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**A Survey on the Use and Application of Information  
Technologies in Construction Management Processes**

Submitted by Sedireng Serumola  
to the School of Engineering Management in Partial Fulfillment of the Requirements for a  
Masters Degree in Engineering Management

**University of Cape Town**

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Date: January 2002

## **Declaration**

I, Sedireng Serumola, hereby declare that this dissertation is my original work and that it has not been submitted in this form or any similar form at any other university.

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## **ACKNOWLEDGEMENT**

I would like to express my sincere gratitude to the following people:

- My supervisor, Mr. Gordon Lister, for his invaluable guidance and support
- Prof. Kevin Bennett, Head of the Department of Mechanical Engineering, for financing part of the survey.
- All the building contractors, architectural and engineering companies that participated in this survey.

Special mention goes to my fiancé, Francinah, for her understanding, support and patience during my studies.

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## ABSTRACT

This dissertation describes the findings of a study that was carried out on the use and application of information technologies (IT) in construction management processes. This study, which was in the form of a survey, was conducted in October and November 2001 covering forty-five (45) architectural, engineering and construction companies operating in the Western Cape province of South Africa. The objectives of the study were: to investigate the extent of use and application of information technologies in construction companies operating in the Western Cape, and to determine the factors influencing IT investments in the construction industry.

The survey results reveal that 96% of respondents have invested in IT during the last two years, and some of the companies are planning to make further IT investments. Although an overwhelming number of companies have invested in IT during the last two years, only 71% of the respondents have IT strategies. From this 71% of the respondents, 34% have their IT strategies in written form and 37% have it in oral form. These construction companies are planning to make further IT investments in computer-aided design, document handling and accounting systems. Only a few companies showed interest in investing in electronic trading, computer product modelling, virtual reality and property information.

The survey has also established that many business processes like bookkeeping, invoicing, scheduling, resource-planning, costing, budgeting and tendering are highly computerised. Despite these large IT investments and high computerisation of the business processes, the outcomes have been mixed. The introduction of IT in the construction industry has resulted in some desirable changes since it has improved the efficiency of doing work, thereby reducing the cost of doing work. Furthermore, IT has increased productivity in general administration, project management, design, and site management. However, the introduction of IT has brought little or no improvement in reducing the mistakes in documents, the number of construction errors, the complexity of work, the administration needs and the proportion of new work.

Continual demand for upgrading hardware and software, and high investment costs are seen as prohibitive to the greater adoption of IT in the construction industry.

Based on the results of the survey, some suggestions are made on strategies for future research on the use of information technologies in the construction industry.

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## GLOSSARY OF TERMS

**Competitiveness** – in the context of business environment, competitiveness means the way a company executes its business strategy to provide best value of its products and services to its customers. Its competitiveness in the industry is defined by how it maintains its position among other companies in the industry.

**Electronic Data Interchange (EDI)** – an electronic transfer of structured data from one computer system to another using agreed standards.

**Electronic Document Management System (EDMS)** – the computer-based system for storage and retrieval of information. EDMS is a key aspect of IT-based knowledge management systems.

**Document Image Processing (DPI)** – the use of computers to store and retrieve electronic copies of documents (Gyampoh et al. 1999).

**Computer-Aided Design (CAD)** – this is system that enables drawings to be constructed on a computer and subsequently stored, manipulated, and updated electronically.

**Integration systems** – in the technical sense, means different computer applications that can communicate effortlessly. It also means sharing of data between two or more computer systems with little or no changes to the original format.

**Construction Processes** – these processes define the essential processes that are needed for the successful management and completion of construction. The processes include but are not limited to the following: project management, accounting, procurement, contracts, computer-aided design, estimating, communications, general administration and document handling.

**Benchmarking** – International Benchmarking Clearing House defines benchmarking as “... a process of continuously comparing and measuring an organisation with leaders anywhere in the world to gain information that will help it to take action to improve its

*performance*" (Lascelles & Peacock, 1996:129). It is a tool for supporting continuous improvement initiatives.

**Best Practice** – it is the performance difference between one or more companies' performance and what is perceived to be the "best practice" in the business. It is generally "best practice" in the context of customer expectations.

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# 1 INTRODUCTION

Information technology is playing an increasing role in both developing and developed economies of the world. It has been regarded as both a driver and an enabler of competitiveness in manufacturing and service organisations. With this view in mind, academic, government agencies and industry practitioners have carried out studies and projects in recent years to investigate the use and application of information technologies in the construction industry. This dissertation presents the results of a survey that was carried out to determine the extent of the use and application of information technologies in the construction management processes. This introductory chapter outlines the background and context of this study.

## 1.1 Understanding Context

The construction industry is one of the key sectors in developing countries. In South Africa, the construction industry is a critical aspect of the government's *Reconstruction and Development Programme* (RDP) aimed at providing housing and infrastructure development to millions of South African citizens. The government, together with the country's construction industry, acknowledges that only efficient construction processes would enable and improve delivery processes (Coetzee & Boshoff, 1998). Some of the problems highlighted by the RDP are declining construction demand, the deteriorating productivity levels, the declining quality outputs and performance of the South African construction sector. In line with RDP national strategic objectives, the Construction Industry Development Board (CIDB) was formally established in April 2001 after three years of consultative process between the South African government, public and private sectors.

The Construction Industry Development Board is aimed at improving efficiency, effectiveness, quality and productivity, health, safety, environmental outcomes and value for money to South African society. In addition, it is aimed at establishing best practices which promote improved industry performance, procurement and delivery management reform, work-process transformation and innovation. The CIDB was therefore formed to

drive the development strategy of the construction industry. It relies on the support from the Department of Works, public and private sectors, and the intellectual capacity of academic researchers.

In the Western Cape province of South Africa, the construction industry employs about 136 000 workers, which represents about 4 to 5% of the regional labour force.

From the United Kingdom (UK), Aoud and Sun (2000) have reported that in 1999 the UK construction output was about 10% of Gross Domestic Product (GDP). In 1996 the Irish construction sector contributed about 13% of the Republic of Ireland gross domestic product (Thomas 1999). In South Africa, the construction industry represents just 3% of GDP (SA Reserve Bank, 2001). Current view on performance of the construction industry is that efficient management processes will facilitate and sustain the success of the construction industry. Developing from this view is that the application of information technologies (IT), especially in automation of processes and collaborative computer systems would facilitate development of the industry. This view is influenced by the relative success in the use and application of IT in other sectors like manufacturing or service sector. The successes have been observed in automation of administration processes, improved procurement systems, reduced time in doing work, improved communication channels, improved quality of work, improved product design processes and others successes that are highlighted in chapter 2.

Research on the use and application of information technologies in the construction industry is a relatively new area of research. The following section presents the context for the development of information technologies in construction.

## 1.2 Background: Establishing Global Construction Cooperation Initiatives

The Construct IT Centre of Excellence (from hereon referred to as the Centre) was formally established in the UK at the beginning of 1995 as an industry-led, government endorsed research agency for coordinating and promoting research in IT in order to improve the competitive performance of the UK construction industry. Although the Centre was formally established in 1995, the foundation of this work was started a few years earlier by collaborative research efforts between the University of Salford and the UK construction industry. The Centre has extended its research focus area far beyond the UK construction industry landscape to include international IT initiatives in construction. Among its key objectives was the need to (Construct IT, 1997):

- promote coordinated construction IT research
- showcase IT development
- inform construction organisations of new IT investments

One of the Centre's milestones was an international meeting held in the small English village of Armathwaite to discuss the future of information technologies in the construction industry. This 1997 global meeting came to be known as the "Armathwaite Initiative" and was attended by representatives of Australia, Finland, Hong Kong, Japan, Slovenia, South Africa, Sweden, UK and USA. The participants undertook to initiate global cooperation among all those working in the field of IT to support improvements in the processes of design, construction and facilities management, with the aim of enhancing value for the industry's clients and prosperity for the industry (Construct IT, p.1, 1997): They planned to this by:

- Forming a global network of Construction IT Centres
- Seeking opportunities for collaborative efforts
- Benchmarking IT in construction
- Encouraging the use of process protocols
- Showcasing research, innovation, practical implementation

Only the few countries that have undertaken these kinds of studies have a clear picture of the extent of the uptake of information technologies. It is partly for this reason that I undertook this study with the aim of making a contribution to the development of the construction industry in South Africa.

In South Africa, one organisation that has taken a leading role in the research and development of information technologies in the construction industry is the Building and Construction Technology (Boutek), a division of the Centre for Scientific and Industrial Research (CSIR). CSIR is a South African industrial research organisation that supports innovation and sustainable development growth for the South African public and private sector. Among the various research departments is the Construction Technologies department. It supports the development of key information technologies that enable best practices in information technology in the construction industry. One of their initiatives is *Integrated Project Services (IPROS)*, which is an internet-based project communication process (<http://ipros.csir.co.za>) that allows for sharing of project information through the Internet.

With this context in mind, the research question was developed as explained in the next section.

### **1.3 Developing the Research Question**

How do South African architectural, engineering and building contractors use information technologies (IT) in their management and business processes? What is the extent of the computerisation of the construction business processes? What are the factors that influence construction companies to invest in information technologies? The initial stages of this study began with preliminary readings on information technologies and their application in the construction industry. It became evident early on, that most of the literature related to this area was from overseas. With this understanding, an attempt was made to contact some people in the South African construction industry during the early stages of the research. Those people that were contacted included some members of academic staff from the Department of Construction Management at the University of Cape Town and those from institutions like the Masters Builders Association which represents building contractors in the Western Cape province of South Africa.

## 1.4 Objectives of the Study

The objectives of this study were:

- To investigate the extent of the use and application of information technologies in architectural, engineering and major building contractors (AEC) in South Africa.
- To determine the factors influencing the decisions made by construction companies to adopt information technologies.
- To suggest strategies for the use and application of information technology based on the outcome of this study.

## 1.5 Definitions

So what is meant by information technologies (IT)? There is always a problem when one tries to restrict a certain concept to one specific definition, because people would always use different words in attempting to describe the same thing. An attempt to make an all-encompassing definition of IT would be difficult, especially for a relatively new and dynamic concept like IT. Here are some definitions of IT:

*“equipment, computers, and telecommunication devices”* (Targett et. al 1999);

Keen (1995) describes it as generally accepted umbrella term for *“rapidly expanding range of equipment, applications, services, and basic technologies”*;

Wilson and Olson (1989) describe it as *“a collection of computers, communications, software, networks and all associated expenses including people dedicated to the management and operation of the IT”*;

Turban et al. (2001) describe it as *“individual components that are typically organised into computer-based information systems”*.

These definitions, and the many that are not quoted here, appear to convey the same idea of “computer systems, computer hardware and accessories, computer software, telecommunication devices like faxes, modems, switches and their associated software

and systems". This is the general conceptualisation of information technologies that was adopted for this study.

## **1.6 Limitations and Scope of the Study**

This survey was conducted in an area where little research has been carried out before, or is currently being done in South Africa.

- The mail survey covered 45 architectural, engineering, building and construction contractors operating in the Western Cape.
- The sample size was limited by the funding available.
- The accuracy of the mail survey (as opposed to other research methods like in-depth interviewing) is limited because there is a good chance that respondents interpret questions differently.
- The author acknowledges that some architectural, engineering and building contractors operating in the Western Cape do not appear either in the Professions and Projects Register, Cape Chamber of Commerce website listing or the Masters Builders Association (Western Cape) listing. The list used for selecting the sample contained only those listed by the above institutions. However, the sample was selected randomly and the sample therefore represents a representative sample of construction companies operating in the Western Cape province.

The assumptions made in this study are that construction management processes include general administration, planning, designing, scheduling, project execution and control. In addition the computer tools that are used in the construction industry are those that reduce or eliminate repetitive tasks, thereby reducing the cost of doing construction work. It is further assumed that the exploitation of IT by the construction industry is one way of improving efficiency and productivity.

## **1.7 Structure of the Report**

Following this introductory chapter, **Chapter 2** reviews authoritative literature pertaining to this study. It also explores the theoretical framework underpinning this study.

**Chapter 3** presents the methodology that was followed in carrying out this study. In addition, chapter 3 also highlights the procedure that was followed in collecting and analysing the data.

**Chapter 4** presents the results (or findings) of this study and the implication of these results regarding the research objectives.

**Chapter 5** presents conclusions that were drawn from this investigation.

**Chapter 6** outlines the recommendations that were developed based on the results of this investigation.

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## 2 LITERATURE REVIEW AND THEORETICAL FRAMEWORK

### 2.1 Introduction

The objective of this chapter is to present key business and management principles that have informed this study. In addition, it presents a review of authoritative literature that has influenced this study. Most of the literature on the use of information technologies in construction is published from overseas.

### 2.2 Key Business and Management Principles

#### 2.2.1 Continuous Business Improvement

For last the two decades or so, the construction industry has been faced with business challenges that were previously observed in other industries like manufacturing. Some of the challenges included:

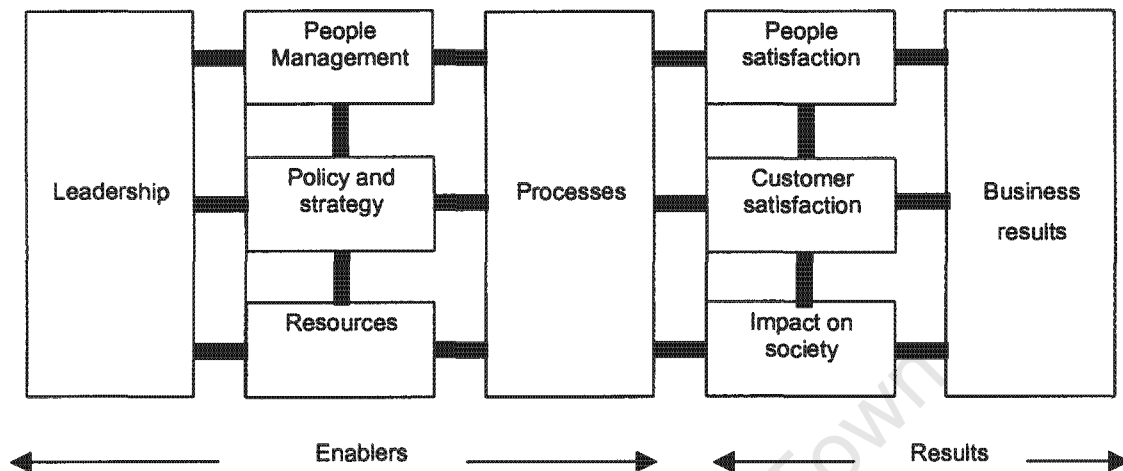
- the need to deliver more units of construction for lower units of expenditure
- the demand for greater efficiency and value for money; increased competition
- the need to improve quality and ensure client satisfaction
- and the increasing requirement for projects to be delivered within tighter time-scales (Anumba, pp.77-78, 1998).

As Turner (p. 246, 1998) cogently put it:

*“ in the past, being a low cost producer, or maintaining one’s market share was often sufficient as a business strategy. Today, such approaches are inadequate. More important is the ability ... to improve customer’s service, and to enhance quality of products and service”.*

It is for these reasons that there has been a growing movement to improve performance in business. Performance improvement measures can take many forms, depending on the culture and contextual environment in which a company operates. The European Business Excellence Model (EBEM), developed by the European Foundation for Total

Quality Management (EFQM) is a typical performance improvement model. Figure 1 below illustrates the European Business Excellence Model.



**Figure 1: European Business Excellence Model (Lascelles & Peacock, p. 14, 1996)**

This was how Lascelles (p. 15, 1996) summarised the model:

*"Customer Satisfaction, People Satisfaction, Impact on Society are achieved through Leadership driving Policy and Strategy, People Management, Resources and Processes leading ultimately to excellence in Business Results"*

The five elements on the left create enabling conditions for a business to achieve desired business results. This model supports total quality management measures in that it recognises the contribution made by people's inputs, rather than relying on technologies to drive business processes.

Lascelles and Peacock (1996) argue that continuous improvement is a never-ending process. Business environment is never static but a dynamic one requiring companies to continuously improve their processes as they face new challenges. Uncertainty is a critical aspect of our environment; that is why management tools like scenario planning and general strategic management are becoming important in clarifying strategic directions. Scenario planning is a strategic planning technique that involves identifying social, political, economic and technological forces that might shape the business

environment and discussing plausible scenarios that might happen as a result of the interactions. Scenario planning is not an attempt to predict the future but show how different forces might interact and affect a company's business environment.

Considering continuous improvement process as a journey, Lascelles and Peacock (1996) have presented a business improvement milestone as illustrated by Figure 2 below:

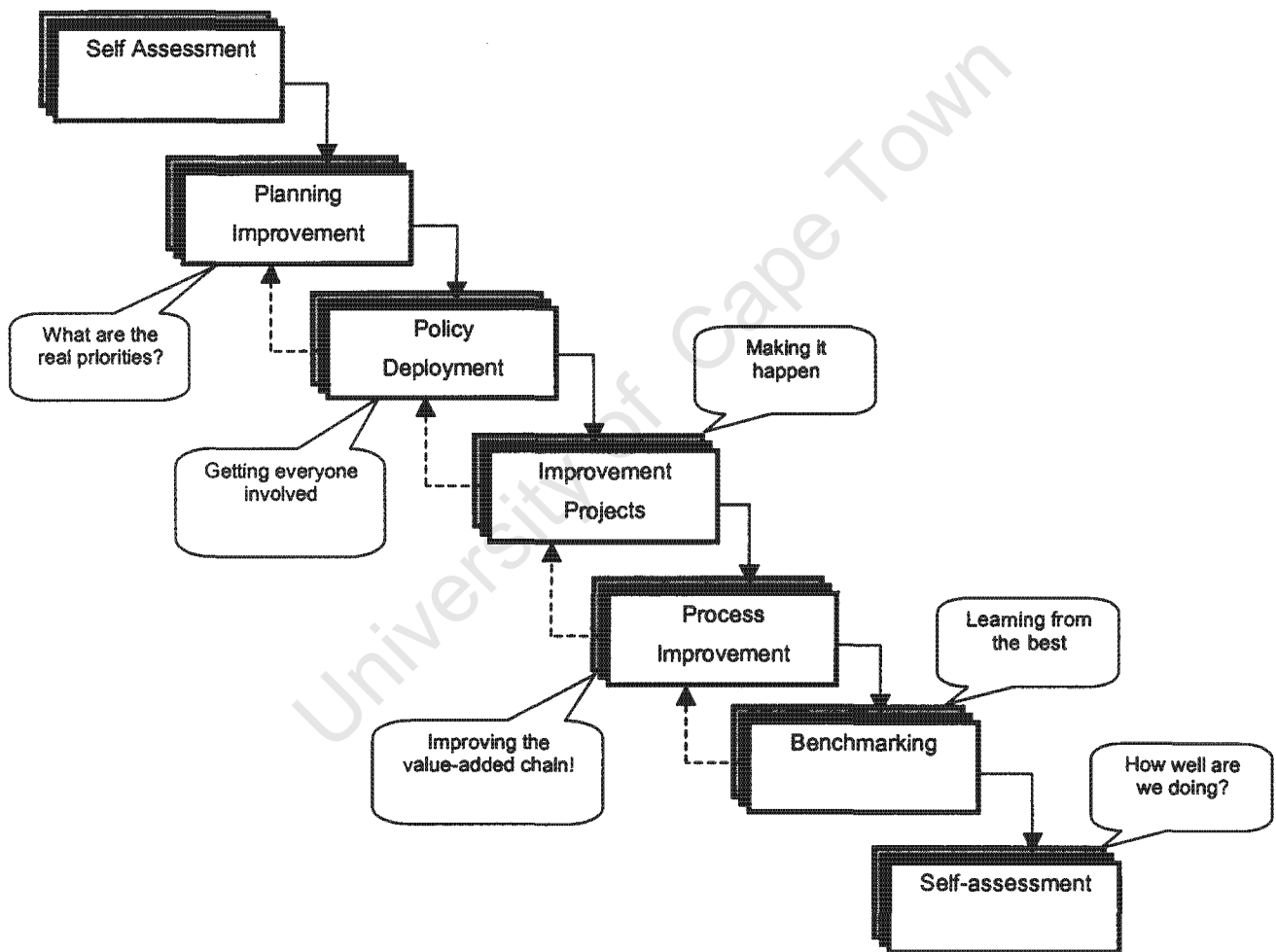


Figure 2: Business Improvement Milestone (Source: Lascelles & Peacock, p. 118, 1996)

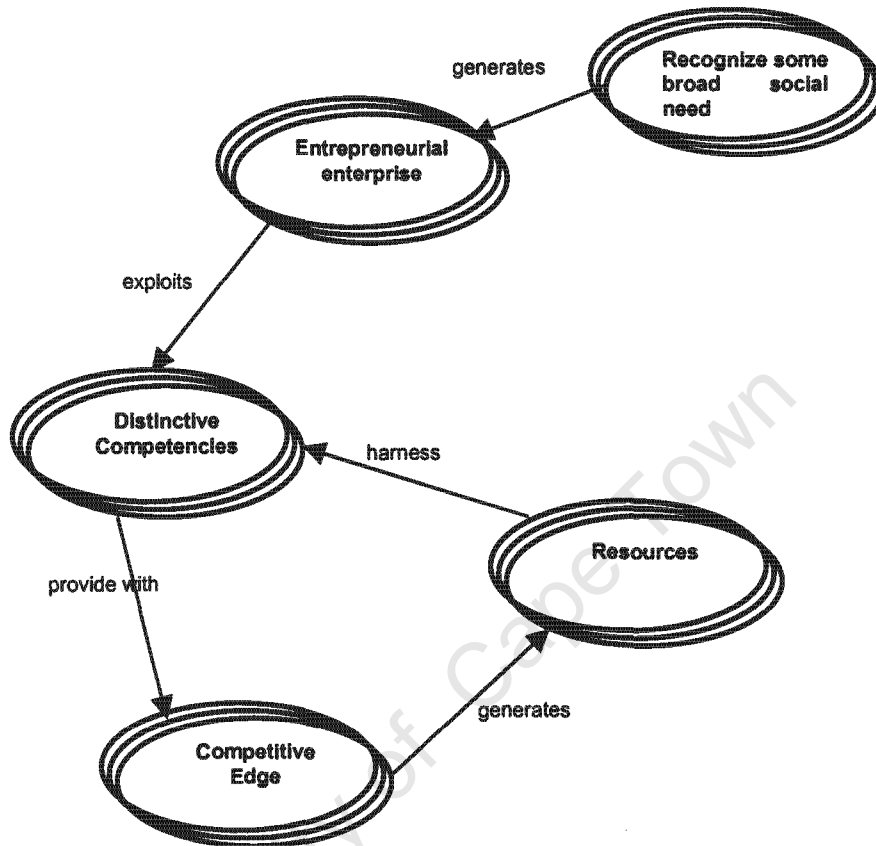
The elements of this performance improvement process are described below:

- Self-assessment:** a systematic review of company's achievements, failures, strengths and weaknesses based on existing business models like European Business Excellence Model, or balanced scorecard.
- Planning Improvement:** what are the real priorities? Based on a scenario planning exercise or simply an annual self-assessment exercise. Are we doing what we ought to be doing?
- Policy deployment:** annual improvement plan is translated at each level of management into specific improvement objectives and concrete action plans. The role of policy deployment is to create enabling conditions for improvement projects.
- Improvement Projects:** the specific tasks and action plans are executed.
- Process Improvement:** Improving the value added through process control, maintenance, or in some cases process redesign.
- Benchmarking:** Measuring own business processes against better performing organisations. This is not the same as copying what others practice but rather learning from their experiences.

### 2.2.2 The Business Idea

One of the objectives of studying the impact of information technologies in any business sector is to find out (and to a limited extent measure) their impact on productivity, efficiency, cost reduction and competitiveness. But why would any company be concerned with the efficiency, productivity, or the performance improvement measures of

its operations? Any business that exists does so for a specific reason. The basis for this argument is the Business Idea concept (Van der Heijden, 1996), illustrated by Figure 3:



*Figure 3: The Business Idea (Van Der Heijden, 1996)*

According to Van der Heijden (1996), the Business Idea drives organisational strategy of an organisation. In its generic form, the Business Idea describes a process that an enterprise goes through as it pursues its purpose. A business enterprise starts by recognising some broad social need that allows an enterprise to develop some kind of entrepreneurial invention. By developing entrepreneurial enterprise, a company can then exploit its distinctive competencies that in turn provide a company with a competitive edge. This competitive edge is then exploited to generate resources. The same resources are further exploited to harness its distinctive competencies. This is a positive feedback loop illustrating that a company strategy is a dynamic one that should reflect business patterns in a contextual environment.

Van der Heijden (1996) also emphasises that the Business Idea does not mean only one business (or core business) but it may encompass more than one business. Although Van der Heijden (1996) does not discuss the role played by information technologies in strategy making, it is suggested here that information technologies can facilitate the exploitation of those distinctive competencies and further facilitate that entrepreneurial invention. Effective implementation of information technologies streamlines the construction business processes by: eliminating repetitive manual tasks; achieving cost savings through reduction of errors in the quality of documents; reducing cost of communication by using faster and cheaper communication channels like email; and improving quality of documents by eliminating typing errors. The progressive and effective introductions of IT systems are the attributes of the continuous improvement initiatives. With regard to the construction industry, some IT initiatives have been taken on integrating technologies, performance measurement, quality programmes, and business process redesign. This dissertation examines the use of information technologies in the South African construction industry because of the possibility that effective implementation of IT would enable and improve the performance of the industry. The formulation of national strategic objectives and development programmes like *Reconstruction and Development Programme* demonstrate the need for a competitive South African construction industry.

### **2.3 Reviewed Literature on Information Technologies in Construction**

It has been difficult to obtain local published reports on the use of information technologies in the South Africa construction industry. Much of the literature that was reviewed originated from overseas. In South Africa, the Centre for Science and Industrial Research (CSIR) has carried out studies and collaborative projects in information technologies in the South African construction industry with the basis of some of the studies originating from overseas studies. The relevance of the literature reviewed in the following sections is to provide a background against which local experiences on information technologies in construction can be made. Whilst some of the reviewed literature (foreign empirical studies) cover the same ground as this survey, some of the literature on the application of IT in areas like electronic data interchange (EDI) and

electronic document management systems (EDMS) were reviewed for background purposes only.

### **2.3.1 Foreign Studies on Information Technologies in Construction**

Howard et al. (1998), Thomas (1999) and Rivard (2000) have respectively carried out survey studies in the use of information technologies in the Canadian, Irish and Scandinavian construction industries.

Howard et al. (1998) compared the results of studies carried out in Denmark, Finland and Sweden on the use of computer hardware, software and communications in the construction industry of each respective country. The surveys carried similar questions with only a few local variations relevant only to that particular country. These studies came to be known as the *IT Barometer Surveys*. The Royal Institute of Technology (KTH) in Sweden originally developed the IT Barometer surveys in 1997. According to Howard et al (1998), one of the objectives of these Barometer surveys was to obtain good base data so that particular differences and successes could be obtained, thus allowing for benchmarking of new IT applications in the construction industry. Howard et al. (1998) has also reported that the respondents from each of the three countries indicated that productivity had increased as a result of using software applications in administration and design, while there was little change in using IT tools in other management processes like project management, site management and materials management. The respondents however indicated willingness to increase investment in CAD, document handling, accounting and the Internet.

In the Denmark study analysed by Howard et al (1998), a quarter of the architects surveyed indicated that they spent about \$8000 on IT per member of staff. Engineers spent between \$3000 and \$8000 whilst contractors spent about \$150 per member of staff.

On the mode of exchange of documents, Howard et al (1998)'s study established that the type of building documents that were regularly exchanged in digital form were minutes, tenders, specifications, orders and invoices. Experiences from the three countries were similar as indicated by Figure 4 (Howard et al., p. 52, 1998). The figure

illustrates the percentages of data that were transferred digitally for each type of document listed on the left.

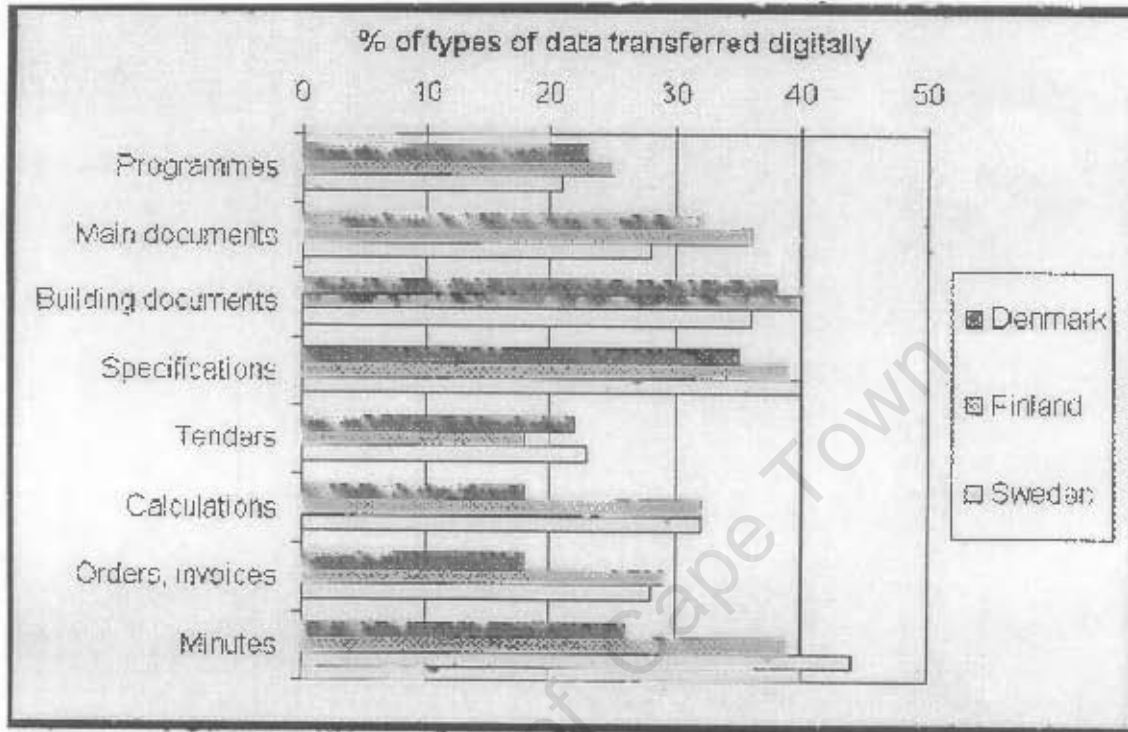


Figure 4: Percentage of types of document exchanged digitally in the three countries

A study conducted by Thomas (1999) in the Irish construction sector focused on computer hardware and software, communications, management of IT, difficulties with IT, IT strategy and the greater influence of IT in the construction sector. One of the key findings of the study was that 68% of the respondents believed that they were not using IT to its full potential. This could be explained by the fact that the majority of construction firms did not have an IT strategy and were unlikely to develop one in the near future. Thomas (1999) however concedes that IT can never be used to its full potential but most firms are aware that they could use more of IT tools with their current resources. The Irish study contrasts with the Canadian study which indicates that Canadian architectural, engineering and contractors firms planned to increase IT investments as they felt that previous IT investments had raised productivity and increased quality of documents, speed of doing work, financial control and communications (Rivard, 2000). In the Thomas study, construction firms identified a number of technological, financial,

environmental and human hindrances to the use of IT in the Irish construction industry. Table 1 below lists those hindrances reported by Irish construction firms. ARCH, ENG, QS and CON are abbreviations for architecture, engineering, quantity surveying, and construction companies.

**Table 1: Problems inhibiting the use of IT in the Irish construction industry**

<b>TECHNOLOGICAL REASONS</b>	<b>ARCH %</b>	<b>ENG %</b>	<b>QS %</b>	<b>CON %</b>	<b>Ave. %</b>
Integration/compatibility problems	35	27	34	64	40
Rapid changes in technology	30	49	26	36	35
Software problems	19	27	13	18	19
Reliability/breakdown problems	30	15	5	9	15
Hardware problems	11	9	5	15	10
Security not guaranteed	8	3	11	9	8

<b>HUMAN REASONS</b>	<b>ARCH %</b>	<b>ENG %</b>	<b>QS %</b>	<b>CON %</b>	<b>Ave. %</b>
Inadequate training	57	39	45	33	44
Lack of knowledge/awareness of available IT	38	33	34	55	40
Fear/mistrust of technology	16	24	18	39	24
Poor management	16	18	18	15	17
Poor teamwork	5	9	5	6	6
Poor leadership	11	6	0	3	5

<b>FINANCIAL REASONS</b>	<b>ARCH %</b>	<b>ENG %</b>	<b>QS %</b>	<b>CON %</b>	<b>Ave. %</b>
Lack of available funding	27	42	26	36	33
Difficulty in proving that the benefits of IT are greater than associated costs	35	18	21	12	22

<b>ENVIRONMENT REASONS</b>	<b>ARCH %</b>	<b>ENG %</b>	<b>QS %</b>	<b>CON %</b>	<b>Ave. %</b>
Conservative industry is slow to change	16	15	16	33	20
Project driven industry with short term outlook	16	27	18	15	19
Complex/fragmented industry	8	15	32	18	18
Susceptibility of industry to economic climate	14	15	8	21	14
Majority of companies in the industry are SMEs	3	15	3	9	7
Majority of clients are not construction experts	8	3	5	0	4

In the Canadian study Rivard (2000) reported that most documents were still sent by non-digital means. The main barriers to widespread exchange of documents by digital means were:

- Slow internet connections
- Lack of common standards that would permit the exchange of data among software applications
- This mode of communication has not been integrated into the business culture of the Canadian construction industry

Rivard (2000) also points out that Canadian firms have indicated that there were cost increases associated with IT investment process, complexity and administration needs of doing work. The Canadian firms also reported their desire to see more research in the areas of implementation of computer-aided design and construction, and the development of new design tools that would facilitate cooperative work efforts in construction projects.

One of the IT applications used in the construction industry is the project management software used in project planning, scheduling and control. Liberatore et al (2001) reported in their study on the use of project management software by construction professionals that 97% of the respondents indicated that they had used project management software in the previous 12 months. Construction professionals also indicated that they used critical path analysis software frequently in planning and control of projects.

In Liberatore et al (2000)'s study the construction professionals indicated their desire for future research in:

- Integration of project management software with software packages for other activities like materials management and financial control.
- Increased flexibility of project management software during project changes
- Improved software capabilities to communicate with field sites
- Improved capabilities to handle project uncertainties/risk
- Improved methods to forecast activity duration

Electronic Data Interchange (EDI) is the electronic transfer of structured data from one computer system to another connected by a communication link. According to McKellar and Akintoye (1997) EDI facilitates effective interchange of documents like invoices and purchase orders. Successful adoption has been seen in automotive, electronic and retail sectors. EDI is well developed in transportation and shipping industry where a large volume of customs clearance is effected. One of the key characteristics of the construction process is a large exchange of information between various participants like owners, quantity surveyors, architects, local authorities, suppliers, engineers and in some cases special interest groups. Effective communication is one of the fundamental requirements for successful completion of a project. Electronic Document Interchange, as an information technology tool, can facilitate this communication link. McKellar and Akintoye (1997) envisage that EDI is largely applied in the exchange of construction project documentation like contracts, bill of quantities, and tender enquiries. EDI is largely an inter-organisational information system (IOS) involving information flow between two or more organisations. Turban et al. (2001) argues that EDI is a direct response of two business pressures; a growing need to reduce costs and a need to improve effectiveness and timeliness of business process. Turban et al. (p. 256, 2001) illustrated major benefits of EDI as shown in Table 2 on the next page. Research indicates that as much as 10% of the construction industry uses EDI (RCSI, 1997). One of the reasons for this situation is that the costs of buying EDI are still high; so as long as there are cheaper options for construction companies, they will go for those options. Success in the implementation of EDI is dependent on a company's trading partners also adopting the technology. Otherwise if a trading partner does not have similar technologies the trading parties would experience problems related to incompatible data during the exchange process.

**Table 2: Benefits of Electronic Data Interchange (Source: Turban et al., p. 256, 2001)**

<b>Benefit</b>	<b>How Benefit is Achieved</b>
Speed, Volume	<ul style="list-style-type: none"> <li>• EDI enables companies to send and receive large amounts of routine transaction information quickly around the globe in a paperless environment.</li> <li>• Sales and other information is delivered to manufacturers, shippers, and warehouses almost in real time.</li> <li>• Once EDI documents are received, they are automatically forwarded to the appropriate department for processing</li> </ul>
Accuracy	<ul style="list-style-type: none"> <li>• There are very few errors in the transformed data as a result of computer-to-computer data transfer. Information is also consistent.</li> </ul>
Collaboration	<ul style="list-style-type: none"> <li>• Companies can access partners' databases to retrieve and store standard transactions.</li> </ul>
Commitment	<ul style="list-style-type: none"> <li>• EDI fosters true (and strategic) partnership relationships, since it involves a commitment to a long-term investment and the refinement of the system over time.</li> </ul>
Profit	<ul style="list-style-type: none"> <li>• The time for collecting payments can be shortened by several weeks, benefiting the recipients of payments.</li> </ul>
Cost Savings	<ul style="list-style-type: none"> <li>• EDI creates a complete paperless transfer processing environment, saving money and increasing efficiency.</li> <li>• EDI enables a just-in-time environment, which means lower (or no) inventories for manufacturers.</li> </ul>

Electronic document management system (EDM) is an IT administrative and communications tool for automation of electronic documents through their entire life cycle in an organisation. EDM is used to store information such as scanned faxes, pictures, images and drawing, word-processing documents, spreadsheet and database reports. The four main functional application areas of EDM are: document image processing, which stores electronic copies of documents; full text retrieval systems, which are computer programs that allows for searching and retrieval of information using keywords; and automatic document capture, which include bar coding, optical mark recognition, optical character recognition and intelligent character recognition. After reviewing document and information exchange during contract administrative process Gyampoh-Vidogah et al. (1999) have suggested that EDM technology could be applied in the construction contract management process. They envisage that EDM technology

could be used to capture all information from accounting, planning, valuation, estimating and cashflow forecasting functions within a construction organisation to facilitate easier access to the information during contract administrative process. Gympoh-Vidogah et al (p. 66, 1999) have suggested that in the context of contract administrative process, EDM offers the following benefits:

- Speedy preparation of documents
- Reduced cost of managing contract documents
- Efficient access and retrieval from all relevant information sources
- Reduced cost of storing and managing paper
- Reduction in (contract) disputes through more efficient and effective documentation

An example of successful implementation of EDM technologies is presented as a case study attached as Appendix I.

### **2.3.2 South African Research on Information Technologies in Construction**

Among the few projects that have been carried out by the Centre for Scientific and Industrial Research (CSIR) in the building industry are a benchmarking exercise and "IT Health Check" for the South African construction industry. The benchmarking exercise was carried out in 1998 focusing "on the extent of the use of information technology to integrate various sub-processes on local construction sites, thereby highlighting areas of productivity improvement" (CSIR, 1999, unpublished). The South African construction industry Health Check was essentially an exercise to ascertain the extent of IT in the construction industry when compared to other international countries. The benchmarking exercise was a project for mapping of construction site processes in the South African construction industry. Due to time constraints the CSIR did not map the construction site processes involving the use of IT in the construction industry.

The "IT Health Check" in the South African construction industry was carried out with 22 leading (based on turnover) South African construction companies focusing on: the position of IT within the competition business strategy of the company; the role of IT within the organisation; and the current IT strategy of the company. Only companies with a substantial annual turnover were involved in the survey. The "IT Health Check"

questions were general in nature covering two broad areas of competition and business strategy, and IT strategy in a company.

The outcome of the exercise indicated that leading South African companies used IT (CSIR document, unpublished):

- to support corporate goals and objectives
- as part of competitive strategy
- to meet clients' requirements more effectively

For the type of score used to analyse the survey responses, the South African companies scored closest to the UK companies and better than the Hong Kong and Australian companies. The areas where the South African construction companies performed relatively poorly were:

- influence of IT on marketing strategy
- lack of fully developed IT departments responsible for strategy and business.
- use of process tools with full information sharing

## **2.4 Summaries of Literature Reviewed**

The extent of the use and application of information technologies (IT) in the construction industry is a growing field of research. Some (limited) published research in the area of information technologies in construction is readily available from foreign studies. Very little published research in this area is available in South Africa. Some of the literature that was reviewed indicates that there is a perception within the construction industry that the industry needs efficient management processes in order to sustain itself. The use and application of information technologies is seen as one of the performance improvement tools that could be used to support construction management processes.

It also appears that there is a growing effort to collaborate and share the results of studies carried out in the construction industries around the world. Some of the previous studies carried out in other countries have been carried out specifically to obtain data that could be used to benchmark IT applications in the construction industry.

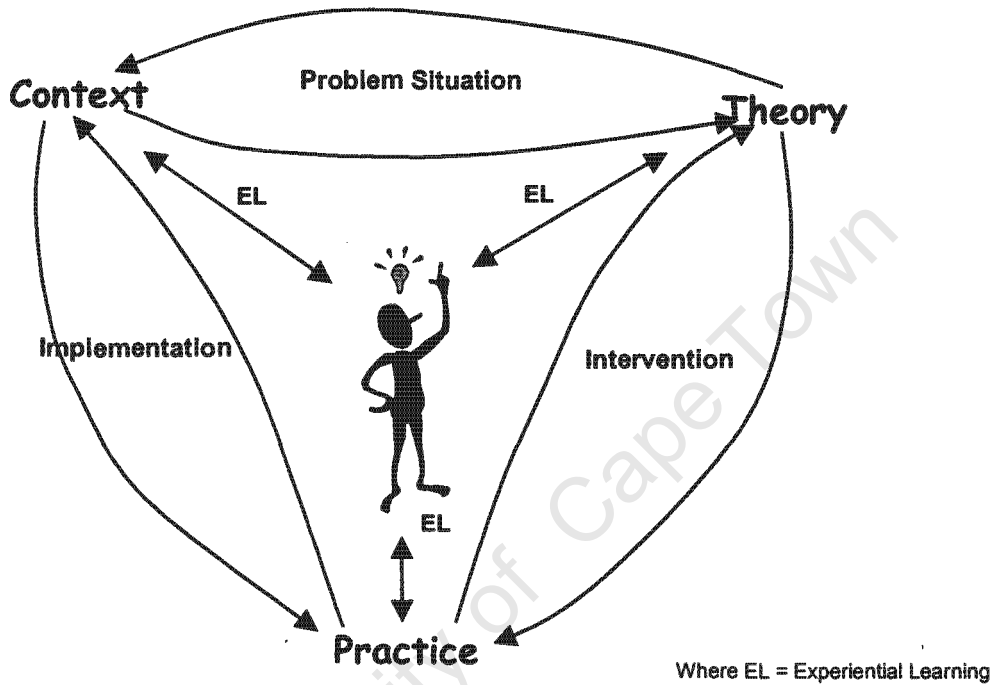
Results from previous surveys are varied; there are some practitioners in the construction industry who feel that the productivities of some construction processes like administration and material management have improved as a result of the introduction of IT. Others feel that there has been little change as a result of the introduction of IT in some processes like project management. Some construction respondents from those surveys discussed in the preceding sections have indicated that IT is not being used to its full potential. This is often attributed to the lack of a clear IT strategy in a company.

The introduction of IT tools like Electronic Document Interchange (EDI) and Electronic Document Management (EDM) has been successfully implemented in some cases. EDI is applied in the construction industry to facilitate exchange of project information. An example of an IT initiative that incorporates some aspects of EDI is *Integrated Project Services (IPROS)* developed by the CSIR in South Africa. IPROS is an internet-based project communication that allows for sharing of project information via the Internet. EDM is administrative and communication tool for automation of electronic document through its entire life cycle. An example of a successful implementation of EDM is attached in Appendix I.

This review of literature influenced the methodology of carrying out the study described in the next section.

### 3 RESEARCH DESIGN AND METHODOLOGY

The philosophy and research methodology that guided this research are explained in this section. At philosophical level the research (learning) process takes the form of Figure 5 below:



*Figure 5: Research Learning Process*

A researcher (whether academic researcher or industrial practitioner) starts by identifying a condition or particular situation that needs to be explored. This interest invariably starts as a broad question on that particular "problem situation". The researcher then formulates a theory about the problem situation. Questions like what is happening? How does this occur and why? These questions and theory lead a researcher to design an intervention mechanism like a research/project proposal. On gaining approval to commence with the study, the researcher then carries out the study, which can be in the form of mail survey or in-depth interviewing of people in the problem situation. The interviews of a mail surveys allow the researcher to gain more understanding about the context of the problem situation. Although the learning process is described as consisting of distinct phases, there is some experiential learning through

reflection. The learning process described above underpins the research methodology and arguments developed thereof.

The research method adopted for this study was a questionnaire survey together with a literature review. The questionnaire survey was designed to collect primary data on the use and application of information technologies in the construction industry. Published literature was used to collect secondary data. The questionnaire for this survey was a slightly modified version of an IT barometer survey carried out in the construction industry of Scandinavian countries (Howard et al 1998). The IT barometer questionnaire is available on the Technical University of Denmark website <http://gk48.gk.dtu.dk/~it/>. The final questionnaire for this study is attached at the end of the report as Appendix II. It consists of five (5) sections covering company details, types of software, operating systems, computer-aided design, IT systems, data and communication techniques, Internet connectivity, IT investment decisions, impact of IT on construction productivity, and obstacles to the greater use of IT in construction. The questionnaire was shortened as it was felt some of the questions that appear in the IT barometer questionnaire were not relevant in the South African construction environment. It was also felt that shortening the questionnaire would appeal to respondents as compared to a long questionnaire. The questionnaire therefore covered only six page of an A4 paper.

Following the preliminary design of the questionnaire, a pilot testing of the questionnaire was carried out with a selected number of architectural practices, consulting engineering and major building contractors operating in the Western Cape. In addition, the draft questionnaire was forwarded to a senior lecturer at the Department of Construction Economics and Management at the University of Cape Town (UCT) for his consideration. The purpose of the pilot testing exercise was to test whether there were any ambiguities contained in the questionnaire. During a follow-up of the pilot survey, some of the respondents suggested that a questionnaire should be addressed to a specific person in a company; otherwise few people would take the initiative to fill the questionnaire and return it. In addition it emerged that one of the companies that was sent the pilot study questionnaire was liquidated. Based on pilot study recommendations, all the 45 companies identified for the study were telephoned first to find out who would be the appropriate person to handle the questionnaire on behalf of the company. By calling the companies before sending the questionnaire it was hoped

that this would improve the response rate. Figure 6 below illustrates the research process for this mail survey.

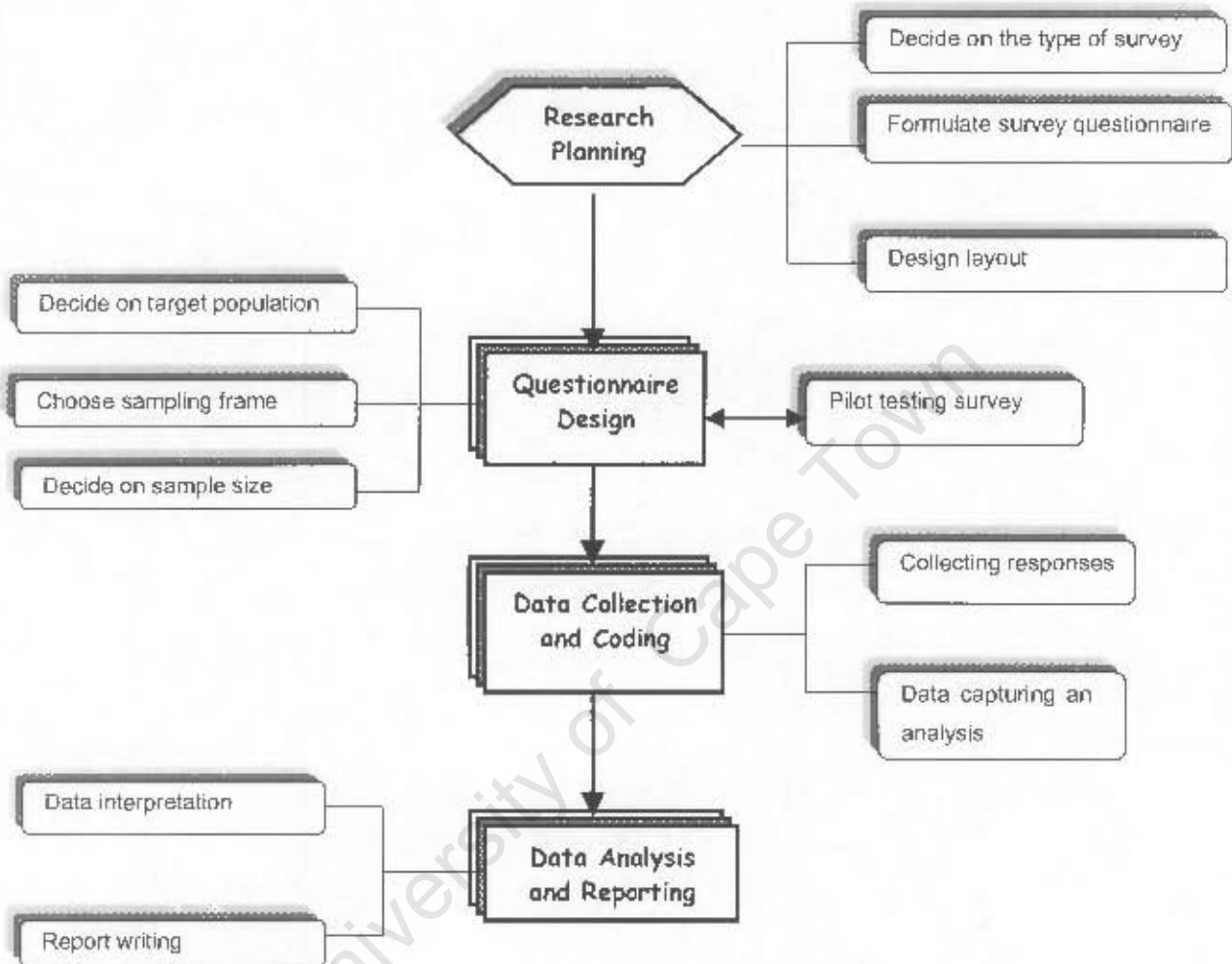


Figure 6: Survey Research Process

Following the pilot survey, and after incorporating some of the recommendations, the survey questionnaire was sent out to forty-five (45) building contractors, architectural and engineering companies operating in the Western Cape province of South Africa. Each questionnaire was accompanied by a covering letter bearing the Engineering Management letterhead. The letter stated the purpose of the study, and respondents were offered the incentive of getting a summary of the results at the end of the project. The list of these 45 architectural practices, construction engineering companies and

building contractors was randomly selected from the Professions and Projects Register listing, Cape Chamber of Commerce listing, and the Masters Builders Association website. The Professions and Projects Register included some members of the South African Institute of Architects, the South African Council of Architectural Profession, the South African Federation of Civil Engineering Contractors and other professional organisations.

The questionnaire was sent out during the second week of October 2001 with the deadline set for the second week of November 2001. On making telephonic follow-ups of the survey, some respondents indicated that they were still busy filling in the questionnaire. In order to give some respondents more time the survey period was extended by another week. At the time of making telephonic follow-ups, only 24% of the respondents had returned a completed questionnaire. Whilst making this telephonic follow-up, three companies indicated that they never received the questionnaire. It was decided then to treat these three cases as non-respondents.

### **3.1 Response Rate**

All the responses were captured into the computer as they were received. Out of 45 questionnaires that were sent out, 23 responses were received. This represents a total response rate of 51%. It is noted that a higher response rate of 77% was received from construction engineering firms, with the second highest response rate of 47% coming from major building contractors. Architectural practices followed with 33% response rate. The low response rate by architectural practices could be attributed to the fact that some companies that were contacted indicated they had just completed a questionnaire from another institution.

Table 3: Response Rate

<b>Construction Sub-Sector</b>	<b>Original Number Sent</b>	<b>Number of replies</b>	<b>Response Rate (%)</b>
<b>Architecture</b>	15	5	33
<b>Consulting and Contract engineers</b>	15	11	73
<b>Major building contractors</b>	15	7	47
<b>TOTAL</b>	45	23	51

### 3.2 Validity of the Results

Although the total response rate was low, it is acceptable as the total response rate for these kinds of surveys typically falls between 10% and 20% (Liberatone et al. 2001). Furthermore Rivard (p. 38, 2000) asserts that the return rate of mail surveys in the construction industry often revolves around 10%.

The survey method has some inherent weaknesses and limitations associated with it:

- Respondents can interpret some of the questions/concepts differently.
- Unlike structured interviews, the researcher misses the depth of interviewee's perspectives on the issues that are being addressed.
- There is a low response rate, therefore limiting the results to only those who have responded.
- There is a possibility of sampling errors.

## 4 RESULTS AND ANALYSIS

This section presents the findings of the survey and how the patterns of response relate to the objectives of the study. The questionnaire used for the survey was a six-page document with questions covering the following sections:

- Company details
- Computer software and operating systems
- Access to computer systems and equipment
- Computer-aided-design
- Computerisation of construction processes
- Data and telecommunication covering Internet and intranet
- Influence of IT on business strategy
- Benefits of IT
- Obstacles on IT

### 4.1 Company details

The company details required by the questionnaire were firstly the type of company; whether it was architectural, engineering, building contractor or any other type of company other than these three. Secondly the respondents were required to fill in the number of employees in their company, and to indicate how many of the total employees were based in an office and how many were based at site.

As already highlighted in Section 3.1, 77% of construction engineers, 47% of major building contractors and 33% of architects responded. Of all the architectural practices that responded, the smallest number of employees was 3, and the maximum number of employees was 12. For the engineering consultants and contractors, the smallest company had 8 employees and the largest 500 employees. For building contractors, the smallest number in a company was 103 and the highest was 4400 employees. The disparity in the size of companies can be attributed to the fact that the companies selected for the survey were selected randomly from available lists without any knowledge of the size of the company. Some of the largest (in terms of the number of employees) construction companies operate not only in the Western Cape but nationally

as well. There is also evidence that some of these companies have carried out projects in neighbouring countries like Lesotho, Swaziland, Namibia and Botswana.

Table 4 indicates that all the architectural firms that responded have all their employees based in an office. This is in contrast to engineers and contractors who have employees at their offices and at construction sites. Engineering companies have on average 83% of their employees based at their offices and 17% based at construction sites. The contractors have an average of 19% of their employees based in an office and 81% based at construction sites. These breakdowns of the average percentages of employees based in an office and at construction site appear reasonable since architects and engineers do most of their work in offices while most building contractors do most of their work at construction sites

**Table 4: Average percentages of employees based in office and at site**

<b>Category of a Firm</b>	<b>Percentage of total employees based in office (%)</b>	<b>Percentage of total employees based at Site (%)</b>
Architects	100	0
Engineers	83	17
Contractors	19	81

## **4.2 Computers in General**

### **4.2.1 Computer Software and Operating Systems**

This section was designed to find out about computer operating systems that are currently used by construction companies. An operating system is a computer system control-program that coordinates overall operation of the computer. It also allocates memory to programs, and provides interface between the user and the computer hardware (Turban et al., p G-12, 2001). The survey results indicate that *Microsoft® (MS)* operating systems are dominant systems across all the three construction sectors. Microsoft operating systems include *MS Windows 95, MS Windows 98, MS Windows 2000, and MS Windows NT*. It is interesting to note that none of the respondents is still

using *DOS* operating, which is one of the original operating systems for IBM personal computers. The survey results for computer-operating systems are depicted in Figure 7.

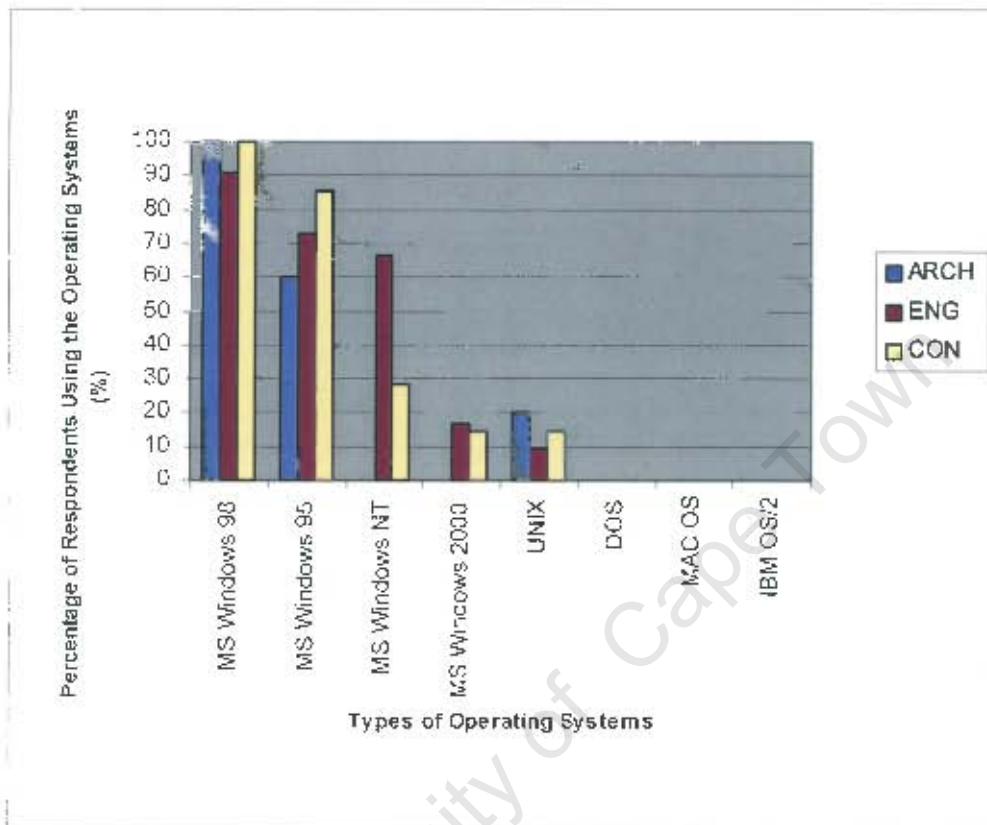


Figure 7: Commercially Available Operating Systems in Use

A characteristic feature of the *UNIX* operating system is that it "can be used on many different sizes of computers and can support many different hardware devices" (Turban et al., p.103, 2001). *UNIX* however appears to be used by 20% or less of contractors, architectural and engineering companies. In addition to *Windows* operating systems, other respondents use *IBM OS/400* and *Novell Network*. It can also be deduced from Figure 7 that a significant number of companies are still using *MS Windows 95* although the later versions of *MS Windows* operating systems like *MS Windows 98* have been on the market for the last four years now. One possible explanation for the continued use of earlier versions of *MS* operating systems is that the latest versions are perceived as offering no major improvements to warrant spending money on the upgrades.

#### 4.2.2 Computer Software Usage

In this section, the respondents were requested to indicate the type of software they used for spreadsheet, project planning, databases, email and word processing. Figure 8 illustrates the proportion of software usage in each of the three sectors.

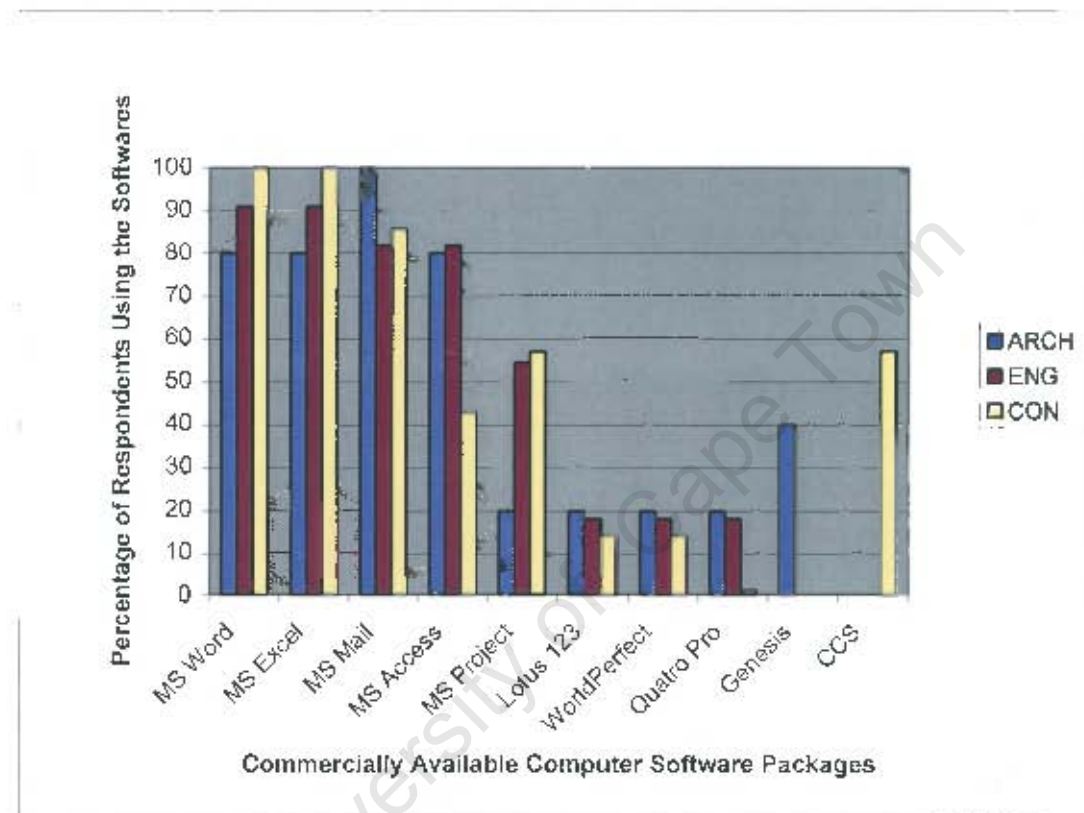


Figure 8: Commercially Available Software in Use

Microsoft software products dominate in all the areas identified above. From the results of the survey, *MS Word* is observed as the leading word processor; *MS Excel* is the leading software in spreadsheet; *MS Project* in project planning; *MS Access* in database applications; and *MS Mail* systems lead in email applications. Over 80% of respondents use *MS Word* for word processing and a similar proportion use *MS Excel* for spreadsheet, and *MS Mail* for email applications. About 20% of architectural and engineering respondents use *Wordperfect* for word processing and a similar proportion use *Quatro Pro* for spreadsheet applications. Other computer software packages appear to be used only in certain sectors of the construction industry: *Genesis* software is used by 40% of architects and *Construction Computer Software (CCS)* is used by 57% of

contractors. There is a large number of software products available in the market such that a software product is chosen based on individual preference, cost, and ease of use. In addition to the above computer software packages, others used in the three sub-sectors are listed below. The numbers in brackets indicate the percentages of respondents using the software in each of the three sub-sectors.

- **Engineering:** *Open Plan* software, which is an enterprise-wide project management software claimed to be used for managing d multiple projects (4%).  
*Oracle*, for emailing, database management, and server management (4%).  
*Project Scheduler*, a project management software (4%).
- **Contractors:** *Sure Trak Scheduler* software, project control/planning, software (14%).  
*Lotus Notes*, integrated internet-based emailing, and calendaring computer application (14%).  
*ACCPAC*, an accounting systems software (14%).

#### **4.2.3 Proportion of staff with access to computer equipment/systems**

The purpose of this section was to gather information on the proportion of staff that has:

- been allocated a personal computer at the workplace
- own email address with the company
- own mobile phone (cell phone) financed by the company
- been provided with a hand-held computer that can link with a personal computer.
- a personal computer at home rented by the employee
- a personal computer at home financed by the company

Only the first two points from the above list are discussed in this section. The other points were not marked by a significant number of respondents to warrant a discussion.

The results of this section present a sense of the level of computerisation in a company. The respondents were required to indicate the percentages of the total staff that have been allocated a PC or terminal at the workplace. These percentages of PC allocation were grouped into three categories: that is 0-49%, 50-89%, and 90% & greater. Figure 9 shows that 15% of the respondents have 0-49% of their total staff supplied with a PC at work. In the other category, 25% of the respondents have supplied their staff with a PC at work. The significance of these results is that the majority of the respondents (60%) have at least 90% of their total staff supplied with personal computers at the workplace.

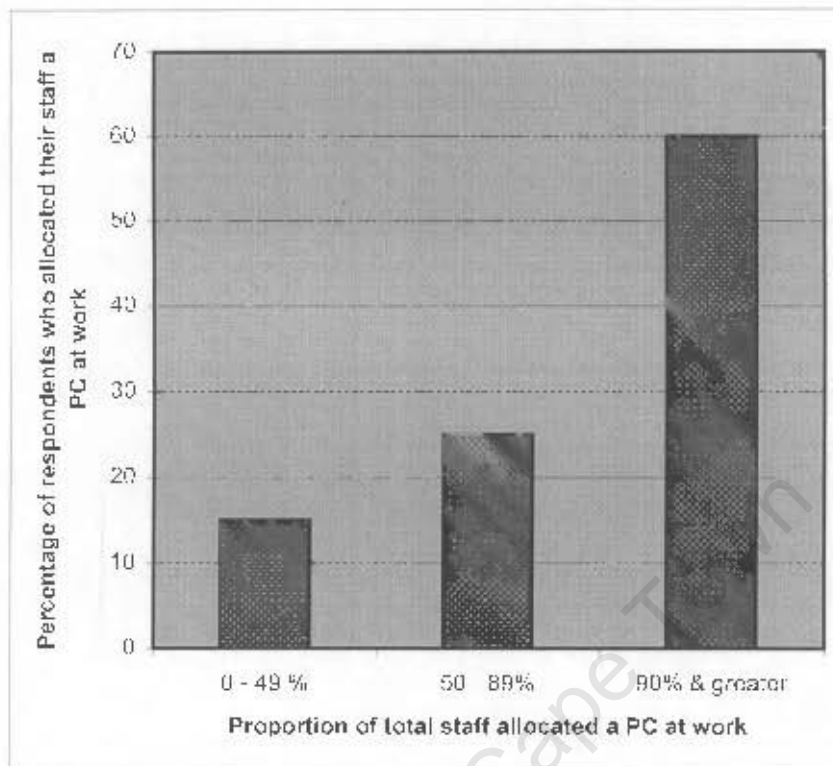
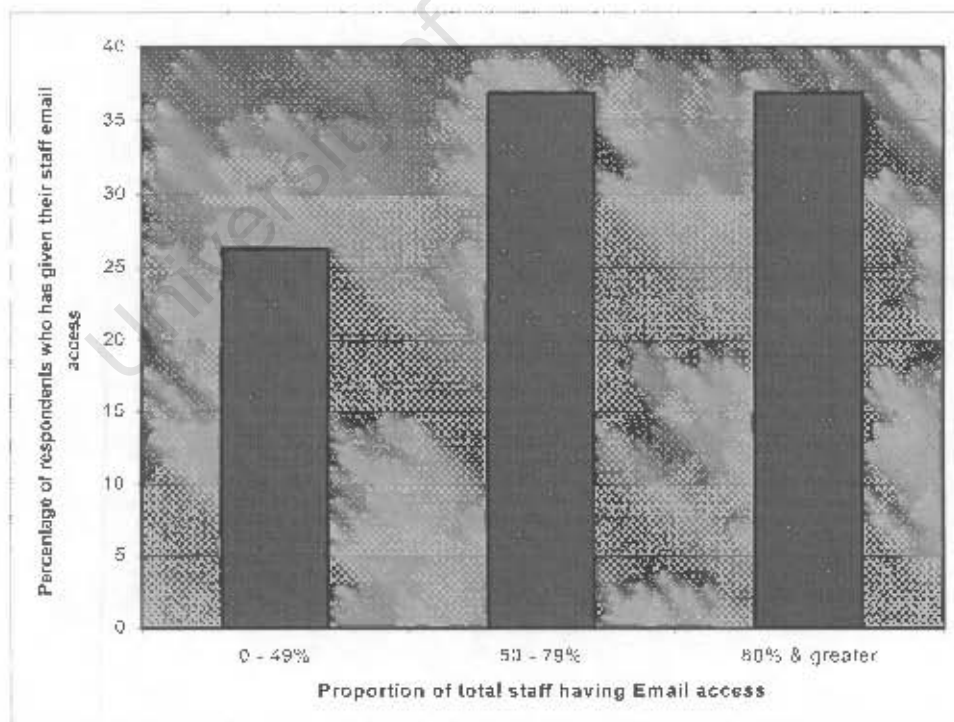


Figure 9: Proportion of Staff allocated a PC at work

Four out of five (80%) architectural firms indicated that all members of their staff have been allocated PCs at work. These architectural respondents represent 57% of all the total respondents in the survey who have all their employees allocated a personal computer or terminal at work. This suggests that these companies have embraced the importance of personal computers in the workplace and have ensured that each employee is provided with one. As mentioned in Section 4.1, the largest architectural firm had 12 employees. It is therefore reasonable to assume that a company of this size can afford to provide all its employees with PCs at work. This might explain why a larger number (80%) of architectural respondents have supplied all their staff with a PC at work. Another explanation for this apparent disparity of computer allocations in the construction sub-sectors might be the fact the work done by engineering and building contractors is generally labour intensive. The respondents who have provided their staff with a PC at work also reported that they have some kind of IT strategy in place, either in oral or written form. The results of an IT strategy survey are discussed in Section 4.6.

During the last ten years, e-mail has become a very important channel of electronic communication. Initially email was used mainly for sending simple text messages between two or more people but it has improved significantly such that nowadays people can exchange project information such as project briefs, pictures and technical documents. E-mail is discussed further in Section 4.

Figure 10 represents the proportions of total staff that have been allocated with their own email addresses by their companies. The three categories, that is 0-49%, 50-79%, and 80% & greater represent the proportions of total staff that have been assigned with their own email addresses by their companies. The survey results show that 25% of the construction companies have 0-49% of their total staff with own email addresses. Combining percentages of the other two categories would indicate that the majority of the construction companies have allocated at least 50% of their employees with email addresses. Depending on the degree of computerisation in a company, the company might allocate email addresses to only key staff members or only members of staff who need it.



*Figure 10: Proportion of staff with own email address with the company*

### 4.3 Computer-Aided Design

Computer-Aided Design (CAD) is the design and construction of drawings using computer software. CAD allows designers (in construction usually engineers or architects) to manipulate drawing parameters while simultaneously observing the effects of doing so. It is learnt from practice that CAD has reduced development-time not only in construction environment but in other industries like automotive and manufacturing industries as well. Modifications can be made on “old” and new drawings as well. Most CAD software offers a 2-dimensional and 3-dimensional representation of drawings. Two-dimensional drawings represent closely what can be drawn by hand. On the other hand 3-dimensional capacity of CAD systems allows for representation of much high complexity than what can be drawn by hand. Examples of 3-dimensional representations are computer product models and prototypes.

One of the survey questions asked the respondents whether they used CAD. Table 5 below shows that all the architectural and engineering respondents used CAD. This suggests that CAD has become an integral part of architecture and engineering construction processes. However, only 43% of building contractors use CAD. This can be expected since architects and engineers usually carry out the design work whilst building contractors construct a specific architectural or engineering design. Building contractors participate mainly in downstream construction processes.

Table 5: Percentages of companies using CAD

Category of a Firm	% of firms using CAD	% of firms not using CAD
Architecture	100	0
Engineering	100	0
Contractors	43	57

Of the 57% of building contractors, who indicated that they didn't use CAD, 75% of them indicated that they do not need it.

In the area of computer-aided design, the survey was also intended to establish the extent of the design time that was taken by drawing by hand, *AutoCAD*, *AutoCAD LT* and *Microstation* CAD software applications. However, the majority of the respondents

just indicated the type of CAD software application they used in their operations. With this in mind, Figure 11 instead presents the commercially available software used in design work in the construction industry. The percentages of engineering respondents using the design software as represented by Figure 11 appear to add to more than 100% because most of the respondents indicated that they used more than one CAD software package.

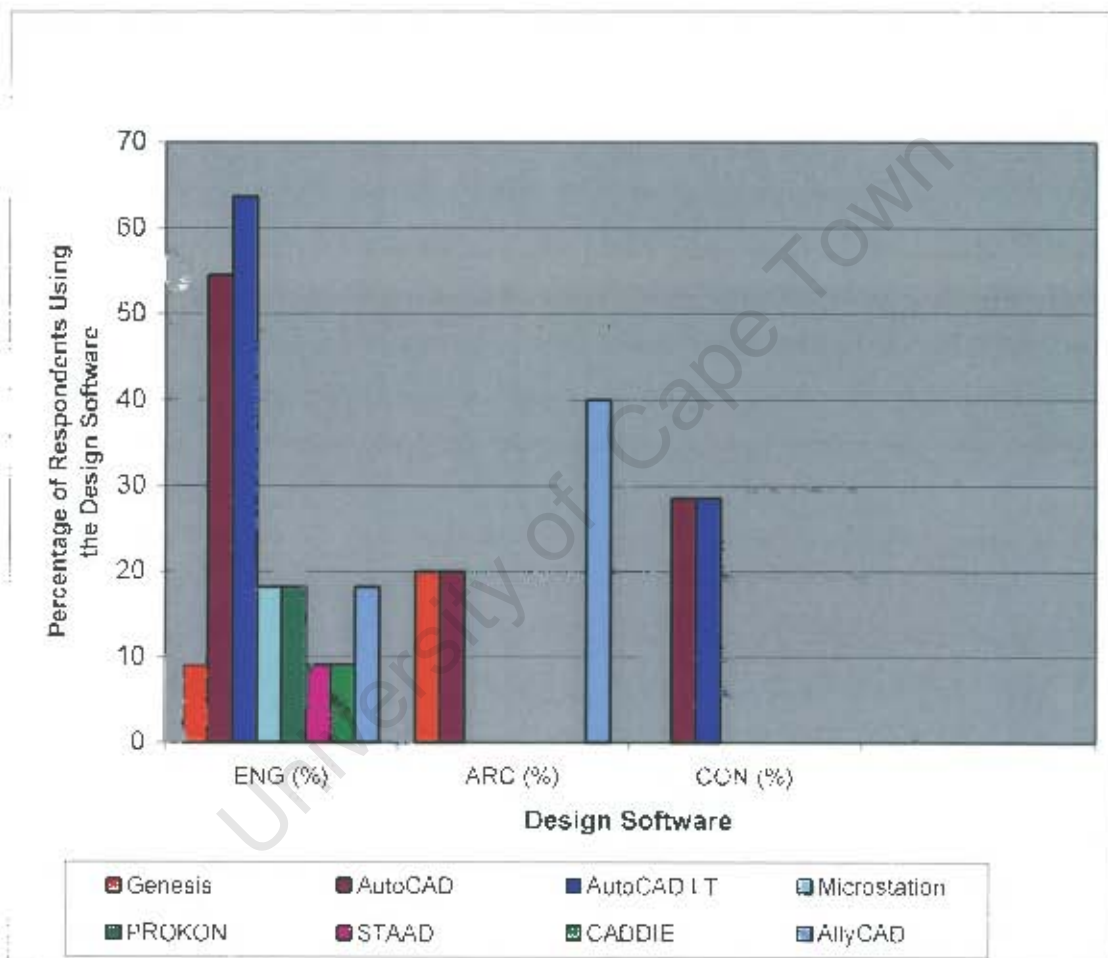


Figure 11: Commercially available software used for design work

There is a good number of commercially available CAD software in the market such as those shown in Figure 11. The survey results show that architectural firms use *Genesis*, *AutoCAD*, and *AllyCAD* software as marked respectively by 20%, 20% and 40% of respondents. In engineering, 55% of respondents use *AutoCAD* and 65% use *AutoCAD*

*LT*, *AutoCAD LT* being a low cost alternative of *AutoCAD* systems. Building contractors have indicated that drawing is done using *AutoCAD* and *AutoCAD LT* software. Other noticeable CAD software packages used in the market are *Microstation* and *Prokon*.

The respondents were also asked to indicate the percentages of the total design time that is taken by drawing by hand. The respondents did not indicate the percentages of the total design time attributed to drawing by hand; instead they just indicated that they do some of the design work by hand. This data was analysed accordingly to find out how many companies still carried out some of their design work by hand drafting. From the survey results, two in five of architectural firms and four in five of engineering firms use hand drawing.

University of Cape Town

## 4.4 IT systems

### 4.4.1 Computerisation of Processes

The survey also gathered data on the extent of computerisation of business processes in construction firms. The business processes that were considered were bookkeeping, invoicing, work descriptions, technical calculations, bill of quantities, scheduling or resource planning, material control, cost or budgeting, tendering and marketing. The respondents were requested to mark the extent of computerisation of their business processes as 1-39%, 40-59%, 60-100%. In addition the respondents were requested to indicate those listed business processes that were operated manually. To clarify the diagram, the three categories of 1-39%, 40-59% and 60-100% are respectively defined as low, fair and high extent of computerisation.

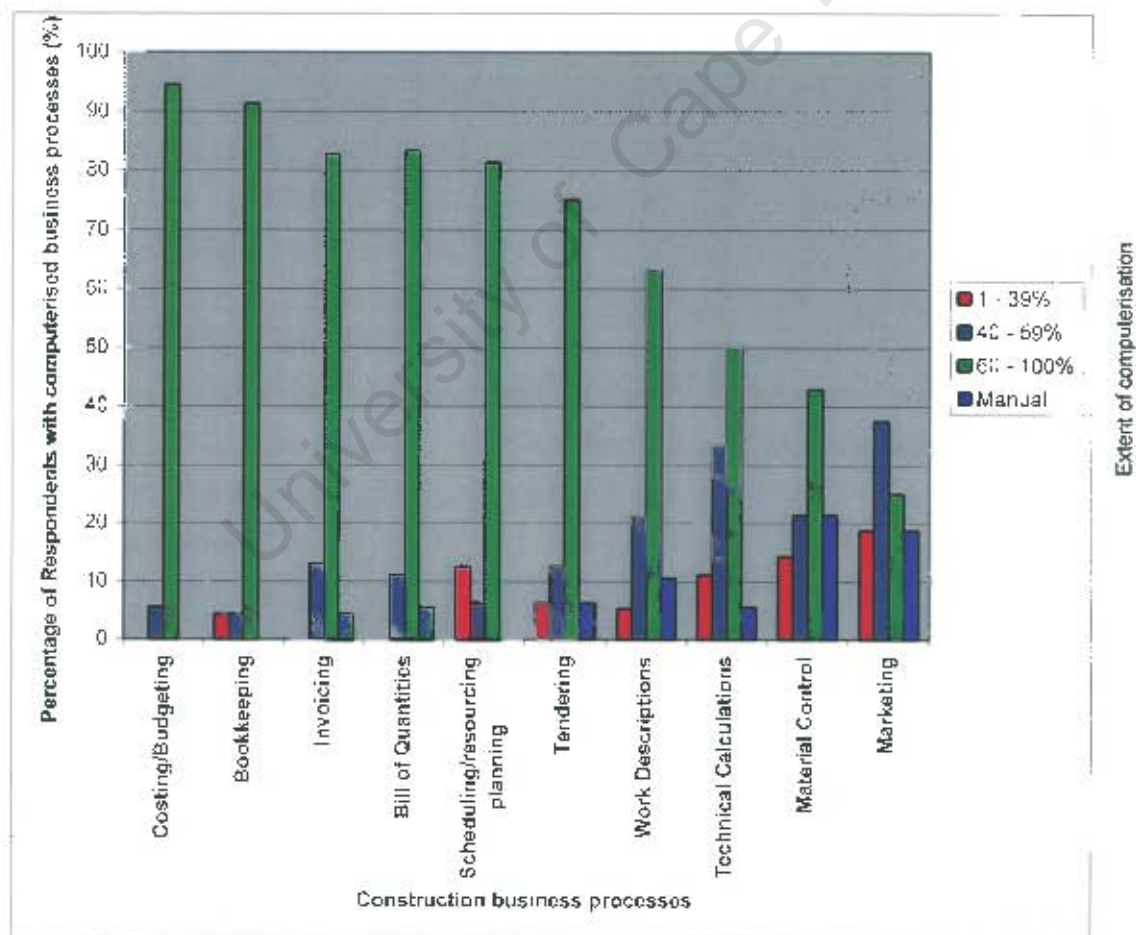


Figure 12: Extent of computerisation of business processes

Figure 12 indicates that costing/budgeting, bookkeeping, bill of quantities, invoicing and scheduling/resource planning are considered by at least 80% of respondents as highly computerised. None of the respondents indicated that they do any manual bookkeeping or costing/budgeting. This then suggests that bookkeeping and costing/budgeting operations are all computerised. Some of the bookkeeping operations are payroll preparation, recording, processing and analysis of financial transactions. In small companies, bookkeeping can be managed by using fairly priced spreadsheet applications like *MS Excel*. However larger companies would probably use specialised accounting computer packages like *ACCPAC*. The higher degree of computerisation of bookkeeping and costing/budgeting operations appear to correlate with the high usage of computer software packages like *MS Excel*, *MS Word* and *MS Project* discussed in the previous sections.

Liberatore et al. (2001) argued elsewhere that the high computerisation of business processes like costing/budgeting and scheduling/resource planning could be attributed to an extensive use of critical path analysis for schedule/resource planning and control, and earned value analysis for control in the construction industry. Software applications or systems associated with invoicing are mainly used in electronic data interchange (discussed in Section 2.3.1). Project management software like *Microsoft Project* and *Primavera* are used for scheduling and resource planning, and spreadsheet computer packages are used for costing and budgeting.

The processes that are only fairly computerised are marketing, material control and technical calculation processes. Considering that print and television media is accessed by a large section of the population, it is not surprising that marketing is only fairly computerised. Although the notion of marketing via the Internet is hailed as a major breakthrough, it has yet to be embraced by construction companies. The survey results also indicate that 20% of the respondents are still doing marketing operations manually.

#### 4.4.2 Electronic Transfer of Documents

The survey also evaluated the extent at which documents are sent digitally in the construction industry. Faxes are assumed to be a digital means of communication since nowadays they have the capabilities to communicate with email systems. In order to establish the proportion of documents that are transferred by electronic means in the construction industry, the respondents were required to indicate the proportion of documents (from the list provided) that were sent by digital means. The proportions of digital exchange of documents were categorised as 1-39%, 40-59% and 60-100% or if possible whether the documents were strictly sent in traditional mode (manual) of exchange. Figure 13 shows the percentages of respondents who sent various types of documents by digital means.

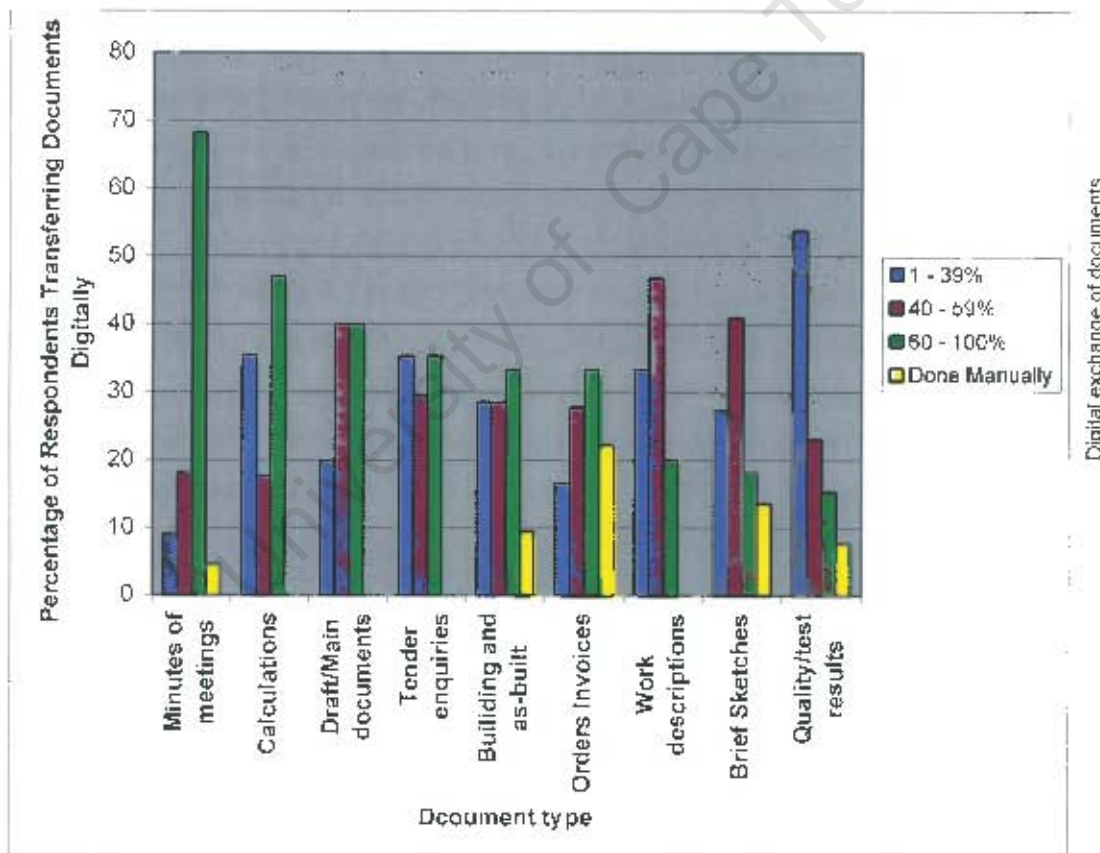


Figure 13: Proportion of Documents that are Sent Digitally

In the 60-100% digital exchange category, the majority of the respondents (68%) send minutes of meetings digitally. This can be expected since minutes of meetings are prepared presumably using wordprocessing software like *Microsoft Word* and *Corel Wordperfect*. Documents prepared using these wordprocessing software applications can be easily sent via email. If a document is fairly large to be sent as an email attachment, it can be sent by other non-digital means. The main conclusion that can be drawn from Figure 13 is that on average, only a third of the respondents send documents by digital means. Again this appears to suggest that despite the plethora of investments in computer applications and systems, the majority of documents are still sent via non-digital means.

#### 4.5 Data and communications

This section evaluates current network communication technologies in construction companies. The rapid development of computer network technologies during the last decade is often regarded as the main driver of information technologies. The Internet has developed from a simple network of computer within a small geographical area to the now complex global network of computers for the exchange of information; it transcends both cultural and geographical boundaries. The Internet is accessed in many ways: connection via Local Area Network (LAN); via dial-up connection; and via worldwide network, or on-line service. LAN is a connection of computers connected by communication devices within the same premises. The Internet offers great potential for the convergence of wireless communication technologies. This offers potential for the use of cellular phones or other hand held devices to access Internet and Intranet sites. Intranets are essentially private networks of computers in a firm and its trading or collaborating partners. The main information contained in these sites includes corporate information, company news, policies, procedures, projects, and personnel information. All the companies that responded to the survey indicated that they have access to the Internet. Table 6 shows the percentages of companies that have Intranets and homepages in the Internet.

Table 6: Percentage of companies with Intranets and homepages in the Internet

Category of Firm	Have Homepage on Internet	No Homepage on Internet	Have Intranet	No Intranet
Architects	20	80	0	100
Engineers	82	18	18	82
Contractors	86	14	43	57

It was found that 82% of the engineering and 86% of major building contractors have homepages on the Internet. However, only 20% of architectural practices had a homepage on the Internet. For all those companies that have indicated that they do not have homepages, 57% indicated that they ought to have one, again reinforcing the perceived significance of the network communications. The majority of construction firms do not have intranets as shown in Table 6.

#### 4.6 IT strategy

The survey also attempted to establish whether the construction companies have any IT strategies. Any type of a company strategy should be the guide that drives business operations. Table 7 shows the response of the construction firms surveyed.

Table 7: IT Strategy in Construction Industry

Category of Firm	IT Strategy		Form of IT Strategy		
	Have No Strategy	Have IT Strategy	Written form	Oral	Both oral and written
Architects	40	60	0	75	0
Engineers	18	82	18	36	18
Contractors	29	71	83	0	0
<b>AVERAGES</b>	<b>29</b>	<b>71</b>	<b>34</b>	<b>37</b>	<b>6</b>

The results show that an average of 71% of the respondents have some form of IT strategy: 34% have it in written form, 37% have it in oral form, and 6% have it in both written and oral form. Of those that indicated that they do not have an IT strategy, 50% indicated that they need one, and 50% said it is not necessary.

The questionnaire also gathered data on whether companies have made IT investments in the last two years. Out of the 23 companies that responded to the survey, only one company has not made any IT investments in the last two years. This means that 96 % of respondents have invested in IT in the last two years. Of those who invested in IT, 64% indicated that IT investment has increased, 32% indicating that it has remained constant, and only 4% indicated that it has been reduced. Table 8 shows how investments in IT have changed in the last two years.

Table 8: Response on how investments in IT have changed in the last two years

Increased	Remained Constant	Decreased
64	32	4

Regarding future IT investments, 52% indicate that they expect their companies to increase investment in IT in the next two years but 48% indicated that it would remain constant. Beyond two years, 45% said it would increase and 55% said it would remain unchanged.

Table 9: Estimation on how investments in IT might change in the future

Time Frame	Increase	Remain Constant	Decrease
In the next two years	52	48	0
Beyond two years	45	55	0

Given these survey results on IT strategy and investments, it is surprising that 96% of construction companies have made IT investments in the last two years and yet only 34% of them have a formal written IT strategy: any formal written IT strategy should guide companies on what kind of information technologies they need, why they need IT, and how they should implement the information technologies. With this apparent lack of formal written IT strategies and continued investment in information technologies, it could be argued that some of the failures in implementation of IT could be attributed to lack of (or unclear) IT strategy.

So what are the factors influencing decisions in IT investments? The results of the survey are shown in Figure 14. Respondents were asked to indicate whether the listed factors were "not important", "slightly important", "important" or "very important" in making decisions about IT investments. Figure 14 shows that 55% of the respondents feel that the desire to have efficient administrative work is very important when making decisions on IT investments. The other factors that were considered important in making decisions on IT investments are employee demand, competition, technical leadership, and development of new products or service. It is interesting to note that one fifth (20%) of the respondents consider customer-demand unimportant in making IT investment decisions.

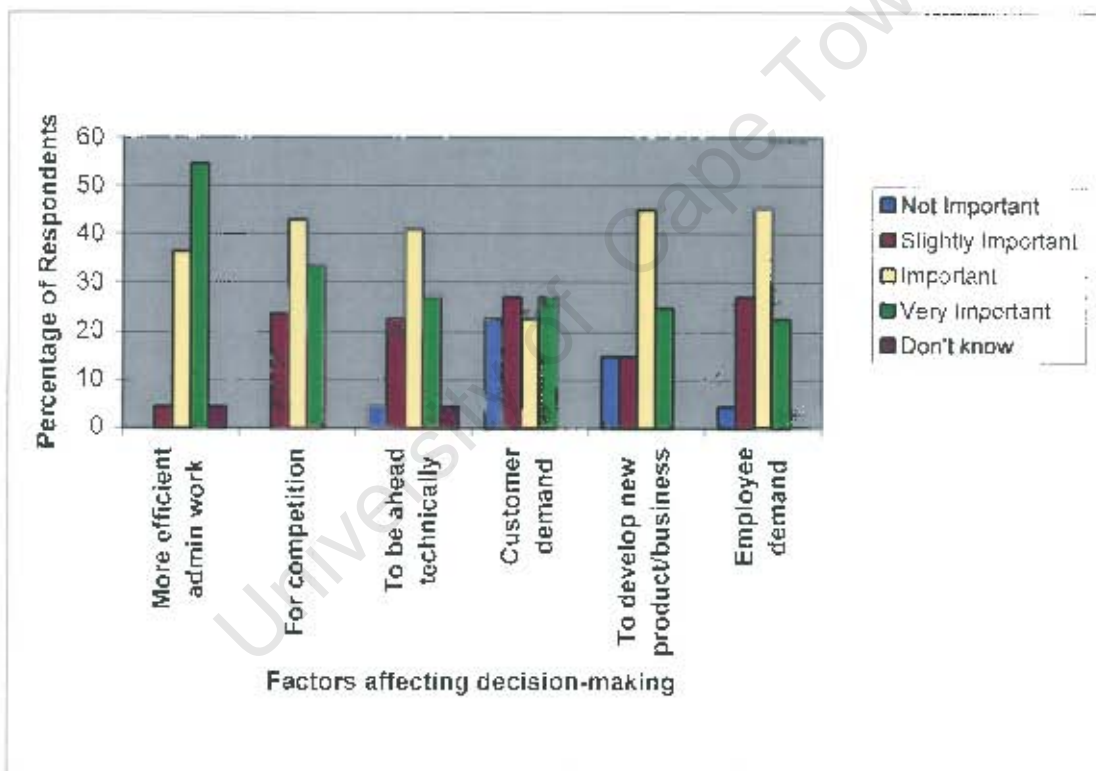


Figure 14: Factors affecting decision-making in IT investment

## 4.7 Impact of IT in construction processes

In this section, the survey was designed to determine how IT has affected the construction processes. The results of the survey indicate both desirable and undesirable changes. According to survey results, the most positive impact of IT has been an increased quality of documents. Quality of documents is improved by using computer tools for editing, checking typing and spelling mistakes and making graphical presentation of some information. Prior to adoption of IT systems, documents were prepared by hand and in some cases quality of documents was not up to today's standards as some people did not write legibly. Software like *MS PowerPoint* has improved graphic presentation of documents significantly. The respondents further indicated that the introduction of IT has increased the speed of doing work. Work here encompasses various processes like document preparation, design, purchasing and other business processes. As shown in Figure 15, the construction industry has yet to realise other benefits as result of the introduction of IT in construction processes.

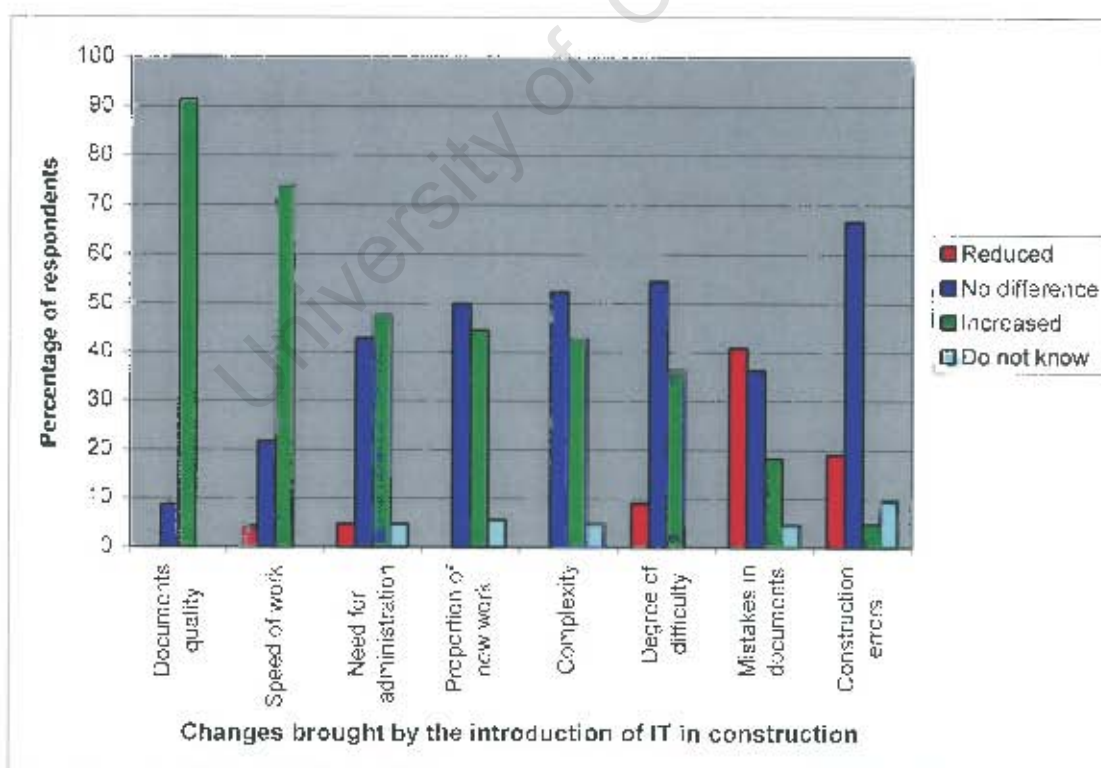


Figure 15: Changes Brought by the introduction of IT in Construction

Close to half of the respondents feel that the introduction of IT has largely made no difference in the complexity of work, the proportion of doing new work, the number of construction errors. Furthermore, the respondents feel IT has neither made any difference nor reduced; the number of mistakes in documentation, and the administration needs. The main conclusion that can be drawn from analysis of Figure 15 is that the introduction of IT in construction has not brought effective changes.

#### 4.8 Perceived Effect of IT on Productivity of Business Activities

The objective of this section was to establish whether the introduction of IT has had any effect on the productivity of construction business activities. Figure 16 shows that in most cases the introduction of IT has either increased the productivities of some business activities or they have remained unchanged. The majority of the respondents indicate that the productivities of general administration, project management, design and site management have increased as a result of the introduction of information technologies.

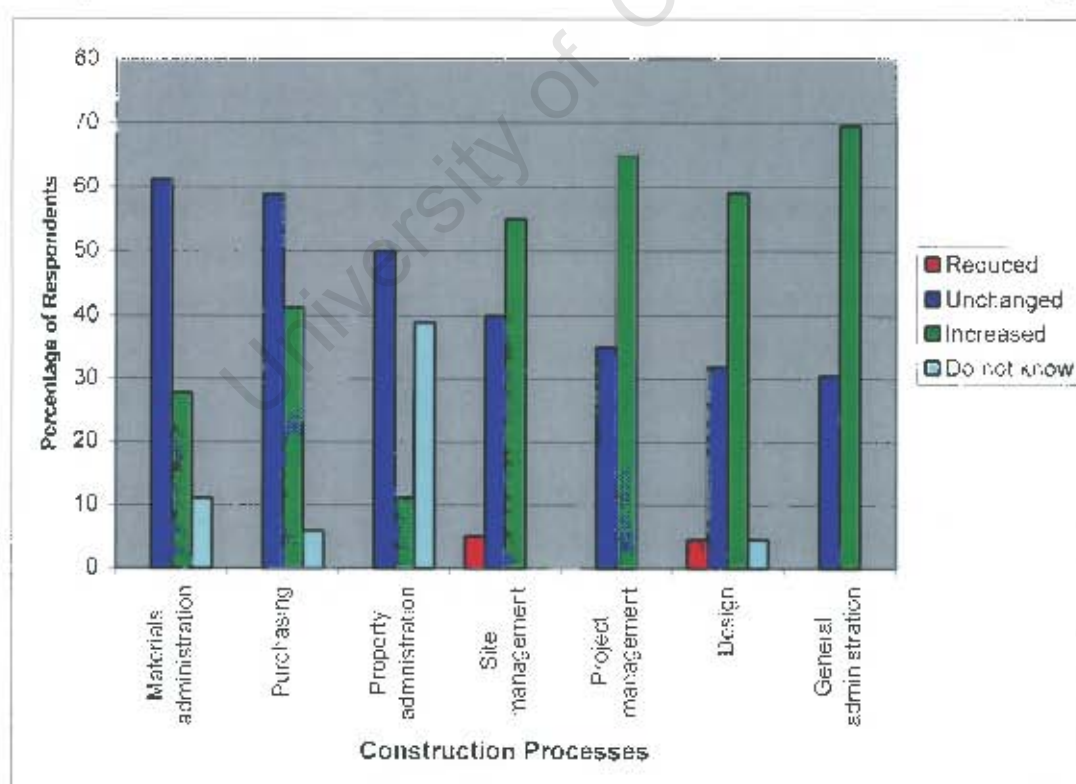


Figure 16: Perception on the Impact of IT on Productivity Business Activities

In management of projects, improvements can be attributed to the emergence of project management software; in design due to CAD systems; in site management due to improved communication technologies; and in general administration due to back-office applications like wordprocessing, spreadsheet and accounting computer systems. However respondents indicated that IT has not had any impact on the productivity of material administration, property and purchasing.

#### 4.9 Planned Areas for Increase in the Use of Information Technologies

Figure 17 indicates areas of planned increase in the use of IT. According to the survey results, 48% of respondents plan to increase IT investment, that is, introduce more computer tools in computer-aided design and handling of documents. A further 35% of respondents plan to invest more in accounting systems. Computerised accounting systems offer faster calculations and easier editing of accounts. From Figure 17, the construction respondents appear to be less interested in investing in areas of computer product modeling, virtual reality, property information, electronic trading, and project management.

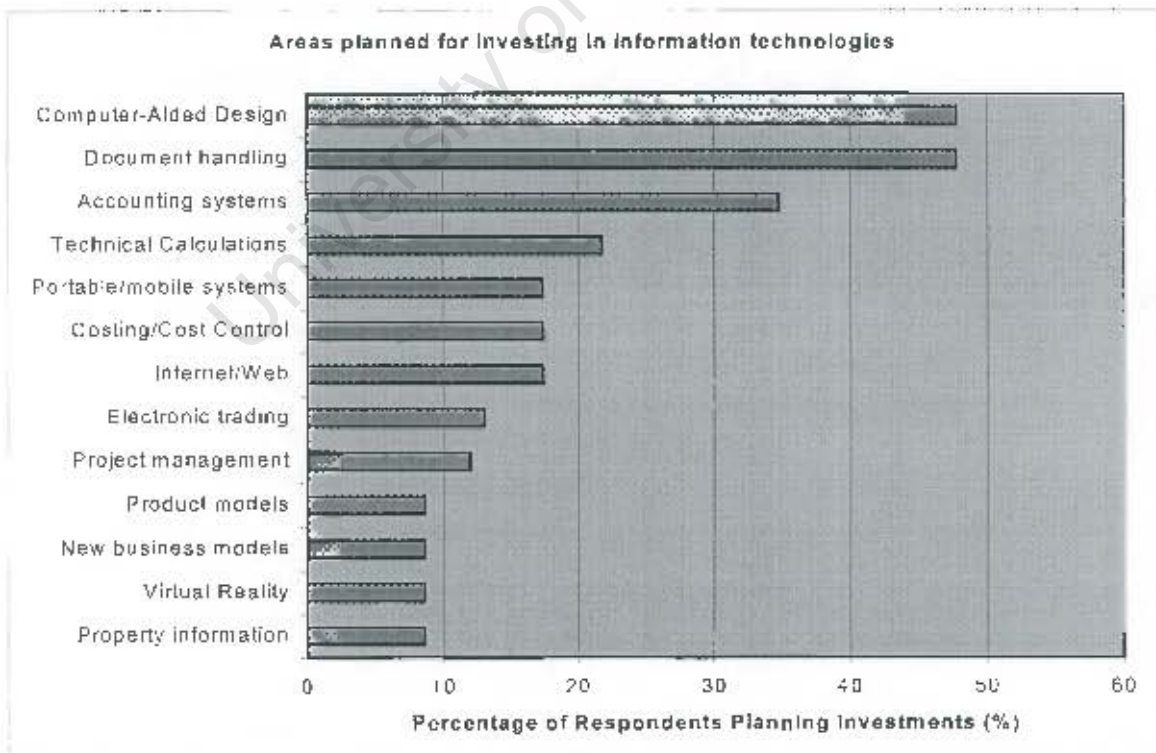


Figure 17: Areas planned for investment in information technologies

#### 4.10 Perceived Benefits of IT in Construction Industry

The main benefits on the use and application of information technologies in construction industry are represented in Figure 18. The respondents indicated that introduction of information technologies in construction has led to better communication, better quality of work, possibility of sharing common information, better financial control, and simpler and faster access to information. Each of the perceived benefits listed above were marked by at least two-thirds (67%) of the respondents. The ability to do work quickly is again marked as one of the benefits brought by the introduction of IT in construction. The notions of adopting IT to; attract new staff, use less paper during construction operations, satisfy customer or reduce the number of staff, do not appear to have provided the respondents with any benefits.

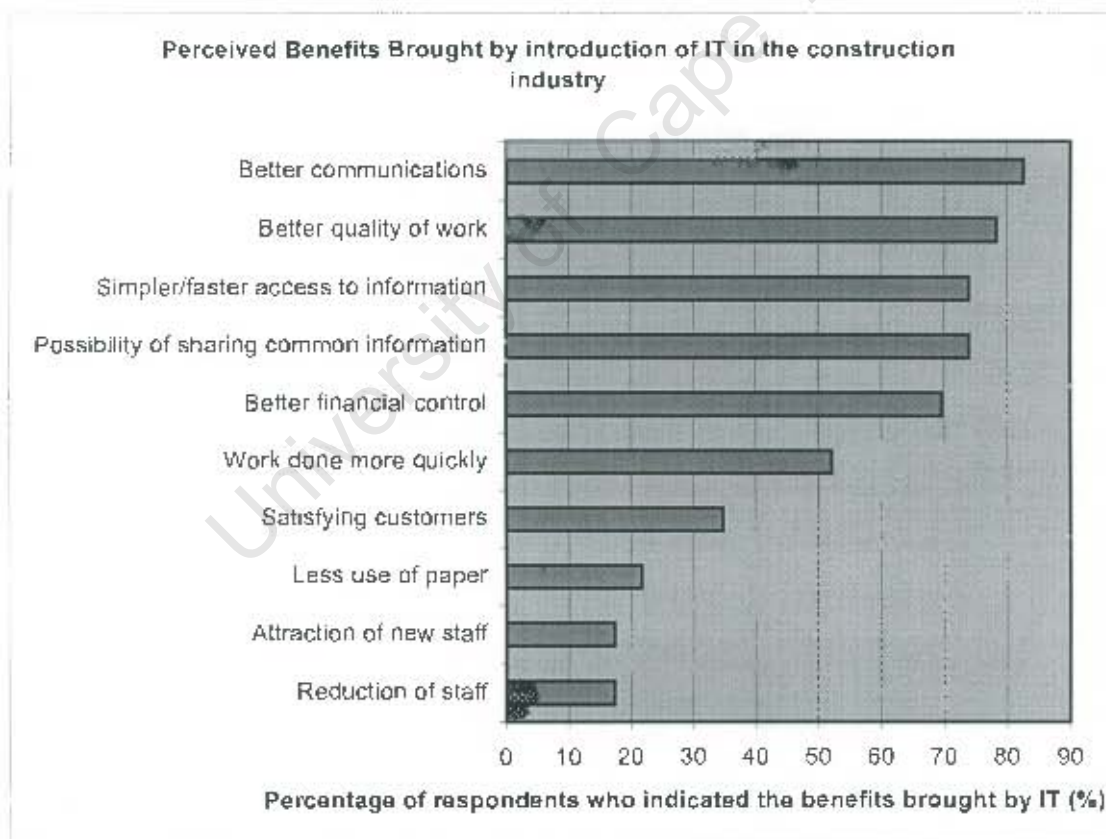


Figure 18: Perceived Benefits of IT in Construction Industry

#### 4.11 Obstacles to Greater Use of IT in Construction

The survey results show that the greatest obstacles to the greater use of IT in construction are continual demand for upgrading hardware or software, and high investment costs. As Figure 19 shows, 29% of respondents marked these two obstacles as the greatest obstacles. Other obstacles selected by 12% of the respondents are the greater know-how required from staff and reduced security as result of implementation IT. Those selected by less than 10% of respondents are lack of commitment from management, decision-makers having no time for IT efforts, and lack of standards and coordination problems. None of the respondents indicated that; over-abundance of information, difficulty in assessing investments, extra work in the form of unnecessary data input, risk associated with IT, or that preferred old ways that work well were inhibiting the greater use of IT in construction.

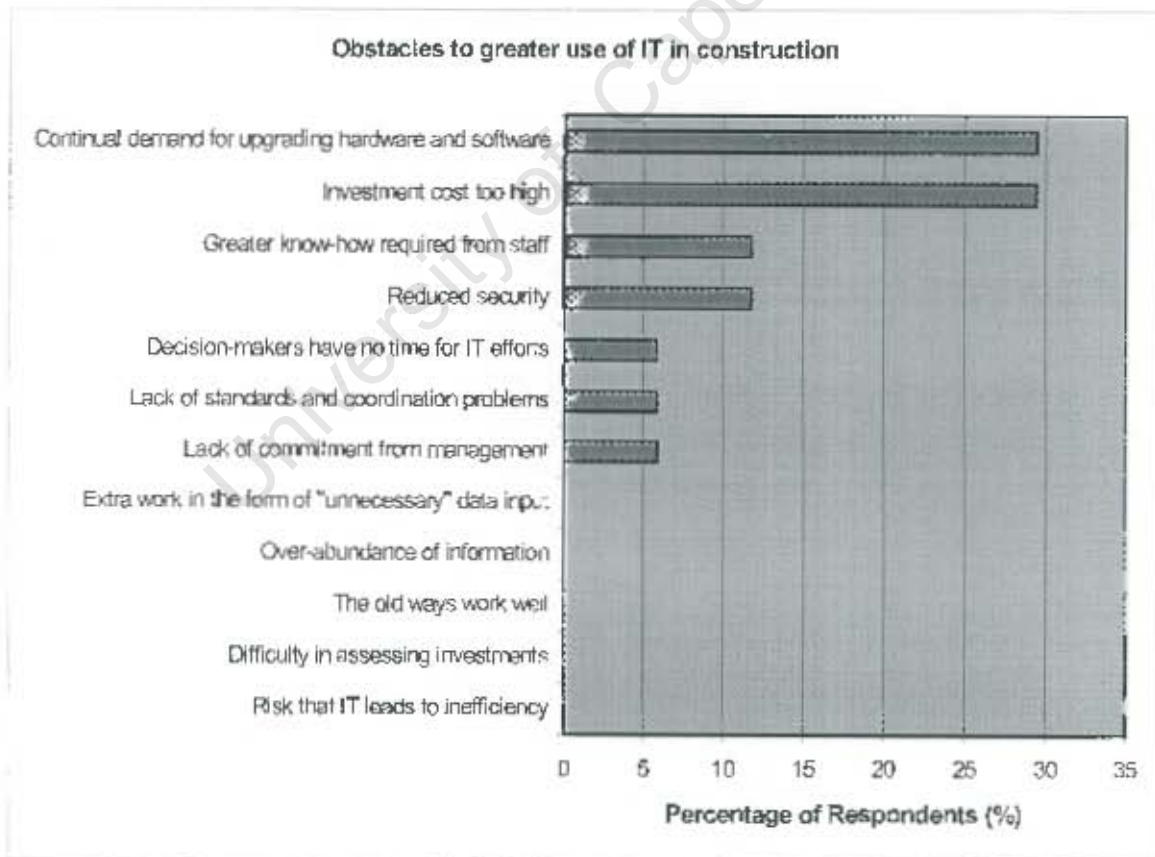


Figure 19: Obstacles to greater use of IT in construction

## 5 CONCLUSIONS

Conclusions arising from the survey that was carried out with companies operating in the construction industry in the Western Cape are that:

- Across all the three construction sub-sectors, 60% of the companies have supplied at least 90% of their total employees with personal computers (PCs) at work. The extent of supply of PCs to employees depends on the type of the company: architectural companies tend to be small and based in an office and therefore supply the majority of their employees with PCs; engineers and contractors tend to have a large number of employees and therefore provide a limited number of their employees with personal computers.
- There are numerous computer software packages and operating systems available in the market. Some companies have indicated that they are using more than one operating system, wordprocessing and spreadsheet applications. The construction firms in the Western Cape appear to use similar computer software packages for general administration. However, the survey results indicate apparent differences in the types of computer software packages used in project design, planning, construction and control. *Genesis* and *CCS* appear to be used exclusively by architects and building contractors respectively, but nevertheless is smooth exchange of data between the architects, engineers and contractors?
- Computer Aided Design (CAD) has become a key software package for architects and engineers. The survey shows that all the architectural and engineering firms use CAD, whilst only 43% of contractors use it. The other 53% indicated that they do not need CAD.
- Closely related to the use of CAD in the construction industry is the availability of software packages for design. There is a significant number of design software packages used in the construction industry. The survey results show that there are at least eight (8) different computer software packages used by engineering firms alone.

- The survey reveals that many construction processes like invoicing, bookkeeping, costing, budgeting, tender documentation, bill of quantities, scheduling and planning are highly computerised. However marketing operations and material management activities are still carried out with little or no use of computers.
- Construction companies appear to be embracing IT communication channels like email system and the Internet. The survey indicates that 70% of the construction companies have allocated at least half of their total employees with email addresses. A company might choose to allocate email addresses to only limited members of staff. All the companies surveyed have indicated that they have access to the Internet. The majority of these companies have homepages on the Internet, with those that don't have homepages indicating the desire to have them. The company Internet sites (homepages) typically contain corporate information, policies, company news and project information.
- The digital transfer of documents is used mainly to exchange minutes of meetings. This is illustrated by the 68% of the respondents who have indicated that 60-100% of the minutes of meetings are exchanged digitally. Tender enquiries, draft documents, brief sketches and quality test results are still exchanged via non-digital means. The survey did not address the reasons for exchanging documents by digital means.
- How do construction companies invest in IT? A partial answer to this is given by the survey results that show that 96% of the respondents have invested in IT in the last two years. For those companies that have invested in IT, 64% of them indicated that IT investments have increased in the last two years, and 32% have kept the level of IT investments unchanged. Only 4% of the respondents have reduced IT investments. 52% of the respondents plan to increase IT investments in the next two years.
- Given this pattern of IT investments, do the construction companies have IT strategies in place? It is surprising that with 96% of the respondents having

invested in IT in the last two years, only 34% of the respondents have their IT strategy in written form, and 37% of them have it in oral form. This then suggests that some of the construction companies are investing in IT without any clear IT strategy. If that is the case, what guides those companies investing in IT on what information technologies they need to buy? Why do they need IT, and how they should implement these information technologies?

- Although there is an apparent mismatch between the formulation of IT strategies and IT investments as discussed above, more than half of the respondents have indicated that decisions on making IT investments are driven by the desire to have more efficient administrative purposes, employee demands, the desire to be ahead of competitors, and the desire to be ahead technically. In the construction industry, customer demands seem to have little influence in planning for IT investments.
- What changes have been brought by the introduction of information technologies in construction? The survey shows that the use and application of IT in construction has led to the improved quality of documents, and has also increased the speed (efficiency) of doing work. However the survey shows that the use and application of IT has neither had any impact nor reduced the administrative needs, the proportion of new work, the complexity of work, the number of mistakes in documents, or the number of construction errors. The main conclusion that can be drawn from these results is that the use and application of information technologies in the construction industry does not appear to have improved the core business processes.
- The survey also reveals that the construction companies plan to make further investment in computer-aided design, document handling, portable/mobile systems, accounting systems and the Internet. Many companies did not indicate much interest in investing in electronic trading, computer product modelling, virtual reality and property information.

- Although some companies are planning to invest in IT, they are prevented from doing so due to the continual demand for upgrading hardware and software, and investment costs which are currently too high. The greater know-how required from staff and reduced security due to the use of information technologies are noted by 24% of the respondents as preventing the greater use of IT in construction.

Based on the results of the survey it is concluded here that the first and second objectives of the thesis have been met. The third objective was only partially met since it was realised at the end of the survey that the questionnaire did not gather enough detailed information to be able to develop strategies for the use of information technologies in the construction industry.

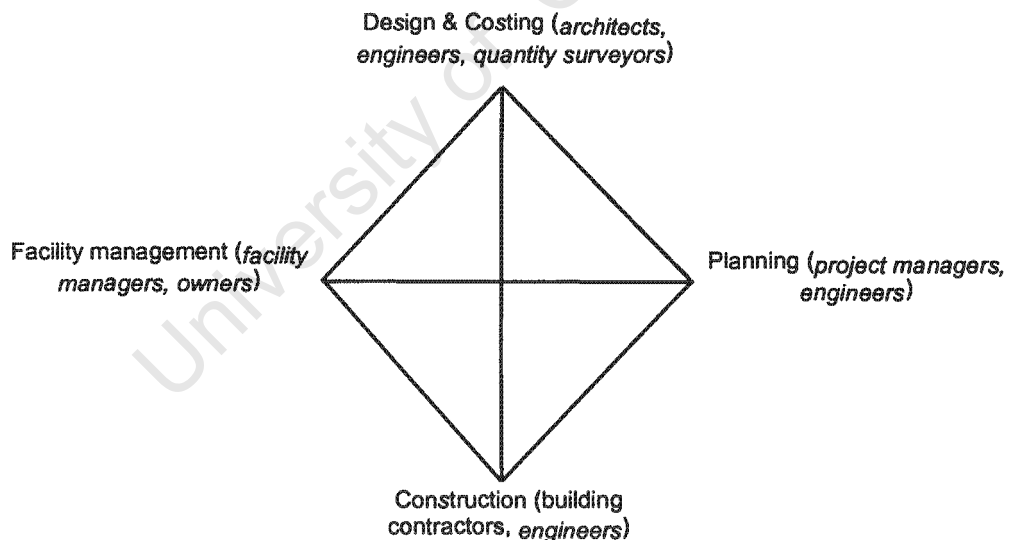
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## 6 RECOMMENDATIONS FOR IMPROVEMENTS

On the basis of the survey results and secondary data from authoritative literature it is suggested here that further research (empirical research in particular) need to be carried out with local construction companies such that the outcomes of this research could benefit the construction industry. More research should examine the application of IT to the core business (without being too technical) so that any construction firm could use that information as a guide to formulate IT strategy or for investing in new information technologies.

Other recommendations and guidelines for improvements are suggested below:

- ❖ Construction processes should not be seen as distinct phases of project design, planning, estimating and execution; but they should be seen in holistic terms where construction participants are involved at every level of the process. Figure 19 below illustrates this systemic approach:



**Figure 20: Proposed Integrated Construction Process**

This approach would ensure that project participants are briefed at all stages of the projects. Their participation would however depend on the stage of the project.

- ❖ Opportunities for the increased adoption of information technologies should be explored beyond the areas of document handling and administration needs. According to the survey respondents, computer tools have improved preparation and presentation of administration documents like accounting reports, minutes of meetings and contracts. But there is still a need to explore other areas like the adoption of information technologies to integrate construction processes.
- ❖ Integration of construction (project phases) processes should be explored through academic and industrial collaboration. Although there is a possibility of doing in-house integration of stand-alone computer applications, this does not offer cost effective solutions in the long run. Instead integration of software systems should start at the software development stage to incorporate design, costing, planning, scheduling, and accounting into computer systems, beyond what is offered by typical project management software or CAD applications. By doing so, the construction industry would improve compatibility of data between the design, planning, construction and maintenance processes. This would facilitate closer interchange of data between architects, engineers and contractors. Should the construction industry improve the compatibility of computer software used in the industry, it could gain some cost savings by reducing the number of computer software packages that are currently used in the industry.
- ❖ By consistently using computer tools to exchange data and information during the construction process, there is a possibility of improving efficiency and productivity in the construction industry. Sustained efficiency and productivity of business processes are the hallmarks of the continuous improvement programmes.
- ❖ Construction companies should formulate IT strategy before making substantial IT investments. The process of formulating IT strategy would in all likelihood differ from company to company, but potential users of the information technologies should be allowed to make an input. The IT strategy should be written to address the following questions: what information technologies are needed in the company? Why are they needed? And how is IT going to be implemented.

- ❖ As part of IT strategy, attempts should be made to assess the (measurable) value of the use and introduction of IT in the construction company particularly to the business results.
  
- ❖ Since the introduction of information technologies in the construction does not appear to have improved the core business process, future research should focus on finding out what contribute to this seemingly ineffectiveness of IT.

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## 8 APPENDICES

### 8.1 Appendix I: Case Study on Electronic Document Management

The *Construction Best Practice Programme* (CBPP) is the UK government initiative that identifies, publicises and supports the use of improved business and management practices for the construction industry. It is funded by the Department of Trade and Industry and is steered by the Government and the Construction Industry Board. One of the initiatives of CBPP is the *IT Construction Best Practice Programme* (ITCBP), which in turn identifies, publicises and supports the use of IT to improve business and management practices for the construction industry. ITCBP publishes a number of case studies on IT use in construction industry. The following case study was published in their website to illustrate successful application of electronic document management in construction industry (<http://www.itcbp.org.uk/itcbp>).

#### **Electronic Document Management at Foster and Partners Architects**

Foster & Partners is an international firm of architects, designers and planners employing over 400 staff working in its London headquarters and three other offices around the world. Faced with enormous and rapidly expanding document archive, and dissatisfied with microfilm as an archival medium, Foster & Partners successfully implemented an Electronic Document Management system. Installed initially for drawing archival purposes, the system has been extended in phases to other areas including the management of financial documents, the operation of a digital print/mail room, and Intranet publication of documents.

#### **Successfully phased implementation of EDM**

In 1992, after 20 years, Foster & Partners had accumulated an archive of more than 1.5 million aperture cards, miles of microfilm, and a vast number of hardcopy drawings. Concerned by the rapid growth of this archive and perceived disadvantages of microfilm medium, Foster's directors initiated a review that encompassed document registration, storage and retrieval, and reprographics and distribution.

**Phase 1 – Drawing archiving:** At the end of 1994, a drawing archival system including a server, three client workstations, large and small format scanners, two plotters/printers, and CD storage were installed and software was customised to Foster's requirements.

**Phase 2 – Integration with accounts:** Document viewing was integrated with the firm's accounting package. Accounting staff now refers to scanned copies of invoices, timesheets and other financial documents when entering data into the accounts system.

**Phase 3 – Correspondence on key projects:** The system was extended to archiving of correspondence on key projects, but for record purposes only.

**Phase 4 -Digital Print/Mail Room:** Incoming and outgoing documents are now scanned, and the practice retains only scanned images of most external consultants' documents.

**Phase 5&6 – Intranet publication and upgrade to Drawing and Finance system:** Web browser technology is being exploited to provide more user-friendly access to documents, and current uses include the publication of selected news clippings via the firm's Intranet.

The company lists the following key benefits:

- Savings on costs and turnover time associated with the use of external microfilming services coupled with higher document image and reproduction quality.
- Savings on document storage and floor space allocations.
- Improved document searching and access: not only faster, but more convenient
- Improved control over document archiving workflow, issuing, and audit trails.

**SURVEY ON THE USE AND STRATEGIC APPROACH TO INFORMATION TECHNOLOGIES IN CONSTRUCTION PROCESSES**

**1 COMPANY DETAILS:**

**1.1 Type of Company**

Architect	<input type="checkbox"/>
Engineer	<input type="checkbox"/>
Contractor	<input type="checkbox"/>

Other \_\_\_\_\_

**1.2 How many employees does your company have?**

Total Number:       Office-based:       Site-based:

**2 COMPUTERS GENERAL**

**2.1 Do you use personal computers at your workplace (central office or site)?**

Yes       No       If NO go to: **5**

**2.2 Which of the following the operating systems does your company use?  
(Please tick only those that are currently being used)**

DOS only <input type="checkbox"/>	Windows 95 <input type="checkbox"/>	Windows 98 <input type="checkbox"/>	Windows NT <input type="checkbox"/>
UNIX <input type="checkbox"/>	OS/2 <input type="checkbox"/>	MAC OS <input type="checkbox"/>	

Other/Comments \_\_\_\_\_  
\_\_\_\_\_

**2.3 Which of the following software does your company use?  
(please tick only that are used in the company)**

**Word processor**

MS Word	<input type="checkbox"/>
WordPerfect	<input type="checkbox"/>
Lotus Ami Pro	<input type="checkbox"/>

Others \_\_\_\_\_

**Spreadsheet**

MS Excel	<input type="checkbox"/>
Lotus 123	<input type="checkbox"/>
Quatro Pro	<input type="checkbox"/>

Others \_\_\_\_\_

**Email**

MS Mail	<input type="checkbox"/>
Pegasus	<input type="checkbox"/>
Hotmail	<input type="checkbox"/>
Internet free mail	<input type="checkbox"/>

Others \_\_\_\_\_

**Project planning**

MS Project	<input type="checkbox"/>
CAD-Super Project	<input type="checkbox"/>
Project Kickstart	<input type="checkbox"/>

Others \_\_\_\_\_

**Databases**

MS Access	<input type="checkbox"/>
Paradox	<input type="checkbox"/>
dBase	<input type="checkbox"/>
Lotus Approach	<input type="checkbox"/>

**Other software  
(e.g estimating)**

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**SURVEY ON THE USE AND STRATEGIC APPROACH TO INFORMATION TECHNOLOGIES IN CONSTRUCTION PROCESSES**

**2.4 What proportion of staff has access to the following equipment?**

	% of total staff	% in Office	% on site
Own PC or terminal at the workplace	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
PC at home, rented by employee	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
PC at home, financed by the company	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Own e-mail address at the company	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Own mobile phone, financed by the company	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Own hand held computer that can link to PC	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**2.5 Does the Company have Computer-Aided Design (CAD)?**

Yes  No

If NOT, do you intend to acquire it:

in 2 years?  in 5 years?

We don't need it:

**2.6 Which of the following techniques/software does the company use for design work?**

	% design time used	Has it increased in the last 2 years? Yes/NO
Drawing by hand	<input type="checkbox"/>	<input type="checkbox"/>
AutoCAD	<input type="checkbox"/>	<input type="checkbox"/>
AutoCAD LT	<input type="checkbox"/>	<input type="checkbox"/>
ArchiCAD	<input type="checkbox"/>	<input type="checkbox"/>
Microstation	<input type="checkbox"/>	<input type="checkbox"/>

Others/Comments \_\_\_\_\_

**3 USE OF I.T. SYSTEMS**

**3.1 Estimate the extent to which the following operations are computerised**

	1 – 39%	40-59%	60-100%	Done Manually
Bookkeeping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Invoicing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Work Descriptions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Technical Calculations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bill of Quantities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Scheduling/ resource planning	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Material control	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Costing/Budgeting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tendering	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Marketing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Other/ Comments \_\_\_\_\_

**SURVEY ON THE USE AND STRATEGIC APPROACH TO INFORMATION TECHNOLOGIES IN CONSTRUCTION PROCESSES**

**3.2 State what proportions of the following documents are sent digitally at your workplace.**

	1-39%	40-59%	60-100%	Done Manually
Briefs/Sketches	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Draft/Main documents	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Building and as-built	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Work descriptions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tender enquiries	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Calculations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Orders, invoices	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Quality/test results	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Minutes of meetings	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Other/Comments \_\_\_\_\_

**4 DATA AND TELECOMMUNICATIONS**

**4.1 Does your company have one or more Local Area Networks at this place**

Yes  No

**4.2 Is there access to the internet at this workplace?**

Yes – via and analogue modem

Yes – ISDN

Yes – via a permanent connection

No

If "No" please move to: **5**

**4.3 Does your company have a home page on the internet?**

Yes  If yes what does it include:

news	<input type="checkbox"/>
presentation of the company	<input type="checkbox"/>
presentation of services, orders	<input type="checkbox"/>

Others \_\_\_\_\_

No – but it ought to have one

No – it does not need one

**4.4 Does your company have an Intranet (a web environment available only internally)?**

Yes  If yes what does it include:

news	<input type="checkbox"/>
manuals	<input type="checkbox"/>
project information	<input type="checkbox"/>
personnel information	<input type="checkbox"/>
quality information	<input type="checkbox"/>

Other \_\_\_\_\_

No – but we should have one

No – it is not necessary

Expected in 2 years

Expected in 3 to 5 years

**SURVEY ON THE USE AND STRATEGIC APPROACH TO INFORMATION TECHNOLOGIES IN CONSTRUCTION PROCESSES**

**5 THE PART PLAYED BY IT IN THE COMPANY**

**5.1 Does the company have an IT strategy?**

Yes – in written form	<input type="checkbox"/>	No – but one is needed	<input type="checkbox"/>
Yes – in oral form	<input type="checkbox"/>	No- it is not necessary	<input type="checkbox"/>
Yes – in both written and oral form	<input type="checkbox"/>		

**5.2 Has the company made any investment in IT in the last two years?**

Yes       No       If No, please go to: **5.4**

**5.3 Estimate how your IT investment has changed, or will change in future:**

	Increase	Constant	Decrease
In the last two years	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
In the next two years	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Beyond 2 years	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**5.4 How important are the following reasons in making decision about new IT investments?**

	Not Important	Slightly Important	Important	Very important	Don't know
Customer demand	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Employee demand	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
For competition	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
More efficient admin work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
To be ahead technically	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
To develop new Product /business	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Others	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**5.5 Has IT resulted in changes in the process (design, construction processes) in the last two years? and, if so, in which ways has it changed?**

	Reduced	No Difference	Increased	Do not know
Mistakes in documents	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Construction errors	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Documents quality	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Speed of work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Complexity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Degree of difficulty	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Need for administration.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Proportion of new work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other changes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**SURVEY ON THE USE AND STRATEGIC APPROACH TO INFORMATION TECHNOLOGIES IN CONSTRUCTION PROCESSES**

**5.6 What effect has IT had on productivity in the last two years?**

	Reduced	Unchanged	Increased	Do not know
General administration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Materials administration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Property administration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Project management	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Design	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Site management	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Purchasing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comments \_\_\_\_\_

**5.7 In which areas does your company plan to increase the use of IT in the next two years? (please mark the three most important areas)**

CAD	<input type="checkbox"/>	Document Handling	<input type="checkbox"/>	Product models	<input type="checkbox"/>
Virtual Reality	<input type="checkbox"/>	Accounting systems	<input type="checkbox"/>	Technical calculations	<input type="checkbox"/>
Project webs	<input type="checkbox"/>	Costing/Cost control	<input type="checkbox"/>	Project Management	<input type="checkbox"/>
Electronic trading	<input type="checkbox"/>	New business models	<input type="checkbox"/>	Property information	<input type="checkbox"/>
Internet/Web	<input type="checkbox"/>	Portable/Mobile systems	<input type="checkbox"/>	Other _____	<input type="checkbox"/>

Comment \_\_\_\_\_

**5.8 What advantages do you think greater use of IT gives your company?**

Better financial control	<input type="checkbox"/>
Better communications	<input type="checkbox"/>
Better quality of work	<input type="checkbox"/>
Work done more quickly	<input type="checkbox"/>
Possibility of sharing common information	<input type="checkbox"/>
Simpler/Faster access to information	<input type="checkbox"/>
Reduction of Staff	<input type="checkbox"/>
Satisfying customers	<input type="checkbox"/>
Less use of paper	<input type="checkbox"/>
Attraction of new staff	<input type="checkbox"/>
Other _____	<input type="checkbox"/>
None	<input type="checkbox"/>

**5.9 What are the greatest obstacles to greater use of IT in your company?**

*(Rate only the biggest three (3) from 1 to 3, with 1 being the greatest)*

<input type="checkbox"/>	Investment costs too high
<input type="checkbox"/>	Continual demand for upgrading hardware and software
<input type="checkbox"/>	Greater know-how required from staff
<input type="checkbox"/>	Over-abundance of information
<input type="checkbox"/>	Risk that IT leads to inefficiency
<input type="checkbox"/>	Decision-makers have no time for IT efforts
<input type="checkbox"/>	Difficulty in assessing investments
<input type="checkbox"/>	Extra work in the form of "unnecessary" data input
<input type="checkbox"/>	The old ways work well
<input type="checkbox"/>	Reduced security
<input type="checkbox"/>	Lack of commitment from management
<input type="checkbox"/>	Lack of standards and coordination problems

**SURVEY ON THE USE AND STRATEGIC APPROACH TO INFORMATION  
TECHNOLOGIES IN CONSTRUCTION PROCESSES**

Thank you for your help in completing this questionnaire.

Please supply your name, mailing address, telephone number and email address (if you have one) if you want summary of the results. This will be treated in confidence.

Name:

Company Name:

Mailing Address:

Email address:

Telephone No.

University of Cape Town