it is evident that the light steel frame construction is a foreign concept that requires continuous research and development. Therefore further research is recommended in the following areas of study:

- A couple of reasons were explored which would be possible reasons behind the lack of adoption and implementation of light steel frame as an alternative building method in South Africa. A related study would be undertaken to discover the measures to be taken to implement this technology fully in the South African construction industry.

References

Anderson, F. and Manseau, A. 1999: *A systemic approach to generation/transmission/use of innovation in construction activities*. Paper presented to the Third International Conference on Technology Policy and Innovation: Global Knowledge Partnership – Creating Value for the 21st century, Austin: TX. 30 August–2 September.

Barlow, J. 2000: *Innovation and learning in complex offshore construction projects*. Research Policy 29 (7–8), 973–89.

Barnard, D,. 2011, *Light steel construction and modular homes as alternative building methods in South Africa*. University of Pretoria

Blayse A.M. Manley K.,gann (2004),"Key influences on construction innovation", Construction Innovation, Vol. 4

Burows, B G and Seymour, D E (1983) '*The evaluation of change in the construction industry.*' Construction Management and Economics, 1(3), 199-215

Campagnac, Elisabeth (1998) '*National system of innovation in France: Plan Construction et Architecture.*' Building Research and Information Volume 26(5), 297-301 Construction Forum.

Dale, J. (2007) *Innovation in construction: Ideas are the currency of the future*. CIOB

Davies, R. (2006) Talking about construction innovation. *In:* Boyd, D (Ed) *Procs 22nd Annual ARCOM Conference,* 4-6 September 2006, Birmingham, UK, Association of Researchers in Construction Management, 771-780.

Dosi, G. (1982) *Technological paradigms and technological trajectories*. Research Policy, 11, 147± 62.

Dubois, A. and Gadde, L.-E. 2002: *The construction industry as a loosely coupled system: implications for productivity and innovation*. Construction Management and Economics 20 (7), 621–32.

Duke, R. (1988) *Local Building Codes and the Use of Cost- Saving Methods*, U.S. Federal Trade Commission, Bureau of Economics, Washington, DC.

Egan J. (1998) *Rethinking Construction*, Department of the Environment, Transport and the Regions.Fellows, R., Liu, A. (2003). *Research methods for Construction*. Blackwell Science 2nd Edition.

Fellows, R., Liu, A. (2003). *Research methods for Construction*. Blackwell Science .2nd Edition.

Fleck, J. (1994) *Learning By trying: the implementation of configurational technology*. Research Policy, 23, 637± 52.

Frankfort-Nachmias, C. and Nachmias, D. (1996) *Research Methods in the Social Sciences*. Fifth Edition, Arnold, London.Gale, A.W. and Fellows, R.F. (1990) '*Challenge and innovation: the challenge to the construction industry.*' Construction Management and Economics, 8(4), 431-436

Gann, D.M. and Salter, A. 2000: *Innovation in project-based, service-enhanced firms: the construction of complex products and systems*. Research Policy 29 (7–8), 955–72.

Gann, David M. (1998) '*Do regulations encourage innovation? The case of energy efficient housing.*' Building Research and Information Volume 26(5), 280-296

Gillham, B. (2000*). Case Study Research Methods*. Continuum International Publishing Group.

Goodman, P.S. and Griffith, T.L. (1991) *A process approach to the implementation of new technology*. Journal of Engineering and Technology Management, 8, 261± 85.

Gray C. (1996) *Value for Money: Helping the UK afford the Buildings it Likes*, Reading

Hogg K I (2000) *Factors inhibiting the expansion of value methodology in the UK construction sector Conference Proceedings; Society of American Value Engineers*, Reno, USA; 2000.Johnson,K.D. and Tatum, C.B. (1993) *Technology in marine construction firms*. Journal of Construction Engineering and Management, 119(1), 148± 62.

Koskela, L. and Vrijhoef, R. 2001: *Is the current theory of construction a hindrance to innovation*? Building Research and Information 29 (3), 197–207.

Kumaraswamy, M. and Dulaimi, M. 2001: *Empowering innovative improvements through creative construction procurement*. Engineering Construction and Architectural Management 8 (5–6), 325–35.

Lowe, John, G.(1996) '*Technological change and construction*.' Journal of Financial management of Property and Construction 1(2), 65-94

Lyn, Richard and Janice M. Morse. (2009) *Read me first for a user's guide to qualitative methods*. 3rd ed

Maroge, N.J. (2012) *An investigation into the use of safety risk management to improve project parameter in the construction industry in South Africa*. Construction Management and Economics

Meyer, A.D. and Goes, J.B. (1988) *Organizational assimilation of innovations: a multilevel contextual analysis*. Academy of Management Journal, 31(4), 897± 923.

Morledge, R. (2000) *Marketing – A Solution to Construction Market Failure*, International Journal for Construction Marketing, Vol 1, Issue1

Murray, M. (2004). *The use of project management techniques in the management of safety and health in construction projects*. Proceedings of the International Conference of CIB Working Commission 099 – Implementation of Safety and Health on Construction Sites, pp. 171 – 194.

Nachimas, C. and Nachimas, D. (1996) *Research methods in the Social Sciences*. 5th Edition. Arnold.

Nam, C H and Tatum C B (1997) '*Leaders and champions for construction innovation.*' Construction Management and Economics, 15(3), 259-270

Nam, C.H. and Tatum, C.B. 1997: *Leaders and champions for construction innovation*. Construction Management and Economics 15 (3), 259–70.

Naoum, S.G. (2007) *Dissertation Research and Writing for construction students*.

Butterworth- Heinemann. 2nd Edition. Oxford.

Nelson, R.R. and Winter, S.G. (1977) *In search of a useful theory of innovation*. Research Policy, 6, 36± 76.

Pries, F. and Janszen, F. (1995) '*Innovation in the construction industry: the dominant role of the environment.*' Construction Management and Economics, 13(1), 43-51

Pries, F. and Janszen, F. (1995) *Innovation in the construction industry: the dominant role of the environment.* Construction Management and Economics, 13, 43± 51.

Rosenfeld, Y. (1994) '*Innovative construction methods*.' Construction Management and Economics, 12(6), 521-541

Saunders M., Lewis, P. and Thornhill, A. (2012). *Research methods for business students*. 6th Edition. Pearson Education Limited. London.

Seaden, G. and Manseau, A. 2001: *Public policy and construction innovation*, Building Research and Information. 29 (3), 182–96.

Semlies, C. (1999) *Inter-Firm Collaboration in the Implementation of Structural Innovations in Building Construction*, Master of Science, Massachusetts Institute of Technology, Cambridge, MA.Slaughter, E Sarah (2000) '*Implementation of construction innovations*.' Building Research and Information Volume 28(1), 2-17

Sidumedi K. S. (2009). *An investigation into the relationship between the corporate culture of South African construction firms and performance.* Wits University – Unpublished MSc Research Report.

Slaughter, E.S. (1993b) *Innovation and learning during implementation: a comparison of user and manufacturer innovations*. Research Policy, 22, 81± 95.

Slaughter, E.S. 1998: *Models of construction innovation*. Journal of Construction Engineering and Management 124 (3), 226–32.Slaughter, E.S. (2010) Implementation of construction innovations, Building Research & Information, 28:1, 2-17,

Thames Valley University (2009) '*Dissertation Guide*' [online] Available from http://brent.tvu.ac.uk/dissguide/hm1u1/hm1u1text2.htm. Accessed 12/04/2012

Von Hippel, E. and Tyre, M.J. (1995) *How learning by doing is done: problem identification in novel process equipment.* Research Policy, 24, 1± 12.

Walker, D. and Hampson, K. 2003: *Procurement choices*. In Walker, D. and Hampson, K., editors, Procurement strategies. UK: Blackwell.

Welman, C., Kruger, F. and Mitchell, B. (2005). *Research methodology* – Third edition. Oxford University Press.

Winch (1999) In Barrett, P.S.; Sexton, M.G.; Miozzo, M.; Wharton, A. & Leho, E. Base Report: *Innovation in Small Construction Firms*, (2001), University of Salford / UMIST

Winch, Graham (1998) '*Zephyrs of creative destruction: understanding the management of innovation in construction*.' Building Research and Information Volume 26(5), 268-279

Appendix

5.4 APPENDIX A: Participant information sheet

Dear Participant,

My name is Nyiko Michavi, a student from the University of the Witwatersrand and I am currently in the process of conducting research in fulfilment of my Masters degree in construction project management, under the supervision of Prof. David Root.

The study aims to investigate the perceptions on the use of light steel frame construction methods for primary schools.

You are kindly requested to partake in this research. Your participation in this study is purely voluntary and should you wish not to contribute, you are entitled not to. The questionnaire is completely anonymous and the findings will be presented as summaries. Your name and details shall not appear anywhere and thus will not be requested in the questionnaire. Your participation in completing and submitting the questionnaire gives consent and you are highly appreciated for it.

The questionnaire will only take approximately 5-10 minutes of your time in answering. Your answers will contribute to the successful completion of the research. Your participation is respected and valued. For any concerns and queries, kindly contact me at michaving@yahoo.com or 073 244 5807

The questionnaire can be sent to the above email address or I will personally collect it.

Kind Regards

Nyiko Michavi

5.5 APPENDIX B: Consent form for participating in the study

Study title: **Perceptions on the use of light steel frame construction methods for primary schools.**

I hereby confirm to being briefed by the research conductor, Ms. Nyiko Michavi, about the study. I have read and understand the written participant information sheet. I am aware that the information I provide will be used anonymously and I can withdraw from participating in this study at any time.

I agree to participate in this study.

Participant

_____	_____	_____
Printed name	Signature	Date

I, Nyiko Michavi, herewith confirm that the above study participant has been fully informed about the nature and conduct of the above study

Researcher

_____	_____	_____
Printed name	Signature	Date

5.6 APPENDIX C: Questionnaire: Perception on the use of light steel frame construction methods on primary schools

Participant profile

Q1

What best describes your current position within the Construction Industry?

- Architect
- Project Manager
- Quantity Surveyor
- Electrical Engineer
- Civil & Structural Engineer
- Health & Safety Representative
- Foreman
- Mechanical Engineer

Q2

Provide the number of years of experience in the construction industry.

- < 5 years
- 5 to 10 years
- > 10 years

Q3

Provide the number of Construction projects you have been involved in.

- < 5

5 to 10

> 10

Q4

Have you worked on any light steel frame project in the Gauteng region?

Yes

No

Most probable factors

Why do you think Light steel frame is not considered as an alternative building method in South Africa for primary schools? (Please tick the most appealing, options range from 1 (least applicable), 5 (neutral) and 10 (most applicable)

	Least Applicable	Neutral	Most applicable
It limits job creations in communities.			
It is only perceived as a temporary accommodation solution.			
It is perceived as an overseas construction method only.			
It does not look strong.			
South Africa lacks skilled contractors.			
Assembling the structure is more expensive than traditional method.			
It has been attempted before in South Africa			

	Least Applicable	Neutral	Most applicable
and failed dismally.			
Accreditation: local authorities are not familiar with the technology.			
Established contractors and suppliers to the traditional building sectors may see the technology as a threat.			
High expenditure in familiarizing builders with the technology.			
South African construction industry inhibits new technologies.			
The supply side of the construction industry is reluctant to embrace new idea.			
There is a weak demand-side in terms of number of clients who have access to innovative techniques			
Hesitant decision making bodies in embracing the new technology.			

Please give suggestions on what could be done for South Africa to adopt this building method.

……
……