

**PERFORMANCE IMPROVEMENT IN SOUTH AFRICAN CONSTRUCTION**

**FIDELIS ABUMERE EMUZE**

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THE NELSON MANDELA METROPOLITAN UNIVERSITY**

**PROMOTER: PROF JOHN JULIAN SMALLWOOD**

**SEPTEMBER 2011**

### DECLARATION OF ORIGINAL AUTHORSHIP

I, **FIDELIS ABUMERE EMUZE** on this day 5<sup>th</sup> of September 2011 declare that:

- The work in this thesis is my personal effort;
- Sources used or referred to have been acknowledged, and
- The thesis has not been submitted in full or partial fulfilment of the requirements for an equivalent or higher qualification at any other recognised educational institution previously.

Signed

A handwritten signature in black ink, appearing to read 'F. Abumere', is written over a horizontal line.

## ABSTRACT

In general, dreams are conceived, ideas are conceptualised, and initiatives are embarked upon in order to alter the state of realities. Dreams change realities; when mechanisms are put in place to realise them, dreams succeed. However, anecdotal evidence as well as empirical findings has continued to reiterate the difficulties associated with realising dreams related to construction projects.

Extending the ‘dream’ analogy to the South African construction industry context therefore paints an uninspiring picture. Dreams associated with construction do not have a 100% chance of becoming realities as evident in reported poor project performance in the industry. Shattered dreams in the form of poor performing projects, poorly implemented construction processes, or worst, projects delivered at the expense of unexpected cost to the client as a direct result of poor H&S or time overruns, negate the intent of dreams.

This thesis is primarily concerned with project performance related bottlenecks in South African construction. After an extensive review of related literature that entails the analysis of publications related to non-value adding activities (NVAAs), supply chain management (SCM), and system dynamics (SD) in the construction project management realm, an exhaustive mixed-mode quantitative survey was conducted among key participants in the South African infrastructure sector. Public sector clients, consulting engineers and contractors that were involved in civil engineering projects were surveyed repeatedly with approximately five survey instruments at convenient intervals. Results arising from the study, *inter-alia*, indicate that:

- an appreciable amount of NVAAs occur in South African construction;
- these NVAAs become further compounded when propagated into other value adding activities (VAAs) in the construction process;
- the identified NVAAs equally perpetrate the menace associated with poor performance to the detriment of the achievement of cost, H&S, quality, and time project targets, and
- the root cause of these NVAAs that often contribute to poor performance is not far from the much reported ‘shortage of skills’ in South Africa.

Notable contributions to the body of knowledge include SD models are extendable regardless of the source of their empirical data as evident in the qualitative models proposed in this study; within the SD domain, it is advisable to consider the ‘competence’ of individuals assigned to tasks especially in a developing country as this study revealed that human resources issues predominate among the sources of NVAAs that eventuate in a range of poor project performance; the NVAAs that occur, and their causes on projects are perceived to be due to lapses and / or inadequacies that involved the entire construction supply chain; there is no single construction process / task that is immune from being affected by NVAAs; and within the South African, and by implication construction context generally

in developing countries, the adequacy of required knowledge among project stakeholders is the most crucial determinant of project performance.

As opposed to what is obtainable in developed countries, the construction industry in developing countries, particularly in South Africa, should take advantage of knowledge management (KM) techniques such as brainstorming, communities of practices, and face-to-face interactions. These techniques can be driven through appropriate mentorship programmes, industry focused built environment education, and other human resources driven avenues that do not necessarily require substantial investment in technologies, so that to a large extent organisations in the industry can prioritise KM, and thereafter, continually engage in it for future performance improvement.

Using inferential statistical methods for hypotheses testing, and SD concepts for creating qualitative models led to a range of recommendations which, *inter-alia*, propose that halting the tide of NVAAs and poor performance requires the management of both tacit and explicit knowledge gained in construction; and most importantly, it requires the assurance that ‘competence’ is the overriding criteria for selecting project partners, and also, for assigning either design or construction related activities to responsible parties involved in project realisation in South Africa.

In effect, in order to engender a culture of continuous improvement in South African construction, other considerations should be subservient to ‘competence’ in the construction supply chain. Competence must be located among everyone involved in project realisation, that is, enhancing the competence of all involved in project realisation is as good as ensuring performance improvement, which in turn, equates to the acceleration of project delivery in South Africa.

**Keywords:** Construction, Infrastructure, Supply Chain Management, Non-Value Adding Activities, Performance, Procurement, System Dynamics, South Africa

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## DEDICATION

First and foremost, this thesis is dedicated to the love and inspiration of my father, Deputy Superintendent of Police B.A Emuze (Rtd), the first educated civil servant from Izogen, and the one that laid the foundation that culminated in the pursuit of this study.

Second, the thesis is dedicated to the unknown and faceless construction stakeholder that failed to achieved pursued dreams because of lapses relative to H&S in the industry; struggles daily in order to retain its workforce by maintaining certain levels in its order book due to a lack of profitability and the unattractive image of the industry, and failed to achieved targeted objectives due to lacklustre project performance.

*Therefore, God Almighty, the thesis is dedicated unto you for the sole reason that the intent of the study shall be realisable as transformation in the form of fewer accidents, increased profitability, and improved service delivery for the benefit of the South African construction industry, and the sub-Saharan African region as a whole shall begin to manifest.*

*Derhalwe, God die Almagtige, word hierdie tesis aan U opgedra want slegs dan kan dit wat met hierdie studie beoog word gerealiseer word in die vorm van minder ongelukke, `n toename in winsgewendheid en verbeterde dienslewering in die konstruksiebedryf wat tot voordeel sal strek van Suid-Afrika en die Sub-Sahara Afrikastreek in geheel<sup>1</sup>.*

Ngoko ke, thixo somandla, ndibulela wena ngalencwadi yophando ngoba, ngayo izakunciphisa iingozi, yandise ukwenziwa kwemali, ize iphucule ukunikezelwa kweenkonzo kwicandelo lezokwakha laseMzantsi Africa nalasembindini welizwekazi i-Africa jikelele<sup>2</sup>.

*Olorun lo ni Ogo*

*Olorun Baba, Olorun Omo, Olorun Emimimon Iba Re o<sup>3</sup>*

*Osablua U Wese<sup>4</sup>*

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<sup>1</sup> Afrikaans-A major language in South Africa

<sup>2</sup> Xhosa- A major language in South Africa

<sup>3</sup> Yoruba- A major language in Nigeria

<sup>4</sup> Edo-A major language among the minorities in Nigeria

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## **ABBREVIATIONS**

|        |                                                           |
|--------|-----------------------------------------------------------|
| 3D     | Three dimensional                                         |
| ACSA   | Airports Company South Africa                             |
| AEC    | Architectural, Engineering and Construction               |
| AsgiSA | Accelerated and Shared Growth Initiative for South Africa |
| BAA    | British Airports Authority                                |
| BBBEE  | Broad Based Black Economic Empowerment                    |
| BE     | Built Environment                                         |
| BIM    | Building Information Modelling                            |
| BOT    | Build-Operate-Transfer                                    |
| C&D    | Construction and Demolition                               |
| CETA   | Construction Education & Training Authority               |
| CII    | Construction Industry Indicators                          |
| cidb   | Construction Industry Development Board                   |
| CLD    | Causal Loop Diagram                                       |
| CLM    | Council of Logistics Management                           |
| CoA    | Cost of Accidents                                         |
| D&B    | Design and Build                                          |
| DBFO   | Design-Build-Finance-Operate                              |
| EDMS   | Electronic Document Management Systems                    |
| EPC    | Engineering, Procurement and Construction                 |

|       |                                                  |
|-------|--------------------------------------------------|
| FIDIC | International Federation of Consulting Engineers |
| GCC   | General Conditions of Contract                   |
| H&S   | Health and safety                                |
| ICT   | Information and communication technology         |
| IGLC  | International Group for Lean Construction        |
| IT    | Information Technology                           |
| ITS   | Information Management System                    |
| JBCC  | Joint Building Contracts Committee               |
| JIT   | Just in Time                                     |
| KM    | Knowledge Management                             |
| KPI   | Key Performance Indicators                       |
| LADPW | Local Authorities Department of Public Works     |
| NEC   | New Engineering Contract                         |
| NVAA  | Non-value adding activities                      |
| OGC   | Office of Government Commerce                    |
| OSC   | Organisational Supply Chain                      |
| PFI   | Private Finance Initiative                       |
| PPP   | Public Private Partnership                       |
| PRA   | Pugh-Roberts & Associates                        |
| PSC   | Project Supply Chain                             |
| R&D   | Research & Development                           |

|        |                                                     |
|--------|-----------------------------------------------------|
| RFI    | Request for information                             |
| RFID   | Radio Frequency Identification                      |
| RSL    | Registered Social Landlords in the UK               |
| SAICE  | South Africa Institution of Civil Engineering       |
| SANRAL | South African National Roads Agency Limited         |
| SC     | Supply Chain                                        |
| SCM    | Supply Chain Management                             |
| SCO    | Supply Chain Organisation                           |
| SD     | Systems Dynamics                                    |
| SFU    | Standard for uniformity in construction procurement |
| SME    | Small and medium size enterprises                   |
| SPV    | Special Purpose Vehicle                             |
| T5     | Heathrow Terminal 5                                 |
| TQM    | Total Quality Management                            |
| VAAAs  | Value adding activities                             |
| VSAAs  | Value supporting activities                         |
| VMI    | Vendor-managed-inventory                            |
| UK     | United Kingdom                                      |
| USA    | United States of America                            |

## **DEFINITION OF TERMS**

### **Innovation**

Innovation is the application of new knowledge to industry, and includes new products, new processes, and social and organisational change (Firth and Mellor, 1999 cited by Widen, 2003: 144).

### **Knowledge management**

Knowledge management (KM) is the process by which information is created, captured, stored, shared, transferred, implemented, exploited, and measured to meet the needs of an organisation (Egbu *et al.*, 2001 cited by Emmitt and Gorse, 2003: 25).

### **Logistics**

According to the Council of Logistics Management (CLM), logistics can be defined as that aspect of the supply chain process that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements (Blanchard, 2004: 4).

### **Organisational culture**

Organisational culture can also be defined as the way things are done and operated within the internal environment of the workplace (Naoum, 2001: 162).

### **Procurement**

Watermeyer and Jacquet (2004: 1.1) define procurement as the process which creates, manages, and fulfils contracts relating to the provision of supplies, services or engineering and construction works, the hiring of anything, disposals, and the acquisition of any rights and concessions.

### **Non-value adding activities**

Non-value adding activities (NVAAs) are wasted efforts that consume time and resources without directly or indirectly adding value to project requirements (Han *et al.*, 2007: 2082).

### **Supply chain**

Supply chain is a set of three or more entities (individual / firms) directly involved in the upstream and downstream flow of products, services, finances, and / or information flow from a source to a customer (Blanchard, 2004: 6).

### **Supply chain management**

Supply chain management is the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular firm and across businesses with the

supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole (Blanchard, 2004: 6).

### **System dynamics**

System dynamics (SD), which is partly a method for developing management flight simulators in the form of simulation models, is a method to enhance learning in complex systems. SD models are developed to enhance learning about complex systems, understand the sources of policy resistance, and also to facilitate the design of more effective policies. Therefore, SD is fundamentally interdisciplinary because it is not only concerned with the behaviour of complex systems, but also it is grounded in the theory of nonlinear dynamics and feedback control developed in mathematics, physics, and engineering. In addition, because SD tools are applied to the study of behaviours of human, physical, and technical systems, it draws on cognitive and social psychology, economics, and other social sciences (Sterman, 2000: 4-5).

### **System thinking**

System thinking is the ability to see the world as a complex system in which we understand that “you can’t just do one thing” and that “everything is connected to everything else.” (Sterman, 2000: 4-5)

System thinking is a discipline for seeing wholes rather than snapshots, that is, it is a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static snapshots.” (Senge, 2005: 68)

## **1.0 BACKGROUND OF THE STUDY**

### **1.1 Introduction**

Innovation is the application of new knowledge in an industry in the form of new products, new processes, social change, and organisational change (Firth and Mellor, 1999 cited by Widen, 2003: 144). Innovation is neither a single nor an instantaneous act, but rather it is a whole sequence of events that occurs over time, which involves all activities related to bringing new products to the market (Jones and Saad, 2003: 136). Similarly, process innovation denotes innovation where the process by which a product is developed is not only exposed to new ideas, but also leads to new sophisticated methods of production (Egbu, 2005: 121). Innovation and improvement of the construction process hold benefits for all members of the construction supply chain and the industry.

However, the limited pace of innovations and performance improvement in construction have been a major concern to both the industry and academia. The limited pace is because the construction industry is beset with problems such as inadequate investment in training, research and development; fragmentation; adversarial relationships; inadequate involvement of suppliers, and a large number of small and medium-sized enterprises (Bower, 2003a: 9-11).

The increase in the use of subcontracting within the industry is compounding problems associated with adversarial relationships and fragmentation as there is always another party in the supply chain who is attempting to earn margins to the detriment of other firms in the chain (Cox and Ireland, 2002: 410). In spite of increasing competitive pressures and clients' demand for improved performance, it is surprising that most firms still manage and execute projects in a traditional manner. This may account for firms focusing mostly on the acquisition of work in the short-term in order to survive. The effect of this myopic focus can potentially limit the levels of performance improvement within the industry. These identified and recorded anomalies as well as other project related complexities in the industry gave rise to a number of industry enquiries and subsequent reports.

Published reports suggested different philosophies / or methodologies for improvement in the form of benchmarking; lean construction; total quality management (TQM), and supply chain management (SCM). These suggestions have been widely embraced by the industry to varying degrees and / or forms. The philosophies are all intended to eliminate waste relative to time, material, labour, and finance, and reduce uncertainties in the construction process (Murray *et al.*, 2002: 150). As a result thereof, these suggestions have instigated the introduction of various forms of improvement in the construction process. For example, the primary purpose of SCM is to ensure reliability of quality and delivery time for a given product / service for an agreed price, and at the same time to enable innovation and continuous measurable improvement relative to the product / service (Fisher and

Morledge, 2002: 205). However, Widen (2003: 148) suggests that the level of innovation is dependent on:

- the client's recognition of the need for innovation;
- contractual incentives to encourage innovation;
- creation of symbiotic learning environment, and
- open communication at all levels.

The abovementioned criteria singled out the client as the critical member within the construction supply chain that may be able to influence the upstream and downstream processes in construction. Therefore, the responsibility for creating an effective construction team in an effective contract system to deliver generic and specific project requirements remains largely with the client (Tookey *et al.*, 2002: 132). Thus clients' decisions at the inception of construction procurement impacts project delivery outcomes. In the construction industry context, the specific role of the client indicates that the client is not only the purchaser of the constructed facility as the product, but the decider of if, when, and how a project is executed (Girmscheid and Hartmann, 2002: 373). It follows that in the construction industry, the clients play a principal role in the decision-making process.

Decision processes play crucial roles in innovation as organisations are constantly faced with difficult choices to innovate or not, to select from different innovations and methods of implementation, and the associated uncertainty and risk (Jones and Saad, 2003: 137). Research conducted by Briscoe *et al.* (2004: 199) determined that the client's role in the integration of the construction supply chain is critical. Clients are shown to be the key drivers of performance improvement initiatives as well as the most significant factor in achieving integration in the construction supply chain. The research, which adopted a case study approach to examine construction supply chains, investigated three different client organisations and their supply chains (Briscoe *et al.*, 2004: 194). The findings of the research, which indicated that for SCM to be realised, change must to be driven by construction clients, correlated with the literature. The ability of clients to effect change, or rather innovate in the construction process requires a thorough understanding of the main stages through which innovation is developed (Jones and Saad, 2003: 149). The challenge is how to continuously improve the activities associated with project / or product delivery including design, procurement in the form of tender appraisal and material purchasing, specification, construction, project management, and knowledge management across construction organisations (Anumba *et al.*, 2005: 1). Hence, SCM as a form of innovation has been developed to address the problems associated with outsourcing, to introduce greater coordination and integration, and to respond as effectively as possible to the needs of customers and changes in the wider environment (Jones and Saad, 2003: 222). Anecdotal evidence

therefore suggests that the trend today is to establish ambitious targets, to seek for new technological solutions and concepts, and to look for effective and efficient ways of organising and managing construction projects.

To this end, the South African government acting both as a regulator and client of the construction industry also realised the impact of clients in the quest for industry improvement. This realisation led to the promulgation of the white paper entitled *Creating an Enabling Environment for Reconstruction, Growth and Development in the Construction Industry* (Republic of South Africa, 1999). The white paper provides a framework that enables the construction industry to play a more strategic role in the socio-economic growth of the nation. It sets out Government's vision for an enabling strategy aimed at enhanced service delivery, greater stability, improved industry performance, value for money and the growth of the emerging sector. It is premised on increasing public-sector demand, and identifies the need for improved public sector capacity to manage the construction delivery process. In addition, a major highlight of the white paper was the provision of the platform for the establishment of the Construction Industry Development Board (cidb), having described the impediments to the growth of the industry, and also reiterated the fact that government is a major client of the industry that can influence performance in the industry in section 2.3 of the paper.

Construction SCM emphasises the delivery of value to the client without compromising the ability of each member of the chain to make a fair profit relative to projects. The supply chain (SC) includes all activities associated with procurement, production, scheduling, order processing, inventory management, transport, storage, customer service, and information systems for communication purposes (O'Brien *et al.*, 2009: 2-5). Improved SCM and logistical performance may address construction clients' incessant demand for cost reduction and efficiency in the construction industry (Shakantu *et al.*, 2007: 108).

### **1.1.1 South Africa's Infrastructure Status**

The South African Institution of Civil Engineering (SAICE) (2006: 4) defines built environment infrastructure as that part of a nation's capital stock that produces services that are consumed by members of households such as hospital services, water, sanitation and electricity, or that facilitates economic production or serves as inputs to production such as electricity, roads, and ports. Such infrastructure influences the level of economic development of nations. Though lack of financial and managerial resources can constrain the development and maintenance of infrastructure, yet an emerging nation such as South Africa needs to find ways and means of mitigating these constraints.

South Africa has a reasonably modern and well developed infrastructure, which has declined somewhat over the last decade mainly due to under investment and shortage of skills. The road system is extensive and in relatively good condition. According to the information on the website of the

South African National Roads Agency (SANRAL), the total proclaimed roads in the country amount to approximately 535 000 km in length, 366 872 km of non-urban roads, and 168 000 km of urban roads. These roads fall under the jurisdiction of the National, Provincial, and Municipal spheres of Government ([www.nra.co.za](http://www.nra.co.za)). While the three spheres of Government procure these roads, the responsibility for maintenance falls on SANRAL and the local governments of the nine provinces. However, the road infrastructure is under severe pressure due to inadequate funding of maintenance, overloading of heavy vehicles, and increased volumes of road freight vehicles (Lincoln, 2009: 2).

The ports of Southern Africa play important roles in the economies of each country and the region. Durban is Africa's busiest port and the largest container terminal in Southern Africa and Richard's Bay is the largest bulk coal terminal (Lincoln, 2009: 2). South Africa's extensive rail network is the tenth longest in the world and among the best in the southern hemisphere. Though, the rail lines are used for both passenger and haulage purposes, under funding and low utilisation of the network, have resulted in a backlog of infrastructure challenges that are being continuously addressed by stakeholders.

South Africa's ten major airports, which include three international airports situated in Johannesburg, Durban, and Cape Town, are operated by the Airports Company South Africa (ACSA), who oversees the infrastructure on behalf of the government. Although South Africa's built environment infrastructure is very good, extensive maintenance and refurbishment backlogs have necessitated an increment in investment related to infrastructure development. Eskom, South Africa's power utility parastatal, and Transnet, South Africa's railway and port parastatal have multiyear infrastructure development programmes in excess of R300b, SANRAL and the Department of Public Works as well as other governmental entities also have huge investment plans for infrastructure in the short and long-term. In brief, the summary research report for the Accelerated and Shared Growth Initiative for South Africa (AsgiSA) infrastructure input sector strategy indicates the expected investment in infrastructure between now and 2016 (SPAID, 2007: 10-16). In particular, though focused investment since 2006 has resulted in additional new infrastructure and an improvement in the condition of some existing assets, infrastructure at municipal level remains poor and is deteriorating in many places (SAICE, 2011: 9). Given the expected scale of investment, the performance of the construction industry will be under the microscope. The consequential increase in demand provides an enabling environment to improve the construction process. The primary project parameters of cost, H&S, quality, and time can be improved, and then, benchmarked against the best internationally.

### **1.1.2 South Africa's Construction Industry Performance**

As Africa's largest construction market, most supply chains on the continent can be deemed to point towards South Africa. According to Datamonitor (2009: 8), the value of the South African

construction and engineering industry is \$9.2 billion. The industry grew by 11.7% in 2008 to reach these figures. The civil engineering segment proved to be the most lucrative with 61.6% of the total revenue, while the non-residential building is 38.4%. These segments of the industry are charged with the delivery of infrastructure nationwide. By 2013, the industry is forecasted to have a value of \$15.3 billion, an increase of 67.3% from the 2008 figures (Datamonitor, 2009: 17). The aforementioned statistics indicate the buoyancy of the industry and the level of current and expected infrastructure spend. The investments in the sector necessitate an increase in industry performance. However, the annual cidb survey of contractors, clients, consultants, and other stakeholders that assess the industry performance in the form of construction industry indicators (CII) suggest that the performance of the industry is sub-optima.

For example, the indicators related to completed projects in the year 2007 that were derived from 282 clients and 1 204 contractors from all the nine provinces of South Africa, emphasised the need to raise the performance of the industry as a whole, and in particular, performance related to construction industry indicators such as client satisfaction, contractor satisfaction, profitability and payment delays, procurement indicators, and health and safety (H&S) (cidb, 2008: 2). The report also highlighted areas involving clients and contractors that are in need of improvement. Specifically, the report reveals that:

- clients were neutral or dissatisfied with the overall performance of the contractor on 21% of projects;
- clients were neutral or dissatisfied with the quality of work delivered on 20% of projects;
- around 18% of the projects surveyed had levels of defects which are regarded as inappropriate;
- contractors were neutral or dissatisfied with the quality of tender documents and specifications on around 29% of the projects surveyed;
- contractors were neutral / or dissatisfied with the management of variation orders on 35% of the projects surveyed, and there was a noticeable difference between satisfaction with public sector clients (62%) and private sector clients (72%), and
- 42% of payments by clients were made within 30 days of invoicing, 51% between 30 to 90 days, and 7% over 90 days. Prompt payment of contractors shows a significant deterioration between the 2005 and 2008 surveys. Significant differences were also obtained between the public and private sectors, with only 35% of payments being made within 30 days of invoicing in the private sector and 46% in the public sector.

In empirical terms, published cidb CII reports indicate that a number of lapses are occurring in South African construction. As indicated in Table 1, clients' neutrality / dissatisfaction with respect to contractor performance, level of defects recorded in projects, and construction schedule have

consistently been estimated to occur on approximately 30% of projects surveyed in 2007, 2008, and 2009; delays relative to payment of contractors is on the increase with a steady growth noticeable with payment delays longer than 90 days; and though improvement can be seen in clients neutrality / dissatisfaction relative to quality of works delivered, the management of variation orders, and quality of tender documents, the improvement is however marginal (cidb, 2007: 1; 2008: 1; 2009a: 2).

Table 1.1 Areas of concern according to cidb CII reports

| Key focus areas                                                             | Response (%) |      |      |
|-----------------------------------------------------------------------------|--------------|------|------|
|                                                                             | 2007         | 2008 | 2009 |
| Clients were neutral / dissatisfied with contractor performance             | 24.0         | 21.0 | 18.0 |
| Clients were neutral / dissatisfied with quality of works delivered         | 33.0         | 20.0 | 19.0 |
| Clients were neutral / dissatisfied with level of defects in projects       | 24.0         | 18.0 | 12.0 |
| Clients were neutral / dissatisfied with construction schedule              | 24.0         | 22.0 | 21.0 |
| Clients' payment made to contractors between 30 and 90 days                 | 38.0         | 51.0 | 48.0 |
| Clients' payment made to contractors longer than 90 days                    | 6.0          | 7.0  | 9.0  |
| Contractors were neutral / dissatisfied with management of variation orders | 36.0         | 34.0 | 31.0 |
| Contractors were neutral / dissatisfied with quality of tender documents    | 29.0         | 29.0 | 26.0 |

Source: cidb (2007: 1; 2008: 1; 2009a: 2)

Although these statistics are based on empirical surveys conducted among mixed sample frames (Table 2), the usefulness of the results cannot be in doubt as perceptions expressed were deemed to be that of key construction industry stakeholders across the nine provinces of South Africa.

Table 1.2 CII survey respondents groups

| Survey respondents | Year (No.) |      |      |
|--------------------|------------|------|------|
|                    | 2007       | 2008 | 2009 |
| Clients            | 114        | 282  | 332  |
| Contractors        | 219        | 1204 | 1169 |
| Total              | 333        | 1486 | 1501 |

Source: cidb (2007: 1; 2008: 1; 2009a: 2)

Another significant issue of concern that is continuously highlighted in cidb CII reports is that of construction H&S, which is deemed to be worrisome on construction sites (cidb, 2007: 1; 2008: 1; 2009a: 2). For example, the 2007 report revealed that the industry recorded 9 184 accidents and 73 fatalities in the year 2006. A comparison between the 2007 H&S statistics with that of 2008 and 2009 do not yield a positive outlook. The cidb (2009b: 9 ) report *Construction Health and Safety in South Africa Status & Recommendations* revealed that: overall construction H&S is not improving commensurately; construction continues to contribute a disproportionate number of fatalities and injuries relative to other industrial sectors; and there continues to be high levels of non-compliance with H&S legislation generally, and specifically the Construction Regulations and other H&S legislation in South Africa. These findings in effect raise the question as to the importance and status of H&S in relation to the traditional performance parameters of cost, quality, and time, which are deemed to have been afforded status greater than that afforded H&S.

A more comprehensive report indicates that many public sector clients and some private clients are losing the ability to scope and define projects, and to appoint and brief consultants (cidb, 2004: 19). The cidb suggests that these constraints, together with an inability to make decisions during implementation leads to contract delays and disputes. The report reveals the general perception of survey respondents relative to procurement practices. Some salient perceptions of the respondents indicated that (cidb, 2004: 20):

- unbundling of projects is resulting in an inappropriate division of responsibilities, increased contractual risk, and increased administration requirements, all of which increase costs to client and to design and supervising consultants, and tie up the limited capacity available;
- extensions to tender validity periods are becoming more prevalent, which indicates that decision-making is being delayed. Many clients and contractors referred to examples of clients re-negotiating after tender closures, although most clients indicated that they would not contemplate such a practice. Cases were cited where clients have ignored the recommendations of consultants advice with respect to how to award tenders;
- delayed interim payments and settlement of final accounts are common and place strain on contractors and professional service providers alike. The cidb measurement of indicators over two years shows that only about 60% of payments are made within 30 days;
- the non-competitive selection of consultants, particularly in the public sector, restricts growth of businesses, discourages innovation, frequently results in the appointment of under qualified or inexperienced consultants, and does not reward performance or specialisation, and
- undue focus on lowest price to the detriment of best value also impacts on the performance of contractors who invest their innovation in the winning of the contract, fully prepared for the claims that will be necessary to remain afloat. This fundamentally flawed procurement approach is infusing increasing levels of adversity into the delivery process and lags behind international trends.

In line with the foregoing, the performance of the contracting sector of the industry can be deemed to be sub-optimal. There seems to be little evidence of process or productivity improvement and very little attention is being paid to systematic performance improvement (cidb, 2004: 27). Though the quality of services and products provided by contractors is perceived to be highly variable (cidb, 2004: 25), clients have a major responsibility to ensure ethical and uniform procurement practices that support a sustainable and improving industry, including the elimination of waste in the system (cidb, 2004: 22). Since 2004, the situation has not changed significantly because contractors at different cidb grades are not fully satisfied with clients' performance in the cidb CII survey of 2007. The

performance of client bodies relative to documentation, procurement, and management of variation orders is quite low according to Marx (2009: 564).

The performance related problems are not peculiar to South Africa. Research indicates that the performance of the industry in developing nations is very unsatisfactory. For instance, Kalidindi and Thomas (2002: 352) report that the Indian construction sector is besieged with project procurement and execution problems ranging from inadequate and / or incomplete site investigation, non-receipt of drawings and instructions on site, non-availability of materials and equipment as per schedule, delay in payments of the completed work due to paucity of funds, to inadequate escalation clauses leading to the occurrence of disputes, and a nagging lack of mechanisms for seeking redress. These problems may be responsible for the prevalence of cost and time overruns on infrastructure projects identified by the Indian Ministry of Statistics and programme implementation (Kalidindi and Thomas, 2002: 351). These findings suggest that the problems identified in South Africa are not significantly different from the ones in India and elsewhere in the developing world. Therefore, it is imperative for both the industry and academia to seek remedies that can reverse the lacklustre performance of the industry worldwide.

### **1.1.3 The nature of the Construction Supply Chain in South Africa**

The construction industry's performance is closely related to the individual performance of the construction supply chain. Given that clients are the first member of the construction supply chain, clients and their procurement practices are the drivers of industry behaviour, performance, and transformation (cidb, 2004: 18).

Clients and their procurement processes bring together a changing range of players and expertise that constitute the construction supply chain. Each procured project assembles a range of design professionals, contractors, subcontractors, and suppliers to deliver specific client requirements. Fragmentation of procurement practices through different authorities and client bodies has generated concerns in the industry over the years. This client practice relates to the wide variety of tender and contract documentation, variable preferential practices, delayed evaluation and award of contract as well as the cancellation of tenders and re-tendering, which leads to cost overruns, increased risk, and wasteful use of scarce resources (cidb, 2004: 22). However, the cidb (2004: 21) reiterates the assumption that the introduction of SCM principles, the standard for uniformity in construction procurement and the implementation of the cidb contractor grading system in public contracts will begin to address these issues and spur improved procurement efficiency in the industry. It is also apparent from research findings (cidb, 2004: 22) that definite process improvement is achieved when modern procurement methods are used to promote partnering, teamwork and concurrent engineering methods that yield win-win benefits to all members of the construction supply chain.

Similarly, the contracting sector of the industry is plagued with process related issues. Contractors expressed the view that design professionals do not have enough knowledge in developing specifications and documentations, changes in construction processes, and technologies. This results in adversarial and time-consuming processes to settle variation orders, unnecessary design rework by contractors and eventual construction delays (cidb, 2004: 22). Pursuant to the attempt made to address perceived process and other issues plaguing the industry, the cidb embarked upon the registration of contractors in order to effectively target the development of contractors; provide information about the size, distribution and capability of contractors; facilitate sustainable empowerment; assist contractors to develop proper track records; provide risk management tools for contractors and clients, and also establish a foundation for implementing the National Contractor Development Programme (cidb, 2011a).

However, though progress is being made by the cidb in this context, Table 3 indicates that the cidb is still very far from achieving its objectives in this regard. In particular, Table 3 shows that there is a genuine reason for concern with regard to the unusually high percentage (89.3%) of grade 1 registered contractors. This suggests that organisations with low contracting capacity dominate the register (cidb, 2011a), which grades all contractors according to their capability to perform. The capability to perform in turn is determined by the financial and competency based work capabilities exhibited by contractors in previous projects.

Table1.3 The proportion of cidb registered active contractors by grade

| <b>Contractor grading designation</b> | <b>Maximum Contract Limit (R)</b> | <b>Active Contractors by grade (No.)</b> | <b>Proportion (%)</b> |
|---------------------------------------|-----------------------------------|------------------------------------------|-----------------------|
| 9                                     | No limit                          | 133                                      | 0.1                   |
| 8                                     | 130 000 000.00                    | 194                                      | 0.2                   |
| 7                                     | 40 000 000.00                     | 575                                      | 0.5                   |
| 6                                     | 13 000 000.00                     | 1 428                                    | 1.3                   |
| 5                                     | 6 500 000.00                      | 1 864                                    | 1.7                   |
| 4                                     | 4 000 000.00                      | 2 131                                    | 1.9                   |
| 3                                     | 2 000 000.00                      | 1 397                                    | 1.2                   |
| 2                                     | 650 000.00                        | 4 333                                    | 3.9                   |
| 1                                     | 200 000.00                        | 100 147                                  | 89.3                  |
| Total                                 |                                   | 112 202                                  | 100                   |

Source: <http://registers.cidb.org.za/reports/contractinglisting.asp#columns>

The table further suggests that the register may be dominated by emerging contractors, which the cidb described as mostly black owned construction contracting entities with significant developmental potential, but without requisite finance and / or competence that acts as impediments to their ability to become established construction firms (cidb, 2011a).

In addition, recent research conducted among contracting organisations that are members of the Master Builders South Africa (MBSA), indicates that contractors concur that (Emuze, 2009: 104-107):

- SCM is vital for project success;
- short term objectives and a price oriented approach persist in the industry;
- the number of irregular clients, which necessitates short term view of project objectives, is high;
- the construction supply chain is fragmented;
- strict and inflexible adherence to contents of contract data is common;
- the use of modularisation in order to reduce construction time is poor;
- risk management competency is scarce in the industry;
- inefficient and ineffective problem solving mechanisms, especially between contractors and subcontractors is a problem;
- the uptake of lean construction as a management tool to eliminate waste in the construction process is poor;
- open book accounting is still a mirage, and
- the penetration of information technology in the industry is still weak.

Given the ripple effects associated with these issues, the research concludes that knowledge sharing and transfer is possible in a collaborative working environment in South African construction.

Collaboration can simplify the construction process by removing bottlenecks occasioned by individual perceptions and attitudes. The quality of service between suppliers, subcontractors, and contractors can be improved as well as the quality of service delivered to clients and other project stakeholders. Closer relationships have the potential to break down barriers such as organisational and individual cultures. A consistent workload is beneficiary to long term relationships and long term and stable relationships may persuade subcontractors to focus on value rather than profit.

Contractors can also adopt collaborative procurement methods to promote innovation and creativity on construction projects. The procurement method may facilitate the negotiation of common project goals and objectives in an agreeable manner. Collaboration can also mitigate avoidable communication problems as well as logistics related issues. Therefore, in order to engender continuous project performance improvement in the industry, Emuze (2009: 108), *inter-alia*, recommends:

- ensuring the early involvement of key project team members that have expert knowledge so that an appropriate level of client satisfaction and value can be defined;
- establishing subcontractor and supplier relationships by selecting teams based on value rather than lowest price;
- integrating pre-construction and construction activities and adopting common processes such as ICT;
- managing the project parameters of cost, schedule, quality, and H&S in unison;
- developing and monitoring continuous improvement programmes;
- developing and implementing appropriate risk management processes;
- dealing with risks and rewards equitably by using modern commercial arrangements such as collaborative contract forms, target cost and open book accounting;
- using non-adversarial forms of contract and ensuring that contractual relationships are appropriate for expected project objectives;
- mobilising and developing people in order to ensure employee satisfaction through integrated teams, and
- adopting the Latham / Egan collaborative working principles

## **1.2 Statement of the Problem**

Performance relative to the of project parameters of cost, H&S, quality, and time is poor in the South African construction industry (Manthe, 2008: 227). This poor performance related to cost, H&S, quality, and time in turn hampers the smooth delivery of infrastructure projects. The poor performance can be occasioned by recurrent waste in the construction process (Han *et al.*, 2007: 2088).

Waste refers to all non-value adding activities (NVAAs) in the construction process (Forbes and Ahmed, 2011: 53). Empirical findings suggest that as much as 49.6% of operational efforts are devoted to NVAAs (Horman and Kenley, 2005: 59). In terms of public sector construction project procurement, it can be argued that cost overruns could exacerbate budget constraint problems, time overruns / or delay may slow down service delivery, poor quality increase maintenance cost and shorten design / or service life of infrastructure, and poor H&S could increase both industry and public fatalities.

In effect, ineffective management of the construction supply chain results in the industry suffering from delivered construction projects that are unsatisfactory from the perspective of clients because of high costs, non-conforming work, late delivery, and low profitability for those within the numerous construction supply chains (Cox and Ireland, 2002: 412). Thus, these anomalies within the

construction process may further stagnate / or reduce the competitiveness of organisations, the supply chain, the industry, and also impact the economy of a nation.

The research problem statement states that “poor performances relative to cost, H&S, quality, and time in the South African construction industry hampers the smooth delivery of infrastructure projects as recurrent NVAAs in the construction process may propagate cost overruns that exacerbate budget constraint problems; time overruns and / or delays that slow down service delivery; poor quality that increases maintenance cost and shortens design / or service life of infrastructure, and poor H&S that increases incidents, accidents, injuries, and fatalities in the industry.”

The research problem statement is amplified by the sub-problems and hypotheses postulated in Table 1.4. The problem statement, sub-problems and hypotheses were compiled based on the findings of a preliminary literature review related to project performance. As indicated in Table 1.4, poor performance relative to cost, H&S, quality, and time may be magnified through problems such as inadequate risk management practices, lack of skills necessary for project delivery, inadequate knowledge management, poor organisational culture among project partners, poor interaction between consultants, poor management of construction logistics, non-integrative H&S practices, and non-integrative quality management.

These sub-problems that can be deemed contributory factors to how huge the statement of the problem can be magnified and beget a range of consequences. For instance, poor risk management practices may result in poor choice of procurement strategy; lack of skills may lead to project implementation / delivery issues; inadequate documentation of experience and performance in the form of knowledge management may lead to poor organisational knowledge; poor culture among project partners may harm attempts to change and innovate; poor interface between consultants may derail projects through repetitive revisions and attendant rework; poor logistics management can result in a range of consequences that has cost implications, and isolated addressing of H&S and quality requirements of a project may lead to sub-optimal performance in construction.

In essence, in order to provide more insight into the causes of these problems and their effects, an extensive review of related literature was undertaken so as to reveal salient and latent issues that can be deemed to be propagating poor project performance, and thereafter empirical investigations were conducted in the South African construction industry.

Table 1.4 Research sub-problems and hypotheses

| Sub-Problems                                                                                                                             | Hypotheses                                                                                                                                                                                                                                                 |
|------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Sub-Problem 1:</b><br>Public sector clients could occasional make inappropriate choice of procurement strategy.                       | <b>Hypothesis 1:</b><br>Inconsistent and inadequate risk allocation and management practices leads to inappropriate choice of procurement strategy in the public sector.                                                                                   |
| <b>Sub-Problem 2:</b><br>There is poor implementation of procurement strategies in the public sector.                                    | <b>Hypothesis 2:</b><br>The lack of infrastructure delivery management skills within the public sector result in poor implementation of construction procurement strategies.                                                                               |
| <b>Sub-Problem 3:</b><br>There is poor organisational knowledge, learning and transfer in the construction supply chain.                 | <b>Hypothesis 3:</b><br>Inadequate documentation and transfer of experiences and performance result in low organisational knowledge, learning, and transfer.                                                                                               |
| <b>Sub-Problem 4:</b><br>There is resistance to change and innovation in the construction supply chain.                                  | <b>Hypothesis 4:</b><br>Inappropriate organisational culture among project partners leads to resistance to change and innovation in the construction supply chain.                                                                                         |
| <b>Sub-Problem 5:</b><br>Inadequate instructions, drawings, and information for construction delay the start of construction activities. | <b>Hypothesis 5:</b><br>Poor interface between multidisciplinary design advisor / consultants lead to delay and rework relative to construction activities.                                                                                                |
| <b>Sub-Problem 6:</b><br>There is haphazard inventory management on construction sites.                                                  | <b>Hypothesis 6:</b><br>Inefficient and unstable logistics management leads to haphazard processing of orders, storage of materials, and poor inventory management.                                                                                        |
| <b>Sub-Problem 7:</b><br>There are recurrent accidents, injuries, and ill-health on construction sites.                                  | <b>Hypothesis 7:</b><br>Unacceptable coordination and regard for H&S upstream and downstream of the construction supply chain result in recurrent accidents, injuries, and ill-health on construction site.                                                |
| <b>Sub-Problem 8:</b><br>There is a high level of defects, rework, and non-conformance in construction.                                  | <b>Hypothesis 8:</b><br>Inadequate coordination and integration of quality standard requirements within the supply chain result in an unusually high level of defects, rework, and non-conformance relative to quality at construction project completion. |

### **1.3 Scope of the Investigation**

- 1.3.1 Completed or continuous projects within the last 5 years.
- 1.3.2 Civil engineering and non-residential building projects.
- 1.3.3 Public sector owned infrastructure.
- 1.3.4 Infrastructure projects funded by public or public / private sources.

### **1.4 Assumptions**

- 1.4.1 A range of procurement methods are used in construction.
- 1.4.2 Outsourcing of activities is undertaken extensively on construction projects.
- 1.4.3 Government and other public agencies procure construction services.
- 1.4.4 Infrastructure projects are undertaken for developmental purposes.

### **1.5 The Importance of the Study**

The significance of the study is to add to the existing Built Environment Body of Knowledge (BEBOK) in the area of performance improvement. The research entails extensive empirical investigations and recommendations that are intended to be disseminated through seminars and publications for the benefit of South African construction, and the international construction industry in general. The research explored the synergy between project partners that can improve project performance in terms of construction H&S, time predictability, cost predictability, and quality with the overall aim of engendering continuous performance improvement in South African construction.

The research also sought new ways of managing the construction SC so that the required value for money on public procurement will be assured. The study addressed philosophies that tend to propagate best value, and practices that can assist the construction industry, and by implication the country in its drive for a better standard of living for its citizens through the provision of infrastructure. Such philosophies include lean construction, TQM, SCM, and system dynamics (SD).

### **1.6 The Aims and Objectives of the Study**

According to Wirick (2009: 8) public sector projects can be more difficult than many private-sector projects because they operate in an environment of often conflicting goals and outcomes, involve many layers of stakeholders with varied interests, must placate political interests and operate under media scrutiny, are allowed little tolerance for failure, operate in organisations that often have difficulties identifying outcome measures and missions, are required to be performed under constraints imposed by administrative rules and often cumbersome policies and processes that can delay projects and consume project resources, require the cooperation and performance of agencies

outside of the project team for purchasing, hiring, and other functions. Based on the aforementioned and other inherent challenges in public sector construction procurement, the study:

- identified NVAAs and their sources in South African construction;
- identified the causes of NVAAs in South African construction;
- assessed the impact of the NVAAs on project performance in South Africa, and
- recommend mitigation strategies that can address the impact of NVAAs in construction in an attempt to address poor performance experienced during project delivery.

These objectives are based on the premise that notable outcomes of NVAAs, *inter-alia*, include recurrent cost and time overruns which are common-place in the public sector; poor management of construction logistics leads to a high level of vehicular movement, which consequently result in poor environmental, and H&S issues; non-conformances result in a short design life and a huge amount spent on rehabilitation, and industrial output in terms of economic impact.

The central issue or rather the overall aim in this particular research is the seemingly inadequate achievement of optimum performance in the construction process, either with respect to value for money for the client and the entire construction supply chain or value in terms of the utility derived from built assets, in spite of efforts by government and governmental bodies such as the cidb to increase industry performance.

Key project stakeholders, both upstream and downstream of the construction supply chain, were scrutinized. Specifically, the intelligence of clients with respect to their choice of procurement strategy, implementation of the strategy, and their quest for value for money in construction was examined. Also, the salient issues emanating from the multiplicity of client advisors such as engineering / or specialist consultants, as well as the interface of these advisors with the rest of the supply chain were closely evaluated. The research equally checked the appropriateness of risk transfer between clients and their principal contractors; and the level of availability of skills necessary for infrastructure project delivery in terms of logistics management, knowledge management, organisational culture, H&S programmes, and TQM in the South Africa construction industry.

Navigation of the thesis entails nine chapters that were structured and contextually linked in order to provide an adequate platform for understanding the study. As indicated in Figure 1.1, the thesis begins with chapter 1 that presents the background of the study, and then proceeds with an extensive review of related literature presented in four chapters. Chapter 2 provides an overview of procurement in the construction context, chapter 3 introduces the concept of SCM, chapter 4 provides the conceptual and theoretical perspectives arising from national and international construction management literature with respect to the study, and chapter 5 provides an overview of SD in construction project

management in the form of ‘project dynamics’. While chapter 6 addresses the research methodological issues, chapter 7 and chapter 8 present the results and proposed models of the study respectively. Chapter 9, which is the final chapter in the thesis, presents the conclusions and recommendations. This chapter provides general conclusions, conclusions relative to general comments made by respondents to the survey, conclusions relative to the research objectives, conclusions relative to the research hypotheses, conclusions that arose from the model development and testing process, recommendations relative to the research objectives, recommendations relative to the research hypotheses, recommendations relative to the proposed models, contributions to knowledge, justification of the title adopted for the thesis, limitations of the study, and future research that can be conducted based on the study.

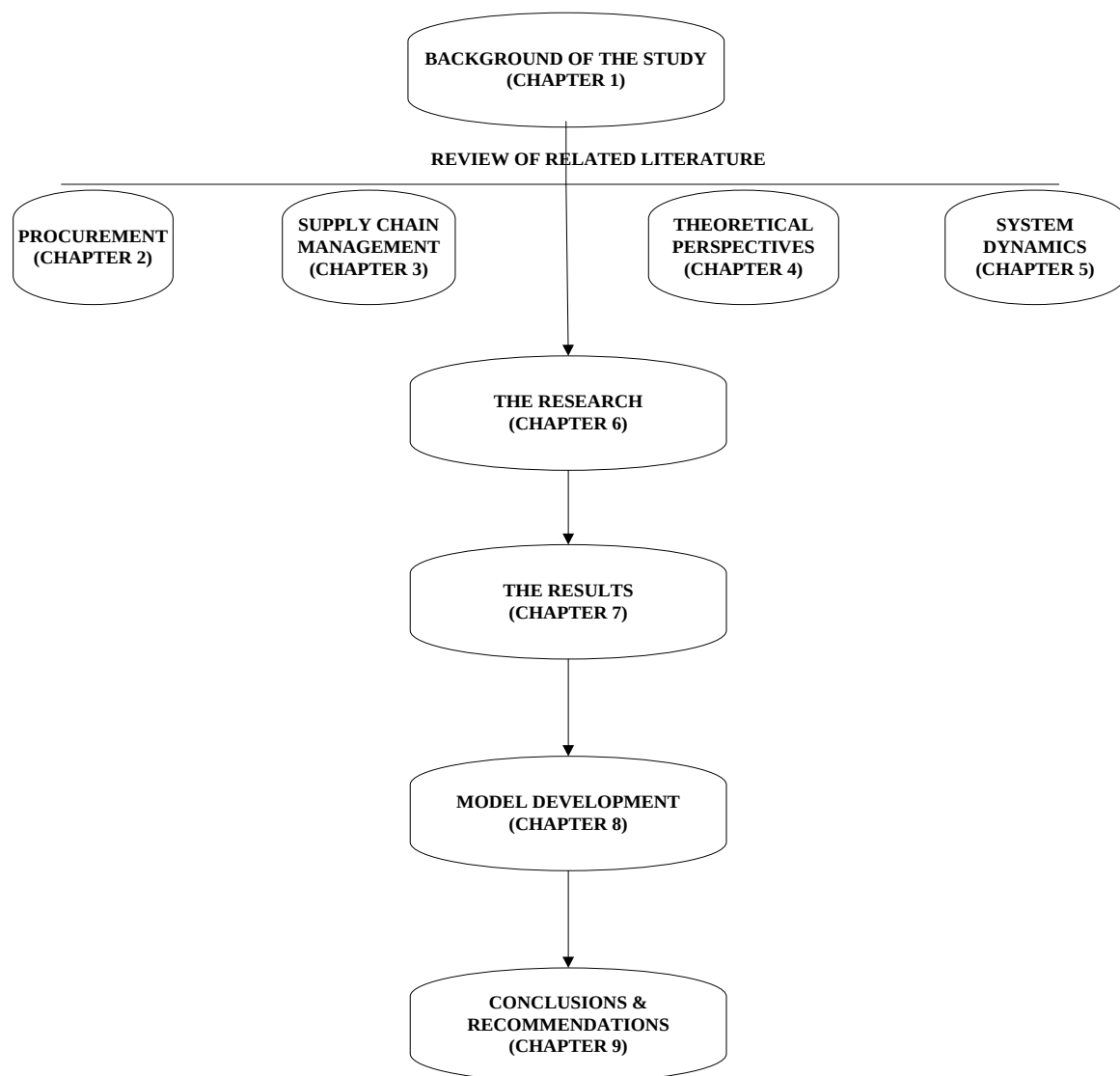


Figure 1.1 Structure of the thesis

## **2.0. REVIEW OF RELATED LITERATURE: PROCUREMENT**

The construction process starts with a client's decision to procure a facility or infrastructure in order to satisfy a particular need. The need may be profit / social oriented, depending on the type of client organisation. The quest for an improved standard of living in a society is aided by the availability of infrastructure, which is normally provided by the public sector. Infrastructure that requires huge capital outlay is commonly financed by the public sector and in some cases, when the private sector is given enough incentive, private funds can be used. However, before infrastructure is put to use at the operational phase, it must be built by participants of the construction SC. The principal member of the SC is the client that normally decides the procurement route that will be undertaken for the provision of the infrastructure. Timely provision of quality infrastructure by the public sector therefore depends on the procurement system adopted for construction. The procurement system impacts on the organisational, financial and administrative structure of the project, and could contribute crucially to its success or failure (Walker and Greenwood, 2002: 15). Yet, Hall (2000 cited by Murray *et al.*, 2002: 150) notes that some clients are wasting vast amounts of money and experiencing long delays because they fail to educate themselves about the available choices relative to methods of procurement. It is perceived that most clients are unaware that procurement is the process of acquiring new services / products and includes contract strategy, contract documentation and contractor selection, and that it also extends to all members of the supply chain (Bower, 2003b: 1).

### **2.1 Procurement in the construction industry**

Within the construction sector, procurement refers not only to what is bought, but also to a diverse array of methods for acquiring a huge range of immovable assets (Hughes *et al.*, 2006: 7). In addition, the process of selecting competent suppliers is known as the process of procurement (Winch, 2010: 99). In fact Watermeyer and Jacquet (2004: 1.1) define procurement as the process which creates, manages, and fulfils contracts relating to the provision of supplies, services or engineering and construction works, the hiring of anything, disposal, and the acquisition of any rights and concessions. These definitions suggest that the way in which clients, designers, contractors, and suppliers work together as a team is determined by the procurement strategy as well as the forms of contract entered into between project participants and the clients (Morledge, 2002: 174). Procurement systems have important implications for the way project risks can be allocated among project participants, management of the risks, and the strategies for getting the required value in terms of major project variables (Walker and Greenwood, 2002: 16). The implication is that in order to optimise construction performance, it is vital to understand all aspects of procurement (Tookey *et al.*, 2002: 133). For example, risk deflection is an integral part of procurement. In other words, contracts are used for risk deflection because they create an avenue for deflecting risks away from the client. There

are two ways available to owners to get project work done. Built environment immovable assets can either be procured in-house or outsourced (Figure 2.1). An in-house approach refers to owners undertaking the work using their own resources and capabilities. In time past, it is not unusual for South African municipal engineers to undertake routine construction and maintenance works in-house. But in recent times the norm in the public sector is outsourcing. There are two possible reasons for this reverse; one is technical and the other economic.

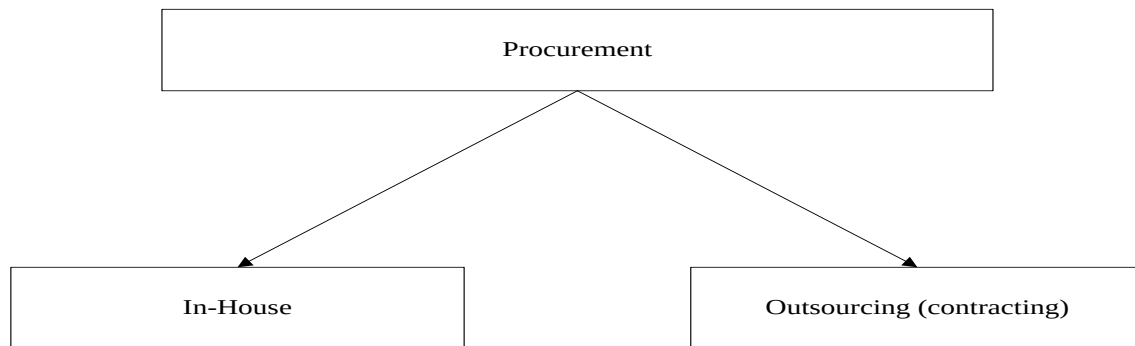


Figure 2.1 Procurement options / routes

Firstly, the speed of technological advancements and technical competence is so fast that no single firm can provide the spectrum of skills necessary for design and production, especially for complex projects. Secondly, the fragmentation of the construction process, with its origins in technical diversity, has been exacerbated by economic forces (Walker and Greenwood, 2002: 15). In fact economic forces have continued to influence the public sector's engagement with the industry. In brief, Winch (2002: 98) identifies the following as disadvantages of in-house procurement:

- if construction is not the core business of the client, then managing construction activities directly may be a diversion;
- low transaction frequency may make investment in an in-house capability unviable or inefficient, and
- lack of competition may lead to production inefficiencies within the in-house supplier, thereby raising production costs.

Consequently, contracting work out is now an accepted practice in areas such as infrastructure development. Since the advantages of contracting out far outweigh its disadvantages, most infrastructure projects are procured through contracting. In South Africa, the cidb Standard for Uniformity in Construction Procurement recommends the use of the following standard forms of contract for engineering and construction works (cidb, 2009: 3):

- General Conditions of Contract (GCC) for Construction Works as published by the South African Institution of Civil Engineering;

- JBCC Series 2000 Principal Building Agreement as published by the Joint Building Contracts Committee;
- JBCC Series 2000 Minor Works Agreement as published by the Joint Building Contracts Committee;
- NEC3 Engineering and Construction Short Contract as published by the Institution of Civil Engineers;
- NEC3 Engineering and Construction Contract as published by the Institution of Civil Engineers;
- NEC3 Professional Services Contract as published by the Institution of Civil Engineers;
- NEC3 Term Services Contract as published by the Institution of Civil Engineers;
- Conditions of Contract for Construction for Building and Engineering Works designed by the Employer ('Red Book') (1999) as published by the International Federation of Consulting Engineers (FIDIC);
- Conditions of Contract for Plant and Design-Build for Electrical and Mechanical Plant and for Building and Engineering Works, designed by the Contractor ('Yellow Book') (1999) as published by the International Federation of Consulting Engineers (FIDIC);
- Conditions of Contract for EPC Turnkey Projects ('Silver Book') (1999) as published by the International Federation of Consulting Engineers (FIDIC), and
- Short Form of Contract ('Green Book') (1999) as published by the International Federation of Consulting Engineers (FIDIC).

The GCC, the NEC, and the FIDIC predominate in civil engineering construction, and by implication in infrastructure construction projects. The primary objective of the NEC is to shift the emphasis of control from procedures for the calculation of extra payment to the contractor, if things go wrong, to arranging matters so that things do not always go wrong. The NEC is written in plain English and also includes flow charts that assist users. The NEC can also be used in all types of engineering and construction work. According to Potts (2008: 249), the NEC is founded on three key principles, which include:

- foresighted and cooperative management shrinks risks and mitigate problems;
- parties are motivated to work together if it is in their professional and commercial interest to do so, and
- clear division of function and responsibility helps accountability and motivates people to play their part.

Though, using the NEC system is based on the concept of cooperation with a proactive team-based approach through its early warning and compensation event features, great emphasis is placed on communications, programming and disciplined contract management by parties (Potts, 2008: 256).

The FIDIC forms of contracts on the other hand are the most widely used standard international construction contracts especially for public works contracts. The FIDIC also attempts to balance risks between project parties. The Red Book attempts to allocate risks fairly between project parties (Potts, 2008: 260). The basic principle, which is in conformance with established industry norms in the treatment of risks, is to allocate risks to the party that is best able to bear and control the risk. Payment types are basically through two approaches. It can either be price-based payment systems or cost-based payment systems. Price-based systems include lump-sum arrangements and re-measurable contracts. The price-based system is characterized by the contract bill of quantities, and is typical of traditional general contracting particularly in civil engineering projects. In lump sum or fixed price contracts, disputes are likely to occur as there is very little scope for the incorporation of change and the client may be required to pay the contractor more money in the long term (Smith *et al.*, 2006: 157). It follows that the implication of the fixed price approach is that contractors are responsible for risks over which they have limited control, and of which their understanding and knowledge may be at best incomplete. Conventional contracts are used in public works mainly because risks in the project are generally low and quantifiable, the programme is almost fixed and the design is always almost complete (Smith *et al.*, 2006: 158).

Conversely, cost-based systems include cost-plus and target-cost contracts that effectively remove the risk of variable production costs from the contractor, who is paid on the basis of time spent and materials used rather than on the basis of a tendered price (Hughes *et al.*, 2006: 11). Cost-based contracts are appropriate for projects where there is a need for an early start while the scope is not well defined. They are used where the quantity of work is not known, demolition, site clearing, repair works or incomplete contracts where work was interrupted and for innovative works where research and development or novel design is required (Smith *et al.*, 2006: 159). The flexibility of this approach and the amount of risk the clients are responsible for make client involvement a prerequisite in the administration of the contract.

The literature suggests that procurement in the construction industry, international and domestic, is governed by a number of regulations enacted in order to ensure maximum fairness and transparency in tendering and contractor selection process (Morledge *et al.*, 2006: 124). In order to match capabilities with requirements in the selection of a main contractor, a number of established steps / procedures may be followed. Such tender evaluation procedures comprise of the pre-qualification of contractors in terms of technical and managerial skills necessary for the work. It also includes

interviews and desk-top evaluations of bid submission in terms of price (commercial evaluation) and technical considerations such as management team, personnel issues, proposed approach to work, environmental practices and solution, productivity, H&S, quality assurance, and project materials (Morledge *et al.*, 2006: 125). This procedure normally cumulated in the award of contract after assigning appropriate weightings to the price / quality ratios (Morledge *et al.*, 2006: 129).

However, the South African Preferential Procurement Policy Framework Act requires that tenders be evaluated and awarded to a tenderer with the highest weighted points relative to price, and specific goals (cidb, 2006: 3). The Act did not make specific provisions for quality in tender evaluation, but the cidb construction procurement best practice guideline #A4 (2006: 3) suggests that quality may form part of the specific goals for which a preference is provided, other objective criteria, eligibility criteria included in the conditions of tender, price used for comparative purposes, and a tender offer.

## **2.2 Enablers of successful construction procurement**

In South Africa as well as elsewhere in the developing world, the primary objective of public sector clients is to provide infrastructure that will raise the standard of living of its citizens. To this end, public sector clients use several procurement approaches and contract forms to fulfil their mandate within stated performance parameters. The construction industry usually makes use of performance parameters either in the form of key performance indicators (KPI) or construction industry indicators (CII) to evaluate project or industry performance. However, often project success and outcome depends on the primary parameters of cost, H&S, quality, and time. These parameters are principal factors to project success (Walker and Greenwood, 2002: 1). Project management is about managing environmental factors impacting projects both internally and externally, so that the primary performance parameters can be achieved (Figure 2.2). These performance parameters are supported by other key performance indicators such as client satisfaction-product; client satisfaction-service; profitability; productivity, and defects. It is instructive to note that the performance of these parameters is related to each other; for instance quality failures may result in time and cost overruns.

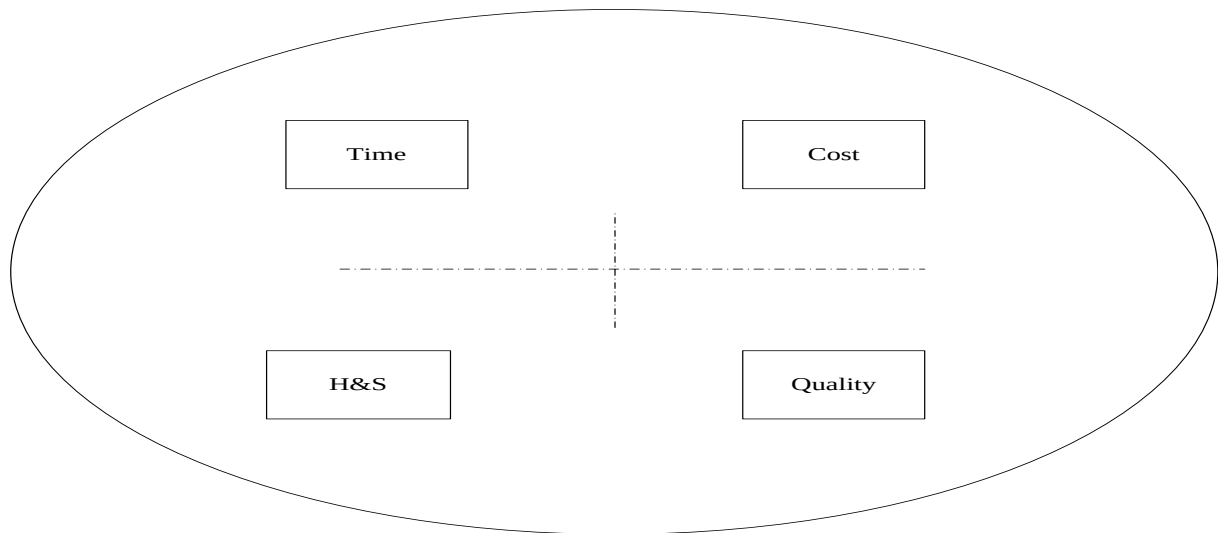


Figure 2.2 Primary performance parameters (adapted from Walker and Greenwood, 2002: 2)

And the control of time cannot be addressed in isolation from resources as well as cost. In addition, cost management offers benefits at the pre-contract stage, especially in multi-contract projects. It helps the project team to better establish the appropriate project strategy (Potts, 2008: 49). For example, it helps to determine which work should be placed in which contract and possibly the form of contract which should be adopted for particular contracts. Each of these four primary parameters may be subject to risk and uncertainty. It is vital to recognise the root causes of risks, and not to wait until the project is in trouble before action is taken. Therefore, project delivery managers should undertake or propose actions, which eliminate risks before they occur and guide against low performance related to the parameters. Salient interventions that may be termed enablers, which may potentially improve the construction process include:

- risk allocation and management;
- availability of critical skills;
- knowledge management;
- dynamic organisational culture;
- synergy between designers;
- management of construction logistics;
- co-ordination and respect for construction H&S, and
- co-ordination and integration of quality requirements.

### 2.2.1 Risk allocation and management

In construction, the procurement arrangements dictate the availability, and responsible person / or organisations that provide the project inputs. The client initiates the project, and in case of the public sector, the client often provides the project finance and design. The design may be done in-house or by private designers contracted directly with the client. The inputs of contractors, subcontractors, and suppliers are visible at the construction phase of project procurement. However, because of the structure of the supply side of the industry, project inputs can come from a multiplicity of sources in many possible combinations. The chosen procurement arrangement can be referred to as the procurement strategy.

Decision making at project inception is crucial because it impacts the delivery outcome. Clients' decisions affect the responsibilities of the project parties; influence the control of design, construction, and commissioning. Risk management is about predicting the future by making decisions in a systematic manner. Decisions are made against a predetermined set of objectives, rules / or priorities based upon knowledge, data, and information relevant to the issue (Smith *et al.*, 2006: 3).

Unfortunately, clients do not make their decisions following this process. Research indicates that clients and their advisors select procurement systems in an illogical and inappropriate manner (Masterman, 1992 cited by Tookey *et al.*, 2002: 132). That is, decisions are often ill-founded and are not based on a logical assessment of project-specific criteria despite the industry wide knowledge that risk does not always refer to the occurrence of bad consequences, but also the possibility of opportunities. Smith *et al.* (2006: 4) contend that risk exists when a decision is expressed in terms of a range of possible outcomes, and when known probabilities can be attached to the outcomes; and uncertainty exists when there is more than one possible outcome of a course of action, but the probability of each outcome is not known.

It follows that risks fall into three categories, namely known, known unknowns, and unknown unknowns. Risk, and whether it should be retained, avoided or transferred, is very much at the centre of all procurement strategy (Jaggar *et al.*, 2002: 181). An intelligent client should be able to address these risk types before a procurement strategy is chosen. Though, most commonly, clients have an overall risk management strategy and policy, some fail to see that the main issues concerning how project risk exposure and transfer determines how well a procurement strategy performs. Notably, in construction there are four common routes for the transfer of risk. Perry and Hayes (1985 cited by Potts, 2008: 116), noted that such routes include:

- transfer of risks from client to contractor;
- transfer of risks from contractor to subcontractor;

- transfer of risks from client, contractor, subcontractor, designer to insurer, and
- transfer of risks from contractor and / or subcontractor to surety.

In effect, if risks can be transferred, then their impact can be shared or totally carried out by another party in the construction supply chain. Therefore, importance is reportedly attached to project start up decisions because of the perception that the opportunity to control project outcomes diminishes as the project proceeds. Initial decisions increase the chance of control and influence as at project inception, control can be exercised when clients sanction commitment to a project of particular characteristics, award contracts to contractors, and commit to major cost expenditure (Smith *et al.*, 2006: 6).

This is perhaps the reason why the literature suggests that when a project is conceived, the client should undertake risk assessment, and also evaluate the risks associated with the project. After this, the client should be able to decide whether to proceed with the project or not. In case the risks associated with the project are high, a careful development of the project execution plan (PEP) may be able to eliminate, transfer or insure the risks. The PEP facilitates the development of the contract strategy after taking into account the available strategies, selection procedures, and other related factors. The project should be mapped onto a chart as in Figure 2.3 to determine the level of risk, control, motivation, and design completion that will aid the choice of strategy. The principal choices being made here relate to work, motive and risk transfer through the supply chain, which will be influenced by the novelty and complexity of the project, and by other factors (Smith *et al.*, 2006: 137). The management of the whole supply chain is increasingly being recognised as crucial to the success of projects because it allows strategies that transfer risk to the party best able to manage that risk to be developed (Smith *et al.*, 2006: 139). Risks cannot be eliminated through contracts, but the chosen strategy can influence the management and allocation of risks. Selecting a contract strategy requires decisions about the type and location of project, number of packages, and responsibilities of project parties, flexibility required, project life cycle, terms of payment, available resources, and the basis for selecting contractors.

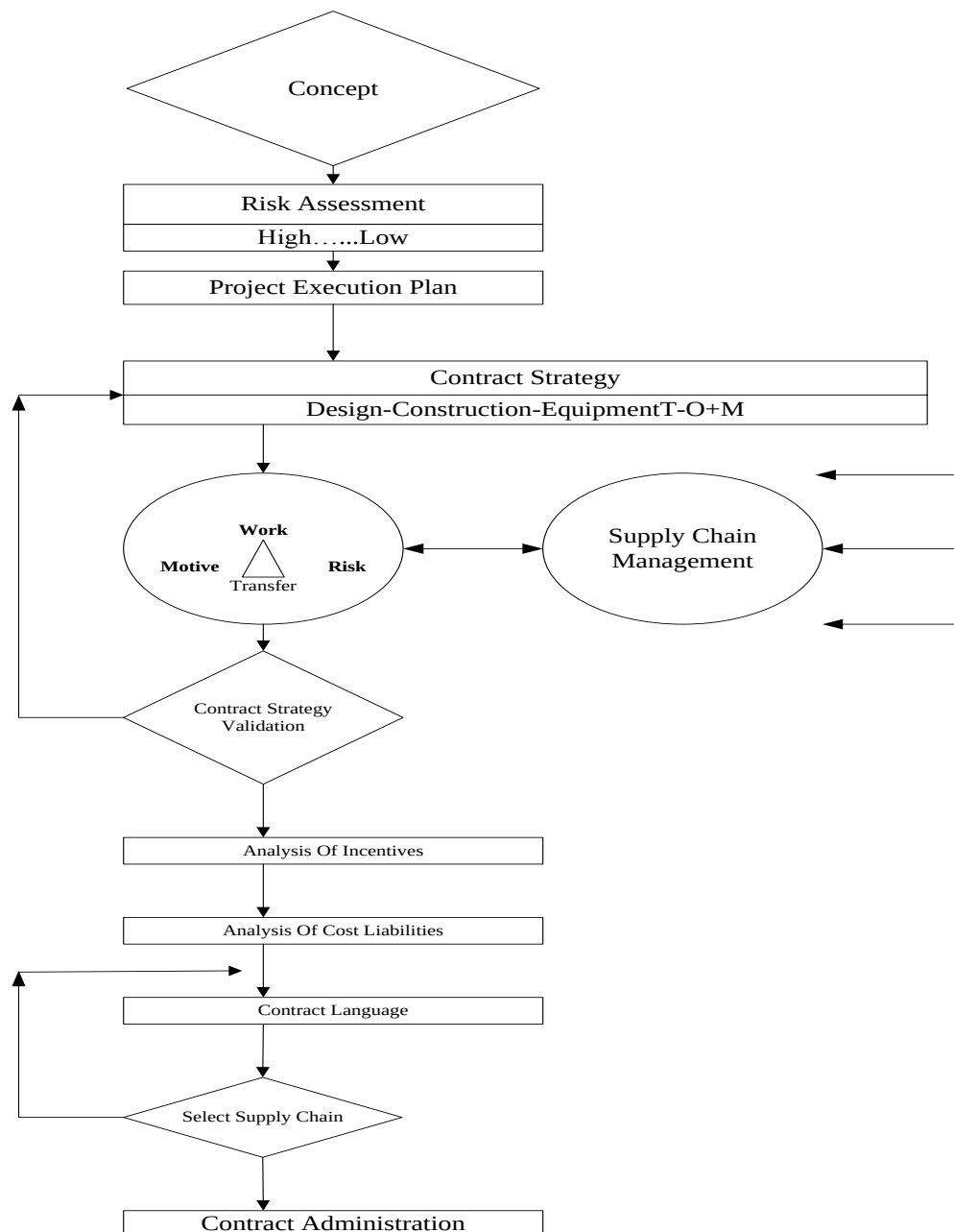


Figure 2.3 The contracting process (adapted from Smith *et al.*, 2006: 137)

Once the decision about the contract strategy is made, the construction supply chain members may be selected through a rigorous tender evaluation procedure. According to Smith *et al.* (2006: 140), at contract award key objectives for the clients are advice to obtain a fair price for the work, bearing in mind the general state of the construction market at the time, and to enter into an agreement with a contractor, who possesses the necessary technical competence, resources, and financial backing to give the client the best possible chance of the project been completed within the required cost, H&S, quality, and time standards.

Since no construction project is risk free (Murray *et al.*, 2002: 148), risks inherent in projects should be made known to the whole supply chain so that they can be considered based on which party can best control events; which party can best manage risks; which party should carry the risk if it cannot be controlled, and what is the cost of transferring the risk (Smith *et al.*, 2006: 143).

Nevertheless, Abrahamson (1984 cited by Potts, 2008: 116) states that a party should bear a construction risk where it is in his control; the party can transfer the risk by insurance; the preponderant economic benefit of running the risk accrues to the party; to place the risk on the party is in the interest of efficiency, and if the risk eventuates, it is not practicable to transfer the loss to another party.

The impact of risk events can always be quantified because in most cases, the impact has cost implications. Time delays and failures relative to materials and equipment inevitably have consequential cost implications. Therefore, when making risk allocation decisions, clients should appreciate that they will pay for those risks that are the responsibility of the contractor, as well as those that are their own. For example, clients pay for risks through the contingencies attached to contractors' tender documents. And when risk events that are a client's responsibility eventuate, contractors are refunded by the client for the specific risk event. Therefore, clients should determine risk allocation strategies at the inception of projects (Smith *et al.*, 2006: 145). Though the choice of contract and hence risk allocation strategy is determined by the policy decisions of the client and specific requirements of projects, when policy considerations take precedence over specific project requirements, it is important that clients remember that inappropriate strategy on the retention or distribution of risks will jeopardise projects (Bower, 2003b: 18). As an illustration, clients' organisations need to identify all risks that affect the whole supply chain with considerations given to risk allocation between designer and suppliers as well as other members of the supply chain. Also, in order to ensure that risks are dealt with in the best way, clients have to determine the contract strategy best suited to a particular project life cycle. The performance of the project at the contract administration stage will reveal the wisdom in the choice of the procurement strategy, that is, the contract administration phase is when the chosen strategy is tested to reveal its appropriateness.

### **Contract strategy in terms of organisational structure**

Each procurement route / or approach is unique with site specific problems requiring bespoke solutions that make 'off the shelf' or 'one size fits all' procurement impossible (Tookey *et al.*, 2002: 141). It is imperative to be familiar with, and also understand different procurement approaches so that an informed decision can be made during selection. In identifying the most appropriate procurement strategy to achieve the optimal balance between cost, H&S, quality, and time, the following criteria may be considered (Jaggar *et al.*, 2002: 181):

- the economic use of construction resources;
- the need for the contractor to contribute to the design and construction process;
- the incentive to make production cost savings and their subsequent control;
- continuity of work, and
- risks and the assessment of who should bear the risks.

**Conventional approach:** Employer-financed projects are normally undertaken through this procurement strategy. This is the traditional and most prevalent procurement approach in the public sector in the past few decades. Project parties' roles and responsibilities are based on the separation of design from construction. Design is provided by independent consultants in direct contracts with the client or in-house by engineers / or architects in the public sector. A separate contract for the construction of the project is placed with a general contractor (GC), who may sub-let parts of the work. The construction contract is usually supervised and administered by the engineering design consultant working on behalf of the client. The lead designer is usually in control throughout all stages of the project, from conceptual design through design development, tendering, contract administration, supervision of the works, and final project commissioning. The contract between the client and GC is often preceded by competitive tendering. Payment for the works is typically monthly, based on certified quantity of work done relative to unit rates and lump sums in the contractual bill of quantities. The main contract is between the client and the contractor, while the contract between the contractor, subcontractors, specialist subcontractors, and suppliers is referred to as a 'subcontract'. Subcontractors have a legal relationship with contractors, who are responsible to the owner for the performance of the subcontractors. Typical contractual links in this procurement strategy are indicated in Figure 2.4. Because of the division of the responsibilities of the contracting parties, the risk allocation in the supply chain varies.

The organisational structure allocates the risk of changes in the price of the items to the contractor while the risk of delay can be allocated to either the contractor or the client. The tendered prices used in this type of contract include a contingency for risk, which again means that the client is likely to pay more for the privilege of transferring the risks to the contractor than if the contractor had accepted it (Smith *et al.*, 2006: 149). The traditional route is readily understood, but it has become less popular as more clients become aware of the potential high risks carried by them in case the design is incomplete or the bill of quantities is discovered to be inaccurate late in the project delivery process (Potts, 2008: 137).

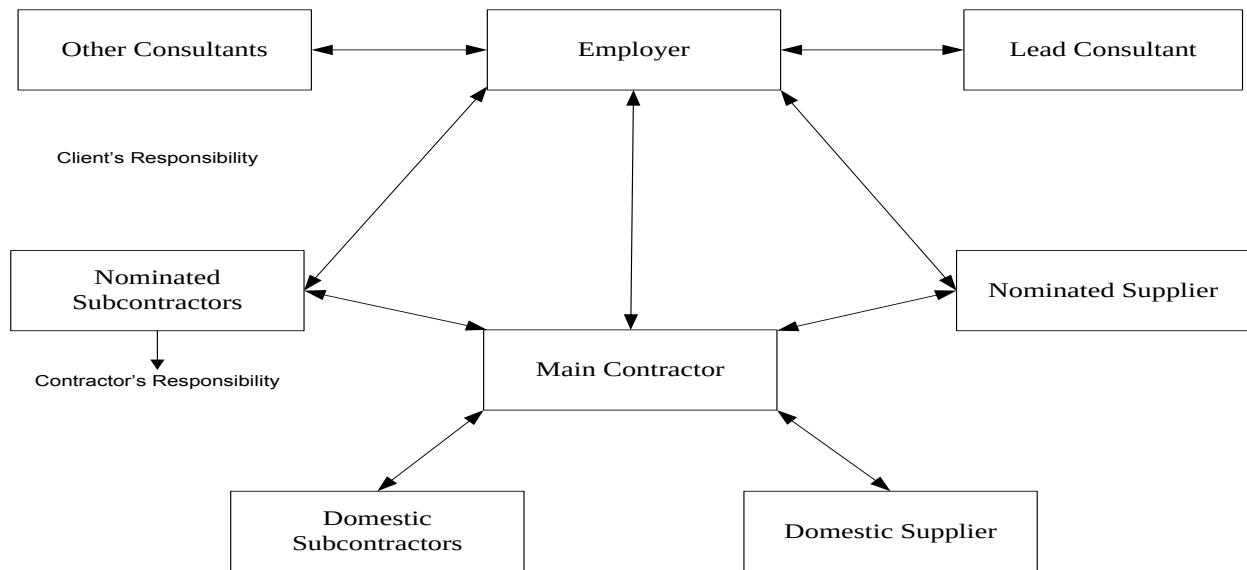


Figure 2.4 Contractual links in a conventional approach (adapted from Walker and Greenwood, 2002: 18)

According to Potts (2008: 138) the strength of the traditional approach generally includes a high degree of certainty on the basis of the cost and specified performance before a commitment to build; however, variations and claims can make this less so; clear accountability and tight control at every stage; again, variations and claims can make this less so; competitive prices between main contractors; opportunity to combine best design and contracting skills in well-understood relationships; scope for nomination of particular specialists by clients; flexibility in developing the design up to the contract documentation stage, and if necessary varying the construction design; however, cost can become less certain; well tested, in practice and in law; the client is able to recover costs from the main contractor in the event that the latter fails to meet contractual obligations, and flushes out ambiguities in the documentation prior to tender. The weaknesses of the approach include: an uneasy, guarded relationship between the parties-can easily become adversarial; engineer / architect has no liability for the performance of other members of the design team; client has no right of communication or instruction with the contractor; overall programme may be longer than for other strategies; no opportunity for contractor to influence design during the design process; split responsibilities - client is in direct contract with many different parties, which can be a serious weakness in the event of major defects occurring, and does not entail a fully integrated design and construction team.

**Design and Build (D&B):** Design and Build is a procurement approach whereby a single firm is responsible for both design and construction of the works. The client engages a GC who assumes a substantial part of the risks inherent in the works. Payment may be monthly or at a pre-determined

interval between both parties, but the payment is usually based upon a lump sum. Turnkey arrangements are similar to design and build. In a Turnkey approach, the client provides a detailed specification of requirements and awards a single contract for the entire infrastructure. A Turnkey approach is usually adopted when the design and method of construction are interrelated, a patented process is required, and where early completion is desired or where sophisticated clients perceive that the most cost effective approach is to give all the work to a specialist (Smith *et al.*, 2006: 150).

D&B can be assumed to relieve the owner of coordination responsibilities by transferring coordination responsibility and risks to the contractor. Further, D&B enables the owner to retain control over the concept design, reduce scope for extension of time and variation claims, broaden scope for innovation, and fasten overall project duration. Walker and Greenwood (2002: 18-19) indicate that D&B offers advantages to both clients and contractors. According to them clients' advantages include minimum up-front expenditure or in-house resources; economic design for construction, which translate to shorter overall project time; greater certainty of price because of reduced risk of variations, and major risks are passed to the contractor, since the contractor is the single point of responsibility. Advantages to contractors include the potential for almost total control of all aspects, from design to commissioning; scope for value engineering, and an enhanced opportunity to manage risk in return for reward. However, the weaknesses in the D&B approach include competing schemes may not meet client's requirements unless specified in detail before the bidding begins; the cheapest building in terms of whole-life cycle cost may not be produced; the client loses control over quality of design; a clearly defined client brief is required at commencement; changes after commencement are expensive, and analysis of tenders may be subjective (Potts, 2008: 144).

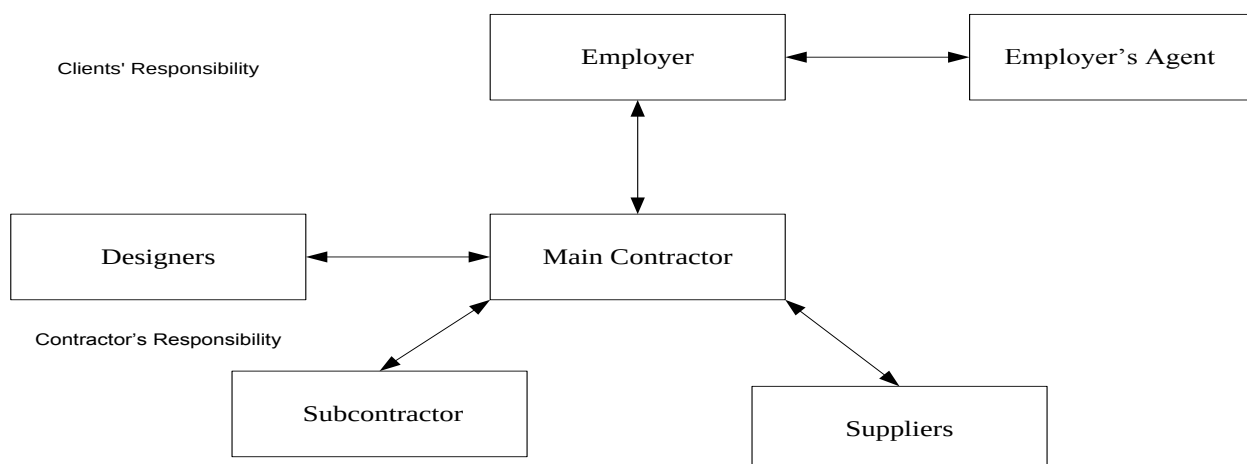


Figure 2.5 Contractual links in Design and Build (source: Walker and Greenwood, 2002: 19)

With respect to risks in D&B, the contractor accepts all the risks associated with the design and construction of the project while the client usually accepts the non-project specific risks and the risks related to the operation of the facility. Although the client transfers the project risks to the contractor, once the specifications for the facility have been issued, it is extremely difficult for clients to effect changes. Furthermore, if the client wishes to make any changes or alterations, it will result in increased premiums and increase the chance that the project will not meet its objectives (Smith *et al.*, 2006: 151).

**Framework agreements, Partnering and Alliance:** A Framework agreement is a long-term commitment between project parties to enable clients to place contracts on pre-agreed terms, specifications, rates, prices and mark-up to cover a certain type of work over a particular duration or in a certain location or both. An important feature of a Framework agreement is its constituents such as enabling elements, confidence in partner cooperation, and ownership balance and structure.

According to Smith *et al.* (2006: 153), the enabling elements are goal compatibility, complementary resources, commitment, capability, financial traits, organisational traits, strategic traits, and cultural traits. Confidence in partner co-operation refers to trust between parties. Ownership balance and structure can usually be related to the level of risk, commitment, provision of resources, the agreement, financial contribution, and the organisational structure. All these constituents are interrelated and by implication a change in a constituent triggers change in the other two constituent, and thus alters the balance of risk between the parties (Smith *et al.*, 2006: 152). A high profile project where the Framework agreement was used is the Heathrow Terminal Five (T5) project in the UK. The T5 project indicated that a Framework agreement can influence project outcomes positively.

Partnering enables project parties to reap benefits of cost savings, profit sharing, quality enhancement, and time management (Smith *et al.*, 2006: 155). Essentially, partnering promotes improved performance through collaborative business relationships based on best value rather than lowest cost (Potts, 2008: 150). In Canada, research findings supported the premise that partnering projects result in lower cost when changes are required (Christian, 2002: 119), and in Australia, research findings reveal that partnering is a good way of achieving understanding and good relationships between clients and contractors (Bajaj, 2002: 327). Alliances on the other hand, are another way for organisations to work together to achieve mutual objectives. The alliance project execution strategy is based on general principles such as aligned goals and objectives; commitment to aggressive cost reduction; working to remove process inefficiencies, duplication and traditional contract interfaces; formation of integrated teams; early involvement of contractors to optimise design and reduce costs; aligned and equitable contracts; shared profits and risks through individual contractor performance

and overall alliance performance, and promotion and maintenance of the highest standard of H&S (Smith *et al.*, 2006: 156).

In the alliance approach, contracting parties share pain / or gain relative to balance of risk. In other words, benefits of partnering include increased customer satisfaction; better value for clients; recognition and protection of profit margins for contractors and suppliers; staff development and satisfaction; creation of an environment that encourages innovation and technical development; better understanding between partners and driving down of real cost; design integration with specialists in the supply chain; improved constructability through early involvement of contractors; elimination of duplication; better predictability of time and cost; shorter overall delivery period; improved quality and H&S, and stability which provides more confidence for better planning and investment in staff and resources (Potts, 2008: 151).

Love (2002: 768) suggests that cooperative learning alliances can create a shared vision of mutual learning. He affirms that such learning can enhance a construction organisation's capacity to learn as well as improve the effectiveness of their business operations, which can result in both internal and external customer satisfaction.

**Private Finance:** The major feature of this procurement approach is the introduction of private funds into public construction projects. Terms used for private finance projects include Build-Operate-Transfer (BOT), Design-Build-Finance-Operate (DBFO), and Public-Private Partnership (PPP). Unlike the traditional public sector projects whose capital costs are largely financed by tax revenues or loans raised by government, private financed projects are typically financed by a combination of debt and equity capital. The procurement approach became popular following the success of the privatisation policies embarked upon in the UK in the recent past. It became apparent that involving the private sector would inject the needed capital into public infrastructure and help exploit the full range of private sector commercial and creative skills (Ahadzi and Bowles, 2002: 16). In line with the foregoing, many projects realised in developing countries have been funded through multilateral, bilateral or tied funding sources. In most cases the lack of a sophisticated money market has resulted in funding being restricted to a limited number of sources. Still, the risk of repayment in exotic currencies where there is no active exchange market often deters lenders from funding projects in developing countries (Smith *et al.*, 2006: 165). Construction risks, political risks, technical risks, financial risks, and logistical risks are associated with construction contracts in developing countries. For example, logistical risks may include embargo; availability of spares, supplies, fuel and unskilled and skilled labour resources; loss or damage in transportation of materials and equipment, and access and communication.

Usually in private finance projects the public sector client initiates the process that normally takes a considerable number of months or years at the planning stage. The long planning phase is occasioned by public enquiries and negotiations between interested parties. A special purpose vehicle (SPV), which is made of financial providers, contractors, and operators takes responsibility for bringing the facility to market and operating it. The SPV has an upstream contract with the owner, client or project sponsor and downstream contracts with contractors, suppliers, and service providers (Figure 2.6).

From inception of the initiative to date, strong evidence seems to suggest that PFI (PPP) projects are far better at keeping to time and budget than other forms of procurement in the UK (Potts, 2008: 72). It is not surprising therefore that the procurement approach is attractive to governments worldwide as it allows them to keep public borrowing down as projects are funded throughout their usable life cycle.

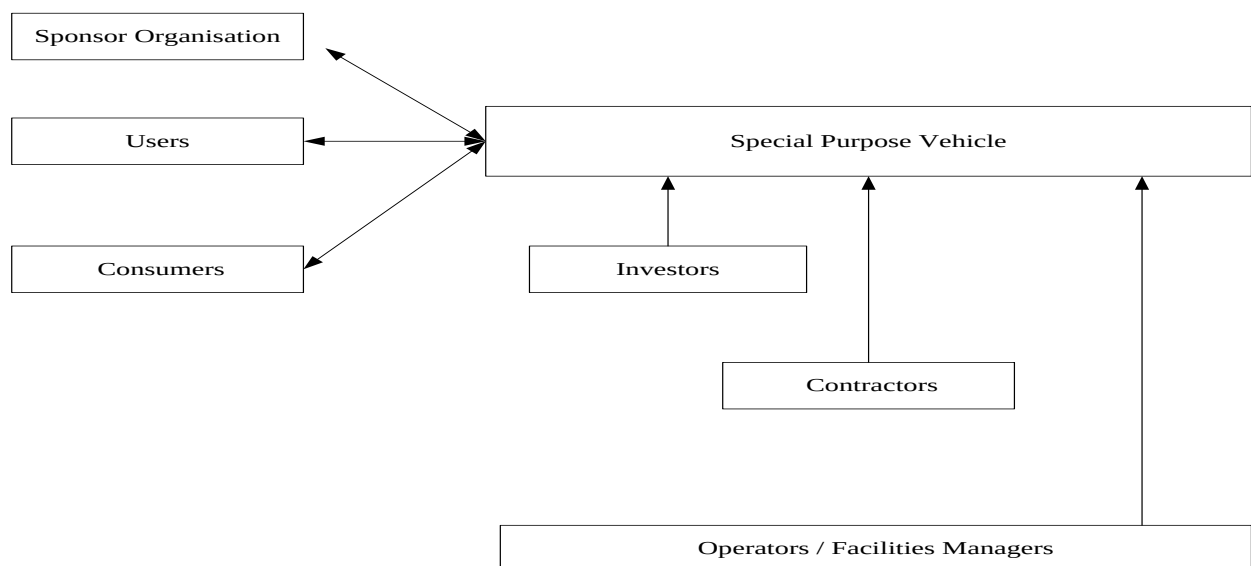


Figure 2.6 Typical private financed contracts (source: Walker and Greenwood, 2002: 22)

Based on the success recorded in the developed world, nations such as South Africa, a developing nation, that is keen on infrastructure development, has embraced the opportunity offered by this procurement system. Some infrastructure projects especially in the transport sector are procured under this route. However, the study of South African PPPs by Nyagwachi (2008: 165), *inter alia*, revealed that:

- there is a need for government departments and other PPP implementing agencies to build and sustain capacity, in order to facilitate deal flow for PPP projects in provincial governments and municipalities;

- it is necessary to adopt a project management approach to the implementation of PPP projects in South Africa at all levels;
- where appropriate, the use of PPP should be adopted as an alternative procurement strategy, since research findings indicate that it delivers benefits due to budget restrictions in public sector capital budgets;
- there is a need for training in project management skills for accounting officers and other staff to be able to conceptualise PPP viable projects, in order to increase PPP projects throughputs;
- ineffective risk distribution can lead to huge financial losses and renegotiation of PPP contracts: PPP agencies should ensure fair and appropriate risk allocation, and
- research findings show that the existing PPP policy framework and guidelines in South Africa are adequate, and if properly interpreted and applied, can catalyse more PPP projects and spur growth in the infrastructure sector. PPP guidelines and implementation toolkits should be standard and used by various PPP agencies.

Similarly, a study conducted in the UK by Ahadzi and Bowles (2002: 20) revealed that institutional frameworks and structures backed by appropriate policy guidance and training from the centre in addition to having quality staff at the departmental levels is necessary for effectively promoting the PPP procurement strategy. Lessons learned in the USA include developing the technical concept early in the project; establishing and agreeing the fixed lump sum price by project parties; maintaining critical momentum by allowing pre engineering activities while contract negotiations are underway, and measuring design progress by integrating design with construction (Vorster *et al.*, 2002: 48-50).

When developing a contract strategy it is important for the client to communicate to project parties the intended objectives of the project. The client must ensure that the most appropriate risk sharing strategy is chosen and reflected by the organisational structure and payment mechanism. In determining the risk allocation and contract strategy, it is imperative to apply risk analysis and management techniques to ensure that provision is made for risk that may jeopardize the project as the literature reveals that real benefits can accrue with the appropriate use of risk management techniques and methodologies for construction projects (Bajaj, 2002: 320). Notable risk management benefits include (Smith *et al.*, 2006: 191):

- risks associated with the investments or portfolios are clearly defined well in advance of the venture;
- management decisions are supported through the analysis of data, allowing estimations to be made with greater confidence;

- improvement of investment or portfolio planning by asking What if questions with imaginative scenarios;
- the definition and structure of the investments are continually monitored;
- the provision of alternative plans, appropriate contingencies and concerning managers are part of a risk response;
- the generation of imaginative responses to risk;
- statistical profiles of historical risk being built up allowing improved modelling for future investments;
- investments issues are understood for each investment;
- decisions are supported by the analysis of data made available;
- the structure and definition of the investment or portfolio are continually and objectively monitored, and
- contingency planning allows prompt, controlled, and pre-evaluated response to risk, which may materialise.

There is no single procurement strategy that fits all situations so much so that the selection of a contract strategy requires objective appraisal of the alternatives. As a guide, *Achieving Excellence in Construction in the UK* recommends that the following questions are asked about the contract strategy (Potts, 2008: 173):

- What resources and expertise does the client have?
- What influence / or control does the client need to exert over design?
- Who is best able to carry out the design?
- What influence / or control does the client wish to exert over management of planning (project, construction), interfaces (project, end-users), risk, design, and construction?
- What can the market provide and what framework agreements are already in place?

After the choice of the contract strategy has been made, the procurement route may be assessed by asking the following questions (OGC, 2003 cited by Potts, 2008: 174):

- Is this the right procurement route for the project, backed up with a contract in which the roles and responsibilities are clearly defined?

- Are choices about allocating risk and control tailored to the circumstances of the project and reflected in the procurement strategy?
- Has the most appropriate integrated procurement route been chosen - PFI, design and build or prime contracting?

And in assessing the contract, the following questions can be asked:

- Have improvement targets and measurement arrangements been agreed with the integrated project team and quantified?
- Have incentives been included in the contract to encourage the integrated project team to perform well and achieve the client's objective?
- Have the required benefits been quantified before incentive payments are paid?

Past studies that addressed choice of procurement method and contract documents have concluded that contracts should allow the explicit allocation of specific identified risks between parties; contracts should include incentives for risk control and sound management practice, and risks should only be allocated to the parties who are best able to control them and / or sustain their effects (Lewis *et al.*, 1992 cited by Bajaj 2002: 319).

The selection of appropriate contract arrangements for any project therefore depend on factors such as project size, cost, time, accountability, design, quality assurance, organisation, complexity, market, finance, and risk (Ashworth, 2001: 111). These factors and other client's priorities go a long way in deciding the choice of procurement strategy adopted in the construction process. Therefore, it is wise to keep in mind that the key factor in establishing the final strategy is a balance between prioritised objectives and attitude to risk (Morledge, 2002: 174). Because the majority of firms do not have the necessary methodologies in place to provide the necessary knowledge to fully understand the supply chain circumstances within which they operate, the intent of the procurement suffers. Specifically, methodologies should address those factors that impact upon the nature of demand and supply within the industry. Therefore, clients and built environment practitioners need to develop a way of thinking based upon a robust methodology that provides the necessary knowledge and understanding to fully understand the appropriate way to procure external resources and manage their supply chain (Cox and Ireland, 2002: 414).

### **2.2.2 Project delivery management skills**

Highly skilled individuals and competent teams that consist of clients, designers, suppliers, and contractors are important for the construction process. Standard construction requires individuals with basic knowledge and skills. However, problem-solving people are required for innovative

infrastructural projects that are often ill-defined and complex to implement. Individuals with tacit knowledge are central to the creativity required in the design and construction of innovative projects (Egbu and Robinson, 2005: 38). A number of industry reports in South Africa indicate that the industry suffers from skills shortages, which affect the capacity of the industry as well as the ability of the public sector clients to deliver the government's programme of infrastructure renewal. Reports emanating from enquiries commissioned by the cidb differentiate between scarce skills and critical skills. Scarce skills refer to those skills that are in short supply, but which can be obtained through short-term targeted training, while critical skills refer to particularly high-level skills within certain occupations that can only be developed through experience and mentorship (cidb, 2007: 3). In addition, the SAICE report (2006: 5) indicates that built environment skills, from professionals through to technicians and artisans, are in short supply in South Africa. The SAICE infrastructure report card lamented the level of lack of in-house engineering expertise in the public sector. The differing levels of skills in the industry directly result in poor performance relative to the construction performance parameters of cost, H&S, quality, and time. On a wider scale, the ability of the public sector to meet its infrastructure roll out target is equally affected. The recent expansion of the industry due to world cup hosting related procurements have resulted in maximum industrial capacity relative to construction and engineering operations. The maximum industrial capacity coupled with the mentioned differing level of skills has impacted on all performance parameters in the industry.

Furthermore, the Construction Education and Training Authority (CETA) affirms challenges regarding the sourcing of particular types of expertise to ensure that major projects, primarily in the state-owned enterprise sector, are rolled out as planned (CETA, 2008: 43). The challenge before the nation is to address critical skills that may retard progress in design and construction of specific projects such as power plants. The lack of skills is estimated to be in tens of senior engineering and project management capacity and in the order of hundreds for certain artisan categories (CETA, 2008: 43). In the same breath, the research conducted by Dapub (2008: 79-80) that investigated the role and competence of project managers in South African municipalities reveals that:

- municipalities in South Africa have not fully integrated the project management process into their organisations and will have to adapt and change to support more effective project management;
- a lack of project management skills and experience is a major constraint in achieving project objectives;
- the majority of the project managers are middle level managers that have a poor understanding of the link between projects and organisational goals;
- municipalities have not embraced the project management culture, and

- there is a lack of necessary operational infrastructure and technology to drive effective project management.

In terms of competencies that need immediate attention based on clients' perceptions, Crafford (2007: 187) suggests that the civil engineering discipline requires skills relative to the economics of construction, advanced financial management, business management, environmental knowledge, law, risk management, work with emerging contractors, value management, valuation, and marketing. According to him, the construction management discipline requires competencies relative to macro-economic perspective, law, marketing, and research methodology, while the project management discipline requires competencies relative to macro-economic perspectives, marketing, and law. All the mentioned skills and competencies are critically important for all developing nations with particular emphasis on countries such as South Africa that has mapped out huge investments in infrastructure.

For example, in the UK construction industry, quantity surveyors and project managers have established themselves as key participants within PFI / PPP projects in a number of areas. As well as performing advisory roles for public sector clients, cost and project managers are called upon to assist with the other key parties to a PFI / PPP transaction, namely the bidders and the financiers. Therefore, construction cost managers and project managers have a significant role to play in this challenging environment not only in the UK, but also internationally in countries such as South Africa and Australia (Potts, 2008: 72).

Lawless (2007: 50) even contends that the total number of civil engineers employed in the public sector is so inadequate that technical and project management support necessary for developing road networks and other major projects may become highly difficult to come by. Apart from service delivery challenges, the shortage of skills has resulted in loss of institutional knowledge, uncoordinated housing developments, and endangers the performance of new projects (Lawless, 2007: 125-150).

### **2.2.3 Knowledge management**

Knowledge management (KM) can be viewed as a systematic process of discovering, choosing, arranging, refining and presenting information in such a way that it improves an employee's comprehension relative to a specific area of interest (Sommerville and Craig, 2006: 61). Similarly, Egbu *et al.* (2001 cited by Emmitt and Gorse, 2003: 25) say KM is the process by which information is created, captured, stored, shared, transferred, implemented, exploited, and measured to meet the needs of an organisation. In other words, KM is the discipline of creating a thriving work and learning environment that fosters the continuous creation, aggregation, use, and re-use of both organisational and personal knowledge in the pursuit of new business value (Cross, 1998 cited by Quintas, 2005: 12). This process and action oriented definition of KM indicates that it may be applicable to the

improvement of the construction process. This is because the construction industry, which is a major sector for the delivery of key government programmes / or infrastructure, is an industry that is heterogeneous, diverse, multi-organisational, and dominated by small and medium size enterprises (SMEs). The high levels of service-inputs characterised by professional knowledge or expertise relative to a specific technical or functional domain may qualify the industry as a knowledge-intensive industry. In fact, documented research findings indicate that design, architecture, surveying, and other construction services are knowledge-intensive service sectors (Egbu and Robinson, 2005: 33). Within any organisation KM may perhaps have the same degree of importance as labour, plant, and materials (Ferne *et al.*, 2003 cited by Sommerville and Craig, 2006: 62).

Consequentially, a significant percentage of the training and experience of built environment professionals are based on the balance between explicit and tacit knowledge. Tacit knowledge is stored in individuals' heads, while explicit knowledge is codified and available in document or related format (Ferne *et al.*, 2002: 558). In this respect, organisational knowledge is a combination of both tacit and explicit knowledge. Since the construction supply chain consists of multiple organisations, its effectiveness depends on the organisational knowledge inherent in the individual organisations that make up the supply chain. In construction, tacit knowledge may include supervisory and administrative skills acquired over time through cognate site experience that include preparing bids, understanding the construction process, interaction with project teams, and the general understanding of the environment. Explicit knowledge that is often codified in written form or other formats is reusable in a consistent manner, easy to share, and transfer. Based on these explanations, codes of practise, specifications, and drawings can be deemed to be clear examples of explicit knowledge databases.

Construction knowledge is created through the actions of individuals, project teams, organisations, and the interaction between tacit and explicit knowledge in the project life cycle, that is, it is the dynamic interactions between explicit and tacit knowledge that facilitates decision-making in the implementation of construction projects (Egbu and Robinson, 2005: 35-36). The decoding and interpretation of drawing, data, and other documents depend on the training received by construction professionals. Data and information required to conceive, develop, realise, and terminate a project can be termed project knowledge (Kamara *et al.*, 2005: 107). For example, construction project knowledge may be inclusive of knowledge relative to end product, processes, and resources. The type of knowledge to be managed is influenced by a combination of client, end-user, and market characteristics. Project knowledge requirements with respect to project delivery and the professionals involved are usually fragmented as indicated in Table 2.1. Because project knowledge is domiciled in different firms within the supply chain therefore, a key aspect of KM is the transfer or sharing of knowledge for the benefit of the project. Many innovation processes in the management and

procurement of construction activities are distributed within organisations and across organisational boundaries (Egbu and Robinson, 2005: 41). Consequently, organisations working together in supply chains are likely to spread and share best practice as well as the results of research and development. Because of the spread of project knowledge within the supply chain, it is imperative to capture knowledge.

Table 2.1 Project knowledge requirements and participants

| Project stage                  | Knowledge requirements                                                                                                                                                                                                                                                                                              | Participants                                                                                                                                             |
|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Conception                     | Do we need a project? What purpose will the facility serve? How much funding can we commit to the project? Where is it going to be built? How will the facility be procured? Who are the best firms to do the job? Who will look after our interests?                                                               | Development managers; property managers; project managers; financial consultants; facility managers; business managers; planning authorities             |
| Design and specification       | What does the client really want? What are the characteristics of the site for the facility? How do the relevant regulations apply to this facility? What will the facility look like? What kind of materials do we need, and in what quantity? How much is it going to cost? How will the facility be constructed? | Architects; engineers (building services, civil, structural); planning supervisors; facility managers; quantity surveyors; project managers; contractors |
| Construction of infrastructure | Have all materials been specified? Where can we obtain the materials? How and when do we need them on site? How can we organise ourselves better to do the job efficiently? How can different components be assembled efficiently? How can we ensure the quality of workmanship?                                    | Contractors; project managers; specialist contractors; materials and equipment suppliers; architects; engineers                                          |
| Commissioning and handover     | Is the facility performing as expected? Is it serving the purpose for which it was created? Are all components and systems working effectively? Are all interest groups satisfied?                                                                                                                                  | Facility managers (operators); architect; contractors; clients / or end users                                                                            |

Source: Kamara *et al.* (2005: 108)

The capture of current and relevant project knowledge offers advantages that have a significant impact on the construction process. The advantages include (Kamara *et al.*, 2005: 118):

- The construction supply chain will benefit through shared experiences that are captured as part of the learning related to key events. The benefits to this group are both short and long term: short

term, in the sense that project teams would be enabled to better manage the subsequent phases of a project; long term, because it will increase their capacity to better plan future projects and their ability to collaborate better with other organisations. Learning from past projects can be used to train new employees and project managers;

- Other project teams can use the learning captured from previous / or similar projects to deal with problems; reflection on previous learning can also trigger innovative thinking;
- Client organisations benefit from enriched knowledge about the development and construction of their assets. This will contribute to the effective management of facilities and the commissioning of other projects. In the longer term, clients will benefit from the increased certainty with which construction firms can predict project outcomes;
- Project staff and students of project / construction management and the institutions providing such courses / or training will also benefit through the use of captured project knowledge as case study material, and
- It will lead to improved supply chain management, as team members would work more collaboratively and share the lessons learnt on construction projects.

### **Knowledge transfer and sharing**

Proliferation of procurement options / or strategy, growing complexity and cost relative to projects, and ever increasing clients' demands and expectations presents a situation where organisations have to collaborate and share knowledge, skills and expertise in order to meet the needs of project stakeholders. In order to stay competitive, organisations must not only be open to formal and informal information and knowledge flows from networks and markets, they must also protect and preserve their intellectual capital and knowledge base because it is upon the latter point that a firm's survival and growth depends. KM is an emerging vital activity for organisations to preserve valuable knowledge and exploit the creativity of individuals that generates innovation (Egbu, 2005: 122). KM, which is defined as organisational learning from the project process experience is a vital element of the project life cycle (Winch, 2002: 193).

A construction organisation's ability to learn from its partners or supply chain is affected by its ability to harness information, and transform / or transfer it internally amongst the supply chain as knowledge (Sommerville and Craig, 2006: 69). Fernie *et al.* (2002: 559) suggest that the environment within which the knowledge sharing occurs between people, influences the extent to which tacit knowledge can be appropriated or shared. Within the construction supply chain therefore, the transfer / or sharing of knowledge is between different professionals involved in each phase of the project; different stages of the project, and projects through a particular construction firm to another (Kamara

*et al.*, 2005: 108). Thus the level of knowledge transfer depends on the organisation, project structure in the form of procurement, contractual, and communication, and the relationship between project partners.

KM tools are communication IT and non-IT tools that are required to capture, create, share, transfer, and modify knowledge. Table 2.2 indicates available tools for KM. KM techniques do not require technology to implement them in organisations. These techniques are not only easy to access and use, but are important due to a number of factors. These factors include affordability; ease of implementation and maintenance, and the retention and increase in organisational tacit knowledge (Al-Ghassani *et al.*, 2005: 84). KM technologies on the other hand are relatively expensive to implement and they focus on explicit knowledge.

Table 2.2 Available KM techniques and Technologies

| KM tools                         |                                               |
|----------------------------------|-----------------------------------------------|
| KM techniques                    | KM technologies                               |
| Require strategies for learning  | Require IT infrastructure                     |
| More involvement of people       | Require IT skills                             |
| Affordable to most organisations | Expensive to acquire and / or maintain        |
| Easy to implement and maintain   | Sophisticated implementation / or maintenance |
| More focus on tacit knowledge    | More focus on explicit knowledge              |
| Example of tools include:        | Examples of tools include:                    |
| 1. Brainstorming                 | 1. Data and text mining                       |
| 2. Communities of practice       | 2. Groupware                                  |
| 3. Face-to-face interactions     | 3. Intranets or extranets                     |
| 4. Recruitment and training      | 4. Knowledge bases and ontology               |

Adapted from Al-Ghassani *et al.*(2005: 84)

KM technologies depend heavily on IT as the main platform for implementation (Al-Ghassani *et al.*, 2005: 86). IT provides an enabling platform across the construction supply chain to promote accountability and responsibility (Sommerville and Craig, 2006: 63). It allows for easy identification of key personnel involved in a project and provides a solid foundation for the exploration of innovative methods that aid the movement of information and knowledge within the construction supply chain. The adoption and application of IT as a KM tool will aid knowledge capture and indeed

the IT tools available have proven their worth in the distribution, creation, and management of project information (Sommerville and Craig, 2006: 65). According to Sommerville and Craig (2006: 66), the benefits of knowledge sharing when using IT systems include:

- provision of fast, easy access to present and prior construction work that can be re-used for new projects and new ideas;
- saving of project time by delivering informative advice and knowledge ‘just in time’;
- availability of essential information for organisations and their employees for continued exploitation thus saving valuable time that would otherwise be spent in searching for information;
- spread and duplication of expertise organisation wide, and
- the availability of knowledge for utilisation in the future.

However, only when IT and non-IT tools are used together, can the development of appropriate methodology for the live capture of construction project knowledge be possible. Lessons from past research initiatives suggest that the combination of both tools / or approach is the most sensible step that delivers a more complete solution that integrates ‘soft’ issues with ‘hard’ technological issues (Kamara *et al.*, 2005: 114). The considerable quantity of project documentation produced on any project is amenable to robust implementation of SCM techniques, which adopt IT as a tool to control processes, and as the awareness and acceptance of IT increases, so the members of the construction supply chain will be melded together and coalesce in sharing project knowledge in a meaningful manner (Sommerville and Craig, 2006: 67).

### **Advantages of KM**

KM impacts upon organisational and project performance improvement in many ways through interrelated factors. Factors such as human, technological, economic, social, environment, and legal issues associated with the creation, sharing, transferring, storing and exploitation of tacit and explicit knowledge impacts organisational innovation (Egbu, 2005: 129). A good internal organisational structure that strikes a balance between creativity and formal systems should be able to adapt to chaotic external pressures more easily. KM is important for a number of reasons. Egbu (2005: 123) suggests the importance of KM, which includes the rise of time-based competition as a marketing weapon requires organisations to learn quickly; globalisation of operations; growth in number of mergers and take-overs where multiple organisations must share knowledge in a collaborative forum, and in project-based organisations, KM brings together diverse knowledge sources from different sections of the demand and supply chains, achieving cross-functional integration. Construction management researchers have also affirmed the potential of improved knowledge management in

construction. KM enables construction organisations to identify key knowledge deficiencies (Egbu, 2008: 233). Anumba *et al.* (2005: 215) equally state that:

- innovation is more likely to thrive in an environment where there is a clear strategy for managing knowledge;
- improved performance will result from the pooling of an organisation's knowledge as workers will be both more effective and more efficient;
- KM is vital for improved construction project delivery, as lessons learned from one project can be carried on to future projects, resulting in continuous improvement;
- KM can facilitate the transfer of knowledge across a variety of project interfaces;
- with effective KM, firms and project teams can avoid repeating past mistakes and / or reinventing the wheel;
- increased intellectual capital is a major benefit for many organisations, which is able to narrow the gap between what employees know and what the organisations;
- firms that adequately manage their knowledge are better placed to respond quickly to clients' needs and other external factors;
- KM results in improved support for teams of knowledge workers in an organisation or project team;
- dissemination of best practice is one of the results of knowledge sharing - this can happen both within and across organisations;
- organisations can retain the tacit knowledge that would otherwise be lost when valued employees leave, retire or die;
- increased value can be provided to the customers of construction organisations through better management of knowledge;
- with effective KM, construction organisations can be more agile and better able to respond to organisational changes, and
- risk minimisation is one of the key benefits of KM, as the enhanced knowledge base means that organisations have fewer uncertainties to deal with.

Given the aforementioned benefits, construction firms that intend to stay competitive must embark on processes that assure improvement relative to KM. The processes of creating, acquiring, and applying knowledge require learning and understanding. The process of learning and understanding requires

investment and resources in KM. Therefore, it can be inferred that with the potency of KM, the effective management of the knowledge sharing process is tantamount to the successful management of the construction supply chain (Ribeiro and Lopes, 2001 cited by Sommerville and Craig, 2006: 62).

#### **2.2.4 Organisational culture**

The present nature and structure of the industry indicate that many processes are replicated resulting in NVAAs and inefficiencies within the supply chain. In order for the industry to improve its performance the industry needs to change its prevailing culture, and by implication supply chain member firms need to change their culture towards a culture that support continuous improvement. This culture will not only allow information sharing between projects, teams, and organisational boundaries, but will also support the construction sector in adopting new / or innovative processes, which improves quality and productivity (Sommerville and Craig, 2006: 47). Girmscheid and Hartmann (2002: 373) also suggest that organisational culture that fosters performance improvement is highlighted through a high status of innovation; freedom of the members of the organisation to act autonomously and to be creative; support for members of the organisation that are especially innovative; preparedness to take risks and willingness to tolerate mistakes, and open multi-directional communication in the organisation.

In this sense, culture in construction project scenarios refers to the culture of the project team comprising different contracting entities in the supply chain and also includes company-wide inter-departmental members and others who contribute in some way to the final product or service to be delivered (Mackay, 1993 cited by Rahman *et al.*, 2002: 387). Organisational culture can also be defined as the way things are done and operated within the internal environment of the workplace, which is evident through common beliefs, patterns of behaviour, norms, values and rules within the organisation (Naoum, 2001: 162). In addition, organisational culture has major dimensions such as social culture, technical culture, and managerial culture (Naoum, 2001: 163).

Social culture refers to the way individuals behave and the means in which people are motivated at work. Technical culture refers to the techniques used for executing tasks, equipment, processes and other production inputs. Managerial culture refers to the style of management and organisational structure, and to ways in which tasks are differentiated and activities are integrated. Since the survival and progress of organisations depend on their ability to change their culture in response to external environmental factors, the culture in organisations must be dynamic, and performance oriented (Naoum, 2001: 168). The dynamism of organisational culture is illustrated in Figure 2.7.

Further, organisational culture influences communication within the construction supply chain. The culture of the social systems and networks that form the temporary project organisation will influence how individuals within this system communicate (Emmitt and Gorse, 2003: 30). For instance, design

that is a participatory process involves individuals from different cultural backgrounds. Each member of the design team brings unique agenda, goals, values and experiences to the design group. The attributes will influence the interaction of team members and the efficiency of communication in the supply chain. A change in culture is necessary for innovation, which is seen as key to implementing change and improving quality of products and processes.

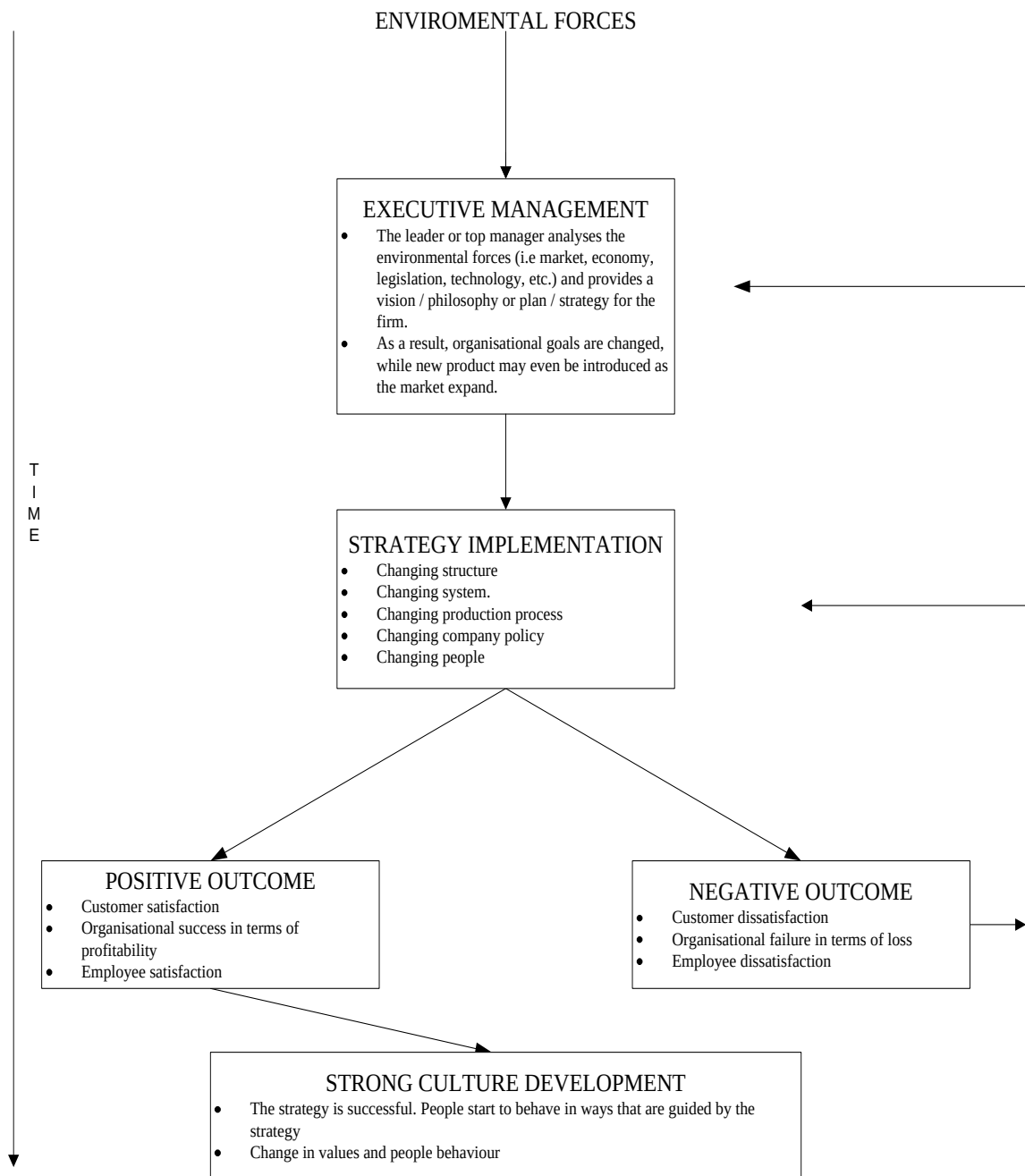


Figure 2.7 Development of organisational culture (adapted from Naoum, 2001: 169)

According to the results of the investigation conducted by Girmscheid and Hartmann (2002: 380), innovative potential that is created by procurement strategy can only be used if the organisational culture of construction firms is open to performance improvement. That is the culture of organisations involved in projects impact the level of performance improvement witnessed in the process.

### **2.2.5 Integrated design team**

The Architectural, Engineering, and Construction (AEC) sector is highly information-dependent. Projects are regularly delivered by temporary, multi-disciplinary, multi-firm, multi-location groups of people. Thus, the construction process relies on enormous quantities of information being generated, transmitted and interpreted to facilitate projects to be built, maintained, and demolished. However, cross discipline communication between professionals that are involved in a project is often problematic and a major contributory factor to poor project performance. Communication has often been cited as a weakness in construction. A case study research conducted by Murray *et al.* (2002: 157) ranked communication first among other issues plaguing construction. They identify communication in the design team as the most difficult in the case study. However, the nature and characteristics of projects in the industry contribute to communication problems. Some of the communication problems may be attributed to the characteristics of construction projects. Construction project characteristics include (Emmitt and Gorse, 2003: 4):

- lack of continuity within and between projects makes the establishment and promotion of efficient and effective communications particularly challenging;
- each new project has different participants, thus relationships and communication channels have to be created for each project;
- individual projects are unique in design and specification, material specifications alter between projects, consistent supply chain is difficult to achieve, and
- projects can last a long time and during this time participants may change and thus interpersonal communication channels will need to be re-established.

Supply chain members are concerned with information exchange through drawings, specifications, cost data, schedule programmes and other plans prepared by individuals from diverse backgrounds with different methods of graphical representation. The majority of verbal / or e-mail exchanges between supply chain members address queries over the interpretation or adequacy of information provided. This phenomenon leads to the much canvassed lack of integration and coordination between professionals and the subsequent calls for more collaborative working arrangements in construction. The benefits of collaboration include elimination of problems at design stage, engendering confidence

that facilitates problem elimination, creation of a better working environment, greater co-ordination and an increase in project efficiency (Sommerville and Craig, 2006: 47).

Information Technology (IT) is an enabler of collaborative working within the construction supply chain. The use of IT in construction to manage and control project information has reduced manual tasks and processes. It allows clients, designers, contractors, subcontractors, and suppliers to make timely and unambiguous requests for drawing details, instructions, project information, and other work related procedures. The use of IT can minimise costly design changes. For example, it was determined that the average cost of design changes was larger than the average cost of construction changes for all types of procurement approaches in Canada (Christian, 2002: 118). Similarly, an analysis of present working methods with respect to information management indicates that standardised IT systems are the way forward if documentation is to be controlled, structured and made readily available to all construction professionals involved in a project (Sommerville and Craig, 2006: 48).

Information that is classified as a key resource in the construction process, gives supply chain members unique advantages in decision-making (Ugwu, *et al.*, 2005: 102). However, presently delays, rework, and errors occur because most construction tasks and projects are not only geographically dispersed, but the exchange of information is also slow and unreliable. It is notable that despite the advantages of ICT, the use of paper as a form of communication is still the main medium of information transfer and sharing within the industry. This medium of communication exposes an organisation and the entire supply chain to errors because it is extremely difficult for clients and contractors to obtain up to date information, and virtually impossible to resolve processes such as RFIs within the required time (Sommerville and Craig, 2006: 89). Previous research indicates that communication breakdown occurs between project team members during times of uncertainty and crisis (Emmitt and Gorse, 2003: 10). The communication breakdowns, which can either be minor or major, portend negative consequences for projects.

To remedy this anomaly, the implementation of document / or information management systems and associated mobile technologies will allow construction organisations to become IT compliant while at the same time allowing the remotely based construction operative the opportunity to collect and transfer project information electronically (Sommerville and Craig, 2006: 49). Information management systems (IMs) can facilitate the coherent management and electronic sharing of information during construction projects. It enables collaborative design to take place as a precursor to efficient delivery of construction products. This requires that multiple distributed participants work together to achieve project goals, which are often anchored in H&S, quality, time, and cost (Ugwu *et al.*, 2005: 103). In furtherance of this purpose, construction collaboration technology was developed.

Wilkinson (2008: 83) defines construction collaboration technology as a combination of technologies that together create a single shared interface between multiple interested individuals, enabling them to participate in creative processes in which they can share their collective skills, expertise, understanding and knowledge and thereby jointly deliver the best solution that meets their common goals, while simultaneously creating an auditable electronic record of the people, processes and information employed in the delivery of the solution. It follows that as the industry embraces integrated collaborative working ways, a change from a paper based communication medium to an electronic based communication medium will result in a communication process that is structured and coordinated throughout the construction supply chain (Sommerville and Craig, 2006: 52). The combination of communication systems used to manage projects should be designed to induce new participants; inform and agree action; identify targets; allocate responsibility; measure and control performance; coordinate information and activities; check and remind others that critical activities are in place; encourage, persuade and enforce action and behaviour; identify and resolve problems; re-schedule activities; provide feedback on client satisfaction; manage and resolve conflict, and negotiate and control disputes (Emmitt and Gorse, 2003: 92).

Through the use of sophisticated structured methods of communication such as Electronic Document Management Systems (EDMS), the burden of administration can be reduced and higher quality relevant documents that can be used and relied upon in projects (Sommerville and Craig, 2006: 57).

The essence of effective and efficient communication within the construction supply chain is to engender informed decision-making processes. Decision-making is an essential part of the design and construction project delivery. The availability and currency of information is important to the decision-making process. The communication interface between designers is essential for smooth operations on construction sites. Ineffective / or poor communication between designers may result in the quality of service delivery being below the specified standard, and may also result in projects that fail to meet specified performance requirements (Emmitt and Gorse, 2003: 22). Arguably therefore, the failure to ask questions / or admit that more information is required often leads to problems within the supply chain.

Nevertheless, the past few decades have witnessed significant changes in the industry. The industry, and the IT tools will continue to evolve as individuals, organisations and project teams that have experienced the usefulness of IT, will not resort to paper-based communication. Instead, there may be continued development in four main areas (Wilkinson, 2008: 102):

- declining reliance on paper-based processes to share project information;
- greater integration between design, construction, operation and maintenance, and between people, processes and technology;

- more transparent, longer-term commercial relationships, both within conventional project teams and in relation to technology vendors, and
- an improved industry reputation for efficiency, reliability, H&S and innovation.

### **2.2.6 Management of construction logistics**

According to the Council of Logistics Management (CLM), logistics can be defined as that aspect of the supply chain process that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements (Blanchard, 2004: 4). In the same context, logistics management refers to the science of planning, procurement, maintenance, distribution and replacement of materials and personnel. This means having the right person / vehicle / equipment / material in the right place at the right time. The principal responsibility of a construction / project manager of a construction project revolves around the optimisation of daily operations of facilities through careful planning, organising, directing, and controlling activities before and during construction. Operational efficiencies that involve day-to-day decisions relative to logistics are directly part of the responsibilities of site management. In this context, construction logistics activities include (Jang *et al.*, 2003: 1 134):

- material supply, storage, processing and handling;
- manpower supply;
- schedule control;
- site infrastructure and equipment location;
- site material flow management on a job site, and
- management of information related to all physical and services flows.

The aspects of logistics support in the production process, and by implication the construction process, involves all the supply chain activities that include the purchasing and physical supply of items to the manufacturer / or producer, the internal flow of materials within the producer's operation, and the physical distribution of finished products from the factory / and or dealer to the construction site (Blanchard, 2004: 319). Table 2.3 reveals the salient logistics activities in the production process that are similar to construction logistics. As an illustration, in order to perform an activity or carry out a task on site, certain conditions must be fulfilled. These conditions entail the availability of appropriately skilled labour, materials, access to work area, plant and equipment, design information, completion of previous critical tasks, acceptable weather conditions, and agreed safe work procedures. Should one or two of these conditions not be met or available, a task cannot be completed and the construction process is delayed. Coordinating and directing resources so that all these conditions can be met falls within the process of logistics management. Site management as well as workers play

principal roles in logistics management. However, planning, managing, and reporting on these activities, is the responsibility of site management. For instance, heavy duty trucks for material haulage are often driven by site workers for the primary purpose of moving materials from point A to B. The movement of concrete, reinforcement, timber, and steel frames, falls under logistics.

Table 2.3 Logistics activities in the production process

| <b>Physical supply</b> | <b>Manufacturing</b> | <b>Physical distribution</b> |
|------------------------|----------------------|------------------------------|
| Demand forecasting     | Production planning  | Demand forecasting           |
| Order processing       | Purchasing           | Order processing             |
| Procurement            | Material handling    | Inventory management         |
| Inventory management   | Inventory management | Transportation / traffic     |
| Transportation / flow  | Packaging / shipping | Customer service             |
| Information flow       | Information flow     | Information flow             |

Adapted from Blanchard (2004: 5)

For example, the material procurement process is characterised with a large number of participants and changes throughout a project life cycle. According to Udejaja and Tah (2005: 278), the characteristics of construction material supply chains include:

- Multiple organisations are often involved in the supply chain. Each organisation attempts to maximise its own profit within the overall activity;
- Organisations are physically distributed, which may be across one site, across a country or even continents. This situation is even more apparent for virtual organisations that form alliances for short periods of time and then disband when it is no longer profitable to stay together;
- In a project or inside organisations, there is a decentralised ownership of the tasks, information and resources involved in the supply chain;
- Different groups within the project or inside organisations are relatively autonomous. They control who, at what cost and in what time frame, consumes resources. They also have their own information systems, with their own idiosyncratic representations, for managing their resources;
- There is a high degree of natural concurrency. That is, many interrelated tasks are running at any given point of the supply chain process;

- There is a requirement to monitor and manage the project. Although the control and resources of the constituent sub-parts are decentralised, there is often a need to place constraints on the entire process, and
- Material supply chains are highly dynamic and unpredictable. It is difficult to provide a complete priority specification of all the activities that need to be performed and how they should be ordered. Any detailed time plans which are produced are often disrupted by unavoidable delays or unanticipated events.

Logistics management that addresses material movement, seeks to introduce efficiency in the construction process because project management is principally concerned with the effectiveness of the construction process, that is, logistics management is an approach concerned with optimising flows within an organisation (Fisher and Morledge, 2002: 205). The goals and objectives of logistics in the supply chain include (Blanchard, 2004: 91):

- the right product: being able to deliver a quality product in response to a client's need;
- the right location: delivering the product where the client wants it;
- the right time: delivering the product when the client wants it;
- the right service: providing the customer with the information needed in real time, and
- the right value: ensuring that the client believes that a great product, with a great service, for the right price has been offered.

In general, construction logistics can be divided into supply logistics and site logistics. Supply logistics are related to activities in the production process that are cyclic such as the specification of supply resources such as materials, equipment, and labour, supply planning, acquisition of resources, transport to a site and delivery, and storage control. Site logistics are related to the physical flow of on-site processes such as the management of handling systems, H&S equipment, site layout, defining activity sequence, and resolving conflicts among various production teams related to the on-site activities (Jang *et al.*, 2003: 1 134).

In fact the importance of construction logistics to project managers in the industry cannot be over-emphasised. The work of Jang *et al.* (2003: 1 141) demonstrates this importance, when they report that key construction material logistics factors such as personnel, material flow, schedule adherence, contractors' organisations, and information flow have significant relationships between the construction logistics process and satisfaction of project managers. This indicates that the factors are significant predictors of overall satisfaction for the construction logistic process.

In spite of this knowledge, the situation in the South African construction industry relative to logistics and its management is very unattractive. Specifically, based upon a multi-case study research conducted in Cape Town, Shakantu *et al.* (2008: 437) pointed out that the logistics of building materials and construction and demolition (C&D) waste are not integrated, and that the movements for both materials delivery and C&D waste are sub-optimal. They affirm that integration of disparate logistics would not only provide scope for utilisation of spare capacity, but would also ultimately improve the logistics of the construction industry. The utilisation of spare capacity would immediately increase the utility of vehicles, reduce unit costs, and also lower the number of empty vehicular movement in and about construction sites.

Given the abovementioned findings in the South Africa construction industry, it is imperative to advocate the objectives and advantages of logistics management. In other sectors of the economy, the objective of logistics management is to design, develop, and implement an overall process that will be completely responsive to customer requirements. These merits are transferable to the construction industry that is faced with increasing demand from clients relative to performance and conformance to requirements. In this context, logistics management enable requirements that will lead to (Blanchard, 2004: 320):

- minimising the overall response time from when a need is first identified to delivery and installation of the finished product at the user's site;
- minimising the number of steps in the decision-making process;
- minimising the steps and time required in the materials purchasing process;
- increasing asset visibility and minimising inventory requirements;
- the number of warehouses necessary and storage requirements;
- minimising packaging and transportation times, and
- minimising cost from a system life cycle perspective.

It follows that the realisation of the abovementioned objectives is dependent on a reliable information flow and logistics requirements in SCM activities including the forward and reverse flows. Clients' demand for improvement and new technologies makes the adoption of sound logistics practices imperative in the industry. Building Information Modelling (BIM) and IT collaboration tools have set the stage for substantial change and by implication improvement in the design and construction process. BIM and IT collaboration technologies potentially facilitates standardisation / or modularisation in off-site locations that offers greatest production efficiency and quality.

With the use of IT tools such as Vendor-Managed-Inventory (VMI) in construction, the time and work relative to logistics and administration functions to manage procurement of small items on construction sites can be reduced significantly (Tanskenen *et al.*, 2009: 39). Also, Song *et al.* (2007: 67) report that the location of materials in motion as well as those in storage can be tracked through the use of a material tracker integrated with Radio Frequency Identification (RFID) and Zigbee. Agent technology offers a new approach to handling the complex nature of materials in the supply chain environment, and is capable of solving material supply chain problems (Udeaja and Tah, 2005: 305). Udeaja and Tah developed a prototype for construction material supply chain decision-support by role modelling the construction material procurement processes. The model was done by representing the collaboration between activities and participants, building the system on independent platform architecture, and linking it to other planning and database packages.

The literature shows that efficiency gains accrue if the concept of logistics management is optimised in construction as logistics adds value to economic activities in the construction process through place and time utility (Coyle *et al.*, 2003: 41). Logistics also provides place utility by moving goods from production surplus points to where demand exists and time utility by making sure the goods are available when they are needed. Logistics creates place utility primarily through transportation, and time utility through proper inventory maintenance and strategic location of goods and services.

### **2.2.7 Coordination and respect for H&S**

Though H&S awareness has increased in recent times as a result of large-scale construction accidents in South Africa and the attendant media coverage, the industry H&S performance is still far from satisfactory. Notably, construction consistently contributes a disproportionate number of work related injuries and fatalities, and there continues to be a low level of awareness regarding, as well as non-compliance with, H&S legislation and regulations in South Africa. The Construction Regulations (2003) provide a legislative platform for addressing H&S in South Africa, and have implications for all stakeholders involved in the construction supply chain. The philosophy behind the regulations is to inculcate optimum H&S practices among clients, consultants in the form of designers and project managers, contractors, subcontractors, suppliers, and other stakeholders in the construction process. This implies that all the participants of the construction supply chain are responsible for construction H&S on-site and off-site. The coordination, respect for, and implementation of H&S are significant elements of the construction process. However, the recently published construction H&S status report in South Africa indicates, *inter-alia*, that (cidb, 2009: 9):

- an understanding of construction H&S is hampered by a lack of available statistics, and in particular that from the Compensation Commissioner;

- statistics for 1999 showed that the construction industry accounts for around the third highest number of fatalities per 100 000 workers, and the ninth highest number of permanent disabilities per 100 000 workers;
- the fatality rate in the construction industry is around 20 per 100 000 workers, or around 150 fatalities per year excluding construction related motor-vehicle accidents;
- motor-vehicle accidents account for around another 100 fatalities per year;
- there is a high rate of non-compliance with the requirements of the Construction Regulations manifested in approximately 50% of construction sites being found to be non-compliant during the August 2007 ‘construction blitz inspections’;
- H&S in the construction industry in South Africa lags significantly behind that in developed countries;
- the construction industry currently has the third highest prevalence of HIV positive workers, and the industry faces increasing lost workdays due to absenteeism and productivity decreases, together with skills shortages, and increased costs of construction due to rising overheads;
- the cost of accidents (CoA) is estimated to be around 5% of the value of construction costs which ultimately is passed onto clients;
- inadequate or lack of H&S negatively affects other project parameters such as productivity, quality, and cost, and
- the total CoA exceeds the cost of H&S, and therefore, H&S is in essence a profit centre.

The abovementioned findings from the cidb report attest to the sub-optimal performance of construction H&S in South Africa, and underscore the persistent call for improvement. Also, the report indicates that not much has changed in the industry in almost a decade in terms of construction H&S. It is instructive to note that almost a decade before the report Smallwood (2000: 467) determined that:

- H&S related practices are inadequate;
- inadequate H&S has a substantial negative effect on labour productivity;
- inadequate H&S has a negative effect on quality;
- inadequate H&S has a substantial negative effect on cost and a lesser negative effect on client and worker satisfaction, schedule and the environment;
- the causes of inadequate H&S, poor labour productivity and rework are common, and

- the actions / agencies / aspects which improve or contribute to an improvement in H&S, labour productivity and quality are common.

Yet, research findings, reports, and media reports have not spurred the anticipated rapid change in the industry. Examination of the reasons for the slow pace of change cannot be far from the state / or nature of the industry. However, the continuing poor H&S performance of the construction industry in the form of fatalities, injuries, and disease, the number of large-scale construction accidents, and the general ‘non-participation’ by key project stakeholders such as clients and designers, provided the catalyst for a new approach to construction H&S (Smallwood and Haupt, 2005: 2).

The culture, perceptions, and values relative to construction H&S must be optimised in the construction supply chain, to realise an accident and injury free industry. This may be achieved through coordination and integration of H&S in the value chain of projects.

### **2.2.8 Coordination and integration of quality requirements**

Quality is one of the primary project performance parameters. Quality has been defined by various authors in different contexts. Oakland and Marosszeky (2006: 4) define quality as simply meeting customer requirements. In addition, the cidb (2009: 25) standard for uniformity in construction procurement (SFU) refers to quality as functionality. The cidb construction procurement best practice guideline #A4 (2006: 2) reiterates the various forms of definitions relative to quality, which include:

- fitness for use;
- conformance to stated requirements;
- meeting or exceeding customer expectations at a cost that represents a value to them;
- surpassing customer needs and expectations throughout the life of the product;
- the customers' perceptions of the value of the suppliers' work output;
- attention to detail;
- the amounts of the unpriced attributes contained in each unit of the priced attribute;
- the totality of features and characteristics of a product or service that bear on its ability to satisfy given needs;
- an inherent or distinguishing characteristic, a degree or grade of excellence, and
- conformance to a set of predetermined design and workmanship standards.

Therefore, the client, contractor, designers, subcontractors, and suppliers all contribute to quality to diverse degrees. They are responsible for standards / or quality relative to process, procedure, service, and product in the construction process. Investigations relative to issues impacting quality in the South African construction industry reveal salient findings about the state of quality in the industry. Specifically, Rwelamila and Nangolo (2002: 412) discovered that the implementation of Total Quality

Management (TQM) at Local Authorities Department of Public Works (LADPW) is not satisfactory. The study, which focuses on TQM implementation and understanding in Public Works Departments of the Western Cape Province Local Authorities, reports that:

- LADPWs were generally unfamiliar with TQM principles;
- LADPWs clearly acknowledged that TQM had not been formally adopted as a quality improvement strategy;
- LADPWs need a comprehensive and formal TQM implementation program;
- Respondents indicate that lack of administrative support for TQM, lack of awareness / or understanding of TQM, lack of financial resources, difficulty in measuring the effectiveness of TQM improvement are the most obvious barriers to successful TQM implementation, and
- Resistance to change is not a potential barrier to the implementation of TQM.

Though, the abovementioned findings focus on a client organisation, other research conducted by Smallwood (2000: 467), which addresses the entire industry discovered that quality related practices are inadequate; rework constitutes on average not more than 4% of project value; rework has a substantial negative effect on labour productivity; labour productivity related practices are inadequate; the overall level of labour productivity based upon labour utilisation and efficiency is approximately 60%; rework has a substantial negative effect on cost, client satisfaction and schedule, a lesser negative effect on worker satisfaction, and a limited negative effect on the environment, and poor labour productivity has a substantial negative effect on cost, client satisfaction and schedule. In particular, the cidb report *Construction Quality in South Africa: A Client perspective* revealed that public sector clients are neutral or dissatisfied with the quality of construction on around 20% of all projects, and around 12% of the projects surveyed had levels of defects which are regarded as inappropriate (cidb, 2011b:1-7). The report noted that client dissatisfaction with the quality of completed works on around 2% of the projects surveyed in 2009 translates to dissatisfaction on completed work in the public sector to a value of around R3.5 billion per year.

The report then postulated that the majority of those cases in which clients are not satisfied with construction quality could probably be attributed largely to procurement related barriers that included fraud and corruption in the appointment of contractors that were not capable of undertaking the required works (cidb, 2011b: 32). It further postulated that the majority of those cases in which clients are neither satisfied nor dissatisfied with construction quality could probably be attributed largely to design or construction related barriers, or attributable to barriers in the role of the client's agent in not ensuring quality. In terms of construction related barriers to quality, the report indicated that key barriers to quality include poor site management; focus on time and cost; skills and competence

issues; lack of quality improvement processes; and lack of worker participation in quality circles and quality improvement teams (cidb, 2011b: 31). Clearly, the report amplified the argument that the achievement of optimum quality in South African construction is confronted with a range of barriers that must be overcome.

Incontrovertible evidence from these research endeavours suggest that quality failure responsibility does not only rest with all members of the construction supply chain, but it must also be improved holistically across organisations in the industry. This implies that the role of clients, designers, contractors and suppliers contributes to quality significantly. In construction, quality is often defined in terms of conformance to customer requirements. This definition means quality requirements have wider implications. The requirements may entail availability, durability, reliability, maintainability, cost effectiveness, and other attributes. Therefore, quality of product / or service has two aspects, which include quality of design and quality of conformance to design. Quality of design is a measure of how well the product / or service is designed to achieve the agreed requirements, while quality of conformance to design is the extent to which the product / or service achieves the quality of design (Oakland and Marosszeky, 2006: 17). Quality / or standard / or functionality is important to all stakeholders in the construction industry. Quality in construction has far reaching implications for infrastructure in a country. It impacts the availability, longevity, and durability of infrastructure. It also impacts the ability of government to respond to the sundry needs of its citizens.

SCM in construction presents a positive contribution towards quality improvement on projects and the industry at large. According to Cox and Ireland (2002: 411) integrated SCM is less at arms length and more focused on the creation of jointly developed innovations in the supply chain. These innovations were always driven by the assembly firm (client), and focus on waste eradication, cost minimisation and maximisation of operation efficiency. The ultimate objective of the innovations is to develop better value products that are passed to the final customers. Central to these principles is the high level of product quality, minimum lead times, and information transparency (Cox and Ireland, 2002: 412). The management interventions that were addressed as enablers can thus improve construction procurement, especially from the SCM perspective. Thus, the next chapter presented a synopsis of SCM in construction.

### 3.0. REVIEW OF RELATED LITERATURE: SUPPLY CHAIN MANAGEMENT

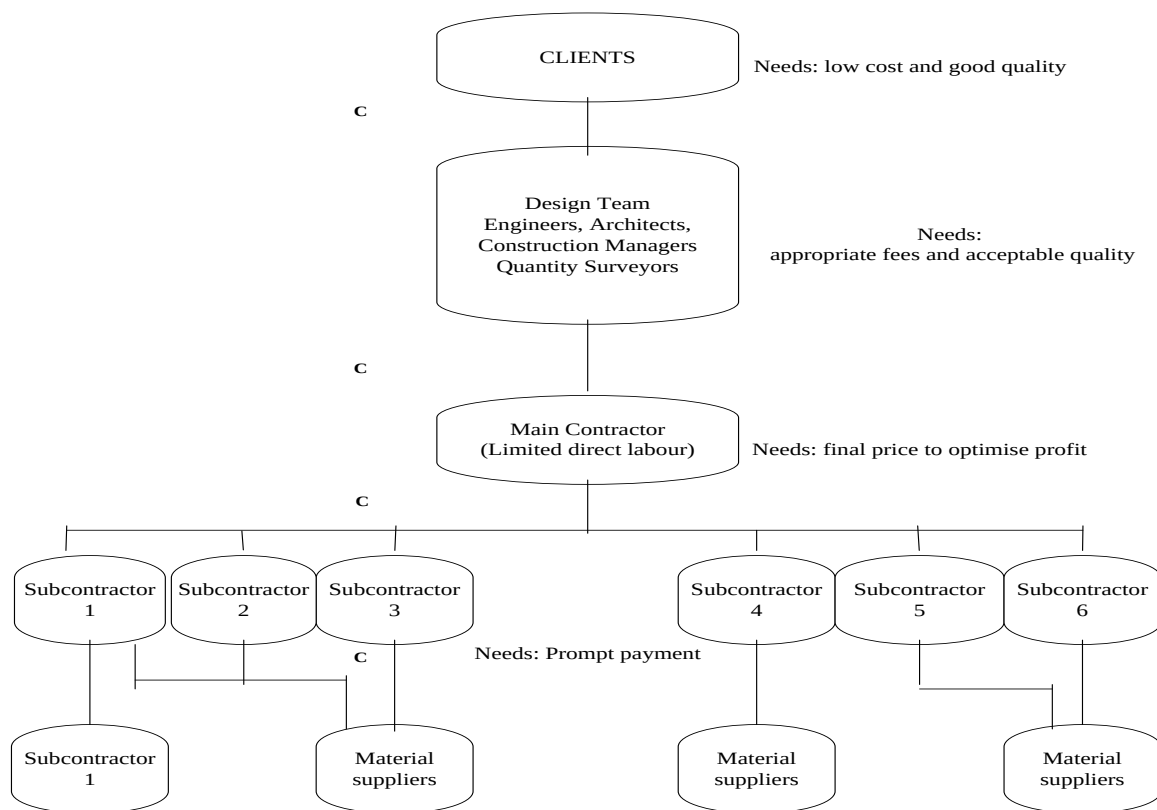
Drivers of change in the design and construction process such as the convergence of economic dislocation, client demand for improvement, deployment of new technologies, and demographic shifts in labour are forcing participants / or firms in the construction process to adapt and to possibly reinvent, create, and perfect more efficient and cost effective processes in the industry. Much of this adaptation is occurring in the construction supply chain as the effective organisation of a supply chain is essential to the success of the construction project (Sommerville and Craig, 2006: 67). The supply chain is thus the focus for more effective ways of creating value for clients; as a vehicle for innovation and continuous improvement, integration of systems, and possibly improved industry-wide profitability (Pryke, 2009: 1).

However, construction supply chains are highly fragmented: due in part to the unique entities found operating within the industry and the myriad of professional bodies (Sommerville and Craig, 2006: 67). Increased fragmentation brings increased transaction volumes at lower average values and inevitably higher levels of opportunism, which leads to less trust, more self-interest and adversarial relationship in the industry (Morledge *et al.*, 2009: 25).

For example, the organisations / actors as indicated in Figure 3.1, all of whom have conflicting priorities and objectives play varying roles and all use their own unique processes to undertake tasks in the construction process (Sommerville and Craig, 2006: 67). The application of SCM in the industry offers opportunity for improvement of the construction process. In terms of the construction industry SCM may be defined as the management of upstream and downstream relationships involving clients and other project partners in order to achieve greater project value at lesser cost (Rimmer, 2009: 138). The definition takes account of the bespoke, one-off nature of construction projects; the fact that designers, being largely independent firms, can be regarded as suppliers, and the fact that the client is a key actor in the process. The implication of the definition is that a focal firm must drive SCM in construction. The application of SCM to the construction industry requires a huge effort in terms of implementation. In spite of the enormity of the required effort, it is advisable to implement SCM in construction because (Morledge *et al.*, 2009: 36):

- SCM focuses on the impact of the SC on construction site activities and aims to reduce the cost and duration of those activities through the establishment of a reliable flow of materials and labour to the site;
- SCM focuses on the SC itself and aims to reduce cost, especially those costs related to logistics, lead time, and inventory;
- SCM focuses on transferring activities from the site to earlier stages in the SC, and

- SCM focuses on the integrated management and improvement of the SC and site production.



C = Potential for conflict and additional cost at each stage

Figure 3.1 Common industry structure (adapted from Morledge *et al.*, 2009: 25)

The implementation of SCM in construction and by implication the management of the integrated SC provides the opportunity to capture increased value and to minimise risks to the client (Edkins, 2009: 121). For instance, previous investigations suggest that the causes of failure in major projects are relative to the way the supply chain was engaged and the way risk was managed (Potts, 2009: 160). An example is the success recorded by the British Airports Authority (BAA) with respect to the construction of Heathrow Terminal 5. The BAA elected to hold the risk that would be problems, and ensured that such problems were paid for out of the project held risk funds (Edkins, 2009: 127). The BAA success affirms the popular belief that risks should be transferred either through contracts or insurance optimally, instead of maximally. Maximum transfer of project risks within the SC can potentially hinder the achievement of expected outcomes. Whether risks are managed through the viewpoint of the project or the supply chain organisations (SCO), risks must be transferred to the stakeholder best positioned to manage the risks. The management of project risks within the supply chain thus should be continuous (Edkins, 2009: 132).

Organisational factors (Table 3.1) and project factors (Table 3.2) impact SCM in construction. Based on the fact that projects cannot be divorced from its participants / or environments, the application and

implementation of SCM in construction must take cognizance of organisational factors as well as project specific factors. The project specific factors account for the uniqueness of most projects.

Table 3.1 A model for SCM in construction: organisational factor

| <b>Organisational factors</b> | <b>SCM characteristics</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Business development          | There is a clear need to understand client business drivers, and this requires establishing long-term relationships with clients, where negotiation and not competitive tendering is the preferred mode of contractor selection. Contractors obtain a competitive advantage from their supply chain, and this can lead to business development opportunities for offering an integrated design and construct service involving suppliers, who are also client focused. The business development function will also need to address retaining teams to work on succeeding projects. |
| Supplier sourcing             | Key suppliers should be selected based on their skills, commitment to collaborative ways of working, a willingness to support contractor business objectives and continuous improvement. A supply chain champion should be appointed, preferably from within the procurement function of the main contractor. The main contractor and key suppliers should have a joint commitment to technology and process improvement, with a protocol setting out the rules of the relationship, which will be based on trust, openness, consistency, fairness and respect.                    |
| Management of change          | There needs to be a commitment from the main contractor's top management to drive SCM into the organisation and to develop an appropriate strategy, including allocating resources to supply chain training. There needs to be a supplier measurement system implemented and a commitment to SCM established through pilot projects demonstrating measurable results and benefits.                                                                                                                                                                                                 |

Source: Male, 2003b: 236

Table 3.2 A model for SCM in construction: project factor

| <b>Project factors</b>                 | <b>SCM characteristics</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Management of the design process       | Client needs must be to the forefront. Functional specifications should be adopted, using a structured and formalised design process to optimise functionality and minimise cost, and employing value management and value engineering. An integrated approach to design should be adopted, with the main contractor offering single-point responsibility for project delivery. A clustering strategy should be adopted for design development using suppliers and users from the outset. There should be a commitment to risk management and risks allocated to those best able to manage them. IT should be utilised to improve the communication of design, cost and planning information. |
| Cost management                        | Profit and overheads should be agreed up front, with target cost and incentive mechanisms utilised to drive improvements. A formal, documented system of value analysis should be adopted throughout, with costs readily understood and transparent to all.                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Management of the construction process | Best practice should be adopted throughout and documented. Planning for the construction stage should commence during detail design and should involve suppliers within cluster groups. Continuous-improvement teams should be utilised extensively to remove waste, and resources should be allocated to team training. If the preceding is implemented then, consequently, quality checks on suppliers become redundant.                                                                                                                                                                                                                                                                    |

Source: Male, 2003b: 237

The combination of these factors provides a platform for performance improvement in projects when SCM is duly deployed in the construction process.

### 3.1 Innovation in Construction

Morledge *et al.* (2009: 35), contend that traditional unmanaged supply chains are characterised by short-term focus, with little regard for mutual long-term success; adversarial relationships that include ‘win-lose’ negotiations; little concern for risk sharing; primary emphasis on cost and timely delivery, with little concern for added value. As a result, traditional supply chains in construction projects are complex and temporary, involving actors who may not contribute other than to complete their small, often isolated, part of one-off project. Consequently, the construction process lags the mainstream industrial production process in terms of performance improvement. The ability to improve processes has been the backbone of sustainability of many processes. It is in line with this aspiration that different philosophies have been introduced into the construction industry. Most of these concepts emanate from the production arm of manufacturing entities. SCM is traditionally a process that has been tested and trusted in the manufacturing sector. In fact Pryke (2009: 9) opines that the Egan report recommend that construction industry should the adopt features of SCM such as:

- acquisition of new suppliers through value based sourcing;
- organisation and management of the supply chain to maximise innovation, learning and efficiency;
- supplier development and measurement of suppliers’ performance;
- management of workload to match capacity and provision of incentives for suppliers in order to improve performance, and
- capture of suppliers’ innovations in components and systems.

However, for successful implementation of SCM in construction, an enabling platform must be in place. According to Rimmer (2009: 150), the necessary characteristics of a successful platform would be consistent strong leadership dedicated to driving the new agenda; more open management structures, less command-and-control and less bureaucracy; recognition, respect for and involvement of the people who carry out the work on site with systematic feedback on improvement ideas from them; investment in product / process development as well as performance measurement; single point responsibility for both main contractors and key specialist contractors, and appropriate commercial terms for each relationship with the emphasis on openness, collaboration, and negotiation.

The platform and the subsequent implementation of SCM can be a springboard for performance improvement. The case of BAA’s Genesis project is a classic example. Successful mapping of productive and non productive working time in all site processes leads to the development of a productivity tool kit called CALIBRE (Potts, 2009: 166). This innovative performance monitoring

software system enabled information to be generated on a daily, weekly or monthly basis for the purpose of studying the whole site processes rather the study of individual task in isolation.

### **3.2 Lean in Construction Supply Chain**

NVAAs and inefficiencies are perceived to be present throughout the construction process. The goal of lean construction is similar to that of lean production, namely to weed out NVAAs and inefficiencies in the production process. The principal stakeholders in the construction process are members of the supply chain, which encompasses all those activities associated with processing from raw materials to completion of the end-product for the client. This includes procurement, production scheduling, order processing, inventory management, transport, storage, customer service, and all the necessary supporting information systems (Fisher and Morledge, 2002: 205). Therefore, the goal of lean SCM is to remove NVAAs in the construction supply chain for the purpose of enacting improvements in the construction process through added value. Value can be defined as any characteristics, feature or performance of a design, building, or project that is important to the customer / or client (Rimmer, 2009: 138). Therefore, lean construction's main focus is on documented operations on construction site, while lean SCM addresses the entire value stream of a construction operation since NVAAs are still evident in the supply chain that includes contractors, subcontractors, suppliers, and manufacturers as indicated in Figure 3.2.

In terms of construction logistics NVAAs occur through ineffective supplier relations and transactions. Based on observations relative to fabrication and logistics management of deliveries and inventories from a case study research performed on a local contractor in the USA, Zimmer *et al.* (2008: 386) recommended that fabricators and suppliers should perform a brief value stream assessment of each supply chain for each job, give higher consideration to fabricators that practice lean manufacturing in their shops during job bidding, develop strategies incorporating lean principles with preferred and common fabricators, suppliers, and subcontractors, and discuss new options for pre-assembly or pre-fabrication with suppliers and fabricators. Relative to site activity, they recommend that lean supply concepts and inventory control should be incorporated into site planning by organised and efficient usage of staging platforms, and lowering inventory levels and delivery quantities to an acceptable minimum, and with respect to last planner and production control, they suggest that subcontractors' involvement with identifying material constraints and issues ahead of time should be increased during the look ahead process, material variance tracked in last planner should be decreased, and items regarding procurements and material lead times should be included into the last planner reverse phase schedule.

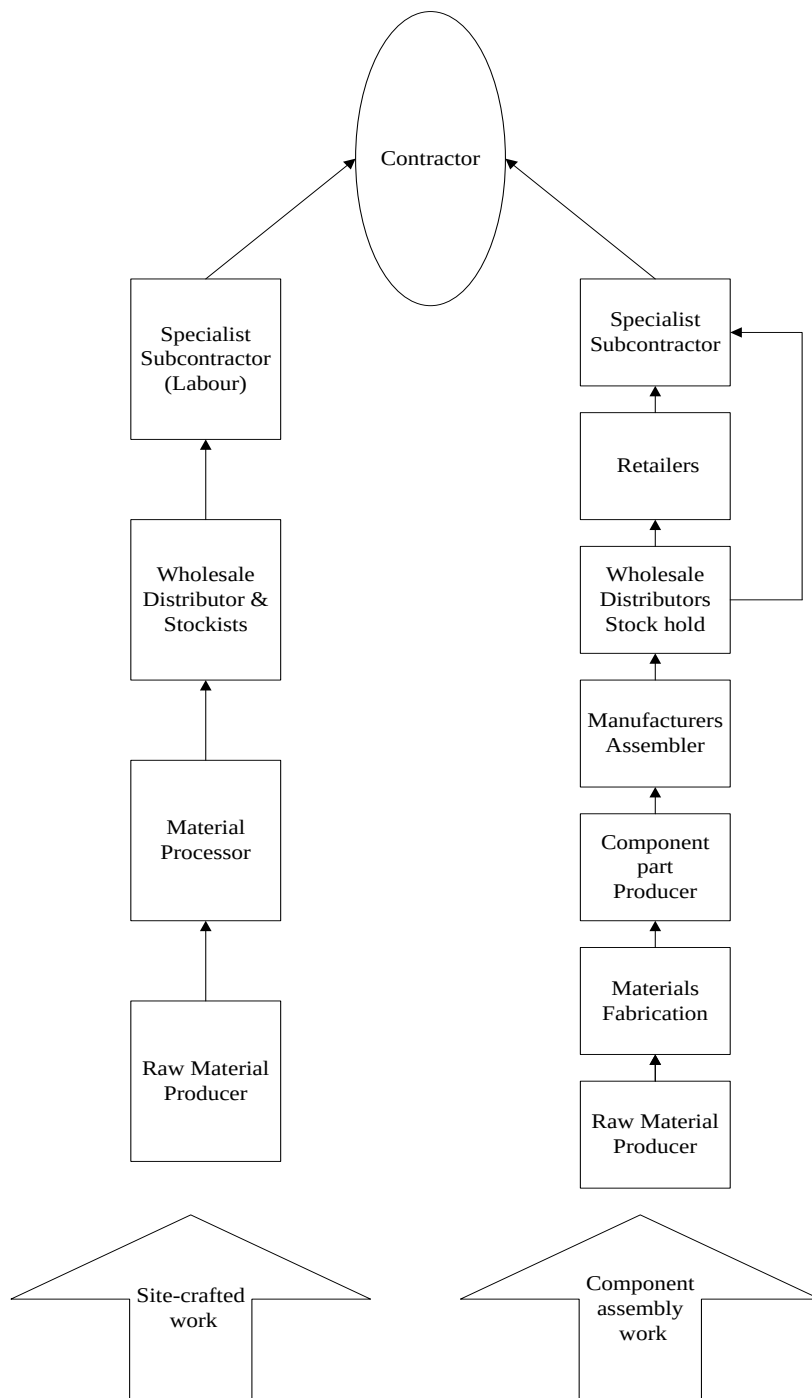


Figure 3.2 An inter-business construction project supply chain (source: Pryke, 2009: 4)

Similarly, the BAA proactively managed construction logistics on the T5 project as a precursor to successful project outcomes. In order to effectively control the delivery, a logistics strategy was developed, which include:

- eliminating the need for lay down space for materials;

- increasing the reliability and efficiency of supplied materials, this in turn increased the productivity from 55-60% to an unprecedented 80-85%;
- reducing the NVAAs created by traditional practices, and
- reducing transport movements that enabled BAA to uphold the project environmental commitments.

Potts (2009: 174) equally observed that the overriding strategy of BAA with respect to construction logistics on the T5 project was to store goods for no more than seven days before the goods were delivered for use at the required workplace. Furthermore, the flow of information was also given utmost attention on the T5 so as to mitigate poor collaboration and ambiguous design details that often result in delays and increased costs, through the use of 3D modelling with a single model environment to facilitate smooth flow of information between designers and every other member of the supply chain (Potts, 2009: 175).

It is instructive to note that logistics primarily deals with the flows to, in and out of organisations / or projects, with an intra-organisational perspective, while SCM is a philosophy that deals with the inter-organisational view of logistics alongside the intra-organisational perspective (Morledge *et al.*, 2009: 31). SCM concepts envisage superior customer value delivered at less cost to the supply chain as a whole through creating internal linkages within the firm and external relationships with suppliers and customers (Male and Mitrovic, 2005: 2). The rationale behind 'lean' focuses on NVAAs removal both inside and between organisations. NVAAs removal is fundamental to a lean value stream for the simple reason that improved productivity leads to leaner operations, which assist in exposing further NVAAs and quality problems in the system (Fearne and Fowler, 2006: 283). The systematic attentions on NVAAs removal translate to a systematic assault on the factors underlying poor quality and other problems in the construction process. In addition, the implementation of 'lean' concepts can spark innovations in the construction process as vividly demonstrated in a research conducted in Brazil by Alves *et al.* (2009: 591).

### **3.3 Clients as drivers of Construction Supply Chain Management**

The construction supply chain involves organisations that are contractually linked together in order to provide services for an expected end. Exploiting the SC involves communications with members of the project team that are inter-dependent / intra-dependent on each other with respect to different forms of contract. The concept of centrality and SCM cannot be over looked in the construction process. According to Pryke (2009: 11), in order to successfully manage any supply chain there is need for a single / principal actor with the authority to deal with all actors within the supply chain. In this case client organisations can influence, initiate and relate with all actors within an SC. The

construction management literature in recent past suggests that concepts of lean construction were adopted in different forms by both public and private sector clients in the UK construction industry.

Though the strategies may not be called lean construction or lean process directly, the underpinning philosophy can be linked to lean thinking. For instance, Khalfan *et al.* (2008: 348) discovered that there is evidence of lean supply chain in a research project that addresses lean construction in a public sector organisation in the UK. The research findings indicate that the kanban strategy, which is a lean approach developed in the automotive industry as a mechanism to pull materials and parts throughout the value stream on a just-in-time basis, is being implemented in the repair and maintenance of social housing stock by Local Authorities and Registered Social Landlords (RSLs) in the UK (Khalfan *et al.*, 2008: 352). The strategy is developed based on the principles that:

- products must be pulled through the supply network as needed by the workforce;
- products must arrive just-in-time that is at the right place, at the right time, in the right quantity, and
- the supply network and material management strategy should achieve the best value for the customer and clients.

The kanban strategy is supported through the integration of suppliers in the construction process. The integration is done at operational level, and based on empirical evidence, it has resulted in benefits. According to Khalfan *et al.* (2008: 356), the application of the kanban strategy in the short term leads to less waste and duplication; improved delivery; greater certainty of cost; and better whole life cycle cost, and in the long term it may result in savings on tender / or procurement cost; lessons learned and rolled forward within the delivery team; benefits of performance management systems; fewer delays; added value to the client; knowledge retention, capture, use, and creation, and building trust in relationships.

As suggested earlier, the time consuming and demanding activities that involve effective construction SCM entail activities ‘from the quarry to the finished project’, and do not only require commitment from clients, but also capacity and knowledge within the supply chain (Pryke, 2009: 5). Though there is no standard scope for SCM in construction, client organisations intending to implement SCM may:

- focus upon the definition and delivery of value;
- create contractual arrangements in which SCM tools could flourish;
- invest in product / process development;
- search for and eliminate NVAAs, and
- measure performance through benchmarking (Rimmer, 2009: 139).

For instance procurement systems such as D&B and PFI / PPP provide the strongest platforms within which SCM can flourish (Rimmer, 2009: 146). Specifically, in D&B the contractor is a party to all the important relationships and decisions, upstream and downstream, and is in the best position to lead the efforts to add value and reduce costs; and in PFI / PPP procurement the constraints to establishing effective relationships and design discontinuities in the supply chain are virtually eliminated.

According to Male and Mitrovic (2005: 2) previous construction industry reports in the UK placed the client at the core of the construction process, while Fisher and Morledge (2002: 204) assert that in construction unless the client takes a strong role in managing the supply chain, the rationalistic approaches to SCM advocated and adopted in manufacturing are less easy to apply.

The literature indicates that substantial gains await clients that embrace SCM in construction. As an example, Slough Estates, a major private sector client in the UK recorded a 20% reduction in costs compared to market comparisons (Rimmer, 2009: 158). The achievements of Slough Estates confirm that improvements are possible in construction through the use of SCM. Though the initiative requires significant client leadership and commitment to supply relationships, the client concluded that the result was worth the effort. Similarly, the BAA recorded significant success in project delivery after the adoption of SCM strategies. But this was aided not only by BAA attitude to risk, but by proactively mapping the supply chain with a view to determining the strengths and weaknesses of SC actors before roles and responsibilities are shared and tasks undertaken (Potts, 2009: 164). However, for these benefits to accrue, clients must be intelligent and knowledgeable.

Clients differ in their level of knowledge of construction, the industry, and the project process, from those that are very knowledgeable at one end of a continuum to those that are less knowledgeable at the opposite end (Male and Mitrovic, 2005: 2). The level of client knowledge plays a significant role in the choice of procurement. The appropriate choice of procurement strategy, links demand and supply sides together within a particular demand and supply chain system (Male, 2002: 267), and the ease with which this system is formed, works, and delivers an end product that is fit for purpose determines if value is added or reduced by the system (Male and Mitrovic, 2005: 5). Within the demand and supply chain system, the client and main contractor are the primary protagonists in construction and depending on the procurement route adopted by the client, and the designers, the SC generates the major cost commitments for most projects. Often designers are responsible for approximately 15%, and main contractors 85% of total project cost. From the client perspective project supply chain (PSC) requirements necessitate an appropriately configured project-focused supply chain comprising different skills and expertise to manage the project process (Male and Mitrovic, 2005: 6).

In the public sector a range of different types of clients exist, from the large corporate government department / agency volume procurers to the medium to small local authorities, and to autonomous organisations that are funded through central government funds such as universities. According to Male and Mitrovic (2005: 10) very knowledgeable clients are those that are high volume procurers that have large physical asset bases supporting core business activity, and where knowledge about construction is embedded within the organisation. Typical examples in South Africa are the Department of Public Works, Department of Transport, Eskom, Transnet, and SANRAL. Relatively knowledgeable clients would be those that require physical assets to support core business, but they may not be perceived as central to organisation functioning since knowledge of construction is not embedded deep within the organisation. Examples of these may be universities and other governmental institutions.

Less knowledgeable clients will be very infrequent procurers that rely heavily on external advisors. Table 3.3 indicates the impact of different types of clients, level of supply chain integration, and demand chain requirements. Based on this table, it can be assumed that central and local government clients at all levels in the UK experimented with increased levels of supply chain integration through innovative procurement practices such as partnering. Based on this analogy, it is envisaged that public sector clients in South Africa should adopt increased levels of supply chain integration since the structure and characteristics of the construction industry in the two countries are not so dissimilar.

Table 3.3 Clients, Demand and Supply chain systems

| <b>Public Sector</b> |                                                            |                                                              |                                                |                                                          |
|----------------------|------------------------------------------------------------|--------------------------------------------------------------|------------------------------------------------|----------------------------------------------------------|
| <b>Client Type</b>   | <b>Knowledgeable</b>                                       |                                                              | <b>Relatively Knowledgeable</b>                |                                                          |
|                      | <b>Regular Procurers</b>                                   |                                                              | <b>Frequent to Infrequent Procurers</b>        |                                                          |
| Unique<br>Customised | Consumer clients:<br>Large owner<br>occupier<br>Integrated | Consumer clients:<br>Medium to small owner<br>occupier       | Consumer clients:<br>Large owner<br>occupier   | Consumer client:<br>Small owner<br>occupier              |
|                      |                                                            | Less integrated<br>& integrated                              | Less integrated<br>& non integrated            | Less integrated<br>& non integrated                      |
| Process              | Integrated                                                 | Less integrated &<br>integrated                              | N/A                                            | N/A                                                      |
| Portfolio            | Integrated                                                 |                                                              | Less integrated                                | N/A                                                      |
| DCM<br>orientation   | Sophisticated<br>leaders<br>Internal advisors              | Sophisticated followers<br>Internal and external<br>advisors | Followers<br>External advisors<br>Wait and See | Reluctant followers<br>External advisors<br>Wait and See |

Adapted from Male and Mitrovic (2005: 11)

### **3.4 Contractors as drivers of Construction Supply Chain Management**

As mentioned earlier, either the client or the contractor can champion the implementation of SCM in construction. That means the SC can be viewed through two perspectives. Male and Mitrovic (2005: 2) offer a useful way of thinking about supply chains by distinguishing between the types of supply chains. They say project supply chain (PSC) is a direct response to a client requirement, and organisational supply chain (OSC) describes the main contractor as a business entity or organisational supply chain. Building on the airport and airline analogy of Male (2002: 288), which saw the main contractor as the supply chain 'hub', meeting various client needs by managing various project-specific supply chains, they drew a distinction between PSC and OSC.

The notion of an OSC is particularly interesting as it draws attention to the main contractor's ability to manage and influence a number of project-specific supply chains for different clients, irrespective of the clients' inclination and ability to utilise SCM. This distinction recognises that main contractors with sufficient organisational and economic size, as the hub of numerous supply networks, have the ability to develop their organisational supply chain and provide numerous highly differentiated clients with the resulting benefits. This is based on the premise that sustained high levels of demand are needed to maintain standing supply chains, whose members are willing to invest and innovate for the benefit of a single client.

Therefore, the main contractor's ability to form long-term relationships with subcontractors stems from its ability to provide a multitude of clients with benefits of an OSC, irrespective of the client's disposition towards SCM (King and Pitt, 2009: 185). Main contractors, as 'hubs' (Figure 3.3) in the constellation of demand and supply chain systems, derive their competitive advantage from balancing the competing needs of these different requirements within PSC through organising the procurement and management of their own multi-project supply network (Male and Mitrovic, 2005: 12).

In this extended role, they are ideally placed to increase their market power and become supply chain leaders working directly for clients on a more regular basis. Their supply chain strategy becomes one of assembling the right teams, at the right time and in the right locations to build various built environment fixed assets for clients.

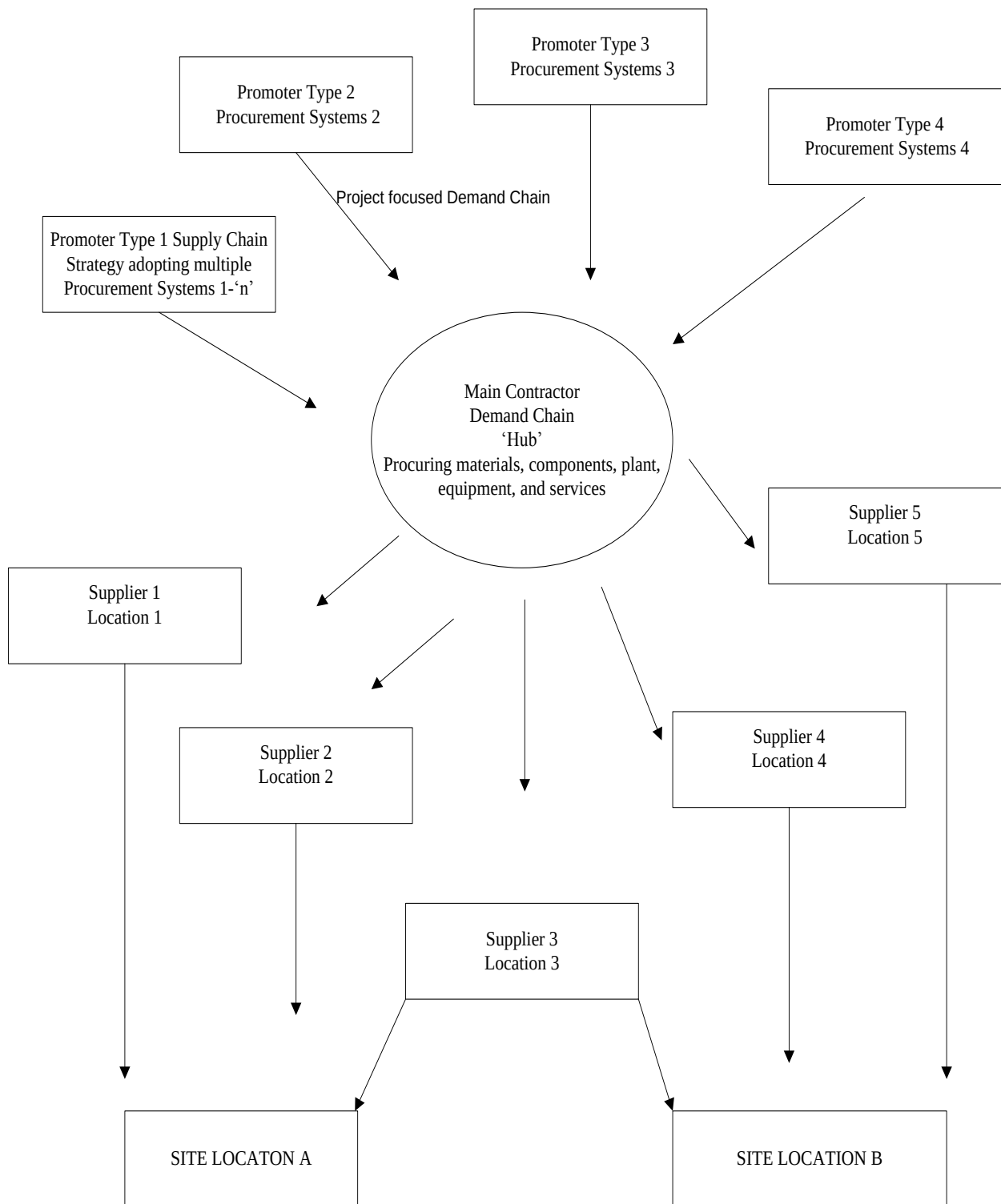


Figure 3.3 Engineering supply chain system (source: Male, 2002: 288)

The literature reviewed reveals that improving the construction supply chain holds significant promise for accelerated infrastructure development. Successes recorded in the UK and elsewhere may be

replicated in South Africa, if SCM opportunities are adopted in the country. Specifically, the construction SCM opportunity provides a platform for addressing issues relative to:

- inappropriate choice of construction procurement strategy by public sector clients;
- unimpressive implementation of procurement strategies by the public sector;
- poor organisational knowledge, learning and transfer in the construction process;
- resistance to change and innovation in the construction supply chain;
- delays occasioned by late instructions, drawings, and information;
- haphazard inventory management on construction sites;
- recurrent accidents, injuries, and ill-health on construction sites, and
- the high level of defects, rework, and non-conformance to quality standards in construction.

The advantages and benefits of the application of construction SCM holistically is not restricted to infrastructure development / or construction projects alone. It holds important opportunity for improvement for housing, property development, and other related projects in the built environment. According to the Accelerating Change report integrated teams and SCs are central to delivering value to clients (Male, 2003a: 194).

The authors of the report contend that clients should appoint established, integrated supply chains that are used to working together, and creates the capability of moving from project to project to engender a culture of learning and continuous improvement in the industry. Therefore, the use of SCM in construction as part of a management strategy or a new way of doing business is widely claimed to be a significant option for achieving better value for money for taxpayers (Fisher and Morledge, 2002: 218). This assertion has implications for all public sector clients that procure construction services as there is evidence to support this claim in the UK construction industry (Fisher and Morledge, 2002: 219). The interventions examined in chapter 2 and the detailed analysis of SCM in construction highlighted in this chapter provided a platform for the compilation of the conceptual and / or theoretical perspectives of the study.

#### 4.0 THE RESEARCH CONCEPTUAL / THEORETICAL PERSPECTIVES

Cousins *et al.* (2006: 698) suggest that the optimisation of internal production through operations management tools and techniques such as world class manufacturing, benchmarking, and business process reengineering are no longer sufficient for the manufacturing environment, and the introduction of lean, which considers the optimisation of the production process as well as the constraints relative to supply chain activities, necessitate the application of, and research into concepts such as JIT, TQM, and their relationships with SCM practices. Storey *et al.* (2006: 760) further contend that much of the theory in supply management is based on idealised schemas of optimal routes and quantities for demand fulfilment when considered from a whole network or a chain perspective. They say nestled beneath the dominant big idea of SCM as a whole are a number of sub theories such as lean (Table 4.1). Therefore, SCM in the construction context represents a move away from the project and its management, towards the supply chain and its management as the main focus in order to engender more effective ways of creating value for the clients; as a vehicle for continuous improvement, integration of systems and maybe even improved, industry-wide, profitability levels (Pryke, 2009: 1). This shift nonetheless retains the emphasis relative to the impact SCM has upon project objectives and performance (Bresnen, 2009: 80).

Table 4.1 Supply chain characteristics

| No. | Characteristics                                                                        |
|-----|----------------------------------------------------------------------------------------|
| 1   | Seamless flow from initial sources to final customer                                   |
| 2   | Demand-led supply chain (only produce what is pulled)                                  |
| 3   | Shared information across the whole chain (end to end pipeline visibility)             |
| 4   | Collaboration and partnering (mutual gains and added value for all; knowledge sharing) |
| 5   | Information Technology enabled                                                         |
| 6   | All products direct to self                                                            |
| 7   | Batch / pack size configured to rate of sale                                           |
| 8   | Customer responsive                                                                    |
| 9   | Agile and lean                                                                         |
| 10  | Mass customisation                                                                     |
| 11  | Market segmentation                                                                    |

Source: Storey *et al.* (2006: 760)

The characteristics tabulated in Table 4.1 are applicable to both manufacturing and project-based production sectors such as the construction industry. The proponents of SCM believe that it is a set of approaches utilized to efficiently and effectively integrate the network of all organisations and their related activities in completing and delivering a product, a service, or a project so that system-wide costs are minimised while maintaining or exceeding customer-service-level requirements (Venkataraman, 2004: 622). To this end, Ruigrok *et al.* (1999 cited by Storey *et al.*, 2006: 769) opine that SCM can be seen as part of a wider set of trends involving outsourcing, cross-boundary working, new organisational forms, and empowerment rather than rigid command and control. Therefore in the construction industry context, SCM focuses on (Walsh *et al.*, 2004: 819):

- the impact of the SC on construction site activities and aims to reduce the cost and duration of those activities: the primary concern is to establish a reliable flow of materials and labour to the site, and improve relationship between the site and direct suppliers;
- the SC itself and aims to reduce costs, especially those related to logistics, lead time, and inventory, and
- transferring activities from the site upstream in the SC and aims to reduce total cost and duration by avoiding inferior conditions on site / or achieving wider concurrency between activities barred by technical dependencies on site, and the integrated management and improvement of the SC and site production, that is, site production is subsumed by SCM.

Based on the foregoing, it can be assumed that the strategic procurement and operations views dominate SCM theoretical perspectives in construction. Further, Croom *et al.* (2000: 69) suggest that the origins of the concept of SCM are unclear, but its development was initially along the lines of physical distributions and transport using the techniques of industrial dynamics and / or total cost approach to distribution and logistics. A situation they say implies that focusing on a single element in the chain cannot assure the effectiveness of the whole systems. As an illustration, it is foolhardy to expect that a total focus on upstream activities (strategic) instead of holistic view of the total construction supply chain will result in optimum performance of the construction process. A strategic and operation view of the construction supply chain thus provides an avenue for effectiveness and efficiency in the project life cycle process.

However, there is a lack of asinificant body of previous theory in SCM, rather much of SCM literature relies on empirical findings with limited theory backing; SCM research could be found in science, social science, engineering, humanities, and key antecedents disciplines such as systems thinking, information theory, industrial dynamics, production economics, social theory, game theory, and production engineering (Croom *et al.*, 2000: 75). This is evident in the definitions of SCM, which tend to emphasise the importance of management being proactive in integrating activities and

business processes across the supply chain in response to the needs of clients with the overall aim of improving performance (Bresnen, 2009: 74). For example, construction SCM can be defined as the strategic management of information flows, activities, tasks, and processes involving various networks of independent organisations and linkages that produce value that is delivered to clients in the form of completed projects (Benton and McHenry, 2010: 8) and / or as the management of upstream and downstream relationships with clients and suppliers in the form of contractors, designers, subcontractors, to achieve greater project value at less cost (Rimmer, 2009: 138).

The effectiveness of SCM requires organisations to focus on critical issues relative to clients, suppliers, designers, and construction operations such as logistics and inventory management, a situation which in turn requires a holistic focus on both the strategic and operational aspects of projects (Venkataraman and Pinto, 2008: 213). Although the prowess of SCM in addressing production problems in the manufacturing sector is well documented in the literature, acceptance, caution, and outright rejection have characterised its introduction into the construction industry. Specifically, having conducted a multi-case study research in the UK, Fernie (2005: 256) suggests that it does not make sense for organisations in the construction sector to adopt, implement, and sustain SCM. His research findings indicate that:

- interpretations of SCM, relevant issues, opportunities and concerns of knowledgeable and reflexive practitioners did not challenge unrealistic assumptions regarding its relevance;
- practitioners interpreted SCM as an initiative focused on addressing and improving relationships with external organisations, that is, SCM is considered to be synonymous with partnering;
- practitioners reflected upon past experience of partnering in how they interpreted the relevance of SCM;
- calls for the adoption of SCM demonstrate a lack of reflection upon the context within which it has proved successful as well as the institutional context within which organisations in the construction sector compete;
- large repeat clients in the construction sector and those who populate the movement for change lack the power to widely institutionalise change in the sector;
- there is need for greater intellectual rigour and reflection on how organisations and / or technocrat elites reflect upon and engage with the construction sector in making recommendations for change;
- no one specific relational form is suitable for all circumstance (contexts);

- competing supply chains and the optimisations of flows across numerous organisations do not make sense in the construction sector;
- practitioners in the construction sector are highly knowledgeable and reflexive in how they interpret, legitimise, and institutionalise managerial practice;
- calls for change need to understand the legitimacy of current practice and thus the scope for sustainable productivity improvement in the sector, and
- past reviews, and the concerns of clients, fail to engage with and recognise the legitimacy of arm-length contractual relationships in the construction sector.

However, the work of Pryke (2001: 489) sharply disagrees. Pryke reiterates that the application of social network analysis (SNA) can successfully provide more insight and understanding of the construction supply chain. Wong *et al.* (2004: 21) maintain that lack of appreciation of other's performance, discourage innovation, deficiencies of the procurement systems, lacking of communal standard for collaboration, ignorance of the contributions and needs of subcontractors and suppliers, resistance towards greater contribution and high cost have being identified as major factors militating against the implementation of SCM on construction projects. In addition, at the centre of the construction SCM literature continuum, London (2004: 406) suggests that the concept of SCM may not be applicable to all sub sectors of the industry, that is, because of structural and behavioural characteristics, the implementation of SCM in the industry should be based on full comprehension of the context and / or environment. The study that was undertaken in Australia reveals that (London, 2004: 406-408):

- supply chains can be classed according to attributes that include uniqueness, property sector, importation and fragmentation: uniqueness refers to supply chains that tend to be grouped by the degree of uniqueness of the commodity into highly customised, standardised and customised, and standardised; property sector refers to supply chains that tend to be grouped by residential, commercial and civil sub sectors; importation refers to supply chains that are either imported by importation or not and that import supply chains are longer and have a lesser degree of traceability; fragmentation refers to supply chains that have high level of diversity in channel structure maps for transfer of ownership of products within commodity types and across commodity types and therefore supply chain structural and behavioural characteristics, which were identified are dependent upon interactions between customer firms, supplier firms, project commodity, project market, and industrial market, which ultimately rely upon supplier firms;
- the perception that the construction industry is fragmented, unstructured, unpredictable, and high risk is clearly a simplistic view of a complex set of varied and numerous markets: there are

sections of the supply chain that are quite predictable, structured and low risk, and sections that are unpredictable, unstructured and high risk; the project nature of the industry and the short-term contracts certainly seems to increase the unpredictability of firm-firm relationships in comparison to the very stable nature of quite long-term contracts in the manufacturing sector;

- industrial organisation economics does not typically embrace a project-based industry with numerous interactions and the conceptual links from object oriented modelling contribute to a new language for industrial organisation economies in terms of firm object classes and market objects within market classes; multiplicity can be accommodated through the class model with firm-firm procurement relationships;
- the integrated industrial organisations object oriented methodology for construction supply chain procurement modelling provides a common ground; rather than a structure-conduct-performance conceptual framework, a structure-conduct-supplier-procurement relationships-supply chain-performance conceptual framework was evolved;
- both fields support a structure-behaviour perspective; however, the industrial organisation economic field has struggled with encapsulating the duality of objects; markets have both structure and behaviour, and firms have both structure and behaviour; the object oriented model provides a mechanism to accommodate this duality, and
- The object oriented methodology provides a set of representational techniques for capturing, specifying, visualising, understanding and documenting objects associated with procurement in the construction supply chain from an industrial organisation economic perspective.

In spite of the divergent views of the implementation of SCM in the construction industry, the research conducted by Cox and Ireland (2002: 417) demonstrated that there is no single way for buyers or suppliers to pursue supply chain relationship management. They say it is evident that the problem for buyers and suppliers is to have in place a methodology or rather a way of thinking that allows them to understand a number of key factors such as the importance of the product or service to the business; the nature of demand and supply for the product or service; the objective power circumstances the firm is in; the opportunities for cost reduction, quality improvement and revenue enhancement that exist for the product / or service; the type of competence and congruence that is required in the relationship, and the appropriate relationship and its subsequent management.

In fact, while Fernie (2005: 256) suggests that it does not make sense for organisations in the construction sector to adopt, implement, and sustain SCM, Tommelein *et al.* (2009: 106) contend that SCM applies to the delivery of capital projects as it does to the delivery of products or services in other industries since it refers to the management of flows of physical products, services, information,

and money between activities or process steps that organisations perform while aiming for customer service as the overall goal. However, there are substantial challenges militating against the implementation of SCM in construction. Factors such as failure to share information, resistance to innovation, poor procurement systems, poor collaboration, ignorance about contributions and needs of subcontractors as well as suppliers, short-termism, transient nature of construction projects, inability to recognise project goals and lack of understanding of supply chain are problems associated with the implementation of SCM in construction (Jones and Saad, 2003: 260; Wong *et al.*, 2004: 21; Benton and McHenry, 2010: 15).

#### 4.1 Strategic Perspective of SCM in construction

The strategic view is anchored on the challenge for project organisations to provide client value by managing the inevitable scope changes without incurring significant project schedule and cost overruns (Venkataraman and Pinto, 2008: 213). The procurement portion of the project supply chain, which is typically long, is the area where the greatest opportunities for cost reduction and enhancing value of the whole supply chain exist (Venkataraman and Pinto, 2008: 222). Figure 4.1 indicates the phases of a project supply chain. The first phase (procurement) is crucial for a successful project outcome especially in an industry that is characterised with fragmentation, specialisation, and adversarial relationships within the SC (Venkataraman and Pinto, 2008: 223). Granted that there is no single procurement strategy that works best for all situations in construction, a careful analysis of client needs and implementation of procurement strategies that is best for the realisation of the needs seems a positive way forward in the industry.

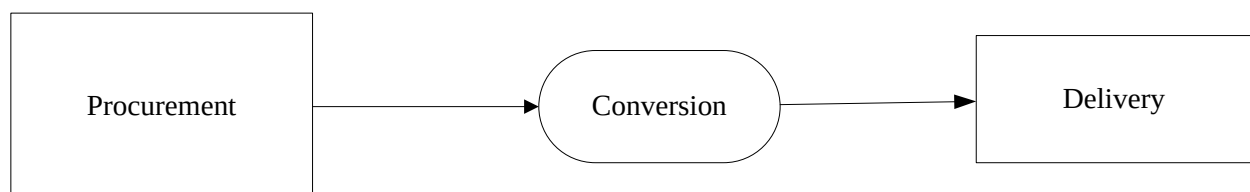


Figure 4.1 Project SC process framework (source: Venkataraman and Pinto, 2008: 221)

For instance, Kumaraswamy *et al.* (2000: 677) point out that in Hong Kong, methods used for selecting the overall procurement system, contractors, and subcontractors are not only critical, but they also require an integrated approach in order to synergise chosen options within each procurement sub-system that is aimed at a project-specific desired performance. The argument of Venkataraman and Pinto (2008: 223-224) that supply chain relationships and supplier development are key aspects of procurement may hold true. They say value optimisation in projects cannot be achieved in the absence of close and trusting relationships among project partners, that is, when all members of the supply chain are involved in translating the design concept into reality, they are better able to ensure that

appropriate cost criteria are met. Just as important as the relationships between SC partners is to project success is also the integration of various components of the project supply chain. This is evident in the application of concurrent engineering principles, which Nicolini *et al.* (2001: 46) suggest leads to project supply chain integration, which in turn improves value, eliminates inefficiencies, and reduces project costs in the UK construction industry.

The next phase shown in Figure 4.1, which is the conversion stage, is required for value optimisation. This is the phase whereby the project's product is actually created, and the degree of successful value that can be achieved at this stage is dictated by the efficiency and effectiveness of the procurement phase (Venkataraman and Pinto, 2008: 224). The final phase of the project supply chain process is the delivery of the completed project to the client (Figure 4.1). The importance of the phase is anchored on client satisfaction, that is, with clients becoming increasingly risk-averse, the willingness of the project organisation to assume some additional risks is certain to add value and provide a distinct competitive advantage to the whole SC (Venkataraman and Pinto, 2008: 225).

In addition to strategic initiatives, the following practical steps may be undertaken to add value to projects (Hutchins, 2002: 112):

- flowchart the project supply chain processes before the project is initiated: this process will show the various links or steps involved in completing the project, and each step will potentially have a customer and a supplier. The flowchart can identify potential areas of redundancies, waste, or other NVAAAs in the chain, and can facilitate the use of lean management initiatives to eliminate them;
- standardise processes: standardisation of processes throughout the project supply chain by the use of methods such as simultaneous design, concurrent engineering, lean manufacturing, mistake proofing, total productivity maintenance, and collaborative teamwork will ensure consistency;
- control process variation: it is essential that processes across the total project supply chain are monitored and controlled for variation, including lead times, quality in materials, and production processes. Once the supply chain processes are stabilized, they can be improved;
- pre-qualify suppliers through supplier certification: ensure that suppliers in each link of the project supply chain process are ISO 9001 certified. This certification guarantees a pool of quality suppliers;
- audit project supply chain processes and take corrective and preventive actions: processes should be audited periodically for improvement and risk identification. Corrective action should be taken to eliminate the root causes of non-conformance and deficiencies that were uncovered through the audit, while preventive action will ensure that these problems do not reoccur, and

- measure project supply chain performance: without the availability of specific quantifiable performance metrics, project supply chain performance in terms of both efficiency and customer satisfaction cannot be gauged. For this reason, performance metrics should be developed and used, and competitive benchmarking should be performed. These tools will immediately convey how the project supply chain has been performing over time, or in comparison with best-in-class competitors.

## **4.2 Operational Perspective of SCM in construction**

The operations function creates value by converting raw materials and components into finished products at every phase of the supply chain, and is responsible for ensuring quality, reducing waste, and shorter process lead times (Venkataraman and Pinto, 2008: 214). Efficiency of the process at this stage is very crucial. It is notable that the unionist view considers logistics as a sub process in SCM (Hatmoko, 2008: 14).

### **4.2.1 Logistics**

In project management, the logistics function, which entails the transfer, storage, and handling of materials within a facility, as well as incoming and outgoing shipments of goods and materials, requires a thorough understanding of client requirements, expulsion of waste throughout the supply chain to reduce costs, and ensures timely completion and delivery of projects (Venkataraman and Pinto, 2008: 214). Empirical findings suggest that active involvement in the management of logistics not only result in improved main contractor / subcontractor interface, but subcontractor / subcontractor interface, that is, when subcontractors attempt to meet the product and service quality expectations of the trade that will be building upon their work, improved project culture and quality is achieved (Perera *et al.*, 2009: 134). This multi-case study research discovered that a significant shift towards increased focus on the following trade was observed with the trades that were involved in the pre-start process, and this in turn leads to supplier-customer nature relationship between subcontractors leading to significant improvements in quality.

In addition, inventory management that is also part of logistics is necessary because inventories do not only represent a substantial portion of the supply chain cost, but they also impact customer service levels, and constitute a cost trade-off decisions in logistics. In project environments where inventory-related cost can be substantial, effective inventory management can be achieved only through the joint collaboration of all members of the supply chain (Venkataraman and Pinto, 2008: 215). The importance of logistics is underscored by the 2003 report of the Building Research Establishment (BRE), which indicated that 30% of construction costs are attributed to the transportation of construction materials (BRE, 2003 cited by Shakantu, 2009: 224).

#### **4.2.2 Supplier Management**

The ability of suppliers to provide quality raw materials and components when they are required at reasonable cost can lead to shorter cycle times, reduction in inventory-related costs, and improvement in end-customer service levels, which translate to added value in the chain in spite of the fact that suppliers constitute the back-end portion of the supply chain (Venkataraman and Pinto, 2008: 213). Venkataraman and Pinto (2008: 214) say without the involvement, cooperation, and integration of upstream suppliers, value optimisation in the total supply chain cannot be a reality, that is, managing the dynamic interrelationships and interactions that exist among suppliers is considerably more complex and requires effective integration of project activities into the larger framework of SCM. For instance in the construction industry, empirical results indicate that subcontractor involvement and integration is facilitated by early procurement of subcontractors; subcontractor selection not based solely on lowest price; compensation including joint profit sharing; suitable risk allocation, and use of collaborative tools and approaches (Eriksson *et al.*, 2007: 212).

#### **4.3 Value Drivers of SCM**

Value drivers in a project supply chain are those strategic factors such as clients that significantly add or enhance value and provide a distinct competitive advantage to the chain, cost, flexibility, quality, and time (Venkataraman and Pinto, 2008: 217). In this context, time refers to on-time delivery of completed projects to the end customer, cost refers to total cost incurred at the end of the project supply chain, quality refers to the ability to deliver a completed project that meets or exceeds end customer expectations, flexibility refers to the ability of the project supply chain to quickly recognise and respond to changing client needs, and client refers to the final customer at the end of the project supply chain. Together all the factors are not only drivers of SCM, but they are also important project parameters that indicate the success or failure of a project. In addition, these factors constitute critical elements of the project infrastructure that enhance or optimise project value in the form of cost management, scope management, schedule management, quality management, configuration management, and change control systems (Venkataraman and Pinto, 2008: 256). Within the project infrastructure, cost management is an umbrella system that is concerned with all cost-related subsystems such as accounting and finance, project cost estimation, budgeting, and cost control.

The project value chain, which is an adaptation of Porter's value chain model provides a platform for the integration of cost and risks in a project environment with a view to create and optimise value in spite of challenges and complexities. Several strategies that have proven to be successful in the traditional manufacturing environment, and are gaining ground in project environments are indicated on Table 4.3.

Table 4.2 Strategies for integrating cost and value

| Method                          | Advantages                                                                                                             | Examples                                                                      |
|---------------------------------|------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Inbound supply chain management | Primary means to minimise cost through vendor management                                                               | Kaizen, outsourcing, reverse auctions, project partnering                     |
| Project design                  | Allows integration of cost and value through enhanced design, creative problem solving, and collaboration              | Value engineering, concurrent engineering, kano modelling                     |
| Project construction            | Links procurement and design to new product development, allows for gated reviews, rapid product modification response | Total quality management (TQM), Six Sigma, Lean manufacturing, target costing |
| Project delivery management     | Enhances value to customer through carefully managed delivery cycle                                                    | Life cycle costing, turnkey project management                                |

(Source: Venkataraman and Pinto, 2008: 261).

Strategies such as supplier Kaizen, outsourcing, partnering, vendor development, information and risk sharing, lean manufacturing that encompass supplier integration and JIT delivery of parts, and integrating quality management activities of suppliers through TQM will significantly reduce procurement and inventory cost, shorten lead times, and improve the quality of purchased materials, and eventually improve value (Venkataraman and Pinto, 2008: 260).

The integration of value and risk management processes provides conditions that are conducive for positive project delivery outcome that include (Dallas, 2006: 7):

- Clarity of purpose: Value management provides the mechanism to clearly identify long-term project objectives in terms of benefits to the client. Risk management paves the way for the project team to minimise the uncertainty in delivering these benefits;
- People: The two processes together promote leadership by providing a well defined decision-making structure to maximise value and minimise risk. They also promote a culture for all project stakeholders to work together for a common goal;
- Communication: Because both value and risk management require extensive consultation, effective communication channels are established that further improve decision-making and problem resolution;
- Realistic and affordable budgets: Clear identification of project objectives with full understanding of project risks facilitates establishment of realistic and achievable budgets. This, in turn, enables the value and risk management processes to proactively manage the project supply chain to deliver the required quality of materials and the final project facility within budget;

- **Appropriate procurement:** The integrated process provides a project risk profile that enables the allocation of risk to those parties in the project supply chain who are best equipped to manage them, and provides the basis for selecting the most effective procurement strategy;
- **Achievable programme:** adoption and application of the integrated value and risk management process from the very outset of the project provides adequate time to complete project design and preparation activities before a commitment is made to the construction of the project facility. This enhances the ability of the project team to accurately predict completion dates, and
- **Efficient project delivery:** The integrated process provides the structure for optimum delivery processes that lead to performance improvements, in terms of reduction in abortive time and NVAAs during project design and construction activities. In this way, the integrated process not only provides a clear articulation of project objectives, and maximisation of efficiency in terms of cost, time, and quality.

#### **4.4 The Need to Manage the Construction Supply Chain**

The construction supply chain is simply a network of firms that agreed to work together in order to realise objectives relative to construction projects. The days of vertical integration or rather the era whereby a single firm can conceive and realise a construction project can be deemed to be simply over for now. Prevailing circumstances in the industry necessitate a proactive approach to the management of actors / and firms involved in project conception and realisation. Venkataraman and Pinto (2008: 211) contend that as a direct result of factors such as globalisation, best value for customer money, inventory management, and complexities, risks and uncertainties attached to projects necessitate the adoption of SCM approaches. According to them, project supply chain complexities underscore the importance and need for project-based organisations to manage their total supply chain in a more formal and organised manner, that is, SCM approaches such as partnering, information, and risk sharing can greatly reduce uncertainties and complexities attached to project, and management approaches that goes with SCM such as lean construction, TQM, purchasing, distribution, and logistics management will not only enable organisations to realise major gains through the elimination of NVAAs in the process, but also will provide opportunities for businesses to improve their operations. Shakantu (2009: 227) contends that construction could benefit from supply chain optimisation tools such as integration of logistics functions and reverse logistics that have proved to be effective tools to improve transport utility in other industries such as manufacturing, that is, the optimisation of the usage of transport vehicles can significantly improve construction efficiency.

Based on the assumption that clients, cost, flexibility, quality, and time are drivers of SCM, their performance provides a barometer that can successfully measure the performance of a construction

supply chain (Table 4.3). This research adopts the view that SCM can potentially introduce performance improvements in the construction process that will galvanise / or accelerate infrastructure delivery not only in South Africa, but in any developing country. More so, the trend towards outsourcing and the increasing importance of intangibles heightens the need for, and the potential of SCM, that is, the trend towards fragmentation and variety in product and service offerings necessitates greater thought and skill in managing decoupling points and postponement of final product composition, which in turn necessitates greater attention to issues of alignment and logistics, and by implication issues relative to SCM (Cousins *et al.*, 2006: 770; Shakantu *et al.*, 2007: 103).

Table 4.3 Project supply chain performance metrics

| Category    | Performance issues                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Time        | <ol style="list-style-type: none"> <li>1. Was the project completed and delivered on time?</li> <li>2. What is the potential variability in project completion times?</li> <li>3. Was the completed project operational on time to the satisfaction of the client?</li> <li>4. Were the purchased materials and manufactured components delivered on time by upstream suppliers?</li> <li>5. What is the potential variability in procurement lead times?</li> </ol>                                                               |
| Cost        | <ol style="list-style-type: none"> <li>1. Was the completed project within budget for each of the project supply chain members?</li> <li>2. What was the total project supply chain cost? <ul style="list-style-type: none"> <li>• Procurement cost of purchased materials</li> <li>• Manufacturing cost</li> <li>• Inventory-related cost</li> <li>• Transportation cost</li> <li>• Project acceleration costs</li> <li>• Cost of liquidated damages</li> <li>• Other relevant costs: administrative, etc.</li> </ul> </li> </ol> |
| Quality     | <ol style="list-style-type: none"> <li>1. Did the project meet the technical specifications and does it provide the functionality required by client?</li> <li>2. Was the client satisfied with the service provided during project start-up, transfer, and implementation?</li> <li>3. Were the purchased raw materials and manufactured components defect-free?</li> <li>4. Was the completed project's product reliable and durable during its life cycle?</li> </ol>                                                           |
| Flexibility | <ol style="list-style-type: none"> <li>1. Was the client accorded reasonable freedom within a reasonable timeframe to make changes to the project scope, design, and specifications?</li> <li>2. Were upstream suppliers responsive to the reasonable needs of their downstream partners in terms of delivery time and quality issues</li> </ol>                                                                                                                                                                                   |

Source: Coyle *et al.* (2003: 490)

#### 4.5 Improving Construction Supply Chain: Conceptual Perspectives

Figure 4.2 illustrates the key generic supply chains that are required in the integration and delivery of a typical construction project. Though, the figure may suggest that the supply chain is rather simple, but the reality is quite different because of the complexities associated with the management of multi-tier supply chains. The ultimate level of the complexity involved with the management of the construction project is often determined by the specific requirements of the end customer (Cox and Ireland, 2002: 410). Effective SCM requires a thorough understanding of clients' needs, a requirement, which in effect, makes clients the driving force behind SCM (Venkataraman and Pinto, 2008: 213). The figure equally illustrates the roles and links between clients, advisors, contractors, subcontractors, and suppliers. The contractor plays the integrating role while the client initiates and dictates the demand for services. In terms of infrastructure project procurement, clients' roles are usually divergent.

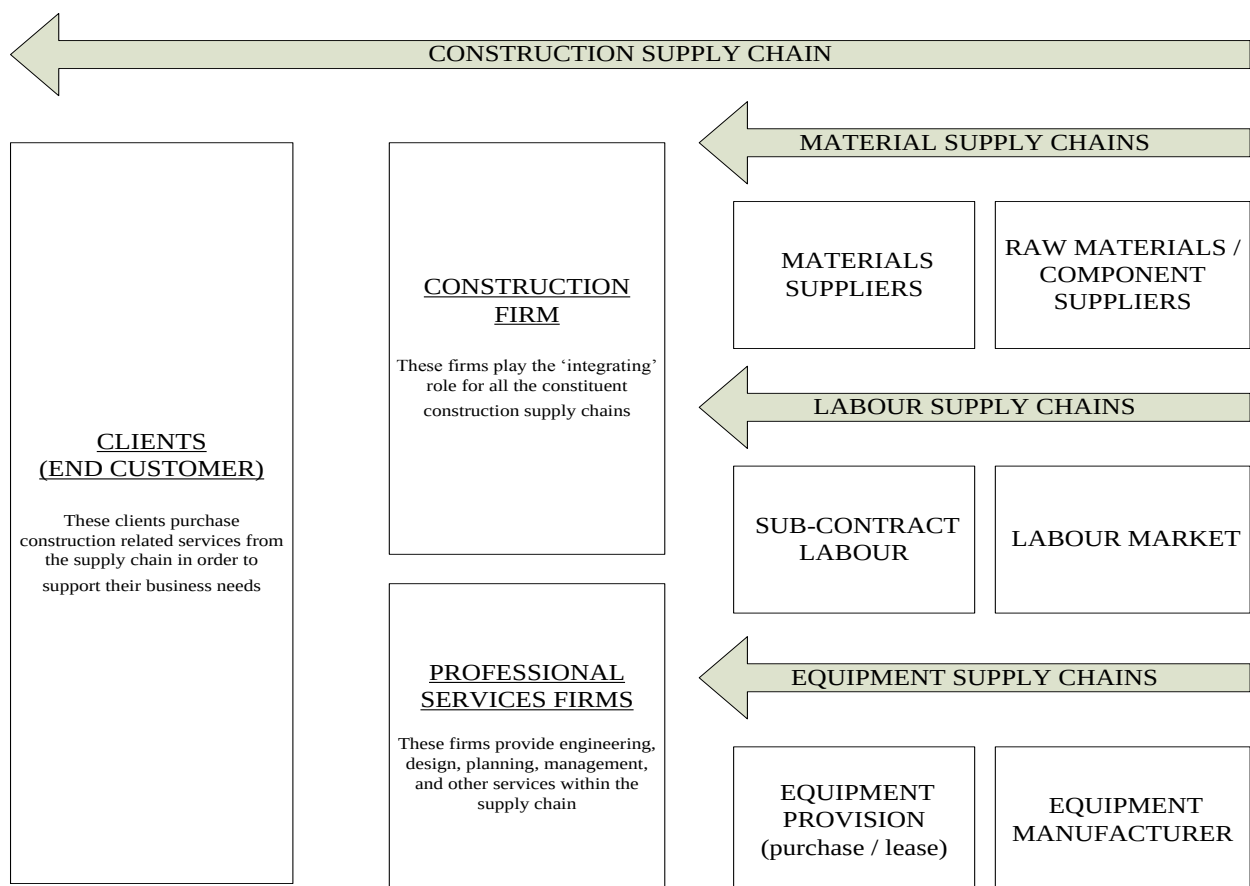


Figure 4.2 Myriad of construction supply chains (adapted from Cox and Ireland, 2002: 411)

According to Pettit (2000: 274), a client's role can be base role, added value role, or interfering role. Base role entails the generation of the need for a project, communication of needs and requirements, financing the project, provision of essential project pre-requisites, and taking ownership of the project

result; added value role entails the provision of project aims and objectives, direction of project specific activities, management of supplier base, management of project base, benefit maximisation, and induction of experience; and interfering role entails change in scope, restrictions to programme, provision of internal resources, control of technical details, usurping the roles of other project participants, and a lack of response to other project participants.

Furthermore, Figure 4.3 indicates that the causal network of this study reflects the assumed conceptual perspective. According to Trafford and Leshem (2008: 84), Miles and Huberman (1984) define a conceptual framework as the current version of the researcher's map of the territory being researched, while Weaver-Hart (1988) defines conceptual frameworks as a structure for organising and supporting ideas; a mechanism for systematically arranging abstractions; sometimes revolutionary or original. They say the conceptual framework provides a theoretical overview of the proposed research and order within the research process. More so, contributions of conceptual frameworks to the research process entail the reduction of theoretical data into statements or models, modelling of relationships between theories, provision of theoretical bases to design and interpret research, and the creation of theoretical links between extant research, current theories, research design, interpretations of findings and conceptual conclusions (Trafford and Leshem, 2008: 87).

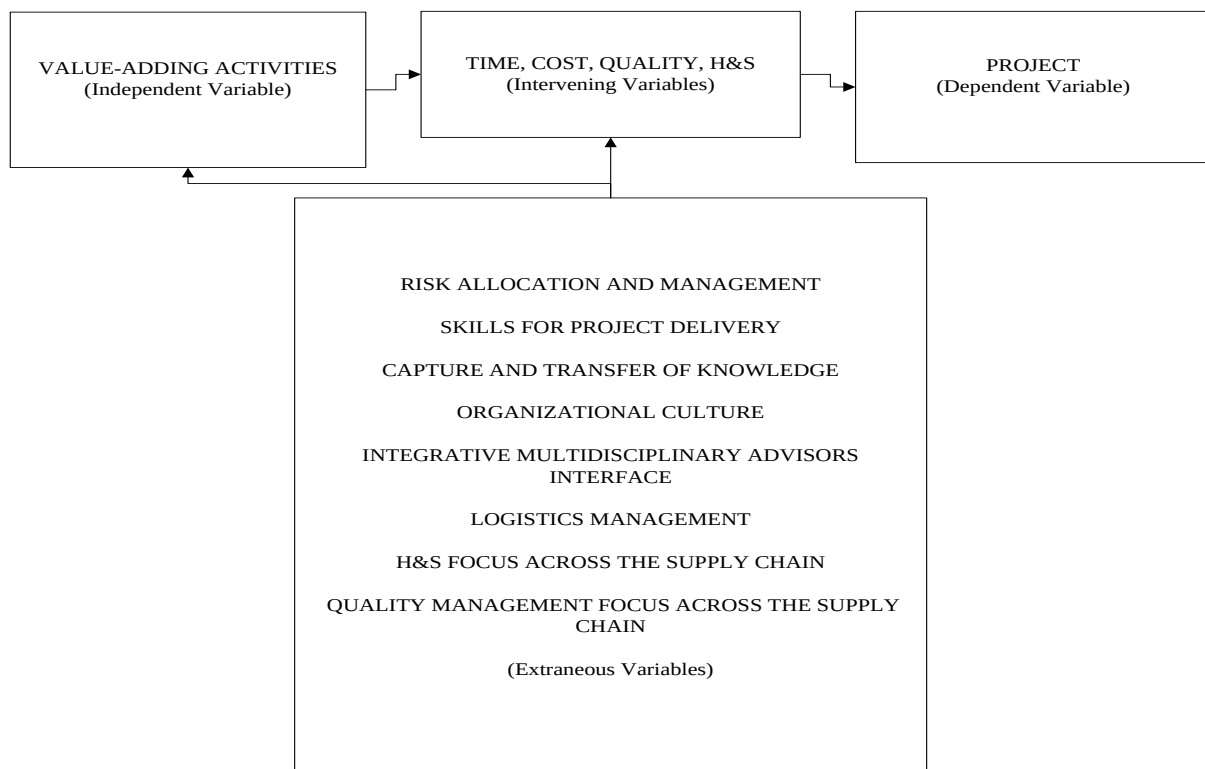


Figure 4.3 Causal Network: Seamless project delivery

The Figure 4.3 indicates the conceptual map for the study, showing the independent variable (change variables), dependent variable (outcome variable), extraneous variables as well as the intervening variables. Kumar (2005: 60) suggests that the independent variable is supposed to be responsible for bringing about change or changes in a phenomenon or situation, the dependent variable is the outcome of the changes brought about by the introduction of an independent variable, the extraneous variables are several factors operating in a real-life situation that effect changes in the dependent variable, that is, these factors may increase or decrease the magnitude or strength of the relationship between independent and dependent variables, and the intervening variables link the independent and dependent variables, that is, the cause variables will have effect on the dependent variable only when the intervening variable is present in the link.

The conceptual map is a graphical representation of the research problem, which states that “poor performances relative to cost, time, quality, and H&S as a result of the inherent NVAAs in the construction process hamper the smooth delivery of infrastructure projects.” The poor performance is occasioned by recurrent NVAAs in the construction process. In terms of public sector construction project procurement, cost overruns may exacerbate budget constraint problems, time overruns / or delay may slow down service delivery, poor quality may increase maintenance cost and shorten design / or service life of infrastructure, and poor H&S may increase both industry and public fatalities. To buttress the point, VAAs are operational efforts that transform project requirements stipulated in contract data into reality (project realisation), while NVAAs are wasted efforts that consume time and / or resources, but do not directly or indirectly result in the achievement of goals stated in the contract data (Han *et al.*, 2007: 2082). This transformation is indicated through the performance of the traditional project performance parameters of cost, H&S, quality, and time. For example, concrete pouring that leads to the formation of slabs, columns or beams on construction sites can be considered as VAAs that record progress toward the realisation of a project with performance parameters of cost, H&S, time, and quality revealing the effectiveness and efficiency inherent in the process. In effect, VAAs are always explicitly identified in contract data, and they are also deemed to be drivers for cost, time, and quality estimation in construction.

However, empirical evidence suggests that an average of 49.6% of operational efforts is devoted to NVAAs (Horman & Kenley, 2005: 59). Alwi *et al.* (2002: 32) contend that NVAAs are not only associated with waste materials in the construction process, but they also are associated with other activities such as rework, waiting time, and delays. They say these issues contribute to a reduction in construction productivity, and increase poor performance in construction. Such findings support the argument that poor performance relative to construction projects seems to be the norm rather than the exception, with both clients and contractors calling for a major shift in project delivery systems. Therefore, the smooth realisation of projects has been largely marginalised by NVAAs (Han *et al.*,

2007: 2088) and other sundry anomalies such as the lack of effective project team integration between clients, the supplier team, and the supply chain (Office of Government Commerce (OGC), 2005: 1-7). This clearly supports the contention of Flyvbjerg *et al.* (2003: 85) that transport infrastructure projects do not perform as promised, and risk as well as uncertainties associated with cost of transport infrastructure projects are substantially high.

To be succinct, a construction project that is besieged with problems relative to the negative sides of issues identified in the extraneous variables' box may witness unlimited NVAAs, and consequential poor performance in terms of cost, H&S, quality, and time. Conversely, a project that proactively engages and addresses issues referred to as extraneous variables may witness appropriate VAAs that result in positive project performance parameters, and eventual successful project delivery. The second scenario not only creates value in the construction process, but it also enhances successful service delivery in the public sector. The intended contributions of the conceptual roadmap to infrastructure delivery is significant because in public sector parlance, service is a means of delivering value to customers by facilitating outcomes customers want to achieve without the ownership of specific costs and risks (OGC, 2007: 11).

In particular, research findings indicate that the choice of contract strategy in the public sector in Mozambique, a neighbouring country to South Africa, is largely influenced by legislation, source of finance, and project size with inequitable risk sharing practices (Baloi, 2002: 402). In fact previous research studies of client-contractor relationships revealed several drawbacks of adversarial exploitation and improper risk-shedding tactics (Palaneeswaran *et al.*, 2003: 580). The client's role tends to be contractually biased in traditional procurement and exhibits a bias towards a managerial approach and performance incentives in the case of new procurement (Pryke, 2001: 486) in spite of the fact that clients have a significant impact on the performance of construction projects (Pettit, 2000: 272). However, in order to achieve value for money in public project development, the public client and private contractor need to reach the best risk allocation scheme before the contract is awarded (Li, 2003: 221). Ideally, the capability of the client organisation may also present risks as departmental employees tend to be generalists, and may not have the technical expertise or experience required for large-scale construction projects (Dalton, 2007: 243). Specialist skills may be needed in the construction environment because the use of SCM shifts the management of the design and production process to a smaller number of key knowledgeable actors in the project teams in order to ensure effectiveness of the supply chain since traditional construction roles are changing rapidly due to design dislocation and other factors (Pryke, 2001: 490). Where clients lack in-house skills to manage the supply chain, they may have to source the role from the private sector so that the integration of design and construction will flow concurrently (Pryke, 2001: 490).

Further, a KM system provides a robust approach for addressing site management problems and for preventing new problems from occurring (Mohamed, 2006: 248). Knowledge sharing relies primarily on attracting and retaining employees most capable of communicating and synthesising knowledge and expertise with others, and the implementation of employee-focused knowledge sharing practices facilitates the integration and regeneration of otherwise fragmented, specialised, and asymmetrically distributed knowledge within the organisation, thus making feasible the production of complex and innovative products and services (Olomolaiye, 2007: 250). Knowledge sharing / management does not only have the potential to solve management, technical and communication problems on construction sites (Mohamed, 2006: 249), but also to create an environment that allows competitive advantage over others, reduction of project re-work, prevention of project period escalation, reduced employee turnover, reduction in time and efforts for supervision and inspection, and promotion of innovation when combined with human resource issues (Olomolaiye, 2007: 250).

KM is an integral part of continuous performance improvement through learning, and it should be adopted to facilitate inter and / or intra organisational collaboration (Mohamed, 2006: 250).

Therefore, knowledge sharing is a very dynamic process due to the influence of organisational strategy, structure, and culture, that is, organisational strategy, structure, and culture may favour or inhibit knowledge sharing in construction organisations (Olomolaiye, 2007: 250). Organisational culture plays a significant role in an organisation's ability to share knowledge, learn, innovate and embrace change. In hindsight therefore, most construction projects and their realisation supply chains include a variety of cultures (organisational and national) that necessitate intercultural competence among site management in order to get the best from the contributing stakeholders, whose position may change rapidly throughout the life of a project (Fellows, 2009: 67). This envisaged intercultural competence requires managers to see the project through the eyes of different stakeholders and to appreciate the performance requirements that they place on the project.

The challenge relative to the information and communication problems associated with the interface between multi-disciplinary design / management advisors can be overcome through the agency of concurrent engineering (CE) or mobile computing and semantic web environment. Bowron (2002: 238) contends that the adoption of CE principles in the construction industry offers improvement in many ways particularly through the early involvement of all personnel involved in the project. He went on to demonstrate this through a new procurement model he developed as part of his doctoral studies. The new model has been shown to adopt the principles of CE and therefore offer the construction industry a new approach to project procurement that improves the collaboration of all parties involved in the construction process. A key area of improvement is the adoption of a design neutral specification as the mechanism for identifying the client's requirements. This specification remains a central document throughout the process and is reviewed at several stages to ensure that the

focus is maintained on the client throughout the process. Another key area is the integration of the downstream participants at an earlier stage, which allows the downstream processes to be fully integrated at an early stage in the overall process. The advantages of the new method include total understanding of the needs of each participant, which translate into a possible reduction in late changes and delays, and increased profit. However, CE is only possible in an ICT enabled construction environment. Pan (2006: 257) argues that semantic web technology can not only improve construction information management in a number of areas such as project knowledge management, collaborative design, and communication between project partners, but also provides an innovative approach to managing construction information because it enables the information in construction documents to be interpretable by computers. This attribute translates to efficiency and precision of construction information management. Similarly, the emergence of mobile computing has the potential to enlarge the boundary of IT support from site offices to actual work sites and improve information and communication between construction workers and the design team, a situation which is the key factor for the integration of design and construction otherwise called concurrent engineering (Chen, 2008: 343). Benefits of the implementation of mobile computing in construction include the reduction in operation and maintenance cost, the reduction in defects, accidents, and NVAAs, the increase in productivity, and the increase in predictability (Chen, 2008: 345).

With respect to logistics management in the South African construction industry, Shakantu (2004: 301-309) determined that the movement of construction materials, as well as C&D materials, are at best sub optimal as the principle of reverse logistics was not used on the construction sites visited during the study. However, Kasim (2008: 185-186) suggests that a real-time tracking system provides a robust and innovative approach for addressing on-site materials tracking and inventory management problems through the integration of the RFID-based materials management with resource modelling in the project management system. The RFID system provides facilities to resolve the problems of current manual practices of material tracking that may occur in managing materials on the construction site. In addition, Udeaja (2002: 291) opines that in an environment such as construction, the ability of a multi-agents system to autonomously plan and pursue their actions and goals, cooperate, coordinate, negotiate with others, and to respond flexibly and intelligently to dynamic and unpredictable situations will provide just-in-time (JIT) supply and materials requirement management. Udeaja (2002: 291) contend that this will invariably lead to significant improvement in the quality and decision-making output of the entire industry.

Uncovering methods of integrating H&S will undoubtedly extend the knowledge and understanding of construction H&S beyond site and design stages of the construction process. However, early project planning is an area where there is presently little integration of H&S management in spite of previous calls for the need for a framework that will integrate H&S early in project lifecycles (Hare,

2006: 200). The last extraneous variable addresses the influence of discontinuities relative to quality of construction process and product. TQM provides a platform to remedy the anomaly but the depth of adoption and implementation of TQM differs across national boundaries (Xiao and Proverbs, 2002: 12). For instance, Aibayouhd (2003: 131) determined that the general level of TQM awareness in the Saudi Arabian construction industry appears to be low (32%). A survey of 112 construction industry organisations determined that the level of awareness and / or enlightenment relative to TQM is 46% for client organisations, 14.5% for advisors / designers, and 27% for construction firms. Yet again, statistics underscore the importance of construction clients in the construction process.

Based on the arguments and counter arguments related to SCM presented from chapters 2 to 4, this research adopts the conceptual view that the actors / networks involved in the construction process can be referred to as construction supply chain (Figure 4.2) that may be continuously improved to the point that projects may be delivered seamlessly (Figure 4.3). This is based on the premise that the relevance of SCM in the construction context lies not in the existence of supply chains, but in their exploitation with a view of improving the construction process (Pryke, 2009: 10; Pryke, 2001: 486-490). More so, O'Brien *et al.* (2009: 1), while highlighting reasons for construction SCM, postulate that effective construction SCM may become tantamount to effective construction project execution. Their stand is understandable given reasons that were identified. These reasons include:

- the organisation and sourcing of materials is becoming increasingly complex across the global construction industry;
- global sourcing of materials and assemblies provided by advances in transportation technologies as well as shortage of craft labour that is forcing increasing amount of value-added work to be conducted off-site deep in the supply chain;
- construction clients' demand for higher quality facilities delivered through faster and more responsive construction processes, and
- mounting evidence of improvement in project performance through a focus on the construction supply chain perspective.

Since NVAAs can be deemed to be the major reason behind schedule delays, cost overruns and other related problems in construction, to successfully execute projects, efforts must be made to minimize the amount of NVAAs in construction (Han *et al.*, 2007: 2088). This is even more imperative in the South African construction industry where recent cidb CII results indicate, *inter alia*, that (cidb, 2010: 2):

- clients were neutral or dissatisfied with the performance of contractors on 18% of the projects surveyed in 2009;

- around 12% of the projects surveyed had levels of defects that are regarded as inappropriate;
- contractors were neutral or dissatisfied with the quality of tender documents and specifications obtained from clients on around 26% of the projects surveyed;
- contractors were neutral or dissatisfied with the management of variation orders on 31% of the projects surveyed, and
- H&S on construction sites remains a concern.

While numerous reports and empirical findings have attributed the not so inspiring performance of the industry to the so called skills shortages (Merrifield, 2006: 38; van Wyk, 2008: 23), emerging findings suggest that there is more to the challenges that must be surmounted in order to improve the industry performance. Though the research findings centred on issues surrounding variations in the industry, Ndiokubwayo and Haupt (2008: 95) and Nghona *et al.* (2009: 156) contend that activities categorised as non-value adding activities are having a detrimental effect on the industry. These NVAAs that are otherwise referred to as waste (Alancon, 1998: 369; Horman and Kenley, 2005: 52) or supportive / interactive activities (Mao and Zhang, 2008: 373) have been given prominence in construction management research endeavours that address construction productivity issues in general, and lean construction at the annual conference of the International Group for Lean Construction (IGLC).

Obviously, regardless of the metrics / names used in the categorisation of NVAAs, empiricism has justified their existence in construction. For example, a case study presented by Arbulu *et al.* (2003: 170) reveals that in the supply chain of pipe support used in power plants in the USA, 96% of time expended is non-value added time. The study in which industry-wide practices with respect to the delivery of the pipe supports was clearly described, highlighted the significant opportunity that exists for the reduction of NVAAs in construction.

The incontrovertible evidence suggests that given the uniqueness of individual construction projects, it is inevitable that one or more of these wastes / NVAAs may occur with unpalatable consequences for project objectives. Therefore, in order to address these NVAAs in construction, awareness relative to what they are, their causes and impacts, and possible mitigation remedies should be inculcated into the minds of construction stakeholders.

#### **4.5.1 The Causes of Non-Value Adding Activities in Construction**

Han *et al.* (2007: 2083) contend that errors and changes generally trigger NVAAs in the construction production system in the form of interruption, productivity loss, and rework, which requires additional time and efforts (additional resources that were not originally planned for) in order to compensate for the lost time and effort. In a doctoral dissertation that produced a model based on system dynamics for the measurement of NVAAs in the construction production system, Han *et al.* (2007: 2088) suggest

that although NVAAs can be identified and quantified through the use of a simulated model, they can nonetheless be easily propagated into other related activities. Therefore, rework in the form of ‘the rework cycle’ that can occur either at the design stage or on construction sites seems to pervade the construction process regardless of project activities, types and / or location (Cooper *et al.*, 2002: 215).

Further, Hwang *et al.* (2009: 197) identified ‘design error / omission appeared’ to be the root cause of rework among other sources that included owner change, design change, constructor error / omission, constructor change, vendor error / omission, vendor change, and transportation error, on both owner and contractor reported projects on the database of the Construction Industry Institute (CII) in the USA. Another study that focused on the construction industry in Australia and Indonesia determined that design changes, lack of trade’s skill, slow decision-making, poor coordination between project partners, poor planning and scheduling, delay in material delivery to site, inappropriate construction method, poor design, poor quality of site documentation, slow drawing revisions and distributions, unclear site drawing, unclear specification, and weather conditions, individually and collectively result in NVAAs in varying degrees (Alwi *et al.*, 2002a: 9).

The sources of NVAAs can be categorised in terms of people, professional management, design and documentation, material, site operations, and physical factors (Alwi *et al.*, 2002b: 7). Sources of NVAAs associated with people include inadequate trades skills, poor distribution of labour, late supervision of work, shortage of skilled supervisors / foremen, inadequate subcontractor skills, and inexperienced inspectors that seems particularly serious in South Africa; sources of NVAAs linked to professional management include poor planning and scheduling, poor information management, poor coordination within the construction supply chain, a slow decision-making process; sources of NVAAs relative to design and documentation include poor quality site documentation, unclear specification, unclear site drawings, slow response to requests for information (RFI), design changes, and poor design; sources of NVAAs relative to material include non-conformance to quality standards, delay of material delivery, poor material handling, inappropriate use of material, and the sources of NVAAs linked to site operation include poor site layout, outdated equipment, shortage of equipment, inappropriate construction methods, and excessive reliance on overtime in order to execute work timely. To be succinct, origins of NVAAs in construction in terms of material or time can be categorised with respect to design, procurement, material handling, site operation, and other construction related activities (Polat and Ballard, 2004: 6-8).

#### **4.5.2 The Impact of Non-Value Adding Activities in Construction**

NVAAs in various forms have a detrimental effect on construction projects (Alwi *et al.*, 2002a: 9; Alwi *et al.*, 2002b: 10). NVAAs in the form of rework impact cost negatively (Hwang *et al.*, 2009: 197), and impact construction productivity negatively (Alwi *et al.*, 2002b: 12; Han *et al.*, 2007: 2088;

Horman and Kenley, 2005: 59; Abdel-Razek *et al.*, 2007: 196; Hanna *et al.*, 2005: 739). In fact, Horman and Kenley (2005: 59) contend that as much as 49.6% of construction operative time may be devoted to NVAAs. Even overtime that seems to be the norm rather than the exception in the construction industry negatively impacts productivity and may increase fatigue, incidents and accidents that eventually increase the cost and time spent on construction projects (Hanna *et al.*, 2005: 734). Notably, these NVAAs, if left unchecked, may have severe consequences for the competitiveness of organisations and by extension, the productivity of the industry (Alwi *et al.*, 2002b: 12; Koskenvesa *et al.*, 2010: 484).

Within the South African construction industry context, NVAAs have been identified as one of the problems negatively impacting a range of issues such as variations. In a study that focused on two completed apartment complexes in Cape Town, South Africa, Ndiokubwayo and Haupt (2008: 94) determined that design changes, design errors, design omissions, and construction changes were the most frequently cited root causes of variation orders on the two projects. Furthermore, these variation orders resulted in completion delays that were approximately 33% for one project, and 9% for the other project when compared with completion dates agreed upon at project inception. The variation orders also increased the project cost of the two complexes by an average of 6% when compared with budgeted project cost. Nghona *et al.* (2009: 155) also, *inter alia*, pointed out that inadequate scoping of work, unnecessary redesign of work, poor design management, and inadequate design briefs lead to NVAAs during the design stage of construction projects. These research findings are based on another study, which was quantitative in nature, conducted in Cape Town, South Africa. The NVAAs that were identified during the design stage do not only consume resources in an attempt to remedy the situation, they also influence activities downstream in the construction supply chain (Nghona *et al.*, 2009: 156).

#### **4.5.3 The Need to Address Non-Value Adding Activities in Construction**

The aforementioned causes of NVAAs may account for the reason why the optimisation of the construction process focuses on the elimination of non-value-added and unnecessary cost-adding activities, which includes change orders for design errors; rework as a result of inappropriate planning and operation; misunderstanding within the construction supply chain; and the inevitable inefficiencies associated with the lack of skilled artisans (Li *et al.*, 2008: 994). As an illustration, the public sector that always procures construction services in order to fulfil electoral pledges and constitutional requirements cannot be said to be fully satisfied with the performance of the industry. For example, Samuel (2008: 169) examined six public sector projects that were not completed satisfactorily in South Africa, and discovered that inadequate tender rates, poor project cost, as well as scope, quality, time, and integration management related problems were the causes of failures linked

with the projects. While noting the poor project management competency among project stakeholders, a situation analysis conducted relative to the identified failures suggest that NVAAs played prominent roles in terms of the problems recorded on the projects. Flyvbjerg *et al.*'s (2003: 85) contention that transport infrastructure projects do not perform as promised, as risk as well as uncertainties associated with cost of transport infrastructure projects are substantially high, may not be far from the truth given the mirage of problems plaguing projects in developing countries. While cost escalation is a pervasive phenomenon in transport infrastructure projects across project types, geographical location and historical period (Flyvbjerg *et al.*, 2003: 79-84), it was discovered that cost escalation was strongly dependent on the length of the implementation phase of construction project delivery (Flyvbjerg *et al.*, 2004: 5). Specifically, Flyvbjerg *et al.*'s (2003: 85-86) findings, *inter alia*, indicate that nine out of ten transport projects fall victim to cost escalation; cost escalation has not decreased over the past seventy years, which suggests that no learning seems to have taken place; cost escalation appears to be a global phenomenon, and it appears to be more pronounced in developing nations than in North America and Europe. Though the work done by Flyvbjerg and other researchers has attempted to address the cost escalation problems through the lens of policy-making and decision-making at project inception, anecdotal evidence seems to suggest that activities both upstream and downstream of the construction supply chain influence the length of the implementation phase of project delivery, and contribute to the final cost of projects at their completion.

Clearly, there is good reason to be concerned about sluggish planning and implementation of projects (Flyvbjerg *et al.*, 2004: 8). Delays occasioned through long project implementation phase can potentially damage project objectives especially in developing countries. Long *et al.* (2004: 556) suggest that failure to meet project objectives may stem from project delays, cost overruns, accidents, non achievement of quality, and even disputes between parties (Iyer *et al.*, 2008: 175). During research conducted in Vietnam, a developing country in Asia, 62 construction related problems were investigated with the intent of categorising and identifying the most important problems militating against the achievement of project objectives (Long *et al.*, 2004: 556).

Relying on statistical analysis that is rooted in factor analysis, the most important problems were categorised into incompetent designers and contractors, poor estimation and change management, social and technological issues, site related issues, and improper techniques and tools (Long *et al.*, 2004: 560). The problems that were under the influence of owners, consultants, and contractors that seem to occur with high frequency include inaccurate time estimating, slow site clearance, excessive change orders, severe overtime, bureaucracy, obsolete technology and equipment, improper planning and scheduling, poor site management, impractical design, and incompetent project team (Long *et al.*, 2004: 557).

Even the developed countries have not fared significantly better than the developing countries in terms of cost escalation and its associated problems in construction. For example, the Boston Big Dig project that was estimated at \$2.6 billion at its inception in 1982 experienced so many problems that in 2002 the estimated cost at completion had to be changed to \$14.6 billion (Shane *et al.*, 2009: 223). In their research findings, Shane *et al.* (2009: 224) contend that delivery / procurement approach, project schedule changes, engineering and construction complexities, scope changes, scope creep, faulty execution are among cost escalation factors identified through a research conducted among public sector clients in the USA. These problems singularly or collectively result in NVAAs either in the form of rework or other activities that consume resources and time without commensurate contributions towards the progress of work in the construction process.

The construction management literature is populated with a plethora of problems associated with the construction process to the extent that failure to attempt redress through a multi-dimensional perspective may not augur well for the industry and academia. Therefore, the efforts of researchers, especially the lean construction researchers, must be commended in terms of performance improvement through the reduction and / or elimination of NVAAs. For example, Kraemer *et al.* (2007: 130) contend that from 1993 to 2001, approximately 48% of conference papers presented at the IGLC annual conferences addressed issues surrounding value adding and non-value adding activities in construction. However, while recognising the efforts of the lean construction researchers, it is nevertheless imperative to note that due to the nature and characteristics of NVAAs, their management in the construction process requires an holistic approach (Han *et al.* 2007: 2088), which attempts to remedy problems by focusing on the whole rather than individual processes / organisations involved in project objective realisation (Senge, 2006: 69-91).

In order to improve project performance therefore, learning must recognise past good performance, and improve upon it systematically and continuously (Cooper *et al.*, 2002: 213). Management approaches relative to SCM such as lean construction, TQM, and logistics management provides opportunities for reducing NVAAs in the construction process, while engendering cultures of continuous improvement at the same time. For example, Shakantu (2009: 227) contends that construction could benefit substantially from supply chain optimisation tools such as the concept of reverse logistics that have proved to be effective in improving transport utility in other industries such as manufacturing; Abdel-Razek *et al.* (2007: 196) suggest that lean construction is an effective tool for managing the construction process after they successfully applied lean construction principles to labour productivity measurement in 11 Egyptian construction projects; and lean principles can be applied in construction process reengineering in order to significantly improve the performance of the industry (Mao and Zhang, 2008: 380; Ibrahim *et al.*, 2010: 244).

However, in order to fully appreciate the effectiveness and efficiency of these processes that have proven their worth in the manufacturing environment, anecdotal evidence suggests that they must be modified and applied with caution, bearing in mind the uniqueness of the construction industry environment. Though acknowledging that improving the performance of supply chains is not an easy task due to complexities and the fragmented nature of the industry, Arbulu *et al.* (2003: 170) nevertheless suggest that supply chain participants intending to reduce lead times through the elimination of NVAAs should consider selecting project partners early, share unambiguous information, and also endeavour to make use of integrated computer tools for optimum project performance.

It is not gainsaying that the identified constraints in this research so far provide a platform for further empirical studies in the South African construction context with a view to finding answers to questions such as:

- What construction related activities can be classified as NVAAs in South Africa?
- What are the causes of the identified NVAAs in South African construction?
- What are the consequences of NVAAs in South African construction?
- What impact do these NVAAs have on cost, H&S, time and quality in South Africa?
- What is the relative frequency of non-value adding activities in South African construction?

Arguably therefore, responses to these questions as well as other empirical findings generated through a mixed-mode quantitative research method during the empirical process may create awareness relative to NVAAs in construction, their sources, effects, and interventions applicable to the South African construction context. The initiative is underpinned by the assumption that improvement of the construction supply chain may not only reduce NVAAs, but may also increase efficiency in the construction process by embracing concepts inherent in system dynamics for model development and testing.

## 5.0 SYSTEM DYNAMICS IN CONSTRUCTION RESEARCH

Many project models are SD-oriented, but if the research work is not done through the SD modelling methodology lens, that is, if the work failed to use feedback, accumulation, nonlinear relationships to explain how structure and behaviour interact, then the work has not fully applied the system dynamics methodology to project management (Ford, 2007: 11). According to the June 2007 'SD Project Management Bibliography' compiled by David Ford, SD is presently gaining ground in construction project related research endeavours with respect to various phenomena such as quality, rework, project strategy, project dynamics, litigation, project performance, contingency management, constructability reviews, uncertainty, risks, cost overruns, schedule overruns, concurrent project development, delay, nature of project leaderships, change management, iterative error and change circle, resource allocation, reliability buffering as well as planning and control (Ford, 2007: 2-8). Though, authored by people with different academic and professional background, the bibliography however points to the undeniable fact that SD offers significant opportunity for resolving construction project related problems.

It is also notable that all publications listed in the bibliography were done through the SD methodology lens as described in Forrester (1961: 60-66) and Sterman (2000: 83-106). Sterman (2000: 4-5) contends that SD, which is partly a method for developing management flight simulators in the form of simulation models, is a method to enhance learning in complex systems. He emphasized that SD models are developed to enhance learning about complex systems, understand the sources of policy resistance, and also to facilitate the design of more effective policies. SD is reportedly fundamentally interdisciplinary in nature since it is not only concerned with the behaviour of complex systems, but also grounded in the theory of nonlinear dynamics and feedback control developed in mathematics, physics, and engineering related fields. Sterman (2000: 5) suggests that because SD tools are applied to the study of behaviours of human, physical, and technical systems, it draws on cognitive and social psychology, economics, and other social sciences.

Thus the explanations about 'what SD is' seem to suggest that SD, though related to system thinking, is much more than system thinking. System thinking is mainly a discipline for seeing wholes rather than snapshots, that is, it is a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static 'snapshots' (Senge, 2005: 68). It is the ability to see the world as a complex system in which we understand that "you can't just do one thing" and that "everything is connected to everything else." (Sterman, 2000: 4-5). Regardless of the research perspectives adopted for a construction management research study, which is regarded as an applied field of investigation that is seemingly rooted in the positivist tradition (Dainty, 2008: 10), it should embrace concepts, which may assist in engendering continuous improvement (Fellows, 2010: 6). System thinking and

SD holds useful opportunities for the advancement of decision-making and policies, central to the project management domain in general, and South African construction in particular (Taylor, 2010: 99-100).

### **5.1 Historical Background of System Dynamics**

After an exemplary career in engineering, Jay W. Forrester created a new field called ‘industrial dynamics’ at MIT’s Alfred P. Sloan School of Management between 1957 and 1958 (Sterman, 2007: 89; Roberts, 2007: 119). Forrester’s unique contribution to the new field was to develop ideas about feedback systems and their dynamics into a rigorous, yet practical method for ‘enterprise design’, which translated into a method that was designed to find management policies and organisational structures that can lead to greater success by eliminating important top management problems (Forrester, 1961: 449; Sterman, 2007: 90).

This new field, which was subsequently renamed ‘System Dynamics’ (Roberts, 2007: 119) is grounded in control theory and nonlinear dynamics that involved a qualitative and quantitative approach, hard and soft approach, a theoretical, and a pragmatic approach for model development and policy design (Sterman, 2007: 90). For example, books authored by Jay W. Forrester (*Industrial Dynamics* published in 1961; *Urban Dynamics* published in 1969; and *World Dynamics* published in 1971) and John D. Sterman (*Business Dynamics* published in 2000) individually and collectively demonstrate key concepts of SD that include feedback, counterintuitive behaviour, limits to growth, nonlinearity, tipping points, and many others concepts that are now completely integrated into management discourse and social theory.

Explicitly, Industrial Dynamics introduced systems perspective to industrial management literature (Forrester, 1961: 451); Urban Dynamics (Forrester, 1969: 115-128) drew attention to the contradictions in low cost housing policy that was being implemented particularly within the black community in inner cities of the USA; and World Dynamics (Forrester, 1971: 124) addressed factors affecting the quality of life and the dynamism of population in the global context. The world’s first PhD dissertation in SD authored by Edward B. Roberts in 1962 was a large-scale model of the life cycle of a research and development (R&D) project, which addressed interactions between a sponsoring customer and a performing organisation with the overall aim of modelling the economic system between both parties (Roberts, 2007: 121). It is notable that the dissertation that was later published in 1964 as *The Dynamics of Research and Development* made extensive use of academic literature and empirical studies in the R&D domain. To be succinct, SD has being applied and will continue to be applied to problems relative to corporate growth and stagnation; the diffusion of new technologies; business cycles; speculative bubbles; the use and reliability of forecasts; the design of

supply chains ; service quality management; transportation policy and traffic congestion; product development, and project management (Stermann, 2000: 41-72).

However, underpinning the application of SD to these issues is the competence relative to the use of simulation software such as STELLA, Powersim, ithink, DYNAMO, VENSIM (Stermann, 2000: 904; Jackson, 2003: 73; Forrester, 2007: 353). Any one of this user friendly software enable the conversion of causal loop and 'stock and flow' diagrams into sophisticated computer simulations that facilitates the creation of micro worlds otherwise called management flight simulators (Jackson, 2003: 73; Forrester, 2007: 353). These management flight simulators present managers with an easily understood control panel that hides a gaming environment, which allows managers to try out various decision rules relative to situations they are facing at work in order to see what consequences may ensue. However, it is imperative to note that while management games focus on decision-making, SD emphasises the design of policies for guiding decisions (Forrester, 2007: 355). This according to the exact words of Forrester (2007: 355) *"suggest that system thinking that encourages people to believe the existence of systems is perhaps 5 percent of the way into understanding systems, while the other 95 percent lies in SD structuring of models and simulations."*

System thinking that is seemingly in the majority in construction management research especially at the PhD level can be a first step toward the dynamic understanding of complex problems. As a result, in SD model development undertakings, implementation and achievement of change with realistic data is strongly advocated (Roberts, 2007: 134).

## **5.2 Project Dynamics**

Through a literature study, Lyneis and Ford (2007: 157) observed that measured in terms of new SD theory, new and improved model structures, number of applications, number of practitioners, value of consulting revenues, and value to clients, 'project dynamics' stands as an example of the success of SD in action due to project conditions and performance that usually evolve over time as a result of feedback responses involving nonlinear relationships, and accumulations of project progress and resources. They opine that in terms of project model structures, project features, the rework cycle, project control, and the ripple and knock-on effects dominate the project dynamics literature (Lyneis and Ford, 2007: 158-159).

### **5.2.1 Project Features**

Further, Lyneis and Ford (2007: 158-159) determined that SD project models focus on development processes, resources, managerial mental models, and decision making. Modelling these important components of actual projects therefore increases the ability to simulate realistic project dynamics and relate directly to the experiences of practitioners. Their study reveals that a principal feature of all SD project models is the representation of development tasks (work packages) as they flow through a

project. These tasks typically start in a stock of ‘tasks to be done’, and then flow through the projects development processes until the stock of ‘tasks done’ reaches the level of project completion. Another important feature of projects represented in SD models is the application of resources to manage the flows in the development process, based on managements’ perceptions of project conditions.

For instance, the first published model of a project introduced the flows of project work in terms of ‘job units’ based on resources applied and productivity gained (Roberts, 1964 cited by Lyneis and Ford, 2007: 159). The publication introduced several important concepts that represented management’s understanding of project conditions with respect to perceived performance gaps, that is, differences between perceived progress and actual progress and between perceived productivity and actual productivity; and also underestimation of project scope and effort required for project realisation. These errors can lead to poor allocation of resources that eventually feed back to impact project performance (Lyneis and Ford, 2007: 159). Further, recent SD research publications have continue to address the human aspects of project management such as the use of contingency funds (Ford, 2002: 34), schedule buffers in construction projects (Park and Pena-Mora, 2004: 630), and resource allocation policies for reducing project durations (Lee *et al.*, 2007: 557). Incontrovertibly, these features clearly exploit the ability of SD to model human decision making such as modelling decisions driven by performance gaps, delay in human processes, and nonlinear relationships (Lyneis and Ford, 2007: 160).

As indicated in Figure 5.1 and to a limited extent in Figure 5.2, the primary focus of SD modelling is to identify the feedback structure, analyse cause and effect relationships between variables (qualitative modelling), and mathematically formulate the identified feedback structure with the use of stock and flow concepts (quantitative modelling); and then utilise the developed SD model to identify root causes of poor project performance, and thereafter postulate effective policy that can improve the performance by re-organising the internal feedback structure (Han, 2008: 53).

### **5.2.2. The rework cycle**

The rework cycle refers to a set of canonical structures that drive much of the dynamics of specific model types (Lyneis and Ford, 2007: 158). A typical example of the rework cycle is the inventory-WIP structure in supply lines documented in Sterman’s business dynamics (Sterman, 2000: 661-788). According to Lyneis and Ford (2007: 160), the rework cycle is the most important feature of SD project models because of its recursive nature, which enable its iterations to pervade the entire project duration with the attendant behavioural problems. The analogy behind the rework cycle and its associated building blocks, namely productivity and quality, as indicated in Figure 5.1, is its tendency to become pervasive in a project, and the high level of commonality associated with its existence in a wide variety of projects (Cooper *et al.*, 2002: 216). For example, Park and Pena-Mora (2003: 220)



Lyneis *et al.* (2001: 238) suggest that the tendency for project managers to view a project statically or narrowly, results in continued mistakes and failure to learn from past experience that are always exhibited in consistent overestimations relative to progress and productivity of projects. Inevitably, SD models are usually developed to remedy the situation by simulating three project control options namely ‘hire additional workforce (add people)’, ‘work overtime (work more)’, and ‘work faster (work faster / slack off).’ In these loops, an expected completion delay that is indicated by more time required to finish the work remaining than the time remaining to the project deadline initiates hiring, overtime, higher intensity of work, or a combination (Lyneis and Ford, 2007: 162). In generic terms, SD models are based on the premise that dynamic complexity arises because systems are dynamic and tightly coupled; and they are governed by feedback, nonlinear, history-dependent, self-organising, adaptive, counterintuitive, policy resistance, which are mostly characterised by trade-offs (Sterman, 2000: 22).

#### **5.2.4 Ripple and Knock-on Effects**

Actions that are intended to control projects by closing the gap between project performance and targets often generate side effects in the form of policy resistance (Sterman, 2000: 5). These effects typically reduce productivity, and possibly may also reduce quality in projects at the same time (Lyneis and Ford, 2007: 163). In addition, ‘knock on’ relationships can generate significant harmful dynamics such as (Lyneis and Ford, 2007: 165-166):

- “Haste creates out-of-sequence work”, that is, trying to accomplish more tasks in parallel than physical or information constraints allow, whether by adding resources or exerting schedule pressure can cause work to be done out of initial sequences. This situation reduces productivity, and increase errors simultaneously (Lyneis *et al.*, 2001: 247; Ford and Sterman, 2003: 213);
- “Error builds errors”, that is, undiscovered errors in upstream work products (design) that are inherited by downstream project phases (construction) reduce the quality of downstream work as these undiscovered problems are built into downstream work products as exemplified in Lyneis *et al.* (2001: 238-241);
- “Errors create more work”, that is, the process of correcting errors can increase the number of tasks that need to be done in order to fix the problem, or can increase the work required because fixing the error takes more effort than doing the original work. For instance, the ‘tipping point’ dynamics, which is a demonstration of this feedback process, indicates that if these processes are not managed properly, project failure may occur (Taylor and Ford, 2006: 67), and
- “Hopelessness”, that is, morale problems can exacerbate the effects in the form of fatigue, and also rework can create a sense of ‘hopelessness’ that increases errors and reduces productivity.

Lyneis and Ford (2007: 166) also observed that though the primary adverse ripple and knock-on feedback typically modelled by SD researchers are internal to the project, adverse feedback through clients and customers may initiate and amplify internal project dynamics. Examples of these external actions include (Lyneis and Ford, 2007: 166-167):

- Clients often change scope or requirements, activating project control actions, ripple effects, and knock-on effects, thereby degrading projects that were otherwise successful;
- Projects which are under budgeted can lead to efforts by the contractor to increase the budget through change orders, which divert efforts from other project work;
- Poor schedule performance and slipping of deadlines can reduce client trust in the project team, with the resultant demand for more progress reports; more time spent on progress reporting and interacting with the client reduces productivity, slows progress and necessitates additional schedule slip through a reinforcing loop;
- Reduced client trust can also lead to reluctance by the client to tolerate further deadline slippage, which increase schedule pressure and aggravate project control problems, and
- In the extreme, if project problems lead to litigation while the project is still on-going, then diversion of management attention to litigation activities can reduce attention to the project itself, thereby aggravating project performance problems.

In simple terms, the avoidance of policy resistance, and enactment of high leverage policies requires the expansion of the boundaries of mental models so that awareness and understanding relative to the implications of the feedback created by policy decisions can be engendered, that is, learning must include the structure and dynamics of the increasingly complex systems in which policy decisions are embedded (Sterman, 2000: 12).

### **5.3 SD in Construction Project Management**

With the increasing acknowledgement that a project is more than just the sum of its separate processes, researchers have proposed the extension of simulation focus from the ‘operation level’ to the ‘project level’ in order to adequately understand project behaviour as actual applications of simulation results reported significant improvement in construction productivity (Shi, 2002: 483). Coupled with this reason and the reported limitation of Discrete Event Approach (DES), SD was introduced into the construction management domain because of its ability to effectively capture feedback processes (Lyneis *et al.*, 2001: 238; Lee *et al.*, 2006: 84). The key idea behind SD is based on the assumption that the majority of the complex dynamics arise from the feedback among the various components of the system, and not from the complexities of the components themselves (Sterman, 2000: 27). In other words, SD’s emphasis on the system structure (the feedback process) bolsters the understanding of the system (Han, 2008: 52).

Because the commonest behaviour of actual projects cited in the literature is failure to achieve performance targets (Lyneis *et al.*, 2001: 237-238), most SD models have used the aforementioned project structures and methodology to explain these failures and suggest policies for improvements (Lyneis and Ford, 2007: 167). In fact Lyneis and Ford (2007: 170) contend that research and application in project dynamics have focused on understanding the drivers of cost and schedule overrun in particular situations, and then on developing actions that either avoid or minimise the overruns, or on obtaining compensation for the additional costs. They say while there are some overlaps, the research and applications addressed general project management areas such as post-mortem assessments for disputes and learning; project estimating and risk assessment; change management, risk management, and project control; and management training and education. For the purpose of this particular research, explanations is limited to post-mortem assessments for disputes and learning; project estimating and risk assessment; and change management, risk management, and project control.

### **5.3.1 Post-Mortem Assessments for Disputes and Learning**

Quite a number of SD applications in the project management domain involve post-project assessment of what happened, that is, how did the project deviate from the initial plan and why did the deviation occur? These questions mostly involve clients and contractors that worked together on particular projects. However, post-project assessments involve attempts to learn from one project to the next within an organisation.

Lyneis and Ford (2007: 171) suggest that in its application to disputes, SD models are used to quantify and explain the impact of direct changes to final project cost. A model can be set up to represent the project as it actually occurred, including the direct impacts, and calibrated to the actual performance of the project. Then client-responsible direct impacts are removed and the model re-simulated to determine what would have happened without the disruptive actions of the client. The difference between the historical and 'would have' simulations is the full cost of the client actions, including ripple and knock-on effects. Thus SD can apportion costs to the client, to other parties, and to the contractor through simulations removing different groups of direct impacts. In fact significant number of SD applications to project dynamics are related to delay and disruption disputes with Pugh-Roberts & Associates (PRA) having done more than 45 of such projects as at 2005 (Stephens *et al.*, 2005: 96).

In project-to-project learning the modelling process is set up to represent what actually happened on the project, including the direct impact of any changes that occurred in the project. The direct impacts of the changes are removed as inputs to the simulation, one at a time, to identify their contribution to any project overrun. In this way, project managers can learn about the changes that had the most

significant impact on the project, and also identify risks that should be addressed in future projects (Lyneis and Ford, 2007: 172).

### **5.3.2 Project Estimating and Risk Assessment**

Empirical evidence suggest that, in addition to unanticipated changes to the plan, another common trigger for adverse project dynamics is underestimating work scope or under-budgeting for the estimated work scope (Flyvberg *et al.*, 2003: 86). While post-project evaluations are essential for understanding what happened, their greatest value may be in improving project estimating and risk assessment, that is, evolving a way of developing project budgets and plans that are more realistic and robust is the main thrust of a post-project review (Lyneis and Ford, 2007: 173). For instance, projects that are underestimated end up costing more because of the adverse ripple effect dynamics that may occur once the underestimation is discovered.

In addition, SD has been used for risk assessment with respect to post-project evaluations that determines the magnitude of changes that actually occurred on projects as a guide for what may occur on future projects, while pre-project simulation tests are usually done so as to highlight the consequences of similar risks for current project undertakings (Lyneis and Ford, 2007: 174).

### **5.3.3 Change Management, Risk Management, and Project Control**

Lyneis and Ford (2007: 176) contend that a SD model can provide valuable input into decisions relative to change management, risk management, and project control by taking into consideration feedback in projects, especially the adverse ripple effects of management actions. For example, with respect to change management, Cooper and Reichelt (2004: 749-761) demonstrate that the full consequences of changes and their associated cost, including ripple effects, increases nonlinearly with the cumulative size of all changes, and as the changes occur later in the project. Further examples of applications of SD to change management include Fluor Corporation's, a global engineering, procurement and construction (EPC) contractor, proactive use of project models to forecast and mitigate change impacts, including quantifying the effects of the changes, diagnosing the causes, and planning and testing mitigating actions to reduce overall costs (Lyneis and Ford, 2007: 177). In this case example, Fluor reports that their clients welcome their use of these project models, appreciating the foresight that aids the avoidance of project cost surprises and the minimisation of capital expenditure. In fact an SD based model called 'change impact assessment' system to aid project management at Fluor Corporation has been used for over 100 Fluor projects with a resultant organisational wide better understanding of project-wide effects of changes, and cost savings for Fluor and its clients that is now estimated to be in excess of \$1.3 billion (Cooper and Lee, 2009: 2).

SD project models have also been applied to investigate risk management as an aspect of project management. Case studies (Ford and Ceylan, 2002: 248-254; Alessandri *et al.*, 2004: 758; Johnson *et*

*al.*, 2006: 16) and comparisons with other approaches (Cao *et al.*, 2006: 318) provide a basis for the feedback role in managerial real options. For example, Johnson *et al.* (2006: 16-23) used SD to model value flexibility in equipment delivery strategies in a large petrochemical project. And central to SD project models applied to project control is the rework circle as discussed earlier. The rework cycle is reportedly central to many adverse project dynamics to the extent that in order to control a project adequately, the rework cycle has to be recognised so that management actions can be taken to minimise its detrimental effects on project objectives.

SD project models have been used to identify how managers can improve quality and reduce errors, recognise the existence of undiscovered rework and avoid its consequences, and also avoid the tendency to start downstream work too soon, which may increase the likelihood of unplanned concurrences (Lyneis and Ford, 2007: 178). In addition, SD project models can help managers to significantly improve project performance through efforts directed towards easing performance targets by slipping milestone deadlines and greater efficiency in resource management. Therefore, measured both in terms of academic research and real world application, the use of SD to understand and improve project performance has been a great success (Lyneis and Ford, 2007: 182). Though SD modelling is more strategic in nature than more traditional operational project management tools, its ability to complement other project management tools demonstrates its robustness. For instance, Park and Pena-Mora (2003: 226; 2004: 634) proposed and applied an integrated dynamic schedule buffering using an SD model with critical path modelling. And more recently, SD was combined with DES to form a hybrid model developed to address NVAAAs in construction by enhancing managerial decision-making abilities in the construction domain with the overall aim of improving performance in the strategic-operation phase of construction project management (Han, 2008: 91-140; Pena-Mora *et al.*, 2008: 703-707).

All the aforementioned application domains demonstrate the ability of SD methodology to build theory and improve practice in the construction management domain. For instance issues relative to low productivity, error, and interruption that can potentially derail the execution of a construction project regardless of size and location can be modelled through SD. As indicated in Figure 5.2, Han *et al.* (2007: 2084) show that while traditional approaches lack the capability to deal with feedback mechanisms related to errors and changes, an SD based simulation model was able to indicate that NVAAAs in the construction industry may become radically compounded by its interaction with errors and changes. Due to the major advantage of SD in terms of its effectiveness in representing project environment, which includes feedback and delay that explains chains of causality, SD has being recognised as very effective in incorporating management actions in the construction process to the extent that making its adoption at the strategic project management level, an wholesome decision that could set reliable strategic policy to counter difficult operational issues (Han, 2008: 54-55). For that

reason, and being an applied field of research enquiry, it is argued here that SD offers opportunities for addressing numerous construction management related problems with respect to strategic as well as operational management of projects.

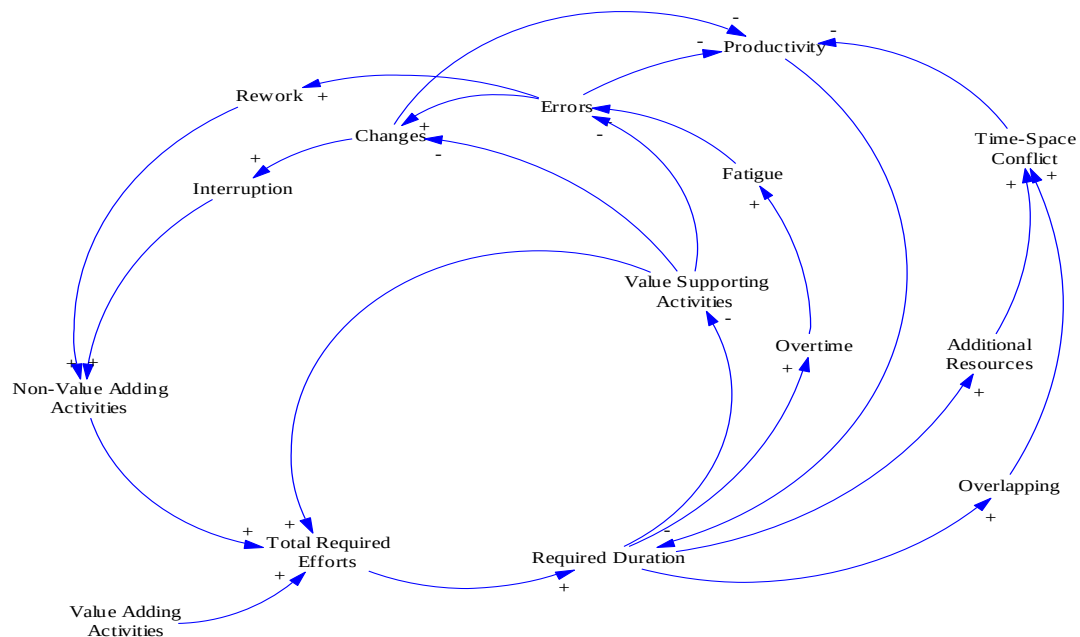


Figure 5.2 Feedback Mechanism Model (Adapted from Han *et al.*, 2007: 2084)

Though the models described in this chapter differ in many ways, they nevertheless illustrate a number of principles for effective development and implementation of SD models. These principles, *inter-alia*, include (Stermann, 2000: 79-81):

- develop a model to solve a particular problem, not to model the system;
- modelling should be integrated into a project from the beginning;
- use other tools and methods as appropriate to complement SD concepts;
- focus on implementation from the start of the project;
- modelling works best as an iterative process of joint inquiry between client and consultant;
- validation is a continuous process of testing and building confidence in the model;
- a broad model boundary is more important than a great deal of detail, and
- implementation does not end with a single project.

## 6.0 THE RESEARCH METHOD

### 6.1 The Data

Often the difference between pure and applied research concerns the questions to be addressed rather than the approach / or approaches to be adopted (Fellows and Liu, 2003: 8). Pure research is usually undertaken to develop knowledge, and to contribute to the body of theory that exists, while applied research seeks to address issues of applications in order to help solve a practical problem with contribution to knowledge as a secondary consideration. In addition, research seeks to solve either closed-ended problems or open-ended problems.

The existence of closed-ended problems, its nature and the variables involved can be identified easily, while open-ended problems tend to be complex, difficult to identify, dynamic, and requires novel solutions. By nature and structure therefore, most problems in the construction management domain could be presumed to be open-ended. The nature of problems encountered in construction management may be responsible for the prevalence of the quantitative approach to empirical research in built environment disciplines. Because of the nature of this study, the quantitative approach, which is a scientific method, is adopted as the need for rigour and objectivity is deemed to be very crucial to the research outcome. As indicated in Table 6.1, the deductive approach is adopted for this research since it allow the use of a theory to develop a preposition / hypothesis, and then design a research framework to test the proposition / hypothesis.

Table 6.1 Differences between deductive and inductive approaches

| <b>Deduction</b>                                                  | <b>Induction</b>                                                               |
|-------------------------------------------------------------------|--------------------------------------------------------------------------------|
| More scientific principles                                        | Gives an understanding of the meanings people attach to various contexts       |
| Move from theory to data                                          | Gives an understanding of the research context                                 |
| Emphasis on quantitative data                                     | Emphasis on qualitative data                                                   |
| A structured approach                                             | A flexible approach which allows a change of emphasis as the project continues |
| The researcher is separate from the process                       | The researcher is part of rather than separate from the research process       |
| Need to generalise results by selecting sample of sufficient size | Less need to generalise results                                                |
| Need to explain causal relationships between variables            |                                                                                |

Most importantly, the choice between deductive and inductive / or a combination of both approaches should be made as it permits a researcher to make an informed decision about the research design; it assists the researcher to think about the choices and research strategies that works best for the researcher; and the knowledge of the different research traditions enable the researcher to cater for potential constraints such as a lack of prior knowledge of the subject (Collins, 2010: 43).

### 6.1.1 Philosophy underpinning the research

Research methodology does not only refer to the methods adopted in a particular research endeavour, but rather it also entails the rationale and philosophical assumptions that support the study. The rationale and philosophical background in turn influence the actual research methods used to investigate problems and to collect, analyse, and interpret data. In other words, research methods cannot be viewed in isolation from the epistemological and ontological position adopted by a researcher (Dainty, 2008: 3). Hence, the term ‘research philosophy’ refers to the development and nature of knowledge (Collins, 2010: 36).

In philosophy, epistemology is principally concerned with theories of knowledge (Knight and Turnbull, 2008: 65) and / or conceptions of reality (Dainty, 2008: 3). This term is derived from the ancient Greek words of *episteme*, which means knowledge, and *logos*, which means account. Knowledge in philosophy thus refers to ‘justified true belief.’ Further, ontology reflects beliefs about what exists and definition of the ways or senses of being (Niglas *et al.*, 2008: 176) and / or is concerned with ‘existence or being’, and what we assume to exist clearly has implications for what we claim to know (Knight and Turnbull, 2008: 66). In addition, Bryman and Bell (2003 cited by Dainty, 2008: 3) contend that objectivist ontology sees social phenomena and their meanings as existing independently of social actions, and constructivist ontology infers that social phenomena are produced through social interaction and then in a constant state of revision. In this context, ontology concerns epistemology and paradigms (a lens through which the world is viewed) (Collins, 2010: 38) and so, relate directly to methodology and, thence, proceed to data collection and analyses that is justifiable through theoretical and pragmatic considerations (Fellows, 2010: 11).

Briefly, epistemology refers to what should be regarded as acceptable knowledge in a discipline, while ontology deals with the existence aspect of the knowledge. Epistemology is the study of the theory of knowledge, including the nature, scope and limitations of it; and ontology is the philosophical study of the nature of being or existence (Collins, 2010: 36). This particular research adopts an objective orientation, which focuses on discovering factual findings in the subject area by emphasizing causality and generalisation. The research is based on modern epistemological and ontological assumptions. The research method is quantitative in nature, and is appropriately in line with the positivist tradition. It conforms to the construction management field that appears to be firmly rooted within the positivist tradition (Dainty, 2008: 10), a tradition that facilitates the application of either pure / or applied research in the built environment.

Collins (2010: 38) suggests that as a philosophy, positivism is in accordance with the empiricist view that knowledge stems from human experience, which portrays the ontological view of the world as comprising discrete, observable elements and events that interact in an observable, determined, and

regular manner. Thus positivism holds that all phenomena should be understood through the employment of a scientific method and aims to create a theoretically neutral language of observation by stripping hypotheses and theories of subjective content as it is deterministic, de-emphasising free will, emotion, chance, choice and morality; and it posits a conceptual division between ‘fact’ and ‘value’, in which only empirically provable ideas basically count as ‘knowledge’ (Collins, 2010: 38).

## **6.2 Primary Data:**

The primary data was obtained through responses from the research participants through the use of structured questionnaires. The investigation was conducted in two phases. The first phase entailed the posting of questionnaires to the identified sample from the targeted population. At this stage, the objective was to obtain an appropriate set of data, which will permit the research to proceed, given the dynamism of research and practical considerations, with outputs reasonably close to the original intentions (Fellows and Liu, 2003: 138). The second phase followed the pattern similar to the first phase; however it differs in its aims and intentions. The data obtained are parameters, and easy to understand statements relative to issues being investigated. The source was primarily limited to records and accounts of past and present construction projects in South Africa.

The primary data collection embraced the mixed-mode research method, which is referred to as the use of more than one quantitative data collection method (de Leeuw and Hox, 2008: 138). This was done in order to reduce non-response error in the survey because when designing a survey the goal is to optimise data collection procedures and reduce total survey error within available time and budget (de Leeuw, 2005: 235-236). The rationale behind different choice of mixed mode survey methods and their effects (Table 6.2) can be safeguarded through careful construction of robust questions detailed in specially designed questionnaires (de Leeuw and Hox, 2008: 147).

The research design is principally governed by the type of evidence that is needed to answer the research questions in a convincing manner based on the research objectives and hypotheses. In other words, the function of a research design is to ensure that the evidence obtained enables us to answer the initial question as unambiguously as possible (de Vaus, 2001: 9). As an illustration, obtaining relevant evidence entails specifying the type of evidence needed to answer the research question, to test a theory / preposition / hypothesis, and to either evaluate a programme or to accurately describe a phenomenon. Using the construction analogy, before an Architect can develop a work plan or a GC can order materials for site use, the type of building, its uses, and possible needs of its occupants must be established through designs and specifications. So it is with the research process as issues of sampling, method of data collection such as questionnaire, and the design of questions are all subsidiary to the matter of ‘what evidence is needed to be collected’ (de Vaus, 2001: 9).

Table 6.2 Types of mixed mode survey systems

| Mixed-mode system                                                                                                                 | Rationale for implementation                                                                                                                                                        | Effect on data quality                                                                                                                                                                                                                            |
|-----------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Contact phase mode change</b>                                                                                                  |                                                                                                                                                                                     |                                                                                                                                                                                                                                                   |
| Advance notification in different mode than data collection                                                                       | <ul style="list-style-type: none"> <li>• Correct sampling frame</li> <li>• Raise response rate</li> <li>• Enhance credibility / trust</li> </ul>                                    | <ul style="list-style-type: none"> <li>• Reduce coverage and non-response error</li> <li>• No threats to measurement if data collection is single-mode</li> </ul>                                                                                 |
| Recruitment / Screening / Selection in different mode than data collection                                                        | <ul style="list-style-type: none"> <li>• Reduce cost</li> <li>• Enhance efficiency</li> <li>• Update / expand contact information for main mode</li> </ul>                          | <ul style="list-style-type: none"> <li>• Timeliness</li> <li>• If pure screening no threats to measurement</li> <li>• If screening plus first part data collection in other mode risk of potential mode effects on measurement</li> </ul>         |
| <b>Response phase mode change</b>                                                                                                 |                                                                                                                                                                                     |                                                                                                                                                                                                                                                   |
| Different (sample) persons by different modes when collecting data from one sample at one time point                              | <ul style="list-style-type: none"> <li>• Reduce costs</li> <li>• Improve coverage</li> <li>• Improve response</li> </ul>                                                            | <ul style="list-style-type: none"> <li>• Reduction of coverage and non response error</li> <li>• Mode effects on measurement confounded with subgroups</li> </ul>                                                                                 |
| Different parts of a data collection method (example questionnaire) by different modes when studying one sample at one time point | <ul style="list-style-type: none"> <li>• Improve privacy of measurement</li> <li>• Reduce social desirability</li> </ul>                                                            | <ul style="list-style-type: none"> <li>• Improved data quality especially with very sensitive questions</li> </ul>                                                                                                                                |
| Sample persons with different modes in same sample at multiple time points                                                        | <ul style="list-style-type: none"> <li>• Reduce cost</li> </ul>                                                                                                                     | <ul style="list-style-type: none"> <li>• Measurement differences causing confounding of time effects and mode effects</li> </ul>                                                                                                                  |
| Different (whole) samples by different modes, often at different times with different data collection methods                     | <ul style="list-style-type: none"> <li>• Comparative research</li> <li>• Different research traditions</li> <li>• Different coverage</li> <li>• Different cost structure</li> </ul> | <ul style="list-style-type: none"> <li>• Coverage error</li> <li>• Non-response error</li> <li>• Measurement error</li> <li>• Incomparability</li> </ul>                                                                                          |
| <b>Follow-up phase mode change</b>                                                                                                |                                                                                                                                                                                     |                                                                                                                                                                                                                                                   |
| Reminders in different modes from mode in which all respondents are asked to complete questionnaire                               | <ul style="list-style-type: none"> <li>• Raise response</li> </ul>                                                                                                                  | <ul style="list-style-type: none"> <li>• Reduce non-response error</li> <li>• If pure reminder no threats to measurements</li> <li>• If reminder plus part data collection in other mode risk of potential mode effects on measurement</li> </ul> |
| <b>Partly based on</b>                                                                                                            | <b>Dillman (2000)</b>                                                                                                                                                               | <b>Balden (2004)</b>                                                                                                                                                                                                                              |

Source: de Leeuw (2005: 238).

### 6.2.1 Sampling

The population of the survey was limited to organisational and / or association databases relative to:

- public sector clients such as National / Provincial / Municipal departments of public work, transport and infrastructure development such as SANRAL;

- consultant / advisors / designers such as consulting engineers, resident engineers and project managers that are members of Consulting Engineers South Africa (CESA), and
- general contractor (GC) members of the South African Federation of Civil Engineering Contractors (SAFCEC) that are registered in the database of the cidb in the civil engineering category.

Sampling in the surveys employed simple random sampling techniques. The random sampling method provides a practical means of enabling the data collection and processing components of research to be carried out while ensuring that the sample provides a fair representation of the population (Fellow and Liu, 2003: 139). The sampling method was used to generate convenient and appropriate sample size for the surveys. Given the increasing number of research projects and relative respondent apathy, collecting data is becoming increasingly difficult. Therefore, the structured questionnaires were presented neatly, politely, and concisely, so as to ensure that the data is not too sensitive and the respondent can also relate to the intentions of the research thereby optimising the collection of the data. For this reason, the research instruments were not unnecessarily lengthy, and they also assured anonymity of the respondents. In addition, efforts were made to identify the relevant or appropriate respondent in each organisation before questionnaires were posted to an organisation.

### **6.3 Secondary Data:**

The secondary data was located in literature. These were factors, parameters, and statements pertinent to the study. Comparison was specifically made with information from the literature and projects in the UK, USA, and Australia that hold significant contributions to the study. The UK, USA and Australia are nations that have embraced concepts associated with project performance improvement in the construction domain for over a decade, and reports emanating from them indicate that substantial performance improvement is possible when appropriate measurable interventions are put in place.

### **6.4 The criteria governing the admissibility of the data:**

In addition to being reliable, measures must also be valid. Reliability concerns the consistency of a measure (Fellows and Liu, 2003: 157). External reliability concerns the consistency of a measure over time while internal reliability concerns whether each scale is measuring a single variable. Validity is a measure of the truthfulness of a measuring instrument. It indicates whether the instrument measures what it claims to measure. The types of validity considered in this research include (de Vaus, 2001: 27-31; Fellows and Liu, 2003: 157):

#### **6.4.1 Content Validity:**

Content validity is the extent to which a measuring instrument covers a representative sample of the domain of behaviours to be measured. A systematic examination of the test content to determine whether it covers a representative sample of the domains of behaviours to be measured assesses content validity. That is, a test with content validity has items that satisfactorily assess the content being investigated.

#### **6.4.2 Criterion Validity**

Criterion validity is the extent to which a measuring instrument accurately predicts behaviours in a given area. The criterion validity to be used is concurrent validity because the test is used to measure present construction performance in South Africa.

#### **6.4.3 Construct Validity**

This is reported to be the most important validity. It is the degree to which a measuring instrument accurately measures a theoretic constant or trait that it is designed to measure. One means of establishing construct validity is through correlation of performance on the test with performance on a test for which construct validity has already been determined. In the case of this research effort, the test shall be compared with performance of the industry in developed countries.

### **6.5 Research Method**

Many research articles / books confuse research designs with methods as it is not uncommon to see research design treated as a mode of data collection rather than as a logical structure of the inquiry (de Vaus, 2001: 9). However, as indicated in previous sections of this chapter, due to the exploratory nature of the research, the research method adopts the use of structured questionnaires after an extensive survey of the literature that explores the changes that are occurring in the construction project management domain, especially with respect to performance improvement. The questionnaires were generated primarily from issues dealing with present procurement practices and project management outcomes. All research instruments were submitted to the promoter for assessment, and necessary modifications made before they were sent out to the respondents.

The content of the questionnaires were such that it related to issues the respondents were familiar with in the course of their professional practice. Specifically, efforts were made to generate five instruments tailor made to the needs of clients, consultants, and contractors. The first phase of the survey used a single instrument for all respondent groups in the pilot and primary surveys, while the second phase used three similarly designed questionnaires for the investigation by taking cognizance of the relevance of each hypothesis to the perceived professional background of respondents. The advantage of this approach is brevity in questions and the avoidance of unduly lengthy instruments, so

as to increase the research response rate. Possible answers were restricted to tick boxes as far as possible, so that respondents would not be discouraged to respond through the need to record lengthy written responses. In brief, the operational steps used for the research method is as indicated in Figure 6.1.

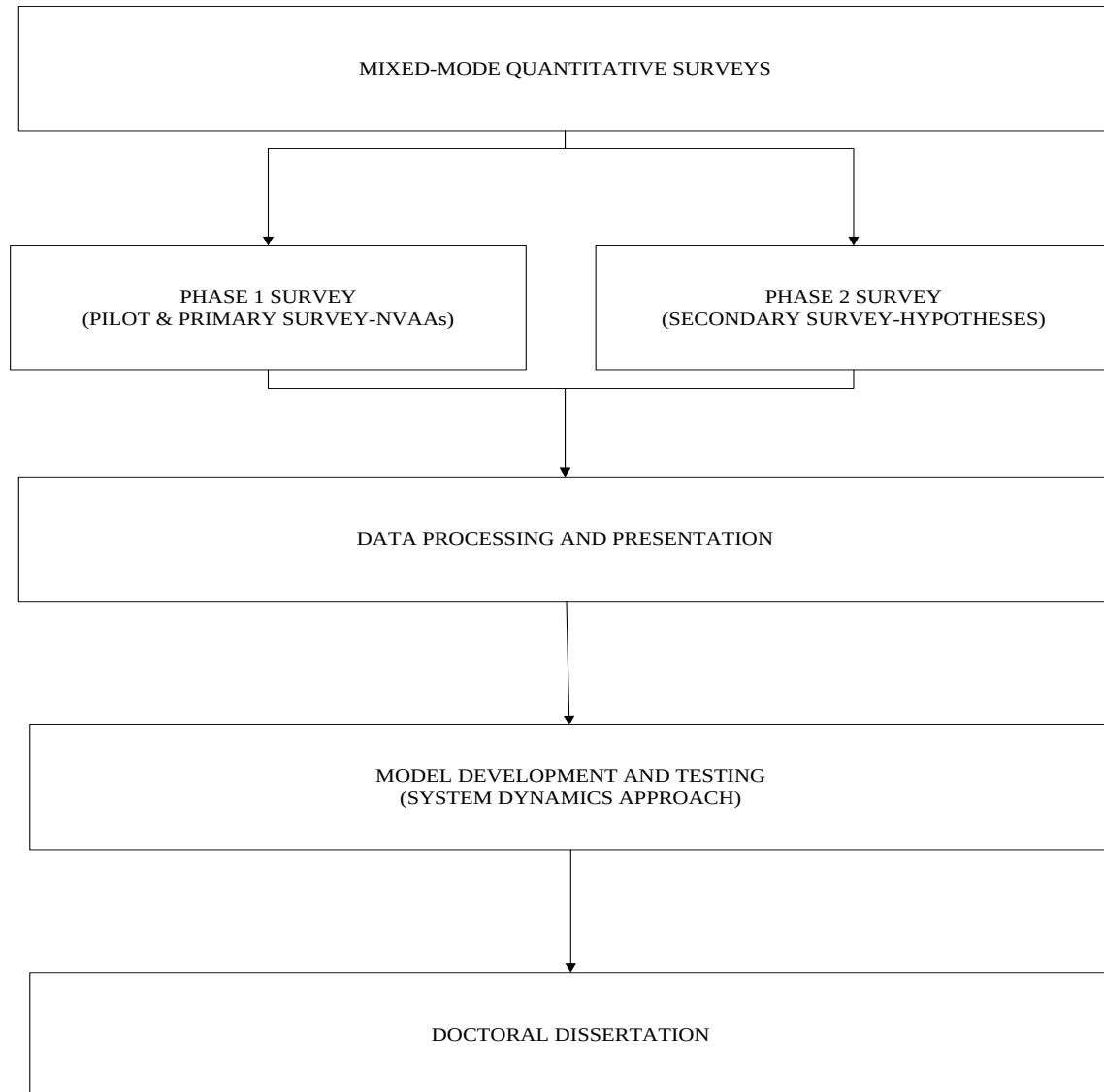


Figure 6.1 Research method operational steps

The descriptive method was used in this research. According to Leedy and Ormond (2005: 179) the descriptive survey method is employed to process the data obtained through observation. They suggest that this type of research involves either identifying the characteristics of an observed phenomenon or exploring possible correlations among two or more phenomena. In every case, descriptive research examines a situation as it is. It does not involve changing or modifying the situation under investigation.

### **6.5.1 Data Collection**

The primary data used in the study was acquired through the administration of structured questionnaires. The administrations of the questionnaires were expedited in two phases as indicated below.

#### **PHASE 1**

Population: Clients, consultants and GCs located through their organisations.

Aim: To gain more insight into the research hypotheses through a pilot survey (1-page questionnaire - Appendix 1). And also to investigate issues relative to the main research problem statement and objectives through the primary survey (5-page questionnaire - Appendix 2).

Period of survey: Pilot survey took approximately 8 weeks (19/05/2010 to 19/07/2010), and the primary survey took approximately 14 weeks (10/08/2010 to 30/11/2010).

#### **PHASE 2**

Population: Clients, consultants and GCs located through their organisations.

Aim: To investigate and test hypotheses through a 3-page questionnaire for client respondent group (Appendix 3), 3-page questionnaire for consultant respondent group (Appendix 4), and 4-page questionnaire for contractor respondent group (Appendix 5).

Period of survey: The survey took approximately 1 week (01/09/2010 to /02/2011).

However, the secondary data used in the research was obtained from journal and conference papers, books, reports, and theses located in libraries and other academic related sources. In particular, the search for information was undertaken principally at the Nelson Mandela Metropolitan University North Campus library, and the computer workstation situated at the Construction Management Department. The following databases were accessed during the literature search:

- EBSCO;
- Emerald Insight online;
- Business periodicals index;
- Social Sciences Index,
- Wiley InterScience, and
- NMMU's own database.

### **6.5.2 The Design of the Questionnaires**

Since the questionnaires were intended to serve as a comprehensive source of data, the questionnaires were designed based on findings emanating from the survey of the related literature. The pilot survey

questions were compiled based on the research sub-problems and hypotheses as indicated in chapter 1. The primary survey in the phase 1 investigation was based on issues relative to NVAAs as indicated in chapter 1 and chapter 4. And the phase 2 investigation was principally drawn from variables relative to the research hypotheses as indicated in chapter 2.

Empirical publications such as Koskela (1992: 34-41); Arbulu (1997: 370); Alwi *et al.* (2002a: 8); Alwi *et al.* (2002b: 7-12); Polat and Ballard (2004: 6-8); Horman and Kenley (2005: 59); Hanna *et al.* (2005: 734-739); Han *et al.* (2007: 2088); Abdel-Razek *et al.* (2007: 196); Ndiokubwayo and Haupt (2008: 94); Hwang *et al.* (2009: 197); Nghona *et al.* (2009: 156); Koskenvesa *et al.* (2010: 484) provided the basis for the questionnaire that was compiled for the primary survey. A total number of forty NVAAs, forty causes of NVAAs and fourteen consequences of NVAAs were identified and used for the empirical study. Given that a number of these publications relied on data generated through quantitative surveys, the postal and e-mail survey method was used for collecting the primary data for the study.

The method was deemed useful as one of the key heuristic principles of lean construction suggests that NVAAs can be reduced through identification, measurement, and redesign (Forbes and Ahmed, 2011:54). In particular, the forty variables relative to NVAAs that contribute to poor project performance were separated into five classifications with eight variables assigned to each category: NVAA categories that occur due to rework, waiting periods, material, movement, and human resources. Similarly, the forty variables relative to causes of NVAAs were separated into five classifications with eight variables assigned to each category: causes of NVAA categories that occur due to human resources, designers, information and documentation, material / equipment, and site operations. The survey questionnaire was designed by asking respondents to identify NVAAs that contribute to poor project performance, construction related activities that lead to NVAAs (causes of NVAAs), and the issues that occur as a result of NVAAs in construction. Respondents were also able to identify NVAAs and their causes using a five-point likert-type scale: (1) Minor extent; (2) Near minor extent; (3) Some extent; (4) Near major extent; (5) Major extent. In order to record the effects on NVAAs in South African construction, respondents were able to express their perceptions using a five-point likert-type scale: (1) Never; (2) Rarely; (3) Sometimes; (4) Often, and (5) Always.

The secondary survey was designed with closed ended questions and one open ended question so that respondents can identify performance impediments, and their effects based on the literature reviewed, and also offer general comments. Respondents were able to identify performance impediments using five scales: (1) Minor extent; (2) Near minor extent; (3) Some extent; (4) Near major extent; (5) Major extent. And in order to score the effects of the impediments, respondents were provided with five scales: (1) Totally disagree; (2) Disagree; (3) Neutral; (4) Agree; (5) Totally agree. In all instances

that the likert-scale type question was used, an ‘unsure’ option was provided for the respondents. In brief, types of categorical data and quantitative data used for the study include ordinal data that were ordered, though the differences between values are not important (for example restaurant ratings); and ratio data that are ordered on a constant scale that has a natural zero (for example age and length) (Easton and McColl, 2004: 1-15).

### 6.5.3 Sample Size

A sample is the subset of the population for whom data exists (Agresti and Franklin, 2007: 10). Therefore, MS Excel software was used to operationalise the adopted systematic random sampling method for the generation of random numbers used for arriving at the sample size indicated in Table 6.3.

Table 6.3 Sample Size Distributions

| Respondent Group      | Phase 1            |                      | Phase 2              |
|-----------------------|--------------------|----------------------|----------------------|
|                       | Pilot Survey (No.) | Primary Survey (No.) | Primary Survey (No.) |
| Public sector clients | 17                 | 122                  | 42                   |
| Members of CESA       | 73                 | 117                  | 55                   |
| Members of SAFCEC     | 34                 | 108                  | 56                   |
| Total                 | 124                | 347                  | 153                  |

## 6.6 The Treatment of the Data

Agresti and Franklin (2007: 11) suggest that descriptive statistics, which is a method for summarizing data in the form of averages, percentages, and graphs, are used for data analysis due to three principal reasons, which include:

- Design, which refers to planning how to obtain data;
- Description, which means exploring and summarizing patterns in data, and
- Inference, which means making decisions or predictions based on the obtained data.

As a result, statistical methods provide ways and means to measure and understand variability. A variable is thus any uniqueness that is recorded for subjects in a study. The data values observed for a variable are referred to as the observations. The analysis of data directly depends on the type of variable observed. In terms of this research, the variables are quantitative in nature and discrete.

### 6.6.1 Numerical (Statistical) Analysis

The Statistica (version 10.0) statistical analysis software package was used by the NMMU Unit for Statistical Support to generate the descriptive and inferential statistics, while the Microsoft Excel Ranking function was used to compute the rank of mean scores recorded in the data analysis. This ranking method enabled the importance of individual statements, problems, and parameters to be

evaluated relative to each other. The ranking was limited to percentage responses to the five-point likert type-scale. The likert-scale questions in the instruments required respondents to indicate their opinions on how strongly they agree or disagree with statements and / or questions, ranging from totally disagree to totally agree with an option to tick the unsure option in case the respondents were not familiar with the questions. In addition, similar likert type-scales were used for questions that elicited response to ranges such as minor to major, never to always, limited to extensive, and poor to excellent.

The  $p$  value, which is the level of significance for the test was 5%. The  $p$  value, which is calculated by presuming that the null hypothesis  $H_0$  is true, is the probability that the test statistics equal the observed value or a value even more extreme (Agresti and Franklin, 2007: 371). In plain English, the  $p$  value is a tail probability beyond the observed test statistics value. In addition, smaller  $p$  values provide stronger evidence against the null hypothesis.

### **6.6.2 Tests for Association**

Association exists between two variables if a particular value for one variable is more likely to occur with certain values of the other variable, that is, when there is an association, the likelihood of a particular value for one variable depends on the value of the other variable (Agresti and Franklin, 2007: 90). The inferential parts of regression use the tools of confidence intervals and significance tests to provide inference about the regression equation and correlation, and  $r^2$  in the population (Agresti and Franklin, 2007: 546). Therefore, the Spearman rank order test was used to test for the nature and extent of association between two variables.

The value of the  $r$  ranges from  $-1$  to  $+1$ , with  $+1$  indicating a perfect positive relationship,  $-1$  indicating a perfect negative relationship, and  $0$  indicating perfect independence. The intent of the exercise is to analyse the strength of association, which reveals whether the association is an important one or rather if the association is statistically significant, weak, or unimportant in practical terms.

### **6.6.3 Independence versus Dependence**

Two categorical variables are independent if the population conditional distributions for one of them are identical at each category of the other, while the variables are dependent or associated if the conditional distributions are not identical (Agresti and Franklin, 2007: 488). In this sense, a variable is any characteristic that is recorded for subjects in a study, and it is called categorical when each observation belongs to one of a set of categories, while it is called quantitative when observations on it take numerical values that represent different magnitudes of the variable (Agresti and Franklin, 2007: 26). Two categorical variables can be classified as either independent or dependent through a significance test. The hypotheses for the test are:

$H_0$ : The two variables are independent, and

$H_1$ : The two variables are dependent (associated).

The test statistics for the test of independence summarizes how close the observed cell counts fall to the expected cell counts. Symbolized by  $X^2$ , it is called the chi-square statistic, taking the name of its sampling distribution. It is the oldest statistics test in use and it was introduced by the British statistician Karl Pearson in 1900 (Agresti and Franklin, 2007: 492).

#### **6.6.4 Research Modelling Process**

Fellows (2010: 11) suggests that within the construction management research domain, 'new paradigms' should concern migration to stochastic perspectives and approaches from determinism; holism and the acceptance of complexity and its accommodation in investigations (of integrated processes and products); and consequently, the rigorous use of methodological pluralism. In other words, in order to ensure continuous improvement, the construction management domain must not be adverse to the adoption of tested and trusted tools in other industries that contend with similar project / production related complexities. It is in recognition of this assumption that the modelling process for this research seeks to attempt the development of a model or models through the SD approach that was developed principally to solve problems related to complexities in industrial environments. This objective is therefore encapsulated in the very words of Sterman (2002: 527), which says "*What prevents us from overcoming policy resistance is not a lack of resources, technical knowledge, or a genuine commitment to change. What thwarts us is our lack of a meaningful system thinking capability. That capability requires, but is much more than, the ability to understand complexity, to understand stocks and flows, feedback, and time delays. It requires, but is much more than, the use of formal models and simulations. It requires an unswerving commitment to the highest standards, the rigorous application of the scientific method, and the inquiry skills we need to expose our hidden assumptions and biases. It requires that we listen with respect and empathy to others. It requires the curiosity to keep asking those "why" questions. It requires the humility we need to learn and the courage we need to lead, though all our maps are wrong. That is the real purpose of system dynamics: To create the future we truly desire-not just in the here and now, but globally and for the long term. Not just for us, but for our children. Not just for our children, but for all the children.*"

In summary, since SD models can be expanded in order to facilitate broader dissemination of existing work (Lyneis and Ford, 2007: 185), this particular research intends to build on existing models that have been applied in the construction project management domain. For practical purposes that are relevant to the South African construction context, qualitative models were developed in order to guide policy formulation.

## 7.0 DATA ANALYSIS

### 7.1 Response to Investigations

Table 7.1 indicates that out of the 124 pilot survey questionnaires posted, 40 were returned at the end of the survey period. Similarly, 88 valid responses were recorded in the primary survey, and 54 valid responses were recorded in the secondary survey. Though most of the uncompleted questionnaires were not accompanied with feedback statements detailing reasons for respondent's inability to participate in the survey, some e-mail conversations however took place between the researcher and some potential respondents.

Table 7.1 Response to Phase 1 and Phase 2 of the survey

| Respondent group      | Phase 1            |                      | Phase 2                |
|-----------------------|--------------------|----------------------|------------------------|
|                       | Pilot Survey (No.) | Primary Survey (No.) | Secondary Survey (No.) |
| Public sector clients | 4                  | 28                   | 11                     |
| Members of CESA       | 24                 | 35                   | 28                     |
| Members of SAFCEC     | 12                 | 25                   | 15                     |
| Total                 | 40                 | 88                   | 54                     |
| Response rate (%)     | 32.3               | 25.4                 | 35.1                   |

For example, a consultant cited the fact that he is a consulting engineer as the reason why he cannot respond. His exact words read: *"As a consulting engineer I am unable to respond meaningfully on most of the questions which apply to site related activities over which I have no control."*

The statement is more of an indictment relative to the competence of civil engineers that are vested with design and project management responsibilities in the form of resident engineers. As if that was not enough, another consultant said: *"It will be a meaningless exercise for me to reply to all those questions. Our company is small and does not have a large enough database."* While this reason may be plausible in other surveys that require data stored in files or archives, it is really not tenable in this instance for the simple reason that all questions asked endeavoured to elicit responses that were domiciled in the intelligence, knowledge, and experiences of respondents. The high point of e-mail conversations was the exchange involving two consultancies with a nationwide spread in terms of practice. The exchanges clearly show differences in perceptions between researchers and respondents especially within the South African construction industry context. For privacy reasons the names of individuals and their organisations were removed from the two extracts below.

#### Extract 1:

Respondent to Researcher: *"Sir, with respect to your insistence that we comply with your request for responses to your survey, it may be wise for you to consider the following:*

*Your detailed survey could be best done by face to face interviews to validate the interpretations of your questions and the veracity of your response data; a brief examination of your questions indicates on the whole that they could best be answered by people in construction firms in the industry; and the lack of response to your requests may have something to do with the manner of your approach to the addressees. Unfortunately I would not be able to give you answers to your questions.”*

Consultant Head Office Director: *“Hi A, I trust you have assisted Mr Z as representative of XYZ despite the concerns expressed about his approach.”*

**Extract 2:**

Respondent to Researcher: *“Dear Mr Z, we refer to your letter dated 10 August 2010. It is our opinion that it is not possible or correct to try to generalise the impact of the activities mentioned. It varies from structure and project to project. As an example, “rework relative to design” may be a 1 on one site, a 5 on another and a 10 on another. Would it not be more practical to select 10 or so projects and then to focus this sort of assessment on those projects? The benefit of such an approach would be that feedback can be interpreted in the light of project particulars, e.g. not enough time allowed for the design phase having negative results in terms of redesign or design refinements being required. The term “non-value adding activities” is not defined. Excess materials on site is not an activity as such, rather non-essential expenditure? But then, you can purchase certain materials in a limited number of shapes or quantities only, automatically resulting in “excess materials on site.” The term “poor project performance in construction”- rather “poor construction performance on site”? it is not the project as such which does not perform well, it is the construction activity which is not optimal.”*

Respondent to Researcher: *“Dear Z, as we stated, we do not think that it is possible to generalise questions and answers dealing with the topics you address. If we would to complete the questionnaire the data will not be scientifically reliable. We suggest that you rethink the data you collect, your methodology and come up with an alternative. The test is always, if I complete the form now, and do it again after 4 weeks, will the answer be more or less the same? In this case I do not think so. If two people in our firm working with the same projects would complete it, would there be any similarity between their answers? Again I do not think so. The comments are meant to help-and we hope that it does help.*

These two extracts demonstrate the challenges embedded in efforts directed towards increasing responses to surveys in South Africa. The first extract detailed the feedback from a regional director of a consulting firm, while the second extract directly relayed the feedback from a national director of another consultancy. The respondents failed to complete the questionnaires despite politely attending to their concerns through e-mails. It is notable that the second respondent is a registered engineer with

a PhD degree. While noting the intent of his e-mails and the value in the comments, it is unfortunate that the respondent failed to acknowledge the existence and benefits of the positivist approach in academic research. Another unusual occurrence is the attempt at redirecting a research enquiry without having the required background in the investigation. In addition, as a registered engineer, the respondent in Extract 1 failed to acknowledge that consulting engineers are mandated to have minimal site experience prior to being professionally registered. Rather the comments painted consultants as designers without basic knowledge about what goes-on on construction site as directly commented by a contractor that responded to the same survey *“When the consultants on site are under qualified or when the consultants use over qualified office staff that is not practical on site, NVAAs pervade construction.”*

## 7.2 Response Rate

Table 7.2 indicates that the overall response rate achieved in the pilot survey, which was limited to Eastern Cape based respondents that are active in the infrastructure sector, is 32.3%. The general assumption made at this stage was that the sub-problems and hypotheses are issues worth investigating in South Africa. So the pilot survey was able to reaffirm the realism of the research, and allowed it to proceed as planned.

Table 7.2 Response rate relative to the pilot survey

| <b>Respondent group</b> | <b>Sample size (No.)</b> | <b>Response (No.)</b> | <b>Response rate (%)</b> |
|-------------------------|--------------------------|-----------------------|--------------------------|
| Public sector clients   | 17                       | 4                     | 23.5                     |
| Members of CESA         | 73                       | 24                    | 32.9                     |
| Members of SAFCEC       | 34                       | 12                    | 35.3                     |
| Total                   | 124                      | 40                    | 32.3                     |

Table 7.3 indicates that an overall response rate of 25.4% was achieved in the primary survey. It is notable that members of CESA responded the most as they are perceived to be involved in public sector projects given the reported scarcity of requisite skills in government departments in South Africa.

Table 7.3 Response rate relative to the primary survey

| <b>Respondent group</b> | <b>Sample size (No.)</b> | <b>Response (No.)</b> | <b>Response rate (%)</b> |
|-------------------------|--------------------------|-----------------------|--------------------------|
| Public sector clients   | 122                      | 28                    | 23.0                     |
| Members of CESA         | 117                      | 35                    | 29.9                     |
| Members of SAFCEC       | 108                      | 25                    | 23.1                     |
| Total                   | 347                      | 88                    | 25.4                     |

Table 7.4 indicates that the overall response rate recorded in the secondary survey is 35.1%. It is notable that consulting engineers responded the most to this survey too - a 50.0% response rate.

Table 7.4 Response rate relative to the secondary survey

| Respondent group      | Sample size (No.) | Response (No.) | Response rate (%) |
|-----------------------|-------------------|----------------|-------------------|
| Public sector clients | 42                | 11             | 26.2              |
| Members of SAFCEC     | 56                | 15             | 26.8              |
| Members of CESA       | 56                | 28             | 50.0              |
| Total                 | 154               | 54             | 35.1              |

### 7.3 Efforts to Improve the Response Rate

A low response rate was anticipated at the inception of the empirical investigations, therefore in order to mitigate this, the respondents were assured of confidentiality of their responses; the covering letters were designed to make unselfish appeals to the respondents; the length of the questionnaires were kept to a minimum; a reminder e-mail was sent after four weeks of sending the initial questionnaires, and reminder e-mails were sent at a week interval thereafter so as to encourage the respondents to complete the survey within the period of investigation. Notable resistance to response rate improvement attempts were recorded in the investigation (Table 7.5). In spite of this resistance, concerted efforts were made to improve the response rate. Timely responses were provided to respondents in need of clarifications and the main surveys were launched and re-launched at convenient intervals. The procedure followed in the data elicitation process is as indicated in Table 7.6 for the pilot, primary, and secondary surveys.

Table 7.5 Recorded resistance to response rate improvement

| Respondent group      | Pilot survey (No.) |              |          | Primary survey (No.) |              |          | Secondary survey (No.) |              |          |
|-----------------------|--------------------|--------------|----------|----------------------|--------------|----------|------------------------|--------------|----------|
|                       | RTS                | Failed email | No email | RTS                  | Failed email | No email | RTS                    | Failed email | No email |
| Public sector clients | 0                  | 3            | 1        | 28                   | 23           | 26       | 1                      | 6            | 8        |
| Members of CESA       | 0                  | 20           | 16       | 10                   | 16           | 2        | 1                      | 0            | 0        |
| Members of SAFCEC     | 0                  | 4            | 0        | 7                    | 14           | 16       | 0                      | 9            | 1        |
| Total                 | 0                  | 27           | 17       | 45                   | 53           | 44       | 2                      | 15           | 9        |

- RTS = Return to sender; No. = Number.

Table 7.6 Data elicitation procedure relative to the investigation

| Research activity                    | Pilot survey (Date) | Primary survey (Date) | Secondary survey (Date) |
|--------------------------------------|---------------------|-----------------------|-------------------------|
| Initial survey launched by post      | 19/05/2010          | 10/08/2010            | 25/10/2010              |
| 1 <sup>st</sup> e-mail reminder sent | 11/06/2010          | 27/08/2010            | 15/11/2010              |
| 2 <sup>nd</sup> e-mail reminder sent | 18/06/2010          | 07/09/2010            | 22/11/2010              |
| 3 <sup>rd</sup> e-mail reminder sent | 28/06/2010          | 15/09/2010            | 29/11/2010              |
| 4 <sup>th</sup> e-mail reminder sent | 12/07/2010          | 22/09/2010            | 06/12/2010              |
| 5 <sup>th</sup> e-mail reminder sent | -                   | 28/09/2010            | 15/12/2010              |
| Survey re-launched by post           | -                   | 01/10/2010            | 17/01/2011              |
| 6 <sup>th</sup> e-mail reminder sent | -                   | 25/10/2010            | 02/02/2011              |

|                                      |   |            |            |
|--------------------------------------|---|------------|------------|
| 7 <sup>th</sup> e-mail reminder sent | - | 01/11/2010 | 11/02/2011 |
| 8 <sup>th</sup> e-mail reminder sent | - | 08/11/2010 | 17/02/2011 |
| 9 <sup>th</sup> e-mail reminder sent | - | -          | 23/02/2011 |

## 7.4 Interpretation of the Results

With the exception of inferential statistics used for testing postulated research hypotheses, the majority of the likert-scale type questions were discussed based on the measurement scale, and where appropriate, percentages were used in the discussions.

Table 7.7 Terms used to discuss percentage ranges

| Range                | Meaning        |
|----------------------|----------------|
| 100%                 | All            |
| $\geq 80\% < 100\%$  | Most           |
| $\geq 66.7\% < 80\%$ | Majority       |
| $> 50\% < 66.7\%$    | More than half |
| 50%                  | Half           |
| $> 33.3\% < 50\%$    | Less than half |
| $\leq 33.3\%$        | Minority       |

The percentage discussions revolved around terms listed in Table 7.7. Given the descriptive nature of the results, the use of hierarchy noted with ordinal data was considered appropriate for presenting the results. The likert-scale type questions were discussed based upon measurement scales indicated in Table 7.8. The discussion conforms to the argument that ordinal data should not be treated as interval data because even though they can be ranked, yet the intervals between values cannot be presumed equal (Jamieson, 2004: 1217).

The terms used for presenting the results are deliberately simple terms in order to enhance understanding and readability of the research statistical findings. All the results therefore are presented in simple terms, that is, all the research findings are made simple with respect to interpretations.

Table 7.8 Terms used to discuss the likert scale of measurement

| Scale | Meaning                                                                                  |
|-------|------------------------------------------------------------------------------------------|
| 5.00  | Major extent; always; extensive; totally agree; definitely; very important; excellent    |
| 4.00  | Near major extent; often; above average; agree; often; more than important; very good    |
| 3.00  | Some extent; sometimes; average; neutral; sometimes; important; good                     |
| 2.00  | Near minor extent; rarely; below average; disagree; rarely; less than important; average |
| 1.00  | Minor extent; never; limited; totally disagree; hardly; not important; poor              |

## 7.5 Results of the Pilot Survey

**Question 1: In general, on a scale of 1 (strongly disagree) to 5 (strongly agree), to what extent do you agree that the following occurrences negatively impact construction project delivery (please note the ‘Unsure’ option)?**

In order to contextualise the results of the pilot survey, Table 7.9 indicates the respondents’ degree of concurrence relative to eight statements pertaining to occurrences negatively impacting project delivery in the South African infrastructure sector in terms of responses to a scale of 1 (strongly disagree) to 5 (strongly agree), and a mean score (MS) ranging between 1.00 and 5.00. It is notable that seven of the eight mean scores are above the midpoint MS of 3.00, which indicates that in general the respondents can be deemed to agree with most of the statements.

Table 7.9 Occurrences negatively impacting construction project delivery

| Occurrence                                                          | Unsure | Response %                        |      |      |      |      | MS   | Rank |
|---------------------------------------------------------------------|--------|-----------------------------------|------|------|------|------|------|------|
|                                                                     |        | Strongly disagree. Strongly agree |      |      |      |      |      |      |
|                                                                     |        | 1                                 | 2    | 3    | 4    | 5    |      |      |
| Lack of infrastructure delivery management skills                   | 0.0    | 2.4                               | 4.8  | 19.0 | 31.0 | 42.9 | 4.07 | 1    |
| Inconsistent & inadequate risk allocation & management practices    | 4.8    | 4.8                               | 11.9 | 21.4 | 26.2 | 31.0 | 3.70 | 2    |
| Poor definition and coordination of process / product quality       | 0.0    | 4.8                               | 14.3 | 16.7 | 35.7 | 28.6 | 3.69 | 3    |
| Inadequate documentation and transfer of knowledge                  | 2.4    | 4.8                               | 9.5  | 26.2 | 35.7 | 21.4 | 3.61 | 4    |
| Inappropriate organizational culture among project partners         | 9.5    | 4.8                               | 9.5  | 31.0 | 21.4 | 23.8 | 3.55 | 5    |
| Inefficient and unreliable logistics management practices           | 9.5    | 0.0                               | 16.7 | 35.7 | 16.7 | 21.4 | 3.47 | 6    |
| Non-integrative H&S practices                                       | 11.9   | 7.1                               | 19.0 | 33.3 | 19.0 | 9.5  | 3.05 | 7    |
| Poor interface between multidisciplinary design teams (consultants) | 2.4    | 11.9                              | 31.0 | 21.4 | 26.2 | 7.1  | 2.85 | 8    |

The hierarchy on the table suggests that the respondents are of the opinion that lack of infrastructure delivery management skills, which is ranked first, may have the greatest negative impact on construction project delivery.

Further, the research reveals that the respondents perceive that poor definition and coordination of process / product quality, inconsistent and inadequate risk allocation and management practices, inappropriate organisational culture among project partners, inadequate documentation and transfer of knowledge as well as inefficient and unreliable logistics management practices are militating against construction project delivery, and by implication infrastructural development in the country.

**Question 2: On a scale of 1 (minor) to 5 (major), to what extent could the following interventions / strategies contribute to an improvement in the delivery of infrastructure projects (please note the ‘unsure’ option)?**

Table 7.10 indicates nine statements pertaining to interventions that can positively impact project delivery in the South African construction sector. It is notable that all the nine MSs are above the midpoint score of 3.00, which indicates that in general the respondents can be deemed to agree with all the statements.

Table 7.10 Interventions / Strategies positively impacting construction project delivery

| Intervention / Strategy                                              | Unsure | Response %        |      |      |      |      | MS   | Rank |
|----------------------------------------------------------------------|--------|-------------------|------|------|------|------|------|------|
|                                                                      |        | Minor ..... Major |      |      |      |      |      |      |
|                                                                      |        | 1                 | 2    | 3    | 4    | 5    |      |      |
| Continuous development of human resources                            | 0.0    | 2.4               | 2.4  | 14.3 | 38.1 | 42.9 | 4.17 | 1    |
| Knowledge sharing and management                                     | 0.0    | 2.4               | 4.8  | 23.8 | 33.3 | 35.7 | 3.95 | 2    |
| Implementation of TQM collectively among project partners            | 12.5   | 2.5               | 2.5  | 25.0 | 37.5 | 20.0 | 3.80 | 3    |
| Innovative management of construction logistics                      | 0.0    | 4.8               | 7.1  | 19.0 | 47.6 | 21.4 | 3.74 | 4    |
| Holistic implementation of practices inherent in lean construction   | 26.8   | 0.0               | 9.8  | 19.5 | 29.3 | 14.6 | 3.67 | 5    |
| Adoption and utilization of principles of concurrent engineering     | 14.6   | 2.4               | 4.9  | 36.6 | 24.4 | 17.1 | 3.57 | 6    |
| Elimination of organizational resistance to change                   | 7.3    | 7.3               | 14.6 | 22.0 | 17.1 | 31.7 | 3.55 | 7    |
| Open and integrative approach to H&S, quality, environment, and cost | 4.8    | 4.8               | 9.5  | 28.6 | 35.7 | 16.7 | 3.53 | 8    |
| Robust deployment of ICT tools and techniques                        | 4.9    | 2.4               | 19.5 | 39.0 | 19.5 | 14.6 | 3.26 | 9    |

It is notable that continuous development of human resources achieved the highest MS in the table. This is an indication of the greatest challenge undermining project delivery and infrastructure development in South Africa in recent times. While short term solutions are possible, in the long run, it is both formal and informal education that connects with current realities that may assure continuous supply of skilled construction professionals and artisans. Consequentially, these results suggest that the postulated hypotheses may enable the research to progress as initially intended.

**Question 3: Do you have any comments in general regarding the improvement of the construction supply chain?**

Table 7.11 Comments in general relative to improvement of the construction supply chain

| Comments (No.) | Response (%) |
|----------------|--------------|
| 0              | 45.0         |
| 1              | 40.0         |
| 2              | 12.5         |
| 8              | 2.5          |

In general, though 40% (Table 7.11) of the respondents made 1 comment, most of the comments amplified issues relative to shortage of skills as indicated in Table 7.12. Another issue that featured in the respondents' general comments is relative to contract award. Quite a number of respondents mentioned shortcomings such as prolonged waiting period between tender submission and award, award of contracts based on criteria that exclude quality, and poor documentation issues (Table 7.12). They say all these shortcomings lead to anomalies such as increased project prices, poor planning of construction, and corruption in the industry.

Other industry issues highlighted include the need to increase investment relative to R&D in the industry, elimination of delay relative to payment for work done, and issues relative to demand for construction services. The respondents to the pilot survey commented on burning issues in construction related media such as *Construction World*. This suggests that there is major scope for improving performance in the South African construction industry.

It is notable that the pilot survey indicates that a major issue at stake is the shortage of skills in the industry. Also, the occurrence of these issues is perceived to constitute barriers to project delivery by the survey respondents. So the research findings provided a platform for further literature review and subsequent empirical investigations. Based on the research findings, an empirical survey based on NVAAs and their impact on construction project performance was conducted within the South African infrastructure construction sector with the overall intent of realising the research aims and objectives.

Table 7.12 Classification of general comments relative to the pilot survey

| Problem | Comment                                                                                                                                                                                                                                                                                                                                                                |
|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Skills  | 1. Little or no capacity at all levels of government starting at the municipal level. Government must stop making political appointments and rather employ people with the correct skills.                                                                                                                                                                             |
|         | 2. Motivation of government specifically at provincial level.                                                                                                                                                                                                                                                                                                          |
|         | 3. Continuous training, less BEE procurement without the correct experience and knowledge.                                                                                                                                                                                                                                                                             |
|         | 4. The single largest stumbling block, which affects plus or minus 40 – 60% of project delivery, is lack of clients' ability to manage projects i.e. district & local municipalities lack capacity.                                                                                                                                                                    |
|         | 5. Yes, the old system of work creates work for consultants especially for clients with low skills base.                                                                                                                                                                                                                                                               |
|         | 6. Need to employ skilled persons in the construction trade                                                                                                                                                                                                                                                                                                            |
|         | 7. My opinion is that poor construction project delivery is the result of contractors appointed without required skills. Clients force BEE through projects.                                                                                                                                                                                                           |
|         | 8. 40 Consultants recently submitted tenders for the construction of roads in the township R20m project. Fee - / + R1.5M expanded public works project. 30 of us could've been working on infrastructure delivery projects. This is an indication that the consultants do not have work. Hence, the problem lies with government-lack of skills to implement projects. |
|         | 9. The undermining of engineering skills in the country and political interference in the administration of engineers slow service delivery substantially.                                                                                                                                                                                                             |
|         | 10. The average BEE contractor has very little knowledge of the contract, minimal cash flow,                                                                                                                                                                                                                                                                           |

|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                 | <p>and a lack of skilled resources instead of being awarded small contracts, they are being awarded large projects that they cannot handle, which in turn lead to bankruptcy or termination or both.</p> <ol style="list-style-type: none"> <li>11. The cidb gradings granted to these fledgling companies are totally unrealistic.</li> <li>12. Consulting companies often rely on unregistered technicians to sign off designs &amp; drawings. A minimum amount of effort is put into the preparation of design reports leading to uneconomical designs.</li> <li>13. The client bodies have virtually no technical capacity and are unable to quantify whether designs are appropriate.</li> <li>14. The standard of technical training is falling even the BTech students are complaining that some of the lecturers are unsure of their subject matter.</li> <li>15. The emphasis on producing technicians has led to a surplus of poorly equipped students for which there are few jobs. The country would be better equipped by reviving an artisan development programme producing bricklayers, carpenters, plasterers, pipelayers etc.</li> <li>16. Government supply chain practices very resource scarce e.g. skills hungry especially tenders for consultants.</li> <li>17. Department of housing needs big help please we have to do something.</li> <li>18. The problem lies with inexperience from the client and awarding contracts to inappropriate contractors.</li> </ol> |
| Procurement     | <ol style="list-style-type: none"> <li>1. Implementing a reduction in lag time between quoting / tendering to awarding of contract to overcome various barriers e.g. increased prices, corruption, and poor planning.</li> <li>2. In terms of tendering / procurement of professional services to monitor construction – national treasury demands price vs quality dictates. Leads to “buying of work” by proxy at expense of quality.</li> <li>3. The interpretation of supply chain rules and laws differ substantially from one client to the other with the result that there is great confusion of what is right and what is wrong as far as the appointment of contractors or consultants are concerned.</li> <li>4. Problems are mainly up to the award of tender stage. Once awarded provided the contractor is competent (correct cidb grading), the project is rounded out.</li> <li>5. Consultants and clients should focus more on improving the quality of tender documentation (including tender notices) that they produce. Poor specifications and scoping are the cause of many delayed or in-completed projects.</li> <li>6. Very poor understanding of the bid adjudication committees on what skills + resources are needed to complete a contract is leading to inappropriate appointment of contractors leading to disastrous results.</li> </ol>                                                                                                                     |
| Industry issues | <ol style="list-style-type: none"> <li>1. Continuous workflow from client will improve situation. High and low peaks damage efficiency.</li> <li>2. More time and money should be spent on R&amp;D.</li> <li>3. H&amp;S plan approvals must be linked to commencement date as defined in October 2004 of tender stage.</li> <li>4. Slow payments from the clients are having a disastrous effect on the viability of the industry as a whole.</li> <li>5. Better understanding of the construction industry by the supply chain practitioners would ensure better delivery of projects.</li> <li>6. Contracts with suppliers for facility management – local manufacturers to be created.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

## 7.6 Results of the Primary Survey

As indicated earlier, the aim of this phase of the research process is to identify NVAAAs in South African construction, causes of these NVAAAs, and their impact on the construction process. Therefore, questions relative to project performance were predominately used in this particular survey.

**Question 1: On a scale of 1 (minor) to 5 (major), to what extent do the following non-value adding activities contribute to poor project performance in construction (please note the ‘unsure’ option)?**

The questions asked in this questionnaire that was circulated to clients, consultants, and contractors that are active in the South African infrastructure sector, elicited responses that enabled the achievement of the research objectives. All the questions were evolved based on previous research publications relative to NVAAs and project performance improvement in construction as expanded upon in chapter 4 of this dissertation. Table 7.13 and Table 7.14 indicate the respondents’ perceptions relative to statements pertaining to the contributions of NVAAs to poor project performance in construction as well as the causes of these NVAAs in terms of responses to a scale of 1 (minor) to 5 (major), and a MS ranging between 1.00 and 5.00.

In Table 7.13, it is notable that 23 of the 40 MSs are above the midpoint score of 3.00, which indicates that in general the respondents can be deemed to perceive that the 23 NVAAs contribute more of a major than a minor extent to poor project performance in South African construction.

It is notable that all the MSs associated with human resources related NVAAs are above the midpoint of 3.00, which indicate that in general, these NVAAs may be deemed to contribute significantly to poor project performance in South African construction. These findings reemphasised the shortage of skills dilemma marginalising South African construction. As indicated in chapter 4, NVAAs affect construction performance in different geographical locations. However, country and industry environmental factors seem to suggest that what constitute the most worrisome set of NVAAs in a particular country may not be the same in another. In this context, human resources related NVAAs seems to dominate South African construction.

Nevertheless, Table 7.13 presents the NVAAs based on their categorised mode of occurrence (rework; waiting periods; material; movement; human resources). In the category of rework, rework relative to design, structural works, foundation works, and finishing works are perceived by the respondents to be contributing majorly to poor performance in South African construction. However, the respondents are of the opinion that the contributions of rework relative to formwork, mechanical works, electrical works, and services to poor project performance in South African construction could be minor. In the category of waiting periods, it is notable that not all the MSs are > 3.00. This suggests that the respondents are of the opinion that waiting for materials, waiting for instruction / information, and waiting for critical tasks to be finished contribute significantly to poor performance. This is then followed by the contributions of NVAAs related to waiting for equipment, waiting for specialists to arrive, waiting for labour to arrive, waiting for work space / platform, and waiting for inspections.

Table 7.13 Extent to which NVAAs contribute to poor project performance in South Africa

| NVAA                                        | Response % |                 |      |      |      |      | MS   | Rank |
|---------------------------------------------|------------|-----------------|------|------|------|------|------|------|
|                                             | Unsure     | Minor.....Major |      |      |      |      |      |      |
|                                             |            | 1               | 2    | 3    | 4    | 5    |      |      |
| Rework relative to:                         |            |                 |      |      |      |      |      |      |
| • Design                                    | 1.1        | 13.6            | 11.4 | 15.9 | 23.9 | 34.1 | 3.54 | 1    |
| • Foundation works                          | 5.7        | 8.0             | 21.6 | 18.2 | 18.2 | 28.4 | 3.40 | 2    |
| • Structural works                          | 8.0        | 10.2            | 12.5 | 26.1 | 21.6 | 21.6 | 3.35 | 3    |
| • Finishing works                           | 9.2        | 9.2             | 14.9 | 24.1 | 21.8 | 20.7 | 3.33 | 4    |
| • Formwork                                  | 9.1        | 11.4            | 25.0 | 26.1 | 13.6 | 14.8 | 2.95 | 5    |
| • Electrical works e.g. conduit             | 17.2       | 10.3            | 25.3 | 24.1 | 12.6 | 10.3 | 2.85 | 6    |
| • Service-for example plumbing works        | 10.3       | 9.2             | 27.6 | 32.2 | 10.3 | 10.3 | 2.83 | 7    |
| • Mechanical works e.g. a/c                 | 17.2       | 8.0             | 26.4 | 29.9 | 9.2  | 9.2  | 2.82 | 8    |
| Waiting periods:                            |            |                 |      |      |      |      |      |      |
| • Waiting for critical tasks to be finished | 1.1        | 6.8             | 13.6 | 19.3 | 26.1 | 33.0 | 3.66 | 1    |
| • Waiting for materials                     | 0.0        | 3.4             | 19.3 | 19.3 | 29.5 | 28.4 | 3.60 | 2    |
| • Waiting for instruction / information     | 0.0        | 6.8             | 17.0 | 20.5 | 21.6 | 34.1 | 3.59 | 3    |
| • Waiting for equipment                     | 2.3        | 5.7             | 27.3 | 21.6 | 23.9 | 19.3 | 3.24 | 4    |
| • Waiting for specialist to arrive          | 3.4        | 13.8            | 17.2 | 27.6 | 17.2 | 20.7 | 3.14 | 5    |
| • Waiting for labour to arrive              | 3.4        | 13.6            | 25.0 | 20.5 | 23.9 | 13.6 | 2.99 | 6    |
| • Waiting for work space / platform         | 6.8        | 12.5            | 21.6 | 27.3 | 19.3 | 12.5 | 2.98 | 7    |
| • Waiting for inspections                   | 1.1        | 10.2            | 30.7 | 29.5 | 14.8 | 13.6 | 2.91 | 8    |
| Material:                                   |            |                 |      |      |      |      |      |      |
| • Non-conformance to specification          | 1.1        | 3.4             | 15.9 | 17.0 | 38.6 | 23.9 | 3.64 | 1    |
| • Defective materials on site               | 3.4        | 11.4            | 21.6 | 25.0 | 19.3 | 19.3 | 3.14 | 2    |
| • Loss of materials on site                 | 1.1        | 9.1             | 28.4 | 33.0 | 19.3 | 9.1  | 2.91 | 3    |
| • Unnecessary material handling             | 4.5        | 14.8            | 25.0 | 34.1 | 15.9 | 5.7  | 2.71 | 4    |
| • Waste of raw materials on site            | 2.3        | 19.3            | 27.3 | 30.7 | 11.4 | 9.1  | 2.63 | 5    |
| • Deterioration of materials on site        | 3.4        | 22.7            | 21.6 | 33.0 | 13.6 | 5.7  | 2.56 | 6    |
| • Excess materials on site                  | 4.5        | 14.8            | 47.7 | 23.9 | 5.7  | 3.4  | 2.32 | 7    |
| • Excessive inspection of materials         | 8.0        | 34.1            | 15.9 | 25.0 | 14.8 | 2.3  | 2.30 | 8    |
| Movement:                                   |            |                 |      |      |      |      |      |      |
| • Poor coordination of resources            | 2.3        | 5.7             | 15.9 | 25.0 | 33.0 | 18.2 | 3.43 | 1    |
| • Poor sequencing of tasks                  | 4.5        | 4.5             | 19.3 | 26.1 | 27.3 | 18.2 | 3.37 | 2    |
| • Unreliable / defective equipment          | 1.1        | 11.4            | 19.3 | 26.1 | 26.1 | 15.9 | 3.16 | 3    |
| • Inappropriate positioning of cranes       | 20.7       | 17.2            | 6.9  | 21.8 | 23.0 | 10.3 | 3.03 | 4    |
| • Poor ergonomics and injuries              | 15.9       | 15.9            | 15.9 | 19.3 | 21.6 | 11.4 | 2.96 | 5    |
| • Poor equipment movement                   | 5.7        | 12.6            | 20.7 | 31.0 | 24.1 | 5.7  | 2.89 | 6    |
| • Poor vehicle / truck movement             | 8.0        | 10.2            | 22.7 | 35.2 | 21.6 | 2.3  | 2.81 | 7    |
| • Unnecessary repetitive handling of tools  | 18.2       | 12.5            | 20.5 | 34.1 | 12.5 | 2.3  | 2.65 | 8    |
| Human Resources:                            |            |                 |      |      |      |      |      |      |
| • Lack of required competencies             | 0.0        | 2.3             | 8.0  | 18.4 | 31.0 | 40.2 | 3.99 | 1    |
| • Inadequate supervision                    | 0.0        | 0.0             | 10.3 | 21.8 | 32.2 | 35.6 | 3.93 | 2    |
| • Human error / mistake                     | 3.4        | 4.6             | 16.1 | 26.4 | 29.9 | 19.5 | 3.45 | 3    |
| • Ignorance                                 | 1.1        | 6.9             | 20.7 | 21.8 | 28.7 | 20.7 | 3.36 | 4    |
| • Strikes                                   | 3.5        | 16.3            | 18.6 | 15.1 | 15.1 | 31.4 | 3.28 | 5    |
| • Low employee morale                       | 1.1        | 11.5            | 10.3 | 35.6 | 27.6 | 13.8 | 3.22 | 6    |
| • Idleness on site                          | 2.3        | 9.2             | 21.8 | 31.0 | 19.5 | 16.1 | 3.12 | 7    |
| • Unnecessary work                          | 4.6        | 4.6             | 27.6 | 27.6 | 24.1 | 11.5 | 3.11 | 8    |

These NVAAs have constituted significant barriers to performance as documented in papers presented in the annual conference of the IGLC.

In the category of material, it is notable that only 2 MSs are > 3.00. Therefore, it can be assumed that the respondents perceive that non-conformance to specification contributes the most to poor performance in this category. This is distantly followed by defective materials on site related NVAAs. However, NVAAs related to loss of materials on site, unnecessary material handling, waste of raw materials on site, deterioration of materials on site, excess materials on site and excessive inspection of materials contribute more of a minor as opposed to a major extent to poor project performance in South African construction. In the category of movement, it is notable that poor coordination of resources, poor sequencing of tasks, unreliable / defective equipment, and inappropriate positioning of cranes related NVAAs are considered by the respondents to be contributing majorly to poor project performance. Meanwhile, the findings suggest that poor ergonomics and injuries, poor equipment movement, poor vehicle / truck movement, and unnecessary repetitive handling of tools related NVAAs constructions to poor performance can be deemed to be less than major. In addition, in the category of human resources, it is notable that the category does not only record the highest overall MS (3.99) in the table, it also has all the MSs in the category > 3.00. This suggests that lack of required competencies, inadequate supervision, and human error / mistake related NVAAs are considered to be contributing the most to poor project performance. The contributions of strikes, low employee morale, idleness on site, unnecessary work, and ignorance related NVAAs to poor project performance in South African construction can also be considered to be major.

**Question 2: On a scale of 1 (minor) to 5 (major), to what extent do the following result in non-value adding activities in construction (please note the ‘unsure’ option)?**

In Table 7.14, it is notable that 31 of the 40 MSs are above the midpoint score of 3.00, which indicates that in general more than 70% of the respondents can be deemed to perceive that the causes of NVAAs contribute more of a major than a minor extent to NVAAs in South African construction.

It is notable that MSs relative to site operations as well as information and documentation related causes of NVAAs are above the midpoint of 3.00, which indicates that in general, the likelihood of these causes contributing to NVAAs may be significant in South African construction. These findings seem to suggest that site related activities in South African construction may be susceptible to the detrimental effects of NVAAs. As indicated in chapter 4, the causes of NVAAs that limit construction performance are not project / tasks / geographically limited.

In addition, while only 3 MSs are above the midpoint of 3.00 among the causes of NVAAs relative to materials / equipment, 6 MSs are above the midpoint of 3.00 among causes of NVAAs relative to human resources and designers. These suggest that whereas the causes of NVAAs relative to materials

/ equipment are not so major, attention must be given to causes of NVAAs relative to human resources and designers. In particular, given the results tabulated in Table 7.15, from a multi-stakeholder perspective, human resources related issues are in need of proper attention. Notably, all NVAAs and causes of NVAAs that are above the midpoint of 3.00 in Table 7.13 and Table 7.14 should be given attention in order to improve project performance in the South African construction industry.

In the category of human resources, it is notable that although the category recorded the overall highest MS in the table (3.85), 2 MSs are however less than the midpoint score of 3.00. The hierarchy in the category suggests that the respondents perceive that lack of appropriately skilled workers, lack of leadership abilities, and poor decision-making abilities to be contributing the most to the occurrence of NVAAs in South African construction. This is followed by the lack of cooperation among workers, scarcity of workers, poor team spirit among workers, low morale among workers, and lack of empowerment related NVAAs. In the category of designer (consultants), the rankings suggest that the respondents perceive that delay in design approval, poor interaction among designers, repetitive revisions and changes, bureaucracy, and slow response to RFI (request for information), and design not requested by clients can be considered to be significant causes of NVAAs in South African construction. However, over design, and excessive control and inspection can be deemed to be minor causes of NVAAs in South African construction.

In the category of information and documentation, it is notable that though all the causes of NVAAs in the category can be considered significant, late dissemination of information, error in material specifications, incomplete drawings / designs, unrealistic project execution plan, unclear design / details constitute causes that contribute the most. In the category of materials / equipment, it is notable that only 2 MSs are > 3.00. This indicates that with the exception of scarcity of equipment, and over / under ordering of materials, the other causes can be deemed to be minor. That is, delays in material transportation, inappropriate use of equipment, scarcity of materials, error in material specifications, and poor waste management practices and removal of unspecified material can be deemed to be minor causes of NVAAs in South African construction.

In the category of site operations, it is notable that all the MSs are > 3.00. This suggests that the respondents can be deemed to perceive that poor planning of construction, inadequate design information, and inappropriate construction methods can be considered the most significant causes in the category. The rankings further show that external influence on operations, accidents due to poor H&S, inadequate material control, poor site layout, and inadequate staging areas / platforms can be deemed to be major causes of NVAAs in South African construction.

Table 7.14 Extent to which causes contribute to NVAAAs in South Africa

| Cause of NVAAAs | Response % |                 |   |   |   |   | MS | Rank |
|-----------------|------------|-----------------|---|---|---|---|----|------|
|                 | Unsure     | Minor.....Major |   |   |   |   |    |      |
|                 |            | 1               | 2 | 3 | 4 | 5 |    |      |

|                                         |      |      |      |      |      |      |      |   |
|-----------------------------------------|------|------|------|------|------|------|------|---|
| Human Resources:                        |      |      |      |      |      |      |      |   |
| • Lack of appropriately skilled workers | 1.2  | 4.7  | 9.3  | 19.8 | 27.9 | 37.2 | 3.85 | 1 |
| • Lack of leadership abilities          | 0.0  | 2.3  | 14.9 | 29.9 | 35.6 | 17.2 | 3.51 | 2 |
| • Poor decision-making abilities        | 0.0  | 4.6  | 13.8 | 34.5 | 26.4 | 20.7 | 3.45 | 3 |
| • Lack of cooperation among workers     | 3.4  | 8.0  | 22.7 | 33.0 | 21.6 | 11.4 | 3.06 | 4 |
| • Scarcity of workers                   | 2.3  | 12.5 | 19.3 | 31.8 | 18.2 | 15.9 | 3.06 | 5 |
| • Poor team spirit among workers        | 3.4  | 9.1  | 21.6 | 30.7 | 28.4 | 6.8  | 3.02 | 6 |
| • Low morale among workers              | 2.3  | 11.5 | 21.8 | 33.3 | 20.7 | 10.3 | 2.96 | 7 |
| • Lack of empowerment                   | 4.5  | 14.8 | 28.4 | 29.5 | 18.2 | 4.5  | 2.68 | 8 |
| Designer (Consultants):                 |      |      |      |      |      |      |      |   |
| • Repetitive revisions and changes      | 1.2  | 5.8  | 14.0 | 14.0 | 25.6 | 39.5 | 3.80 | 1 |
| • Delay in design approval              | 1.2  | 8.1  | 11.6 | 15.1 | 27.9 | 36.0 | 3.73 | 2 |
| • Poor interaction                      | 2.3  | 3.5  | 17.4 | 20.9 | 29.1 | 26.7 | 3.60 | 3 |
| • Bureaucracy                           | 2.3  | 8.0  | 17.2 | 18.4 | 25.3 | 28.7 | 3.51 | 4 |
| • Slow response to RFI                  | 15.3 | 9.4  | 7.1  | 23.5 | 24.7 | 20.0 | 3.46 | 5 |
| • Design not requested by client        | 13.8 | 10.3 | 23.0 | 26.4 | 9.2  | 17.2 | 3.00 | 6 |
| • Over design                           | 3.4  | 12.6 | 27.6 | 26.4 | 17.2 | 12.6 | 2.89 | 7 |
| • Excessive control & inspection        | 2.3  | 20.7 | 21.8 | 34.5 | 12.6 | 8.0  | 2.65 | 8 |
| Information and documentation:          |      |      |      |      |      |      |      |   |
| • Late dissemination of information     | 1.1  | 5.7  | 11.5 | 19.5 | 40.2 | 21.8 | 3.62 | 1 |
| • Incomplete drawings / designs         | 0.0  | 9.2  | 13.8 | 17.2 | 29.9 | 29.9 | 3.57 | 2 |
| • Error in material specifications      | 1.1  | 11.5 | 14.9 | 14.9 | 28.7 | 28.7 | 3.49 | 3 |
| • Unclear design / details              | 1.1  | 6.9  | 13.8 | 24.1 | 34.5 | 19.5 | 3.47 | 4 |
| • Unrealistic project execution plan    | 1.2  | 10.5 | 12.8 | 23.3 | 26.7 | 25.6 | 3.45 | 5 |
| • Contradictions in design documents    | 2.3  | 12.6 | 12.6 | 20.7 | 29.9 | 21.8 | 3.36 | 6 |
| • Design revisions                      | 1.1  | 8.0  | 18.4 | 32.2 | 25.3 | 14.9 | 3.21 | 7 |
| • Poor document control system          | 2.3  | 9.2  | 17.2 | 34.5 | 24.1 | 12.6 | 3.14 | 8 |
| Materials / Equipment:                  |      |      |      |      |      |      |      |   |
| • Scarcity of materials                 | 10.2 | 8.0  | 15.9 | 27.3 | 22.7 | 15.9 | 3.25 | 1 |
| • Error in material specifications      | 6.9  | 11.5 | 14.9 | 23.0 | 32.2 | 11.5 | 3.19 | 2 |
| • Delays in material transportation     | 4.5  | 12.5 | 22.7 | 23.9 | 25.0 | 11.4 | 3.00 | 3 |
| • Scarcity of equipment                 | 6.8  | 13.6 | 19.3 | 27.3 | 20.5 | 12.5 | 2.99 | 4 |
| • Over / Under ordering materials       | 5.7  | 10.2 | 23.9 | 29.5 | 22.7 | 8.0  | 2.94 | 5 |
| • Inappropriate use of equipment        | 5.7  | 12.5 | 25.0 | 31.8 | 18.2 | 6.8  | 2.81 | 6 |
| • Poor waste management practices       | 9.1  | 18.2 | 27.3 | 30.7 | 11.4 | 3.4  | 2.50 | 7 |
| • Removal of unspecified material       | 10.2 | 19.3 | 26.1 | 31.8 | 6.8  | 5.7  | 2.48 | 8 |
| Site operations:                        |      |      |      |      |      |      |      |   |
| • Poor planning of construction         | 1.1  | 4.5  | 12.5 | 21.6 | 33.0 | 27.3 | 3.67 | 1 |
| • Inadequate design information         | 1.1  | 9.1  | 14.8 | 23.9 | 25.0 | 26.1 | 3.45 | 2 |
| • Inappropriate construction methods    | 1.1  | 4.5  | 17.0 | 30.7 | 27.3 | 19.3 | 3.40 | 3 |
| • Accidents due to poor H&S             | 2.3  | 12.5 | 20.5 | 20.5 | 21.6 | 22.7 | 3.22 | 4 |
| • External influence on operations      | 13.6 | 5.7  | 15.9 | 33.0 | 18.2 | 13.6 | 3.21 | 5 |
| • Inadequate materials control          | 2.3  | 6.8  | 18.2 | 33.0 | 34.1 | 5.7  | 3.14 | 6 |
| • Poor site layout                      | 5.7  | 6.9  | 20.7 | 33.3 | 26.4 | 6.9  | 3.06 | 7 |
| • Inadequate staging areas / platforms  | 11.4 | 8.0  | 20.5 | 29.5 | 23.9 | 6.8  | 3.01 | 8 |

Therefore, these results (Table 7.13 and Table 7.14) seem to suggest that in order to reduce poor performance arising from NVAAs in South African construction, almost all the aforementioned causes of NVAAs must be adequately addressed.

**Question 3: In general, on a scale of 1 (never) to 5 (always), to what extent do the following practices / issues occur as a result of non-value adding activities in construction (please note the ‘unsure’ option)?**

Table 7.15 indicates the respondents’ perceptions of the frequency at which consequences of NVAAs occur in terms of responses to a scale of 1 (never) to 5 (always), and a MS ranging between 1.00 and 5.00. It is notable that 11 of the 14 MSs are above the midpoint of 3.00, which indicates that in general the respondents can be deemed to perceive that the majority of the practices / issues occur as a result of NVAAs in South African construction.

The findings suggest that 43.3% of the respondents perceive that time overruns occur often; while 27.3% perceive that time overruns occur always in South African construction. In terms of cost overruns, 40.9% of the respondents perceive that it occur often, while 27.3% are of the opinion that it occur always. In other words, time overruns and cost overruns occurrence due to NVAAs range between often and always in South African construction. Looking at the results, it emerges that time overruns, cost overruns, and variations / claims that are ranked 1<sup>st</sup>, 2<sup>nd</sup>, and 3<sup>rd</sup> respectively seems to occur frequently in South Africa.

Table 7.15 Frequency at which the consequences of NVAAs occur in South African construction

| Practice / Issue                   | Response % |                    |      |      |      |      | MS   | Rank |
|------------------------------------|------------|--------------------|------|------|------|------|------|------|
|                                    | Unsure     | Never ..... Always |      |      |      |      |      |      |
|                                    |            | 1                  | 2    | 3    | 4    | 5    |      |      |
| Time overruns                      | 4.5        | 1.1                | 8.0  | 15.9 | 43.2 | 27.3 | 3.92 | 1    |
| Cost overruns                      | 4.5        | 1.1                | 12.5 | 23.9 | 40.9 | 17.0 | 3.63 | 2    |
| Variations / Claims                | 0.0        | 2.3                | 17.0 | 29.5 | 33.0 | 18.2 | 3.48 | 3    |
| Reduced productivity               | 2.3        | 2.3                | 18.2 | 30.7 | 31.8 | 14.8 | 3.40 | 4    |
| Client dissatisfaction             | 3.4        | 6.8                | 21.6 | 19.3 | 29.5 | 19.3 | 3.34 | 5    |
| Non-conformances                   | 3.4        | 2.3                | 26.4 | 26.4 | 33.3 | 8.0  | 3.19 | 6    |
| Interruptions to activity sequence | 3.4        | 0.0                | 23.9 | 35.2 | 33.0 | 4.5  | 3.19 | 7    |
| Clash / Overlapping of activities  | 6.8        | 2.3                | 17.0 | 40.9 | 27.3 | 5.7  | 3.18 | 8    |
| Overtime                           | 8.0        | 4.5                | 23.9 | 25.0 | 28.4 | 10.2 | 3.17 | 9    |
| Additional resource allocation     | 3.4        | 8.0                | 17.0 | 36.4 | 26.1 | 9.1  | 3.12 | 10   |
| Time-space conflict                | 13.8       | 4.6                | 17.2 | 37.9 | 20.7 | 5.7  | 3.07 | 11   |
| Incidents and accidents            | 4.5        | 13.6               | 27.3 | 21.6 | 22.7 | 10.2 | 2.88 | 12   |
| Fatigue                            | 8.0        | 9.1                | 23.9 | 34.1 | 21.6 | 3.4  | 2.85 | 13   |
| Damage to the environment          | 5.7        | 11.4               | 29.5 | 31.8 | 14.8 | 6.8  | 2.75 | 14   |

The hierarchy in the table suggest that because of NVAAs in South African construction, the likelihood of occurrence of reduced productivity, client dissatisfaction, non-conformances,

interruptions / disruptions to activity sequence, clash / overlapping of activities, overtime, additional resource allocation, time-space conflict is higher than that of incidents and accidents, fatigue, and damage to the environment. Consequently, priority should be given to issues that lead to time overruns, cost overruns, and variations in South African construction.

**Question 4: On a scale of 1 (limited) to 5 (extensive), how would you rate the impact of wasteful construction processes / or non-value adding activities on the following parameters (please note the ‘unsure’ option)?**

Table 7.16 indicates the respondents’ perceptions of the extent to which NVAAs impact on performance relative to the project parameters in South Africa in terms of responses to a scale of 1 (limited) to 5 (extensive), and a MS ranging between 1.00 and 5.00. Most significantly, time, cost, quality, and H&S are ranked 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup> respectively with respect to the impact of NVAAs (Table 7.16). It is notable that ‘time’ with the MS of 4.07 is not only ranked 1<sup>st</sup> in Table 7.16, but time overruns is also ranked 1<sup>st</sup> in Table 7.15.

According to this result, the respondents can be deemed to perceive the impact of NVAAs on time, cost, quality, and H&S performance as extensive, as opposed to limited. With extensive ratings of 36.4% for time, 29.5% for cost, 19.5% for quality, 9.1% for H&S, and 6.8% for environment, it can be concluded that the respondents are of the opinion that time is mostly impacted by NVAAs in South Africa. Therefore, the impact of NVAAs on performance relative to these parameters, and most especially that of time should be closely monitored.

Table 7.16 Extent to which NVAAs impact project performance parameters in South Africa

| Parameter               | Response % |                        |      |      |      |      | MS   | Rank |
|-------------------------|------------|------------------------|------|------|------|------|------|------|
|                         | Unsure     | Limited .....Extensive |      |      |      |      |      |      |
|                         |            | 1                      | 2    | 3    | 4    | 5    |      |      |
| Time                    | 2.3        | 1.1                    | 5.7  | 14.8 | 39.8 | 36.4 | 4.07 | 1    |
| Cost                    | 1.1        | 4.5                    | 8.0  | 22.7 | 34.1 | 29.5 | 3.77 | 2    |
| Quality                 | 1.1        | 6.8                    | 10.2 | 14.8 | 47.7 | 19.3 | 3.63 | 3    |
| Health and safety (H&S) | 2.3        | 9.1                    | 20.5 | 23.9 | 35.2 | 9.1  | 3.15 | 4    |
| Environment             | 3.4        | 6.8                    | 23.9 | 37.5 | 21.6 | 6.8  | 2.98 | 5    |

**Question 5: On a scale of 1 (limited) to 5 (extensive), rate your knowledge of non-value adding activities in the South African construction industry (please note the ‘unsure’ option)?**

Table 7.17 to 7.19 indicates the respondents’ perceptions relative to three NVAA related aspects of the South African construction industry in terms of percentage responses to a scale of 1 (limited) to 5 (extensive), and a MS ranging between 1.00 and 5.00. Table 7.17 indicates that in general, respondents can be deemed to be aware of NVAAs in South African construction. The table indicates that 39.5% of the respondents rate their knowledge of NVAAs in South African construction to be

average; 32.6% rate their knowledge to be above average; while only 4.7% rate their knowledge to be extensive. Therefore, the majority of the respondents can be considered to have an average knowledge of NVAAs in South Africa construction.

Table 7.17 Rating of knowledge of NVAAs in South African construction

| Unsure | Response %    |      |      |      |           | MS   |
|--------|---------------|------|------|------|-----------|------|
|        | Limited ..... |      |      |      | Extensive |      |
|        | 1             | 2    | 3    | 4    | 5         |      |
| 4.7    | 2.3           | 16.3 | 39.5 | 32.6 | 4.7       | 3.22 |

**Question 6: On a scale of 1 (limited) to 5 (extensive), rate your encounter with non-value adding activities in the South African construction industry (please note the ‘unsure’ option)?**

Table 7.18 suggests that in general, respondents can be deemed to have encountered NVAAs in South African construction. 34.5% rate their encounter with NVAAs as average; another 34.5% further rate their encounter to be above average; while only 9.2% rate their encounter as extensive. In effect, the majority of the respondents are of the opinion that their encounter with NVAAs in the South African construction industry is not extensive.

Table 7.18 Rating of encounter with NVAAs in South African construction

| Unsure | Response %    |     |      |      |           | MS   |
|--------|---------------|-----|------|------|-----------|------|
|        | Limited ..... |     |      |      | Extensive |      |
|        | 1             | 2   | 3    | 4    | 5         |      |
| 8.0    | 4.6           | 9.2 | 34.5 | 34.5 | 9.2       | 3.38 |

**Question 7: On a scale of 1 (limited) to 5 (extensive), rate South African construction in terms of frequency of wasteful / non-value adding activities in the construction process (please note the ‘unsure’ option)?**

Table 7.19 suggests that in general, the majority of the respondents can be deemed to perceive that the frequency of NVAAs in South African construction to be between average and above average. While only 5.9% are of the opinion that the frequency of NVAAs in South African construction can be deemed to be extensive, 32.9% and 29.4% perceive that the frequency can be deemed to be average and above average respectively.

Table 7.19 Frequency of NVAAs in South African construction

|  | Response % |         |       |           |      | MS   |
|--|------------|---------|-------|-----------|------|------|
|  | Unsure     | Limited | ..... | Extensive |      |      |
|  |            | 1       | 2     | 3         | 4    | 5    |
|  | 14.1       | 1.2     | 16.5  | 32.9      | 29.4 | 5.9  |
|  |            |         |       |           |      | 3.26 |

**Question 8: On a scale of 1 (poor) to 5 (excellent), how would you rate performance relative to the following parameters in South African construction (please note the ‘unsure’ option)?**

Table 7.20 indicates the respondents’ rating of the performance of South African construction relative to five parameters in terms of responses to a scale of 1 (poor) to 5 (excellent), and a MS ranging between 1.00 and 5.00. It is notable that with the exception of environment, all listed project performance parameters achieved MSs above the midpoint of 3.00. This indicates that in general, the respondents can be deemed to rate the performance between average and above average. Therefore, the result is not at variance with prior research outputs that have continued to call for improvements in project performance in the sector. Coincidentally or rather, yet again, time with a MS of 3.21 is not performing optimally as indicated in the table.

Table 7.20 Rating of the performance of the South African construction industry

| Parameter               | Response % |      |       |           |      | MS  | Rank |
|-------------------------|------------|------|-------|-----------|------|-----|------|
|                         | Unsure     | Poor | ..... | Excellent |      |     |      |
|                         |            | 1    | 2     | 3         | 4    | 5   |      |
| Cost                    | 5.7        | 2.3  | 12.5  | 43.2      | 31.8 | 4.5 | 3.25 |
| Quality                 | 4.5        | 2.3  | 18.2  | 37.5      | 31.8 | 5.7 | 3.21 |
| Time                    | 4.5        | 4.5  | 18.2  | 34.1      | 29.5 | 9.1 | 3.21 |
| Health and safety (H&S) | 5.7        | 3.4  | 18.2  | 40.9      | 27.3 | 4.5 | 3.12 |
| Environment             | 5.7        | 6.8  | 22.7  | 43.2      | 18.2 | 3.4 | 2.88 |

**Question 9: On a scale of 1 (minor) to 5 (major), to what extent do the following perspectives / practices / interventions contribute to the achievement of value or rather suppress non-value adding activities in construction (please note the ‘unsure’ option)?**

Table 7.21 indicates the respondents’ view of the extent to which enablers could reduce NVAAs in South African construction in terms of responses to a scale of 1 (minor) to 5 (major), and a MS ranging between 1.00 and 5.00. It is notable that all the perspectives / practices / interventions are above the midpoint of 3.00. This suggests that the respondents are of the opinion that the perspectives / practices / interventions could reduce NVAAs in South African construction.

However, total quality management of all processes, adequate documentation and transfer of knowledge, and good organisational culture among project partners recorded higher ratings than other perspectives. Reliable and efficient logistics management practices, robust open information sharing among the project team, reduction of time spent on NVAAs, continuous human resources

development, and others were also considered to be major management strategies that could reduce NVAAs, and improve performance in South African construction. Given that the enablers could reduce NVAAs in construction, the respondents can be deemed to advocate ‘lean’ either directly, or indirectly. This is even more imperative because one of the survey’s respondents rightly opined that *“non-value adding activities should be minimised to ensure project success in South African construction.”*

Table 7.21 Extent to which enablers could reduce NVAAs in South African construction

| Perspective / Practice / Intervention               | Response % |                 |      |      |      |      | MS   | Rank |
|-----------------------------------------------------|------------|-----------------|------|------|------|------|------|------|
|                                                     | Unsure     | Minor.....Major |      |      |      |      |      |      |
|                                                     |            | 1               | 2    | 3    | 4    | 5    |      |      |
| Total Quality Management of all processes           | 3.4        | 1.1             | 3.4  | 20.7 | 44.8 | 26.4 | 3.95 | 1    |
| Adequate documentation and transfer of knowledge    | 5.7        | 1.1             | 4.5  | 21.6 | 39.8 | 27.3 | 3.93 | 2    |
| Good organisational culture among project partners  | 5.7        | 2.3             | 6.8  | 14.8 | 44.3 | 26.1 | 3.90 | 3    |
| Reliable & efficient logistics management practices | 6.8        | 0.0             | 8.0  | 19.3 | 46.6 | 19.3 | 3.83 | 4    |
| Robust open information sharing among project team  | 4.5        | 1.1             | 10.2 | 22.7 | 36.4 | 25.0 | 3.77 | 5    |
| Reduce time spent on non-value adding activities    | 13.6       | 3.4             | 5.7  | 28.4 | 23.9 | 25.0 | 3.71 | 6    |
| Continuous human resources development              | 3.4        | 1.1             | 11.4 | 26.1 | 39.8 | 18.2 | 3.65 | 7    |
| Reduce the need for non-value adding activities     | 13.6       | 3.4             | 9.1  | 28.4 | 22.7 | 22.7 | 3.61 | 8    |
| Appropriate allocation of project risk              | 4.6        | 3.4             | 10.3 | 33.3 | 32.2 | 16.1 | 3.49 | 9    |
| Integrative H&S management practices                | 9.1        | 3.4             | 12.5 | 30.7 | 30.7 | 13.6 | 3.43 | 10   |

**Question 10: Please indicate the type of ongoing / past infrastructural projects undertaken in your organisation – please state the approximate percentage contributions?**

Table 7.22 indicates the types of projects that the survey respondents have undertaken in their respective organisations. The results suggest that the majority of the respondents have participated in transport (70.1%), water (69.3%), and other non-residential construction projects (75.0%). Though only a minority have participated in power projects (23.0%), it is safe to assume that the respondents have participated in the South African infrastructure sector. Hence, their perceptions of the ills and possible remedies applicable to the sector and the entire industry as a whole can be deemed valuable. It is also important to note that when respondents acknowledge their participation in these project types, transport related projects have the highest percentage contributions (50.0%).

Table 7.22 Types of project undertaken by respondents

| <b>Project category</b>              | <b>Response (%)</b> | <b>Mean (%)</b> |
|--------------------------------------|---------------------|-----------------|
| Transport (roads, port, harbour )    | 70.1                | 50.0            |
| Power (dam, gas, coal)               | 23.0                | 29.2            |
| Water (storm water, treatment plant) | 69.3                | 33.9            |
| Other non-residential construction   | 75.0                | 45.2            |

Of the respondents that have undertaken power projects, on average these power projects contribute approximately 29.2% of their organisational project portfolio. Respondents that have undertaken water related projects state that they constitute approximately 33.9% of their organisational project portfolio. The group of respondents that indicated that they have undertaken other non-residential types of construction projects also indicated that these projects constitute approximately 45.2% of their organisational project portfolio.

**Question 11: Please indicate the kind of organisation you work for?**

As indicated in Table 7.23, consultants were the largest response group (39.8%), followed by clients (31.8%), and contractors (28.4%).

Table 7.23 Category of respondents to the primary survey

| <b>Respondent (%)</b> |                   |                   |              |
|-----------------------|-------------------|-------------------|--------------|
| <b>Client</b>         | <b>Consultant</b> | <b>Contractor</b> | <b>Total</b> |
| 31.8                  | 39.8              | 28.4              | 100.0        |

Given that the response rates were not so distant from each other; the question of inappropriate skewness of the results is within allowable tolerance.

**Question 12: Do you have any comments in general regarding the impact of non-value adding activities in South African construction?**

Table 7.24 indicates that the majority of the respondents did not make general comments, while only 20.0% of the respondents made 1 comment. In general, the minority made general comments which are categorised in Table 7.25.

Table 7.24 General comments relative to NVAAs in South African construction

| <b>Comment (No.)</b> | <b>Response %</b> |
|----------------------|-------------------|
| 0                    | 69.3              |
| 1                    | 20.5              |
| 2                    | 8.0               |
| 3                    | 2.3               |

Even among the minority that commented, issues relative to shortage of skills as indicated in Table 7.25 dominated among the comments. Though, the survey respondents' knowledge of, encounter

with, and perceived frequency of NVAAs in the South African infrastructure construction sector may be deemed moderate or average, the mere acknowledgement of the existence of these NVAAs and their detrimental effects is a cause for concern. Another issue of concern is that of time overruns, which in turn may be influenced by the impact of NVAAs on project time as indicated in the research findings. Detrimental effects of notable NVAAs such as inadequate supervision, rework relative to design, lack of required competencies, and non-conformance to specifications are also issues of concern with respect to project performance improvement in South African construction.

While recognising the perceptions of the survey respondents in terms of possible interventions that can eliminate the consequences of NVAAs in the form of time overruns, variations / claims, and cost overruns, it is herein suggested that the removal or reduction of notable causes of NVAAs such as delay in design approval and lack of appropriately skilled workers provides a platform for reducing the frequency of NVAAs in the construction process. In other words, regardless of the remedial strategy adopted in a quest to remove NVAAs in construction, an attempt without elements of ‘leanness’ may not yield the desired results.

Table 7.25 Classification of general comments relative to the primary survey

| Problem | Comment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Skills  | <ol style="list-style-type: none"> <li>1. Most emerging contractors do not have artisan and management training. The intention is to earn lots of money quickly (this is possible). However, their loss is due to personal lack of knowledge and skills in construction, having to rely on others to get a job done and thereby “robbed”.</li> <li>2. Most of the non-value items become more important on big construction sites (buildings, bridges, tunnels and major water and sewer projects. My own experience in the last 20 years was mainly on water and sanitation projects and O&amp;M.</li> <li>3. Too many political and non practical people (e.g. academia) interfere, which results in frustration, cost and time delay. All try to do the right thing, but it ends up in accusations and unhappiness all around.</li> <li>4. I am very interested in becoming a construction manager professional.</li> <li>5. If clients &amp; designers do not plan effectively, then redesign work impacts the complete construction process.</li> <li>6. No skilled labourers in our industry-by shortage of the above are required (we need to learn from the UK practices).</li> <li>7. Lack of capacity in client organisations contributes significantly to non-value adding activities.</li> <li>8. HR Management: low productivity of labour force; lack of skills i.e. skilled labour is a scarce commodity; lack of commitment; lack of job pride; low standard of workmanship results in come-backs; “first-time-right” approach is non-existent; client delay in decision making often is the one single item with the biggest impact on time, cost, and quality. Inexperience of consulting engineers in practical execution of designs is a growing factor.</li> <li>9. Being a consultant it is difficult to comment on behalf of contractors.</li> <li>10. The BBBEE contractors who are awarded contracts beyond their means, experience + financial capability are costing clients a great deal in terms of effective + affordable service delivery.</li> <li>11. When the consultants on site are under qualified or when the consultant use over qualified office staff that is not practical on site.</li> <li>12. Too many chiefs and not enough Indians.</li> </ol> |

|                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                             | 13. Clients in government sector, generally waste time in making decisions in the best interest of the project. Thus impacting on cost & schedule.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Procurement                 | <ol style="list-style-type: none"> <li>1. Poor selection of implementing agencies by government departments such as the IDT (cause unnecessary delay &amp; inaction in decision making process).</li> <li>2. Current requirements for designers to tender results in “cost effective” design process, which in turn results in increased construction costs. If design = 10% total cost &amp; construction = 90%. And 10% reduction in design cost = 20% increase in construction cost. Therefore overall project cost = 9% +108% = 117%.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Industry issues             | <ol style="list-style-type: none"> <li>1. The supply chain for goods and services are far too long. Projects are rarely completed in a financial year. Availability and quality of materials for projects are poor. Service providers should supply on time.</li> <li>2. H&amp;S is a very important component, however in some instances this is excessive and leads to time wastage, which is passed onto the client.</li> <li>3. Some of the questions above are a bit obscure. I believe there is a good deal of wasted time and cost on the average SA construction site. Often chain labour requirements mean that new labour is hired &amp; trained on every project rather than stable construction industry labour resources.</li> <li>4. Health &amp; safety is costing the client too much. Policing of the contractor by external companies adds unnecessary cost. Contractors should be able to enforce safety in his own company and relevant checks could be done by the engineer.</li> </ol>                  |
| Non-value adding activities | <ol style="list-style-type: none"> <li>1. I cannot really comment since as a highly visible public sector client body, we have to comply with the legislation in place, so reduction of the non-value activities listed in the survey is not an option.</li> <li>2. Time is money – we have neither to waste.</li> <li>3. Non-value adding activities should be minimized to ensure project success.</li> <li>4. It is imperative that a module be established to eliminate non-value adding activities as much as necessary so as to ensure unscheduled spending and ensure the production of attractive and efficient product.</li> <li>5. Non-value adding activities in SA construction are a product of poor project management.</li> <li>6. Non-value activities to be listed and publicised in order to inform construction industry to be aware of such activities in order to avoid or eliminate them.</li> <li>7. Non-value adding activities can be detrimental to any project if not managed properly.</li> </ol> |

Table 7.26 presents the overall ranking of NVAAs in South African construction with particular reference to the infrastructure sector. Table 7.26 and Table 7.27 are mainly important because of the need to create awareness relative to NVAAs in the industry. In Table 7.26, out of the 9 NVAAs above 3.40, lack of required competencies is ranked 1<sup>st</sup>.

The finding is underscored by previous research that has addressed issues relative to skills shortages. This NVAA is closely related to the other 8 NVAAs that are above 3.40. For instance, a measure of competence is required for adequacy of supervision, avoidance of rework, reduction of human error / mistake, and the coordination of resources. The 28 NVAAs that fall within the range  $> 2.60 \leq 3.40$  are equally deserving of required attention as they can potentially derail the smooth progress of construction projects. For example, defective materials on site or unreliable equipment on site may slow down the execution of critical tasks on site and in turn affect the overall project schedule with the attendant cost implications. Rework in any form poses significant challenges in terms of quality and H&S often lead to unforeseen consequences. Therefore, these 28 NVAAs should be given the attention they deserve in order to avoid poor project performance in South African construction.

These examples justify documented research findings that assert that NVAAs are the major reason behind schedule delays, cost overruns, and poor construction productivity (Horman and Kenley, 2005: 59; Han *et al.*, 2007: 2088; Alwi *et al.*, 2002b: 7-12; Abdel-Razek *et al.*, 2007: 196; Hanna *et al.*, 2005: 734-739). Even within the South African construction, the prevalence of NVAAs is reportedly increasing the amount of variations / claims recorded in projects (Ndiokubwayo and Haupt, 2008: 94). The need to address these NVAAs is thus imperative in South African construction that is contending with performance related issues.

In addition, Table 7.27 indicates the causes of NVAAs in the South African infrastructure construction sector. Out of the 15 causes of NVAAs that are above 3.40, lack of appropriately skilled workers is ranked 1<sup>st</sup>. The obvious implications for this particular result is that availability of skills may be closely related to the NVAA, lack of required competencies that is ranked 1<sup>st</sup> in Table 7.26. Repetitive revisions and changes, poor interaction, incomplete drawings / designs, error in material specifications, unclear design / details, slow response to RFI, late dissemination of information, and inadequate design information are causes of NVAAs with severe cost and schedule implications that are predominately under the influence of designers / consultants. Whereas, delay in design approval and bureaucracy may be attributed to lapses in client organisations, while poor planning of construction, lack of leadership abilities, poor decision-making abilities, and unrealistic project execution plan are causes of NVAAs directly related to contractors site operational efforts. Therefore, the causes of NVAAs ranked 1<sup>st</sup> to 15<sup>th</sup> in Table 7.27 are associated with the responsibilities of clients, designers, and contractors, which suggest that their reduction / elimination depend on the entire construction supply chain as against a single party in the construction process.

Furthermore, the 16 causes of NVAAs that are above 3.00, but below 3.40 should be equally addressed as their existence exposes a project to the possibility of poor performance. For instance, inappropriate construction methods may lead to rework, and then affect the morale of workers through fatigue and stress, which in turn, may propagate poor performance in the construction process. The same analogy applies to the other 22 causes of NVAAs in various forms. Given the importance of the aforesaid, it is therefore paramount for project stakeholders to engage in project performance improvement initiatives that involved the entire construction supply chain members. Nevertheless, the matrix relative to all the questions asked in the primary survey is indicated in Table 7.28 as a guide for analysing the performance related issues. The table clearly amplifies the intent of this phase of the empirical study with the use of 40 variables relative to NVAAs, 40 variables relative to the causes of NVAAs, and 14 variables relative to the consequences of NVAAs for the investigation. Overall, a total of 123 variables were used for the primary survey that eventually enabled investigations relative to the research objectives to proceed unhindered.

Table 7.26 Non-value adding activities in South African construction

| NVAA                                             | Response % |                 |      |      |      |      | MS   | Rank |
|--------------------------------------------------|------------|-----------------|------|------|------|------|------|------|
|                                                  | Unsure     | Minor.....Major |      |      |      |      |      |      |
|                                                  |            | 1               | 2    | 3    | 4    | 5    |      |      |
| Lack of required competencies                    | 0.0        | 2.3             | 8.0  | 18.4 | 31.0 | 40.2 | 3.99 | 1    |
| Inadequate supervision                           | 0.0        | 0.0             | 10.3 | 21.8 | 32.2 | 35.6 | 3.93 | 2    |
| Waiting for critical tasks to be finished        | 1.1        | 6.8             | 13.6 | 19.3 | 26.1 | 33.0 | 3.66 | 3    |
| Non-conformance of materials to specification    | 1.1        | 3.4             | 15.9 | 17.0 | 38.6 | 23.9 | 3.64 | 4    |
| Waiting for materials                            | 0.0        | 3.4             | 19.3 | 19.3 | 29.5 | 28.4 | 3.60 | 5    |
| Waiting for instruction / information            | 0.0        | 6.8             | 17.0 | 20.5 | 21.6 | 34.1 | 3.59 | 6    |
| Rework relative to design                        | 1.1        | 13.6            | 11.4 | 15.9 | 23.9 | 34.1 | 3.54 | 7    |
| Human error / mistake                            | 3.4        | 4.6             | 16.1 | 26.4 | 29.9 | 19.5 | 3.45 | 8    |
| Poor coordination of resources                   | 2.3        | 5.7             | 15.9 | 25.0 | 33.0 | 18.2 | 3.43 | 9    |
| Rework relative to foundation works              | 5.7        | 8.0             | 21.6 | 18.2 | 18.2 | 28.4 | 3.40 | 10   |
| Poor sequencing of tasks                         | 4.5        | 4.5             | 19.3 | 26.1 | 27.3 | 18.2 | 3.37 | 11   |
| Ignorance                                        | 1.1        | 6.9             | 20.7 | 21.8 | 28.7 | 20.7 | 3.36 | 12   |
| Rework relative to structural works              | 8.0        | 10.2            | 12.5 | 26.1 | 21.6 | 21.6 | 3.35 | 13   |
| Rework relative to finishing works               | 9.2        | 9.2             | 14.9 | 24.1 | 21.8 | 20.7 | 3.33 | 14   |
| Strikes                                          | 3.5        | 16.3            | 18.6 | 15.1 | 15.1 | 31.4 | 3.28 | 15   |
| Waiting for equipment                            | 2.3        | 5.7             | 27.3 | 21.6 | 23.9 | 19.3 | 3.24 | 16   |
| Low employee morale                              | 1.1        | 11.5            | 10.3 | 35.6 | 27.6 | 13.8 | 3.22 | 17   |
| Unreliable / defective equipment                 | 1.1        | 11.4            | 19.3 | 26.1 | 26.1 | 15.9 | 3.16 | 18   |
| Waiting for specialist to arrive                 | 3.4        | 13.8            | 17.2 | 27.6 | 17.2 | 20.7 | 3.14 | 19   |
| Defective materials on site                      | 3.4        | 11.4            | 21.6 | 25.0 | 19.3 | 19.3 | 3.14 | 20   |
| Idleness on site                                 | 2.3        | 9.2             | 21.8 | 31.0 | 19.5 | 16.1 | 3.12 | 21   |
| Unnecessary work                                 | 4.6        | 4.6             | 27.6 | 27.6 | 24.1 | 11.5 | 3.11 | 22   |
| Inappropriate positioning of cranes              | 20.7       | 17.2            | 6.9  | 21.8 | 23.0 | 10.3 | 3.03 | 23   |
| Waiting for labour to arrive                     | 3.4        | 13.6            | 25.0 | 20.5 | 23.9 | 13.6 | 2.99 | 24   |
| Waiting for work space / platform                | 6.8        | 12.5            | 21.6 | 27.3 | 19.3 | 12.5 | 2.98 | 25   |
| Poor ergonomics and injuries                     | 15.9       | 15.9            | 15.9 | 19.3 | 21.6 | 11.4 | 2.96 | 26   |
| Rework relative to formwork                      | 9.1        | 11.4            | 25.0 | 26.1 | 13.6 | 14.8 | 2.95 | 27   |
| Loss of materials on site                        | 1.1        | 9.1             | 28.4 | 33.0 | 19.3 | 9.1  | 2.91 | 28   |
| Waiting for inspections                          | 1.1        | 10.2            | 30.7 | 29.5 | 14.8 | 13.6 | 2.91 | 29   |
| Poor equipment movement                          | 5.7        | 12.6            | 20.7 | 31.0 | 24.1 | 5.7  | 2.89 | 30   |
| Rework relative to electrical works e.g. conduit | 17.2       | 10.3            | 25.3 | 24.1 | 12.6 | 10.3 | 2.85 | 31   |
| Rework relative to services e.g. plumbing works  | 10.3       | 9.2             | 27.6 | 32.2 | 10.3 | 10.3 | 2.83 | 32   |
| Rework relative to mechanical works e.g. a/c     | 17.2       | 8.0             | 26.4 | 29.9 | 9.2  | 9.2  | 2.82 | 33   |
| Poor vehicle / truck movement                    | 8.0        | 10.2            | 22.7 | 35.2 | 21.6 | 2.3  | 2.81 | 34   |
| Unnecessary material handling                    | 4.5        | 14.8            | 25.0 | 34.1 | 15.9 | 5.7  | 2.71 | 35   |
| Unnecessary repetitive handling of tools         | 18.2       | 12.5            | 20.5 | 34.1 | 12.5 | 2.3  | 2.65 | 36   |
| Waste of raw materials on site                   | 2.3        | 19.3            | 27.3 | 30.7 | 11.4 | 9.1  | 2.63 | 37   |
| Deterioration of materials on site               | 3.4        | 22.7            | 21.6 | 33.0 | 13.6 | 5.7  | 2.56 | 38   |
| Excess materials on site                         | 4.5        | 14.8            | 47.7 | 23.9 | 5.7  | 3.4  | 2.32 | 39   |
| Excessive inspection of materials                | 8.0        | 34.1            | 15.9 | 25.0 | 14.8 | 2.3  | 2.30 | 40   |

Table 7.27 Causes of non-value adding activities in South African construction

| Cause of NVAAs                        | Response % |                 |      |      |      | MS   | Rank |    |
|---------------------------------------|------------|-----------------|------|------|------|------|------|----|
|                                       | Unsure     | Minor.....Major |      |      |      |      |      |    |
|                                       |            | 1               | 2    | 3    | 4    |      |      | 5  |
| Lack of appropriately skilled workers | 1.2        | 4.7             | 9.3  | 19.8 | 27.9 | 37.2 | 3.85 | 1  |
| Repetitive revisions and changes      | 1.2        | 5.8             | 14.0 | 14.0 | 25.6 | 39.5 | 3.80 | 2  |
| Delay in design approval              | 1.2        | 8.1             | 11.6 | 15.1 | 27.9 | 36.0 | 3.73 | 3  |
| Poor planning of construction         | 1.1        | 4.5             | 12.5 | 21.6 | 33.0 | 27.3 | 3.67 | 4  |
| Late dissemination of information     | 1.1        | 5.7             | 11.5 | 19.5 | 40.2 | 21.8 | 3.62 | 5  |
| Poor interaction                      | 2.3        | 3.5             | 17.4 | 20.9 | 29.1 | 26.7 | 3.60 | 6  |
| Incomplete drawings / designs         | 0.0        | 9.2             | 13.8 | 17.2 | 29.9 | 29.9 | 3.57 | 7  |
| Bureaucracy                           | 2.3        | 8.0             | 17.2 | 18.4 | 25.3 | 28.7 | 3.51 | 8  |
| Lack of leadership abilities          | 0.0        | 2.3             | 14.9 | 29.9 | 35.6 | 17.2 | 3.51 | 9  |
| Error in material specifications      | 1.1        | 11.5            | 14.9 | 14.9 | 28.7 | 28.7 | 3.49 | 10 |
| Unclear design / details              | 1.1        | 6.9             | 13.8 | 24.1 | 34.5 | 19.5 | 3.47 | 11 |
| Slow response to RFI                  | 15.3       | 9.4             | 7.1  | 23.5 | 24.7 | 20.0 | 3.46 | 12 |
| Poor decision-making abilities        | 0.0        | 4.6             | 13.8 | 34.5 | 26.4 | 20.7 | 3.45 | 13 |
| Inadequate design information         | 1.1        | 9.1             | 14.8 | 23.9 | 25.0 | 26.1 | 3.45 | 14 |
| Unrealistic project execution plan    | 1.2        | 10.5            | 12.8 | 23.3 | 26.7 | 25.6 | 3.45 | 15 |
| Inappropriate construction methods    | 1.1        | 4.5             | 17.0 | 30.7 | 27.3 | 19.3 | 3.40 | 16 |
| Contradictions in design documents    | 2.3        | 12.6            | 12.6 | 20.7 | 29.9 | 21.8 | 3.36 | 17 |
| Scarcity of materials                 | 10.2       | 8.0             | 15.9 | 27.3 | 22.7 | 15.9 | 3.25 | 18 |
| Accidents due to poor H&S             | 2.3        | 12.5            | 20.5 | 20.5 | 21.6 | 22.7 | 3.22 | 19 |
| External influence on operations      | 13.6       | 5.7             | 15.9 | 33.0 | 18.2 | 13.6 | 3.21 | 20 |
| Design revisions                      | 1.1        | 8.0             | 18.4 | 32.2 | 25.3 | 14.9 | 3.21 | 21 |
| Error in material specifications      | 6.9        | 11.5            | 14.9 | 23.0 | 32.2 | 11.5 | 3.19 | 22 |
| Poor document control system          | 2.3        | 9.2             | 17.2 | 34.5 | 24.1 | 12.6 | 3.14 | 23 |
| Inadequate materials control          | 2.3        | 6.8             | 18.2 | 33.0 | 34.1 | 5.7  | 3.14 | 24 |
| Poor site layout                      | 5.7        | 6.9             | 20.7 | 33.3 | 26.4 | 6.9  | 3.06 | 25 |
| Lack of cooperation among workers     | 3.4        | 8.0             | 22.7 | 33.0 | 21.6 | 11.4 | 3.06 | 26 |
| Scarcity of workers                   | 2.3        | 12.5            | 19.3 | 31.8 | 18.2 | 15.9 | 3.06 | 27 |
| Poor team spirit among workers        | 3.4        | 9.1             | 21.6 | 30.7 | 28.4 | 6.8  | 3.02 | 28 |
| Inadequate staging areas / platforms  | 11.4       | 8.0             | 20.5 | 29.5 | 23.9 | 6.8  | 3.01 | 29 |
| Delays in material transportation     | 4.5        | 12.5            | 22.7 | 23.9 | 25.0 | 11.4 | 3.00 | 30 |
| Design not requested by client        | 13.8       | 10.3            | 23.0 | 26.4 | 9.2  | 17.2 | 3.00 | 31 |
| Scarcity of equipment                 | 6.8        | 13.6            | 19.3 | 27.3 | 20.5 | 12.5 | 2.99 | 32 |
| Low morale among workers              | 2.3        | 11.5            | 21.8 | 33.3 | 20.7 | 10.3 | 2.96 | 33 |
| Over / Under ordering materials       | 5.7        | 10.2            | 23.9 | 29.5 | 22.7 | 8.0  | 2.94 | 34 |
| Over design                           | 3.4        | 12.6            | 27.6 | 26.4 | 17.2 | 12.6 | 2.89 | 35 |
| Inappropriate use of equipment        | 5.7        | 12.5            | 25.0 | 31.8 | 18.2 | 6.8  | 2.81 | 36 |
| Lack of empowerment                   | 4.5        | 14.8            | 28.4 | 29.5 | 18.2 | 4.5  | 2.68 | 37 |
| Excessive control & inspection        | 2.3        | 20.7            | 21.8 | 34.5 | 12.6 | 8.0  | 2.65 | 38 |
| Poor waste management practices       | 9.1        | 18.2            | 27.3 | 30.7 | 11.4 | 3.4  | 2.50 | 39 |
| Removal of unspecified material       | 10.2       | 19.3            | 26.1 | 31.8 | 6.8  | 5.7  | 2.48 | 40 |

All the questions were asked in order to get to the root of the causes of the much reported sub-optimal project performance in the South African construction industry. In particular, given that project implementation consume most of the resources allocated to construction projects especially in the public sector; it becomes imperative to ask these questions so that improvement interventions may be recommended.

As indicated in Appendix 2 and Table 7.28, the research problem statement was addressed through Q1, Q2, Q9, Q14 and Q15 in the primary survey. In addition, Q4 to Q8 as well as Q10 to Q14 addressed the research objectives, while Q9 specifically addressed the fourth research objective and all postulated hypotheses. Thus, the purpose of the primary survey that is underpinned by the research problem statement and objectives can be deemed achieved with the instrument.

Table 7.28 Matrix: Phase 1 Questionnaire

| Description                       | Questions |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
|-----------------------------------|-----------|---|---|---|---|---|---|---|---|----|----|----|----|----|----|
|                                   | 1         | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| <b>Research Problem Statement</b> | Y         | Y |   |   |   |   |   |   | Y |    |    |    |    | Y  | Y  |
| <b>Research objectives:</b>       |           |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| 1                                 |           |   |   |   | Y | Y | Y | Y |   | Y  | Y  |    |    |    |    |
| 2                                 |           |   |   |   | Y | Y | Y | Y |   | Y  | Y  | Y  |    |    |    |
| 3                                 |           |   | Y |   | Y | Y | Y | Y |   | Y  | Y  |    |    |    |    |
| 4                                 |           |   |   |   |   |   |   |   | Y |    |    |    | Y  | Y  |    |
| <b>Hypotheses:</b>                |           |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| H1                                |           |   |   |   |   |   |   |   | Y | Y  |    |    |    |    |    |
| H2                                |           |   |   |   |   |   |   |   | Y | Y  | Y  |    |    |    |    |
| H3                                |           |   |   |   |   |   |   |   | Y | Y  |    |    |    |    |    |
| H4                                |           |   |   |   |   |   |   |   | Y | Y  |    |    |    |    |    |
| H5                                |           |   |   |   |   |   |   |   | Y | Y  |    |    |    |    |    |
| H6                                |           |   |   |   |   |   |   |   | Y | Y  |    |    |    |    |    |
| H7                                |           |   |   |   |   |   |   |   | Y | Y  |    |    |    |    |    |
| H8                                |           |   |   |   |   |   |   |   | Y | Y  |    |    |    |    |    |

## 7.7 Results of the Secondary Survey

As indicated earlier, the aim of this phase of the research process was to identify construction performance impediments and solutions that are deemed useful in South Africa. Therefore, questions relative to performance with respect to the postulated research hypotheses were basically used in this particular survey. And for consistency and simplicity, project stakeholders in the form of public sector clients, consultants, and civil engineering contractors were surveyed. However, in order to avoid respondents' apathy or bias, only respondents that were not previously surveyed were sent the questionnaires. Though the sample size was less than that of the primary survey due to the limited size of the infrastructure sector in South Africa, the response generated can be deemed admissible for this particular survey.

Further, Table 7.29 indicates the consolidated questionnaire numbering adopted for presenting the results. The questions used for hypotheses testing as well as their corresponding numbers in questionnaires are indicated on the table.

Table 7.29 Phase 2 questions and their respective numbers in questionnaires

| Number | Corresponding Numbers in Questionnaires |        |             |             |
|--------|-----------------------------------------|--------|-------------|-------------|
|        | Hypotheses                              | Client | Consultants | Contractors |
| 1      | H1                                      | 1      | -           | -           |
| 2      | H1                                      | 2      | -           | -           |
| 3      | H1                                      | 3      | 1           | -           |
| 4      | H3                                      | 4      | 3           | 1           |
| 5      | H3                                      | 5      | 4           | 2           |
| 6      | H7                                      | 6      | 7           | 9           |
| 7      | H7                                      | 7      | 8           | 10          |
| 8      | H8                                      | 8      | 9           | 11          |
| 9      | H8                                      | 9      | 10          | 12          |
| 10     | H2                                      | -      | 2           | -           |
| 11     | H4                                      | -      | 5           | 3           |
| 12     | H4                                      | -      | 6           | 4           |
| 13     | H5                                      | -      | -           | 5           |
| 14     | H5                                      | -      | -           | 6           |
| 15     | H6                                      | -      | -           | 7           |
| 16     | H6                                      | -      | -           | 8           |
| 17     |                                         | 10     | 11          | 13          |
| 18     |                                         | 11     | 12          | 14          |
| 19     |                                         | 12     | 13          | 15          |
| 20     |                                         | 13.1   | 14.1        | 16.1        |
| 21     |                                         | 13.2   | 14.2        | 16.2        |
| 22     |                                         | 13.3   | 14.3        | 16.3        |
| 23     |                                         | 14     | 15          | 17          |

This is done in order to avoid duplication since three different questionnaires were administered to phase 2 respondents based on their organisational category because of the need to reduce the number of pages the respondents had to complete, as well as the need to make sure respondents only respond to questions deemed pertinent to their professional practice. Though, Table 7.29 indicates that a total number of 23 questions were used in the secondary survey, the actual number of variables identifiable under various questions is approximately 120. The range is a minimum of 4, and a maximum of 10 variables under each question.

**1. On a scale of 1 (minor) to 5 (major), to what extent do the following risk allocation strategies contribute to the choice of procurement / contract strategy in infrastructure project delivery (please note the ‘unsure’ option)?**

Table 7.30 indicates the respondents’ perceptions of the extent that identified risk allocation strategies contribute to the choice of procurement / contract strategy in infrastructure project delivery in terms of percentage responses to a scale of 1 (minor) to 5 (major), and a MS ranging between 1.00 and 5.00. It is notable that 4 of the 5 MSs are above the midpoint of 3.00, which indicates that in general the

respondents can be deemed to perceive that identification of risk avoidance / prevention measures, considerations relative to contract pricing strategies, cost of risk transferred to project partners, and the establishment of contingency plans contribute more of a major than a minor extent.

In specific terms, the findings suggest that the respondents perceive that identification of risk avoidance / prevention measures contributes the most to the choice of procurement strategy. This is then closely followed by considerations relative to contract pricing strategies, and cost of risk transferred to project partners. However, the contributions of the establishment of contingency plans and incentives to improve project performance can be considered to be minor. In particular, it is notable that incentives to improve project performance recorded the lowest MS (2.70), which suggest that performance incentives are not prioritised when choosing a construction procurement strategy.

Table 7.30 Risk allocation strategies contribution to the choice of procurement strategy

| Strategy                                               | Response (%) |                 |      |      |      |      | MS   | Rank |
|--------------------------------------------------------|--------------|-----------------|------|------|------|------|------|------|
|                                                        | Unsure       | Minor.....Major |      |      |      |      |      |      |
|                                                        |              | 1               | 2    | 3    | 4    | 5    |      |      |
| Identification of risk avoidance / prevention measures | 0.0          | 9.1             | 0.0  | 9.1  | 36.4 | 45.5 | 4.09 | 1    |
| Considerations relative to contract pricing strategies | 0.0          | 9.1             | 0.0  | 9.1  | 54.5 | 27.3 | 3.91 | 2    |
| Cost of risk transferred to project partners           | 0.0          | 18.2            | 18.2 | 0.0  | 18.2 | 45.5 | 3.55 | 3    |
| Establishment of contingency plans                     | 0.0          | 18.2            | 9.1  | 27.3 | 36.4 | 9.1  | 3.09 | 4    |
| Incentives to improve project performance              | 9.1          | 36.4            | 18.2 | 0.0  | 9.1  | 27.3 | 2.70 | 5    |

**2. On a scale of 1 (minor) to 5 (major), to what extent do the following procurement criteria determine the choice of procurement / contract strategy in infrastructure project delivery (please note the ‘unsure’ option)?**

Table 7.31 indicates the respondents’ perceptions of the extent that identified criteria determine the choice of procurement / contract strategy in infrastructure project delivery in terms of percentage responses to a scale of 1 (minor) to 5 (major), and a MS ranging between 1.00 and 5.00. It is notable that all the MSs are greater than the midpoint of 3.00, which indicates that the respondents can be deemed to perceive that the criteria contribute more of a major than a minor extent towards the determination of the choice of procurement strategy in South African construction.

The findings suggest that the respondents perceive that to a large extent, design responsibility and accountability could determine the choice of procurement strategy. This is closely followed by project certainty relative to cost, quality, and time; legislation relative to preferential procurement (BEE); and project complexity relative to constructability. The MS (3.00) and to some extent, the rating relative

to attitudes to risk transfer, amplifies the need to address the appropriateness of risk management practices in South African construction.

Table 7.31 Procurement criteria determining the choice of procurement strategy

| Criterion                                             | Response (%) |                 |      |      |      |      | MS   | Rank |
|-------------------------------------------------------|--------------|-----------------|------|------|------|------|------|------|
|                                                       | Unsure       | Minor.....Major |      |      |      |      |      |      |
|                                                       |              | 1               | 2    | 3    | 4    | 5    |      |      |
| Design responsibility and accountability              | 0.0          | 18.2            | 0.0  | 0.0  | 27.3 | 54.5 | 4.00 | 1    |
| Project certainty relative to cost, quality, and time | 0.0          | 18.2            | 0.0  | 9.1  | 27.3 | 45.5 | 3.82 | 2    |
| Legislation relative to preferential procurement      | 0.0          | 9.1             | 9.1  | 9.1  | 36.4 | 36.4 | 3.82 | 3    |
| Project complexity relative to constructability       | 0.0          | 18.2            | 0.0  | 27.3 | 18.2 | 36.4 | 3.55 | 4    |
| Attitudes to risk transfer                            | 9.1          | 18.2            | 18.2 | 18.2 | 18.2 | 18.2 | 3.00 | 5    |

**3. On a scale of 1 (hardly) to 5 (definitely), to what extent do the following situations occur as a result of the misallocation of project risks in infrastructure project delivery (please note the ‘unsure’ option)?**

Table 7.32 indicates the respondents’ perceptions of the extent that identified situations occur due to the misallocation of project risks in infrastructure project delivery in terms of percentage responses to a scale of 1 (hardly) to 5 (definitely), and a MS ranging between 1.00 and 5.00. It is notable that all the MSs are above the midpoint of 3.00, which suggests that the respondents can be deemed to perceive that these situations occur. This suggests that the respondents perceive that delay in project completion and increased total project cost can be considered as the most significant, among the listed consequences of misallocation of project risks.

Table 7.32 Consequences of misallocation of project risks

| Situation                                       | Response (%) |                       |      |      |      |      | MS   | Rank |
|-------------------------------------------------|--------------|-----------------------|------|------|------|------|------|------|
|                                                 | Unsure       | Hardly.....Definitely |      |      |      |      |      |      |
|                                                 |              | 1                     | 2    | 3    | 4    | 5    |      |      |
| Delay in project completion                     | 2.6          | 0.0                   | 10.5 | 15.8 | 47.4 | 23.7 | 3.86 | 1    |
| Increased total project cost                    | 2.6          | 2.6                   | 7.9  | 15.8 | 47.4 | 23.7 | 3.84 | 2    |
| Delay in award of the tender                    | 5.3          | 7.9                   | 15.8 | 13.2 | 23.7 | 34.2 | 3.64 | 3    |
| Likelihood of disputes between project partners | 2.6          | 2.6                   | 18.4 | 28.9 | 28.9 | 18.4 | 3.43 | 4    |
| High amount devoted to contingency plans        | 2.6          | 10.5                  | 13.2 | 28.9 | 36.8 | 7.9  | 3.19 | 5    |

Nevertheless, with a ranking of 3<sup>rd</sup> and 4<sup>th</sup>, delay in award of the tender and the likelihood of disputes between project partners, could also eventuate due to misallocation of project risks. High amount devoted to contingency plans can equally be considered as an important consequence of misallocation of project risks in South African construction.

**4. On a scale of 1 (minor) to 5 (major), to what extent do the following practices / situations contribute to inadequate documentation and transfer of knowledge in construction (please note the ‘unsure’ option)?**

Table 7.33 indicates the respondents’ perceptions of the extent that identified practices / situations contribute to inadequate documentation and transfer of knowledge in South African construction in terms of percentage responses to a scale of 1 (minor) to 5 (major), and a MS ranging between 1.00 and 5.00. It is notable that all the MSs are above the midpoint of 3.00, which indicates that the respondents are of the opinion that the practices contribute more of a major than a minor extent. The results suggest that poor information management contributes the most to inadequate documentation and transfer of knowledge. After poor information management, lack of mentorship programmes, poor allocation of resources to knowledge capture, and lack of post project reviews / reports can then be considered as significant contributors to the malaise. Though, it recorded the lowest MS (3.39), 16.7% of the respondents perceive that lack of detailed databases relative to past projects contributes a major extent to inadequate documentation and transfer of knowledge in South African construction .

Table 7.33 Practices contributing to inadequate recordation and transfer of knowledge in construction

| Practice / Situation                                 | Response (%) |                 |      |      |      |      | MS   | Rank |
|------------------------------------------------------|--------------|-----------------|------|------|------|------|------|------|
|                                                      | Unsure       | Minor.....Major |      |      |      |      |      |      |
|                                                      |              | 1               | 2    | 3    | 4    | 5    |      |      |
| Poor information management                          | 0.0          | 3.7             | 11.1 | 18.5 | 40.7 | 25.9 | 3.74 | 1    |
| Lack of mentorship programmes                        | 1.9          | 3.7             | 9.3  | 29.6 | 42.6 | 13.0 | 3.53 | 2    |
| Poor allocation of resources to knowledge capture    | 5.6          | 5.6             | 11.1 | 25.9 | 33.3 | 18.5 | 3.51 | 3    |
| Lack of post project reviews / reports               | 1.9          | 11.1            | 7.4  | 22.2 | 37.0 | 20.4 | 3.49 | 4    |
| Lack of detailed databases relative to past projects | 0.0          | 5.6             | 18.5 | 24.1 | 35.2 | 16.7 | 3.39 | 5    |

**5. On a scale of 1 (totally disagree) to 5 (totally agree), to what extent do the following situations occur due to the lack of proper documentation and transfer of knowledge in construction (please note the ‘unsure’ option)?**

Table 7.34 indicates the respondents' degree of concurrence relative to the extent that identified situations occur due to inadequate documentation and transfer of knowledge in South African construction in terms of percentage responses to a scale of 1 (totally disagree) to 5 (totally agree), and a MS ranging between 1.00 and 5.00. It is notable that all the MSs are above the midpoint of 3.00, which indicate that the respondents can be deemed to agree as opposed to disagree that the situations could occur in South African construction.

Table 7.34 Consequences of the lack of proper documentation and transfer of knowledge in construction

| Situation                                                 | Response (%) |                                    |      |      |      |      | MS   | Rank |
|-----------------------------------------------------------|--------------|------------------------------------|------|------|------|------|------|------|
|                                                           | Unsure       | Totally disagree.....Totally agree |      |      |      |      |      |      |
|                                                           |              | 1                                  | 2    | 3    | 4    | 5    |      |      |
| Inability to tackle risks / uncertainties effectively     | 1.9          | 3.7                                | 13.0 | 14.8 | 46.3 | 20.4 | 3.68 | 1    |
| Inability to disseminate ‘best practices’                 | 1.9          | 5.6                                | 7.4  | 27.8 | 29.6 | 27.8 | 3.68 | 2    |
| Repetition of past project mistakes                       | 1.9          | 7.4                                | 3.7  | 29.6 | 33.3 | 24.1 | 3.64 | 3    |
| Inability to innovate and respond to clients’ needs       | 3.7          | 5.6                                | 13.0 | 20.4 | 29.6 | 27.8 | 3.63 | 4    |
| Ineffective problem solving capabilities                  | 0.0          | 7.4                                | 11.1 | 22.2 | 33.3 | 25.9 | 3.59 | 5    |
| Lost opportunities to improve project performance         | 3.7          | 3.7                                | 11.1 | 24.1 | 40.7 | 16.7 | 3.58 | 6    |
| Poor response to organisational and project changes       | 3.7          | 3.7                                | 14.8 | 24.1 | 31.5 | 22.2 | 3.56 | 7    |
| Loss of contractor, subcontractor / supplier track record | 3.7          | 11.1                               | 9.3  | 33.3 | 25.9 | 16.7 | 3.29 | 8    |

Among the consequences listed in the table, inability to tackle risks / uncertainties effectively and inability to disseminate 'best practices' are considered to be the most significant. The respondents also agree that repetition of past project mistakes; inability to innovate and respond to clients' needs; ineffective problem solving capabilities; lost opportunities to improve project performance; poor response to organisational and project changes; and loss of contractor, subcontractor / supplier track record could eventuate due to lack of proper documentation and transfer of knowledge.

**6. On a scale of 1 (minor) to 5 (major), to what extent do the following practices contribute to unacceptable coordination and regard for H&S in construction (please note the 'unsure' option)?**

Table 7.35 indicates the respondents' perceptions of the extent that identified practices contribute to unacceptable coordination and regard for H&S in South African construction in terms of percentage responses to a scale of 1 (minor) to 5 (major), and a MS ranging between 1.00 and 5.00. It is notable that all the MSs are above the midpoint of 3.00, which indicates that the respondents are of the

opinion that the practices can be deemed to contribute more of a major than a minor extent to unacceptable coordination and regard for H&S in South African construction.

The findings indicate that the respondents perceive that inadequate knowledge relative to nature of work and H&S competence of project participants could be contributing the most to unacceptable coordination and regard for H&S in South African construction. Though ranked 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> consecutively, the contributions of collective organisational values relative to H&S, H&S management procedures / systems and poor comprehension of project characteristics can be deemed to be major in South African construction.

Table 7.35 Practices contributing to unacceptable coordination and regard for H&S in construction

| Practice                                         | Response (%) |                 |      |      |      |      | MS   | Rank |
|--------------------------------------------------|--------------|-----------------|------|------|------|------|------|------|
|                                                  | Unsure       | Minor.....Major |      |      |      |      |      |      |
|                                                  |              | 1               | 2    | 3    | 4    | 5    |      |      |
| Inadequate knowledge relative to nature of work  | 3.8          | 7.5             | 5.7  | 13.2 | 45.3 | 24.5 | 3.76 | 1    |
| H&S competence of project participants           | 1.9          | 9.4             | 9.4  | 15.1 | 41.5 | 22.6 | 3.60 | 2    |
| Collective organisational values relative to H&S | 7.5          | 9.4             | 13.2 | 17.0 | 34.0 | 18.9 | 3.43 | 3    |
| H&S management procedures / systems              | 1.9          | 13.2            | 13.2 | 22.6 | 24.5 | 24.5 | 3.35 | 4    |
| Poor comprehension of project characteristics    | 7.5          | 7.5             | 17.0 | 22.6 | 34.0 | 11.3 | 3.27 | 5    |

**7. On a scale of 1 (totally disagree) to 5 (totally agree), to what extent do the following situations occur due to unacceptable coordination and regard for H&S in construction (please note the ‘unsure’ options)?**

Table 7.36 indicates the respondents’ degree of concurrence relative to the extent that identified situations occur due to unacceptable coordination and regard for H&S in South African construction in terms of percentage responses to a scale of 1 (totally disagree) to 5 (totally agree), and a MS ranging between 1.00 and 5.00. It is notable that all the MSs are above the midpoint of 3.00, which indicates that, the respondents can be deemed to agree as opposed to disagree that these situations could occur in South African construction.

Among these consequences of unacceptable coordination and regard for H&S, it is notable that the respondents perceived that ineffective H&S monitoring and inspection occur the most. However, work stoppages, injuries and fatalities; poor status of H&S within the construction process; lack of project specific H&S specifications; and lack of project specific H&S plan can also arise due to unacceptable coordination and regard for H&S. Though, these MSs are not above 4.20, they should nonetheless be viewed as important factors given that a slight slip in H&S on construction may lead to

severe injuries and / or fatalities as several cidb reports continue to echo the fact that H&S is still a concern in South African construction.

Table 7.36 Consequences of unacceptable coordination and regard for H&S in construction

| Situation                                          | Response (%) |                                    |      |      |      |      | MS   | Rank |
|----------------------------------------------------|--------------|------------------------------------|------|------|------|------|------|------|
|                                                    | Unsure       | Totally disagree.....Totally agree |      |      |      |      |      |      |
|                                                    |              | 1                                  | 2    | 3    | 4    | 5    |      |      |
| Ineffective H&S monitoring and inspection          | 3.7          | 13.0                               | 14.8 | 13.0 | 31.5 | 24.1 | 3.40 | 1    |
| Work stoppages, injuries, and fatalities           | 3.7          | 14.8                               | 18.5 | 20.4 | 14.8 | 27.8 | 3.23 | 3    |
| Poor status of H&S within the construction process | 3.7          | 14.8                               | 20.4 | 11.1 | 24.1 | 25.9 | 3.27 | 2    |
| Lack of project specific H&S specifications        | 3.7          | 11.1                               | 25.9 | 14.8 | 27.8 | 16.7 | 3.13 | 4    |
| Lack of project specific H&S plan                  | 3.7          | 11.1                               | 24.1 | 20.4 | 25.9 | 14.8 | 3.10 | 5    |

**8. On a scale of 1 (minor) to 5 (major), to what extent do the following practices / situations contribute to inadequate management of quality in construction (please note the ‘unsure’ option)?**

Table 7.37 indicates the respondents’ perceptions of the extent that identified practices / situations contribute to inadequate management of quality in South African construction in terms of percentage responses to a scale of 1 (minor) to 5 (major), and a MS ranging between 1.00 and 5.00. It is notable that all the MSs are above the midpoint of 3.00, which indicate that the respondents are of the opinion that the practices can be deemed to contribute more of a major than a minor extent.

The findings indicate that the respondents perceive that poor work procedures / methods, poor understanding of quality, poor project specifications, poor exchange of project information, and poor project cost and schedule data can be deemed to contribute between some extent to a near major extent to inadequate management of quality in South African construction, though poor work procedures / methods is ranked 1<sup>st</sup>.

Table 7.37 Practices contributing to inadequate management of quality in construction

| Practice / Situation                 | Response (%) |                 |      |      |      |      | MS   | Rank |
|--------------------------------------|--------------|-----------------|------|------|------|------|------|------|
|                                      | Unsure       | Minor.....Major |      |      |      |      |      |      |
|                                      |              | 1               | 2    | 3    | 4    | 5    |      |      |
| Poor work procedures / methods       | 0.0          | 3.7             | 5.6  | 22.2 | 35.2 | 33.3 | 3.89 | 1    |
| Poor understanding of quality        | 0.0          | 11.1            | 3.7  | 9.3  | 40.7 | 35.2 | 3.85 | 2    |
| Poor project specifications          | 0.0          | 7.4             | 13.0 | 18.5 | 29.6 | 31.5 | 3.65 | 3    |
| Poor exchange of project information | 0.0          | 9.3             | 7.4  | 25.9 | 37.0 | 20.4 | 3.52 | 4    |
| Poor project cost and schedule data  | 1.9          | 7.4             | 14.8 | 24.1 | 33.3 | 18.5 | 3.42 | 5    |

**9. On a scale of 1 (totally disagree) to 5 (totally agree), to what extent do the following situations occur due to inadequate management of quality in construction (please note the ‘unsure’ option)?**

Table 7.38 indicates the respondents’ concurrence relative to the extent that identified situations occur due to inadequate management of quality in South African construction in terms of percentage responses to a scale of 1 (totally disagree) to 5 (totally agree), and a MS ranging between 1.00 and 5.00. It is notable that 4 MSs are above the midpoint of 3.00, which indicates that the respondents can be deemed to agree as opposed to disagree that these situations could occur in South African construction.

Table 7.38 Consequences of inadequate management of quality in construction

| Situation                           | Response (%) |                                    |      |      |      |      | MS   | Rank |
|-------------------------------------|--------------|------------------------------------|------|------|------|------|------|------|
|                                     | Unsure       | Totally disagree.....Totally agree |      |      |      |      |      |      |
|                                     |              | 1                                  | 2    | 3    | 4    | 5    |      |      |
| Defects and rework                  | 0.0          | 5.6                                | 1.9  | 16.7 | 33.3 | 42.6 | 4.06 | 1    |
| Increased project duration and cost | 1.9          | 3.8                                | 9.4  | 15.1 | 39.6 | 30.2 | 3.85 | 2    |
| Client dissatisfaction              | 1.9          | 9.3                                | 7.4  | 14.8 | 25.9 | 40.7 | 3.83 | 3    |
| High built asset maintenance cost   | 5.6          | 9.3                                | 16.7 | 22.2 | 27.8 | 18.5 | 3.31 | 4    |
| Iniuries and fatalities             | 1.9          | 11.1                               | 31.5 | 24.1 | 20.4 | 11.1 | 2.89 | 5    |

Defects and rework, which is ranked 1<sup>st</sup> in the table, can be considered the most significant consequence based on perceptions of the survey respondents. Increased project duration and cost, client dissatisfaction, and high built asset maintenance cost can also be considered to be significant consequences. However, with a MS lower than 3.00, injuries and fatalities can be considered not to be a major manifestation of inadequate management of quality in South African construction. In effect, the respondents were of the opinion that the possibilities of having H&S related problems arising during the execution of construction projects due to quality failings are minimal.

**10. On a scale of 1 (totally disagree) to 5 (totally agree), to what extent do the following situations indicate the extent of skills shortages in public sector departments responsible for project delivery (please note the ‘unsure’ option)?**

Table 7.39 indicates the respondents’ concurrence relative to the extent that identified situations indicate the extent of skills shortages in public sector departments responsible for project delivery in South African construction in terms of percentage responses to a scale of 1 (totally disagree) to 5 (totally agree), and a MS ranging between 1.00 and 5.00. It is notable that all the MSs are above the midpoint of 3.00, which indicates that the respondents can be deemed to agree as opposed to disagree

that these situations reveal the extent of skills shortages in public sector departments responsible for project delivery in South African construction.

Table 7.39 Consequences of skills shortages in public sector departments

| Situation                                        | Response (%) |                                    |      |      |      |      | MS   | Rank |
|--------------------------------------------------|--------------|------------------------------------|------|------|------|------|------|------|
|                                                  | Unsure       | Totally disagree.....Totally agree |      |      |      |      |      |      |
|                                                  |              | 1                                  | 2    | 3    | 4    | 5    |      |      |
| Decision-making relative to procurement strategy | 0.0          | 0.0                                | 0.0  | 19.2 | 38.5 | 42.3 | 4.23 | 1    |
| Delay in payments relative to executed tasks     | 0.0          | 0.0                                | 7.1  | 17.9 | 35.7 | 39.3 | 4.07 | 2    |
| Poor establishment of what is to be procured     | 0.0          | 3.6                                | 14.3 | 7.1  | 28.6 | 46.4 | 4.00 | 3    |
| Poor implementation of procurement strategy      | 0.0          | 7.1                                | 7.1  | 14.3 | 28.6 | 42.9 | 3.93 | 4    |
| Increased total project cost                     | 0.0          | 7.1                                | 3.6  | 14.3 | 39.3 | 35.7 | 3.93 | 5    |
| Unclear contract / procurement documentation     | 0.0          | 7.1                                | 17.9 | 7.1  | 17.9 | 50.0 | 3.86 | 6    |
| Delay in contract award after tender submission  | 0.0          | 7.1                                | 10.7 | 25.0 | 10.7 | 46.4 | 3.79 | 7    |
| Scope changes, claims, and variations            | 0.0          | 17.9                               | 3.6  | 10.7 | 39.3 | 28.6 | 3.57 | 8    |

The findings indicate that 38.5% agree and 42.3% of the respondents totally agree that decision-making relative to procurement strategy shows how severe skills shortages are perceived to be in government departments in South Africa. Further, the results suggest that the respondents concurred that delay in payments relative to executed tasks, poor establishment of what is to be procured, poor implementation of procurement strategy, increased total project cost, unclear contract / procurement documentation, delay in contract award after tender submission, and scope changes, claims, and variations occur in South African construction due to skills shortages in public sector departments responsible for project delivery. Thus the findings presented in this table concur with previous construction industry skills related findings and the general comments made by the survey respondents. In other words, the South African public sector departments responsible for infrastructure delivery may be deemed handicapped by the lack of appropriately qualified employees that can ensure that service delivery goes on without encumbrances in the country.

# **11. On a scale of 1 (minor) to 5 (major), to what extent do the following practices contribute to an inappropriate organisational culture in construction (please note the ‘unsure’ options)?**

Table 7.40 indicates the respondents’ perceptions of the extent that identified practices contribute to inappropriate organisational culture in South African construction in terms of percentage responses to a scale of 1 (minor) to 5 (major), and a MS ranging between 1.00 and 5.00. It is notable that all the

MSs are above the midpoint of 3.00, which indicates that the respondents are of the opinion that the practices contribute more of a major than a minor extent.

Table 7.40 Practices contributing to inappropriate organisational culture in construction

| Practice                                           | Response (%) |                 |      |      |      |      | MS   | Rank |
|----------------------------------------------------|--------------|-----------------|------|------|------|------|------|------|
|                                                    | Unsure       | Minor.....Major |      |      |      |      |      |      |
|                                                    |              | 1               | 2    | 3    | 4    | 5    |      |      |
| Poor analysis of issues and their impact           | 7.0          | 4.7             | 14.0 | 14.0 | 41.9 | 18.6 | 3.60 | 1    |
| Lack of trust within project teams                 | 2.3          | 7.0             | 14.0 | 25.6 | 23.3 | 27.9 | 3.52 | 2    |
| Apathy toward idea generation and evaluation       | 9.3          | 9.3             | 11.6 | 25.6 | 23.3 | 20.9 | 3.38 | 3    |
| Closed one-directional communication mediums       | 11.6         | 7.0             | 14.0 | 27.9 | 20.9 | 18.6 | 3.34 | 4    |
| Non-inclusive decision-making within project teams | 7.0          | 9.3             | 11.6 | 30.2 | 23.3 | 18.6 | 3.33 | 5    |
| Improper worker motivation and empowerment         | 4.7          | 9.3             | 9.3  | 34.9 | 25.6 | 16.3 | 3.32 | 6    |

The findings suggest that the respondents perceive that poor analysis of issues and their impact as well as the lack of trust within project teams can be considered to contribute the most to inappropriate organisational culture in South African construction. The findings also indicate that the respondents are of the opinion that apathy towards idea generation and evaluation, closed one-directional communication mediums, non-inclusive decision-making within project teams, and improper worker motivation and empowerment can contribute to inappropriate organisational culture in South African construction, albeit at varying degrees.

**12. On a scale of 1 (totally disagree) to 5 (totally agree), to what extent do the following situations occur due to an inappropriate organisation culture in construction (please note the ‘unsure’ option)?**

Table 7.41 indicates the respondents’ concurrence in terms of the extent that identified situations occur due to inappropriate organisational culture in South African construction in terms of percentage responses to a scale of 1 (totally disagree) to 5 (totally agree), and a MS ranging between 1.00 and 5.00. It is notable that all MSs are above the midpoint of 3.00, which indicates that the respondents can be deemed to agree as opposed to disagree that these situations could occur in South African construction.

The results suggest that inadequate site relationship management and poor problem identification and resolution could occur more frequently than other consequences listed in the table. The findings further show that consequences such as poor harnessing of skills within project teams; organisational

stagnation / failure; increased resistance to change; client dissatisfaction; employee dissatisfaction; and poor handling of social issues associated with projects could also occur.

Table 7.41 Consequences of inappropriate organisational culture in construction

| Situation                                               | Response (%) |                                    |      |      |      |      | MS   | Rank |
|---------------------------------------------------------|--------------|------------------------------------|------|------|------|------|------|------|
|                                                         | Unsure       | Totally disagree.....Totally agree |      |      |      |      |      |      |
|                                                         |              | 1                                  | 2    | 3    | 4    | 5    |      |      |
| Inadequate site relationship management                 | 7.0          | 4.7                                | 11.6 | 25.6 | 25.6 | 25.6 | 3.60 | 1    |
| Poor problem identification and resolution              | 4.7          | 7.0                                | 9.3  | 20.9 | 39.5 | 18.6 | 3.56 | 2    |
| Poor harnessing of skills within project teams          | 7.0          | 7.0                                | 14.0 | 20.9 | 34.9 | 16.3 | 3.43 | 3    |
| Organisational stagnation / failure                     | 9.3          | 11.6                               | 7.0  | 25.6 | 25.6 | 20.9 | 3.41 | 4    |
| Increased resistance to change                          | 7.0          | 9.3                                | 9.3  | 32.6 | 30.2 | 11.6 | 3.28 | 5    |
| Customer / Client dissatisfaction                       | 9.3          | 2.3                                | 27.9 | 23.3 | 18.6 | 18.6 | 3.26 | 6    |
| Employee dissatisfaction                                | 9.3          | 7.0                                | 23.3 | 16.3 | 30.2 | 14.0 | 3.23 | 7    |
| Poor handling of social issues associated with projects | 4.7          | 7.0                                | 18.6 | 30.2 | 25.6 | 14.0 | 3.22 | 8    |

**13. On a scale of 1 (minor) to 5 (major), to what extent do the following practices contribute to poor multidisciplinary interface between consultants in construction (please note the ‘unsure’ option)?**

Table 7.42 indicates the respondents’ perceptions of the extent that identified practices contribute to poor multidisciplinary interface between consultants in South African construction in terms of percentage responses to a scale of 1 (minor) to 5 (major), and a MS ranging between 1.00 and 5.00. It is notable that all the MSs are above the midpoint of 3.00, which indicates that the respondents are of the opinion that the practices can be deemed to contribute more of a major than a minor extent.

Table 7.42 Practices contributing to poor multidisciplinary interface between consultants

| Practice                                        | Response (%) |                 |      |      |      |      | MS   | Rank |
|-------------------------------------------------|--------------|-----------------|------|------|------|------|------|------|
|                                                 | Unsure       | Minor.....Major |      |      |      |      |      |      |
|                                                 |              | 1               | 2    | 3    | 4    | 5    |      |      |
| Unequal design expertise                        | 15.4         | 0.0             | 0.0  | 15.4 | 53.8 | 15.4 | 4.00 | 1    |
| Change in personnel during the project duration | 0.0          | 0.0             | 7.7  | 23.1 | 53.8 | 15.4 | 3.77 | 2    |
| Behavioural tendencies within project teams     | 0.0          | 0.0             | 0.0  | 38.5 | 46.2 | 15.4 | 3.77 | 3    |
| Commitment to different project objectives      | 15.4         | 0.0             | 7.7  | 23.1 | 38.5 | 15.4 | 3.73 | 4    |
| Paper transmission of project information       | 7.7          | 0.0             | 23.1 | 23.1 | 38.5 | 7.7  | 3.33 | 5    |

The results suggest that though unequal design expertise is ranked 1<sup>st</sup>, change in personnel during the project duration, behavioural tendencies within project teams, commitment to different project objectives, and paper transmission of project information can be considered to be contributing majorly to poor multidisciplinary interface between consultants in South African construction.

**14. On a scale of 1 (totally disagree) to 5 (totally agree), to what extent do the following practices occur due to poor multidisciplinary interface between consultants in construction (please note the ‘unsure’ option)?**

Table 7.43 indicates the respondents’ degree of concurrence relative to the extent that identified practices occur due to poor multidisciplinary interface between consultants in South African construction in terms of percentage responses to a scale of 1 (totally disagree) to 5 (totally agree), and a MS ranging between 1.00 and 5.00. It is notable that all MSs are above the midpoint of 3.00, which indicates that the respondents can be deemed to agree as opposed to disagree that these situations could occur due to poor multidisciplinary interface between consultants in South African construction. The results reveal that delay and rework on site, unclear design and specification, and extensive revisions of design can be considered as the most significant consequences of poor multidisciplinary interface between consultants in South African construction. Equally worthy of note is the possibility that constant RFIs from site management and costly design changes could occur due to poor multidisciplinary interface between consultants in South Africa. It is informative to note that since all the MSs are above 4.00, these practices should be considered important practices that could occur in South African construction due to design related lapses.

Table 7.43 Consequences of poor multidisciplinary interface between consultants in construction

| Practice                           | Response (%) |                                    |     |      |      |      | MS   | Rank |
|------------------------------------|--------------|------------------------------------|-----|------|------|------|------|------|
|                                    | Unsure       | Totally disagree.....Totally agree |     |      |      |      |      |      |
|                                    |              | 1                                  | 2   | 3    | 4    | 5    |      |      |
| Delay and rework on site           | 7.1          | 0.0                                | 0.0 | 14.3 | 28.6 | 50.0 | 4.38 | 1    |
| Unclear design and specification   | 7.1          | 0.0                                | 0.0 | 14.3 | 28.6 | 50.0 | 4.38 | 2    |
| Extensive revisions of design      | 7.1          | 0.0                                | 0.0 | 14.3 | 28.6 | 50.0 | 4.38 | 3    |
| Constant RFIs from site management | 14.3         | 0.0                                | 0.0 | 21.4 | 28.6 | 35.7 | 4.17 | 4    |
| Costlv design changes              | 14.3         | 0.0                                | 7.1 | 14.3 | 28.6 | 35.7 | 4.08 | 5    |

**15. On a scale of 1 (minor) to 5 (major), to what extent do the following practices contribute to inadequate management of logistics in construction (please note the ‘unsure’ option)?**

Table 7.44 indicates the respondents’ perceptions of the extent that identified practices contribute to inadequate management of logistics in South African construction in terms of percentage responses to

a scale of 1 (minor) to 5 (major), and a MS ranging between 1.00 and 5.00. It is notable that 6 MSs are above the midpoint of 3.00, which indicates that the respondents can be deemed to perceive them to contribute more of a major than a minor extent.

Table 7.44 Practices contributing to inadequate management of logistics in construction

| Practice                                                 | Response (%) |                 |      |      |      |      | MS   | Rank |
|----------------------------------------------------------|--------------|-----------------|------|------|------|------|------|------|
|                                                          | Unsure       | Minor.....Major |      |      |      |      |      |      |
|                                                          |              | 1               | 2    | 3    | 4    | 5    |      |      |
| Lack of site management competence relative to logistics | 0.0          | 0.0             | 0.0  | 15.4 | 23.1 | 61.5 | 4.46 | 1    |
| Lack of formal training relative to logistics            | 0.0          | 0.0             | 7.7  | 15.4 | 46.2 | 30.8 | 4.00 | 2    |
| Poor site material flow management                       | 0.0          | 0.0             | 0.0  | 28.6 | 50.0 | 21.4 | 3.93 | 3    |
| Poor work schedule control                               | 0.0          | 0.0             | 0.0  | 28.6 | 57.1 | 14.3 | 3.86 | 4    |
| Poor material supply, storage, and handling              | 0.0          | 7.1             | 14.3 | 28.6 | 21.4 | 28.6 | 3.50 | 5    |
| Poor infrastructure and equipment location               | 0.0          | 0.0             | 7.1  | 42.9 | 42.9 | 7.1  | 3.50 | 6    |
| Poor site layout                                         | 0.0          | 0.0             | 64.3 | 7.1  | 14.3 | 14.3 | 2.79 | 7    |

With a ranking of 1<sup>st</sup>, the findings suggest that the respondents perceive that lack of site management competence relative to logistics can be deemed to contribute the most to inadequate management of logistics in South African construction. This is then followed by the contributions of lack of formal training relative to logistics, poor site material flow management, poor work schedule control, poor material supply, storage, and handling, and poor infrastructure and equipment location.

**16. On a scale of 1 (totally disagree) to 5 (totally agree), to what extent do the following situations occur due to inadequate management of logistics in construction (please note the ‘unsure’ option)?**

Table 7.45 indicates the respondents’ degree of concurrence relative to the extent that identified situations occur due to inadequate management of logistics in South African construction in terms of percentage responses to a scale of 1 (totally disagree) to 5 (totally agree), and a MS ranging between 1.00 and 5.00. It is notable that all the MSs are above the midpoint of 3.00, which indicates that the respondents can be deemed to agree as opposed to disagree that these situations could occur due to inadequate management of logistics in South African construction.

The findings reveal that poor quality and time management, and added cost in the project can be deemed to be the most significant consequences of logistics related problems on site. In addition, the findings indicate that the occurrence of under utilisation of construction vehicles, material loss due to defects and theft, high level of construction waste on site, added risks relative to H&S, poor image of

the industry in terms of climate change, and long material off-loading time on site can be due to inadequate management of logistics in South African construction.

Table 7.45 Consequences of inadequate management of logistics in construction

| Situation                                             | Response (%) |                                    |      |      |      | MS   | Rank |   |
|-------------------------------------------------------|--------------|------------------------------------|------|------|------|------|------|---|
|                                                       | Unsure       | Totally disagree.....Totally agree |      |      |      |      |      |   |
|                                                       |              | 1                                  | 2    | 3    | 4    |      |      | 5 |
| Poor quality and time management                      | 0.0          | 0.0                                | 0.0  | 7.1  | 42.9 | 50.0 | 4.43 | 1 |
| Added cost in the project                             | 0.0          | 0.0                                | 7.1  | 7.1  | 35.7 | 50.0 | 4.29 | 2 |
| Under utilisation of construction vehicles            | 0.0          | 0.0                                | 0.0  | 21.4 | 42.9 | 35.7 | 4.14 | 3 |
| Material loss due to defects and theft                | 0.0          | 0.0                                | 14.3 | 7.1  | 35.7 | 42.9 | 4.07 | 4 |
| High level of construction waste on site              | 0.0          | 0.0                                | 7.1  | 14.3 | 42.9 | 35.7 | 4.07 | 5 |
| Added risks relative to H&S                           | 0.0          | 0.0                                | 14.3 | 35.7 | 21.4 | 28.6 | 3.64 | 6 |
| Poor image of the industry in terms of climate change | 21.4         | 0.0                                | 14.3 | 35.7 | 7.1  | 21.4 | 3.45 | 7 |
| Long material off-loading time on site                | 0.0          | 7.1                                | 21.4 | 21.4 | 35.7 | 14.3 | 3.29 | 8 |

It is important to note that without addressing SCM issues of which logistics management is an important aspect, realising project objectives may become a mirage within a very short space of time. Thus, consideration should be given to the strategic, tactical and operational phases of construction project delivery for improvement purposes.

**17. On a scale of 1 (minor) to 5 (major), to what extent do the following perspectives / practices / interventions contribute to performance improvement in construction (please note the ‘unsure’ option)?**

Table 7.46 indicates the respondents’ perceptions of the extent that identified perspectives / practices / interventions could contribute to performance improvement in South African construction in terms of percentage responses to a scale of 1 (minor) to 5 (major), and a MS ranging between 1.00 and 5.00. It is notable that all MSs are above the midpoint of 3.00, which indicates that the respondents can be deemed to perceive them to have the potential to contribute more of a major than a minor extent.

The results reveal that the respondents perceive that adequate documentation and transfer of knowledge and good organisational culture among project partners can contribute the most to project performance improvement in South Africa. However, continuous human resources development, total quality management of all processes, robust open information sharing among project partners, appropriate allocation of project risk, reliable and efficient logistics management, and integrative H&S management practices also have significant potential in terms of performance improvement in South African construction.

Table 7.46 Interventions contributing to project performance improvement in construction

| Perspective / Practice / Intervention                 | Response (%) |                 |      |      |      |      | MS   | Rank |
|-------------------------------------------------------|--------------|-----------------|------|------|------|------|------|------|
|                                                       | Unsure       | Minor.....Major |      |      |      |      |      |      |
|                                                       |              | 1               | 2    | 3    | 4    | 5    |      |      |
| Adequate documentation and transfer of knowledge      | 1.9          | 1.9             | 0.0  | 13.0 | 37.0 | 46.3 | 4.28 | 1    |
| Good organisational culture among project partners    | 1.9          | 0.0             | 0.0  | 16.7 | 46.3 | 35.2 | 4.19 | 2    |
| Continuous human resources development                | 1.9          | 1.9             | 0.0  | 16.7 | 40.7 | 38.9 | 4.17 | 3    |
| Total Quality Management of all processes             | 1.9          | 1.9             | 5.6  | 13.0 | 33.3 | 44.4 | 4.15 | 4    |
| Robust open information sharing among project team    | 1.9          | 1.9             | 0.0  | 22.2 | 37.0 | 37.0 | 4.09 | 5    |
| Appropriate allocation of project risk                | 1.9          | 0.0             | 5.6  | 20.4 | 35.2 | 37.0 | 4.06 | 6    |
| Reliable and efficient logistics management practices | 1.9          | 0.0             | 1.9  | 22.2 | 48.1 | 25.9 | 4.00 | 7    |
| Reduce the need for non-value adding activities       | 11.5         | 3.8             | 0.0  | 19.2 | 38.5 | 26.9 | 3.96 | 8    |
| Integrative H&S management practices                  | 3.7          | 1.9             | 13.0 | 14.8 | 35.2 | 31.5 | 3.85 | 9    |

It is notable that the secondary survey respondents also concurred that these interventions may improve project performance, just as the primary survey respondents agreed to their ability to reduce NVAAs, and improve project performance in South Africa. Therefore, the use of one or a combination of these interventions in South African construction could result in significant project performance improvement that may be propagated in the industry in the form of best practices. Though, the South African construction industry cannot be said to lag that of the developed world significantly, the perceived low levels of performance improvement in the industry is an opportunity to advocate for the use of these perspectives / practices / interventions.

**18. Please indicate the type of ongoing / past infrastructural projects undertaken in your organisation – please state the approximate percentage contributions?**

Table 7.47 indicates that 72.2% (majority) of the respondents have undertaken transport related projects; 64.8% have undertaken other non-residential construction projects; 61.1% have undertaken water related projects; and 16.7% have undertaken power related construction projects in the South African infrastructure sector. Therefore, it can be assumed that all the respondents have experience in the South African infrastructure sector.

The percentage contributions column indicates that where respondents have undertaken power related projects, it constituted 55.0% of their project portfolio; where respondents have undertaken transport related projects, it constituted 45.7% of their project portfolio; where respondents have undertaken other non-residential construction such as public works buildings, it constituted 45.6% of their project

portfolio; and where respondents have undertaken water related projects, it constituted 35.6% of their project portfolio.

Table 7.47 Types of infrastructure projects undertaken by respondents

| <b>Project category</b>              | <b>Yes (%)</b> | <b>Mean contribution (%)</b> |
|--------------------------------------|----------------|------------------------------|
| Transport (roads, port, harbour )    | 72.2           | 45.7                         |
| Power (dam, gas, coal)               | 16.7           | 55.0                         |
| Water (storm water, treatment plant) | 61.1           | 35.6                         |
| Other non-residential construction   | 64.8           | 45.6                         |

**19. Please indicate the type of contract strategy used for infrastructural projects undertaken in your organisation – please state the approximate percentage contributions?**

Table 7.48 indicates that the type of contract strategy used for infrastructure projects the respondents have undertaken in their respective organisations. The table indicates that 72.2% have taken part in design by employer (traditional); 64.8% have taken part in construction management; 48.1% have taken part in design and build, and 33.3% have taken part in management contracting and public private partnerships (PPP) projects.

The percentage contributions as indicated in the table, reveal that where respondents have participated in design by employer type of contract, it constituted 67.9% of their project portfolio; where the respondents have taken part in construction management, it constituted 38.3% of their project portfolio; where respondents have taken part in design and build, it constituted 25.9% of their project portfolio; where the respondents have undertaken management contracting type of contract, it constituted 23.2%; and where the respondents have taken part in PPP projects, it constituted 12.4% of their project portfolio.

Table 7.48 Types of contract strategy used for infrastructure projects

| <b>Project category</b>            | <b>Yes (%)</b> | <b>Mean contribution (%)</b> |
|------------------------------------|----------------|------------------------------|
| Construction Management            | 64.8           | 38.3                         |
| Design and Build                   | 48.1           | 25.9                         |
| Design by Employer (traditional)   | 72.2           | 67.9                         |
| Management Contracting             | 33.3           | 23.2                         |
| Public Private Partnerships (PPPs) | 33.3           | 12.4                         |

**20. Please indicate the number of projects you have undertaken in the box provided below.**

Table 7.49 indicates that 79.6% of the respondents have undertaken more than 20 projects in the construction industry; 11.2% between 11-20 projects, and 9.3% between 1 and 10 projects. Therefore, it can be assumed that the majority of the respondents have undertaken more than 1 project in South African construction industry.

Table 7.49 Number of projects respondents have undertaken in the industry

| Range   | ≤ 5 | 6 – 10 | 11 – 15 | 16 – 20 | > 20 |
|---------|-----|--------|---------|---------|------|
| Yes (%) | 1.9 | 7.4    | 5.6     | 5.6     | 79.6 |

**21. Please indicate the length of your construction industry experience in the box provided below.**

Table 7.50 indicates that 64.8% of the respondents have more than 20 years of construction industry experience; 27.8% between 11-20 years, and 7.4% between 6 and 10 years. Most importantly, all the survey respondents have more than 5 years of industry experience. Therefore, it can be assumed that the majority of the respondents can be deemed to be experienced construction professionals.

Table 7.50 Length of construction industry experience of respondents

| Range   | ≤ 5 years | 6 – 10 years | 11 – 15 years | 16 – 20 years | > 20 years |
|---------|-----------|--------------|---------------|---------------|------------|
| Yes (%) | 0.0       | 7.4          | 14.8          | 13.0          | 64.8       |

**22. Please indicate your highest formal education in the box provided below.**

Table 7.51 indicates the highest formal educational level achieved by respondents to the survey. With 59.3%, BTech / BSc (Hon) predominates. This is distantly followed by MSc / MTech degree holders (18.5%), National Diploma holders (14.8%), PhD / DTech holders (3.7%), and matric certificate (1.9%).

Table 7.51 Highest formal education achieved by respondents

| Range   | Matric Certificate | N Dip. | BTech / BSc (Hon) | MSc / MTech | PhD / DTech |
|---------|--------------------|--------|-------------------|-------------|-------------|
| Yes (%) | 1.9                | 14.8   | 59.3              | 18.5        | 3.7         |

**23. Do you have any comments in general regarding improving the construction supply chain in South African construction?**

Table 7.52 indicates that 29.6% of the respondents made 1 comment, while only 9.3% made 2 comments. Further, Table 7.53 enumerates the general comments made by the survey respondents. As

indicated in the pilot survey as well as the primary survey, skills related issues were cited most by respondents.

Table 7.52 Comments relative to improving the construction supply chain in South African construction

| Comment (No.) | Response % |
|---------------|------------|
| 0             | 61.1       |
| 1             | 29.6       |
| 2             | 9.3        |

Table 7.53 Classification of general comments relative to the secondary survey

| Problem                     | Comment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Skills                      | <ol style="list-style-type: none"> <li>1. More training to decision makers in the construction industry.</li> <li>2. Improve professionalism in design and supervision, that is, learn to crawl before you want to walk.</li> <li>3. The public sector needs better training and performance should be monitored-particularly at the local government level.</li> <li>4. Recruit back the expertise that has left RSA. Reward “moral” standards or work ethics. Condemn placements arising from political motives. Reject cronyism and encourage real entrepreneurship.</li> <li>5. Better utilisation of experienced resources and education and training of upcoming generation. Transfer of experience and knowledge from experienced skilled persons to young professionals and equal opportunities to all races.</li> <li>6. SCM people to have some technical background so as to appreciate construction related challenges including risk factors. Employment of properly qualified people in responsible positions.</li> <li>7. Making use of adequately trained professional staff appointed on merit.</li> <li>8. Get qualified (university graduates) into responsible government positions with decision making authority who will not be overruled by political appointed people with little or no technical knowledge.</li> <li>9. Re-implement the pre-1990 tertiary education system-back to the basis.</li> <li>10. Government departments need to employ educated and competent personnel in order to improve delivery. The quality of their personnel has been seriously eroded over the past decade.</li> </ol> |
| Procurement                 | <ol style="list-style-type: none"> <li>1. Improve notification systems to the public with regards to new applicable legislation.</li> <li>2. Apply procurement regulations uniformly.</li> <li>3. Specifications and procedures are too complicated for new / young BEE companies. They get rejected during procurement process.</li> <li>4. Government has to change the procurement policy to allow for BBBEE certificate currently only HD1% is used in government tenders for consultants.</li> <li>5. BBBEE status must be terminated in order to give everybody the same opportunity to tender.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Industry issues             | <ol style="list-style-type: none"> <li>1. cidb contractor rating system should be improved.</li> <li>2. Construction industry professionals should continue to be treated as experts and be awarded contract on cost or rather tendering and be paid on gazetted rates as the current situation is undesirable for professional which are paid with low rates that lead to low quality.</li> <li>3. Appoint knowledgeable qualified people to position of accountability.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Non-value adding activities | <ol style="list-style-type: none"> <li>1. Each area of discipline needs to isolate and define their role so as to eliminate repetition and confusion of responsibilities and accountability (each one should be better equipt to know their part).</li> <li>2. Construction supply chain management should be separated from traditional supply chain management as currently it is treated in the same manner while it should not.</li> <li>3. Adopting continuous improvement principles.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

4. Generally the standard of information provided to contractors by professional consultants is getting worse and worse. Co-ordination of the different services are often non-existent. This leads to frustration with the contracting team and results in the potential profits not being realised.

Table 7.54 indicates the summary of the project performance improvement enablers based on their MSs in the primary and secondary surveys. It is notable that adequate documentation and transfer of knowledge achieved the highest MS, and therefore, it is ranked 1<sup>st</sup> in the table. KM is closely followed by TQM and organisational culture. In addition, though integrative H&S management practices is ranked lowest, all the enablers are useful for improving performance in construction.

Table 7.54 Project performance improvement enablers in South African construction

| Perspective / Practice / Intervention               | Phase 1 survey |      | Phase 2 survey |      | Mean | Rank |
|-----------------------------------------------------|----------------|------|----------------|------|------|------|
|                                                     | MS             | Rank | MS             | Rank |      |      |
| Adequate documentation and transfer of knowledge    | 3.93           | 2    | 4.28           | 1    | 4.11 | 1    |
| Total Quality Management of all processes           | 3.95           | 1    | 4.15           | 4    | 4.05 | 2    |
| Good organisational culture among project partners  | 3.90           | 3    | 4.19           | 2    | 4.05 | 3    |
| Robust open information sharing among project team  | 3.77           | 5    | 4.09           | 5    | 3.93 | 4    |
| Reliable & efficient logistics management practices | 3.83           | 4    | 4.00           | 7    | 3.92 | 5    |
| Continuous human resources development              | 3.65           | 7    | 4.17           | 3    | 3.91 | 6    |
| Reduce the need for non-value adding activities     | 3.61           | 8    | 3.96           | 8    | 3.79 | 7    |
| Appropriate allocation of project risk              | 3.49           | 9    | 4.06           | 6    | 3.78 | 8    |
| Integrative H&S management practices                | 3.43           | 10   | 3.85           | 9    | 3.64 | 9    |

Table 7.55 indicates that a greater percentage of the consultant sample stratum responded to the secondary survey (51.9%), than the other sample strata - the response rates relative to the clients and contractors are 20.4% and 27.8% respectively. In addition, Table 7.56 indicates that a higher percentage of the consultant sample stratum responded to the primary and secondary surveys (44.4%), than the other sample strata - the response rate for contractors and clients are 28.2% and 27.5% respectively. Thus, it can be deemed that these findings suggest that the perceptions of consultants dominate the views expressed among completed questionnaires, followed by that of contractors. Hence, based on the response rates it may be assumed that the results are skewed towards the views expressed by consultants. Figure 7.1 indicates the overall sample size of the empirical study with the exception of the pilot survey. The figure presents the affiliation of the sample size related to the primary and secondary surveys.

Table 7.55 Category of respondents to the secondary survey

| Response % |            |            |       |
|------------|------------|------------|-------|
| Client     | Consultant | Contractor | Total |
| 20.4       | 51.9       | 27.8       | 100.0 |

Table 7.56 Overall response rate achieved in the empirical study

| Respondent group      | Phase 1     |          | Phase2      |          | Overall | Response | %    |
|-----------------------|-------------|----------|-------------|----------|---------|----------|------|
|                       | Sample size | Response | Sample size | Response |         |          |      |
| Public sector clients | 122         | 28       | 42          | 11       | 164     | 39       | 27.5 |
| Members of CESA       | 117         | 35       | 56          | 28       | 173     | 63       | 44.4 |
| Members of SAFCEC     | 108         | 25       | 56          | 15       | 164     | 40       | 28.2 |
| Total                 | 347         | 88       | 154         | 54       | 501     | 142      | 28.3 |

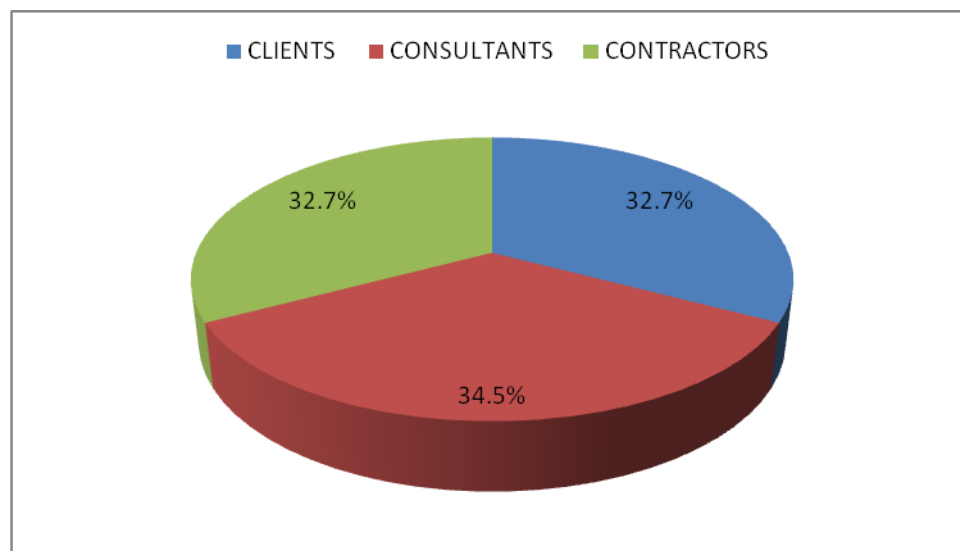


Figure 7.1 Overall sample size based on surveyed organisational classification

## 7.8 Testing of the Research Hypotheses

This section presents the inferential statistical results obtained from further analysis of the descriptive statistics presented in section 7.6. Thus, for clarity purposes Tables 7.57, 7.58, and Table 7.59 present questions used for analysing the hypotheses. Table 7.57 presents the hypotheses and the question numbers in the client's questionnaire in a matrix form. It is instructive to note that information elicited in the questionnaire only relates to four hypotheses such as inadequate risk management practices lead to poor choice of procurement strategy (H1), inadequate documentation of experience leads to poor organisational knowledge (H3), non-integrative H&S practices lead to injuries and accidents (H7), and non-integrative quality management practices lead to defects and rework (H8) (Table 7.57).

Similarly, Table 7.58 indicates that responses elicited through the consultants' questionnaire were related to six hypotheses, which include inadequate risk management practices lead to poor choice of procurement (H1), lack of skills result in poor project implementation (H2), inadequate documentation of experience leads to poor organisational knowledge (H3), poor organisational culture results in resistance to change and innovation (H4), non-integrative H&S practices lead to injuries and accidents (H7), and poor interface between designers leads to rework and delay (H8).

Table 7.57 Matrix: Phase 2 Client Questionnaire

| Hypotheses                                                                            | Questions |   |   |   |   |   |   |   |   |
|---------------------------------------------------------------------------------------|-----------|---|---|---|---|---|---|---|---|
|                                                                                       | 1         | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| H1: Inadequate risk management practices leads to poor choice of procurement strategy | Y         | Y | Y |   |   |   |   |   |   |
| H2: Lack of skills result in poor project implementation                              |           |   |   |   |   |   |   |   |   |
| H3: Inadequate documentation of experience leads to poor organisational knowledge     |           |   |   | Y | Y |   |   |   |   |
| H4: Poor organisational culture results in resistance to change and innovation        |           |   |   |   |   |   |   |   |   |
| H5: Poor interface between designers leads to rework and delay                        |           |   |   |   |   |   |   |   |   |
| H6: Poor logistics management practices lead to inventory and movement problems       |           |   |   |   |   |   |   |   |   |
| H7: Non-integrative H&S practices lead to injuries and accidents                      |           |   |   |   |   | Y | Y |   |   |
| H8: Non-integrative quality management practices lead to defects and rework           |           |   |   |   |   |   |   | Y | Y |

Table 7.58 Matrix: Phase 2 Consultant Questionnaire

| Hypotheses                                                                        | Questions |   |   |   |   |   |   |   |   |    |
|-----------------------------------------------------------------------------------|-----------|---|---|---|---|---|---|---|---|----|
|                                                                                   | 1         | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| H1: Inadequate risk management practices leads to poor choice of procurement      | Y         |   |   |   |   |   |   |   |   |    |
| H2: Lack of skills result in poor project implementation                          |           | Y |   |   |   |   |   |   |   |    |
| H3: Inadequate documentation of experience leads to poor organisational knowledge |           |   | Y | Y |   |   |   |   |   |    |
| H4: Poor organisational culture results in resistance to change and innovation    |           |   |   |   | Y | Y |   |   |   |    |
| H5: Poor interface between designers leads to rework and delay                    |           |   |   |   |   |   |   |   |   |    |
| H6: Poor logistics management practices lead to inventory and movement problems   |           |   |   |   |   |   |   |   |   |    |
| H7: Non-integrative H&S practices lead to injuries and accidents                  |           |   |   |   |   |   | Y | Y |   |    |
| H8: Non-integrative quality management practices lead to defects and rework       |           |   |   |   |   |   |   |   | Y | Y  |

In addition, Table 7.59 indicates that responses elicited through the contractors' questionnaire were related to six hypotheses such as inadequate documentation of experience leads to poor organisational knowledge (H3), poor organisational culture results in resistance to change and innovation (H4), poor interface between designers leads to rework and delay (H5), poor logistics management practices lead to inventory and movement problems (H6), non-integrative H&S practices lead to injuries and accidents (H7), and poor interface between designers leads to rework and delay (H8).

Table 7.59 Matrix: Phase 2 Contractors Questionnaire

| Hypotheses | Questions |   |   |   |   |   |   |   |   |    |    |    |
|------------|-----------|---|---|---|---|---|---|---|---|----|----|----|
|            | 1         | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |

---

|                                                                                   |   |   |   |   |   |   |   |   |     |
|-----------------------------------------------------------------------------------|---|---|---|---|---|---|---|---|-----|
| H1: Inadequate risk management practices lead to poor choice of contract strategy |   |   |   |   |   |   |   |   |     |
| H2: Lack of skills results in poor project implementation                         |   |   |   |   |   |   |   |   |     |
| H3: Inadequate documentation of experience leads to poor organisational knowledge | Y | Y |   |   |   |   |   |   |     |
| H4: Poor organisational culture results in resistance to change and innovation    |   |   | Y | Y |   |   |   |   |     |
| H5: Poor interface between designers leads to rework and delay                    |   |   |   |   | Y | Y |   |   |     |
| H6: Poor logistics management practices lead to inventory and movement problems   |   |   |   |   |   |   | Y | Y |     |
| H7: Non-integrative H&S practices lead to injuries and accidents                  |   |   |   |   |   |   |   | Y | Y   |
| H8: Non-integrative quality management practices lead to defects and rework       |   |   |   |   |   |   |   |   | Y Y |

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The inferential statistics presented for all the hypotheses involved the Cronbach's alpha internal reliability test, average inter-item correlation used for correlations, and the test of means against reference constant used for the hypotheses testing. The criteria relative to association, independence, dependence, *p*-value, correlation are explicitly written in Chapter 6 as amplified in Agresti and Franklin (2007: 360-495). However, specific information is required at the stage in order to provide clarity for the presented results. Cronbach's alpha data presented alongside the correlation data show that the individual mean scores recorded in a question can be reliably combined into a single mean. Cronbach alpha is use for combining or summing items in likert-type scales that use each individual item to measure a phenomenon that has an underlying quantitative measurement continuum (Gliem and Gliem, 2003: 82).

According to Yu (2001: 1), the Cronbach alpha coefficient is a measure of squared correlation between observed scores and true scores, that is, it is reliability measured in terms of the ratio of the true score variance to the observed score variance. Reliability that can be measured in terms of stability, equivalence, and consistency is commonly expressed in the form of the 1951 coefficient proposed by Cronbach (Yu, 2001: 1). Though, there is actually no lower limit to the coefficient, Cronbach's alpha reliability coefficient normally ranges between 0.0 and 1.0 (Gliem and Gliem, 2003: 87). In other words, the closer Cronbach's alpha is to 1.0, the greater the internal consistency of the items in the scale, that is, the higher the alpha coefficient, the more reliable the test (Yu, 2001: 3; Gliem and Gliem, 2003: 87). In brief, George and Mallery (2003: 231) provide the following rules of thumb: > .9 - Excellent; > .8 - Good; > .7 - Acceptable; > .6 - Questionable; > .5 - Poor, and < .5 - Unacceptable for interpreting Cronbach's alpha coefficients.

In addition, as empirical research usually aims to compare groups or relationships between variables, a statistical test is performed to see whether the observed difference / relationship between variables,

is statistically significant. This significance is often the result of testing a null hypothesis against an alternative hypothesis with the aim of producing a  $p$ -value as part of the output. In this context, the null hypothesis is a statement that the parameter takes a particular value, which represents no effect; while the alternative hypothesis states that the parameter falls in some alternative range of values, which represents an effect of some type (Agresti and Franklin, 2007: 369). Further, the result of the statistical test is then said to be statistically significant at some predetermined level of significance, which is usually the 5% level. This suggests that the  $p$ -value may be assumed to be less than 0.05 as the smaller the  $p$ -value, the stronger the evidence is against the null hypothesis (Franklin and Agresti, 2007: 369). This statistical significance however, only means that the probability of rejecting the null hypothesis when it is true is very small (less than 0.05) without providing information about the size and practical importance of the difference or relationship between the variables in spite of the fact that Cohen (1990 cited by LeCroy and Krysik, 2007: 243) argued that the primary product of a research inquiry is one of measures of effect size as opposed to measures of  $p$  values. Effect size thus refers to a metric that estimates the size of a treatment effect (Meline and Wang, 2004: 204).

Specifically, LeCroy and Krysik (2007: 243) contend that measures of effect size provide critically different information from alpha levels as they address the practical importance of the results through the assessment of the magnitude of the effect. They support this argument by citing incidences whereby statistically significant results may turn out not to be of practical significance. According to them, one basic misunderstanding in statistical analysis is the thinking that an observed  $p$ -value that is considered highly significant, for example  $p = .0001$ , also reflects a large effect. However, the  $p$ -value simply represents the likelihood that a finding is due to chance or sampling error, and reveals nothing about the size of the effect. In other words, one reason to use effect size measures is that they can assist the researcher to consider the importance of research findings apart from the statistical significance (LeCroy and Krysik, 2007: 243; Meline and Wang, 2004: 204). Indeed, as frequently found in many quantitative survey findings that are undermined by poor sample size, the response rate may lead to statistically non-significant results, which may lead a researcher to erroneously conclude that a finding is of 'no difference', when in fact, an effect size would show that there was a meaningful difference; in effect, what can be gained from using effect sizes in conjunction with  $p$ -values is that researchers learn to resist the common practice of making automatic, anti-null decisions when a  $p$ -value is less than the standard rejection level and pro-null decisions when  $p$ -value is greater than the rejection level (LeCroy and Krysik, 2007: 244).

Meline and Wang (2004: 206) suggest that  $p$ -values cannot be used as an effective vehicle for escaping disagreement and confrontations regarding subjective judgement arising from research results as statistical significance tests have nothing to do with practical significance. They opine that on

the other hand, effect size metrics have everything to do with practical significance, that is, effect size metrics are important avenues for bridging the gap between research and practice.

Nevertheless, it is advisable that effect size interpretations should not be void of measurement considerations such as score reliability (LeCroy and Krysik, 2007: 244), and therefore reliability tables and test of means against a reference constant tables are provided to support the test of each hypothesis in this study. There are other effect size measures; the standardized mean difference known as Cohen's *d* is used in this study. According to LeCroy and Krysik (2007: 245) and Meline and Wang (2004: 205), Cohen's *d* is a measure of treatment magnitude not influenced by sample size; most common method for reporting effect sizes; and the interpretation of their value range between small effect size ( $\leq 0.35$ ), medium effect size ( $\leq 0.65$ ), and large effect size ( $> 0.65$ ). The Cohen's *d* is adopted in this study because when interpretations of the effect size cannot be based on experience from earlier studies with the same dependent variables, the best resource for interpretation of effect size may be Cohen's criteria (Meline and Wang, 2004: 205).

In brief, in terms of this particular study:

The null hypothesis is  $H_0: p = 3$ , and

The alternative hypothesis is  $H_1: p > 3$ .

### **Hypothesis 1:**

***Inconsistent and inadequate risk allocation and management practices lead to inappropriate choice of procurement strategy in the public sector.***

Table 7.60, Table 7.61, Table 7.62 and Table 7.63 present the descriptive statistics and inferential statistics relative to the abovementioned hypothesis. Table 7.60 suggests that the individual MSs of the variables relative to risk allocation strategies can be safely combined into a single mean with a good internal reliability (Cronbach's alpha) of 0.84, and the variables can also be deemed to be correlated with average inter-item correlation of 0.60.

Table 7.60 Reliability for risk allocation strategies variables (Q1)

| Strategies                                             | Valid N | MS   | Std.Dv. | Rank |
|--------------------------------------------------------|---------|------|---------|------|
| Identification of risk avoidance / prevention measures | 11      | 4.09 | 1.2     | 1    |
| Considerations relative to contract pricing strategies | 11      | 3.91 | 1.1     | 2    |
| Cost of risk transferred to project partners           | 11      | 3.55 | 1.7     | 3    |
| Establishment of contingency plans                     | 11      | 3.09 | 1.3     | 4    |
| Incentives to improve project performance              | 10      | 2.70 | 1.8     | 5    |
| Cronbach alpha: 0.84                                   |         |      |         |      |
| Average inter-item correlation: 0.60                   |         |      |         |      |

It should be noted that in this table and subsequent tables used for hypotheses related explanations, the concept of valid number refers to the actual responses recorded for each question. Table 7.61 suggests that the individual MSs of the variables relative to procurement criteria can be safely combined into a single mean with a good internal reliability (Cronbach's alpha) of 0.80, and the variables can also be deemed to be correlated with average inter-item correlation of 0.58.

Table 7.61 Reliability for procurement criteria variables (Q2)

| Criteria                                               | Valid N | MS   | Std.Dv. | Rank |
|--------------------------------------------------------|---------|------|---------|------|
| Design responsibility and accountability               | 11      | 4.00 | 1.5     | 1    |
| Project certainty relative to cost, quality, and time  | 11      | 3.82 | 1.3     | 2    |
| Legislation relative to preferential procurement (BEE) | 11      | 3.82 | 1.5     | 3    |
| Project complexity relative to constructability        | 11      | 3.55 | 1.5     | 4    |
| Attitudes to risks transfer                            | 10      | 3.00 | 1.5     | 5    |
| Cronbach alpha: 0.80                                   |         |      |         |      |
| Average inter-item correlation: 0.58                   |         |      |         |      |

Table 7.62 suggests that the individual MSs of the variables relative to misallocation of project risks can be safely combined into a single mean with a questionable internal reliability (Cronbach's alpha) of 0.66, and the variables can also be deemed correlated with average inter-item correlation of 0.31.

Table 7.62 Reliability for misallocation of project risks variables (Q3)

| Situations                                      | Valid N | MS   | Std.Dv. | Rank |
|-------------------------------------------------|---------|------|---------|------|
| Delay in project completion                     | 37      | 3.86 | 0.9     | 1    |
| Increased total project cost                    | 37      | 3.84 | 1.0     | 2    |
| Delay in award of the tender                    | 36      | 3.64 | 1.4     | 3    |
| Likelihood of disputes between project partners | 37      | 3.43 | 1.1     | 4    |
| High amount devoted to contingency plans        | 37      | 3.19 | 1.1     | 5    |
| Cronbach alpha: 0.66                            |         |      |         |      |
| Average inter-item correlation: 0.31            |         |      |         |      |

Table 7.63 presents the test of means against reference constant relative to hypothesis 1. It is notable that for all such tables, the mean is the combined mean score of variables relative to the question, Std. Dv. is the standard deviation for the mean, number is the number of recorded responses relative to the question, RC is the reference constant, t-value is the single tail test statistics, df is the difference in number, the *p*-value is the probability that the test statistics equals the observed value, and Cohen's *d* is the effect size value and ranges. Therefore, based on the statistics in Table 7.63, it can be assumed that for hypothesis 1:

- In terms of Q1, the mean is not significantly greater than the reference constant, hence  $H_0$  cannot be rejected and  $H_1$  also cannot be accepted;
- In terms of Q2, the mean is not significantly greater than the reference constant, hence  $H_0$  cannot be rejected and  $H_1$  also cannot be accepted, and
- In terms of Q3, the mean is significantly greater than the reference constant, hence  $H_0$  can be deemed rejected, while  $H_1$  can be deemed accepted.

However, the Cohen's d effect size measure indicates that though the significance test statistics for Q1 and Q2 are not so favourable, the result has a medium effect size with Cohen's d values of 0.44 and 0.60 respectively. It is equally notable that the results for Q3 have large effect size measures with Cohen's d value of 0.80. In other words, in spite of the statistical test non-significance status of Q1 and Q2, all the results relative to hypothesis 1 are of medium and large practical importance. Therefore, in order to interpret the results in the right perspective, it is necessary to state  $H_0$  and  $H_1$  in practical terms.

$H_0$  = *Inconsistent and inadequate risk allocation and management practices do not lead to inappropriate choice of procurement strategy in the public sector.*

$H_1$  = *Inconsistent and inadequate risk allocation and management practices lead to inappropriate choice of procurement strategy in the public sector.*

Consequently, Table 7.63 indicates that inconsistent and inadequate risk allocation and management practices may indeed lead to inappropriate choice of procurement strategy in South African's public sector departments responsible for the delivery of infrastructure met for service delivery.

Table 7.63 Test of means against reference constant (value) relative to hypothesis 1

| Question | Mean | Std.Dv. | Number | RC | t-value | df | p-value | Cohen's d |
|----------|------|---------|--------|----|---------|----|---------|-----------|
| Q1_ave   | 3.48 | 1.10    | 11     | 3  | 1.46    | 10 | 0.17558 | 0.44 M    |
| Q2_ave   | 3.66 | 1.09    | 11     | 3  | 2.00    | 10 | 0.07378 | 0.60 M    |
| Q3_ave   | 3.59 | 0.73    | 37     | 3  | 4.87    | 36 | 0.00002 | 0.80 L    |

## Hypothesis 2:

*The lack of infrastructure delivery management skills within the public sector result in poor implementation of construction procurement strategies.*

Table 7.64 Reliability for skills shortages in public sector variables (Q10)

| Situations                                       | Valid N | MS   | Std.Dv. | Rank |
|--------------------------------------------------|---------|------|---------|------|
| Decision-making relative to procurement strategy | 26      | 4.23 | 0.8     | 1    |
| Delay in payments relative to executed tasks     | 28      | 4.07 | 0.9     | 2    |
| Poor establishment of what is to be procured     | 28      | 4.00 | 1.2     | 3    |
| Poor implementation of procurement strategy      | 28      | 3.93 | 1.2     | 4    |
| Increased total project cost                     | 28      | 3.93 | 1.4     | 5    |
| Unclear contract / procurement documentation     | 28      | 3.86 | 1.2     | 6    |
| Delay in contract award after tender submission  | 28      | 3.79 | 1.3     | 7    |
| Scope changes, claims, and variations            | 28      | 3.57 | 1.4     | 8    |
| Cronbach alpha: 0.83                             |         |      |         |      |
| Average inter-item correlation: 0.41             |         |      |         |      |

Table 7.64 and Table 7.65 present the descriptive statistics and inferential statistics relative to the abovementioned hypothesis. Table 7.73 suggests that the individual MSs of the variables relative to skills shortages in public sector departments that are responsible for project delivery can be safely combined into a single mean with a good internal reliability (Cronbach's alpha) of 0.83, and the variables can also be deemed correlated with average inter-item correlation of 0.41.

Therefore, based on the statistics in Table 7.65, it can be assumed that for hypothesis 2 in terms of Q10, the mean is significantly greater than the reference constant, hence  $H_0$  can be deemed rejected, while  $H_1$  can be deemed accepted.

It is notable that the results for Q10 have large effect size with Cohen's d value of 1.00. In other words, the results relative to hypothesis 2 are of large practical importance. Therefore, in order to interpret the results in the right perspective, it is crucial to state  $H_0$  and  $H_1$  in practical terms.

$H_0$  = the lack of infrastructure delivery management skills within the public sector does not result in poor implementation of construction procurement strategies.

$H_1$  = the lack of infrastructure delivery management skills within the public sector result in poor implementation of construction procurement strategies.

Consequently, Table 7.74 suggests that the lack of infrastructure delivery management skills within the public sector may indeed result in poor implementation of construction procurement.

Table 7.65 Test of means against reference constant (value) relative to hypothesis 2

| Question | Mean | Std.Dv. | Number | RC | t-value | df | p-value | Cohen's d |
|----------|------|---------|--------|----|---------|----|---------|-----------|
| Q10_ave  | 3.91 | 0.90    | 28     | 3  | 5.30    | 27 | 0.00001 | 1.00 L    |

### Hypothesis 3:

#### *Inadequate documentation and transfer of experiences and performance result in low organisational knowledge, learning, and transfer.*

Table 7.66, Table 7.67, and Table 7.68 present the descriptive statistics and inferential statistics relative to the abovementioned hypothesis. Table 7.66 suggests that the individual mean scores of the variables relative to inadequate documentation and transfer of knowledge can be safely combined into a single mean with a good internal reliability (Cronbach's alpha) of 0.81, and the variables can also be deemed to be correlated with average inter-item correlation of 0.47.

Table 7.66 Reliability for inadequate documentation and transfer of knowledge variables (Q4)

| Practices / Situations                               | Valid N | MS   | Std.Dv. | Rank |
|------------------------------------------------------|---------|------|---------|------|
| Poor information management                          | 54      | 3.74 | 1.1     | 1    |
| Lack of mentorship programmes                        | 53      | 3.53 | 1.0     | 2    |
| Poor allocation of resources to knowledge capture    | 51      | 3.51 | 1.1     | 3    |
| Lack of post project reviews / reports               | 53      | 3.49 | 1.2     | 4    |
| Lack of detailed databases relative to past projects | 54      | 3.39 | 1.1     | 5    |
| Cronbach alpha: 0.81                                 |         |      |         |      |
| Average inter-item correlation: 0.47                 |         |      |         |      |

Table 7.67 suggests that the individual MSs of the variables relative to risk allocation strategies can be safely combined into a single mean with an excellent internal reliability (Cronbach's alpha) of 0.92, and the variables can also be deemed to be correlated with average inter-item correlation of 0.59.

Table 7.67 Reliability for effect of improper documentation and transfer of knowledge variables (Q5)

| Situations                                                | Valid N | MS   | Std.Dv. | Rank |
|-----------------------------------------------------------|---------|------|---------|------|
| Inability to tackle risks / uncertainties effectively     | 53      | 3.68 | 1.1     | 1    |
| Inability to disseminate 'best practices'                 | 53      | 3.68 | 1.1     | 2    |
| Repetition of past project mistakes                       | 53      | 3.64 | 1.1     | 3    |
| Inability to innovate and respond to clients' needs       | 52      | 3.63 | 1.0     | 4    |
| Ineffective problem solving capabilities                  | 54      | 3.59 | 1.2     | 5    |
| Lost opportunities to improve project performance         | 52      | 3.58 | 1.1     | 6    |
| Poor response to organisational and project changes       | 52      | 3.56 | 1.1     | 7    |
| Loss of contractor, subcontractor / supplier track record | 53      | 3.29 | 1.2     | 8    |
| Cronbach alpha: 0.92                                      |         |      |         |      |
| Average inter-item correlation: 0.59                      |         |      |         |      |

Therefore, based on the statistics in Table 7.68, it can be assumed that for hypothesis 3:

- In terms of Q4, the mean is significantly greater than the reference constant, hence  $H_0$  can be deemed rejected, while  $H_1$  can be deemed accepted, and

- In terms of Q5, the mean is significantly greater than the reference constant, hence  $H_0$  can be deemed rejected, while  $H_1$  can be deemed accepted.

It is equally notable that the results for Q4 and Q5 have medium effect size measures with Cohen's  $d$  value of 0.65 and 0.63 respectively. In other words, all the results relative to hypothesis 3 are of medium practical importance. Therefore, in order to interpret the results in the right perspective, it is necessary to state  $H_0$  and  $H_1$  in practical terms.

$H_0$  = *Inadequate documentation and transfer of experiences and performance do not result in low organisational knowledge, learning, and transfer.*

$H_1$  = *Inadequate documentation and transfer of experiences and performance result in low organisational knowledge, learning, and transfer.*

Consequently, Table 7.68 suggests that inadequate documentation and transfer of experiences and performance may actually result in low organisational knowledge, learning, and transfer.

Table 7.66 Test of means against reference constant (value) relative to hypothesis 3

| Question | Mean | Std.Dv. | Number | RC | t-value | df | p-value | Cohen's d |
|----------|------|---------|--------|----|---------|----|---------|-----------|
| Q4_ave   | 3.54 | 0.83    | 54     | 3  | 4.77    | 53 | 0.00001 | 0.65 M    |
| Q5_ave   | 3.57 | 0.91    | 54     | 3  | 4.60    | 53 | 0.00003 | 0.63 M    |

#### Hypothesis 4:

***Inappropriate organisational culture among project partners leads to resistance to change and innovation in the construction supply chain.***

Table 7.69 Reliability for inappropriate organisational culture variables (Q11)

| Practices                                          | Valid N | MS   | Std.Dv. | Rank |
|----------------------------------------------------|---------|------|---------|------|
| Poor analysis of issues and their impact           | 40      | 3.60 | 1.1     | 1    |
| Lack of trust within project teams                 | 42      | 3.52 | 1.3     | 2    |
| Apathy toward idea generation and evaluation       | 39      | 3.38 | 1.3     | 3    |
| Closed one-directional communication mediums       | 40      | 3.34 | 1.2     | 4    |
| Non-inclusive decision-making within project teams | 41      | 3.33 | 1.2     | 5    |
| Improper worker motivation and empowerment         | 38      | 3.32 | 1.2     | 6    |
| Cronbach alpha: 0.90                               |         |      |         |      |
| Average inter-item correlation: 0.60               |         |      |         |      |

Table 7.69, Table 7.70, and Table 7.71 present the descriptive statistics and inferential statistics relative to the abovementioned hypothesis. Table 7.69 suggests that the individual MSs of the variables relative to inappropriate organisational culture can be safely combined into a single mean

with an excellent internal reliability (Cronbach's alpha) of 0.90, and the variables can also be deemed to be correlated with average inter-item correlation of 0.60. Table 7.70 suggests that the individual MSs of the variables relative to the effect of inappropriate organisational culture can be safely combined into a single mean with a good internal reliability (Cronbach's alpha) of 0.87, and the variables can also be deemed correlated with average inter-item correlation of 0.46.

Table 7.70 Reliability for effect of inappropriate organisational culture variables (Q12)

| Situations                                              | Valid N | MS   | Std.Dv. | Rank |
|---------------------------------------------------------|---------|------|---------|------|
| Inadequate site relationship management                 | 41      | 3.60 | 1.1     | 1    |
| Poor problem identification and resolution              | 40      | 3.56 | 1.2     | 2    |
| Poor harnessing of skills within project teams          | 40      | 3.43 | 1.2     | 3    |
| Organisational stagnation / failure                     | 39      | 3.41 | 1.3     | 4    |
| Increased resistance to change                          | 40      | 3.28 | 1.1     | 5    |
| Customer / Client dissatisfaction                       | 39      | 3.26 | 1.2     | 6    |
| Employee dissatisfaction                                | 41      | 3.23 | 1.2     | 7    |
| Poor handling of social issues associated with projects | 39      | 3.22 | 1.2     | 8    |
| Cronbach alpha: 0.87                                    |         |      |         |      |
| Average inter-item correlation: 0.46                    |         |      |         |      |

Therefore, based on the statistics in Table 7.71, it can be assumed that for hypothesis 4:

- In terms of Q11, the mean is significantly greater than the reference constant, hence  $H_0$  can be deemed rejected, while  $H_1$  can be deemed accepted, and
- In terms of Q12, the mean is significantly greater than the reference constant, hence  $H_0$  can be deemed rejected, while  $H_1$  can be deemed accepted.

It is notable that the results for Q11 and Q12 have medium effect size measures with Cohen's d value of 0.47 and 0.45 respectively. In other words, all the results relative to hypothesis 4 are of medium practical importance. Therefore, in order to interpret the results in the right perspective, it is necessary to state  $H_0$  and  $H_1$  in practical terms.

$H_0$  = *Inappropriate organisational culture among project partners does not lead to resistance to change and innovation in the construction supply chain.*

$H_1$  = *Inappropriate organisational culture among project partners leads to resistance to change and innovation in the construction supply chain.*

Consequently, Table 7.71 suggests that inappropriate organisational culture among project partners leads to resistance to change and innovation in the construction supply chain.

Table 7.71 Test of means against reference constant (value) relative to hypothesis 4

| Question | Mean | Std.Dv. | Number | RC | t-value | df | p-value | Cohen's d |
|----------|------|---------|--------|----|---------|----|---------|-----------|
| Q11_ave  | 3.46 | 0.99    | 42     | 3  | 3.02    | 41 | 0.00430 | 0.47 M    |
| Q12_ave  | 3.37 | 0.83    | 41     | 3  | 2.90    | 40 | 0.00600 | 0.45 M    |

#### Hypothesis 5:

***Poor interface between multidisciplinary design advisor / consultants lead to delay and rework relative to construction activities.***

Table 7.72, Table 7.73, and Table 7.74 present the descriptive statistics and inferential statistics relative to the abovementioned hypothesis. Table 7.72 suggests that the individual MSs of the variables relative to poor multidisciplinary interface between consultants can be safely combined into a single mean with a questionable internal reliability (Cronbach's alpha) of 0.65, and the variables can also be deemed correlated with average inter-item correlation of 0.28.

Table 7.72 Reliability for poor multidisciplinary interface between consultants' variables (Q13)

| Practices                                       | Valid N | MS   | Std.Dv. | Rank |
|-------------------------------------------------|---------|------|---------|------|
| Unequal design expertise                        | 11      | 4.00 | 0.6     | 1    |
| Change in personnel during the project duration | 13      | 3.77 | 0.7     | 2    |
| Behavioural tendencies within project teams     | 13      | 3.77 | 0.8     | 3    |
| Commitment to different project objectives      | 11      | 3.73 | 0.9     | 4    |
| Paper transmission of project information       | 12      | 3.33 | 1.0     | 5    |
| Cronbach alpha: 0.65                            |         |      |         |      |
| Average inter-item correlation: 0.28            |         |      |         |      |

Table 7.73 suggests that the individual MSs of the variables relative to the effect of poor multidisciplinary interface between consultants can be safely combined into a single mean with a good internal reliability (Cronbach's alpha) of 0.82, and the variables can also be deemed to be correlated with average inter-item correlation of 0.54.

Table 7.73 Reliability for effect of poor multidisciplinary interface between consultants' variables (Q14)

| Practices                            | Valid N | MS   | Std.Dv. | Rank |
|--------------------------------------|---------|------|---------|------|
| Delay and rework on site             | 13      | 4.38 | 0.8     | 1    |
| Unclear design and specification     | 13      | 4.38 | 0.8     | 2    |
| Extensive revisions of design        | 13      | 4.38 | 0.8     | 3    |
| Constant RFIs from site management   | 12      | 4.17 | 0.8     | 4    |
| Costly design changes                | 12      | 4.08 | 1.0     | 5    |
| Cronbach alpha: 0.82                 |         |      |         |      |
| Average inter-item correlation: 0.54 |         |      |         |      |

Therefore, based on the statistics in Table 7.74, it can be assumed that for hypothesis 5:

- In terms of Q13, the mean is significantly greater than the reference constant, hence  $H_0$  can be deemed rejected, while  $H_1$  can be deemed accepted, and
- In terms of Q14, the mean is significantly greater than the reference constant, hence  $H_0$  can be deemed rejected, while  $H_1$  can be deemed accepted.

It is equally notable that the results for Q13 and Q14 have large effect size measures with Cohen's  $d$  value of 1.41 and 2.14 respectively. In other words, the results relative to hypothesis 5 are of large practical importance. Therefore, in order to interpret the results in the right perspective, it is necessary to state  $H_0$  and  $H_1$  in practical terms.

$H_0$  = *Poor interface between multidisciplinary design advisor / consultants does not lead to delay and rework relative to construction activities.*

$H_1$  = *Poor interface between multidisciplinary design advisor / consultants leads to delay and rework relative to construction activities.*

Consequently, Table 7.74 suggests that poor interface between multidisciplinary design advisor / consultants lead to delay and rework relative to construction activities in South African construction.

Table 7.74 Test of means against reference constant (value) relative to hypothesis 5

| Question | Mean | Std.Dv. | Number | RC | t-value | df | p-value | Cohen's d |
|----------|------|---------|--------|----|---------|----|---------|-----------|
| Q13_ave  | 3.72 | 0.51    | 13     | 3  | 5.08    | 12 | 0.00027 | 1.41 L    |
| Q14_ave  | 4.28 | 0.60    | 13     | 3  | 7.72    | 12 | 0.00001 | 2.14 L    |

#### Hypothesis 6:

***Inefficient and unstable logistics management leads to haphazard processing of orders, storage of materials, and poor inventory management.***

Table 7.75, Table 7.76, and Table 7.77 present the descriptive statistics and inferential statistics relative to the abovementioned hypothesis. Table 7.76 suggests that the individual MSs of the variables relative to inadequate management of logistics can be safely combined into a single mean with an acceptable internal reliability (Cronbach's  $\alpha$ ) of 0.77, and the variables can also be deemed correlated with average inter-item correlation of 0.39.

Table 7.75 Reliability for inadequate management of logistics variables (Q15)

| Practices                                                | Valid N | MS   | Std.Dv. | Rank |
|----------------------------------------------------------|---------|------|---------|------|
| Lack of site management competence relative to logistics | 13      | 4.46 | 0.8     | 1    |
| Lack of formal training relative to logistics            | 13      | 4.00 | 0.9     | 2    |
| Poor site material flow management                       | 14      | 3.93 | 0.7     | 3    |
| Poor work schedule control                               | 14      | 3.86 | 0.7     | 4    |
| Poor material supply, storage, and handling              | 14      | 3.50 | 0.8     | 5    |
| Poor infrastructure and equipment location               | 14      | 3.50 | 1.3     | 6    |
| Poor site layout                                         | 14      | 2.79 | 1.2     | 7    |
| Cronbach alpha: 0.77                                     |         |      |         |      |
| Average inter-item correlation: 0.39                     |         |      |         |      |

Table 7.76 suggests that the individual MSs of the variables relative to the effect of inadequate management of logistics can be safely combined into a single mean with a good internal reliability (Cronbach's alpha) of 0.83, and the variables can also be deemed correlated with average inter-item correlation of 0.42.

Table 7.76 Reliability for effect of inadequate management of logistics variables (Q16)

| Situations                                            | Valid N | MS   | Std.Dv. | Rank |
|-------------------------------------------------------|---------|------|---------|------|
| Poor quality and time management                      | 14      | 4.43 | 0.6     | 1    |
| Added cost in the project                             | 14      | 4.29 | 0.9     | 2    |
| Under utilisation of construction vehicles            | 14      | 4.14 | 0.8     | 3    |
| Material loss due to defects and theft                | 14      | 4.07 | 0.9     | 4    |
| High level of construction waste on site              | 14      | 4.07 | 1.1     | 5    |
| Added risks relative to H&S                           | 14      | 3.64 | 1.1     | 6    |
| Poor image of the industry in terms of climate change | 11      | 3.45 | 1.1     | 7    |
| Long material off-loading time on site                | 14      | 3.29 | 1.2     | 8    |
| Cronbach alpha: 0.83                                  |         |      |         |      |
| Average inter-item correlation: 0.42                  |         |      |         |      |

Therefore, based on the statistics in Table 7.77, it can be assumed that for hypothesis 6:

- In terms of Q15, the mean is significantly greater than the reference constant, hence  $H_0$  can be deemed rejected, while  $H_1$  can be deemed accepted, and
- In terms of Q16, the mean is significantly greater than the reference constant, hence  $H_0$  can be deemed rejected, while  $H_1$  can be deemed accepted.

It is notable that the results for Q15 and Q16 have large effect size measures with Cohen's d value of 1.10 and 1.51 respectively. In other words, the results relative to hypothesis 6 are of large practical importance. Therefore, in order to interpret the results in the right perspective, it is necessary to state  $H_0$  and  $H_1$  in practical terms.

$H_0$  = *Inefficient and unstable logistics management does not lead to haphazard processing of orders, storage of materials, and poor inventory management.*

$H_1$  = *Inefficient and unstable logistics management leads to haphazard processing of orders, storage of materials, and poor inventory management.*

Consequently, Table 7.77 suggests that inefficient and unstable logistics management may actually lead to haphazard processing of orders, storage of materials, and poor inventory management.

Table 7.77 Test of means against reference constant (value) relative to hypothesis 6

| Question | Mean | Std.Dv. | Number | RC | t-value | df | p-value | Cohen's d |
|----------|------|---------|--------|----|---------|----|---------|-----------|
| Q15_ave  | 3.69 | 0.63    | 14     | 3  | 4.10    | 13 | 0.00126 | 1.10 L    |
| Q16_ave  | 3.99 | 0.66    | 14     | 3  | 5.64    | 13 | 0.00008 | 1.51 L    |

### Hypothesis 7:

***Unacceptable coordination and regard for H&S upstream and downstream of the construction supply chain results in recurrent accidents, injuries, and ill-health on construction site.***

Table 7.78, Table 7.79, and Table 7.80 present the descriptive statistics and inferential statistics relative to the abovementioned hypothesis. Table 7.78 suggests that the individual MSs of the variables relative to unacceptable coordination and regard for H&S can be safely combined into a single mean with an excellent internal reliability (Cronbach's alpha) of 0.91, and the variables can also be deemed to be correlated with average inter-item correlation of 0.68.

Table 7.78 Reliability for unacceptable coordination and regard for H&S variables (Q6)

| Practices                                       | Valid N | MS   | Std.Dv. | Rank |
|-------------------------------------------------|---------|------|---------|------|
| Inadequate knowledge relative to nature of work | 51      | 3.76 | 1.1     | 1    |
| H&S competence of project participants          | 52      | 3.60 | 1.2     | 2    |
| Collective organisation values relative to H&S  | 49      | 3.43 | 1.3     | 3    |
| H&S management procedures / systems             | 52      | 3.35 | 1.4     | 4    |
| Poor comprehension of project characteristics   | 49      | 3.27 | 1.2     | 5    |
| Cronbach alpha: 0.91                            |         |      |         |      |
| Average inter-item correlation: 0.68            |         |      |         |      |

Table 7.79 suggests that the individual MSs of the variables relative to the effect of unacceptable coordination and regard for H&S can be safely combined into a single mean with an excellent internal reliability (Cronbach's alpha) of 0.93, and the variables can also be deemed to be properly correlated with average inter-tem correlation of 0.76.

Table 7.79 Reliability for effect of unacceptable coordination and regard for H&S variables (Q7)

| Situations                                         | Valid N | MS   | Std.Dv. | Rank |
|----------------------------------------------------|---------|------|---------|------|
| Ineffective H&S monitoring and inspection          | 52      | 3.40 | 1.4     | 1    |
| Poor status of H&S within the construction process | 52      | 3.27 | 1.5     | 2    |
| Work stoppages, injuries, and fatalities           | 52      | 3.23 | 1.5     | 3    |
| Lack of project specific H&S specification         | 52      | 3.13 | 1.3     | 4    |
| Lack of project specific H&S plan                  | 52      | 3.10 | 1.3     | 5    |
| Cronbach alpha: 0.93                               |         |      |         |      |
| Average inter-item correlation: 0.76               |         |      |         |      |

Therefore, based on the statistics in Table 7.80, it can be assumed that for hypothesis 7:

- In terms of Q6, the mean is significantly greater than the reference constant, hence  $H_0$  can be deemed rejected, while  $H_1$  can be deemed accepted, and
- In terms of Q7, the mean is not significantly greater than the reference constant, hence  $H_0$  cannot be deemed rejected, and  $H_1$  cannot also be deemed accepted.

It is equally notable that while the results for Q6 have medium effect size measures with Cohen's d value of 0.48, the results for Q7 have small effect size measures with Cohen's d value of 0.19. In other words, the results relative to hypothesis 7 are of medium and small practical importance. Specifically, results for Q6 indicates that it is statistically significant and practically important, while that of Q7 indicates that it is statistically non-significant and also of small practical importance. Therefore, in order to interpret the results in the right perspective, it is necessary to state  $H_0$  and  $H_1$  in practical terms.

$H_0$  = Unacceptable coordination and regard for H&S upstream and downstream of the construction supply chain does not result in recurrent accidents, injuries, and ill-health on construction site.

$H_1$  = Unacceptable coordination and regard for H&S upstream and downstream of the construction supply chain may indeed result in recurrent accidents, injuries, and ill-health on construction site.

Consequently, Table 7.80 suggests that unacceptable coordination and regard for H&S upstream and downstream of the construction supply may or may not result in recurrent accidents, injuries, and ill-health on construction sites. Perhaps, there are other contributing factors to the occurrence of poor H&S on construction sites. Nevertheless, Q6 suggests that unacceptable coordination and regard for H&S upstream and downstream of the construction supply chain may indeed result in recurrent accidents, injuries, and accidents, while Q7 can be deemed to suggest that the results are not conclusive.

Table 7.80 Test of means against reference constant (value) relative to hypothesis 7

| Question | Mean | Std.Dv. | Number | RC | t-value | df | p-value | Cohen's d |   |
|----------|------|---------|--------|----|---------|----|---------|-----------|---|
| Q6_ave   | 3.49 | 1.02    | 52     | 3  | 3.46    | 51 | 0.00110 | 0.48      | M |
| Q7_ave   | 3.23 | 1.23    | 53     | 3  | 1.37    | 52 | 0.17697 | 0.19      | S |

#### Hypothesis 8:

***Inadequate coordination and integration of quality standard requirements within the supply chain result in an unusually high level of defects, rework, and non-conformance relative to quality at construction project completion.***

Table 7.81, Table 7.82, and Table 7.83 present the descriptive statistics and inferential statistics relative to the abovementioned hypothesis.

Table 7.81 Reliability for inadequate management of quality variables (Q8)

| Practices / Situations               | Valid N | MS   | Std.Dv. | Rank |
|--------------------------------------|---------|------|---------|------|
| Poor work procedures / methods       | 54      | 3.89 | 1.1     | 1    |
| Poor understanding of quality        | 54      | 3.85 | 1.3     | 2    |
| Poor project specifications          | 54      | 3.65 | 1.3     | 3    |
| Poor exchange of project information | 54      | 3.52 | 1.2     | 4    |
| Poor project cost and schedule data  | 53      | 3.42 | 1.2     | 5    |
| Cronbach alpha: 0.84                 |         |      |         |      |
| Average inter-item correlation: 0.53 |         |      |         |      |

Table 7.81 suggests that the individual MSs of the variables relative to inadequate management of quality can be safely combined into a single mean with a good reliability (Cronbach's alpha) of 0.84, and the variables can also be deemed to be correlated with average inter-item correlation of 0.53.

Table 7.82 suggests that the individual MSs of the variables relative to the effect of inadequate management of quality can be safely combined into a single mean with a good internal reliability (Cronbach's alpha) of 0.89, and the variables can also be deemed to be correlated with average inter-item correlation of 0.64.

Table 7.82 Reliability for effect of inadequate management of quality variables (Q9)

| Situations                          | Valid N | MS   | Std.Dv. | Rank |
|-------------------------------------|---------|------|---------|------|
| Defects and rework                  | 54      | 4.06 | 1.1     | 1    |
| Increased project duration and cost | 52      | 3.85 | 1.1     | 2    |
| Client dissatisfaction              | 53      | 3.83 | 1.3     | 3    |
| High built asset maintenance cost   | 51      | 3.31 | 1.3     | 4    |
| Injuries and fatalities             | 53      | 2.89 | 1.2     | 5    |

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|                                      |
|--------------------------------------|
| Cronbach alpha: 0.89                 |
| Average inter-item correlation: 0.64 |

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Therefore, based on the statistics in Table 7.83, it can be assumed that for hypothesis 8:

- In terms of Q8, the mean is significantly greater than the reference constant, hence  $H_0$  can be deemed rejected, while  $H_1$  can be deemed accepted, and
- In terms of Q9, the mean is significantly greater than the reference constant, hence  $H_0$  can be deemed rejected, while  $H_1$  can be deemed accepted.

It is equally notable that the results for Q8 have large effect size with Cohen's  $d$  value of 0.73, while Q9 have medium effect size measures with Cohen's  $d$  value of 0.60. In other words, the results relative to hypothesis 8 are of large and medium practical importance. Therefore, in order to interpret the results in the right perspective, it is essential to state  $H_0$  and  $H_1$  in practical terms.

$H_0$  = *Inadequate coordination and integration of quality standard requirements within the supply chain does not result in an unusually high level of defects, rework, and non-conformance relative to quality at construction project completion.*

$H_1$  = *Inadequate coordination and integration of quality standard requirements within the supply chain may result in an unusually high level of defects, rework, and non-conformance relative to quality at construction project completion.*

Consequently, Table 7.83 suggests that inadequate coordination and integration of quality standard requirements within the supply chain may indeed result in an unusually high level of defects, rework, and non-conformance relative to quality at construction project completion.

Table 7.83 Test of means against reference constant (value) relative to hypothesis 8

| Question | Mean | Std.Dv. | Number | RC | t-value | df | p-value | Cohen's d |
|----------|------|---------|--------|----|---------|----|---------|-----------|
| Q8_ave   | 3.67 | 0.92    | 54     | 3  | 5.33    | 53 | 0.00000 | 0.73 L    |
| Q9_ave   | 3.59 | 0.99    | 54     | 3  | 4.40    | 53 | 0.00005 | 0.60 M    |

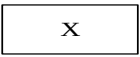
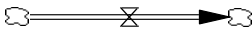
The test of hypotheses through  $p$ -values and effect sizes reveals that in practical importance terms, seven of the research hypotheses are significant, while one hypothesis cannot be said to be practically important. The main advantages of effect sizes are that unlike the statistical significance test, the value is independent of the sample size, they are expressed in standardised units that facilitate comparison across studies, and they also represent the magnitude of the differences that are deemed to be meaningful to researchers (LeCroy and Krysik, 2007: 244).

## 8.0 THE MODEL DEVELOPMENT PROCESS

At the end of the data collection and analysis phase of the study, SD concepts were used for model development based on the debate that SD models provide excellent platforms for eliciting information required for indentifying important managerial problems and their solutions (Gary *et al.*, 2008: 415). In specific terms, Forrester (2007: 355) is of the opinion that SD modelling can organise the descriptive information, retain the richness of real processes, build on the experiential knowledge of managers, and also reveal the variety of dynamic behaviours that follow from different choices of policies.

SD emphasises the design of policies that guide decisions (Forrester, 2007: 355). The proposed models, which were developed with ‘Vensim<sup>®</sup> software’, are mainly based on data generated through empirical investigations conducted in this research, and the researcher’s mental models based on construction site management experiences gained in Nigeria and South Africa. The site management experiences that spanned over seven years, involved roles such as project / construction engineer / site agent on building construction and civil engineering projects. The two basic sources of information used for the proposed models are well known within the SD research community as SD researchers have always drawn on numerical, written, and mental databases to identify system structures, including the stocks and decision-making policies driving related rates of flow that are responsible for the dynamic behaviour of interest (Gary *et al.*, 2008: 416). For the sake of simplicity and easy understanding of the models, the conventions indicated in Table 8.1 were used.

Table 8.1 Conventions used in model development

| Symbol                                                                              | Interpretation                                                                                                  | Reference           |
|-------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|---------------------|
|  | All else equal, if X increases (decreases), then Y increases (decreases) above (below) what it would have been. | Sterman (2000: 139) |
|  | All else equal, if X increases (decreases), then Y decreases (increases) above (below) what it would have been. | Sterman (2000: 139) |
|  | Stock (stock of variable x).                                                                                    | Sterman (2000: 193) |
|  | Source, Flow, Valve (Flow regulator), and Sink.                                                                 | Sterman (2000: 193) |

It is notable that causal loop diagrams (CLDs) that are used for developing the qualitative models are excellent for quickly capturing hypotheses about the causes of dynamics; eliciting and capturing the mental models of individuals or teams; and for communicating the important feedback that is deemed responsible for problems (Sterman, 2000: 137).

The underpinning theme for proposed models is anchored on the need to build compelling explanations for how performance differences arise, persist, and disappear over time with particular emphasis on South African construction. The primary objective of the research is thus underpinned by the need to investigate the dynamics that have seemingly engendered poor project performance in the construction industry in the form of cost and time overruns, which is reportedly due to the menace of NVAAs in construction (Han *et al.*, 2007: 2088).

### **8.1 Qualitative Model: Causes of NVAAs in South African Construction**

Variables with MSs less than 3.40 are excluded from Table 8.2 as they can be deemed to contribute a minor as opposed to a major extent to the occurrences of NVAAs, and by implication poor performance in South African construction. Table 8.2 indicates the respondents' perceptions of the extent to which causes contribute to NVAAs in South African construction in terms of percentage responses to a scale of 1 (minor) to 5 (major), and a MS ranging between 1.00 and 5.00.

Given that the causes of NVAAs that are ranked from first to fifteenth are based on responses from clients, consultants, and contractors that are active in the infrastructure sector, the survey respondents can be deemed to perceive these causes to contribute more of a major than a minor extent to the occurrences of NVAAs in South Africa (Table 8.2). The findings suggest that respondents perceive that lack of appropriately skilled workers; repetitive revisions and changes; delay in design approval; poor planning of construction; late dissemination of information; poor interaction (presumably among consultants); incomplete drawings / designs; bureaucracy; lack of leadership abilities; error in material specifications; unclear design / details; slow response to RFI; poor decision-making abilities; inadequate design information, and unrealistic project execution plan contribute significantly to the malaise.

This suggests that at the very least on a project, the likelihood of occurrence of any of the causes of NVAAs in Table 8.2 may be major as opposed to minor. Relying on the data and common construction project processes, a conceptual qualitative model is herein proposed.

The variables identified in Table 8.2 enabled the development of a qualitative model (Figure 8.1) for a hypothetical project A. In construction, it is normally assumed that the skills of designers determine the standard of designs and specifications compiled for project activities, albeit at varying degrees due to skill / performance-based errors in the form of lapses and slips (Lopez *et al.*, 2010: 400). Skill-based errors relative to lapses and slips that normally arise due to carelessness and neglect may lead to

unanticipated outcomes when diligence is not observed in the execution of tasks (Love *et al.*, 2008: 241). However, when the disruptive tendencies of errors are removed from the execution process, the skills of designers will significantly influence the adequacy of design information (1, 2, 3, and 4 in Figure 8.1). Nevertheless, if the design information provided to contractors is deemed to be adequate by the users, design related NVAAs may become minimal on the project (9 in Figure 8.1).

Table 8.2 Extent to which causes contribute to NVAAs in South African construction

| Causes of NVAAs                       | Response % |                 |      |      |      |      | MS   | Rank |
|---------------------------------------|------------|-----------------|------|------|------|------|------|------|
|                                       | Unsure     | Minor.....Major |      |      |      |      |      |      |
|                                       |            | 1               | 2    | 3    | 4    | 5    |      |      |
| Lack of appropriately skilled workers | 1.2        | 4.7             | 9.3  | 19.8 | 27.9 | 37.2 | 3.85 | 1    |
| Repetitive revisions and changes      | 1.2        | 5.8             | 14.0 | 14.0 | 25.6 | 39.5 | 3.80 | 2    |
| Delay in design approval              | 1.2        | 8.1             | 11.6 | 15.1 | 27.9 | 36.0 | 3.73 | 3    |
| Poor planning of construction         | 1.1        | 4.5             | 12.5 | 21.6 | 33.0 | 27.3 | 3.67 | 4    |
| Late dissemination of information     | 1.1        | 5.7             | 11.5 | 19.5 | 40.2 | 21.8 | 3.62 | 5    |
| Poor interaction                      | 2.3        | 3.5             | 17.4 | 20.9 | 29.1 | 26.7 | 3.60 | 6    |
| Incomplete drawings / designs         | 0.0        | 9.2             | 13.8 | 17.2 | 29.9 | 29.9 | 3.57 | 7    |
| Bureaucracy                           | 2.3        | 8.0             | 17.2 | 18.4 | 25.3 | 28.7 | 3.51 | 8    |
| Lack of leadership abilities          | 0.0        | 2.3             | 14.9 | 29.9 | 35.6 | 17.2 | 3.51 | 9    |
| Error in material specifications      | 1.1        | 11.5            | 14.9 | 14.9 | 28.7 | 28.7 | 3.49 | 10   |
| Unclear design / details              | 1.1        | 6.9             | 13.8 | 24.1 | 34.5 | 19.5 | 3.47 | 11   |
| Slow response to RFI                  | 15.3       | 9.4             | 7.1  | 23.5 | 24.7 | 20.0 | 3.46 | 12   |
| Poor decision-making abilities        | 0.0        | 4.6             | 13.8 | 34.5 | 26.4 | 20.7 | 3.45 | 13   |
| Inadequate design information         | 1.1        | 9.1             | 14.8 | 23.9 | 25.0 | 26.1 | 3.45 | 14   |
| Unrealistic project execution plan    | 1.2        | 10.5            | 12.8 | 23.3 | 26.7 | 25.6 | 3.45 | 15   |

As demonstrated in the construction management literature, design information is often inadequate (Love *et al.*, 2008: 235). Whenever this inadequacy occurs, it can lead to increases in design changes, coordination problems, rework, and in extreme cases fatalities (Lopez *et al.*, 2010: 402). This perceived inadequacy leads to requests for information (RFI) that originate mostly from site management professionals to designers (5 in Figure 8.1). The generated RFIs will unsurprisingly lead to revision of information (6 in Figure 8.1), which may be delayed by bureaucracy and / or approval of design (17 and 18 in Figure 8.1). However, when the revision of information is ready, the design information may be deemed adequate (7 in Figure 8.1). According to Love *et al.* (2008: 236), a significant factor that contributes to the production of poor quality design information is relative to the reluctance of designers to diligently check for errors because of their high job demands. As a result of these shortcomings, revision of information that often increases the likelihood of NVAAs may occur on project A (Love *et al.*, 2008: 239; 8 in Figure 8.1).

Further, the more time project participants spend on NVAAs, the less chance they have to improve their skills (10 in Figure 8.1), that is, it is only by engaging in meaningful activities that may add to the progress of the works (project) and also evolve relevant experiences that translate to skills gained by project participants. Similarly, the level of skills of construction professionals influence their

ability to plan assigned construction work, whereas proper planning of construction decreases NVAAs in the project (15 and 16 in Figure 8.1). Still within the same analogy, the level of skills of foremen / supervisors determines the robustness of their decision-making abilities as well as their ability to lead other workers, which in turn diminished NVAAs in the project (11, 12, 13 and 14 in Figure 8.1).

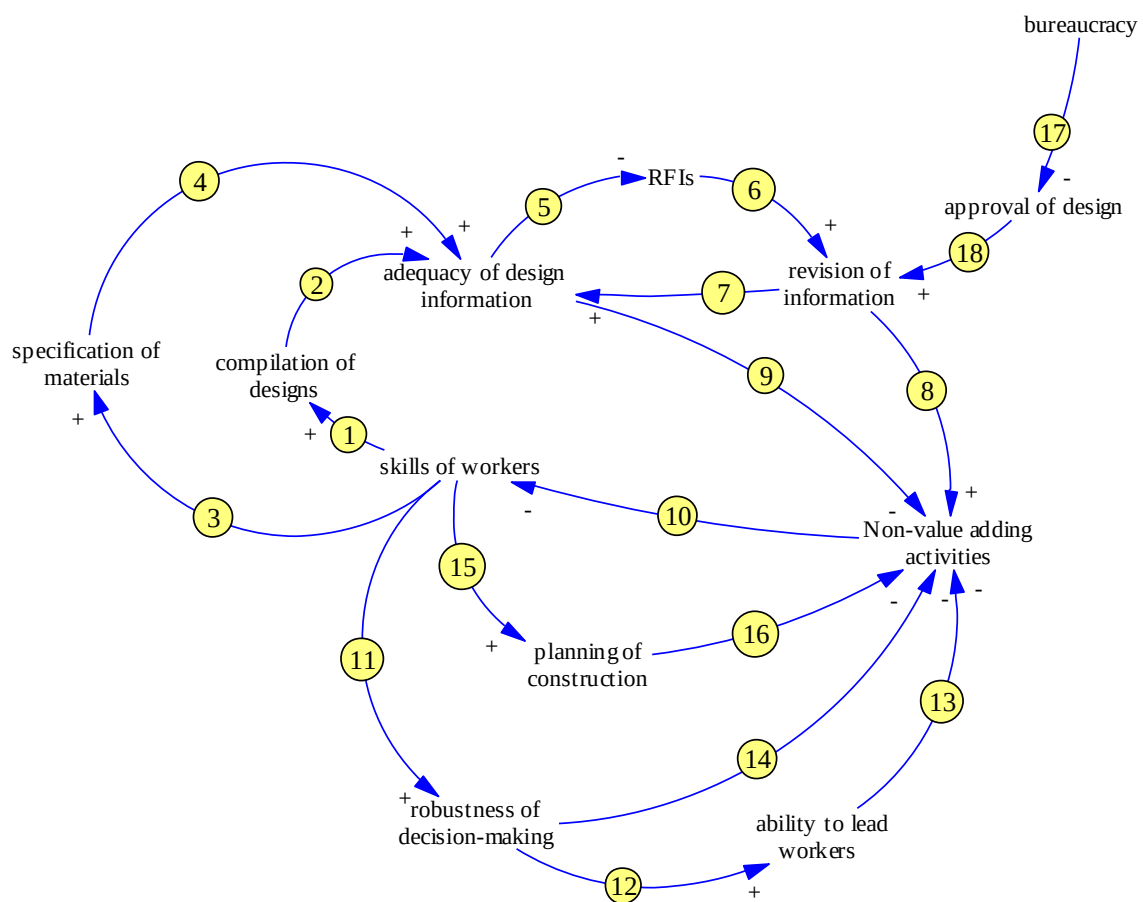


Figure 8.1 Dynamics of the causes of non-value adding activities in South African construction.

## 8.2 Qualitative Model: Extended NVAs Feedback Process Model

Further, it is instructive to note that despite the fact that variables documented in Figure 8.1 may be significant in the South African context, due to the different industry characteristics, they may not be



opinion that reduced productivity, client dissatisfaction, non-conformances, interruptions / disruptions to activity sequence, clash / overlapping of activities, overtime, additional resource allocation, time-space conflict, incidents and accidents, fatigue, and damage to the environment occur rarely or sometimes as a result of NVAAs in South African construction.

Essentially, the table also reveals that quality issues (changes, interruption, and rework in Figure 8.2) as well as productivity issues (productivity, fatigue, overtime, overlapping in Figure 8.2) may arise due to NVAAs in South African construction. Using the same hypothetical project A as an example, and the illustration of Han (2008: 76-78), the proposed extended feedback process model is herein explained. In the proposed model (Figure 8.2), it is important to note that revision of information, bureaucracy, and approval of design that were part of Figure 8.1 are subsumed by changes and rework in Figure 8.2. The thick red coloured arrows that are the new additions to the existing model proposed by Han (2008: 77) only attempted to decrease the occurrence of NVAAs when these causes are adequately addressed. As an illustration, if in project A design information is inadequate, construction is poorly planned, decision-making is inappropriate, and construction workers in the form of foremen / or supervisors cannot lead when they are supposed to do so, then it will not be a surprise if problems associated with cost, time, quality, and H&S begin to consume resources, slow down the progress of work, and in worst case scenarios, marginalise the realisation of project objectives.

Table 8.3 Frequency of consequences of NVAAs in South African construction

| Practices / Issues                               | Response % |                    |      |      |      |      | MS   | Rank |
|--------------------------------------------------|------------|--------------------|------|------|------|------|------|------|
|                                                  | Unsure     | Never ..... Always |      |      |      |      |      |      |
|                                                  |            | 1                  | 2    | 3    | 4    | 5    |      |      |
| Time overruns                                    | 4.5        | 1.1                | 8.0  | 15.9 | 43.2 | 27.3 | 3.92 | 1    |
| Cost overruns                                    | 4.5        | 1.1                | 12.5 | 23.9 | 40.9 | 17.0 | 3.63 | 2    |
| Variations / Claims                              | 0.0        | 2.3                | 17.0 | 29.5 | 33.0 | 18.2 | 3.48 | 3    |
| Reduced productivity                             | 2.3        | 2.3                | 18.2 | 30.7 | 31.8 | 14.8 | 3.40 | 4    |
| Client dissatisfaction                           | 3.4        | 6.8                | 21.6 | 19.3 | 29.5 | 19.3 | 3.34 | 5    |
| Non-conformances                                 | 3.4        | 2.3                | 26.4 | 26.4 | 33.3 | 8.0  | 3.19 | 6    |
| Interruptions / Disruptions to activity sequence | 3.4        | 0.0                | 23.9 | 35.2 | 33.0 | 4.5  | 3.19 | 7    |
| Clash / Overlapping of activities                | 6.8        | 2.3                | 17.0 | 40.9 | 27.3 | 5.7  | 3.18 | 8    |
| Overtime                                         | 8.0        | 4.5                | 23.9 | 25.0 | 28.4 | 10.2 | 3.17 | 9    |
| Additional resource allocation                   | 3.4        | 8.0                | 17.0 | 36.4 | 26.1 | 9.1  | 3.12 | 10   |
| Time-space conflict                              | 13.8       | 4.6                | 17.2 | 37.9 | 20.7 | 5.7  | 3.07 | 11   |
| Incidents and accidents                          | 4.5        | 13.6               | 27.3 | 21.6 | 22.7 | 10.2 | 2.88 | 12   |
| Fatigue                                          | 8.0        | 9.1                | 23.9 | 34.1 | 21.6 | 3.4  | 2.85 | 13   |
| Damage to the environment                        | 5.7        | 11.4               | 29.5 | 31.8 | 14.8 | 6.8  | 2.75 | 14   |

Conversely, if in the project the quality of design information is determined to be adequate by the users, construction planning is proper, decisions are consistently robust while construction supervisors / foremen can lead fellow workers properly, then NVAAs may become minimal in the project.

Another key issue emanating from the illustration thus far is the connection between NVAAs and the skills of construction practitioners.

As mentioned earlier, it can be deduced that the total amount of effort consumed in a project is the summation of VAAs, VSAs and NVAAs (Han, 2008: 69-78; 1, 2, and 3 in Figure 8.3). Given the nature of most project environments, it is not unusual to encounter errors during the execution of construction tasks as humans are fallible due to a range of reasons, such as loss of biorhythm and adverse behaviours (Lopez *et al.*, 2010: 402). The moment errors are detected through inspection; they may need to be reworked, which ultimately increases the amount of NVAAs in construction (Han, 2008: 70; 4 and 5 in Figure 8.3). In addition, because rework is usually accompanied by the demolition of what has already been built, construction managers may decide to avoid rework on problematic activities by modifying their design and specification according to Park and Pena-Mora (2003: 216; 6 in Figure 8.3). Further, design change issues can also arise due to different site conditions or the owner's preference. Han (2008: 77) opines that in such a case, RFIs would be sent to the design team, and consequently the process would be interrupted until the requested information is ready for use. These inevitably generate NVAAs as indicated in Figure 8.3 (7 and 8). With respect to errors and changes, Han (2008: 77) showed that they may significantly lower productivity (9 and 10 in Figure 8.3). For instance, if a process is executed with lower productivity than initially planned, the process would require additional time and / or resources that may lead to delays and cost overruns (11 in Figure 8.3).

In addition, Han (2008: 77) contends that when actual progress lags behind the planned progress it is most likely that the construction manager may not overlook the schedule slippage and instead focus on corrective actions in order to keep the process on track. For example, in order to speed up a delayed schedule, overtime policy is mostly adopted as it can result in a higher rate of progress without coordination problems (Hanna *et al.*, 2005: 735). However, overtime policy may introduce additional problems such as fatigue that may result in more errors and productivity loss (Lee *et al.*, 2005: 891; 12, 13, 14, and 15 in Figure 8.3).

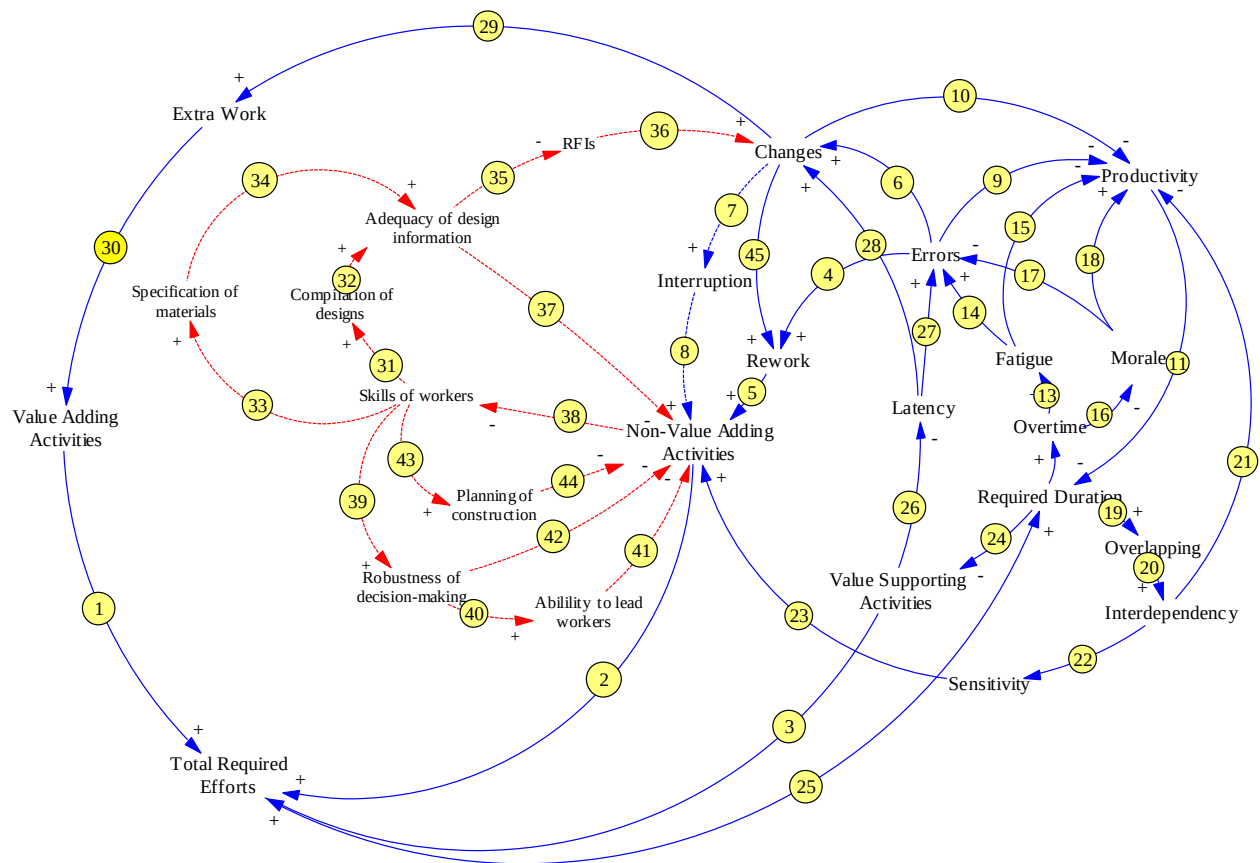


Figure 8.3 Non-value adding activities in construction feedback process model

If not handled carefully, prolonged overtime may decrease workers' morale to the extent that quality and low productivity problems may manifest themselves (Hanna *et al.*, 2005: 735; 16, 17, and 18 in Figure 8.3). Apart from overtime policy, overlapping policy (concurrency) is also often used for schedule acceleration. Han (2008: 78) suggests that while overlapping policy may not lead to fatigue directly, it nevertheless usually increases interdependency with other related processes. In his opinion, the interdependency situation may not only decrease productivity in a given process, but it can also propagate detrimental effects of NVAAs on related processes (19, 20, 21, 22 and 23 in Figure 8.3).

In order to reduce the amount of time required for a particular process, the construction manager may also assign less effort for VSAs such as inspections as they do not really add value to the process (Park and Pena-Mora, 2003: 226). In this case, the construction manager may temporarily decrease the total effort required for the process and may also reduce the duration of the process (3, 24, and 25 in Figure 8.3). However, this may hinder the timely detection of errors and changes, which may result in an additional detrimental impact on project performance due to sensitivity and latency.

In this context, sensitivity refers to an amplifier variable that captures the degree to which a given activity is interdependent on other related activities (Pena-Mora and Li, 2001: 8; Park and Pena-Mora,

2003: 226; Lee *et al.*, 2005: 893). Whereas, latency refers to a delay variable used to capture the time spent in identifying NVAAs, that is, it is the difference in time between the occurrence of an NVAA and when it is addressed (Lee *et al.*, 2005: 894). The reason for the increase due to the explained ‘sensitivity and latency’ is that the longer it takes to identify errors and changes, the more serious is the potential damage (Han, 2008: 78). Therefore, more complex and costly corrective actions may become necessary in order to remedy the situation (Han, 2008: 78; 26, 27, and 28 in Figure 8.3). Explained in this manner, it can be argued that such a feedback mechanism suggests that the amount of NVAAs can be dramatically compounded by error and changes if they are not timely and thoroughly addressed and resolved (Han, 2008: 78-79). In addition, the amount of VAAs (work scope) could be creeping during execution, which also can increase the likelihood of schedule delays and cost overruns (Han, 2008: 79; 29 and 30 in Figure 8.3).

Though, these feedback mechanisms that Han (2008: 77) proposed have identified variables that increase NVAAs in construction projects, nevertheless the model is arguably extendable since SD models are mostly developed in a robust manner so as to accommodate future considerations. Therefore, variables coloured in red dash arrows were introduced into the model in order to explicitly include the influences and / or effects that ‘competence’ has on NVAAs. As aforesaid, in construction it is not unusual to assume that to a large extent the skills of designers such as architects or engineers, determine the standard of designs and specifications compiled for project activities, which in turn influence the adequacy of design information (31, 32, 33, and 34 in Figure 8.3). If the design information is deemed adequate then design related NVAAs is minimal on the project (37 in Figure 8.3). However, as demonstrated in construction management literature, design information is often inadequate (Love *et al.*, 2008: 235). This perceived inadequacy eventually leads to RFIs from construction sites (35 in Figure 8.3). The generated RFIs will unsurprisingly lead to changes (36 in Figure 8.3), which eventually lead to rework (45 in Figure 8.3). If the design information is adequate there may not be the need for an RFI (37 in Figure 8.3). However, when due diligence is not observed in the execution of tasks, skills of designers will often not be enough to ensure the realisation of anticipated outcomes (Lopez *et al.*, 2010: 400).

The more time project participants expend on NVAAs decreases their chances of partaking in VAAs repeatedly so much so that opportunities to improve their skills may become eventually elusive to them (38 in Figure 8.3), that is, it is the engagement in meaningful activities (VAAs) that adds to relevant experience and knowledge, which in turn potentially translates to improved skills. Similarly, the level of skills of construction professionals determines their ability to plan assigned construction work, as proper planning of construction decreases NVAAs in the project (43 and 44 in Figure 8.3).

The level of skills of workers also influences the robustness of their decision-making abilities as well as their ability to lead other workers, a situation which may in turn diminish NVAAs in the project (39, 40, 41 and 42 in Figure 8.3). The added variables may either increase the amount of NVAAs or decrease its amount in construction. The importance of the additional variables (31 to 45 in Figure 8.3) is underpinned by the assumption that the construction process is still largely human resource driven as in developing nations, and by implication the competence of everyone involved in project execution (clients, designers, contractors, and possibly suppliers) is critical for the successful completion of projects regardless of type and / or size. In particular, this is important to the strategic management of projects as astute decisions based on the dynamics influencing performance may assist managers in making sure that construction activities / tasks are completed successfully.

### **8.3 Qualitative Model: NVAAs in South African Construction**

Similar to Table 8.2, variables with MSs less than 3.40 are excluded from Table 8.4 as they can be deemed to contribute a minor, as opposed to a major extent to the occurrence of poor performance in South African construction. Therefore, Table 8.4 indicates the respondents' perceptions of the extent to which NVAAs contribute to poor performance in South African construction in terms of percentage responses to a scale of 1 (minor) to 5 (major), and a MS ranging between 1.00 and 5.00.

Table 8.4 indicates the NVAAs that are ranked first to ninth based on responses from clients, consultants, and contractors that are active in the South African infrastructure sector. The table suggests that respondents perceive that lack of required competencies; inadequate supervision; waiting for critical tasks to be finished; non-conformance of materials to specification; waiting for materials; waiting for instruction / information; rework relative to design; human error / mistake; and poor coordination can be deemed to contribute significantly to poor performance in South African construction. It is however important to note that while not down grading the importance of the other thirty-one NVAAs used as variables in the empirical survey, the results suggest that the likelihood of occurrence of the NVAAs listed in Table 4 impacting on project performance, may be major.

The possibility of poor performance being recorded on a project where these NVAAs are allowed to dominate the process is deemed to be high. Therefore, relying on the data and common construction project processes yet again, a conceptual qualitative model is herein proposed. The model presented in Figure 8.4 is an attempt to highlight the dynamics associated with NVAAs and their ability to either propagate poor performance when they are not properly addressed, or reduce poor performance when they are properly addressed in South African construction.

Table 8.4 Primary NVAAs in South African construction

| Non-value adding activities                   | Response % |                 |      |      |      |      | MS   | Rank |
|-----------------------------------------------|------------|-----------------|------|------|------|------|------|------|
|                                               | Unsure     | Minor.....Major |      |      |      |      |      |      |
|                                               |            | 1               | 2    | 3    | 4    | 5    |      |      |
| Lack of required competencies                 | 0.0        | 2.3             | 8.0  | 18.4 | 31.0 | 40.2 | 3.99 | 1    |
| Inadequate supervision                        | 0.0        | 0.0             | 10.3 | 21.8 | 32.2 | 35.6 | 3.93 | 2    |
| Waiting for critical tasks to be finished     | 1.1        | 6.8             | 13.6 | 19.3 | 26.1 | 33.0 | 3.66 | 3    |
| Non-conformance of materials to specification | 1.1        | 3.4             | 15.9 | 17.0 | 38.6 | 23.9 | 3.64 | 4    |
| Waiting for materials                         | 0.0        | 3.4             | 19.3 | 19.3 | 29.5 | 28.4 | 3.60 | 5    |
| Waiting for instruction / information         | 0.0        | 6.8             | 17.0 | 20.5 | 21.6 | 34.1 | 3.59 | 6    |
| Rework relative to design                     | 1.1        | 13.6            | 11.4 | 15.9 | 23.9 | 34.1 | 3.54 | 7    |
| Human error / mistake                         | 3.4        | 4.6             | 16.1 | 26.4 | 29.9 | 19.5 | 3.45 | 8    |
| Poor coordination of resources                | 2.3        | 5.7             | 15.9 | 25.0 | 33.0 | 18.2 | 3.43 | 9    |

Still on the assumed project A, it is very possible for the accomplishment of assigned critical tasks to be preceded by coordination and supervision of resources as well as conformance to specifications relative to project deliverables such as a ‘concrete slab’ (2 and 3 in Figure 8.4). However, the coordination of resources and the degree of conformance achieved may be dependent on the level of competence of those involved in the process (1 in Figure 8.4). For example, though a ‘plan’ may be acceptable, its execution needs to be attentively followed in order to reap the anticipated results (Love *et al.*, 2008: 244). The availability of required materials may either improve conformance to specifications or decrease conformance to specifications achieved on construction sites (11 in Figure 8.4).

On the other hand, the accomplishment of critical tasks do not only speed up the progress of project implementation, but it may also add to the experiential knowledge of project stakeholders involved in the project as it can form aspects of informal training. In other words, accomplishment of critical tasks may invariably increase the competence of reflective individuals that are among the project team (4 in Figure 8.4). Though, documented reports suggest that the combination of formal education and experiential training determines the competence of individuals, recent research findings suggest that this combination only holds true when both education and training are appropriate (van Wyk, 2008: 23; 10 and 12 in Figure 8.4). In the event that formal education and experiential training fell short of required expectations, then rework relative to designs may occur or avoidable human error may become unavoidable (5 and 8 in Figure 8.4).



NVAAs tend to have feedback processes that may reinforce their intensity and frequency in the construction process; and Figure 8.4 demonstrated the dynamics of NVAAs in South African construction with respect to project performance through the accomplishment of stated project critical tasks (milestones).

The policy implications of the empirical findings for the management of construction projects are threefold. Firstly, clients, in particular public sector clients, should promote objective assignment of construction project procurement / administration / management responsibilities to appropriately skilled and / or competent in-house experts. Secondly, consultants should avoid the use of fresh graduates without the requisite ‘know-how’ to sign-off jobs on construction sites as instead of being viewed as experts on construction sites, their input may be considered immature or not practicable by site management professionals. Thirdly, contractors should place emphasis on both academic and professional development of their existing employees, and also ensure that new recruits are armed with appropriate built environment qualifications to ensure their suitability for their challenging roles in the industry.

In brief, the study concludes that the lack of appropriate skills among construction professionals (artisans and site management employees) increases the amount of NVAAs, which in turn, increases poor project performance recorded in South African construction (Figure 8.5). Therefore, improving construction project performance in South African construction is synonymous with the assignment of project activities to appropriately skilled construction practitioners so as to increase the amount of VAAs, which adds to the progress of the works (Figure 8.6). However, it is arguable that the dynamics that have hindered project performance improvement in South African construction is as indicated in Figure 8.7.

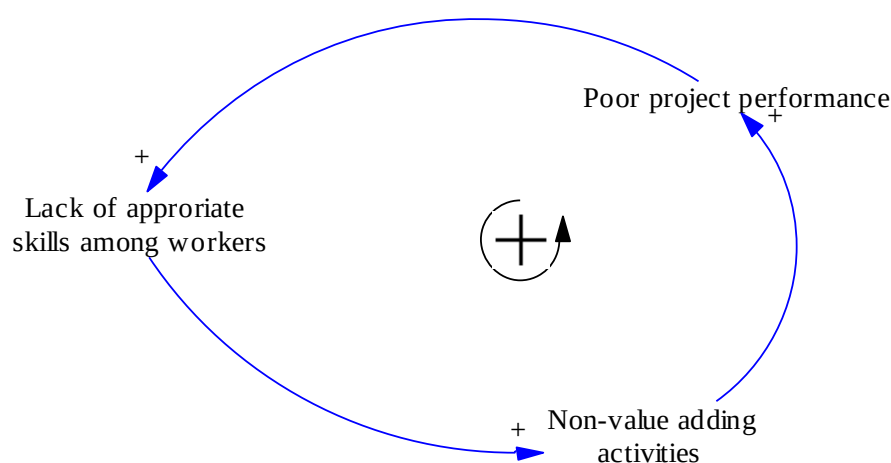


Figure 8.5 Dynamics of poor project performance in South African construction

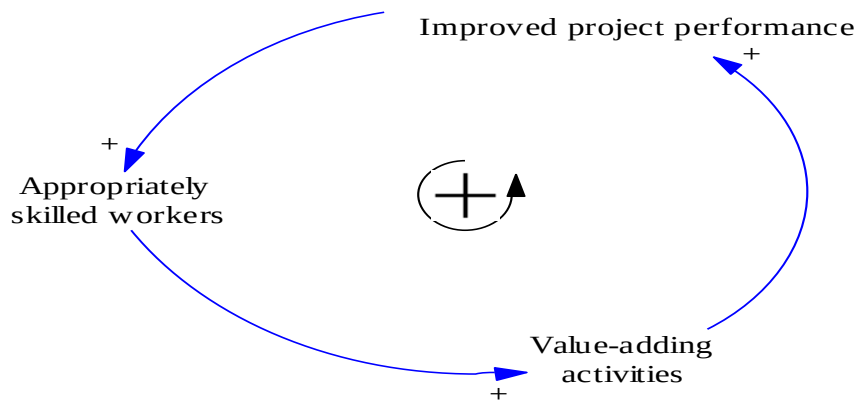


Figure 8.6 Dynamics of improved project performance in South African construction

Consequently, Figure 8.7 proposed that either the increase in skills of project stakeholders can potentially reduce the amount of NVAAs, and promote improved project performance in South Africa, or the lack of skills can also potentially increase the amount of NVAAs, which in turn promote poor performance (reduce improved performance) in South Africa. Though, empirical results show there is substantial variation in mental model accuracy, and that decision makers with more accurate mental models achieve higher performance (Gary *et al.*, 2008: 413), the proposed models nevertheless are deemed to be simple and robust enough to accommodate modifications and extensions that may allow their use for addressing unanticipated future policy resistance.

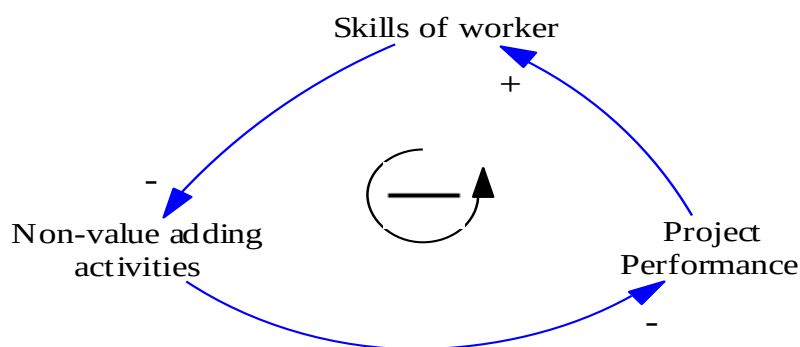


Figure 8.7 Dynamics of the propagation of NVAAs in South African construction

The implications of the research findings and its model development efforts is that though there may be commonality between NVAAs recorded in South African construction and other countries, their frequency and effects on project performance differs. However, these NVAAs can be deemed responsible for and / or contribute to poor performance in construction as the dynamics associated with their existence and propagation ensure that NVAAs become pervasive in the construction process.

### **8.5 Validation: Variable Relationships in models**

A group interview was convened in order to validate the relationships assumed for the model variables. This was done by sending all the models to an engineering consulting firm that focused on infrastructure delivery in South Africa. After studying the models for approximately two weeks, a meeting was held at the Port Elizabeth branch office of the firm with the delegated representative of the firm. In a meeting between the researcher and the firm representative, who is a registered professional engineer with several years of experience spanning civil engineering construction both in the UK and South Africa, a number of conclusions were reached concerning the models.

It is notable that the engineers in the firm perceive that the relationships between all models' variables are plausible in South African infrastructure sector. In particular, relative to Figure 8.1, it is their assumption that adequacy of design information may become the greatest challenge in the industry in years to come. In the words of the interviewee *“RFIs will increase due to inadequate design information due to limited professional fees paid by clients as a result of the tendering process.”* As an illustration, before now the appointment of consultants by clients was not based on competitive tendering, but in recent times that competitive tendering has been introduced into the process after pre-qualification on quality, consultants are offering their services in prices considered too low for a thorough job to be done. This phenomenon manifests itself in inadequate / or inflexible designs / or overdesigns without opportunity for alternatives. In addition, another issue of concern is the incapacity and lack of expertise at local municipalities, which is assumed to be responsible for delays relative to approval of design. According to the perceptions of the interviewee, the lack of technical capacity at local municipalities is due to political interference in what can be deemed purely engineering matters. With respect to Figure 8.1, Figure 8.3, and Figure 8.4, the interviewee contends that competence is the determinate of performance as accurately demonstrated in the models. Further, he is of the opinion that a severe lack of artisans in the industry contributes to the problems experienced on construction sites. This argument is supported by an empirical finding that contends that there is a positive association between construction site management teams and project performance within a specific setting, that is, construction site management teams and good performance are inseparable (Tennant, 2007: 258).

## **9.0 CONCLUSIONS AND RECOMMENDATIONS**

### **9.1 General Conclusions**

This Thesis is presented in chapters that range from 1 to 9, and a number of appendixes (6). Chapter 1 presented the background of the study in the form of sections and sub-sections that include the introduction, South Africa's infrastructure status, South Africa's construction industry performance, the nature of the construction supply chain in South Africa, statement of the problem, the sub-problems and hypotheses, scope of the investigation, assumptions, the importance of the study, and the aims and objectives of the study. In effect, chapter 1 provided the platform for the articulation of identified performance related problems in the South African construction industry, and the need to find robust remedies to the problems.

Chapter 2 of the dissertation is the first chapter that addressed the review of related literature. The literature review spans 4 chapters, namely chapter 2, chapter 3, chapter 4, and chapter 5. Chapter 2 begins by introducing what is met by procurement in the construction industry context, identified procurement options available to clients of the industry in general, enumerated the characteristics, and suitability of cidb approved standard forms of contract for engineering and construction works contracts, and amplified the importance of achieving set project objectives in term of traditional performance parameters of cost, H&S, quality, and time. The amplification eventually introduced a range of concepts or rather enablers that could ensure successful outcomes for construction project procurement. Such enablers include risk allocation and management; availability of critical skills; knowledge management; dynamic organizational culture; synergy between designers; management of construction logistics; co-ordination and respect for construction H&S, and the co-ordination and integration of quality requirements in a project undertaking.

Chapter 3 introduced literature relative to SCM in construction with particular emphasis on the industry structure. Both organisational factors and project factors that contribute to SCM in construction were highlighted; the perception of SCM as a philosophy for innovation and performance improvement was discussed; the ability to apply lean construction principles in the construction SC so as to drive out NVAAs in the process was considered; and key drivers of construction SCM (clients and contractors) were identified and amplified with literatures that emanated from countries where the concepts of SCM have generated interest in the academia and industry.

Chapter 4 presented the conceptual and / or theoretical perspectives underpinning SCM in general, and its introduction, acceptance, rejection, and use in the construction industry. The chapter traced the origins of SCM through the principal component bodies of SC literature, which is located in mainstream manufacturing production systems. The chapter then identified the focus of SCM in the construction context by citing publications advocating for or rejecting SCM in construction; discussed

the basic views of SCM (strategic and operational); shed more light on value drivers of SCM; advocated for the need to manage the construction SC; and support the need to engender improved project performance with a proposed causal network. With the aid of the causal network, conceptual perspectives for improving the project performance were proposed. The central theme in the causal network is the assumption that VAAs realise projects when project parameters of cost, H&S, quality, and time are met, while enablers such as risk allocation and management, skills for project delivery, capture and transfer of knowledge, organizational culture, integrative multidisciplinary advisors interface, logistics management, H&S focus across the supply chain, quality management focus across the SC could influence and / or affect both VAAs and the project parameters either positively or negatively. In addition, reasons for implementing SCM, and removing NVAAs in construction projects were discussed in the chapter. Specifically, literature located in the construction project management domain provided the platform for identifying NVAAs, the causes of these NVAAs, and their impact in construction. Hence, the need to address NVAAs in construction was articulated in the chapter.

Chapter 5 introduced SD as a modelling tool into the thesis. The relevance, advantages, and historical background of SD was provided with particular emphasis on project management. The chapter showed that measured in terms of theory, new and improved model structures, number of applications, and value to clients 'project dynamics' stands as an example of the success of the relatively new field of SD that was pioneered by Jay W. Forrester at MIT's Alfred P. Sloan School of Management between 1957 and 1958. Through project features, the rework cycle, project control, and the ripple and knock-on effects, key attributes of SD were amplified with the aid of key SD models. SD applications in the construction project management domain such as post-mortem assessment for disputes and learning; project estimating and risk assessment; and change management, risk management, and project control were highlighted.

Chapter 6 presented the research primary and secondary data sources, the philosophy underpinning the research, the sampling method, the criteria governing the admissibility of the data, the research method, and the data collection process, the design of the questionnaires, the sample sizes, and the treatment of the data with respect to statistical analysis. The chapter also highlighted the research modelling process that cumulated in the models documented in chapter 8 after the presentation of the results in chapter 7.

Chapter 7 presented the results of the pilot survey, the primary survey that was conducted based on the research objectives, the secondary survey that was conducted based on the postulated hypotheses, and closed with the testing of the research hypotheses through inferential statistics. It is notable that the chapter began by providing background information relative to the response rate to the surveys,

and efforts expended towards increasing the response rate. Then it proceeded by documenting the results of the surveys based on the sequence in which they were carried out and their numbering in each questionnaire used.

Chapter 8 began by providing arguments related to the suitability of SD for modelling the research findings, and then went on to propose three qualitative models. The qualitative models “*dynamics of the causes of non-value adding activities in South African construction*, *non-value adding activities in construction feedback process model*, and *dynamics of non-value adding activities in South African construction*”, documented the feedback processes associated with NVAAs both in South African construction and the international construction industry. Policy recommendations based on the models were used to support the concluding section of the chapter.

## **9.2 Conclusions Relative to Respondents’ General Comments**

According to Table 7.12, Table 7.25, and Table 7.53, a total number of seventy eight general comments were made by respondents during the pilot survey, primary survey, and secondary survey conducted in the study. Of these, forty one are relative to skills shortage challenges (52.6%); thirteen are relative to procurement challenges (16.7%); thirteen are relative to other construction industry issues (16.7%), and eleven are relative to NVAAs in South African construction (14.1%).

It is notable that the skills shortage challenges amplify the need for built environment training and education as well as mentorship of construction professionals in order to improve ‘competence’ and / or project delivery capability in South Africa. The respondents were of the opinion that skills shortages are evident in client, consultant, and contracting organisations with government departments at local government level and emerging contractors cited as the most affected entities in South Africa. In the context of this study, emerging contractors can be referred to small and medium size enterprises that are limited in terms of their capacity to contract due to competency and financial related constraints. This category of contractors can be seen in the cidb register, from grade 1 to 4. Further, the respondents opined that the skills malaise is impacting contract award processes (tendering / procurement) negatively. For example, one respondent rightly said that “*implementing a reduction in lag time between quoting and / or tendering to awarding of contract to overcome various barriers such as increased prices, corruption, and poor planning.*”

Another contentious issue cited in terms of procurement is that of the capacity of BBBEE (otherwise known as emerging) contractors. While one respondent contends that the cidb grading granted to fledgling BBBEE contractors is totally unrealistic, another respondent suggests that specifications and procedures are too complicated for new / young emerging organisations. In effect, what the respondents were saying is that the BBBEE government policy should be examined with particular emphasis on the effects of its implementation on project performance in South Africa.

With respect to other construction industry issues and NVAAs, the majority of the general comments centred on the need to address the cidb grading of contractors, payment delays to contractors, excessive H&S inspections, political appointments, elimination of repetition in processes, and the need to create an industry wide awareness about NVAAs.

### **9.3 Conclusions Relative to the Research Problem Statement**

The research problem statement state that “poor performances relative to cost, H&S, quality, and time in the South Africa construction industry hampers the smooth delivery of infrastructure projects as recurrent NVAAs in the construction process propagates cost overruns that exacerbate budget constraint problems; time overruns / or delay that slow down service delivery; poor quality that increase maintenance cost and shorten design / or service life of infrastructure, and poor H&S that increase incidents, accidents, injuries, and fatalities in the industry.”

The findings arising from the study support the problem statement as poor performances relative to cost, time, quality, and H&S may occur due to the consequences of NVAAs in South African construction (Table 7.15); NVAAs can be deemed to impact time, cost, quality and H&S in South African construction (Table 7.16); and the rating of the performance of the South African construction industry in terms of cost, environment, H&S, quality, and time can be deemed to be between below average to average / average (Table 7.20). Incontrovertibly therefore, there is major scope for performance improvement in South African construction especially with respect to the performance of the aforesaid project parameters. This is particularly important as NVAAs that are deemed to be responsible for poor project performance can be encountered (Table 7.18) in South African construction since their frequency of occurrence is between below average / average (Table 7.19), though respondents’ knowledge relative to NVAAs may be deemed to be between below average / average (Table 7.17).

### **9.4 Conclusions Relative to the Research Hypotheses**

#### **Hypothesis 1:**

***Inconsistent and inadequate risk allocation and management practices lead to inappropriate choice of procurement strategy in the public sector.***

Based upon the research results, it can be concluded that inconsistent and inadequate risk allocation and management practices could lead to inappropriate choice of procurement strategy in the public sector. The descriptive statistics, *inter-alia*, suggest that in terms of risk allocation strategies contributing to the choice of procurement strategy, the identification of risk avoidance / prevention measures; considerations relative to contract pricing strategies; and cost of risk transferred to project partners can be deemed to contribute more of a major as opposed to a minor extent to the choice of

procurement strategy. However, among procurement criteria determining the choice of procurement strategy, design responsibility and accountability; project certainty relative to cost, quality, and time; legislation relative to preferential procurement (BBBEE); and project complexity relative to constructability can be deemed to contribute more of a major than a minor extent to attitudes to risks transfer. Major consequences of misallocation of project risks such as delay in project completion, increase to total project cost, delay in award of tenders, and the likelihood of disputes between project partners provide a platform for altering project stakeholders' attitudes towards risks transfer. Therefore, risk allocation and management practices that influence the choice of procurement strategy in the public sector should be adequately and consistently implemented.

### **Hypothesis 2:**

***The lack of infrastructure delivery management skills within the public sector result in poor implementation of construction procurement strategies.***

The results suggest that the lack of infrastructure delivery management skills within the public sector may indeed result in poor implementation of construction procurement. In particular, the consequences of skills shortages in public sector departments responsible for project delivery are multi-faceted with decision-making relative to procurement strategy affected the most. Other notable consequences include delay in payments relative to executed tasks, poor establishment of what is to be procured, poor implementation of procurement strategy, increased total project cost, unclear contract / procurement documentation, delay in contract award after tender submission, scope changes, claims, and variations. Clearly, the empirical study revealed that the lack of infrastructure delivery management skills within public sector result in poor implementation of construction procurement strategies.

### **Hypothesis 3:**

***Inadequate documentation and transfer of experiences and performance result in low organisational knowledge, learning, and transfer.***

Inadequate documentation and transfer of experiences and performance may actually result in low organisational knowledge, learning, and transfer in South African. In other words, failure to mentor new entrants into the industry, and also failure to learn from past mistakes and best performances do not augur well for South African construction. In terms of practices contributing to inadequate documentation and transfer of knowledge, poor information management, lack of mentorship programmes, poor allocation of resources to knowledge capture, lack of post project reviews / reports, and lack of detailed databases relative to past projects, marginalises project performance in South Africa. Consequences of lack of proper documentation and transfer of knowledge such as inability to tackle risks / uncertainties effectively; inability to disseminate 'best practices'; repetition of past

project mistakes; inability to innovate and respond to clients' needs; ineffective problem solving capabilities; lost opportunities to improve project performance; and poor response to organisational and project changes amplify the need to adequately document and transfer experiences and performances so as to ensure appropriate organisational learning in South African construction.

#### **Hypothesis 4:**

***Inappropriate organisational culture among project partners leads to resistance to change and innovation in the construction supply chain.***

With respect to hypothesis 4, it can be observed that inappropriate organisational culture among project partners leads to resistance to change and innovation in the construction SC. The organisational culture pertaining to the cultures in clients, consultants, contractors, and every other organisation involved in project realisation must be improved. In this sense, the study findings indicate that practices contributing to inappropriate organisational culture include poor analysis of issues and their impact; lack of trust within project teams; apathy toward idea generation and evaluation; closed one-directional communication mediums; non-inclusive decision-making within project teams, and improper worker motivation and empowerment. These practices and others associated with organisational culture may in turn result in inadequate site relationship management; poor problem identification and resolution; poor harnessing of skills within project teams; organisational stagnation / failure; increased resistance to change, and client dissatisfaction. Therefore, it is obvious that these practices as well as their consequences call for the need to ensure that organisational culture among project partners in South African construction is appropriate.

#### **Hypothesis 5:**

***Poor interface between multidisciplinary design advisor / consultants leads to delay and rework relative to construction activities.***

The results suggest that poor interface between multidisciplinary design advisor /consultants leads to delay and rework relative to construction activities. The importance of the hypothesis cannot be overemphasised as the construction management literature is inundated with publications linking design with the occurrence of rework in construction. In particular, practices such as disparity in design expertise; change in personnel during the project duration; behavioural tendencies within project teams, and commitment to different project objectives that are deemed to be contributing to poor multidisciplinary interface between consultants in South African construction must be addressed. Consequences of poor multi-disciplinary interface between consultants such as delay and rework on site; unclear design and specification; extensive revisions of design; constant RFIs from site management, and costly design changes, strengthen the need to improve the interface between consultants involved in projects.

**Hypothesis 6:**

***Inefficient and unstable logistics management leads to haphazard processing of orders, storage of materials, and poor inventory management.***

Findings emanating from the study indicate that inefficient and unstable logistics management may actually lead to haphazard processing of orders, storage of materials, and poor inventory management. The statistical test relative to this hypothesis is not only significant, but also, its effect size can be deemed large in terms of practical importance. In addition, practices such as lack of site management competence relative to logistics, lack of formal training relative to logistics, poor site material flow management, poor work schedule control, poor infrastructure and equipment location, and poor material supply, storage, and handling can be deemed to contribute to inadequate management of logistics in South African construction. Further, consequences of inadequate management of logistics such as poor quality and time management; added cost in the project; under utilisation of construction vehicles; material loss due to defects and theft; high level of construction waste on site, and added risks relative to H&S support the argument that inefficient and unstable logistics management may actually lead to haphazard processing of orders, storage of materials, and poor inventory management in construction.

**Hypothesis 7:**

***Unacceptable coordination and regard for H&S upstream and downstream of the construction supply chain result in recurrent accidents, injuries, and ill-health on construction site.***

The findings relative to hypothesis 7 were inconclusive. Particularly, the findings suggest that unacceptable coordination and regard for H&S upstream and downstream of the construction supply chain may or may not necessary result in recurrent accidents, injuries, and ill-health on sites due to other contributing factors that were not considered in the study. However, practices such as inadequate knowledge relative to nature of work; H&S competence of project participants; and collective organisational values relative to H&S contributing to unacceptable coordination and regard for H&S support the hypothesis. Nevertheless, it is important to address H&S related issues as H&S performance in South African construction can still be improved.

**Hypothesis 8:**

***Inadequate coordination and integration of quality standard requirements within the supply chain result in an unusually high level of defects, rework, and non-conformance relative to quality at construction project completion.***

In terms of hypothesis 8, the primary data suggests that inadequate coordination and integration of quality standard requirements within the SC may indeed result in an unusually high level of defects,

rework, and non-conformance relative to quality at construction project completion. Specifically, poor work procedures / methods; poor understanding of quality; poor project specifications; poor exchange of project information; and poor project cost and schedule data can be deemed to be practices contributing to inadequate management of quality in South African construction. Based on these practices and other related factors, defects and rework; increased project duration and cost; and client dissatisfaction may be deemed to occur due to inadequate management of quality in South African construction. Therefore, it is imperative to address the management of quality in South African construction.

## **9.5 Conclusions Relative to the Research Objectives**

The study was conducted with the primary objectives such as the identification of NVAAs, the sources of these NVAAs as well as their impact on project performance in South Africa. Mitigation strategies that can address the impact the identified NVAAs formed part of the research objectives.

### **9.5.1 Identification of NVAAs in South African construction**

The first objective was successfully achieved as indicated in Table 7.13 and Table 7.26. Out of a total number of 40 NVAAs identified in the literature, 23 recorded MSs above the midpoint score of 3.00, which indicates that the survey respondents can be deemed to perceive that these NVAAs contribute significantly to poor project performance in South African construction. It is notable that NVAAs such as lack of required competencies; inadequate supervision; waiting for critical tasks to be finished; non-conformance of materials to specification; waiting for materials; waiting for instruction / information; rework relative to design; human error / mistake; and poor coordination of resources must be addressed in order to improve performance in South African construction. Though the level and / or frequency of occurrence may be different for individual projects, the mere fact that these NVAAs can occur is a genuine cause for concern. These NVAAs are not restricted to a particular set of activities because they seem to pervade the entire construction process. Though NVAAs relative to human resources predominate in terms of NVAAs that achieved MSs above the midpoint of 3.00, other NVAAs relative to rework, waiting period, material, and movement are equally important in order to address poor project performance in South African construction.

### **9.5.2 Sources of NVAAs in South African construction**

As indicated in Table 7.14 and Table 7.27, the abovementioned objective was successfully achieved in the study. Notable causes of NVAAs include lack of appropriately skilled workers; repetitive revisions and changes; delay in design approval; poor planning of construction; late dissemination of information; poor interaction; incomplete drawings / designs; bureaucracy; lack of leadership abilities; error in material specifications; unclear design / details; slow response to RFIs; poor decision-making abilities; and unrealistic project execution plan. Though, the other 25 causes of NVAAs out of the 40

causes of NVAAs identified in the literature did not achieve MSs above 3.40, they are nonetheless important for project performance improvement purposes. These causes of NVAAs can be due to human resources, designers, information and documentation, material / equipment, and site operations. In particular, causes of NVAAs relative to site operations as well as information and documentation are significant in the South African construction context.

### **9.5.3 Impact of NVAAs in South African construction**

The empirical study successfully revealed that a range of practices / issues occur due to NVAAs in South African construction. Findings arising from the study indicate that practices / issues such as time overruns; cost overruns; variations / claims; reduced productivity; client dissatisfaction; non-conformances; interruptions / disruptions to activity sequence; clash / overlapping of activities; overtime; additional resource allocation; and time-space conflict occur due to NVAAs in South African construction. Consequently, the objective can be deemed achieved.

### **9.5.4 Mitigation strategies valuable to the South African construction industry**

The abovementioned objective was also achieved in the study. Based on the research findings, a range of perspectives / practices / interventions were affirmed by the respondents as having the potential to reduce or eliminate NVAAs, and improve project performance in South African construction. These perspectives/ practices / interventions include adequate documentation and transfer of knowledge; total quality management of all processes; good organisational culture among project partners; robust open information sharing among project team; reliable and efficient logistics management practices; continuous human resources development; reduce the need for NVAAs; appropriate allocation of project risk, and integrative H&S management practices. However, it is particularly notable that adequate documentation and transfer of knowledge, total quality management of all processes, and good organisational culture among project partners achieved MSs above 4.00, which indicate that these interventions may be very useful in the South African construction context.

### **9.5.5 Conclusions relative to proposed SD models**

As part of efforts to develop robust ways of preventing NVAAs from further propagating poor project performance in South Africa, a number of SD based models were developed. Conclusions based on the qualitative SD models include:

- Though there is commonality between NVAAs recorded in South African construction and other countries, their frequency and effects on project performance differ;
- NVAAs can be deemed responsible for and / or contribute to poor performance in construction as the dynamics associated with their existence and propagation ensure that NVAAs become pervasive in the construction process;

- The qualitative models suggest that there is a link between skills, NVAAs, and project performance in South African construction;
- Though, the conceptual models are rather simple in relation to other SD models documented in the construction project management domain, especially with respect to models proposed in developed countries, it nevertheless addressed sub-optimal project performance in South African construction;
- The conceptual models built compelling explanations for how performance differences arise, persist, and disappear over time in South African construction;
- Since one of the modelling efforts successfully extended an existing model that was developed in the USA, it can be concluded that SD models are robust enough to accommodate future considerations;
- The dynamics of the causes of NVAAS in South African construction model explains why the level of skills of workers, designers, and other construction professionals are considered important in project implementation. In particular, as skills shortages is an undeniable key aspect of this dynamic behaviour of the causes of NVAAs, the model suggests that a range of issues may lead to the propagation of NVAAs in South African construction;
- The NVAAs in construction feedback process model that is underpinned by the assumption that the construction process is still largely human resource driven, suggests that the amount of NVAAs in construction can either be increased or decreased depending on decisions made at the strategic management level. In effect, the model suggests that NVAAs tend to have feedback processes that may reinforce their intensity and frequency in the construction process, and
- The dynamics of NVAAs in South African construction model further show the dynamic structures at play in terms of project performance in South African construction with particular emphasis on the accomplishment of critical tasks that is otherwise known as project milestones.

## **9.6 Recommendations**

In general, since identified NVAAs, their causes, and impact affect the entire construction SC in South Africa, project performance improvement then depends on the entire SC as an entity as opposed to an organisation in the SC. In order to advance project performance in South African construction, the contributions of each stakeholder must be improved. General comments made by the study respondents indicate that skill related issues that are marginalising project performance in various ways were systemic. The findings revealed that the skills shortages and its effects were not limited to a particular project partner in the construction SC; rather the study suggests that clients, consultants and contracting organisations are contending with skills related challenges. Hence, performance

improvement in South African construction requires the ‘improvement of the competence’ of the entire SC involved in a project.

#### **9.6.1 Recommendations based on the research objectives**

Based on the research objectives, it is herein recommended that:

- All identified NVAAs in South African construction should be reduced / eliminated so as to limit poor performance in the form of cost and time overruns in the industry;
- NVAAs relative to human resources such as lack of required competencies and inadequate supervision should be avoided on projects;
- NVAAs relative to waiting periods such as waiting for critical tasks to be finished and waiting for materials should not be allowed to occur;
- NVAAs related to design such as rework relative to design and that which is related to material such as non-conformance to specification should be purged from the construction process;
- All identified causes of NVAAs should be addressed by responsible parties in the construction process;
- Causes of NVAAs relative to site operations such as poor planning of construction, inadequate design information, and inappropriate construction methods should be closely monitored and if possible eliminated by contractors, and other project stakeholders;
- Causes of NVAAs relative to information and documentation such as late dissemination of information, incomplete drawings and designs, error in material specifications, and unclear design / details should be monitored and eliminated by both designers and contractors early in the project;
- Causes of NVAAs relative to designers such as repetitive revisions and changes, delay in design approval, poor interaction among designers, and bureaucracy should be monitored, reduced, and if possible, eliminated at all phases of the construction process;
- Causes of NVAAs relative to human resources such as lack of appropriately skilled workers, lack of leadership abilities, and poor decision-making abilities of workers should not be allowed to compromise the realisation of project objectives;
- Regardless of project size or type, the consequences of NVAAs such as time overruns, cost overruns, variations / claims, reduced productivity, client dissatisfaction, and non-conformances should not be allowed to materialise in the implementation of construction projects as they have

the tendency to spiral out of the control of stakeholders, and also harm the image of the industry in general;

- The impact of NVAAs on project parameters of time (project schedule) should be closely monitored with a view to reducing the impact to the absolute minimum;
- The impact of NVAAs on cost and quality should be controlled as it could be propagated into other VAAs;
- The construction industry stakeholders' knowledge relative to NVAAs, their causes and effects should be increased, particularly among contractors and consultants;
- The encounter with NVAAs in South African construction should be minimised by all involved in project realisation;
- The frequency of NVAAs in South African construction should be reduced to the extent that their existence will not have a negative effect on project performance;
- In general, there is a need to improve performance related to cost, environment, H&S, quality, and time, H&S in South African construction;
- Mitigation strategies that advocate 'right first time' should be adopted by project stakeholders;
- Mitigation strategies that advocate 'elements of leanness' should be embraced by project stakeholders;
- Project clients, consultants, and contractors should ensure adequate recordation and transfer of knowledge so that 'reinventing the wheel' can be avoided, and 'best practices' can be promoted in South African construction;
- All tasks incidental to project realisation should benefit from TQM principles so that they can be done 'right first time';
- Project stakeholders should endeavour to create and foster good organisational culture;
- Both internal and external logistics requirements in a project should be reliably and efficiently managed by stakeholders especially the contractors;
- Human resources development within project organisations should be continuous as there is no substitute for knowledge;
- At the inception of projects, risk allocation should be done among project partners optimally and appropriately;

- The management of H&S should cut across organisational boundaries so that everyone involved in project realisation can perceive H&S to be a value, rather than a cost element;
- Efforts should be made to reduce the need for NVAAs such as excessive inspections on site;
- Industry-wide awareness about NVAAs and their potential negative effects should be created;
- Each project stakeholder must isolate and define its role so as to avoid duplication of responsibilities, and
- All construction project partners should adopt continuous project improvement principles.

### **9.6.2 Recommendations based on the research hypotheses**

Since the empirical study results suggest that inconsistent and inadequate risk allocation and management practices may indeed lead to inappropriate choice of procurement strategy in South Africa's public sector departments responsible for the delivery of infrastructure met for service delivery, it is recommended that appropriate allocation and management of project risk should be prioritised when making decisions relative to the choice of procurement strategy. It is suggested that public sector clients should endeavour to include appropriate incentives to improve project performance as part of the risk allocation strategies that contributes to the choice of procurement strategy. In addition, the status of attitudes to risk transfer among the criteria determining the choice of procurement strategy should be upgraded in order to avoid consequences of misallocation of project risks such as delay in project completion, increased total project cost, delay in award of tenders, and the likelihood of disputes among project partners.

The findings of the empirical study also suggest that the lack of infrastructure delivery management skills within the public sector may indeed result in poor implementation of construction projects. The discovery invariably leads to a range of recommendations that include:

- The public sector should ensure that only competent construction professionals are assigned construction implementation responsibilities;
- Each discipline / department should be administered by experts in the discipline as opposed to 'putting round pegs into square holes';
- Although the public sector engages the use of consultants, a limited amount of such specialists should be domiciled in government departments for critical decision-making purposes;
- Public sector organisations should increase their capacity in speciality areas such as civil engineering, construction management, and project management;
- The perceived lack of capacity at the municipal level should be addressed without further delay;

- Political interference should be avoided in the administration of technical departments in the public sector;
- The perceived lack of experience by the few technical professionals in public sector departments should be addressed immediately, possibly through mentorship programmes;
- Engagement in lifelong learning should be encouraged in the public sector;
- Professionalism and continuous personal development should be encouraged in the public sector, and
- New recruits into public sector departments should be mentored to ensure appropriate transfer of knowledge by experienced professionals;

All the aforementioned recommendations should be considered in order to ensure that decision-making relative to procurement strategy, and payments for executed tasks are not delayed; establishment of what is to be procured and implementation of procurement strategy are not below expectations, and the total project cost is not unnecessarily increased.

Based on the research findings, it can be recommended that experiences and best performance in the industry should be recorded for knowledge transfer purposes. The research hypotheses relative to knowledge management indicate that inadequate documentation and transfer of experiences and performance may actually result in limited organisational knowledge, learning, and transfer, which results in a range of consequences. Such consequences include the inability to tackle risks / uncertainties effectively, the inability to disseminate ‘best practice’, repetition of past project mistakes, and the inability to innovate and respond to clients’ needs. Hence, in order to forestall the occurrence of these consequences, it is imperative that project stakeholders manage project information adequately, promote mentorship programmes, allocate adequate resources to knowledge capture, and also carry out post project reviews at the end of each construction project.

The results relative to hypothesis 4 that reveal that inappropriate organisational culture among project partners may actually lead to resistance to change and innovation in the construction SC invariably suggest that the organisational culture within project partners / teams must be improved upon in South African construction. Failure to engender good organisational culture among project partners may marginalise projects in the form of inadequate site relationship management, poor problem identification and resolution, and poor harnessing of skills within project teams or worse, organisational stagnation / failure. Therefore, practices such as poor analysis of issues and their impact, lack of trust within project teams, and apathy toward idea generation and evaluation should be jettisoned for the sake of successful project completion. Rather, project stakeholders should strive to

work collaboratively without marginalising the ability of other project partners involved in projects to realise their objectives.

According to the results, it is also imperative to address the poor interface between designers involved in the realisation of a project. The research findings suggest that poor interface between multi-disciplinary design advisors / consultants leads to delay and rework in South African construction. The interface should be examined and improved upon so as to prevent delays and rework on construction sites, unclear design and specifications, extensive revisions of design, constant RFIs emanating from site, and costly design changes. It is further suggested that consistent design expertise among designers, avoidance of changes in personnel during project execution, elimination negative behavioural tendencies among project teams, and the alignment of project objectives offers improvement opportunities with respect to the interface between consultants.

The findings relative to hypothesis 6, which indicate that inefficient and unstable logistics management may actually lead to haphazard processing of orders, storage of materials and poor inventory management underscore the importance of logistics within the context of construction project delivery. In effect, it is imperative to address a number of practices that perpetrate inadequate management of logistics in South Africa. For instance, it is vital that site management should be competent in terms of logistics. They should undergo some form of logistics related training so as to ensure adequate management of material flow.

With respect to H&S, though the result of testing the hypothesis can be deemed inconclusive, the findings in the literature suggest that efforts devoted to H&S improvement are not wasted. It is recommended that project stakeholders should collectively value H&S, and regard a minor H&S oversight by any party as having the potential to lead to accidents, and even fatalities. Since the result suggests that unacceptable coordination and regard for H&S upstream and downstream of the construction SC may or may not result in recurrent accidents, injuries, and ill-health on construction sites, it is only wise to recommend that project stakeholders should be knowledgeable about the nature of work to be undertaken, be H&S competent, collectively value H&S, and put in place proper up-to-date H&S management procedures / systems in their organisations.

Findings relative to hypothesis 8 indicate that inadequate coordination and integration of quality standard requirements may indeed result in an unusually high level of defects, rework, and non-conformance in construction. In order to prevent defects, rework, increased project duration and cost, as well as client dissatisfaction from marginalising projects, it is important to address problematic areas such as poor work procedures / methods and poor understanding of quality in South African construction. It is recommended that project stakeholders should adopt principles of TQM, and also ensure standard work procedures / methods are used in construction. In addition, it is important that

all employees in an organisation should understand quality, project specifications should be produced without mistakes, and information exchange between project partners should be correct, adequate, timely and consistent.

### **9.6.3 Recommendations based on proposed SD models**

The modelling effort policy recommendations for the management of construction projects are threefold. Firstly, clients (in particular public sector clients) should promote objective assignment of project procurement / administration / management responsibilities to appropriately skilled and / or competent in-house experts. Secondly, consultants (designers) should avoid the use of fresh graduates without the requisite 'know-how' to sign-off jobs on sites as instead of being viewed as experts on construction sites, their input may be considered immature or not practicable by site management professionals. Thirdly, contractors should place emphasis on both academic and professional development of their employees, and also ensure that new recruits are armed with appropriate built environment qualifications so that they are sure of their suitability for challenging roles in the industry.

Specifically, project stakeholders should endeavour to ensure that more VAAs are performed on construction sites so that the project team will have opportunities for learning, transfer of knowledge, and eventual improvement of skills; VAAs should take precedence over NVAAs and VSAs so that total required efforts for tasks completion will be adequately utilised; and project tasks should be assigned to appropriately skilled and / or competent party in the construction SC.

### **9.7 Justification of the Title of the Research**

The research that is titled *Performance improvement in South Africa construction* focused on project performance in South African construction. The adopted title is appropriate as the research findings have revealed that in order to improve performance and accelerate project delivery in South Africa, a range of issues within the construction SC must either be eliminated and / or improved.

As indicated in Chapter 5, Chapter 7, Chapter 8, and this particular chapter, it is clear that issues that lead to poor project performance can be located in client, consultant, or contractor organisations. As a result, project improvement relies on the removal of bottlenecks in the construction process as horizontal integration is presently the preferred mode of project delivery.

### **9.8 Contributions to Knowledge**

Notable contributions to the body of knowledge include:

- the application of SCM principles in the construction project management context provides opportunity for looking at the entire supply chain as a single project entity rather than as individual firms;

- both SCM principles and SD concepts allow problems to be viewed and solved collectively through feedback processes, as opposed to isolated treatment of issues;
- project dynamics models are extendable regardless of the source of their empirical data as indicated in a model proposed in this study;
- within the project dynamics domain, it is proper to consider the competence of individuals assigned to tasks especially in a developing country, as this study revealed that human resources issues dominate the sources of NVAAs in construction;
- the NVAAs that occur, and their causes in projects are perceived to be due to lapses and / or inadequacies that involve the entire construction SC, that is, no single member of the construction process can singularly reduce or eliminate NVAAs without the input of other members;
- there is no single construction process / task that is immune from NVAAs, though the effect varies from tasks to tasks, and then, from projects to projects;
- within the South African construction industry context, political interference and the perceived lacklustre implementation of BBBEE is believed to be severely thwarting project performance improvement initiatives;
- though a range of perspectives / practices / interventions are perceived to be valuable avenues of addressing NVAAs, and by extension, poor project performance in South African construction, KM is perceived to be the most significant intervention;
- it is the contention of this particular research output that within the South African, and by implication construction context generally in developing countries, adequacies related to required knowledge among project stakeholders is the most crucial determinant of project performance;
- the single phenomenon having the most profound effect on performance improvement in South African construction is the dynamic relationship between shortage of skills and competence, and
- it can be argued that the shortage of skills malaise is not entirely about the numbers of engineers, contract managers, construction managers, and artisans available in the industry, but rather, it is about the 'competence' of these construction professionals.

Thus, as opposed to what is obtainable in developed countries, the construction industry in developing countries, particularly South Africa, should further take advantage of KM techniques such as brainstorming, communities of practices, and face-to-face interactions. These techniques can be driven through appropriate mentorship programmes, industry focused built environment education, and other human resources driven avenues that do not necessarily require substantial investment in technologies, so that to a large extent organisations in the industry can prioritise KM, and continually

engage in it for future project performance improvement. Given that *skills and competence inadequacies are deemed to be the root causes of poor performance, and knowledge recordation and transfer emerged as the most important intervention, it can therefore be concluded that the most significant contribution to knowledge recorded in this study is the criticality of knowledge management* in the industry. Though, most publications have amplified the benefits of other interventions such as TQM, it is herein recommended that in order to ensure project performance improvement, project teams must have experiences and foundational knowledge in the form of academic qualifications relevant to projects to be executed. This is predicated on the assumption that team knowledge of historical issues pertinent to projects can enable the importation of learning underpinned by principles of continuous improvement, which in turn, provides the platform for future projects to be more effectively and efficiently managed and / or delivered.

### **9.9 Limitations of the Research**

It is important to note that the empirical data generated in the research process were limited to civil engineering and non-residential building projects; infrastructure that were in the ownership of the public sector, and infrastructure projects that are deemed to be funded by governmental sources. In addition, perhaps as a result of lack of capacity, the results failed to capture enough perceptions from municipalities and provincial departments responsible for construction project delivery.

Most importantly, the results were based on only key members of the construction SC. All empirical surveys conducted were only among client, consultant, and contractor organisations active in South African infrastructure sector. However, a survey among the other members of a typical construction SC such as subcontractors, specialist contractors, suppliers, and manufacturers may have generated a more robust data. The empirical findings were dominated by the perceptions of consultants as they responded to the surveys the most. But a more proportionate response data may provide a more balance view of the issues, and also lead to more reliable results. Further, the fact that the private sector responsible for commercial and residential construction was not surveyed should also be noted. Although most respondents in the form of consultants and contractors operate in the private sector, it is assumed that other organisations in the construction industry may not be involved with public sector projects so their perceptions were therefore not captured in this study.

A research method was used as opposed to a research methodology for the investigation. The use of research methodology that may lead to the use of more than one method may produce further information than what is presented in this particular thesis. In addition, although the research modelling efforts developed qualitative models, it however did not develop a robust quantitative model that can capture all the variables in simulations.

### **9.10 Future Research**

Future research that will entail a mixed-method or qualitative / quantitative investigations is being considered. NVAAs in the light of various project types, sizes, and location shall be investigated; and policy resistance relative to the ‘rework cycle’, skills shortages, quality, and H&S in South African construction shall also be researched.

The lack of capacity issues shall be investigated in terms of the effects of political interference in matters considered purely technical in government departments. The individual contributions of artisans and site management to the capacity problems should also receive the attention of future research. Future research should equally extensively examine the depth of knowledge management practices in South African construction, and the techniques / or tool that can be used to increase the dissemination of both tacit and explicit knowledge in the industry. Factors that are working against the sharing of past and current project knowledge as well as factors that seem to propagate repeat of past mistakes should be investigated. As part of investigation relative to interventions, the depth of TQM practices should also be revisited in clients, consultants and contractor organisations.

In terms of the SD models, the development of a robust quantitative model that captures the impact of NVAAs on project performance shall form the cornerstone of future research. This is because Sterman (2000: 166) contends that causal diagrams can never be comprehensive enough; they are never final, but always provisional as the maps evolve as the understanding and the purpose for modelling improves. In particular, it is envisaged that a simulation model for analysing the effects ‘competence’ has on the accomplishment of critical tasks shall be developed in the near future. Tertiary built environment education, site experience, and continuous professional development programmes are intended to form aspects of and / or contribute to ‘competence’ in the simulation model.

The ‘stock and flow’ diagram to be developed shall endeavour to detail the salient parameters that contribute to the process of assigning critical tasks to competent specialists within the South African construction industry context. Attempts shall be made to derive estimates for the model parameters from site experiences of researchers, and thereafter validate the estimates through a focus group that will be made up of principal construction industry project stakeholders. The assumptions are expected to revolve around ‘competence’ and ‘critical tasks’ based on the level of education of responsible construction professionals, their past site experiences, and other factors that will be identified through the focus group. Thereafter, it is envisage that the simulation model will be applied to selected case projects in South African construction so as to assess its robustness and usefulness in the construction project management domain.

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**APPENDIX 1**

**SUMMERSTRAND SOUTH  
DEPARTMENT OF CONSTRUCTION MANAGEMENT**  
Tel. +27 (0)41 504 2790 Fax. +27 (0)41 504 2345

19 May 2010

Dear Madam / Sir

**Re: Improving the construction supply chain: Accelerating infrastructure delivery in South Africa (revised to Performance Improvement in South African Construction)**

This survey is part of a research project aimed at meeting the requirements for a PhD (Construction Management) at the Nelson Mandela Metropolitan University.

The aim of the research is to evolve ways of improving the construction process for the purpose of accelerating infrastructure delivery in South Africa

Kindly complete the accompanying questionnaire and return same to:

Department of Construction Management  
Nelson Mandela Metropolitan University  
PO Box 77000  
Port Elizabeth  
6031

Please return either through the postal service or per facsimile to: (041) 504 2345 on or before 19 July 2010.

Attention: Prof John Smallwood / Mr Fidelis Emuze

Should you have any queries please do not hesitate to contact Mr Fidelis Emuze at 071 450 9442 or per e-mail: [s208090281@live.nmmu.ac.za](mailto:s208090281@live.nmmu.ac.za)

Please note that the confidentiality of your response is assured.

**Thanking you in anticipation of your response.**



**Mr Fidelis Emuze**  
**PhD (Construction Management) Candidate**



**Prof John Smallwood\_PhD (Construction Management)**  
**Supervisor**  
**Professor, and Head, Department of Construction Management**  
**Programme Director, MSc (Built Environment) Programme**

## Improving the Construction Supply Chain: Accelerating Infrastructure Delivery in South Africa

|  |  |  |
|--|--|--|
|  |  |  |
|--|--|--|

1. In general, on a scale of **1 (strongly disagree)** to **5 (strongly agree)**, to what extent do you agree that the following occurrences negatively impact construction project delivery (**please note the 'Unsure' option**)?

|     | Occurrences                                                          | Unsure | Strongly disagree....Strongly agree |   |   |   |   |
|-----|----------------------------------------------------------------------|--------|-------------------------------------|---|---|---|---|
|     |                                                                      |        | 1                                   | 2 | 3 | 4 | 5 |
| 1.1 | Inconsistent & inadequate risk allocation & management practices     | U      | 1                                   | 2 | 3 | 4 | 5 |
| 1.2 | Lack of infrastructure delivery management skills                    | U      | 1                                   | 2 | 3 | 4 | 5 |
| 1.3 | Inadequate documentation and transfer of knowledge                   | U      | 1                                   | 2 | 3 | 4 | 5 |
| 1.4 | Inappropriate organisational culture among project partners          | U      | 1                                   | 2 | 3 | 4 | 5 |
| 1.5 | Poor interface between multi-disciplinary design teams (consultants) | U      | 1                                   | 2 | 3 | 4 | 5 |
| 1.6 | Inefficient and unreliable logistics management practices            | U      | 1                                   | 2 | 3 | 4 | 5 |
| 1.7 | Non-integrative H&S practices                                        | U      | 1                                   | 2 | 3 | 4 | 5 |
| 1.8 | Poor definition and coordination of process / product quality        | U      | 1                                   | 2 | 3 | 4 | 5 |

2. On a scale of **1 (minor)** to **5 (major)**, to what extent could the following interventions / strategies contribute to an improvement in the delivery of infrastructure projects (**please note the 'unsure' option**)?

|     | Interventions / Strategies                                            | Unsure | Minor ..... Major |   |   |   |   |
|-----|-----------------------------------------------------------------------|--------|-------------------|---|---|---|---|
|     |                                                                       |        | 1                 | 2 | 3 | 4 | 5 |
| 2.1 | Implementation of TQM collectively among project partners             | U      | 1                 | 2 | 3 | 4 | 5 |
| 2.2 | Adoption and utilisation of principles of concurrent engineering      | U      | 1                 | 2 | 3 | 4 | 5 |
| 2.3 | Continuous development of human resources                             | U      | 1                 | 2 | 3 | 4 | 5 |
| 2.4 | Innovative management of construction logistics (internal & external) | U      | 1                 | 2 | 3 | 4 | 5 |
| 2.5 | Knowledge sharing and management                                      | U      | 1                 | 2 | 3 | 4 | 5 |
| 2.6 | Robust deployment of ICT tools and techniques                         | U      | 1                 | 2 | 3 | 4 | 5 |
| 2.7 | Open and integrative approach to H&S, quality, environment, and cost  | U      | 1                 | 2 | 3 | 4 | 5 |
| 2.8 | Holistic implementation of practices inherent in lean construction    | U      | 1                 | 2 | 3 | 4 | 5 |
| 2.9 | Elimination of organisational resistance to change                    | U      | 1                 | 2 | 3 | 4 | 5 |

3. Do you have any comments in general regarding the improvement of the construction supply chain?

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Please record your details below to facilitate contacting you, in the event that a query should arise. **Please note that the data provided in this questionnaire will be treated in the strictest confidence.**

|            |               |
|------------|---------------|
| Name:      | Organisation: |
| Mobile No: | Facsimile:    |

**Thank you for your contribution to efforts directed towards improving construction in South Africa.**

© Fidelis Emuze May 2010



**SUMMERSTRAND SOUTH  
DEPARTMENT OF CONSTRUCTION MANAGEMENT**

Tel. +27 (0)41 504 2790 Fax. +27 (0)41 504 2345

**APPENDIX 2**

10 August 2010

Dear Madam / Sir

**Re: Improving the construction supply chain: Accelerating infrastructure delivery in South Africa (revised to Performance Improvement in South African Construction)**

This survey is part of a research project aimed at meeting the requirements for a PhD (Construction Management) at the Nelson Mandela Metropolitan University.

The aim of this phase of the research process is to identify non-value adding activities in construction, causes of these non-value adding activities, and their impact on the construction process.

Kindly complete the accompanying questionnaire and return same to:

Department of Construction Management  
Nelson Mandela Metropolitan University  
PO Box 77000  
Port Elizabeth  
6031

Please return either through the postal service or per facsimile to: (041) 504 2345 on or before 19 September 2010.

Attention: Prof John Smallwood / Mr Fidelis Emuze

Should you have any queries please do not hesitate to contact Mr Fidelis Emuze at 071 450 9442 or per e-mail: [s208090281@live.nmmu.ac.za](mailto:s208090281@live.nmmu.ac.za)

Please note that the confidentiality of your response is assured.

**Thanking you in anticipation of your response.**

**Mr Fidelis Emuze MSc (Built Environment), GMICE, AMSAICE  
PhD (Construction Management) Candidate**

**Prof John Smallwood PhD (Construction Management)  
Promoter**

**Professor, and Head, Department of Construction Management  
Programme Director, MSc (Built Environment) Programme**

1. On a scale of **1 (minor)** to **5 (major)**, to what extent do the following non-value adding activities contribute to poor project performance in construction (**please note the 'unsure' options**)?

|       | Non-value adding activities                 | Unsure | Minor.....Major |   |   |   |   |
|-------|---------------------------------------------|--------|-----------------|---|---|---|---|
|       |                                             |        | 1               | 2 | 3 | 4 | 5 |
| 1.1   | Rework relative to:                         |        |                 |   |   |   |   |
| 1.1.1 | • design                                    | U      | 1               | 2 | 3 | 4 | 5 |
| 1.1.2 | • foundation works                          | U      | 1               | 2 | 3 | 4 | 5 |
| 1.1.3 | • structural works                          | U      | 1               | 2 | 3 | 4 | 5 |
| 1.1.4 | • formwork                                  | U      | 1               | 2 | 3 | 4 | 5 |
| 1.1.5 | • service-for example plumbing works        | U      | 1               | 2 | 3 | 4 | 5 |
| 1.1.6 | • mechanical works-for example a/c          | U      | 1               | 2 | 3 | 4 | 5 |
| 1.1.7 | • electrical works-for example conduit      | U      | 1               | 2 | 3 | 4 | 5 |
| 1.1.8 | • finishing works                           | U      | 1               | 2 | 3 | 4 | 5 |
| 1.2   | Waiting periods:                            |        |                 |   |   |   |   |
| 1.2.1 | • Waiting for instruction / information     | U      | 1               | 2 | 3 | 4 | 5 |
| 1.2.2 | • Waiting for materials                     | U      | 1               | 2 | 3 | 4 | 5 |
| 1.2.3 | • Waiting for equipment                     | U      | 1               | 2 | 3 | 4 | 5 |
| 1.2.4 | • Waiting for labour to arrive              | U      | 1               | 2 | 3 | 4 | 5 |
| 1.2.5 | • Waiting for inspections                   | U      | 1               | 2 | 3 | 4 | 5 |
| 1.2.6 | • Waiting for critical tasks to be finished | U      | 1               | 2 | 3 | 4 | 5 |
| 1.2.7 | • Waiting for specialist to arrive          | U      | 1               | 2 | 3 | 4 | 5 |
| 1.2.8 | • Waiting for work space / platform         | U      | 1               | 2 | 3 | 4 | 5 |
| 1.3   | Material:                                   |        |                 |   |   |   |   |
| 1.3.1 | • Waste of raw materials on site            | U      | 1               | 2 | 3 | 4 | 5 |
| 1.3.2 | • Non-conformance to specification          | U      | 1               | 2 | 3 | 4 | 5 |
| 1.3.3 | • Loss of materials on site                 | U      | 1               | 2 | 3 | 4 | 5 |
| 1.3.4 | • Excess materials on site                  | U      | 1               | 2 | 3 | 4 | 5 |
| 1.3.5 | • Unnecessary material handling             | U      | 1               | 2 | 3 | 4 | 5 |
| 1.3.6 | • Deterioration of materials on site        | U      | 1               | 2 | 3 | 4 | 5 |
| 1.3.7 | • Defective materials on site               | U      | 1               | 2 | 3 | 4 | 5 |
| 1.3.8 | • Excessive inspection of materials         | U      | 1               | 2 | 3 | 4 | 5 |
| 1.4   | Movement:                                   |        |                 |   |   |   |   |
| 1.4.1 | • Inappropriate positioning of cranes       | U      | 1               | 2 | 3 | 4 | 5 |
| 1.4.2 | • Unnecessary repetitive handling of tools  | U      | 1               | 2 | 3 | 4 | 5 |
| 1.4.3 | • Poor ergonomics and injuries              | U      | 1               | 2 | 3 | 4 | 5 |
| 1.4.4 | • Poor sequencing of tasks                  | U      | 1               | 2 | 3 | 4 | 5 |
| 1.4.5 | • Poor coordination of resources            | U      | 1               | 2 | 3 | 4 | 5 |
| 1.4.6 | • Poor equipment movement                   | U      | 1               | 2 | 3 | 4 | 5 |
| 1.4.7 | • Poor vehicle / truck movement             | U      | 1               | 2 | 3 | 4 | 5 |
| 1.4.8 | • Unreliable / defective equipment          | U      | 1               | 2 | 3 | 4 | 5 |
| 1.5   | Human Resources:                            |        |                 |   |   |   |   |
| 1.5.1 | • Lack of required competencies             | U      | 1               | 2 | 3 | 4 | 5 |
| 1.5.2 | • Inadequate supervision                    | U      | 1               | 2 | 3 | 4 | 5 |
| 1.5.3 | • Low employee morale                       | U      | 1               | 2 | 3 | 4 | 5 |
| 1.5.4 | • Idleness on site                          | U      | 1               | 2 | 3 | 4 | 5 |
| 1.5.5 | • Ignorance                                 | U      | 1               | 2 | 3 | 4 | 5 |
| 1.5.6 | • Strikes                                   | U      | 1               | 2 | 3 | 4 | 5 |
| 1.5.7 | • Unnecessary work                          | U      | 1               | 2 | 3 | 4 | 5 |
| 1.5.8 | • Human error / mistake                     | U      | 1               | 2 | 3 | 4 | 5 |

2. On a scale of 1 (minor) to 5 (major), to what extent do the following result in non-value adding activities in construction (please note the 'unsure' options)?

|       | Causes of non-value adding activities   | Unsure | Minor..... |   |   |   | Major |
|-------|-----------------------------------------|--------|------------|---|---|---|-------|
|       |                                         |        | 1          | 2 | 3 | 4 | 5     |
| 2.1   | Human Resources:                        |        |            |   |   |   |       |
| 2.1.1 | • Scarcity of workers                   | U      | 1          | 2 | 3 | 4 | 5     |
| 2.1.2 | • Lack of cooperation among workers     | U      | 1          | 2 | 3 | 4 | 5     |
| 2.1.3 | • Poor decision-making abilities        | U      | 1          | 2 | 3 | 4 | 5     |
| 2.1.4 | • Low morale among workers              | U      | 1          | 2 | 3 | 4 | 5     |
| 2.1.5 | • Lack of empowerment                   | U      | 1          | 2 | 3 | 4 | 5     |
| 2.1.6 | • Lack of leadership abilities          | U      | 1          | 2 | 3 | 4 | 5     |
| 2.1.7 | • Poor team spirit among workers        | U      | 1          | 2 | 3 | 4 | 5     |
| 2.1.8 | • Lack of appropriately skilled workers | U      | 1          | 2 | 3 | 4 | 5     |
| 2.2   | Designer (Consultants):                 |        |            |   |   |   |       |
| 2.2.1 | • Poor interaction                      | U      | 1          | 2 | 3 | 4 | 5     |
| 2.2.2 | • Repetitive revisions and changes      | U      | 1          | 2 | 3 | 4 | 5     |
| 2.2.3 | • Delay in design approval              | U      | 1          | 2 | 3 | 4 | 5     |
| 2.2.4 | • Slow response to RFI                  | U      | 1          | 2 | 3 | 4 | 5     |
| 2.2.5 | • Excessive control & inspection        | U      | 1          | 2 | 3 | 4 | 5     |
| 2.2.6 | • Bureaucracy                           | U      | 1          | 2 | 3 | 4 | 5     |
| 2.2.7 | • Over design                           | U      | 1          | 2 | 3 | 4 | 5     |
| 2.2.8 | • Design not requested by client        | U      | 1          | 2 | 3 | 4 | 5     |
| 2.3   | Information and documentation:          |        |            |   |   |   |       |
| 2.3.1 | • Error in material specifications      | U      | 1          | 2 | 3 | 4 | 5     |
| 2.3.2 | • Contradictions in design documents    | U      | 1          | 2 | 3 | 4 | 5     |
| 2.3.3 | • Unrealistic project execution plan    | U      | 1          | 2 | 3 | 4 | 5     |
| 2.3.4 | • Poor document control system          | U      | 1          | 2 | 3 | 4 | 5     |
| 2.3.5 | • Design revisions                      | U      | 1          | 2 | 3 | 4 | 5     |
| 2.3.6 | • Incomplete drawings / designs         | U      | 1          | 2 | 3 | 4 | 5     |
| 2.3.7 | • Late dissemination of information     | U      | 1          | 2 | 3 | 4 | 5     |
| 2.3.8 | • Unclear design / details              | U      | 1          | 2 | 3 | 4 | 5     |
| 2.4   | Materials / Equipment:                  |        |            |   |   |   |       |
| 2.4.1 | • Removal of unspecified material       | U      | 1          | 2 | 3 | 4 | 5     |
| 2.4.2 | • Poor waste management practices       | U      | 1          | 2 | 3 | 4 | 5     |
| 2.4.3 | • Error in material specifications      | U      | 1          | 2 | 3 | 4 | 5     |
| 2.4.4 | • Over / Under ordering materials       | U      | 1          | 2 | 3 | 4 | 5     |
| 2.4.5 | • Scarcity of materials                 | U      | 1          | 2 | 3 | 4 | 5     |
| 2.4.6 | • Scarcity of equipment                 | U      | 1          | 2 | 3 | 4 | 5     |
| 2.4.7 | • Delays in material transportation     | U      | 1          | 2 | 3 | 4 | 5     |
| 2.4.8 | • Inappropriate use of equipment        | U      | 1          | 2 | 3 | 4 | 5     |
| 2.5   | Site operations:                        |        |            |   |   |   |       |
| 2.5.1 | • Inadequate design information         | U      | 1          | 2 | 3 | 4 | 5     |
| 2.5.2 | • Inappropriate construction methods    | U      | 1          | 2 | 3 | 4 | 5     |
| 2.5.3 | • Accidents due to poor H&S             | U      | 1          | 2 | 3 | 4 | 5     |
| 2.5.4 | • Poor planning of construction         | U      | 1          | 2 | 3 | 4 | 5     |
| 2.5.5 | • Inadequate materials control          | U      | 1          | 2 | 3 | 4 | 5     |
| 2.5.6 | • Inadequate staging areas / platforms  | U      | 1          | 2 | 3 | 4 | 5     |
| 2.5.7 | • Poor site layout                      | U      | 1          | 2 | 3 | 4 | 5     |
| 2.5.8 | • External influence on operations      | U      | 1          | 2 | 3 | 4 | 5     |

3. In general, on a scale of **1 (never)** to **5 (always)**, to what extent do the following practices / issues occur as a result of non-value adding activities in construction (**please note the 'unsure' response**)?

|      | Practices / Issues                               | Unsure | Never ..... Always |   |   |   |   |
|------|--------------------------------------------------|--------|--------------------|---|---|---|---|
|      |                                                  |        | 1                  | 2 | 3 | 4 | 5 |
| 3.1  | Overtime                                         | U      | 1                  | 2 | 3 | 4 | 5 |
| 3.2  | Fatigue                                          | U      | 1                  | 2 | 3 | 4 | 5 |
| 3.3  | Time-space conflict                              | U      | 1                  | 2 | 3 | 4 | 5 |
| 3.4  | Clash / Overlapping of activities                | U      | 1                  | 2 | 3 | 4 | 5 |
| 3.5  | Interruptions / Disruptions to activity sequence | U      | 1                  | 2 | 3 | 4 | 5 |
| 3.6  | Additional resource allocation                   | U      | 1                  | 2 | 3 | 4 | 5 |
| 3.7  | Reduced productivity                             | U      | 1                  | 2 | 3 | 4 | 5 |
| 3.8  | Non-conformances                                 | U      | 1                  | 2 | 3 | 4 | 5 |
| 3.9  | Cost overruns                                    | U      | 1                  | 2 | 3 | 4 | 5 |
| 3.10 | Time overruns                                    | U      | 1                  | 2 | 3 | 4 | 5 |
| 3.11 | Incidents and accidents                          | U      | 1                  | 2 | 3 | 4 | 5 |
| 3.12 | Damage to the environment                        | U      | 1                  | 2 | 3 | 4 | 5 |
| 3.13 | Client dissatisfaction                           | U      | 1                  | 2 | 3 | 4 | 5 |
| 3.14 | Variations / Claims                              | U      | 1                  | 2 | 3 | 4 | 5 |

4. On a scale of **1 (limited)** to **5 (extensive)**, how would you rate the impact of **wasteful construction processes / or non-value adding activities** on the following parameters (**please note the 'unsure' option**)?

|     | Parameter               | Unsure | Limited ..... Extensive |   |   |   |   |
|-----|-------------------------|--------|-------------------------|---|---|---|---|
|     |                         |        | 1                       | 2 | 3 | 4 | 5 |
| 4.1 | Cost                    | U      | 1                       | 2 | 3 | 4 | 5 |
| 4.2 | Environment             | U      | 1                       | 2 | 3 | 4 | 5 |
| 4.3 | Health and safety (H&S) | U      | 1                       | 2 | 3 | 4 | 5 |
| 4.4 | Quality                 | U      | 1                       | 2 | 3 | 4 | 5 |
| 4.5 | Time                    | U      | 1                       | 2 | 3 | 4 | 5 |

5. On a scale of **1 (limited)** to **5 (extensive)**, rate your knowledge of non-value adding activities in the **South African** construction industry (**please note the 'unsure' option**)?

| Unsure | Limited ..... Extensive |   |   |   |   |
|--------|-------------------------|---|---|---|---|
|        | 1                       | 2 | 3 | 4 | 5 |

6. On a scale of **1 (limited)** to **5 (extensive)**, rate your encounter with non-value adding activities in the **South African** construction industry (**please note the 'unsure' option**)?

| Unsure | Limited ..... Extensive |   |   |   |   |
|--------|-------------------------|---|---|---|---|
|        | 1                       | 2 | 3 | 4 | 5 |

7. On a scale of **1 (limited)** to **5 (extensive)**, rate **South African** construction in terms of frequency of wasteful / non-value adding activities in the construction process (**please note the 'unsure' option**)?

| Unsure | Limited ..... Extensive |   |   |   |   |
|--------|-------------------------|---|---|---|---|
|        | 1                       | 2 | 3 | 4 | 5 |

8. On a scale of **1 (poor)** to **5 (excellent)**, how would you rate **performance** relative to the following parameters in **South African construction** (**please note the 'unsure' option**)?

|     | Parameter               | Unsure | Poor ..... Excellent |   |   |   |   |
|-----|-------------------------|--------|----------------------|---|---|---|---|
|     |                         |        | 1                    | 2 | 3 | 4 | 5 |
| 8.1 | Cost                    | U      | 1                    | 2 | 3 | 4 | 5 |
| 8.2 | Environment             | U      | 1                    | 2 | 3 | 4 | 5 |
| 8.3 | Health and safety (H&S) | U      | 1                    | 2 | 3 | 4 | 5 |

|     |         |   |   |   |   |   |   |
|-----|---------|---|---|---|---|---|---|
| 8.4 | Quality | U | 1 | 2 | 3 | 4 | 5 |
| 8.5 | Time    | U | 1 | 2 | 3 | 4 | 5 |

9. On a scale of **1 (minor)** to **5 (major)**, to what extent do the following perspectives / practices / interventions contribute to the achievement of value or rather suppress non-value adding activities in construction **(please note the 'unsure' response)**?

|      | Perspective / Practice / Interventions              | Unsure | Minor.....Major |   |   |   |   |
|------|-----------------------------------------------------|--------|-----------------|---|---|---|---|
|      |                                                     |        | 1               | 2 | 3 | 4 | 5 |
| 9.1  | Total Quality Management of all processes           | U      | 1               | 2 | 3 | 4 | 5 |
| 9.2  | Integrative H&S management practices                | U      | 1               | 2 | 3 | 4 | 5 |
| 9.3  | Appropriate allocation of project risk              | U      | 1               | 2 | 3 | 4 | 5 |
| 9.4  | Adequate documentation and transfer of knowledge    | U      | 1               | 2 | 3 | 4 | 5 |
| 9.5  | Good organisational culture among project partners  | U      | 1               | 2 | 3 | 4 | 5 |
| 9.6  | Reliable & efficient logistics management practices | U      | 1               | 2 | 3 | 4 | 5 |
| 9.7  | Continuous human resources development              | U      | 1               | 2 | 3 | 4 | 5 |
| 9.8  | Robust open information sharing among project team  | U      | 1               | 2 | 3 | 4 | 5 |
| 9.9  | Reduce the need for non-value adding activities     | U      | 1               | 2 | 3 | 4 | 5 |
| 9.10 | Reduce time spent on non-value adding activities    | U      | 1               | 2 | 3 | 4 | 5 |

10. Please indicate the type of on going / past **infrastructural projects** undertaken in your organisation – please state the approximate percentage contributions?

|      | Project category                     | Unsure | No | Yes | % |
|------|--------------------------------------|--------|----|-----|---|
| 10.1 | Transport (roads, port, harbour )    |        |    |     |   |
| 10.2 | Power (dam, gas, coal)               |        |    |     |   |
| 10.3 | Water (storm water, treatment plant) |        |    |     |   |
| 10.4 | Other non-residential construction   |        |    |     |   |

11. Please indicate the kind of organisation you work for?

| Client | Consultant | Contractor | Subcontractor | Supplier |
|--------|------------|------------|---------------|----------|
|        |            |            |               |          |

12. Do you have any comments in general regarding impact of non-value adding activities in **South African** construction?

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Please record your details below to facilitate contacting you, in the event that a query should arise. **Please note that the data provided in this questionnaire will be treated in the strictest confidence.**

NAME: \_\_\_\_\_ PHONE: (    ) \_\_\_\_\_

ADDRESS: \_\_\_\_\_ FAX: (    ) \_\_\_\_\_

\_\_\_\_\_ MOBILE: \_\_\_\_\_

\_\_\_\_\_ E-MAIL: \_\_\_\_\_

**APPENDIX 3**

25 November 2010

Dear Madam / Sir

**Re: Improving the construction supply chain: Accelerating infrastructure delivery in South Africa (revised to Performance Improvement in South African Construction)**

This survey is part of a research project aimed at meeting the requirements for a PhD (Construction Management) at the Nelson Mandela Metropolitan University.

The aim of this phase of the research process is to identify performance impediments and possible remedies in South African construction.

Kindly complete the accompanying questionnaire and return same to:

Department of Construction Management  
Nelson Mandela Metropolitan University  
PO Box 77000  
Port Elizabeth  
6031

Please return either through the postal service or per facsimile to: (041) 504 2345 on or before 17 December 2010.

Attention: Mr Fidelis Emuze

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Please note that the confidentiality of your response is assured.

**Thanking you in anticipation of your response.**



**Mr Fidelis Emuze MSc (Built Environment), GMICE, AMSAICE  
PhD (Construction Management) Candidate**



**Prof John Smallwood PhD (Construction Management)  
Promoter  
Professor, and Head, Department of Construction Management  
Programme Director, MSc (Built Environment) Programme**

1. On a scale of **1 (minor)** to **5 (major)**, to what extent do the following risk allocation strategies contribute to the choice of procurement / contract strategy in infrastructure project delivery **(please note the 'unsure' options)?**

|     | Strategies                                             | Unsure | Minor.....Major |   |   |   |   |
|-----|--------------------------------------------------------|--------|-----------------|---|---|---|---|
|     |                                                        |        | 1               | 2 | 3 | 4 | 5 |
| 1.1 | Identification of risk avoidance / prevention measures | U      | 1               | 2 | 3 | 4 | 5 |
| 1.2 | Considerations relative to contract pricing strategies | U      | 1               | 2 | 3 | 4 | 5 |
| 1.3 | Establishment of contingency plans                     | U      | 1               | 2 | 3 | 4 | 5 |
| 1.4 | Cost of risk transferred to project partners           | U      | 1               | 2 | 3 | 4 | 5 |
| 1.5 | Incentives to improve project performance              | U      | 1               | 2 | 3 | 4 | 5 |

2. On a scale of **1 (minor)** to **5 (major)**, to what extent do the following procurement criteria determine the choice of procurement / contract strategy in infrastructure project delivery **(please note the 'unsure' options)?**

|     | Criteria                                               | Unsure | Minor.....Major |   |   |   |   |
|-----|--------------------------------------------------------|--------|-----------------|---|---|---|---|
|     |                                                        |        | 1               | 2 | 3 | 4 | 5 |
| 2.1 | Attitudes to risks transfer                            | U      | 1               | 2 | 3 | 4 | 5 |
| 2.2 | Design responsibility and accountability               | U      | 1               | 2 | 3 | 4 | 5 |
| 2.3 | Project certainty relative to cost, quality, and time  | U      | 1               | 2 | 3 | 4 | 5 |
| 2.4 | Legislation relative to preferential procurement (BEE) | U      | 1               | 2 | 3 | 4 | 5 |
| 2.5 | Project complexity relative to constructability        | U      | 1               | 2 | 3 | 4 | 5 |

3. On a scale of **1 (hardly)** to **5 (definitely)**, to what extent do the following **situations** occur as a result of the misallocation of project risks in infrastructure project delivery **(please note the 'unsure' options)?**

|     | Situations                                      | Unsure | Hardly.....Definitely |   |   |   |   |
|-----|-------------------------------------------------|--------|-----------------------|---|---|---|---|
|     |                                                 |        | 1                     | 2 | 3 | 4 | 5 |
| 3.1 | Increased total project cost                    | U      | 1                     | 2 | 3 | 4 | 5 |
| 3.2 | High amount devoted to contingency plans        | U      | 1                     | 2 | 3 | 4 | 5 |
| 3.3 | Delay in project completion                     | U      | 1                     | 2 | 3 | 4 | 5 |
| 3.4 | Delay in award of the tender                    | U      | 1                     | 2 | 3 | 4 | 5 |
| 3.5 | Likelihood of disputes between project partners | U      | 1                     | 2 | 3 | 4 | 5 |

4. On a scale of **1 (minor)** to **5 (major)**, to what extent do the following **practices / situations** contributes to inadequate documentation and transfer knowledge in construction **(please note the 'unsure' options)?**

|     | Practices / Situations                               | Unsure | Minor.....Major |   |   |   |   |
|-----|------------------------------------------------------|--------|-----------------|---|---|---|---|
|     |                                                      |        | 1               | 2 | 3 | 4 | 5 |
| 4.1 | Lack of post project reviews / reports               | U      | 1               | 2 | 3 | 4 | 5 |
| 4.2 | Lack of mentorship programmes                        | U      | 1               | 2 | 3 | 4 | 5 |
| 4.3 | Lack of detailed databases relative to past projects | U      | 1               | 2 | 3 | 4 | 5 |
| 4.4 | Poor information management                          | U      | 1               | 2 | 3 | 4 | 5 |
| 4.5 | Poor allocation of resources to knowledge capture    | U      | 1               | 2 | 3 | 4 | 5 |

5. On a scale of **1 (totally disagree)** to **5 (totally agree)**, to what extent do the following **situations** occur due to the lack of proper documentation and transfer of knowledge in construction **(please note the 'unsure' options)?**

|     | Situations                                                | Unsure | Totally disagree.....Totally agree |   |   |   |   |
|-----|-----------------------------------------------------------|--------|------------------------------------|---|---|---|---|
|     |                                                           |        | 1                                  | 2 | 3 | 4 | 5 |
| 5.1 | Repetition of past project mistakes                       | U      | 1                                  | 2 | 3 | 4 | 5 |
| 5.2 | Lost opportunities to improve project performance         | U      | 1                                  | 2 | 3 | 4 | 5 |
| 5.3 | Ineffective problem solving capabilities                  | U      | 1                                  | 2 | 3 | 4 | 5 |
| 5.4 | Inability to innovate and respond to clients' needs       | U      | 1                                  | 2 | 3 | 4 | 5 |
| 5.5 | Inability to tackle risks / uncertainties effectively     | U      | 1                                  | 2 | 3 | 4 | 5 |
| 5.6 | Poor response to organisational and project changes       | U      | 1                                  | 2 | 3 | 4 | 5 |
| 5.7 | Loss of contractor, subcontractor / supplier track record | U      | 1                                  | 2 | 3 | 4 | 5 |

|     |                                           |   |   |   |   |   |   |
|-----|-------------------------------------------|---|---|---|---|---|---|
| 5.8 | Inability to disseminate 'best practices' | U | 1 | 2 | 3 | 4 | 5 |
|-----|-------------------------------------------|---|---|---|---|---|---|

6. On a scale of **1 (minor)** to **5 (major)**, to what extent do the following **practices** contribute to unacceptable coordination and regard for H&S in construction (**please note the 'unsure' options**)?

|     | Practices                                              | Unsure | Minor.....Major |   |   |   |   |
|-----|--------------------------------------------------------|--------|-----------------|---|---|---|---|
|     |                                                        |        | 1               | 2 | 3 | 4 | 5 |
| 6.1 | Poor comprehension of project characteristics          | U      | 1               | 2 | 3 | 4 | 5 |
| 6.2 | Inadequate knowledge relative to nature of work / task | U      | 1               | 2 | 3 | 4 | 5 |
| 6.3 | H&S competence of project participants                 | U      | 1               | 2 | 3 | 4 | 5 |
| 6.4 | H&S management procedures / systems                    | U      | 1               | 2 | 3 | 4 | 5 |
| 6.5 | Collective organisation values relative to H&S         | U      | 1               | 2 | 3 | 4 | 5 |

7. On a scale of **1 (totally disagree)** to **5 (totally agree)**, to what extent do the following **situations** occur due to unacceptable coordination and regard for H&S in construction (**please note the 'unsure' options**)?

|     | Situations                                         | Unsure | Totally disagree.....Totally agree |   |   |   |   |
|-----|----------------------------------------------------|--------|------------------------------------|---|---|---|---|
|     |                                                    |        | 1                                  | 2 | 3 | 4 | 5 |
| 7.1 | Lack of project specific H&S specification         | U      | 1                                  | 2 | 3 | 4 | 5 |
| 7.2 | Lack of project specific H&S plan                  | U      | 1                                  | 2 | 3 | 4 | 5 |
| 7.3 | Ineffective H&S monitoring and inspection          | U      | 1                                  | 2 | 3 | 4 | 5 |
| 7.4 | Work stoppages, injuries, and fatalities           | U      | 1                                  | 2 | 3 | 4 | 5 |
| 7.5 | Poor status of H&S within the construction process | U      | 1                                  | 2 | 3 | 4 | 5 |

8. On a scale of **1 (minor)** to **5 (major)**, to what extent do the following **practices / situations** contribute to inadequate management of quality in construction (**please note the 'unsure' options**)?

|     | Practices / Situations               | Unsure | Minor.....Major |   |   |   |   |
|-----|--------------------------------------|--------|-----------------|---|---|---|---|
|     |                                      |        | 1               | 2 | 3 | 4 | 5 |
| 8.1 | Poor exchange of project information | U      | 1               | 2 | 3 | 4 | 5 |
| 8.2 | Poor project specifications          | U      | 1               | 2 | 3 | 4 | 5 |
| 8.3 | Poor project cost and schedule data  | U      | 1               | 2 | 3 | 4 | 5 |
| 8.4 | Poor work procedures / methods       | U      | 1               | 2 | 3 | 4 | 5 |
| 8.5 | Poor understanding of quality        | U      | 1               | 2 | 3 | 4 | 5 |

9. On a scale of **1 (totally agree)** to **5 (totally disagree)**, to what extent do the following **situations** occur due to inadequate management of quality in construction (**please note the 'unsure' options**)?

|     | Situations                          | Unsure | Totally disagree.....Totally agree |   |   |   |   |
|-----|-------------------------------------|--------|------------------------------------|---|---|---|---|
|     |                                     |        | 1                                  | 2 | 3 | 4 | 5 |
| 9.1 | Defects and rework                  | U      | 1                                  | 2 | 3 | 4 | 5 |
| 9.2 | injuries and fatalities             | U      | 1                                  | 2 | 3 | 4 | 5 |
| 9.3 | High built asset maintenance cost   | U      | 1                                  | 2 | 3 | 4 | 5 |
| 9.4 | Increased project duration and cost | U      | 1                                  | 2 | 3 | 4 | 5 |
| 9.5 | Client dissatisfaction              | U      | 1                                  | 2 | 3 | 4 | 5 |

10. On a scale of **1 (minor)** to **5 (major)**, to what extent do the following perspectives / practices / interventions contribute to performance improvement in construction (**please note the 'unsure' response**)?

|      | Perspective / Practice / Interventions                | Unsure | Minor.....Major |   |   |   |   |
|------|-------------------------------------------------------|--------|-----------------|---|---|---|---|
|      |                                                       |        | 1               | 2 | 3 | 4 | 5 |
| 10.1 | Total Quality Management of all processes             | U      | 1               | 2 | 3 | 4 | 5 |
| 10.2 | Integrative H&S management practices                  | U      | 1               | 2 | 3 | 4 | 5 |
| 10.3 | Appropriate allocation of project risk                | U      | 1               | 2 | 3 | 4 | 5 |
| 10.4 | Adequate documentation and transfer of knowledge      | U      | 1               | 2 | 3 | 4 | 5 |
| 10.5 | Good organisational culture among project partners    | U      | 1               | 2 | 3 | 4 | 5 |
| 10.6 | Reliable and efficient logistics management practices | U      | 1               | 2 | 3 | 4 | 5 |

|      |                                                    |   |   |   |   |   |   |
|------|----------------------------------------------------|---|---|---|---|---|---|
| 10.7 | Continuous human resources development             | U | 1 | 2 | 3 | 4 | 5 |
| 10.8 | Robust open information sharing among project team | U | 1 | 2 | 3 | 4 | 5 |
| 10.9 | Reduce the need for non-value adding activities    | U | 1 | 2 | 3 | 4 | 5 |

11. Please indicate the type of on going / past **infrastructural projects** undertaken in your organisation – please state the approximate percentage contributions?

|      | Project category                     | Unsure | No | Yes | % |
|------|--------------------------------------|--------|----|-----|---|
| 11.1 | Transport (roads, port, harbour )    |        |    |     |   |
| 11.2 | Power (dam, gas, coal)               |        |    |     |   |
| 11.3 | Water (storm water, treatment plant) |        |    |     |   |
| 11.4 | Other non-residential construction   |        |    |     |   |

12. Please indicate the type of contract strategy used for **infrastructural projects** undertaken in your organisation – please state the approximate percentage contributions?

|      | Project category                  | Unsure | No | Yes | % |
|------|-----------------------------------|--------|----|-----|---|
| 12.1 | Construction Management           |        |    |     |   |
| 12.2 | Design and Build                  |        |    |     |   |
| 12.3 | Design by Employer (traditional)  |        |    |     |   |
| 12.4 | Management Contracting            |        |    |     |   |
| 12.5 | Public Private Partnerships (PPP) |        |    |     |   |

13. Please provide the following background information for statistical purposes only.

- 13.1 Please indicate the number of projects you have undertaken in the box provided below.

| ≤ 5 | 6 – 10 | 11 – 15 | 16 – 20 | > 20 |
|-----|--------|---------|---------|------|
|     |        |         |         |      |

- 13.2 Please indicate the length of your construction industry experience in the box provided below.

| ≤ 5 years | 6 – 10 years | 11 – 15 years | 16 – 20 years | > 20 years |
|-----------|--------------|---------------|---------------|------------|
|           |              |               |               |            |

- 13.2 Please indicate your highest formal education in the box provided below.

| Matric Certificate | N Dip. | BTech / BSc (Hon) | MSc / MTech | PhD /DTech |
|--------------------|--------|-------------------|-------------|------------|
|                    |        |                   |             |            |

14. Do you have any comments in general regarding improving the construction supply chain in **South African** construction?

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Please record your details below to facilitate contacting you, in the event that a query should arise. **Please note that the data provided in this questionnaire will be treated in the strictest confidence.**

NAME: \_\_\_\_\_ PHONE: (     ) \_\_\_\_\_

ADDRESS: \_\_\_\_\_ FAX: (     ) \_\_\_\_\_

\_\_\_\_\_ MOBILE: \_\_\_\_\_

\_\_\_\_\_ E-MAIL: \_\_\_\_\_



**APPENDIX 4**

21 October 2010

Dear Madam / Sir

**Re: Improving the construction supply chain: Accelerating infrastructure delivery in South Africa (revised to Performance Improvement in South African Construction)**

This survey is part of a research project aimed at meeting the requirements for a PhD (Construction Management) at the Nelson Mandela Metropolitan University.

The aim of this phase of the research process is to identify performance impediments and possible remedies in South African construction.

Kindly complete the accompanying questionnaire and return same to:

Department of Construction Management  
Nelson Mandela Metropolitan University  
PO Box 77000  
Port Elizabeth  
6031

Please return either through the postal service or per facsimile to: (041) 504 2345 on or before 20 November 2010.

Attention: Mr Fidelis Emuze

Should you have any queries please do not hesitate to contact Mr Fidelis Emuze at 071 450 9442 or per e-mail: [s208090281@live.nmmu.ac.za](mailto:s208090281@live.nmmu.ac.za)

Please note that the confidentiality of your response is assured.

**Thanking you in anticipation of your response.**

A handwritten signature in blue ink, appearing to read 'F. Emuze'.

**Mr Fidelis Emuze MSc (Built Environment), GMICE, AMSAICE  
PhD (Construction Management) Candidate**

A handwritten signature in blue ink, appearing to read 'J. Smallwood'.

**Prof John Smallwood PhD (Construction Management)  
Promoter**

**Professor, and Head, Department of Construction Management  
Programme Director, MSc (Built Environment) Programme**

1. On a scale of **1 (hardly)** to **5 (definitely)**, to what extent do the following **situations** occur as a result of misallocation of project risks in infrastructure project delivery (**please note the 'unsure' options**)?

|     | Situations                                      | Unsure | Hardly.....Definitely |   |   |   |   |
|-----|-------------------------------------------------|--------|-----------------------|---|---|---|---|
|     |                                                 |        | 1                     | 2 | 3 | 4 | 5 |
| 1.1 | Increased total project cost                    | U      | 1                     | 2 | 3 | 4 | 5 |
| 1.2 | High amount devoted to contingency plans        | U      | 1                     | 2 | 3 | 4 | 5 |
| 1.3 | Delay in project completion                     | U      | 1                     | 2 | 3 | 4 | 5 |
| 1.4 | Delay in award of tender                        | U      | 1                     | 2 | 3 | 4 | 5 |
| 1.5 | Likelihood of disputes between project partners | U      | 1                     | 2 | 3 | 4 | 5 |

2. On a scale of **1 (totally disagree)** to **5 (totally agree)**, to what extent do the following **situations** indicate the extent of skills shortages in public sector departments responsible for project delivery (**please note the 'unsure' options**)?

|     | Situations                                       | Unsure | Totally disagree.....Totally agree |   |   |   |   |
|-----|--------------------------------------------------|--------|------------------------------------|---|---|---|---|
|     |                                                  |        | 1                                  | 2 | 3 | 4 | 5 |
| 2.1 | Poor establishment of what is to be procured     | U      | 1                                  | 2 | 3 | 4 | 5 |
| 2.2 | Decision-making relative to procurement strategy | U      | 1                                  | 2 | 3 | 4 | 5 |
| 2.3 | Poor implementation of procurement strategy      | U      | 1                                  | 2 | 3 | 4 | 5 |
| 2.4 | Unclear contract / procurement documentation     | U      | 1                                  | 2 | 3 | 4 | 5 |
| 2.5 | Delay in contract award after tender submission  | U      | 1                                  | 2 | 3 | 4 | 5 |
| 2.6 | Increased total project cost                     | U      | 1                                  | 2 | 3 | 4 | 5 |
| 2.7 | Delay in payments relative to executed tasks     | U      | 1                                  | 2 | 3 | 4 | 5 |
| 2.8 | Scope changes, claims, and variations            | U      | 1                                  | 2 | 3 | 4 | 5 |

3. On a scale of **1 (minor)** to **5 (major)**, to what extent do the following **practices / situations** contribute to inadequate documentation and transfer of knowledge in construction (**please note the 'unsure' options**)?

|     | Practices / Situations                               | Unsure | Minor.....Major |   |   |   |   |
|-----|------------------------------------------------------|--------|-----------------|---|---|---|---|
|     |                                                      |        | 1               | 2 | 3 | 4 | 5 |
| 3.1 | Lack of post project reviews / reports               | U      | 1               | 2 | 3 | 4 | 5 |
| 3.2 | Lack of mentorship programmes                        | U      | 1               | 2 | 3 | 4 | 5 |
| 3.3 | Lack of detailed databases relative to past projects | U      | 1               | 2 | 3 | 4 | 5 |
| 3.4 | Poor information management                          | U      | 1               | 2 | 3 | 4 | 5 |
| 3.5 | Poor allocation of resources to knowledge capture    | U      | 1               | 2 | 3 | 4 | 5 |

4. On a scale of **1 (totally disagree)** to **5 (totally agree)**, to what extent do the following **situations** occur due to the lack of proper documentation and transfer of knowledge in construction (**please note the 'unsure' options**)?

|     | Situations                                                | Unsure | Totally disagree.....Totally agree |   |   |   |   |
|-----|-----------------------------------------------------------|--------|------------------------------------|---|---|---|---|
|     |                                                           |        | 1                                  | 2 | 3 | 4 | 5 |
| 4.1 | Repetition of past project mistakes                       | U      | 1                                  | 2 | 3 | 4 | 5 |
| 4.2 | Lost opportunities to improve project performance         | U      | 1                                  | 2 | 3 | 4 | 5 |
| 4.3 | Ineffective problem solving capabilities                  | U      | 1                                  | 2 | 3 | 4 | 5 |
| 4.4 | Inability to innovate and respond to clients' needs       | U      | 1                                  | 2 | 3 | 4 | 5 |
| 4.5 | Inability to tackle risks / uncertainties effectively     | U      | 1                                  | 2 | 3 | 4 | 5 |
| 4.6 | Poor response to organisational and project changes       | U      | 1                                  | 2 | 3 | 4 | 5 |
| 4.7 | Loss of contractor, subcontractor / supplier track record | U      | 1                                  | 2 | 3 | 4 | 5 |
| 4.8 | Inability to disseminate 'best practices'                 | U      | 1                                  | 2 | 3 | 4 | 5 |

5. On a scale of **1 (minor)** to **5 (major)**, to what extent do the following **practices** contribute to an inappropriate organisational culture in construction (**please note the 'unsure' options**)?

|     | Practices                                          | Unsure | Minor.....Major |   |   |   |   |
|-----|----------------------------------------------------|--------|-----------------|---|---|---|---|
|     |                                                    |        | 1               | 2 | 3 | 4 | 5 |
| 5.1 | Non-inclusive decision-making within project teams | U      | 1               | 2 | 3 | 4 | 5 |

|     |                                              |   |   |   |   |   |   |
|-----|----------------------------------------------|---|---|---|---|---|---|
| 5.2 | Apathy toward idea generation and evaluation | U | 1 | 2 | 3 | 4 | 5 |
| 5.3 | Poor analysis of issues and their impact     | U | 1 | 2 | 3 | 4 | 5 |
| 5.4 | Improper worker motivation and empowerment   | U | 1 | 2 | 3 | 4 | 5 |
| 5.5 | Lack of trust within project teams           | U | 1 | 2 | 3 | 4 | 5 |
| 5.6 | Closed one-directional communication mediums | U | 1 | 2 | 3 | 4 | 5 |

6. On a scale of **1 (totally disagree)** to **5 (totally agree)**, to what extent do the following **situations** occur due to an inappropriate organisation culture in construction (**please note the 'unsure' options**)?

|     | Situations                                              | Unsure | Totally disagree.....Totally agree |   |   |   |   |
|-----|---------------------------------------------------------|--------|------------------------------------|---|---|---|---|
|     |                                                         |        | 1                                  | 2 | 3 | 4 | 5 |
| 6.1 | Poor problem identification and resolution              | U      | 1                                  | 2 | 3 | 4 | 5 |
| 6.2 | Poor harnessing of skills within project teams          | U      | 1                                  | 2 | 3 | 4 | 5 |
| 6.3 | Increased resistance to change                          | U      | 1                                  | 2 | 3 | 4 | 5 |
| 6.4 | Inadequate site relationship management                 | U      | 1                                  | 2 | 3 | 4 | 5 |
| 6.5 | Poor handling of social issues associated with projects | U      | 1                                  | 2 | 3 | 4 | 5 |
| 6.6 | Customer / Client dissatisfaction                       | U      | 1                                  | 2 | 3 | 4 | 5 |
| 6.7 | Employee dissatisfaction                                | U      | 1                                  | 2 | 3 | 4 | 5 |
| 6.8 | Organisational stagnation / failure                     | U      | 1                                  | 2 | 3 | 4 | 5 |

7. On a scale of **1 (minor)** to **5 (major)**, to what extent do the following **practices** contribute to unacceptable coordination and regard for H&S in construction (**please note the 'unsure' options**)?

|     | Practices                                              | Unsure | Minor.....Major |   |   |   |   |
|-----|--------------------------------------------------------|--------|-----------------|---|---|---|---|
|     |                                                        |        | 1               | 2 | 3 | 4 | 5 |
| 7.1 | Poor comprehension of project characteristics          | U      | 1               | 2 | 3 | 4 | 5 |
| 7.2 | Inadequate knowledge relative to nature of work / task | U      | 1               | 2 | 3 | 4 | 5 |
| 7.3 | H&S competence of project participants                 | U      | 1               | 2 | 3 | 4 | 5 |
| 7.4 | H&S management procedures / systems                    | U      | 1               | 2 | 3 | 4 | 5 |
| 7.5 | Collective organisation values relative to H&S         | U      | 1               | 2 | 3 | 4 | 5 |

8. On a scale of **1 (totally disagree)** to **5 (totally agree)**, to what extent do the following **situations** occur due to unacceptable coordination and regard for H&S in construction (**please note the 'unsure' options**)?

|     | Situations                                               | Unsure | Totally disagree.....Totally agree |   |   |   |   |
|-----|----------------------------------------------------------|--------|------------------------------------|---|---|---|---|
|     |                                                          |        | 1                                  | 2 | 3 | 4 | 5 |
| 8.1 | Lack of project specific H&S specification               | U      | 1                                  | 2 | 3 | 4 | 5 |
| 8.2 | Lack of project specific H&S plan                        | U      | 1                                  | 2 | 3 | 4 | 5 |
| 8.3 | Ineffective H&S monitoring and inspection                | U      | 1                                  | 2 | 3 | 4 | 5 |
| 8.4 | Work stoppages, injuries, and fatalities                 | U      | 1                                  | 2 | 3 | 4 | 5 |
| 8.5 | Inadequate status of H&S within the construction process | U      | 1                                  | 2 | 3 | 4 | 5 |

9. On a scale of **1 (minor)** to **5 (major)**, to what extent do the following **practices / situations** contribute to inadequate management of quality in construction (**please note the 'unsure' options**)?

|     | Practices / Situations               | Unsure | Minor.....Major |   |   |   |   |
|-----|--------------------------------------|--------|-----------------|---|---|---|---|
|     |                                      |        | 1               | 2 | 3 | 4 | 5 |
| 9.1 | Poor exchange of project information | U      | 1               | 2 | 3 | 4 | 5 |
| 9.2 | Poor project specifications          | U      | 1               | 2 | 3 | 4 | 5 |
| 9.3 | Poor project cost and schedule data  | U      | 1               | 2 | 3 | 4 | 5 |
| 9.4 | Poor work procedures / methods       | U      | 1               | 2 | 3 | 4 | 5 |
| 9.5 | Poor understanding of quality        | U      | 1               | 2 | 3 | 4 | 5 |

10. On a scale of **1 (totally disagree)** to **5 (totally agree)**, to what extent do the following **situations** occur due to inadequate management of quality in construction (**please note the 'unsure' options**)?

| Situations | Unsure | Totally disagree.....Totally agree |  |  |  |  |
|------------|--------|------------------------------------|--|--|--|--|
|------------|--------|------------------------------------|--|--|--|--|

|      |                                     |   | 1 | 2 | 3 | 4 | 5 |
|------|-------------------------------------|---|---|---|---|---|---|
| 10.1 | Defects and rework                  | U | 1 | 2 | 3 | 4 | 5 |
| 10.2 | injuries and fatalities             | U | 1 | 2 | 3 | 4 | 5 |
| 10.3 | High built asset maintenance cost   | U | 1 | 2 | 3 | 4 | 5 |
| 10.4 | Increased project duration and cost | U | 1 | 2 | 3 | 4 | 5 |
| 10.5 | Client dissatisfaction              | U | 1 | 2 | 3 | 4 | 5 |

11. On a scale of **1 (minor)** to **5 (major)**, to what extent do the following perspectives / practices / interventions contribute to performance improvement in construction (**please note the 'unsure' response**)?

|      | Perspective / Practice / Interventions                | Unsure | Minor.....Major |   |   |   |   |
|------|-------------------------------------------------------|--------|-----------------|---|---|---|---|
|      |                                                       |        | 1               | 2 | 3 | 4 | 5 |
| 11.1 | Total Quality Management of all processes             | U      | 1               | 2 | 3 | 4 | 5 |
| 11.2 | Integrative H&S management practices                  | U      | 1               | 2 | 3 | 4 | 5 |
| 11.3 | Appropriate allocation of project risk                | U      | 1               | 2 | 3 | 4 | 5 |
| 11.4 | Adequate documentation and transfer of knowledge      | U      | 1               | 2 | 3 | 4 | 5 |
| 11.5 | Good organisational culture among project partners    | U      | 1               | 2 | 3 | 4 | 5 |
| 11.6 | Reliable and efficient logistics management practices | U      | 1               | 2 | 3 | 4 | 5 |
| 11.7 | Continuous human resources development                | U      | 1               | 2 | 3 | 4 | 5 |
| 11.8 | Robust open information sharing among project team    | U      | 1               | 2 | 3 | 4 | 5 |

12. Please indicate the type of on going / past **infrastructural projects** undertaken in your organisation – please state the approximate percentage contributions?

|      | Project category                     | Unsure | No | Yes | % |
|------|--------------------------------------|--------|----|-----|---|
| 12.1 | Transport (roads, port, harbour )    |        |    |     |   |
| 12.2 | Power (dam, gas, coal)               |        |    |     |   |
| 12.3 | Water (storm water, treatment plant) |        |    |     |   |
| 12.4 | Other non-residential construction   |        |    |     |   |

13. Please indicate the type of contract strategy used for **infrastructural projects** undertaken in your organisation – please state the approximate percentage contributions?

|      | Project category                  | Unsure | No | Yes | % |
|------|-----------------------------------|--------|----|-----|---|
| 13.1 | Construction Management           |        |    |     |   |
| 13.2 | Design and Build                  |        |    |     |   |
| 13.3 | Design by Employer (traditional)  |        |    |     |   |
| 13.4 | Management Contracting            |        |    |     |   |
| 13.5 | Public Private Partnerships (PPP) |        |    |     |   |

14. Please provide the following background information for statistical purposes only.

- 14.1 Please indicate the number of projects you have undertaken in the box provided below.

| ≤ 5 | 6 – 10 | 11 – 15 | 16 – 20 | > 20 |
|-----|--------|---------|---------|------|
|     |        |         |         |      |

- 14.2 Please indicate the length of your construction industry experience in the box provided below.

| ≤ 5 years | 6 – 10 years | 11 – 15 years | 16 – 20 years | > 20 years |
|-----------|--------------|---------------|---------------|------------|
|           |              |               |               |            |

- 14.3 Please indicate your highest formal education in the box provided below.

| Matric Certificate | N Dip. | BTech / BSc (Hon) | MSc / MTech | PhD /DTech |
|--------------------|--------|-------------------|-------------|------------|
|                    |        |                   |             |            |

15. Do you have any comments in general regarding improving the construction supply chain in **South African** construction?

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Please record your details below to facilitate contacting you, in the event that a query should arise. **Please note that the data provided in this questionnaire will be treated in the strictest confidence.**

|          |       |         |           |
|----------|-------|---------|-----------|
| NAME:    | <hr/> | PHONE:  | <hr/> ( ) |
| ADDRESS: | <hr/> | FAX:    | <hr/> ( ) |
|          | <hr/> | MOBILE: | <hr/>     |
|          | <hr/> | E-MAIL: | <hr/>     |
|          | <hr/> |         |           |

© Fidelis Emuze August 2010



**APPENDIX 5**

21 October 2010

Dear Madam / Sir

**Re: Improving the construction supply chain: Accelerating infrastructure delivery in South Africa (revised to Performance Improvement in South African Construction)**

This survey is part of a research project aimed at meeting the requirements for a PhD (Construction Management) at the Nelson Mandela Metropolitan University.

The aim of this phase of the research process is to identify performance impediments and possible remedies in South African construction.

Kindly complete the accompanying questionnaire and return same to:

Department of Construction Management  
Nelson Mandela Metropolitan University  
PO Box 77000  
Port Elizabeth  
6031

Please return either through the postal service or per facsimile to: (041) 504 2345 on or before 20 November 2010.

Attention: Mr Fidelis Emuze

Should you have any queries please do not hesitate to contact Mr Fidelis Emuze at 071 450 9442 or per e-mail: [s208090281@live.nmmu.ac.za](mailto:s208090281@live.nmmu.ac.za)

Please note that the confidentiality of your response is assured.

**Thanking you in anticipation of your response.**

**Mr Fidelis Emuze MSc (Built Environment), GMICE, AMSAICE  
PhD (Construction Management) Candidate**

**Prof John Smallwood PhD (Construction Management)  
Promoter**

**Professor, and Head, Department of Construction Management  
Programme Director, MSc (Built Environment) Programme**

1. On a scale of 1 (minor) to 5 (major), to what extent do the following practices / situations contribute to inadequate documentation and transfer of knowledge in construction (please note the 'unsure' options)?

|     | Practices / Situations                               | Unsure | Minor.....Major |   |   |   |   |
|-----|------------------------------------------------------|--------|-----------------|---|---|---|---|
|     |                                                      |        | 1               | 2 | 3 | 4 | 5 |
| 1.1 | Lack of post project reviews / reports               | U      | 1               | 2 | 3 | 4 | 5 |
| 1.2 | Lack of mentorship programmes                        | U      | 1               | 2 | 3 | 4 | 5 |
| 1.3 | Lack of detailed databases relative to past projects | U      | 1               | 2 | 3 | 4 | 5 |
| 1.4 | Poor information management                          | U      | 1               | 2 | 3 | 4 | 5 |
| 1.5 | Poor allocation of resources to knowledge capture    | U      | 1               | 2 | 3 | 4 | 5 |

2. On a scale of **1 (totally disagree)** to **5 (totally agree)**, to what extent do the following **situations** occur due to the lack of proper documentation and transfer of knowledge in construction (**please note the 'unsure' options**)?

|     | Situations                                                | Unsure | Totally disagree.....Totally agree |   |   |   |   |
|-----|-----------------------------------------------------------|--------|------------------------------------|---|---|---|---|
|     |                                                           |        | 1                                  | 2 | 3 | 4 | 5 |
| 2.1 | Repetition of past project mistakes                       | U      | 1                                  | 2 | 3 | 4 | 5 |
| 2.2 | Lost opportunities to improve project performance         | U      | 1                                  | 2 | 3 | 4 | 5 |
| 2.3 | Ineffective problem solving capabilities                  | U      | 1                                  | 2 | 3 | 4 | 5 |
| 2.4 | Inability to innovate and respond to clients' needs       | U      | 1                                  | 2 | 3 | 4 | 5 |
| 2.5 | Inability to tackle risks / uncertainties effectively     | U      | 1                                  | 2 | 3 | 4 | 5 |
| 2.6 | Poor response to organisational and project changes       | U      | 1                                  | 2 | 3 | 4 | 5 |
| 2.7 | Loss of contractor, subcontractor / supplier track record | U      | 1                                  | 2 | 3 | 4 | 5 |
| 2.8 | Inability to disseminate 'best practices'                 | U      | 1                                  | 2 | 3 | 4 | 5 |

3. On a scale of **1 (minor)** to **5 (major)**, to what extent do the following **practices** contribute to an inappropriate organisational culture in construction (**please note the 'unsure' options**)?

|     | Practices                                          | Unsure | Minor.....Major |   |   |   |   |
|-----|----------------------------------------------------|--------|-----------------|---|---|---|---|
|     |                                                    |        | 1               | 2 | 3 | 4 | 5 |
| 3.1 | Non-inclusive decision-making within project teams | U      | 1               | 2 | 3 | 4 | 5 |
| 3.2 | Apathy towards idea generation and evaluation      | U      | 1               | 2 | 3 | 4 | 5 |
| 3.3 | Poor analysis of issues and their impact           | U      | 1               | 2 | 3 | 4 | 5 |
| 3.4 | Improper worker motivation and empowerment         | U      | 1               | 2 | 3 | 4 | 5 |
| 3.5 | Lack of trust within project teams                 | U      | 1               | 2 | 3 | 4 | 5 |
| 3.6 | Closed one-directional communication mediums       | U      | 1               | 2 | 3 | 4 | 5 |

4. On a scale of **1 (totally disagree)** to **5 (totally agree)**, to what extent do the following **situations** occur due to an inappropriate organisation culture in construction (**please note the 'unsure' options**)?

|     | Situations                                              | Unsure | Totally disagree.....Totally agree |   |   |   |   |
|-----|---------------------------------------------------------|--------|------------------------------------|---|---|---|---|
|     |                                                         |        | 1                                  | 2 | 3 | 4 | 5 |
| 4.1 | Poor problem identification and resolution              | U      | 1                                  | 2 | 3 | 4 | 5 |
| 4.2 | Poor harnessing of skills within project teams          | U      | 1                                  | 2 | 3 | 4 | 5 |
| 4.3 | Increased resistance to change                          | U      | 1                                  | 2 | 3 | 4 | 5 |
| 4.4 | Inadequate site relationship management                 | U      | 1                                  | 2 | 3 | 4 | 5 |
| 4.5 | Poor handling of social issues associated with projects | U      | 1                                  | 2 | 3 | 4 | 5 |
| 4.6 | Customer / client dissatisfaction                       | U      | 1                                  | 2 | 3 | 4 | 5 |
| 4.7 | Employee dissatisfaction                                | U      | 1                                  | 2 | 3 | 4 | 5 |
| 4.8 | Organisational stagnation / failure                     | U      | 1                                  | 2 | 3 | 4 | 5 |

5. On a scale of **1 (minor)** to **5 (major)**, to what extent do the following **practices** contribute to poor multidisciplinary interface between consultants in construction (**please note the 'unsure' options**)?

|     | Practices                                  | Unsure | Minor.....Major |   |   |   |   |
|-----|--------------------------------------------|--------|-----------------|---|---|---|---|
|     |                                            |        | 1               | 2 | 3 | 4 | 5 |
| 5.1 | Commitment to different project objectives | U      | 1               | 2 | 3 | 4 | 5 |
| 5.2 | Unequal design expertise                   | U      | 1               | 2 | 3 | 4 | 5 |

|     |                                                 |   |   |   |   |   |   |
|-----|-------------------------------------------------|---|---|---|---|---|---|
| 5.3 | Change in personnel during the project duration | U | 1 | 2 | 3 | 4 | 5 |
| 5.4 | Paper transmission of project information       | U | 1 | 2 | 3 | 4 | 5 |
| 5.5 | Behavioural tendencies within project teams     | U | 1 | 2 | 3 | 4 | 5 |

6. On a scale of **1 (totally disagree)** to **5 (totally agree)**, to what extent do the following **practices** occur due to poor multidisciplinary interface between consultants in construction (**please note the 'unsure' options**)?

|     | Practices                          | Unsure | Totally disagree.....Totally agree |   |   |   |   |
|-----|------------------------------------|--------|------------------------------------|---|---|---|---|
|     |                                    |        | 1                                  | 2 | 3 | 4 | 5 |
| 6.1 | Costly design changes              | U      | 1                                  | 2 | 3 | 4 | 5 |
| 6.2 | Delay and rework on site           | U      | 1                                  | 2 | 3 | 4 | 5 |
| 6.3 | Unclear design and specification   | U      | 1                                  | 2 | 3 | 4 | 5 |
| 6.4 | Extensive revisions of design      | U      | 1                                  | 2 | 3 | 4 | 5 |
| 6.5 | Constant RFIs from site management | U      | 1                                  | 2 | 3 | 4 | 5 |

7. On a scale of **1 (minor)** to **5 (major)**, to what extent do the following **practices** contribute to inadequate management of logistics in construction (**please note the 'unsure' options**)?

|     | Practices                                                | Unsure | Minor.....Major |   |   |   |   |
|-----|----------------------------------------------------------|--------|-----------------|---|---|---|---|
|     |                                                          |        | 1               | 2 | 3 | 4 | 5 |
| 7.1 | Poor site layout                                         | U      | 1               | 2 | 3 | 4 | 5 |
| 7.2 | Poor material supply, storage, and handling              | U      | 1               | 2 | 3 | 4 | 5 |
| 7.3 | Poor work schedule control                               | U      | 1               | 2 | 3 | 4 | 5 |
| 7.4 | Poor infrastructure and equipment location               | U      | 1               | 2 | 3 | 4 | 5 |
| 7.5 | Poor site material flow management                       | U      | 1               | 2 | 3 | 4 | 5 |
| 7.6 | Lack of site management competence relative to logistics | U      | 1               | 2 | 3 | 4 | 5 |
| 7.7 | Lack of formal training relative to logistics            | U      | 1               | 2 | 3 | 4 | 5 |

8. On a scale of **1 (totally disagree)** to **5 (totally agree)**, to what extent do the following **situations** occur due to inadequate management of logistics in construction (**please note the 'unsure' options**)?

|     | Situations                                            | Unsure | Totally disagree.....Totally agree |   |   |   |   |
|-----|-------------------------------------------------------|--------|------------------------------------|---|---|---|---|
|     |                                                       |        | 1                                  | 2 | 3 | 4 | 5 |
| 8.1 | Under utilisation of construction vehicles            | U      | 1                                  | 2 | 3 | 4 | 5 |
| 8.2 | Long material off-loading time on site                | U      | 1                                  | 2 | 3 | 4 | 5 |
| 8.3 | Material loss due to defects and theft                | U      | 1                                  | 2 | 3 | 4 | 5 |
| 8.4 | High level of construction waste on site              | U      | 1                                  | 2 | 3 | 4 | 5 |
| 8.5 | Added risks relative to H&S                           | U      | 1                                  | 2 | 3 | 4 | 5 |
| 8.6 | Added cost in the project                             | U      | 1                                  | 2 | 3 | 4 | 5 |
| 8.7 | Poor quality and time management                      | U      | 1                                  | 2 | 3 | 4 | 5 |
| 8.8 | Poor image of the industry in terms of climate change | U      | 1                                  | 2 | 3 | 4 | 5 |

9. On a scale of **1 (minor)** to **5 (major)**, to what extent do the following **practices** contribute to unacceptable coordination and regard for H&S in construction (**please note the 'unsure' options**)?

|     | Practices                                              | Unsure | Minor.....Major |   |   |   |   |
|-----|--------------------------------------------------------|--------|-----------------|---|---|---|---|
|     |                                                        |        | 1               | 2 | 3 | 4 | 5 |
| 9.1 | Poor comprehension of project characteristics          | U      | 1               | 2 | 3 | 4 | 5 |
| 9.2 | Inadequate knowledge relative to nature of work / task | U      | 1               | 2 | 3 | 4 | 5 |
| 9.3 | H&S competence of project participants                 | U      | 1               | 2 | 3 | 4 | 5 |
| 9.4 | H&S management procedures / systems                    | U      | 1               | 2 | 3 | 4 | 5 |
| 9.5 | Collective organisation values relative to H&S         | U      | 1               | 2 | 3 | 4 | 5 |

10. On a scale of **1 (totally disagree)** to **5 (totally agree)**, to what extent do the following **situations** occur due to unacceptable coordination and regard for H&S in construction (**please note the 'unsure' options**)?

|      | Situations                                         | Unsure | Totally disagree.....Totally agree |   |   |   |   |
|------|----------------------------------------------------|--------|------------------------------------|---|---|---|---|
|      |                                                    |        | 1                                  | 2 | 3 | 4 | 5 |
| 10.1 | Lack of project specific H&S specification         | U      | 1                                  | 2 | 3 | 4 | 5 |
| 10.2 | Lack of project specific H&S plan                  | U      | 1                                  | 2 | 3 | 4 | 5 |
| 10.3 | Ineffective H&S monitoring and inspection          | U      | 1                                  | 2 | 3 | 4 | 5 |
| 10.4 | Work stoppages, injuries, and fatalities           | U      | 1                                  | 2 | 3 | 4 | 5 |
| 10.5 | Poor status of H&S within the construction process | U      | 1                                  | 2 | 3 | 4 | 5 |

11. On a scale of **1 (minor)** to **5 (major)**, to what extent do the following **practices / situations** contribute to inadequate management of quality in construction (**please note the 'unsure' options**)?

|      | Practices / Situations               | Unsure | Minor.....Major |   |   |   |   |
|------|--------------------------------------|--------|-----------------|---|---|---|---|
|      |                                      |        | 1               | 2 | 3 | 4 | 5 |
| 11.1 | Poor exchange of project information | U      | 1               | 2 | 3 | 4 | 5 |
| 11.2 | Poor project specifications          | U      | 1               | 2 | 3 | 4 | 5 |
| 11.3 | Poor project cost and schedule data  | U      | 1               | 2 | 3 | 4 | 5 |
| 11.4 | Poor work procedures / methods       | U      | 1               | 2 | 3 | 4 | 5 |
| 11.5 | Poor understanding of quality        | U      | 1               | 2 | 3 | 4 | 5 |

12. On a scale of **1 (totally disagree)** to **5 (totally agree)**, to what extent do the following **situations** occur due to inadequate management of quality in construction (**please note the 'unsure' options**)?

|      | Situations                          | Unsure | Totally disagree.....Totally agree |   |   |   |   |
|------|-------------------------------------|--------|------------------------------------|---|---|---|---|
|      |                                     |        | 1                                  | 2 | 3 | 4 | 5 |
| 12.1 | Defects and rework                  | U      | 1                                  | 2 | 3 | 4 | 5 |
| 12.2 | injuries and fatalities             | U      | 1                                  | 2 | 3 | 4 | 5 |
| 12.3 | High built asset maintenance cost   | U      | 1                                  | 2 | 3 | 4 | 5 |
| 12.4 | Increased project duration and cost | U      | 1                                  | 2 | 3 | 4 | 5 |
| 12.5 | Client dissatisfaction              | U      | 1                                  | 2 | 3 | 4 | 5 |

13. On a scale of **1 (minor)** to **5 (major)**, to what extent do the following perspectives / practices / interventions contribute to performance improvement in construction (**please note the 'unsure' response**)?

|      | Perspective / Practice / Interventions                | Unsure | Minor.....Major |   |   |   |   |
|------|-------------------------------------------------------|--------|-----------------|---|---|---|---|
|      |                                                       |        | 1               | 2 | 3 | 4 | 5 |
| 13.1 | Total Quality Management of all processes             | U      | 1               | 2 | 3 | 4 | 5 |
| 13.2 | Integrative H&S management practices                  | U      | 1               | 2 | 3 | 4 | 5 |
| 13.3 | Appropriate allocation of project risk                | U      | 1               | 2 | 3 | 4 | 5 |
| 13.4 | Adequate documentation and transfer of knowledge      | U      | 1               | 2 | 3 | 4 | 5 |
| 13.5 | Good organisational culture among project partners    | U      | 1               | 2 | 3 | 4 | 5 |
| 13.6 | Reliable and efficient logistics management practices | U      | 1               | 2 | 3 | 4 | 5 |
| 13.7 | Continuous human resources development                | U      | 1               | 2 | 3 | 4 | 5 |
| 13.8 | Robust open information sharing among project team    | U      | 1               | 2 | 3 | 4 | 5 |
| 13.9 | Reduce the need for non-value adding activities       | U      | 1               | 2 | 3 | 4 | 5 |

14. Please indicate the type of on going / past **infrastructural projects** undertaken in your organisation – please state the approximate percentage contributions?

|      | Project category                     | Unsure | No | Yes | % |
|------|--------------------------------------|--------|----|-----|---|
| 14.1 | Transport (roads, port, harbour )    |        |    |     |   |
| 14.2 | Power (dam, gas, coal)               |        |    |     |   |
| 14.3 | Water (storm water, treatment plant) |        |    |     |   |
| 14.4 | Other non-residential construction   |        |    |     |   |

15. Please indicate the type of contract strategy used for **infrastructural projects** undertaken in your organisation – please state the approximate percentage contributions?

|      | <b>Project category</b>           | <b>Unsure</b> | <b>No</b> | <b>Yes</b> | <b>%</b> |
|------|-----------------------------------|---------------|-----------|------------|----------|
| 15.1 | Construction Management           |               |           |            |          |
| 15.2 | Design and Build                  |               |           |            |          |
| 15.3 | Design by Employer (traditional)  |               |           |            |          |
| 15.4 | Management Contracting            |               |           |            |          |
| 15.5 | Public Private Partnerships (PPP) |               |           |            |          |

16. Please provide the following background information for statistical purposes only.

16.1 Please indicate the number of projects you have undertaken in the box provided below.

| <b>≤ 5</b> | <b>6 – 10</b> | <b>11 – 15</b> | <b>16 – 20</b> | <b>&gt; 20</b> |
|------------|---------------|----------------|----------------|----------------|
|            |               |                |                |                |

16.2 Please indicate the length of your construction industry experience in the box provided below.

| <b>≤ 5 years</b> | <b>6 – 10 years</b> | <b>11 – 15 years</b> | <b>16 – 20 years</b> | <b>&gt; 20 years</b> |
|------------------|---------------------|----------------------|----------------------|----------------------|
|                  |                     |                      |                      |                      |

16.3 Please indicate your highest formal education in the box provided below.

| <b>Matric Certificate</b> | <b>N Dip.</b> | <b>BTech / BSc (Hon)</b> | <b>MSc / MTech</b> | <b>PhD /DTech</b> |
|---------------------------|---------------|--------------------------|--------------------|-------------------|
|                           |               |                          |                    |                   |

17. Do you have any comments in general regarding improving the construction supply chain in **South African** construction?

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Please record your details below to facilitate contacting you, in the event that a query should arise. **Please note that the data provided in this questionnaire will be treated in the strictest confidence.**

NAME: \_\_\_\_\_ PHONE: (    ) \_\_\_\_\_

ADDRESS: \_\_\_\_\_ FAX: (    ) \_\_\_\_\_

\_\_\_\_\_ MOBILE: \_\_\_\_\_

\_\_\_\_\_ E-MAIL: \_\_\_\_\_

\_\_\_\_\_

## APPENDIX 6

### Model equations

- (01) Availability of materials=  
10  
Units: WorkUnit/(Month\*Person)
- (02) Competence=  
Formal education+project completion rate  
Units: WorkUnit/(Month\*Person)
- (03) Conformance to specifications=  
Availability of materials+Coordination and supervision of resources  
Units: WorkUnit/(Month\*Person)
- (04) Coordination and supervision of resources=  
Competence-Human error-Rework relative to designs  
Units: WorkUnit/(Month\*Person)
- (05) Critical tasks= INTEG (  
+tasks completion rate-project completion rate,  
1000)  
Units: WorkUnit/Person
- (06) FINAL TIME = 100  
Units: Month  
The final time for the simulation.
- (07) Formal education=  
5  
Units: WorkUnit/(Month\*Person)
- (08) Human error=  
0.1\*Competence  
Units: WorkUnit/(Month\*Person)

- (09) INITIAL TIME = 0  
Units: Month  
The initial time for the simulation.
- (10) project completion rate=  
1  
Units: WorkUnit/(Person\*Month)
- (11) Rework relative to designs=  
0.1\*Competence+Human error  
Units: WorkUnit/(Month\*Person)
- (12) SAVEPER =  
TIME STEP  
Units: Month  
The frequency with which output is stored.
- (13) tasks completion rate=  
Conformance to specifications  
Units: WorkUnit/(Month\*Person)
- (14) TIME STEP = 1  
Units: Month  
The time step for the simulation.