PROMOTING THE USE OF ICT IN THE CONSTRUCTION INDUSTRY:

ASSESSING THE FACTORS HINDERING USAGE BY BUILDING CONTRACTORS IN GHANA.

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BY

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SEPTEMBER, 2012

DECLARATION

I declare that I have wholly undertaken the research reported herein under supervision and to the best of my knowledge, it contains no materials previously published except where references have been duly acknowledged.

…….. …….

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I declare that I have supervised the student in undertaken this study and comfirm that the student have my permission to submit it.

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ABSTRACT

Information and communication Technology (ICT) nowadays have great impact on the construction industry and the way it works. The technology is viewed as crucial for effective and successful project delivery. Currently, there is a growing awareness among stakeholders of the industry that, in order to surmount the existing information management and communication deficiencies in the construction business, more emphasis should be given to information and communication technology (ICT). Though, several construction organisations today might perceive that greater use of ICT would enhance their performance and may well employ the technology to improve some specific processes of their endeavor, ICT usage in most construction firms have often been described as relatively limited and ineffective compared to other sectors in most economies. This situation could probably be true for the Ghanaian construction industry. With the need for adequate information concerning the Ghanaian construction industry's ICT platforms, this research focuses on current levels of ICT practice and identifies the reasons hindering its usage by Building and Civil Engineering Contractors in Ghana.

A survey based on structured questionnaire was used to elicit the relevant data from D1K1 and D2K2 contractors. In all, fifty one (51) respondents completed the questionnaire. The data was analyzed using Frequency Analysis, Mean/average Score and One Sample T-test.

The findings suggest that, there is a reasonable level of awareness among the contractors about the potential benefits of ICT. However, current ICT usage in most firms was found to be unsophisticated, with more advanced applications of ICT lacking in most of

the firms. The study also revealed,9 out of 21 factors identified from the literature as important factors affecting the use of ICT by building contractors. A test of significance finally revealed that: *budget constraints for ICT investments, lack of commitment by firm's management towards ICT, lack of training and technical support for construction professionals in ICT, inadequate ICT content of construction education and the fact that majority of client are not interested in firm's ICT base* were the most critical factors hindering use of ICT by building contractors in Ghana.

It plausible to admit from this study that, whilst the posture and interest towards ICT by building contractors in Ghana seems promising, the factors identified from the study could be a major issue that stakeholders and individual organizations' need to address in order to enhance their ICT capacity and derive its full benefit.

The study finally proposed recommendations on the *need for firm's internal policy and financial support for ICT investments, improved training and management support for ICT usage in building construction firms, construction client interest in contractors ICT capacity; probably as a criterion for selection and an improved ICT content in construction education at all levels.*

It is expected the findings from the study could be relevant in addressing the situation in the construction industry in Ghana.

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DEDICATION

This work is dedicated to God almighty and my family for the immerse support throughout this study.

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CHAPTER ONE

GENERAL INTRODUCTION

1.1 Introduction

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This chapter provides an overview of the research. It begins by discussing the background of the study and highlighted the main issue under exploration in the problem statement. The next section addresses the aim and objectives of the research followed by the key research questions which guided the inquiry. Subsequently, a summary of the research methodology and the scope for the study was described. The chapter ended with highlights of the organisation of the research.

1.2 Background to research

The construction industry has often been criticized with issues concerning efficiency, productivity and quality in the delivery of its products. Contractors among the major players of the industry have often been blamed for this situation. In recent times, it has been reported that one of the fundamental issues contributing to the construction industries poor performance is ineffective communication and exchange of information and data amongst the project team (Dainty et.al, 2006).

As observed in Lofgren (2006), a greater part of the production difficulties in the construction industry has strong relation to the communication and information exchange between the parties involve in the construction project.

Interestingly, the level of technologies available in today's marketplace is enormous, and the construction sector should be aware of the benefits from using these technologies to enhance their business and collaboration solutions. Information and communication technology (ICT) among these technology solutions is often regarded as an enabler to facilitate productivity and enhances quality of output.

Indeed, it is widely reported that the use of information and communication technology (ICT) with properly defined structures and communication interfaces has in the manufacturing industry, proved to be an efficient tool that supports the integration of processes for product development, production, materials supply, communication and maintenance processes. As a result, the technology (ICT) has been widely applied across many sectors to increase competitiveness and reduce cost and is widely seen today as a vehicle to gain competitive advantage ((Marsh et al.2000; Earl, 1993).

Incidentally, the construction industry which has been described as adversarial and information intensive (Cox and Townsend, 1998), seems to have most of its problems attributed to the quality and complexity of shared information (Ng T et al, 2001). Unlike other economic sectors, the construction industry is characterized by activities which are discontinuous, dispersed, diverse and distinct. Obviously, this could make the implementation of ICT in the construction industry more difficult than other industries. Yet, the sector is in grave need of innovation and process improvement in order to remain competitive in today's digital economy.

In recent past, the construction industry has recognized the use of Information and Communication Technology (ICT) as essential tool for improving data and communication in construction processes and for creating new construction business opportunities (Doherty 1997; Peansupap, 2005). Indeed, this recognition have motivated several construction organisations around the world to adopt and invest in this technology; and many recent survey results suggest an increasing trend of firms using ICT in the construction industry (Rivard, 2000; Peansupap,2005).

Of course several reasons have been reported on why the use of ICT on construction projects is vital. According to Gunasekaran *et al* (2001), through the use of ICT on construction projects, contractors can benefits from improved operational efficiency, improved quality, reduced project time and cost and increase profit levels. Similarly, Brown et al, (1996) cited that, downward cost pressures, time specific nature of construction projects, increased specialization and technical complexity of projects are major reasons that create demand for ICT usage in the construction industry. This trend was also recounted in Ozumba *et al* (2008) and hinted that, the use of ICT has the potential to enhance both intra and extra site communication including benefits such as enhanced data and material management and in essence enhance overall site management processes.

Again, it is commonplace that parties to a construction project such as the owner, the consultants, contractor and subcontractors, come in with a set of interrelated and interconnect relationships requiring cooperation and collaboration to coordinate time, resources, and communication. Hence, the strategic use of Information and Communication Technologies (ICT) on projects has become vital to enable this goal to

be achieved more effectively and to a large extent (Hassan et al, 2003). Common standards for information and data exchange in the construction industry can also be enhanced through the use of proper ICT based business systems, communication tools and other shared storage servers (Farag, 1999; Lofgren, 2006).

This notwithstanding, several innovations in ICT technologies have provided new opportunities for enhancing communication, collaboration and information management in construction (Stewart, 2007). For instance, advanced applications of ICT such asModelling and Visualization technologies, Mobile Computing and internet based data exchange such as project webs, Electronic Document Management Systems ,Teleconferencing and E-commerce including integrated software such as Enterprise Resource Planning (ERP) have been used to some success in many other countries (Lofgren,2006;Ozumba *et al* 2008).

Besides, the use of site automation technologies such as those based on Radio Frequency Identification sensors (RFID), Global Positioning systems (GPS), Geographical Information Systems (GIS) and Site Surveillance Technologies (CCTV Camera, Digital Video recordings etc) are also being applied on construction project sites to improve productivity (Ozumba *et al*,2008).

While these ICT technologies might help to improve information and communication in construction firms through reduction of numerous paper copies of documents and drawings, better document management and archiving and faster, cheaper and more accurate communication flows, its widespread usage is yet to fully gain grounds in the

construction industry as compared to many other sectors of the economy (Farag, 1999;Egbu and Botterill, 2002).

In spite of this, ICT has been portrayed as a crucial resource in the construction industry and that, contractors and other industry professionals should see it both as critical and value adding in achieving strategic competitive advantage and in context of their overall business strategy of their companies (Isikdag et al, 2007).

Given this significant role and the rising interest of ICT in the construction industry today, the Ghanaian construction industry cannot be left out in this great marketplace.

1.3 Problem statement

From the background information presented, it is evident that, the importance and emerging roles of information and communication Technology (ICT) to the construction industry cannot be ignored. However, one of the obvious contests of the Ghanaian construction industry today is that, majority of the construction process information and data continue to rely heavily on traditional means of documentation and communications such as face-to-face meetings and exchange of paper documents such as drawings, specifications and site instructions (Mohamed and Stewart, 2003).

As recounted by Anumba and Ruikar (2002), the traditional information and communication flows within the construction industry are mostly characterize by manual and slow processes and hence,

- Producing numerous paper copies of documents and drawings.
- Management of 'loose' documents is often time-consuming and tedious.

- Library ‘archives’ of documents need to be maintained to effectively access data as and when required.
- The reliance on third parties, such as courier services, can lead to delays.
- The added expense incurred in the delivery of project documents to project members who are geographically distributed

Yet, the traditional construction sector all over the world including that of Ghana are required to move towards innovation of their products including the production processes improvement to achieve more efficient process with products and production methods. Furthermore, current issues of competition as well as increasing client awareness are creating demand for urgent improvement in productivity and competitiveness in the construction sector. In effect, this suggest that as construction is becoming more complex today, a more sophisticated approach is necessary to deal with issues of initiating, planning, financing, designing, approving, implementing and completing a project, an area in which ICT have proved its greatest impact and enormous application potential (Wang, 1994).

Though, Sarshar *et al*(2004) have hinted that contractors can employ ICTs as an enabler for integration, collaboration, knowledge management, procurement, site management and process improvement; Mak(2001) had reported that the use of ICTs in construction firms continues to be ‘piecemeal’ and that; only few contractors are fully able to integrate ICTs with their core business processes. Issues such as computer illiteracy, inadequate knowledge of ICT among others has been cited as the most frequently reported shortcomings of contractors in many countries (Samuelson, 2002). Again the fact that contractors’ core business activities are mainly performed on construction sites

and applications that support actual work on site are hard to find has also been referred among others.

For this reason, the vast benefits offered by ICT in the construction industry though seems recognized, its adoption and use as normal part of the construction process is still low; and contractors among the major players, have been often been cited as those who use ICT least of all (Peansupap and Walker, 2004).

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While this situation could probably be true for the Ghanaian construction industry, specific details regarding the extent of application and problems facing the use of ICT in the Ghanaian construction industry still remain unclear. This study seeks to assess the situation in building construction firms in Ghana.

1.4 Aim of study.

The aimed of the study is to identify the reasons hindering the use of ICT by Building contractors in Ghana.

1.5 Objectives of study

The specific objectives of this study are;

- To assess the ICT infrastructure platforms of Building Contractors in Ghana.
- To explore the level ICT usage among building contractors
- To identify and evaluate the factors hindering the use of ICT by building contractors in Ghana

1.6 Research questions

To answer the main research problem above, three research questions will be addressed

1. What is the state of ICT infrastructure in Building construction firms in Ghana?
2. To what is extent is ICT being used by building construction firms in Ghana?
3. What significant factors hinder the use of ICT by Building Contractors in Ghana?

1.7 Research methodology

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The research was conducted through survey questionnaires. Survey is one of the most cost effective ways to obtain information from large pool of people given better results-more specific, accurate, faster and most cost effective ways (McQueen and Knussen,2002; Farag et al,2009). The companies surveyed were building and civil engineering construction firms in financial class D1K1 and D2K2.

At first, the study commenced with a thorough literature exploration of both the electronic and hard copy media. This proved helpful in having a better understanding of recent developments of Information and Communication Technology (ICT) aspects in the construction industry. It further provided insight into the research questions, hypotheses and objectives within the theoretical framework for the study. The relevant aspects of the literature search were reviewed to include areas applicable for the study. Subsequently, structured questionnaire was developed and conducted among top management officials and professionals in the contractor organizations who are involved in the construction process and administration. A number of comments and suggestions from an initial pilot study were used to amend the questionnaire before final distribution. The data received will be analyzed using One Sample T-test statistical tools with the help of Statistical Package for Social Sciences (SPSS) Software.

1.8 Scope of the study

The research focuses on Information and Communications Technology (ICT) and its applications in the Ghanaian construction industry. For the purposes of this research, the study focused on ICT usage in the perspective of construction contractors in the financial class D1KI and D2K2 according to the Ministry of Water Resources, Works and Housing classification guidelines in Ghana. This is because such companies usually undertake large volumes of works employ qualified professionals and hence, have the capacity to engage and appreciate technology (ICT) in their operations.

The study areas to be covered are Kumasi and Accra. This is because, the distribution of these contractors in Ghana are largely biased towards the city capitals with more than 70% of the registered Building and Civil engineering contractors, particularly the large organisations, tend to operate officially in the Greater Accra region and Kumasiwhilst the remaining eight regional administrations put together account for the remaining 30% (Ayisi, 2000; Ahadze, 2007);.

1.9 Organisation of the research

The dissertation was organized in five chapters. Chapter one introduces the whole thesis, highlighting the main subject and problem statement; the aims and objective, scope, methodology adopted and research outline.

Chapter two focuses on the literature review and touches on information and communication needs confronting construction industries generally, and the quest forimprovements through the use of information and communication technology (ICT).

The chapter also explains various factors, roles and barriers to ICT implementation in the construction sector. It further explored current drivers for use of ICT and various ICT tools and applications of the construction sector. The chapter ends by discussing the Ghanaian construction industry and its contractor organisations

Chapter three was devoted to the development of the theoretical framework of the research, explains the research methodology employed and also the statistical methods used in analyzing the results.

Chapter four presents the analysis of data obtained, discussions and interpretation of the findings of the survey.

Chapter five summarizes the conclusions of the study and recommendations based on the findings of the study.

1.10 Summary

In this chapter, the general background of the study including the problem statement, aims and objectives and the research methodology have been presented. The next chapter will present comprehensive review of information and communication technology (ICT) applications and usage in the construction industry generally.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter discusses the literature review for this study. The review has been divided into two sections. The first part deals with the construction industry generally, information and communication technology in the construction, including providing a working understanding of issues relating to information and communication needs in construction and current roles of ICT in construction. The second part looks at the drivers for implementing ICT in the construction industry, ICT tools and applications for the sector and perceived challenges for its implementation. Finally the chapter ends with an overview of the contractor organisations in Ghana.

2.2 The construction industry.

Construction industry is one of the most important sectors in many economies, facing a period of rapid and unparalleled change. The Ghanaian construction industry for instance, was valued at over GHC 3,900 million Ghana cedis (through the end products it creates) in 2010, constituting about 9% GDP (*Ghana Statistical service*), and therefore has the potential to influence the country's GDP more than any other service industry.

The construction industry produces long-term, unique, and complex building projects and infrastructure (Levy, 2007). This covers the provision of new structures as well as

additions, alterations, and repairs to existing ones. Major services such as provision of houses, factories, offices, schools, roads, and bridges are only a few of the products of the construction industry. These facilities are necessary for the other sectors of the economy such as education, health, commercial and business activities, housing needs and so on to thrive. Hence, the sector is often regarded as an essential and highly visible contributor to the process of growth in any country (Field and Ofori, 1988).

For that reason, the effects of changes in the construction industry can occur at all levels of the economy and in virtually all aspects of life. This notwithstanding, the industry also contributes significantly to the national socio-economic development by providing significant employment opportunities at non-skilled and skilled levels. For instance, the industry is said to contribute about 50 per cent of all investments in capital goods in many countries (Zawdie and Langford, 2000).

It is the generation of these physical assets that have helped many modern economies both developed and developing to achieve and sustain the requisite socio-economic progress. Beyond this, the construction industry's activities are usually distributed geographically in much the same way as the nation's population and this provide employment at various levels of the economy. Recurrent issues such as population growth, deteriorating infrastructure, and aging buildings continue create demand and generate employment growth in the construction industry.

2.2.1 Nature and characteristic of the construction industry

The nature of the construction industry is quiet different from other industries, such as the manufacturing or retail sector, where processes and the working environment are well defined and controlled (Gann, 1996). The temporary nature and uniqueness of construction projects are often reflected in one-off locations, one-off designs solutions, one off project teams and usually large numbers of geographically dispersed organisations and individuals, which lead to a more fragmented communication platform and making project communication activities inevitably complex.

Beyond that, the industry is also characterized by product uniqueness, on-site production and ad hoc project teams with high turnover rate. In all these efforts, the industry also relies on the use of large amounts of information during the entire life-cycle of a project. As a result of these unique characteristics, it has often been difficult for the construction industry to coordinate, store, and reuse knowledge that is obtained between the organization and its individuals. This has often led to poor communication and inefficient information practices that have contributed to the emergence of dysfunctional supply chains (Love et al., 1999).

The reality is that, construction organisations today are faced with many new challenges, including the need to change current work practices; become more clients orientated; become more competitive; and become more productive (Love, 1996). These challenges are attributable to factors that effect the working environment, including globalization of the economy; greater performance expectations from the clients; increased competition between local contractors; continued restructuring of work practices and industrial relations. It is against this background that at various levels of socio-economic

development, several countries have recognized the need and importance of taking measures to improve the performance of their construction industry in other to meet the aspirations of its developmental goals (Ofori, 2000). One of such measures is the needs to embrace technology and innovations in order to increase project performance.

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2.2.2 The Contractor Organisations in Ghana.

Generally, contractors in the construction industry of Ghana like many others can be classified into three major categories:

- General buildings contractors who builds residential, industrial, commercial, and other buildings.
- Heavy and civil engineering construction contractors build sewers, roads, highways, bridges, tunnels, and other projects.
- Specialty trade contractors are engaged in specialized activities such as labour only contracts, plumbing, and electrical work.

These construction activities are usually done or coordinated in the field by general contractors who are specialize in specific types of construction such as building, civil engineering and / or road construction etc. They take full responsibility for the complete job, except for specified portions of the work that may be omitted from the general contract and sublet to other specialized contractors. Although, contractors may do most of the work with their own crews, they sometimes subcontract portion of the work to their domestic trade contractors. Specialty trade contractors or subcontractors usually do the work of only one trade, such as plumbing or electrical work, or of two or more

closely related trades, such as plumbing and heating. They usually obtain orders for their work from general contractors, architects, or clients. Beyond fitting their work to that of the other trades, specialty trade contractors have no responsibility for the structure as a whole.

According to the classification of ministry of water resources, works and housing in Ghana, contractors are grouped into categories (A, B, C, D, E, G, K and S) according the type of works they undertake. These are: Roads, Airports, and Related Structures (A); Bridges, Culverts and other Structures (B); Labour based road works (C); General building works (D); Electrical works (E); Plumbing works (G); General civil works (K); and Steel bridges and structures: construction rehabilitation and maintenance (S). In each category, they are grouped into 4, 3, 2 and 1 financial classes in increasing order (Dansoh, 2005).

This research focused on contractors in category D and K for general building and civil engineering works. The two main upper classes (D1K1 and D2K2) were chosen since they are considered more organized and hence more stable and have the potential for ICT uptake(Ofori, 2000).

2.3 Information and communication requirements in construction

Typically, the construction sector is considered one of the most information-dependent industries. For instance, a construction project chain may involve large numbers of skilled professionals and companies with, quite often, much repetition of activities and accumulation of paperwork. Majority of these participants require access to the regular project information at one time or another(Murray *et al.*, 2001).

This means that, timely and accurate access to information is therefore important for all project participants as it forms the basis on which decisions are made and physical progress is achieved. Currently, several construction documents such as drawings, specifications, bills of quantities, correspondence, schedules, and programmes produced on construction projects are currently exchanged on paper bases and face to face communication between practitioners in industry(Hore and West, 2005).

Admittedly, effective collaboration between all the role players during construction is not only important but also necessary for the successful completion of a construction project. With so many interested parties, effective communication and information sharing among them is vital. Not only must the formal structures and networks be examined to understand the level of information sharing that is happening on a formal basis, but the informal relationships among parties will depend on how and when information is shared and how and when information is flowing (Perreira and Soares, 2007).

2.3.1 Communication need in construction

Effective communication is vital in construction due to the large number of project participants, the separation of design and construction disciplines and the geographically dispersed nature of the projects (Barrie and Paulson, 1992). Therefore, the improvement of communication in the construction industry has been a target of practitioners and researchers for many years. In order to function effectively, a construction company must have communication systems of different types to cover inter-personal, inter-departmental, and inter-organisational communications(Guevara and Boyer, 1981; Bowden, 2005).

Characteristically, all construction projects generate paper data, and the larger the project the larger the volume of records to be managed (Flowers, 1996). Aninferencethat is often drawn is that, effective communications are held back by the predominantly paper-based world and that; electronic exchange and production of information should alleviate these problems(Moniem, 2000).

2.3.2 Information requirements in construction

Information can broadly be defined as the data and messages that are transmitted between people within a communications network (Mead, 2001). According to Doherty (1997), information plays two vital roles in construction by:

1. specifying the resulting product (i.e. design information)

2. initiates and controls the activities required for constructing the facility (management information).

To this effect, successful management of information has a critical influence on the performance of a project. In view of the above disposition, Murray *et al* (2001) provided information producer and user matrix for as a guide for typical project chain as shown in Fig.1 below.

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	ROLE PLAYERS					
DOCUMENTS	Client	Architect	Quantity surveyor	Engineers	Contractor	Subcontractors and suppliers
Drawings	○	•	○	•	•	○
Specifications	○	•	○	•	○	○
Bills of quantities		○	•	•	○	○
Budget	○	○	•	○	○	○
Contracts	○	○	•	•	•	
Planning	○	○	•	•	•	•
Personnel control			•	○	•	•
Materials control			•	○	•	•
Equipment control			•	○	•	•

LEGEND

• -Produces documents ○ –Requires information from document

FIG 1: Information Producer-User Matrix for a Typical Project Chain-Source: Adapted from Murray et al (2001)

At the pivot of this important matrix is the recognition that, the various participants on a project have to deal with a lot of information; and these information needs to be passed along the chain from team to team(Murray et al ,*2001;*Oladapo, 2006).*)*.

Referring to the contribution by Tenah (1996), construction personnel who have access to timely and accurate information will:

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• reduce or maintain project durations

• make better use of resources

• increase labour and equipment productivity

• decrease cost.

Another contemporary observation worth noting is that, construction project managers typically spend about 70% of their time dealing (generating, managing, sending, collecting and analysis) with data (Fisher and Yin, 1992). Similarly, Newton (1998) concluded that about 65% of contractor-rework is attributed to insufficient, inappropriate or conflicting information. It could therefore be argued that, because most project information are currently stored on paper, which is difficult to access and time consuming to search may be a key input to this situation.

For this reasons, it is crucial that major site issues must be resolved quickly and efficiently to avoid downtime, rework and waste with the associated cost overruns and this often requires collaboration between on and off-site personnel (Miah *et al.*, 1998). Again the foregoing has demonstrated that, the ability to quickly convert data into information, while at the same time reducing the drudgery associated with many of the

administrative tasks is very crucial to improve both staff efficiency and work interest (Flowers, 1996).

Indeed, effective data collation, information transfer and information retrieval have been cited as important areas for improvement in construction (Bowden, 2005). By enhancing information flow between the different site processes and teams, it becomes easier to monitor, control and assess the project progress and hence integrate the on-site process effectively (Moniem, 2000).

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2.4 ICT and the construction industry

2.4.1 ICT defined

Information Technology (IT) can be defined as technology that is used to handle data, information and knowledge. It involves the use of electronic devices and programmes for the processing, storage, transfer and presentation of information (Doherty.1997).Today, Communication technology is an important part of IT, hence, Information and Communication Technology (ICT). According to Ang et al 1997, ICT can broadly be defined as technologies dedicated to information storage, processing and communications and involve a combination of hardware, software and networks to transform raw data into useful information for speedy retrieval (Farag, 2009). Therefore, Construction ICT entails the use of computer systems that are capable of capturing, organizing, storing, analyzing, exchanging, transmitting, and sharing information (Perkinson et al,2006). Examples of ICT include video conferencing, web-based project

management applications, database management systems (DBS), data warehousing (DW), and data mining(Harris and MacCaffer, 2001)

2.4.2 Need for ICT in the construction industry

Quoting from Vadhavkar *et al*(2000), Hassan and McCaffer, (2002) pointed out that, issues of time constraints, complexity and operational disintegration has forced many enterprises both small and large, to incorporate Information and Communication Technologies (ICT) into their business processes Obviously, the implementation of these ICT technologies in construction are aimed at supporting information sharing among individuals and groups since the construction industry of today and of the future demand the use of sustainable systems enabled by information and communication technologies (Hassanain et al, 2000). Currently, Information and Communication Technologies (ICT) are said to be providing construction firms with new opportunities for enhancing information management processes, communication and collaboration (Bowden, 2005). According to Songer (2000), owner organizations are requiring the engineering/construction industry to perform at extraordinary levels of project delivery, hence, advances in project delivery systems and use of information technologies provide tremendous potential for enhancing the construction industry's overall performance.

By that, it is reported that the average annual growth rate of ICT investment in the construction industry is increasing every year and now constitutes a significant part of the total project cost(Löfgren, 2007). Notably, Information and Communication

Technology (ICT) is perceived as the main enabler to implement radical changes in construction business processes(Isikdag*et al*, 2007).

The Roadcon Project (2003) observed that, ICT-based expected improvements and impacts could be envisaged in many activity domains such as:

- Construction stages including planning, design, procurement and site operations;
- Digital sites: introducing ICT and automation in site operations;
- Business processes including project management, contractual and legal matters;
- Life cycle performance(s) of building and construction, including monitoring and performance measurements, as regards e.g. the conformity with customer needs or the management of total Life-cycle costs (investment, operation, maintenance);
- Quick, efficient and cost-effectively construction, along with Building Product customization and differentiation;
- Supply chain management;
- Costing and accounting operations; including
- An enhanced use of communication, team working, & knowledge sharing tools, smooth / transparent use of ICT (for end users), and process improvement through best options / practice and progress monitoring

2.4.3 Role of ICT in the construction process

The benefits offered by ICT on construction project are well documentedin literature. This include among others improved access to richer information to aid decision making, quicker information, improved information flow, greater management control and getting geographically dispersed group to work together(Peansupap, 2004).

The roles of implementing ICT are highlighted in the following stages of the construction process:

2.4.3.1 Tender stage

The main functions of ICT usage at this stage are to advertise and distribute tender documents, select successful tenderers and award contracts. Software used in the stage can:

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- speed up the distribution of documentation and tenderers' communications;
- register tenderers online and download tenders/work packages electronically;
- provide a simple environment to evaluate the tenderers' responses through standard templates;
- prevent unauthorized access through built in security mechanisms;
- Communicate changes in the tender documents, during the tender process, quickly and easily(COBRA, 2009; Çaglar, 2005;Björk, 2002).

2.4.3.2 Design and construction stage

Both design and production of construction projects share a need for rapid access to information and communication in real time (cowel,2005). Improving information and communication support for the core activities at the design and construction stage has become a strategic challenge for the construction industry to increase efficiency and productivity in the construction process (Samuelson, 2003).

Project managers and contractors control and manage the exchange of documents between members of the project team so that the overall deadlines of the project are met(e-Business Market Watch, 2005).

It is essential that each team member receives the right documents at the right time such as the latest version of drawings, specifications requirements among others. ICT softwares are used at this stage to:

- Improve efficiency of work
- reduce the risk of errors and rework by ensuring that everyone in the project team is working with the most current drawings and other documents;
- save time in the query (request for information, RFI) and approval process, by allowing the design team to mark up and comment on drawings online;
- eliminate the risk of losing important files, by maintaining all current and past versions in one central location;
- improve team communication by enabling team members to raise and respond to queries in a structured way;
- maintain a complete log of all communications for tracking purposes (audit trail facility);
- provide clients and other participants with a view of the project as it is built; as some software have incorporated virtual reality models to denote the status of a project at any point in time (a snap shot view of a project);
- Provide a collaborative environment whereby the diverse participants can perform online collaboration via the web.
- The real exchange of information takes place via other, informal channels, where other forms of information and communication technology such as e-mail, SMS messaging and mobile telephones, which enable direct contacts between project

members in network-like cooperation(Çaglar, 2005;Peansupap, 2004; e-Business Market Watch ,2005)

2.4.3.3 Trading (e-commerce)

Purchasing of materials is a lengthy and complex process, which requires the identification of considerable resources and potential suppliers as well as the evaluation of quotes, which are normally received in different formats.

Web-enabled Software used in this stage can:

- save time in the procurement of materials by automating document distribution and communications (E-procurement);
- reduce the administrative costs of document handling and distribution to multiple parties;
- reduce errors due to effective communication;
- ensure ease of comparison and evaluation of bids.
- Despite these significant roles, studies indicate that the ICT utilization ratio is still relatively low in the construction industry (Woksepp and Olofsson, 2007; e-Business Market Watch ,2005)

2.5. Drivers for ICT implementation in the construction

As result of the benefits offered by the use ICT in the construction sector, many constructions organisations are currently motivated to adopt and invest in the technology. Many recent survey outcomes suggest an increasing trend of firms using ICT in the construction industry (Rivard, 2000; peansupap,2004).

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According to Peansupap (2004), ICT can be used to:

- Improve productivity in construction through improved operational efficiency, reduce cost and project cost.
- Support information integration and this in turn can help to reduce the volumeof information processed and reduce data re-entry by transferring information through internet/Intranet protocols. This can provide benefits throughout project phases such as design, construction, and operation.
- Enhance collaboration by supporting communication among project members and sharing of information and documents, especially when team members are located in different geographical areas (Ahmad,2002; Sriprasert and Dawood 2002b).
- Support ‘e-commerce’ and create opportunities to extend business or provide improved customer service (Skibniewski and Nitithamyong, 2004).

The following discusses the above in further details.

2.5.1 ICT- based site management and process improvement in construction

Peansupap (2004) observed that, ICT diffusion in the construction can be seen as an important driver for improving the efficiency and effectiveness of production in the sector. In support of this, Samuelson (2003) commented that ICT utilization was relatively high in the design phase and in facility management and that, its use by contractors and site workers in the production process was surprisingly low. He argued that, part of the poor productivity figures in the construction industry could be explained by the fact that the information needs and communication behaviors in the production at the construction sites are not adequately met. Hitherto, the industry has seen much effort to improve productivity with the help of Information and Communication Technology (ICT) and various studies indicate that there is significant potential for productivity improvement in the construction sector and that ICT can play a role in this (Samuelson, 2003; Lofgren, 2006).

The drive for improved productivity in the construction industry has come with the recognition that productivity is closely linked to competitiveness (Cattell *et al.*, 2004; ISR, 1999) and that the construction industry is yet to keep pace with productivity improvements gained in other industries such as manufacturing and aircraft (Teicholz, 2004).

Due to the nature of construction activities however, possibilities for productivity improvements are often reflected within the efficiency in running the construction business processes. Drawing from this, ICT-based productivity improvements in the construction sector are often manifested in more efficient project management, process integration and workflow improvements, improved communication processes, precise

resource planning and more cost-efficient and effective Customer Relationship Management (e- Business Market Watch, 2004). Again, the construction industry today is also characterized by rapid development of jobsite automation technologies which has resulted in productivity improvements **(**Ahmad and Perkinson, 2005). Construction automation which entails the use of computers to replace and/or enhance a variety of jobsite applications including surveying, the control of equipment, site surveillance and the installation of prefabricated units using Global Positioning System (GPS) technologies and advanced robotic systems have been applied successfully in recent years(Ahmad and Perkinson, 2005). By that, several national construction change initiatives has been promoted to support the use of information technology as a tool to increase productivity, through automating tasks and enhancing collaboration (ISR,1999). Task automation provides productivity enhancements in:

- Delivery of required information e.g. method statements;
- Production of reports e.g. daily progress reports;
- Alerts e.g. notification of safety hazard;
- Datacollation reduces number of administration staff required.

Indeed evidence presently suggest that, the results has been savings in manual labor costs, shorter construction duration as a result of higher productivity, determination of optimal combination of machines and the use of machines in places where the tasks are repetitive or dangerous for the workers (Ahmad and Perkinson, 2005). One other area where significant losses in productivity can occur is downtime on site due to unforeseen problems (Garza and Howitt, 1998). The opportunity for ICT- based mobile technologies to provide immediate access, from the point-of-activity, to the personnel

which may be able to resolve the problem has provided opportunity for an ongoing subject of research in the industry (Bowden, 2005).

2.5.2 ICT- based communication and project management systems in construction.

Notwithstanding the adversarial nature of the construction environment, a number of different ICT- based project management and mobile communication systems have proven their value to the implementing companies in the construction industry. This includes standardization, work coordination and streamlining work process, information sharing, sales and marketing, and logistics (e-Business MarketWatch, 2005).

According to the e-Business Market Watch (2005), ICT solutions for Project management, planning and resource management with special relevance for construction companies are reflected in the use of:

- Mobile devices (Mobile Computing) on site with online access to e-ordering systems, time registration, stock-holding status, delivery times and logistical coordination, etc. Mobile devices allow for more efficient communication and coordination across large geographical distances

- Tools for project planning, evaluation, quality control and process simulation. For example, a comprehensive and specialized project management system can allows companies to plan and schedule operations and deliverables and thus avoid major disruptions in work processes.

- Integrated financial solutions and calculation programmes for cost and resource consumption. For example, a financial system integrated into the project management solution that increases efficiency and eliminates redundancy and waste, as it allows companies to precisely identify where costs are being incurred throughout the enterprise. Further, it allows a company to track cash flow and costs against the project budget, view forecasts and actual amounts – in real time – to proactively manage project costs and respond promptly to changing conditions.

- 3-D modular-based design systems with attached digital information for all stages of theconstruction process and visualisation of all construction work. This technology allows for better communication between, e.g. construction companies and private customers about expectations for final buildings.

These resources have contributed in no small way to enable improvement in the business process of the construction sector.

2.5.3 ICT for Information and Business integration in construction

It is widely recognised that business and social trends are driving the construction industry through a period of radical change. Indeed in the face of increasing challenges to reduce project cost coupled with the increasing technical complexity of projects; all create a demand for the integration of construction project information (Brown *et al*, 1996).

Integration refers to data integration, applications integration and software products that provide integration frameworks and associated tools. Internal integration enables the sharing of data and business functions across applications internally in a company(Ramboll, 2008).

Historically, ICT business applications have been narrowly focused and task-oriented, simplifying business activities and processes such as document handling, order registration, and resource and production planning. Such applications have improved productivity dramatically but also fragmented. Construction companies face the same trends towards streamlining and integrating business processes in a competitive market as companies in many other sectors (Kalakota and Robinson, 2000).

In recent years, companies in the construction sector have become more aware of the importance of system and business process integration. Integration has become more popular, especially in larger enterprises, where most traditional applications were custom-built to address a specific business need (e-Business Market Watch, 2005b).

As enterprises grow, and the need to share information across departments and business areas becomes more critical, companies are turning to integration to provide a method for interconnecting these widely distributed and often proprietary systems. Information integration through the use of ICT can help to reduce the volume of information processed and reduce data re-entry by transferring information through internet/intranet protocols. This can provide benefits throughout project phases such as design, construction, and operation (Sriprasert and Dawood, 2002).

For instance, standards such as Industry Foundation Class (IFC) and Extensible Markup Language (XML) were developed to facilitate information integration and assist construction information exchange (Behrman, 2002). XML is a language that uses standard information exchange to enable different software applications to transfer and exchange information (Doherty, 2004).

The Industry Foundation Classes (IFCs) are: "data elements that represent the parts of buildings, or elements of the process, and contain the relevant information about those parts. IFCs are used by computer applications to assemble a computer readable model of the facility that contains all the information of the parts and their relationships to be shared among project participants"(Peansupap,2004). It attempt to develop a standard product model of construction object so that software application can integrate and share information about these objects throughout the construction project life cycle (Peansupap,2004)

Although it has already been alluded elsewhere in the discussion that, the adoption of ICT is generally low in the construction sector, there are large numbers of enterprises (varying in size, complexity and types of business operations) for whom a stronger focus on integration could prove valuable in order to realise the full potential of their ICT investments (European Commission, 2004A).

The impact of successful integration through ICT according to e-business watch(2005) involves:

- Improves data and information flows within the company, allowing instant access to critical data and constituting a solid platform for strategic decisions.

- Integration between vendor management systems, e-procurement systems and design and
- Planning tools supports coordination between stockholdings, requirements and materials or component needs.
- Integrated systems for resource management, logistical planning and project planning support efficient use of human resources, machinery, materials and transport facilities.
- Access to real-time information from integrated project management systems, calendarsand vendor management systems support realistic time and cost calculations when negotiating a new project or preparing a public tendering.
- A knowledge management system integrated with Customer Relations Management (CRM) and project management tools allows the company to respond quickly to changes in the market, handle specific customer requests and evaluate project runs and recurring problems.
- Time and cost savings as a result of a limited need to manually re-enter data into multiple systems.
- Integration solutions enable companies to create a "single view" of all their enterprise data and an infrastructure for ensuring that applications can exchange and update business-critical data no matter where it resides.
- Cost savings due to streamlined business processes and increased efficiency.
- Cost containment by allowing organisations to continue to use the data and functionality embodied in their existing applications instead of "ripping and replacing" legacy systems.

- Forward-looking benefits: organisations can gain an instant, real-time view of all their data and operations, which can lead to better decision making.
- Flexibility to quickly adapt business processes to accommodate growth and meet new business challenges as they arise.

Notwithstanding this unique contribution however, improved integration of ICT systems is complicated by a number of obstacles caused by internal and external circumstances. As most companies in the construction sector are rather small, most practitioners are affected by general barriers such as lack of competencies and lack of technical expertise.

2.5.5 ICT for external collaboration, communication and Knowledge management

It is notable that, the project-based construction sector brings together many different peoples, organisations and operations to achieve a desired goal. Consequently, cooperation, coordination and information sharing between these stakeholders are critical to effective project and resource management(Roadcon, 2003).

Clearly, digital compatibility with external partners can play a defining role in facilitating external collaborative processes and cooperation (Hassan et al, 2005).

According to Saxon (2003), ICT enabled collaborative working is a prime tool for driving a revolution in the construction industry. Similarly, it confirmed that, ICT can be used as the enabler of Collaboration and Knowledge Management - through the establishment and use of Knowledge Discovery in Databases, Knowledge Management Systems, Knowledge Warehouses, Enterprise Planning and Management Systems,

Decision Support Systems, Virtual Engineering Teams, Groupware Applications, Object Oriented CAD(Sarshar and Isikdag, 2004).

At the pivot of this important aspect is that, ICT can be used to facilitate information exchange between project team members and supports accuracy, effectiveness and timing. According to recent studies, interaction between digital systems to support cooperation and collaborative processes is likely to become a key factor for reducing costs in the construction industry (e-Business Watch, 2004).

Moreover, ICT innovations such as groupware and collaborative software have been identified as offering an important tool for communicating, transferring and coordinating among teams (Tam, 1999). This is considered to be an important factor for project success (Peansupap, 2004).

Over the past two decades, the number and availability of hardware and software programmes to enhance communications have steadily increased, and more professionals involved in construction projects are introducing collaborative software solutions to support their specific operation (Peansupap, 2004).

Collaborative software supports project management and improves productivity through effective online document handling, workflow coordination, drawing mark-ups and knowledge management. One of such ICT tools is known as Electronic Document Management Systems (EDMS) which provide an essential way to manage and enhance communication (Bjork, 2002). EDMS allow precise delivery of document and information to the right person in time and can reduce waiting time within any decision making process (Peansupap, 2004).

Furthermore, it is worth noting that, ICT-enabled cooperation and collaboration offer various potential benefits, depending on issues such as the complexity, numbers of external relations including partnerships and type of shared information. This is possible through a number of ICT solutions which are in the form of seamless and fluid data exchange and online access for all relevant agents attached to a construction project (e-*Business,* 2005). Some of these ICT solutions include;

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- **Virtual project fora /Teleconferencing**to enhance communication between parties involved in construction projects. A virtual project forum constitutes an online organisational frame that helps to coordinate and manage a project and contains all associated information. It serves as a databank and makes all relevant information accessible to organisations participating in the construction project
- **3-D modeling technologies** to improve, for example Business to Consumer communication. These technologies provide instant information exchange between all involved parties in case of changes. Research points to the importance of reducing discrepancies in the construction process between clients' expectations and contractors and designers' interpretations of clients' wishes (European Commission, 2004B)

- **Mobile online devices**to facilitate data transfer between construction project participants. With access to a virtual project forum, the devices allow operators to request drawings, communicate with other stakeholders or calculate the consequences of construction changes.

- **Online construction** project monitoring in virtual groups and electronic calls for

tendersand biddings to promote ICT usage in B2A (Business to Administration) co-operation (European Commission, 2004A)

- **Business to Business communication** in the construction process to enable quicker data transfer, advanced visualization and faster alterations during the construction planning process.

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However, the implementation of collaborative software or ICT-based solutions to support cooperation does not come without its challenges. The complex coordination of numerous players including architects, engineers, project managers, general contractors and sub-contractors constitutes a particular challenge in the construction industry(Peansupap and Walker, 2005).

This process undoubtedly underscores the importance of interoperability of the companies' ICT systems which defines their ability to manage and communicate electronic product and project data between collaborating firms and within individual companies design, construction, and maintenance and business process systems.

2.5.6 ICT for e-procurement and e-commerce in construction.

One more positive note about Information and Communication Technologies is that the technology can be used as a tool to enhance electronic procurement in the construction sector (Sarshar and Isikdag, 2004). This aims to overcome the administrative and communication problems with the many millions of trading documents (such as invoices, tenders and orders) currently exchanged on paper in the construction industry.

Electronic procurement in construction can be classified into electronic Tendering (e-tendering) and electronic purchasing (e-purchasing). E-tendering is the use of electronic

means throughout the tendering processes, i.e. finding and selecting bidders or suppliers of supplies, works or services while E-purchasing is the use of electronic means in the process of purchasing goods, works, services and utilities. This includes the processes from finding a product to invoicing and payment(Peansupap, 2004). Thus, purchasing includes not only the process of ordering, but also the final stages of the procurement process payment (E-Business Market Watch, 2005).

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Both e-tendering and e-purchasing can be conducted by a number of different methods. Online identification of suppliers can, for example, be done via different means such as internet search engines (ww.google.com), e-market places or links from other websites such as websites of business associations(Peansupap, 2004).

E-purchasing is often used to support a reorganization of the procurement workflow. It can be a tool to implement a streamlined workflow in a procurement department by the following steps: issue tenders, select the best suppliers/contractors, sign framework contracts centrally and reduce order number. The expected outcome of this process is a reduction of the number of suppliers, better framework contracts and a better quality/price relation (E-Business Market Watch, 2005).

E-tendering facilitates the access to construction companies of prior notices and publications of tenders in their own and in other countries, enabling them to place bids on projects internationally. Specialized e-marketplaces, e-portals and search machines pinpoint potential customers, vendors and public tender competition, supporting a wider market perspective among companies. E-procurement therefore, can have an impact on

the creation of a market for construction materials and construction services (Alshawi and Ingirige, 2002).

The right implementation of e-procurement systems can increase transparency and access to tender notices. For instance, during the invitation for the bidding period, ICT innovation tools can be useful for publishing the bidding information on a website which can save printing and advertizing cost. It can provide wider opportunity for changing the current pool of available bidders leading to better competition with resulting competitive price and or condition for the building owner. It saves administrative and travelling cost as process performed electronically (Alshawi and Ingirige, 2002).

Another area of using ICT to support e-procurement is the development of web-based construction contractor register (Nget al, 2003). Where the system allows contractors to submit their information for performance evaluation through a wed like prequalification system and this help authorized client to assess real time contractor information.

Based on the above, e-procurement seems to be of particular benefit for construction companies, which use the new procurement tools to support their own procurement operation, and thereby decrease the purchase price of construction materials and make the procurement workflow more efficient.

2.6 ICT tools and applications in the construction sector

Having discussed current roles and drivers for implementing ICT in the construction industry, it is now prudent to look at some of the important ICT tools and applications being used by the construction sector.

As Hore (2006) hinted, Information and Communication Technology (ICT) should support the entire construction process of construction from inception through to the operational maintenance of the building asset. This involves using ICT tools and technology to create, communicate and exchange information and data among the various participants in the project team. Again project models that supports improved co-ordination and management of information throughout the project life cycle has gained increased recognition and that, contractors among the building team can also use ICT throughout the entire process of their operations(Sarshar, 2003).

Generally the use of ICT on a construction project can be classified into communication systems and technical decision support systems (Farag et al, 2009).

Quoting from Doherty (1997), Farag et al (2009) insisted that, the communication domain involves all the common means of communication which are now computerized, while the technical decision support domain involves other computer applications other than for communications.

Drawing from this, the following section discusses key ICT tools and applications for the construction sector.

2.6.1 Electronic Communication and Data exchange systems in construction

According to Harris and McCaffer (2001), the most significant impact that ICT has had on management of information resources in construction is perhaps in the area of communication.

Computers and web-based technology has offered the potential for great advances in transferring information accurately and quickly, and in some instances, approaching the goal of real time information flows (Marosszeky, 2002). Indeed, this has made the use of the Internet and computer-aided communication very essential for closer collaboration among construction project partners. Traditional forms of communication in organizations are carried out through face-to-face interaction; paper-based drawings, letters and graphics; through telephone calls.

Today, the use of electronic communication is doing similar thing through electronic formats. Electronic communication (e-communication) is a system used as a means of sending or retrieving messages through computers or Internet connections. Nowadays, this includes a multitude of communication tools, ranging from simple forms such as e-mails to more complex forms, such as electronic document management (EDM) systems, enterprise resource planning (ERP) systems and project planning systems (ensgbo and magsood ,2007).

The introduction of different e-communication tools may alter the firm operations, providing firms with innovate venues for impacting their management processes. The communication processes (i. e. exchange of information) can occur either internally or externally to the firm. Intra-organizational e-communication is in its simplest mode mere electronic mails via internet, while more enhanced e-communications over Intranet

or local networks can be streamed either in different forms: text, audio and/or visual. Other applications and interface with external parties also comes in the forms of Extranets, Electronic Data Interchange (EDI), e-commerce, electronic document management systems (EDMs) provides support for procurement and collaboration.

According to engsbo et al (2007),the advantages of using electronic communication includes decrease in the cost of communication as compared to traditional means (e. g. distribution of paper copies vs. attaching a file to an email), rapid increase in the speed of communication (e. g. time for an electronic message to arrive compared to a snail mail delivery), and the technologies involved in bringing e-communications are becoming ever more versatile (e. g. both video-conferencing and textual communication simultaneously). However, some disadvantages such as lacking interpersonal exchange and legal implications (e. g. validity of a signed paper compared to one sent by e-mail) are still issues with electronic communication.

The following highlights some of the communication and Data exchange tool in the construction industry.

2.6.1.1 Project Extranets or Project Specific Web Sites

Project extranets or Project Specific Web Sites are web based applications for providing collaboration through ICT investment platform to perform typical project management tasks such as storing and managing project information (Becerik 2004). It is a network that uses Internet protocols and public telecommunication system for communicating both privately and selectively with the contractor's client and business partners. Other terms and acronyms used to describe the same collaboration platform include Web Based Project Management Systems (WPMS) and On-Line Project Management (OPM)

(Colwell, 2008). Project owners, designers, contractors and suppliers can share information and in so doing improving communication, coordination and collaboration. The technology may also allow for instance, contractors to securely share part of its company information resources with suppliers, subcontractors, project partners, clients or other companies(Bowden, 2005).

Typical features include document control (including version control), task automation, file and workflow tracking, electronic design review and file viewing capabilities. Typical documents include drawings, specifications, reports and schedules. Up to date information is available to everyone on the team. Portal access by contractors, subcontractors and suppliers will reduce costs through access to information (Colwell, 2008)

2.6.1.2 The internet and Electronic mails (e-mail)

The Internet has been embraced by the construction companies because it could be used as an efficient tool for communication to bring together the widely dispersed project participants and multinational project teams. The value of the internet to construction companies is mainly derived from its ability to easily connect globally to a vast amount of data which would have otherwise taken much money and time(Tam, 1999)

The main uses of the internet include information sharing, interactions and communications. Electronic mail (e-mail) is perhaps, the most popular use of the internet. Messages and project documents as attached files can be sent by electronic mails to members of a project team at different locations an come with distinct

advantage of speed. By this, details of work sections for instance, can be exchanged between architect and contractor(Harris and McCaffer 2001).

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2.6.1.3 Teleconferencing

Teleconferencing is a technology that allows a group of people to confer simultaneously from different location. Communications within this technology can be in the form of texts, audio and visual formats through the use of computer systems. In the construction industry, use of teleconferencing can allow all parts of a construction project/ projects can become one community to allow for an improved and effective administration. Examples of this form of teleconferencing include Data conferencing and Video conferencing.

Data conferencing allow interaction between parties to confer over text and graphic document only. For instance, designers located in different geographical regions can work on the same drawings simultaneously.

Video conferencing is a communication technology that permits users at two or more different locations to interact by creating a face-to-face meeting environment. This interactive tool incorporates audio, video, computing, and communications technologies to allow people in different locations to electronically collaborate face-to-face, in real time, and share all types of information including data, documents, sound and picture. In essence videoconferencing removes the barrier of distance that separates us. In the construction industry specific applications may includes Executive/Board/ Shareholder

meetings, Team Meetings, Job Training, CAD/Map/Blueprint Reviews, and Collaborative Planning etc.

2.6.1.4 Intranet

Intranets are communication infrastructure that is based on communication and content standards of the internet. With intranet, access to information is restricted only to the construction company's personnel. Construction companies can set up an intranet to allow project managers to access data from both central data banks and different projects(Hore and West, 2005).

2.6.1.5 Electronic Data Interchange (EDI).

Admittedly, construction projects always involve the collaboration of a multi-disciplinary project team located in different parts of a country. Some may be resident on site, others located in an office. The advent of the Internet has greatly enhanced the operational scope of collaboration tools. One example is the application of Electronic Data Interchange (EDI). Electronic Data Interchange (EDI) is the exchange of structured data according to agreed message standards between computer systems(Harris and McCaffer 2001)..

These data transfer is achieved by electronic means without human intervention. Indications are that, Electronic Data Interchange (EDI) has also become a preferred way of compressing and transmitting data between a buying firm and its suppliers in many sectors. Example of EDI application in the construction includes procurement of

materials or other project procedures that employ document type processing such as invoices(Peansupapp, 2004).

2.6.2 Information Systems and Applications

Information systems or software applications are available to support most aspect of a construction project. The improvements of software have increased the possibilities to integrate project information across disciplines and phases to create efficient work processes between the disciplines(Hore, 2006)..

. Today, practically all project information is entered into some software or generated by computer programs and is represented in the many different formats used by the many disciplines involved in a project (Fischer and Kunz, 2004).

For instance, many construction companies use information systems (or software) such as accounting systems (including payroll), project management systems and communication tools such as Internet and email to support their operations(Hore, 2006).. There are other numerous software packages available to complement the working process of the construction industry in varied fields including Architectural Design, Civil Engineering Design and Specifications, Financial Management, Marketing, Contracts, Project Management, Procurement, Quantity Surveying, Site Management, and Valuation etc. Many these applications exist already and can be bought as complete solutions(Hore, 2006).

Again, Sun and Howard (2004) grouped these software applications into the following categories:

- Business and information management
- Computer aided design and visualization
- Computer aided estimating
- Planning, scheduling and site management
- Building Engineering applications
- Computer aided facilities management

The following discusses some of these applications that can support typical activities of a construction firms in details.

2.6.2.1 Administration, Business and information management systems

The construction process is information intensive with a large volume of information generated and consumed by all participants involved. Applications such as Microsoft Office suite is the most widely known commercially available integrated software for general office administration(Doherty,1997).

According to Goh (2005), the common types of software used in construction include word processing and spreadsheet. These softwares are used for administration, communication, marketing, desktop publishing, presentation and project management (Doherty, 1997; Arif and Karam, 2001).

Again, Samuelsson (2002 observed that most computer applications still consist of word processors, spreadsheets, accounts and administrative software. Book-keeping and invoicing are the most common ICT applications in the construction industry of even the most relatively advanced countries in the world (Samuelsson 2002).

Typically, information in construction may include for instance, site surveys, design drawings, cost analysis, documents, correspondence, etc. The use of electronic options to manage such project documentation is growing as a result of ICT. Electronic Document Management (EDM) software can create an environment, within which these forms of information can be linked together, in the context of a project or organisation, to achieve easy access and control. Electronic Document Management softwares (EDMS) provide a combined set of tools for full organisation of all aspect relating to project documents. These systems cover the control of document creation, revision, distribution, storage and retrieval throughout and beyond the project lifecycle(Hore, 2006).

In recent years, there is an increasing awareness of the need for integrated construction process and many researches have investigated related issues. As a result, need for greater integration of business departments is leading to the use Enterprise Resource Planning (ERP) software to link the various facets of an organisation, such as, purchasing, accounts, planning, estimating, plant, salaries, human resources, contracts, marketing (Hore and West ,2005).

2.6.2.2 Computer Aided Design and Visualization systems

Computer Aided Design (CAD) software is widely used by design professionals in both the consulting and contractor organisation, with AutoCAD having the largest share of the CAD market (Howard, 1998).

Other popular CAD packages include Micro station, ArchiCAD, MiniCAD, FastCAD, etc. Indeed, these CAD programmes have replaced the traditional drawing board in the production of design information. 2D CAD systems have dramatically improved the drawing process. 3D modelling can enable designers to investigate the buildings internal spatial system and its relationship with the surrounding environment (Ozumba andShakantu ,2008).

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These have developed rapidly from simple two-dimensional (2D) computer graphics representation (2D CAD), through three-dimensional (3D) computer aided design (CAD) and graphics to four-dimensional CAD (4D CAD). Adding the element of time to 3D virtual environment had created 4D CAD applications with which time passage in projects are simulated and visualised, enabling more efficient planning scheduling. It also enables updating according to progress of work (Wang et al, 2007).

Experience of virtual worlds, and interaction with 3D CAD models in virtual environments, simulating and visualising passage of time and its implications on cybernetic versions of our real world data in 4D CAD have become regular applications in many fields of work today (Ozumba and Shakantu ,2008).

Through ICT, visualization and animation systems, like 3D Studio, Graphisoft, Revitt and ArchiCAD, can produce photo-realistic, static and moving images so that clients can view the final appearance of the building at the design stage. Virtual Reality (VR) technically now allows the user to integrate with the design model and experience the building in simulated reality situations(Hore 2006).

Similarly, Building Information Modelling (BIM) is an innovative new approach to building, design, construction and management. BIM keeps critical design information

in digital forms making it easier to update and share design information. It also creates real-time, consistent relationships between digital design data with the use of innovative parametric modelling technology techniques. Autodesk Architectural Desktop and Autodesk Building Systems are examples of software currently available (Hore 2006).

2.6.2.3 Computer aided estimating systems

Controlling costs is one of the most important requirements during a construction project. To achieve this, contractors and subcontractors must first produce an accurate cost estimate to establish their tender price. Today, there are sophisticated computer software packages such as Esti-mate, Manifest, Resource cost Sheet, WinSmesta which allow project managers to assist in the production of project cost estimates and keep track of project spending(Oladapo 2005).

Many of these programmes can also assist in the quantity take-off in the production of bills of quantities. Examples of such software include, Buildsoft, Masterbill, Manifest CATOPro, WinQS , Snape Vector etc (Hore ,2006; Oladapo, 2005).

Today, most modern cost estimation programs can be integrated with CAD programs and linked data for labour, materials and plant. The advantage is that, cost data does not need to be re-entered thus improving the speed of estimating and avoiding errors.

2.6.2.4 Site management tools, planning and scheduling systems

The production environment of the construction site involves a very tight time schedule with the full attention to planning, coordination and completion of the building activities. Improving information and communication support for the core activities at

construction sites is a strategic challenge for the construction industry to increase efficiency and productivity in the construction process (Samuelson, 2003).

As noted by Sørensen et al (2008), ICT systems that support on-site working practice must:

1. Enable the contractor to easy monitor and present project progress,
2. Enable object oriented quality assurance,
3. Support a wide range of user environments ranging from mobile phones to large displays for presentation and editing data shared in virtual model resources,
4. Enable real-time tracking and location (by GPS) of machines and materials,
5. Capture data to be used for work process optimization, and
6. Predict constructability problems before they cause trouble at the construction site.

In recognition of the above, the following discusses some of the key ICT systems and tools for site management

2.6.2.4.1 Planning and scheduling systems

Project Management software applications include portfolio management, planning and scheduling, resource management, budgeting and cost control, contract management and issue and risk management (Colwel, 2008). Portfolio management assists companies in identifying, evaluating, selecting and implementing the right projects. Planning and scheduling software identifies work packages, their interdependencies, required resource effort and work package durations. By inputting cost data, cash flow projections can be prepared(Moniem, 2000;Colwel, 2008).

Monitoring progress using earned value techniques can provide key performance indicators of cost and schedule at completion. Risk impact can also be modeled and analyzed providing data on a range of mitigation scenarios. Apart from the widespread use of planning packages such as, Microsoft Project, there are solutions from Primavera, Power Project, PMSystems, COINS and growing interest in web-based collaboration tools(Colwel, 2008).

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2.6.2.4.2 Mobile computing.

Electronic mobile communication usually involves three features; mobile device, mobile networks and mobile services (Rebolj, 2002). Some notable attempt to integrate these features has accelerated development of mobile computing in construction. Mobile devices range from Laptop computers, Notebooks, Personal Digital Assistants (PDA), Portable Data terminals (PDT), Tablet personal computers, to Smart phones (Ozumba et al,2008).

Full blown application software such as Microsoft Windows are available in some of these devices. Hence , activities such as material management; timekeeping, safety auditing, e-mail, web conferencing, daily field reports, drawing retrieval and viewing are typical construction site applications ICT with a unique advantage of providing mobility (Colwel, 2008). Also, technologies such as GPS, GPRS and Wireless Local Area Network (WLAN) can be integrated to improve construction site's mobility. Characteristically, many of these technologies are already implemented into mobile devices, to make it easy to take them into use. For instance, with GPS one can locate equipment, or mobile worksites such as road construction etc. WLAN, on the other

hand, can be used especially at remote construction sites to obtain wireless internet and maintain easy communication (Leskinen, 2008).

The developments in this technology have led to the amalgamation of mobile computing devices and mobile communications protocols with integrated mobile connectivity or via a separate mobile phone, through either a wired or wireless connection such as Bluetooth. This provides the mobile user with the ability to upload and download data from anywhere that a mobile signal is provided(Colwel, 2008).

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2.6.2.4.3 Automatic identification

Automatic identification involves technologies such as barcodes and RFID (Radio Frequency Identification) tags. Barcode readers (optical scanners) interpret data stored in the width and spacing of printed parallel lines. Barcodes have been used successfully on pipeline projects formaterial tracking (Pryor, 2001).

When used in conjunction with GPS (Geographic Positioning System), barcodes can keep track of weld locations, identification numbers and pipe material. However, as a result of barcode limitations such as line of sight, durability, range, data volume can only be read one at a time and the introduction of RFID attempts to overcome some of these shortfalls (Ardagh, 2007).

RFID provides a wireless means of communication between system components that include a tag (transponder), a reader and IT infrastructure (network, hardware and software). Unfortunately, the technical feasibility and benefits of RFID in a construction environment remain unproven, indications are that the technology is becoming main-stream and has a lot of potential in the construction industry(Colwel, 2008).

According to Hore and West (2005), building materials account for up to 50% of all construction costs and in the field of business to business (B2B) interactions, there is a huge untapped potential for productivity gains. In this regard, Automatic Identification (Auto-I) and bar coding when assume widespread within the construction industry could resolve some of these challenges.

Besides, field material control, warehouse inventory, tool and consumable material issue are obvious construction applications. In recent times, construction tool manufacturers are building RFID chips into their tools to help prevent theft and loss. Although, RFID technology is today mature enough for practical implementation in construction, a wider introduction by the industry is still to come (Sørensen et al., 2008).

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2.7 Implementating ict in the construction industry

Appropriate implementation of information technologies is a key focus area that must be addressed by the construction industry. The uniqueness of the construction industry poses challenges to the implementation of automation and ICT technologies. In the face of these challenges however, there are several factors indicating that the nature of the construction industry is changing(Çaglar ,2005).

These factors include:

- An extensive lack of skilled workers and a growing average age of the staff;
- An inability to attract and retain talented, educated personnel;
- Increased industry competition;
- A need for works in dangerous and inaccessible areas of operation;

- Increased requirements on the quality of the work execution; and
- An increase in performance and reduction in costs is required to maintain a competitiveadvantage (Perkinson and Ahmad, 2006).

In addition to the above listed industry changes, owner organizations are beginning to demand access to real-time data for their own automated site inspections and these owners expect this access to be available at all times. This has put increased pressure on contractor organizations to embrace new technologies in order to remain competitive and satisfy these changing owner demands (Perkinson and Ahmad, 2006).

Indeed the reality is that, many construction organizations have already begun implementing some form of automation and/or ICT or are considering doing so in the near future. Then again, this create the need for players in the industry to consider expanding their technology programs to include ICT technologies which will utilize real-time data including those collected onsite to improve management and decision making functions (Hampton, 2005). According to Perkinson 2006, a construction contractor can increase his competitive advantage by integrating the automation and ICT technologies thereby creating a total jobsite management tool capable of analyzing the construction project in the areas of:

1) Project performance control,
2) Materials and equipment management, and
3) Human resource management.

Furthermore, some notable potential advantages of integrating automation and ICT for use as a total jobsite management tool may include:

- Real-time monitoring and documenting of construction operations,
- Reduced paperwork,
- Improved project management capabilities in terms of tracking people, equipment, and assets,
- Early detection and fast response time to problems,
- Standardization of data collection and management,
- More accurate performance data which can be used for planning of future projects,
- Creation of a history or baseline for dispute resolution, and
- Reduced contractor reporting requirements because the owner/engineer can continuously observe what is happening onsite.(Perkinson 2006)

In effect however, it seems the traditional manual processes are still being applied for management and decision making purposes. As such, most data produced in the field is oftentimes not recorded and not converted into meaningful information(Ligier, 2001).

2.7.1 Factors affecting the use of ict in construction

Information and communication Technology is an area where increased investment is necessary in order to remain competitive in the market, increase efficiency, reduce timescales and cost, and raise the entry level for a contracting business. Notwithstanding the apparent advantages ICT offers it is commonplace today that the building construction industry invests little in ICTs and is generally slow to exploit their potential compared with the other sectors such as financial services and manufacturing industries (Egbu and Botterill, 2002). This slow ICT uptake can be explained as being a function of:

- The complex nature of the construction industry;
- ICT Immaturity levels;
- Financial constraints;
- Poor availability of tools for evaluating benefits of using ICT; and
- A lack of understanding of the ICT implementation process

In recognition of these effects, Çaglar (2005) indicated that, ICT deployment in the construction industry depends on the following key factors.

- Value of the project
- Technological capability of the parties
- Use of ICT in past projects – previous experience
- Client demands
- Number of parties – greater number and diversity should lead to greater use
- Desire for better and faster communication
- Partnering and desire for better collaboration
- Information overload and desire to reduce the paper mountain
- Wish for greater transparency

Beyond that, levels of competition and changing trends in technology have been identified as among important factors influencing adoption of ICT (Oladapo, 2006, Peansupap and Walker, 2005). Again, Thon and Yap 1995 also concluded that, companies with innovative CEOs had more positive attitude towards ICT use.

2.7.2 Barriers to implementing ICT by contractors

According Gyampoh-Vidogah et al (2003), most problems with information management in companies are due to the slow and cumbersome information

management processes, the lack of a policy on information management in companies, cultural issues and barriers to the adoption of Information Technology (IT).

One reason for the difficulty of implementing ICT is the misalignment of current organizational structures and cultures with ICT models for integrated and collaborative work environments. This is because, the construction industry is largely decentralized and composed of separate organizations, which must participate together on a project by project basis. The multi-participant, multi-organizational framework is a significant barrier to implementing ICT in the industry (Young and Davis, 2001).

According to the Roadcon Project (2003), different barriers have in the past restrained the take up and advanced use of different ICT tools and that, these barriers need to be overcome for the industry to progress further in the exploitation of ICTs to support its business activities.

To this effect, some the notable barriers such as lack of a coherent ICT strategy, Low ICT competencies and lack of resources especially in SMEs, reactive approach to ICT investment, differing demands from customers for systems and functionalities, switching costs related to replacing old systems with new integrated solutions has been cited. Furthermore, some studies has also identified various factors that explain the reluctance of the construction industry to adopt and use ICTs (Rivard, 2000).

According to Acar et al (2005), three of these factors best characterize the overall attitude of construction firms towards ICTs. He observed that apart from technical and financial problems (e.g. continuous demand for upgrading and high investment costs); cultural and psychological factors are increasingly receiving attention as barriers to the

widespread adoption of ICTs (Ba¨ckblom et al., 2003). Secondly, the fact that construction professionals are often satisfied with their traditional business methods and tools is a common barrier (Doherty, 1997; Samuelson, 2002). Thirdly, there is no single magic ICT solution for the whole construction market. The type of the ICT solution required by construction firms is likely to depend on the context of the work done (Egbu and Botterill, 2002).

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Concerning the last argument, Samuelson (2002) argues that the lack of effective applications for the core businesses of contractors might be one explanation for the low use of ICTs by contractors, when compared with other parties in the construction industry.Similarly, e-business Watch Report (2005) on the construction industry cited that, implementation of ICT collaborative systems is hampered by a number of barriers such as:

- Legal and contractual issues regarding for example data ownership and copyright holders, the legal validity of contracts, and digital signatures
- Oral culture and traditions where information is typically shared face-to-face
- Lack of shared standards for information exchange.
- Lack of financial resources, ICT competencies, and knowledge about the cost and financial benefits of ICT investments

Zeng et al (2007) categorized these into organizational structures, individual behaviors and the technical requirements of data in the industry as some of the barriers that hinders the flow of information among the participants in a construction project.

These barriers can be classified as follows;

Financial Barriers: General lack of finance, High cost of ICT investments, Maintenance cost, Budget constraints etc

Organizational Barriers: lack of business incentives, poor ICT strategies, lack of training, lack of appropriate ICT support.

People Barriers: lack of personal incentives, lack of education/training/continuous professional development, cultural issues, reluctance to changes in business processes. On the other hand, the importance given to ICT training, re-design of current processes and support from software vendors appeared as the most critical factors for successfully implementing ICT (Isikdag *et al.*, 2008).

Technology Barriers: difficulties in using new technologies, lack of support from ICT providers (or ICT department), incompatibility/interoperability problems: lack of (use of) standards, inefficient use of software, ill-defined processes and infrastructure related problems.

Legal Barriers: risks for liability, lack of legal support for use of ICT, security of ICT transactions, other issues for electronic information and documentation.

Summary

The presentation so far has discussed literature on major applications, importance and barriers to the use of ICT including a brief discussion on contractor organisations in the Ghanaian construction industry. Drawing from that, the next section will focus on the conceptual framework for the study based on contractor organisations and the research methodology adopted.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1Introduction

Following the review of literature presented in Chapter 2.0, this part now introduces and discusses the research framework and the methodology adopted for the study. A number of processes involved in this research are discussed. In concluding the chapter, a summary of the statistical technique used in analyzing the data is also presented.

3.2 Framework for the Study

A theoretical framework guides the research, determining what things are to be studied, and direction of the research within a boundary. The primary theoretical framework for this study has been discussed in the review of literature in chapter two. This gave an overview of the research in the area of information and communication technology applications in the construction industry. Following this, the conceptual frameworks were developed with the purpose to unravel part of the problems recognize in the literature review as referred in the research objectives. This employed a customized version of the IT – Barometer survey developed at KTH, Stockholm Sweden in autum, 1997. This initiative was aimed to create a method to perform a survey for measuring the use of IT in the construction industry (Samuelson, 1998b).

Subsequently, a number of surveys similar to or modified versions of the IT- Barometer have been carried out in different countries. Examples includes samuelson (1998);

samuelson, (2000) andsamuelson, (2002) in Sweden; Howard and Samuelson (1998) and (2002) in Denmark; Rivard (2000) in Canada; Lim et al (2002) in Malaysia; Sarshar and Isikdag,(2004) in Turkey; Goh (2005) in Singapore; Oladapo (2006) in Nigeria and Samuelson (2008) in Sweden and Finland.

Other surveys which concentrated more on a specific part of the construction industry have also been performed. For instance, Thomas et al. (2001) measured current state of IT usage by Australian subcontractors; Arif and Karam (2001) measured Architectural Practices and Their Use of IT in the Western Cape Province, South Africa; and Oyediran and Odusami studied computer usage by Quantity Surveyors in Nigeria.

3.3 Coverage of the IT barometer

The main topics included in the IT barometer survey are classified in the following way (Samuelson and Howard ,1998):

Type of company - this includes building owners and managers, architects, engineers, contractors, materials suppliers and craftspeople. Number of staff, location of offices, types of work, position of respondent.

Types and numbers of computers: Proportion of usage of different operating systems, past and future change in IT investment, types of general application such as office suites, planning, technical calculations and administration.

2. Softwares/ CAD: Types of software and number of licenses, applications for building and use of GIS, proportion of drawings produced with CAD, types of data structures used.

3. Level of use of IT: Proportion of tasks carried out by each application, types of document transferred digitally, numbers of staff having computers and training, levels of computer competence by different types of staff.

4. Communications: Use of local area and wide area networks, proportion of employees with access to communications, time spent on IT, WWW home pages and Intranets

5. Role of IT in the company: IT department, managers, handbook and strategy, attitudes of staff to IT, reasons for investment, changes resulting from IT use, productivity, future investment

6. Questions adapted to suit each country, e.g.: Awareness and use of research and standards, views on IT knowledge of newly qualified staff, ideas for areas in which research is needed.

In more recent surveys, other variables like barriers and benefits in the use of IT were included and measured (Oladepo, 2005; Samuelson, 2008).

For the purposes of this research, three major perspectives in line with the research objectives were adopted and applied to contractor organisations in Ghana. This covered the following;

ICT infrastructure:

This aspect dealt with firms ICT hardware platforms, softwares in use, operating systems, communication and network platforms and ICT workforce.

Level of ICT usage:

This aspect covered proportion of tasks carried out by computer in the firms; types of document transferred digitally and level of advanced ICT tools and applications in use.

Reasons hindering the use of ICT:

This part covered general issues relating to obstacles and barriers to the use of ICT. The review of literature in Chapter 2.0 identified twenty (20) criteria that could be applied as reasons hindering use of ICT by contractors. These were grouped under five major headings. This include: Financial Reasons, Human Reasons, Technical Reasons, Environmental Reasons and Legal Reasons.

Under financial reasons, general Lack of funding, Cost of ICT (cost of Hardware and software in market), Cost of training professionals in ICT, Limited benefits/Low return on investment in ICT and cost of employing ICT professionals were identified. Human reasons included- inadequate ICT content of construction education, lack of commitment by firm's management towards ICT, inadequate knowledge about return on ICT investment, lack of staff with appropriate skill and knowledge in ICT, fear of personnel abuse/ mistrust in ICT technology, fear of job losses /making professionals redundant, satisfaction with existing method of working, poor leadership and teamwork in the industry. The technical reasons identified rapid changes in ICT technologies, problem of ICT integration/ compatibility in the organization, software and hardware reliability problems, security concerns/ privacy fears, high rate of obsolescence ICT products in the Ghanaian market, lack of technical harmony with other firms, lack of integrated software solution for whole the industry, inadequate/erratic power supply in

the country, access to relatively cheap work force. With regards to environmental reasons issues identified were that majority of client not interested in firms ICT base, industry dominated by too many SME's, lack of adequate jobs in the market, susceptibility of industry to economic climate and complex, fragmented and project based nature of the industry. Finally, the legal reasons were risks for liability, lack of legal support for ICT and security implications of ICT transactions.

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3.4 Research strategy/Approach.

After a thorough review of relevant literature, a questionnaire survey was conducted to identify current level of usage of ICT by Ghanaian building contractors and the factors hindering the level of usage in their organizations. The survey utilized a structured questionnaire approach. Based on the fact that questionnaires are the simplest method to collect data from a huge number of respondents, a well-designed questionnaire that is used effectively can gather information on both the overall performance of the test system as well as information on specific components of the system (Aminudin, 2007). Besides, if questionnaires include demographic questions on the participants, they can be used to correlate performance and satisfaction with the test system among different groups of users. Survey questionnaires are categorized as quantitative research and this was preferred because, quantitative approaches are deemed more specific and result oriented; and involves the collection of numerical data in order to explain, predict, and/or control phenomena of interest (Mojaheed, 2005).

3.5 Research Design

The design of the research involved the following steps

- Questionnaire design
- Sampling technique/Sample Selection
- Determination of sample size
- Pilot Questionnaire
- Main Questionnaire administration
- Data Analysis tools

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3.5.1 The Questionnaire

Based upon a review of current literature and research objectives, structured questionnaire was prepared and self administered to the various respondents. Almost all the questionnaires have closed-ended questions to ensure consistency of respondent feedback. Because it is not entirely possible to design all questions as closed-ended, some questions were left open-ended, to obtain numerical data or to solicit some written comment.

For the purpose of the study, the questions were grouped under four main sections.

1) General Information;

2) ICT Infrastructure;

3) Extent of ICT usage and;

4) Factors hindering ICT usage.

The first section, "General Information" dealt with the demographics with respect to firm's financial class, years of experience in construction, professional background of respondents and general views on ICT. This aspect was deemed necessary in order to

ascertain the reliability and credibility of the data and as a result, be used to correlate performance and satisfaction with the test system among different groups of users.

The second section "ICT Infrastructure" asked more specific questions in relation to objective one of this study. This aspect covered firms ICT hardware platforms, software in use, operating systems, communication and network platforms and ICT workforce.

The third section "Extent of ICT usage" inquires about the level of ICT usage by the firms. This is in relation to proportion of tasks and activities carried out digitally or by the computer and usage ICT tools and applications within the construction firms. It employed the five point type Likert ordinal scale to measure level of usage by responding firms from "Never" to "Always". that is, 1= Never, 2= Not always, 3= Average, 4= Quiet always, 5= Always.

The fourth and the final section "Factors hindering ICT usage" asked responding firms to score identified reasons hindering the use of ICT by contractors in the construction industry. Based on the criteria identified, the Likert rating scale was again adopted to extract the appropriate ratings as per their influence as a reason hindering use of ICT by contractors in Ghana. Once more, the five point likert ordinal scale (1-5) was used where

1= Very weak, 2= Weak, 3= Average, 4= Strong, 5= Very strong.

3.5.2 Sampling Technique used

Chien (2010) citing Naoum (1998) indicated that there are two main criteria that need to be taken into account when selecting the research sample. First, what do you want to know? Second, about whom do you want to know it? Following these recommendations, the study adopted purposive sampling technique to select the

contractors and respondents. This was preferred because purposive sampling allows the researcher to select respondents who have good knowledge about the subject in question. Besides, looking at the nature of the industry, the study seeks to solicit information from a section of the population of contractors in Ghana who by virtue of their financial class and nature of works have the capacity and requisite personnel to invest and use ICT for their operations. This resulted in the selection of contractors in financial Class D1K1 and D2K2. Again, the identification of key respondent to the questionnaires was purposive. This was important because the study wanted to elicit views of respondents who have specific expertise and hence may require specific ICT software for their operations. It targeted professionals and managerial level personnel such as Project Managers, Architects, Quantity Surveyors, Engineers and IT managers working in contractor organizations in Ghana.

Again, the study focused on the most representative samples of the intended population obtains answers relevant to the study. This resulted in targeting contractors in Greater Accra and Ashanti Regions only. This is because, the distribution of these contractors in Ghana are largely biased towards the city capitals with more than 70% of the registered building contractors, particularly the large organisations, tend to operate officially in the Greater Accra region and Kumasi, whilst the remaining eight regional administrations put together account for the remaining 30%(Ayisi, 2000; Ahadze, 2007;Asah-Kissiedu, 2009).

3.5.3 The Sample Size

Israel (1992) cited several approaches used in determining the sample size for a study. These, include using a census for small populations, imitating a sample size of similar studies, using published tables, and lastly applying formulas to calculate a sample size. Due to difficulties encountered in obtaining accurate and reliable data on the population of contractors within the specified class, a total sample size of 100 was adopted and used for the study (Chien and Barthope, 2010). Again, a sample size of 100 agrees with Kish, (1965) formula.

Using Formula:

$$n = n^1/(1+n^1/N) \quad - \quad \text{(Kish, 1965)}$$

where n = Sample size

$n^1 = S^2/V^2$

N = Population size

V = Standard error of sampling distribution = 0.05

S^2 = P(1-P) = (0.5) (0.5)= 0.25

P = the proportion of standard deviation in the population element (total error = 0.1 at 95% confidence level.

Based on the above parameters, a sample size of 100 isalso adequate for larger populationsbecause as the population size (P) increases, the sample (n) size approaches one hundred (100).

TABLE 3.1: SAMPLE FRAME OF THE CONTRACTORS

CONTRACTORS	QUESTIONAIRES ALLOTED
D1K1	50
D2K2	50
TOTAL	**100**

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3.5.4 Pilot Questionnaire

Before the main survey was undertaken, a draft version of the questionnaire was piloted in two construction companies in Kumasi. This pilot study was intended to elicit responses that would help to test the wording of the questionnaire, identify ambiguous questions, and also provide an indication of the time to complete the questionnaire. Some of the comments and suggested amendments from the pilot study respondents were used to amend the questionnaire prior to its final distribution.

3.5.5 Main Questionnaire Administration;

The administration of the questionnaire began in February 2011 and completed in March, 2011. A period of four weeks was allowed for the administration of the questionnaire; however all the completed questionnaires were retrieved by the sixth week. A total of 100 questionnaires were administered to the contractors. Fifty (50) were targeted at D1K1 contractors and the other fifty at D2K2 contractors. A total of 28 respondents from D1K1 contractors and 23 from D2K2 contractors representing 51%

were retrieved. The total administered questionnaires and the return rate are shown in Table 3:2. The data obtained from the field survey were analyzed through a five-point Likert-type scale to measure a range of opinions from "Very weak" to "Very strong" and from "Never" to "Always" as used in the other studied areas.

TABLE 3.2 ***Detail of Questionnaires Administered and Returned***

	NO. SENT	NO.RETURNED	RESPONSE RATE (%)
CONTRACTORS	100	51	51

Source: Questionnaire Survey, February-March, 2011

3.6 DATA ANALYSIS TOOLS

Data collected from the questionnaires were analyzed using three methods. These include Frequency Analysis, Mean/average Index Score and One Sample T-test. In order to generate the result, the researcher used Microsoft Excel and SPSS

3.6.1 Frequency Analysis

Here, descriptive statistical methods such as tables, bar charts and pie charts were used to analyse the responses from the questionnaire.

3.6.2 Mean Score

This was used to generate ranking of the variables of interest based on the scores assigned by the respondents. The factors are then ranked according to the formula below using Excel

The mean score is calculated as follows.

Mean score (I) = $\frac{\Sigma a_1 x_1}{\Sigma x_i}$

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Where I=Mean Score, a=Rank of event i and x=frequency of event i

The formula is very popular with researchers in the construction management field (Egbu and Botterill, 2002;McCaffer and Edum-Fotwe, 2001).

With this formular, the events measured here include: Activities Computerized within the firms and their level of usage of advanced ICT applications.

3.6.3 One Sample T-Test

One sample t-test is a statistical procedure used to examine the mean difference between the sample and the known value of the population mean. The test normally compares the mean score of a sample to a known value which is usually the population mean. That is, the observed mean (from a single sample) is compared to an expected (or reference) mean of the population (e.g., some theoretical mean), and the variation in the population is estimated based on the variation in the observed sample. The procedure involves drawing a random sample from the population and then compares its mean with the population mean and make a statistical decision as to whether or not the sample mean is different from the population. . The *t-test* is the most commonly used method to evaluate

the differences in means between two groups. The test also uses the standard deviation of the sample to estimate (the population standard deviation). If the difference between the sample mean and the test mean is large relative to the variability of the sample mean, then is unlikely to be equal to the test mean.

3.7 Summary

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Indeed the chapter has comprehensively described the entire research design and the methodology for the study. Following this, the design of the survey instrument including the sampling frame, the sample size, techniques for eliciting the relevant data and how the data will be analysed have been described.The next chapter now discusses the analysis of the data and findings from the survey.

CHAPTER FOUR

DATAANALYSIS AND DISCUSSION

4.1 Introduction

This chapter presents data analysis and findings from the survey. It begins with descriptive analysis of the demographics variables of participating firms and respondents. This is followed by analysis of the firms ICT infrastructure platforms and current levels of ICT usage. Finally, the section discuses result from one sample T-test on identified factors hindering the use of ICT by Ghanaian contractors. The main statistical methods and tools used were Mean Score and the One Sample T-test. Data collected from the questionnaires were tabulated and analyzed according to their ranking on relative index. Bar chart and pie charts were created, where appropriate, in support of the descriptive analysis to clarify their status. Again, ratings by respondents on the firms' level of ICT usage and the factors hindering their use were also discussed.

4.2 The Survey Findings

4.2.1 Demographic variables and respondents profiles

With one hundred (100) questionnaires which were administered to the contractors, a total of 51 questionnaires were returned constituting 51% response rate. Table 4.1 below shows the breakdown of the number of response received from the selected organizations. From the survey results from Table 4.1, twenty eight (28) questionnaires out of 50 were received from D1K1 contractors and Twenty three (23) out of 50

received from D2K2 constituting 56% and 44% responses respectively. It is noticeable that, the gap between the responses from the two groups of contractors in the survey was not generally wide.

Table 4.1 ***Details of Response Rate***

CONTRACTORS	**NO. SENT**	**RECEIVED**	**RESPONSE RATE (%)**
D_1K_1	50	28	56
D_2K_2	50	23	46
TOTAL	**100**	**51**	**51**

Concerning the working experience of the companies surveyed, Fig.4.1 shows that 39.2% had worked as contractors in the construction industry for over 20 years, 25.5% between 16-20 years, 11.8% between 11-15 years, 13.8% between 6-10 years and 9.8% for less than 5 years. The high representation (76.5%) of firms with experience of over 10 years is significant to provide some understanding their ICT challenges over these past periods.

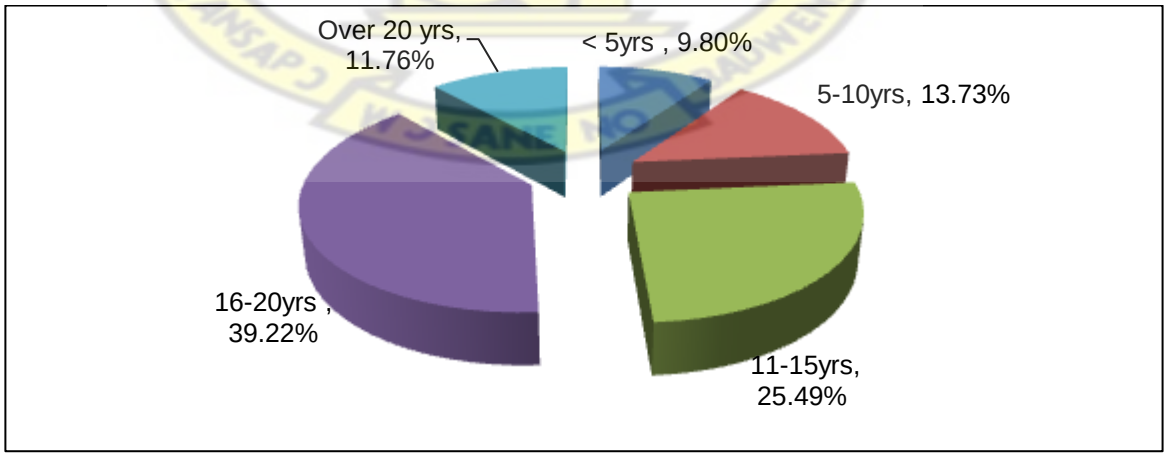

FIG. 4.1 Respondents profession

All the companies (100%) surveyed indicated that, they use computers to aid their operations. As much as 82.35% of the firms indicated they have access to computers and actually use them both at their offices and project sites while 17.65% indicated access and usage at their offices only.

Again, the data analysis revealed that varied professional backgrounds in the contractor's organisations were represented in the survey. According to Fig 4.2, the backgrounds of respondents comprised 6 Managing Directors (11.76%), 18 Project Managers (35.30%), 11 Quantity Surveyors (21.57%), 12 Engineers (23.53%), 2 Architects (3.92%) and 2 IT Managers (3.92%). The high representation of project managers, Engineers and Quantity Surveyors was inevitable as these are the very key professionals usually engaged by contractor organizations in Ghana. Of them, Fig.4.3 indicates that, the majority of 45.1% had experience of between 11-15 years in the construction industry. Over, 33% also indicated that, the have experience of between 5-10 years while about 12% had professional experience of between 16-20 years.

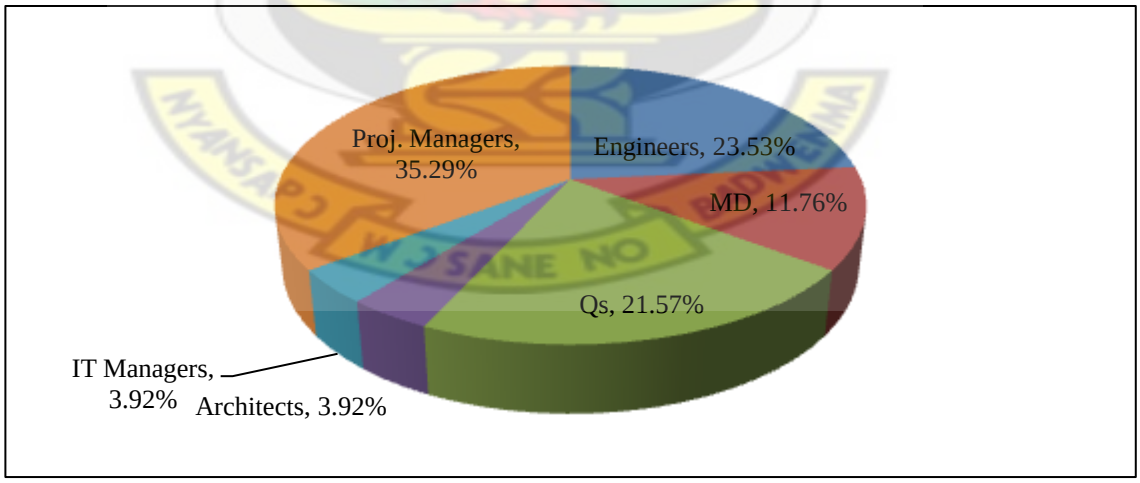

FIG 4.2 Respondents professional background

The minority representing (9.8%) had less than 5 years of experience. However, none of the respondents indicated professional experience of over 20 years.

Concerning respondent's years of computer literacy, the survey revealed that a majority constituting (66.7%) have been computer-literate for between 5-10 years, while only 19.6% have over 10 years of computer literacy and 13.7% had between 1-5 years of computer literacy. Again, the greater part of the respondents (54.9%) considered their levels of computer literacy as average while 33.3% saw their current computer literacy as above average. Not more than 12% of the respondents considered their literacy as below average.

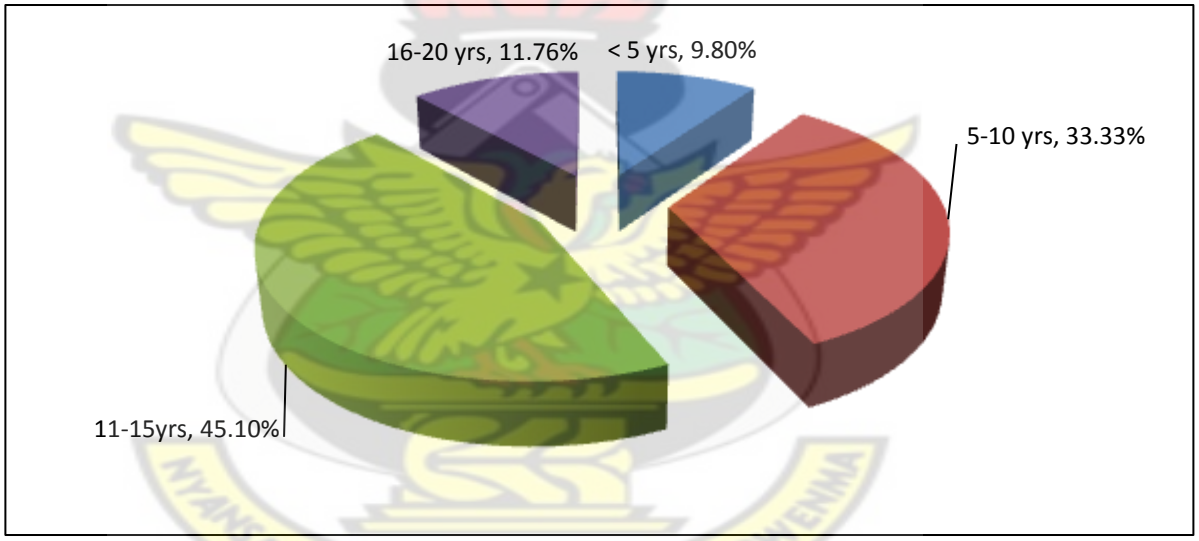

FIG. 4.3 Respondents level of experience

With the modes of acquisition of computer literacy by the respondents, the survey uncovered that about 60% literacy were acquired mainly through private lessons while a little over a quarter (25.49%) were self taught. The other modes of acquisition were those learnt from school (17.65%) and Continuous Professional Development, CPD (5.88%).

TABLE 4.2 ***Demographic Variables about firms and respondents***

YEARS OF COMPUTER LITERACY	**FREQUENCY**	**PERCENTAGE (%)**
Less than 1year	0	0
1-5 years	7	13.73
6-10 year	34	66.67
Over 10 years	10	19.60
TOTAL	**51**	**100**
MODE OF ACQUISITION OF LITERACY		
School	9	17.65
Private class	26	50.98
Self taught	13	25.49
CPD	3	5.88
TOTAL	**51**	**100**

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4.2.2 Views on current usage and perceived roles of ICT in firms

Part of the questionnaire sought respondent's perception on the role of ICT in their firms. From Fig.4.4 below, it can be deduced that the contractors' perceived role of ICT in their firm were mixed. It is however surprising to note that, the majority of the firms (37.25%) sees the role of ICT as supporting compared to a more strategic roles of value adding (33.3%) and critical (29.41%) (see Isigdad et al 2007)

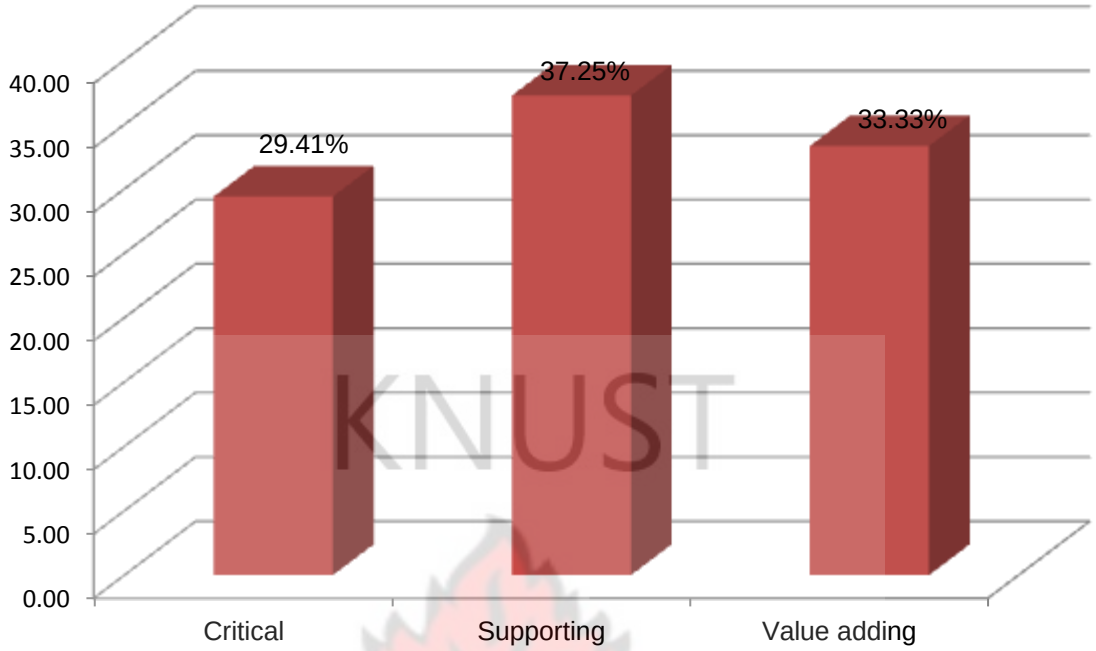

Figure 4.4 Perceived role of ICT

On the issue of respondents viewpoint on the extent of current usage of ICT in their firms, Table 4.3 shows a high percentage (64.71%) of respondents believe their current ICT usage is average while 31.37% considertheir ICT usage as low. Only 3.92% thought they are using ICT to a high extent in their company.

Given the perception of the respondents, there is some level of recognition that their current ICT usage appears ordinary suggesting some aspects for improvements.

Table 4.3Respondents views on the extent of ICT usage in firms

	No. of Respondents	**High**	**Medium**	**Low**	**Total**
Contractors	**51**	**3.92%**	**64.71%**	**31.37%**	**100%**

4.3 Firms ICT Infrastructure Platforms

In this section, respondents answered questions on types of ICT hardware in use, windows operating systems, software preferences, communications and network status, and personnel handling ICT in their organizations.

4.3.1 Firms ICT Hardware status

This part examined the availability and types of computer and communication hardware including windows operating systems used by the contractors. Respondents were asked which ICT device from a specified range, are used in their organisations. Referring to Table 4.4 below, all the contractors surveyed (100%) use both desktop PC and mobile phones in their companies. Also over a third of the companies (82.35% and 88.24%) indicated that, they use Laptops and digital cameras respectively. Mobile ICT hardware's such as Personal Digital assistance (PDAs) and Tablet PCs (used by only 5.8% and 3.92 of the respondents respectively) and multimedia projectors seems not to be popular and covered only 7.84% of the respondents. The result also shows that, the three most common windows operating systems in use are Windows XP, Vista and Window7. A majority of the firms were using windows XP (43.14%) while windows Vista and windows 7 were used by (39.25%) and (17.65%) respectively. It was however surprising to learn that about 4% of the firms were still using Windows 2000/2003 which seems quiet an outdated form of windows operating system.

Table 4.4: ***Types of ICT hardware in use***

	No. of Respondents	Desktops	Laptops	PDAs	Tablet PC	Mobile Phone	Digital camera	Projectors
contractor	**51**	**100%**	**82.35%**	**5.88%**	**3.94%**	**100%**	**88.24%**	**7.84%**

Questions were also included to assess why the choice of the particular operating system. Data analysis showed that, respondents' use of these operating systems were based mainly on preference. As indicated by Table 4.5, about 47% of the contractors choose their operating systems based on familiarity while 29.41% were based on its availability in the market. Other considerations for the choice of windows operating systems as identified by the respondents were in terms of cost (15.69%) and efficiency (7.84%).

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Table 4.5: ***Reasons for choice of particular operating system***

	No. of respondents	Familiarity	Cost	Availability	Efficiency	Total
contractor	**51**	**47.06%**	**15.69%**	**29.41%**	**7.84**	**100%**

4.3.2 Software's in usage

The survey examined the contractors usage of commercially available software applications including those softwares designed specifically for use in-house. According to Table 4.6, the survey results clearly show that, on the average, the use of standard application tools for general office administration such as word processing, spread sheets, presentations and databases by the contractors is generally high. All the respondents indicated they were using word processors and spreadsheet applications. As expected, Microsoft Word (100%) and excel (100%) were the most common applications. About 35% of the firm had also used presentation software (Ms PowerPoint) while 41.18% had used database applications such as Ms Access. About 6% of the respondents also indicated they use an in-house or some form of proprietary applications for their office administration. Table 4.4 further shows that, the most

popular software in use for project planning and scheduling are Ms Project and Primavera. The Ms Project, used by 90.2% of the firms, is the most common application while Primavera recorded 23.5% patronage.

Table 4.6: ***Type of software in use***

Word Processors and spreadsheet	**% using it**
MS Word	100
MS Excel	100
Database	
Ms Access	9.8
Presentation Software	
MS PowerPoint	35.29
Project Planning Software	
MS Project	90.20
Primavera	29.53
Measurement and Estimating Software	
Other	15.69
Architectural/Engineering Design and Drawing Software	
AutoCAD	43.14
ArchiCAD	11.76
ArchiCAD	5.88
Revit	9.80

Generally, Quantity surveying works in contractor organisation are more of cost calculation and budget of construction works and software applications in this area have fully featured Bills of Quantity production package for pricing, tender analysis, estimation and valuation which helps in reducing the workload and labour intensive task. It is surprising to note however that, a large majority of the respondents were not using standard software for quantity surveying purposes. It is remarkable that only 5.9% of respondents use commercially available software for measurement and estimating. A possible explanation could probably be cost implications but familiarity with the

quantity surveying software could also explain this. For instance, none of the contractors could indicate using popular Quantity surveying, measurement and estimating software such as WinQs, Masterbill, Buildsoft, Catopro etc (Oladapo, 2005). Only a small fraction of 5.9% indicated using software such as construction computer software (CCS) and QsPro for quantity surveying purposes while a few of the firms (15.7.4%) also specified usage of software developed in-house based on excel spreadsheets.

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With regards to architectural and engineering software, the respondents indicated usage of AutoCAD (43.14%) as the most popular with the contractors. Archi CAD and Civil CAD were used by 11.76% and 5.88% respectively while Revit was being use by about 10% of the respondents. When the study wanted to know about the contractors desire to support a Ghanaian IT company interested in software development for the construction industry, the result showed an overwhelming outcome with almost all the respondents (88.24%) indicating their willingness to support such companies. stem % using.

4.3.3 Communication and Network Platforms

The ability to exchange data between all those involved in a building project both within the organization and other external parties depends upon the communications facilities which each company has. The study wanted to know the contractors current network platforms as the basis of their ability to communicate electronically within their firms and externally. In general, the survey revealed poor outcome of computer networking within the contractor organisations. As portrayed by Table 4.7 below, only 17.65% of the firms have networked the computers in their companies. This shows that, over two

third (82.35%) of the computers in the respondents organisations works in stand- alone mode.

Table 4.7: ***Network of Computers (LAN/WAN) in Firms***

	No. of Respondents	Yes	No	Total
Contractors	**51**	**17.65 %**	**82.35 %**	**100%**

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With regards to type network infrastructure used by the companies, the analysis in table 4.8 below shows that only about 18% of the total respondents use Local Area Network and Wide Area Network (LAN/WAN) in their offices for data exchanges while almost 69% use wireless network connections based on individual modems for external links with external parties.

Table 4.8: ***Network infrastructure in Firms***

	No. of Respondents	LAN/WAN	WIRELESS	NONE	Total
Contractors	**51**	**17.65 %**	**68.63 %**	**13.725%**	**100%**

The use of electronic mail and access to the internet in the contractor organizations was found to be quite high. This tends to support earlier reports that the internet connectivity and the general use of email and the World Wide Web is viewed as being substantially high in the construction industry (Becerik ,2004).

The electronic mail and the internet represent the basic technologies required for accessing the World Wide Web and electronic communication between businesses and customers. On an average, e-mail usage for official communication by the contractors is about 90%. Indeed, only 10% of the respondents indicated they do not use e-mails. Again, access to the Internet by the firms was very prevalent at nearly 85%.

With regard to where internet is accessed by the company's staff, the study revealed that 27.45% of the firms have access to the internet at their offices only while 72.55% indicated they have access to the internet at both their offices and project sites through wireless networks. On the issue of the companies with a page on the World Wide Web (WWW), the study also shows that about half (47%) of the firms have company website address for external links with the rest of the world. From the above, it can be concluded that, though firms' integration through internal network of computers (LAN) in the individual companies is very low, usage of the internet and e-mail for official communication and collaboration with external partners appear quiet high.

4.3.4 Personnel Handling ICT in the Firms

The section identified personnel handling ICT related works within the contractor's organisations. The average computer to employee ratio and types of ICT services provided in-house and those services out –sourced were also identified. According to the survey, ICT related works in the organisations were mainly handled by the technical and administrative staff at the company offices and project sites. Table 4.7 concluded that, the average number of computer to staff ratio within the firms is about *one computer* to *two employee staffs* (1:2) and this is confirmed by a majority of 72.55% of the

respondents. Only 15.69 % were using computer at a ratio of *one employee staff* to *a computer* (1:1).

The survey further revealed that (Fig 4.5), about a third (31%) of the companies have separate IT division in their organisation. A separate IT division within the organization provides an indication of the extent of use of information and communications technology for the day to day activities of that organization.

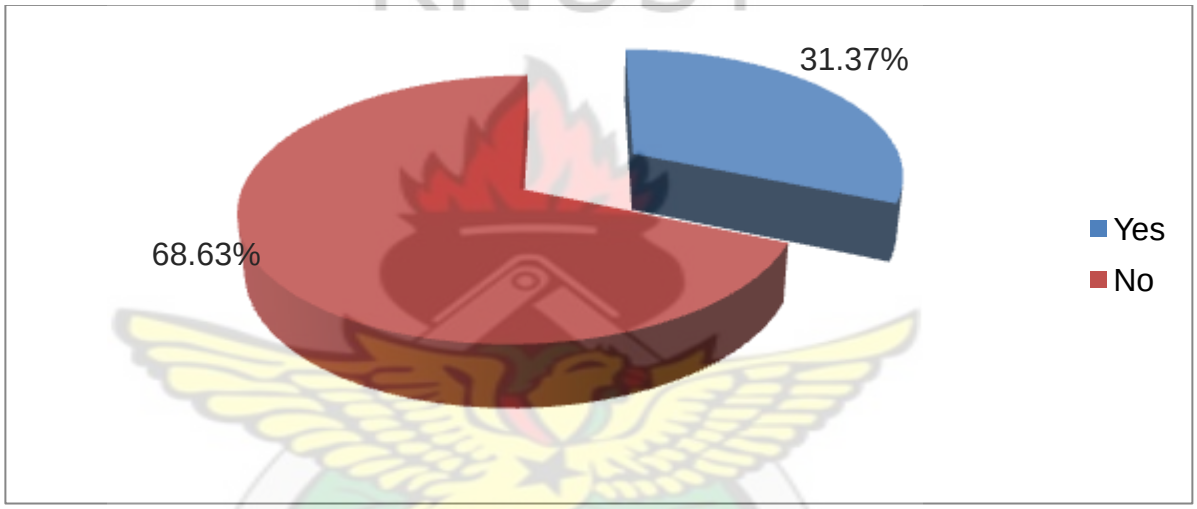

Fig 4.5: ***Firms with Separate IT Division***

Fig 6 below shows the extent of IT support services provided in-house and those out-sourced.

The respondents indicated that their firms obtain technical support services either from the IT division within the organization while some IT services are outsourced to companies specializing in these services. Of those with separate IT division, the main services provided are internet and e-mail support (94.44%) and Data base Management (83.33%) which constitutes 33.33% and 29.41% respectively of the total respondents.

On the other hand, services generally out-sourced include hardware maintenance (84.31%), software maintenance (74.51%) and Database maintenance (62.75%). Of those with Local Area Networks (LAN) in their organisation, about 80% which constitute about 14% of the total respondents outsourced such services to external firms.

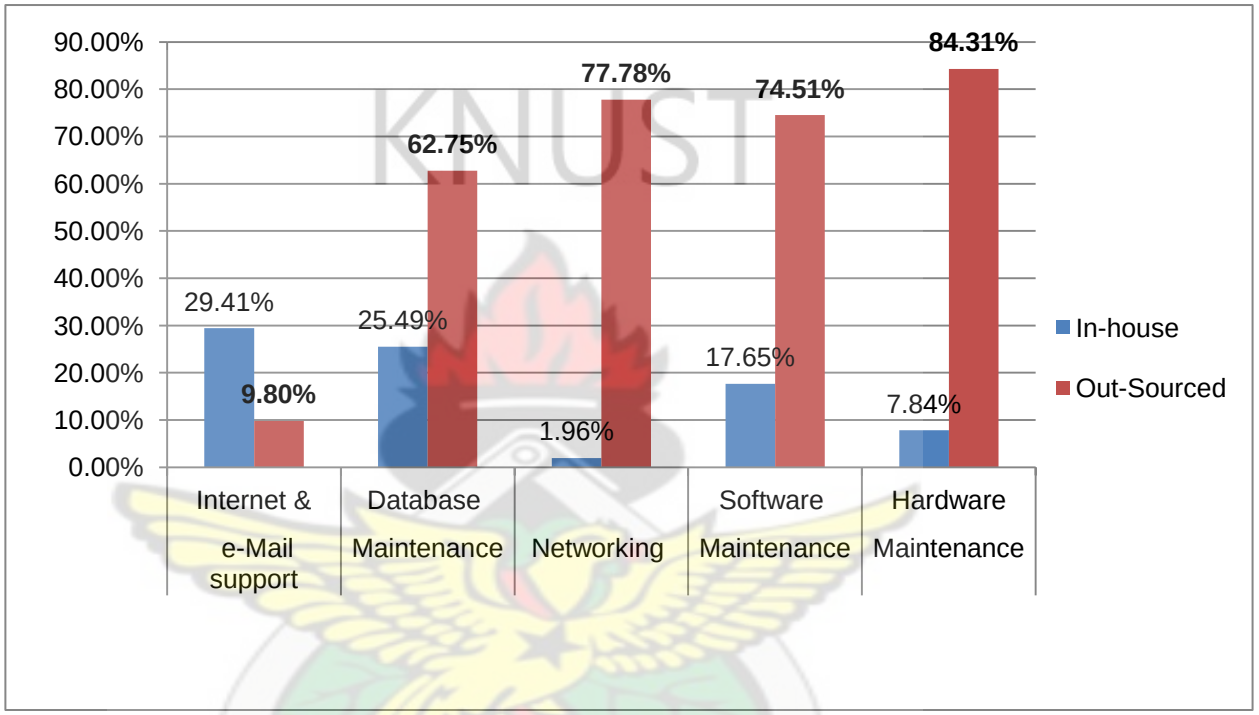

Figure 4.6: ***Services provided In-house and those Out-sourced***

From the results above, it can be concluded that Internet and e-mail support are the main services provided by the in-house IT divisions, while other specialized services such as database maintenance, networking, hardware maintenance and software support services are mainly outsourced.

4.4 ANALYSIS OF FIRMS LEVEL OF USAGE OF ICT.

This section analyzed the level of computerization of the contractors' operations/activities including extent of usage of some advanced ICT tools and applications. The statistical analysis employed in this situation is the Mean index score. In order to determine the degree usage of ICT for the contractors operations, the following classification of the ratings based on the Likert Scaling as were used (Majid ,1997; Aminudin ,2006) where,

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Very Highly Computerized/Used: **4.50 ≤ *mean score*≤ 5.00**
Highly Computerized/Used: **3.50 ≤ *mean score*≤ 4.50**
Moderately Computerized/Used: **2.50 ≤ *mean score*≤ 3.50**
Less Computerized/Used: **1.50 ≤ *mean score*≤ 2.50**
Not Computerized/Used: **1.00 ≤ *mean score*≤ 1.50**

4.4.1 Activities Computerized in the firms

Table 4.9 below itemizes some of the activities or operations of contractor organisation which can be computerized digitally and the mean index score of the contractor's level of digitization. Mean ratings on the level of usage were calculated based on a scale of 1-5 (from "Never" to "always"). On the average, a mean deployment index of about 3 indicates a moderate level of computerization of such operation.

Table 4.9: ***Activities Computerized***

Activities	Mean	Std Deviation	Ranking
Resource planning and Scheduling	**4.4314***	0.96447	1
Payroll	**4.3725***	0.99922	2
Bookkeeping/Accounting	**4.2941***	0.80878	3
Progress Reporting	**4.1961***	0.91694	4
Communication with project site and External Parties	**4.1765***	1.12616	5
Distribution of Project documents	**4.1569***	0.98738	6
Technical Calculations	**4.0196***	1.11073	7
Costing and Budgeting	**3.9804***	0.99410	8
Resource management(labour, Plant and Materials)	**3.9412***	1.13863	9
Project Cost Control	**3.9020***	0.88295	10
Purchases and Invoicing	**3.7255***	1.03621	11
Subcontractor and suppliers information	**3.5686***	1.01286	12
Estimating	**3.3725**	0.90011	13
Previous Project records	**3.2745**	1.02937	14
Financial Management	**3.2353**	1.04638	15
Project Drawings	**2.9804**	0.93053	16
Taken off	**2.9412**	0.99292	17
Site Management and Security	**2.9216**	1.06311	18
*Average Mean	**3.7277****		

From table 4.7 above, it is apparent that the mean response rating for most of the contractor's main operations was above average with an overall average mean score of about 3.73. Of the 18 activities stated above, almost half (8 number) had a standard deviation greater than 1.0. This is an indication that, about half of the respondents, had

variations in the rating of their level of computerization of their activities while a majority of ten (10) had a standard deviation less than 1.0 indicating some level of agreement among the respondents ratings.

According to the survey, the most prominent activities highly computerized/digitize in the respondents organisations are Resource Planning and Scheduling (mean=4.43**),** Payroll (mean= 4.37**)**, Bookkeeping/Accounting **(**mean= 4.29**)**, Progress Reports (mean= 4.20), Communication with project sites and external parties (mean= 4.18), and Technical Calculations (mean= 4.02).

The trend further shows that, computerization of activities such as Costing and Budgeting (mean=3.98), Resource management (labour, Plant and Materials) (mean=3.94), Project Cost Control (mean=3.90), Purchases and Invoicing (mean=3.73) are also above the average value of 3.72. The moderately computerized activities identified by the contractors are Estimating (mean=3.37), Previous project records (mean=3.27), Financial Management (mean=3.24), Distribution of Project documents (mean= 3.21), and Subcontractor and suppliers information (mean=3.17) while operations and activities such as Project Drawings (mean=2.98), Quantity Take off (mean=2.94) and Site Management and Security (mean=2.92) were the least rated.

Based on the findings presented above, it is reasonable to deduce that, digitization of the contractors' main business activities in a developing country like Ghana appears quiet high.

4.4.2 Level of usage of advanced ICT tools and applications

Table 4.10 below provides a range of ICT tools and application and the mean index score of the contractor's level usage. Mean ratings on the level of usage were calculated based on a scale of 1-5 (from "Never" to "always").

Table 4.10: ***Usage of Advanced ICT Tools and Application***

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ICT Application/tool	Mean	Std Deviation	Ranking
Short Message Service (SMS)	**4.2745***	0.91823	1
Mobile Internet	**3.6863***	1.24081	2
Electronic Purchasing (E-purchasing)	**2.4706**	1.03621	3
Modeling and visualization Technologies (eg.3D-Cad)	**2.4510**	1.16552	4
Global Position System (GPS)	**2.4118**	0.96080	5
Electronic Tendering	**2.2941**	1.03128	6
Site Surveillance Technologies (eg. CCTV)	**2.2745**	1.13276	7
Electronic Document Management System (EDMS)	**2.2549**	0.81457	8
Intranet	**2.2353**	0.98140	9
Geographic Information System (GIS)	**2.1176**	1.11672	10
Videoconferencing	**1.4902**	1.26986	11
Project specific website/Extranet	**1.3922**	1.19016	12
Data conferencing	**1.2941**	1.20619	13
Radio frequency Identification (RFID) and Barcode	**1.1176**	1.17457	14
*Average Mean	**2.2689****		

By considering usage the range of emerging ICT technologies; the study revealed that current level of usage by the firms was largely below average (Average mean score of 2.27). According to the data, the most prominent ICT application in used was short message Service (mean=4.27) and mobile internet (mean=3.69). Apart from these technologies which were significantly above average, data analysis revealed that the contractor's usage of other ICT tools and applications are generally deficient. For instance, usage of applications such as Electronic Purchasing (mean=2.47), Modeling and visualization Technologies (eg.3D-Cad) (mean=2.45), Site Surveillance Technologies (e.g. CCTV) (mean=2.41), Electronic Tendering (mean=2.29), Global Position System (GPS) (mean=2.28), Electronic Document management systems (EDMS) (mean=2.25), Intranet (mean=2.12), Geographic Information System (GIS) (mean= 2.24) were found to be very inadequate and below test level of 3.0. Besides, other tools and applications such as Videoconferencing (mean =1.49), Project specific website/Extranet (mean=1.39), Data conferencing (mean=1.29) and Radio frequency Identification (RFID) / Barcodes (mean=1.12) were basically not used.

Drawing from the results above, it is plausible to conclude that more advanced and newer technologies are poorly utilized by contractors in Ghana. The findings suggest that, while there is some level of awareness about these technologies, the motivation for usage is lacking due to both internal and external constraints.

4.5 Analysis of factors hindering use of ICT by the contractors.

As indicated earlier, the one sample t-test was employed in the analysis of this data. This statistical tool was employed basically to ascertain the significant and most important reasons hindering ICT usage by contractors.

4.5.1 The Ranking Criteria of One Sample T-Test.

The one-sample t-test compares the mean score found in an observed sample (sample mean) to a hypothetically assumed value and establishes whether the sample mean is significantly different from a hypothesized mean. Typically the hypothetically assumed value is the population mean.

By the central limit theorem, a normal distribution can be assumed when the sample size is more than 30 (Hair et al,1998). Therefore, with a sample size of 100 it can be assumed that, the underlying suppositions of the central limit theorem were applied and that, the sample size is relatively adequate for use in this statistical inference.

Typically, a one sample t-test reports on the mean of the test group, degree of freedom for the test, the t-value (which is an indication of the strength of the test) and the p-value (which is the probability value that the test is significant) (Reymont and Joreskog, 1993; Hair et al, 1998; Field, 2005). With the use of SPSS, a statistical analysis was performed to determine whether the population agreed on a particular factor as s strong reason or not. The t-test analysis from SPSS usually produces two reports, namely, the one sample statistics and the one sample test showing test significance. The details of the two tables are indicated in Tables 4.9 and 4.10.

With reference to the 5-point Linkert rating scale adopted, ratings of 4 and 5 representing strong and strongly strong reasons respectively. By that, the populations mean μ_o was set at an appropriate level of 3.0 (Oyediran, 2006) and the significance level was also set at 95% in accordance with expected risk levels (Cohen, 1992). Therefore, based on the five-point Linkert rating scale, a factor was considered critical if it had a mean of 3.0 or more. Where two or more criteria have the same mean, the one with the lowest standard deviation was assigned the highest importance ranking (Field, 2005). The standard error is the standard deviation of sample means and is a measure of how representative a sample is likely to be to the population. A large standard error suggests that there is a lot of variability between means of different samples. A small standard error suggests that most sample means are similar to the population mean and so the sample is likely to be an accurate reflection of the population. Clearly, the standard error for all the means is in the close of zero which indicate that the sample chosen is an accurate reflection of the population (Table 4.9)

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Table 4.11: ***Results of T-Test Showing One-Sample Statistics***

FACTORS	N	Mean	Std. Deviation	Std. Error Mean
Inadequate ICT content of construction education	51	3.3333*	1.33666	.18717
Budget Constraints for ICT investment	51	3.6078*	1.21784	.17053
Cost of implementing ICT	51	3.1373*	1.20033	.16808
Perceived limited benefits/Low return on investment in ICT.	51	2.8235	1.29160	.18086
High cost of employing ICT professionals	51	3.0588*	1.39157	.19486
Lack of training and technical support for professionals in ICT	51	3.4902*	1.22266	.17121
Lack of commitment by firm's management towards ICT	51	3.5294*	1.34689	.18860
Inadequate knowledge about return on ICT investment	51	3.1765*	1.21171	.16967
Lack of staff with appropriate skill and knowledge in ICT	51	2.8627	1.31179	.18369
Highly dispersed nature of the industry/projects & participants	51	2.7451	1.27817	.17898
Fear of job losses /making professionals redundant.	51	2.7647	1.32043	.18490
Satisfaction with existing method of working.	51	2.6667	1.17757	.16489
Rapid changes in ICT technologies	51	3.1569*	1.39101	.19478
Software and hardware reliability problems	51	2.3333	.99331	.13909
High rate of obsolescence ICT products in the market	51	2.3922	1.05978	.14840
Lack of legal support for use of ICT	51	2.2941	.98578	.13804
Access to relatively cheap work force	51	2.5686	.98499	.13793
Majority of client not interested in firms ICT base	51	3.3333*	1.47874	.20706
Problem of ICT integration/compatibility in the organization	51	2.7059	1.18818	.16638
Resistance/Mistrust in ICT technology	51	2.1765	.97377	.13636
Security implications of ICT transactions	51	2.2353	.92926	.13012
***Mean > 3.0 (Population mean)**				

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From the results in table 4.11 above, it can be observed that almost all the variables had standard deviation values of more than 1.0. This provides the indication that, the respondents had different interpretations for the factors. Nevertheless, a few of the factors (5) had their standard deviation values less than 1.0, suggesting some level of agreement among respondents in how those factors were interpreted.

Table 4.12 below displays the significance (i.e. p-value) of each factor. This test (P-Value) was conducted on each factor to identify significant factors hindering usage of ICT by the contractors. This then provides a basis for a statistical decision to be made as to whether or not the population mean and sample mean are equal. The significance values (p-value) provided in Table 4.12 is for a two-tailed test. Since our interest is for one-tailed test where we look for only sample means greater than the population mean (i.e. U > Uo), the significant value ("Sig") in Table 4.12 has been divided by two and the results displayed in Table 4.13.

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Table 4.12*Results of One Sample Test showing test significance*

FACTORS	Test Value=3.0					
					95% Confidence interval of the difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Inadequate ICT content of construction education	1.781	50	.081	.33333	-.0426	.7093
Budget Constraints for ICT investment	3.564	50	.001	.60784	.2653	.9504
Cost of implementing ICT	.817	50	.418	.13725	-.2003	.4749
Perceived limited benefits/Low return on investment in ICT.	-.976	50	.334	-.17647	-.5397	.1868
High cost of employing ICT professionals	.302	50	.764	.05882	-.3326	.4502
Lack of training and technical support for professionals in ICT	2.863	50	.006	.49020	.1463	.8341
Lack of commitment by firm's management towards ICT	2.807	50	.007	.52941	.1506	.9082
Inadequate knowledge about return on ICT investment	1.040	50	.303	.17647	-.1643	.5173
Lack of staff with appropriate skill and knowledge in ICT	-.747	50	.458	-.13725	-.5062	.2317
Highly dispersed nature of the industry/projects & participants	-1.424	50	.161	-.25490	-.6144	.1046
Fear of job losses /making professionals redundant.	-1.273	50	.209	-.23529	-.6067	.1361
Satisfaction with existing method of working.	-2.022	50	.049	-.33333	-.6645	-.0021
Rapid changes in ICT technologies	.805	50	.424	.15686	-.2344	.5481
Appropriate software and hardware problems (Availability and reliability)	-4.793	50	.000	-.66667	-.9460	-.3873
High rate of obsolescence ICT products in the Ghanaian market	-4.096	50	.000	-.60784	-.9059	-.3098
Lack of legal support for use of ICT	-5.114	50	.000	-.70588	-.9831	-.4286
Access to relatively cheap work force	-3.128	50	.003	-.43137	-.7084	-.1543
Majority of client not interested in firms ICT base	1.610	50	.099	.33333	-.0826	.7492
Problem of ICT integration /compatibility in the organization	-1.424	50	.161	-.25490	-.6144	.1046
Resistance/Mistrust in ICT technology	-6.040	50	.000	-.82353	-1.0974	-.5497
Security concerns of ICT transactions	-5.877	50	.000	-.76471	-1.0261	-.5033

Table 4.13*Results of One Sample Test showing test significance*

FACTORS	Test Value=3.0					
					95% Confidence interval of the difference	
	t	df	Sig. (1-tailed)	Mean Difference	Lower	Upper
Inadequate ICT content of construction education	1.781	50	.0.045	.33333	-.0426	.7093
Budget Constraints for ICT investment	3.564	50	.0005	.60784	.2653	.9504
Cost of implementing ICT	.817	50	.209	.13725	-.2003	.4749
Perceived limited benefits/Low return on investment in ICT.	-.976	50	.167	-.17647	-.5397	.1868
High cost of employing ICT professionals	.302	50	.382	.05882	-.3326	.4502
Lack of training and technical support for professionals in ICT	2.863	50	.003	.49020	.1463	.8341
Lack of commitment by firm's management towards ICT	2.807	50	.0035	.52941	.1506	.9082
Inadequate knowledge about return on ICT investment	1.040	50	.152	.17647	-.1643	.5173
Lack of staff with appropriate skill and knowledge in ICT	-.747	50	.229	-.13725	-.5062	.2317
Highly dispersed nature of the industry/projects & participants	-1.424	50	.0805	-.25490	-.6144	.1046
Fear of job losses /making professionals redundant.	-1.273	50	.105	-.23529	-.6067	.1361
Satisfaction with existing method of working.	-2.022	50	.0245	-.33333	-.6645	-.0021
Rapid changes in ICT technologies	.805	50	.212	.15686	-.2344	.5481
Appropriate software and hardware problems (Availability and reliability)	-4.793	50	.000	-.66667	-.9460	-.3873
High rate of obsolescence ICT products in the Ghanaian market	-4.096	50	.000	-.60784	-.9059	-.3098
Lack of legal support for use of ICT	-5.114	50	.000	-.70588	-.9831	-.4286
Access to relatively cheap work force	-3.128	50	.0015	-.43137	-.7084	-.1543
Majority of client not interested in firms ICT base	1.610	50	.0495	.33333	-.0826	.7492
Problem of ICT integration /compatibility in the organization	-1.424	50	.0805	-.25490	-.6144	.1046
Resistance/Mistrust in ICT technology	-6.040	50	.000	-.82353	-1.0974	-.5497
Security concerns of ICT transactions	-5.877	50	.000	-.76471	-1.0261	-.5033

4.5.2 Interpretation of results

Referring to the summary of results in Table 4.11 above, it can be deduced that the most important factors from the study are: *Budget constraints for ICT investments (Mean=* 3.6078), *Lack of commitment by firm's management towards ICT (Mean=* 3.5294), *Lack of training and technical support for professionals in ICT (Mean=* 3.4902), *Inadequate ICT content of construction education (Mean=*3.3333), *Majority of client not interested in firms ICT base (Mean=* 3.3333), *Inadequate knowledge about return on ICT investment (Mean=* 3.1765), *Rapid changes in ICT technologies (Mean=* 3.1569), *Cost of implementing ICT in firms (Mean=* 3.1373) and *High cost of employing ICT professionals (Mean=* 3.0588)

Notwithstanding the importance of these factors however, Table 4.13 revealed that the most significant ones among them as reasons hindering the use of ICT by the contractors are:

1. ***Budget constraints for ICT investments,***
2. ***Lack of commitment by firm's management towards ICT,***
3. ***Lack of training and technical support for professionals in ICT***
4. ***Inadequate ICT content of construction education.***
5. ***Majority of construction clients not interested in firms ICT base.***

It is important to note that, whereas *Budget Constraints for ICT investments by firms* (mean= 3.6078, P=0005) came out as the highest ranked factor, issues of *Resistance/Mistrust in ICT technologies (mean=2.1765, P= 0.00025)* was ranked the lowest in terms of the factors hindering ICT usage by the respondents. This suggests that although workers resistance to ICT usage within the contractors' organisations may

appears significant, it was largely perceived by the respondents as not an important barrier to ICT usage.

The perception of the respondents also suggests that, their focal concern was *budget constraint for ICT investments.* This basically agrees with the growing challenge of inadequate funding for major investment activities by contractors in Ghana (Laryea, 2010). Generally, the cost of implementing ICT is a huge venture and involves both the cost of investment of ICT tools and at the same time the maintenance cost of tools. By that, firms annual turnover and hence Project/organizational budget have a great influence on the firms ICT status. But, in spite of this, difficulty in predicting cash flows by contractors due to payment delays, high cost of capital and general lack of funding continue to be a major challenge to contractors in the Ghanaian construction industry (Laryea, 2010).

Further reference to Table 4.13 shows that apart from the issue of budget constraints, *Lack of commitment by firm's management towards ICT (mean =3.5294, P=0.0035), Lack of training and technical support for ICT (mean =3.4902, P=0.0030), Inadequate ICT content of construction education (mean =3.3333, P=0.0405), and the fact that Majority of client not interested in firms ICT base (mean =3.3333, P=0.0449)*were ranked 2nd, 3rd, 4th and 5th significant factors respectively.

The *lack of commitment by firm's management* towards ICT was ranked second at a significance of (*P=0.0035).* This brings to the fore the need to recognize that, effective ICT use will require management focus and leadership commitment on both the technical and organizational aspects for its implementation and use. As a result, the

focus on management support for ICT use in an organisation is therefore quiet critical. This may require the use of corporate power and motivational strategies to create an enabling environment for workforce to be committed to the organizational objectives in implementing and using ICT systems.

By ranking the *Lack of training and technical support for ICT* as the third most significant factor *(P=0.0030)*, by and large agrees with studies such as (Songer *et al.* 2001; Weippert *et al.* 2002b). These studies found lack of training as a key barrier to adopting and using IT/ICT applications. Traditionally, the emergent problems in learning and training in the construction sectors are quiet significant. This is due not only to the nature of the industry but also to a lack of familiarity with new methods of working. Since training in construction is of strategic importance, the creation of not merely learning organisations, but a 'learning sector' is required. Beyond that, he result also confirms that, it is necessary to provide technical support for solving problems when using IT/ICT applications in construction. It is therefore notable to justify training as an essential factor for success of ICT implementation and usage.

It is interesting to record that *Inadequate ICT content of construction education* was ranked fourth at a significant of *(P=0.0405).* Basically this may reflects the respondents' strong view of their level of ICT literacy after leaving school. Indeed, earlier sections of this study (see Section 4.1.0, Page 4) have confirmed that, the modes of acquisition of computer literacy by the respondents were mainly through private lessons (50.98%) with only (17.65%) reflecting those learnt from school. Incidentally, this position of respondents seems to suggest the need for Ghana to revisit ICT in its construction education to include a robust construction software skills acquisition and culture. This

requirement may be necessary both in undergraduate / postgraduate courses to create more receptive and highly trained construction professionals (including the creation of a more common understanding) as well as the role of providing specific research and consultancy support to companies (Weippert et al, 2001). It is therefore plausible recap that, this affirmation is significant to underscore the role education (tertiary) should play in developing and shaping the understanding of ICT as a form technological change and innovation in construction.

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With the view that *Majority of client are not interested in firms ICT base*, the respondents considered it at a significance level of*(P=0.0449)* and ranked fifth on the scale. Clearly, this finding suggest the need for an increased external requirement where customers/clients may perhaps mandate or look for the availability and use of specific ICT technologies in contractor organisations prior to the award of contract. It is not clear the collective motive of the respondents on this criterion; however, it may probably be as a result of the fact that in Ghana, there seems to be a lack of management readiness for increased ICT usage due inadequate knowledge about the benefit of ICT in the contractors organisations.

Surprisingly, while factors such as*inadequate knowledge about return on ICT investment (mean=3.1765, P= 0.1515), rapid changes in ICT technologies (mean=3.1569, P= 0.2120), Cost of implementing ICT (mean=3.1373, P= 0.2090) and cost of employing ICT professionals (mean=3.0588, p= 0.3820)* were considered important (Mean $\geq$ 3.0) and accordingly ranked 6th, 7th, 8th and 9th respectively, they were found to be statistically insignificant ($p > 0.05$) in this circumstance. A suggestion

that, though, the factors may qualify as reasons hindering the use of ICT in the industry, they are currently not significant in the context of the contractor organisations in Ghana.

Another point worth noting from Table 4.11 above is that, whereas factors such as *satisfaction with existing method of working (mean=2.6667, .0245), access to relatively cheap work force (mean= 2.5686, P= 0.0015), high rate of obsolescence ICT products in the Ghanaian market (mean=2.3922, P=0.00025), software and hardware reliability problems (mean=2.3333,P=0 .00025), lack of legal support for use of ICT (mean=2.2941, P= 0.0015), Security implications of ICT transactions (mean= 2.2353, P=0 .00025),issues of Resistance/Mistrust in ICT technologies (mean=2.1765, P= 0.00025);* are considered unimportant (mean < 3.0) by the respondents and ranked 15th - 22nd respectively, they were surprisingly found to be statistically significant ($p \leq 0.05$). This appears to suggest that, although, these factors might not necessarily qualify as major reasons hindering their ICT usage; they should be noted as quiet significant in the context of the Ghanaian contractor's organisation.

Summary

This chapter has presented the analysis of the data from the survey. The analysis undertaken included descriptive statistics on the demographic data, average index analysis on their level of ICT usage and one sample t-test on factors hindering their ICT usage. Findings suggest though there appears to be high level of awareness among respondents on ICT generally, overall level of usage is still inadequate. Reports from the one sample T-test suggest that ICT usage is constraint to some extent by both internal and external factors. Following this analysis, results are hereafter presented with conclusions and recommendations in the next chapter.

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CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATION

5.1 Introduction

This chapter summarizes the results from the research and draws conclusions from the collated data. It begins by summing up all the core issues discussed earlier in previous chapters including a recap of the key research questions. Afterward, a review of how the key objectives were satisfied and a summary of the results are described. Finally, conclusions are drawn and recommendations for action are also included.

5.2 Summary of the research

The research so far has presented the aim, objectives and the background problems that induced the formation of the theoretical framework as well as the research questions. Following this, a research methodology was sequentially adopted to answer the key objectives of the study as presented in the research analysis and findings.

In addressing the aim and the objectives of the research, the main approach used was to review the current state of affairs in construction ICT literature. This was then trailed by investigating the use and relevance of these findings in Ghana through survey questionnaire. At the end of the empirical study, the level of ICT infrastructure in the firms, the extent of ICT usage and a set of reasons hindering the use of ICT reflecting the different perspectives of the contractors were appropriately established. The research came out with key findings some of which addressed the main aim and objectives.

As mentioned earlier in chapter one, this research was set out to identify the factors hindering the use of ICT by Building contractors in Ghana. To achieve this, three research objectives were adopted in order to collectively satisfy this aim.

5.3 Summary of the research findings

The study produced some significant findings that are summarized below.

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5.3.1 Objective 1: To assess the ICT infrastructure of building contractors in Ghana.

As indicated previously, this research objective was achieved by a research framework drawn from the *IT Barometer surveys,1999-2010* to cover firms ICT hardware, operating systems, software in use, communication, networks status and ICT workforce. Indeed, this objective was primarily pursued to assess the availability of these components as the foundation for effective implementation and use of ICT by the firms.

The findings have shown that, majority of the contractors in the survey use ICT and this was reflected in the responds on their ICT infrastructure levels. Results from the investigation also identified a high usage of ICT hardware such as Desktop PC, Laptops, digital cameras and mobile phones among the contractors. However, most potable mobile ICT hardware such as Personal Digital assistance (PDAs) and Tablet PCs were found unpopular. With regards to the windows operating systems in use, Windows XP, Vista and Window7 were the most accepted. Among them, Windows XP was rated high followed by Vista and Window7 respectively. Interestingly, choice of these operating

systems by the firms were based mainly on familiarity followed by its availability and then cost.

Concerning software application status, the study has shown that usage of standard application tools for general office administration such as word processing, spread sheets, presentations and databases was widespread. Microsoft Word and Microsoft excel had the most popular usage. With regard to resource planning and scheduling software, Microsoft Project was the most popular while others such as primavera, etc had very low usage among the firms. Again AutoCAD was the most popularly used engineering and architectural software among the building contractors followed by Archicad, CivilCad and Revit. Surprisingly, the result has revealed that most of the firms do not benefit from the usage of computer aided cost estimating and quantity surveying software. The few software identified here were mainly based on self-developed excel spreadsheet applications.

On the issue of firms' communication and network status, this study has found that usage of Local Area Network and Wide Area Network (LAN/WAN) for internal communication and data exchanges was very minimal. Internet access and e-mail usage by the firms was however found to be very prevalent through the use of wireless network connections and individual modem. Most of the firms use internet at their company head offices and project sites through wireless networks. About half of the firms interviewed also have a page on the World Wide Web (WWW).

The study also revealed that, personnel handling ICT related works within the contractor's organisations were mainly technical and administrative staff at both the

company offices and project sites. Most of the firms outsource their IT related services while about a third of the firms have separate IT division.

5.3.2 Objective 2: To explore current level of ICT usage among building contractors

Based on the review of data from literature, this aspect itemized 18 activities /operations of contractor organisations and 14 advanced ICT tools and applications. It analyzed the level of computerization or digitization of these operations/activities and also the extent of usage of the advanced ICT tools and application using mean score.

The findings have indicated a high ranking level of computerization/ digitization of most activities and operations identified in this study. It revealed that activities related Resource Planning and Scheduling**,** Payrolls, Bookkeeping/Accounting, Progress Reports, Communication with project sites and external parties, Distribution of Project documents, and Technical Calculations were rated as major activities performed digitally. Also the findings suggest that, computerization of activities such as Costing and Budgeting; Resource management (labour, Plant and Materials); Project Cost Control are also high (see chapter 4, table 4.10).

Again, the findings have revealed that certain activities were not fully computerized in the contractors' organisations. These include activities such as Estimating, Purchases and Invoicing, maintenance of previous project records, Financial Management, Subcontractor and suppliers information; while digitization of operations / activities related to Project Drawings, Quantity Take- off, Site Management and Security were the least rated.

Concerning the extent of usage of advanced ICT tools and applications by the contractors, the findings suggest that the contractors were quiet deficient in their use of more advanced and emerging ICT tools and applications. Apart from the use of mobile internet and short message Service (SMS) which were sufficiently represented, exploitation of ICT tools and applications such as Electronic Purchasing, Modeling and visualization (eg.3D-Cad), Site Surveillance Technologies (e.g. CCTV), Electronic Tendering, Global Position System (GPS) ,Electronic Document management systems (EDMS), Intranet, Geographic Information System (GIS) were found lacking in the firms. Again, other tools and applications such as use of Videoconferencing, Project specific website/Extranet, Data conferencing and Radio frequency Identification (RFID) / Barcodes were basically non existent.

5.3.3 Objective 3: To identify the factors hindering the use of ICT by building contractors in Ghana

In fulfilling this objective, twenty one (21) relevant factors affecting the use of ICT were drawn from the literature. These factors were first tested among some professionals in building construction firms in a preliminary survey to ascertain their relevance locally. The factors were then ranked by the survey respondents (building contractors) as per the ranking scale implemented for this study.

The results points to a number of key factors that inhibit the extensive use of ICT by the contractors. Data obtained from the survey indicates that, 9 out of 21 factors obtained from literature as hindrances on their use of ICT were identified as important (see

chapter 4, Table 4.11). These include: *Budget constraints for ICT investments (Mean= 3.6078), Lack of commitment by firm's management towards ICT (Mean= 3.5294), Lack of training and technical support for professionals in ICT (Mean= 3.4902), Inadequate ICT content of construction education (Mean=3.3333), Majority of client not interested in firms ICT base (Mean= 3.3333), Inadequate knowledge about return on ICT investment (Mean= 3.1765), Rapid changes in ICT technologies (Mean= 3.1569), Cost of implementing ICT in firms (Mean= 3.1373) and High cost of employing ICT professionals (Mean= 3.0588)*

Finally, a test for significance (see chapter 4, Table 4.13)on the results has revealed that, the five most significant reasons hindering the use of ICT by building contractors in the Ghana include are:

1. ***Budget constraints for ICT investments;***
2. ***Lack of commitment by firm's management towards ICT;***
3. ***Lack of training and technical support for construction professionals in ICT;***
4. ***Inadequate ICT content of construction education and***
5. ***The fact that majority of client are not interested in firms ICT base.***

5.4 Conclusion

The following conclusions can be drawn from the study:

- Notwithstanding the many challenges of the Ghanaian construction industry, Information and Communication Technology (ICT) is well recognized by building contractors in Ghana as a significant technological spotlight that can help increase the effectiveness of communication and data during the construction process. The study has indeed revealed that, there is a significant level of awareness among the contractors about the potential benefits ICT could offer to their operations. Whilethe use of some selected ICT hardware, notably Desktop PCs, Laptops, digital cameras and mobile phones appears high, more advanced and potable mobile ICT hardware such as Personal Digital assistance (PDA) and Tablet PCs were found deficient. Again, general attitude by the firms towards ICT is positive and this approach may have influenced their confidence to use the technology to various extents. However, current level of ICT usage in general appears to be at a more rudimentary stage consisting of basic hardware and software applications. Though more advanced technical applications of ICT seem to be lacking, most of the firms' perceived their current usage of ICT as average.

- Overall usage of commercially available software applications for specific work tasks such as general office administration, planning and scheduling, architectural and engineering are encouraging and well recognized within current practice. Most common software applications in use included Microsoft word

and excel for general office applications, Ms Project for Planning and scheduling and CAD for Engineering and architectural drawings. Surprisingly, commercially available software for project cost estimating and quantity surveying works are not adequately developed. Most software in use for estimating are self developed and mostly based on Microsoft excel spreadsheets. Although respondents were not aware of any industry specific software developers locally, most firms appear very confident to support such ventures in the future.

- The use of Network infrastructure such as Local and Wide Area Networks (LAN/WAN) by the firms for internal and external communication and data exchanges is generally a less mature field. However, Internet access and use of computer-supported communications such as E-mail and the web is very prevalent through the use of wireless network connections and individual modem. Most ICT related works within the contractor's organisations are handled by technical and administrative staff at both the company offices and project sites.

- Digitization of business activities associated with resource planning and scheduling, Bookkeeping and accounting, payroll, communication and distribution of documents (e-mail), Technical calculations, Costing and Budgeting; Resource management (labour, Plant and Materials), Project Cost Control by the building contractors were very encouraging. Though majority of

firms were deficient in the use of most advanced ICT tools and applications, the trend is that mobile internet applications and Short Message Services (SMS) through the use of mobile phones were significantly gaining adequate level of usage. As a whole, there appears to be a high level of optimism among the firms that more advanced ICT applications such as Electronic Purchasing, Modeling and visualization (eg.3D-Cad), Project Specific Websites, Electronic Tendering, Videoconferencing and intranets applications could gain some patronage in the near future if the necessary awareness is created.

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- Finally, it is notable to recognize from this survey that, the most significant factors affecting the use of ICT by building contractors are: ***Budget constraints*** *for ICT investments, Lack of commitment by firm's management towards ICT, Lack of training and technical support for construction professionals in ICT, Inadequate ICT content of construction education and the fact that majority of client not interested in firms ICT base.*

  These factors should explain the main reason behind current level of ICT usage by among building contractors in Ghana. It is therefore plausible to acknowledge that, whilst the posture and interest towards ICT by building contractors in Ghana seems promising, these factors continue to be a major issue that stakeholders and individual organisations need to address in order to increase usage and derive the full benefit of ICT.

5.5 Recommendations

On the basis of findings and conclusions drawn from the study, the following recommendations areproposed.

5.5.1 Financial support for ICT investment in building firms.

Investing in ICT is no longer primarily buying a piece of hardware or software. It is now more of a potential long term investment in the process of change itself (Cleveland 1999). Due to obvious tight margins for funding ICT within most construction the firms as revealed in this study, there is the need for some internal policies towards ICT investments in building construction firms. It is therefore recommended that,construction firms should be motivated by the directbenefits ofICT and draw deliberate policies that provide some proportion of their internal budget for ICTinvestments. This will aim to improve both productivity and profitability for theirbenefit. Again, based on the understanding on the returns on ICT investment, financial institutions can assist building contractors in Ghana to finance their ICT investment by offering flexible credit facilities to firms seeking to invest in ICT. This willsupporttheir operations to improve efficiency and payback the facility. Furthermore, construction client may support contractors upon request, to procure ICT equipments for their contracts as a means to support efficiency and collaboration on their projects. This will be deducted on installments from their progress payments.

5.5.2 Training and management support for ICT in building construction firms.

As observed from the study, the management of construction activities is gradually moving from the traditional paper based format to more digital processes. It is therefore

recommended that adequate ICT training and technical support for professionals in building construction firms should be vigorously promoted by employers and other stakeholders such as various professional bodies and associations of the industry in Ghana. This should aim at providing the necessary awareness and build capacity to meet future challenges in this marketplace. Again, there should be a closer cooperation between Ghanaian ICT technology developers and contractors to train professional and also develop ICT systems that will address the specific operational needs of Ghanaian contractors.

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5.5.3 Client interest in contractors ICT capacity

The need to promote the use of ICT through increased external requirement is very much recommended. This will require construction customers/clients take into account the contractors ICT technological capabilities as a criterion for selection. Furthermore, clients could often mandate the use of specific ICT technologies on their project, for instance, tendering on-line, specifying project control technologies such as scheduling tools, cost control systems, and communication systems such as email and project webs. This could boost the potential for competitive advantage through the use of ICT technology in the building firms.

5.5.4 Increase ICT content in construction education at all level

As explained by Foresight 2000, the advent of computer and ICT integration in the construction processes creates the need for 'cross disciplinary education'. By recognizing the importance of ICT education in construction, it is recommended that a robust content of ICT education which will generate adequate construction ICT skill acquisition should be incorporated in construction courses as a supplement to technical

knowledge and expertise in various fields of construction study. A re-think' in this respect will help to deliver the require ICT skills for the Ghanaian construction industry. This will also be significant to develop and support the understanding of how ICT could be use to support construction process at all levels to facilitate the necessary change and innovation.

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5.6 Further Research Work

Though this study has proposed recommendations for promoting the use of ICT in the Ghanaian construction industry, these results reflect only the views of Building construction firms in financial class D1K1 and D2K2. It is therefore recommended that further research should be undertaken to ascertain the situation in Small scale contractor (D3K3-D4K4). Again, there is the need to repeat the research for all classes (D1K1-D4K4) and the study expanded to cover construction consultants, clients and academia to give an objective view of the whole construction industry in Ghana.

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APPENDICES

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF ARCHITECTURE AND PLANNING

DEPARTMENT OF BUILDING TECHNOLOGY

SURVEY QUESTIONNAIRE

The research is being undertaken by **Esben ASekou**, a second year postgraduatestudent in Construction Management on**"*The factors affecting the use of ICT by Building and Civil Engineering contractors in Ghana*"**

It is aimed at identifying ICT needs of building and civil engineering contractorsin Ghana and makerecommendationsto promote effective use ICTto enhance their project delivery.

Specific **objectives**are to:

- Assess ICT infrastructure platforms of Building and Civil Engineering Contractors in Ghana.
- Explore firms' level of ICT usage.
- Identify and evaluate reasons hindering the use of ICT within contractor organisations.

As part of the process, this questionnaire has been designed for survey.Your organisation is invited to participate and contribute in this study. Your input, opinions and views would be very much appreciated.

Thank you in advance for your cooperation.

Cell no: 0244587688

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SECTION I: General

1.1 About your firm

1.1.1 Please indicate Financial Class of your company. ☐D1K1☐D2K2 ☐D3K3 ☐D4K4

1.1.2 What is your company's yearof experience in the Ghanaian construction industry (Please Tick)?

☐< 5 years	☐5-10 years	☐10-15 years	☐15-20 yrs	☐Over 20 yrs

1.2About Respondent

1.2.1 Please indicate your current position in this company (Please Tick).

Managing Director	Project Manager	IT Manager	Engineer	Quantity Surveyor	Architect	Ot
☐	☐	☐	☐	☐	☐	

1.2.2 How long have you been practicing in the Ghanaian construction industry (Please

Tick).

☐< 5 years	☐5-10 years	☐10-15 years	☐15-20 yrs	☐Over 20 yrs

1.2.3 Are you computer literate?☐Yes ☐ No -----If NO, Please go to (1.4.1)

1.2.4 If yes, please indicate your years of computer literacy

☐< 1 years	☐1-5 years	☐6-10 years	☐11-15 yrs	☐Over 15 yrs

1.2.5Please indicate your mode of acquisition of computer literacy (Tick the appropriate box/es).

☐Learnt at At school	☐In service by employer	☐Private Lessons	☐Self thought	☐CPD training by Professional body

1.3 ICT General

1.3.1Does your firm own and use computers for its operations?☐ Yes ☐No - (If No,Pls go to section V)

1.3.2 If yes,please indicate where computers can be accessed in your organization? (Pls. tick box/es)

☐Company Office/s only	☐Project Site/s only	☐Both Company Office/s and Project Site/s

1.3.3 In your view, to what extent is ICT currently being applied in your company?

☐High	☐Medium	☐Low

1.3.4 How do you perceive the role of ICT in respect to the overall business strategy of your company?

SECTION II:Firms ICT Infrastructure Status

2.1 Hardware Platforms

2.1.1 Please indicate usage of the following ICT hardware items in your organization (PlsTickbox/es).

01. Desktop computers

02. Laptops

Personal Digital Assistants (PDAs),

03. Handheld computers/Tablet PCs

04. Mobile phones

05. Digital Cameras

06. Multi media projectors

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07. Other(Pls.Specify……)

09 ……

10 ……

2.2Operating systems in use

2.2.1Please indicatetheOperating System currently being used in your organization? Pls. tick.

☐Windows 98	☐Windows 2000/2003	☐Windows XP	☐Windows Vista	☐Other ……

2.2.2 Please statewhy the choice of Operating System indicated above? Pls. tick.

☐Availability	☐Cost	☐Familiarity	☐Other (Pls Specify)……

2.3Communications and Network Platforms

2.3.1. Arecomputers in your organization Networked? (Pls. tick appropriate box)

☐Yes ☐No -- If NO, Please go to (2.3.3)

2.3.2 If yes,please indicate the Computer network infrastructure being used inyour organization? (Pls. tick)

☐Local Area Network (LAN) (Network within office, site etc)	☐Wide Area Network (WAN). (Network among offices& sites)	☐Other Please specify……..

2.3.3 Does your organization have e-mail accounts for official communication?

☐ Yes ☐No

☐ Critical	☐ Value adding	☐ supporting	☐ None

2.3.4 Is your organization connected to the internet?(Pls. tick appropriate box)

☐ Yes ☐No ----If NO, Please go to (2.4.1)

2.3.5Please indicate where internet can be accessed in your organization? (Pls. tick box/es)

☐Company Office/s only	☐Project Site/s only	☐Both Company Office/s and Project Site/s

2.3.6Does your company have a page on the World Wide Web (WWW)? (Pls. tick appropriate box)

☐Yes ☐No

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2.4ICT Workforce

2.4.1 Do you have a Separate IT Division or someone responsible for IT within your organization? ☐ Yes ☐ No ----If NO, Please go to (2.4.3)

2.4.2 If yes, Please indicate which of the following services is/areprovided by your in-house IT Division? (Pls. tick relevant box/es)

01. Desk sidesupport ☐
02. Internet & e-Mail support ☐
03. DatabaseMaintenance ☐
04. Networking ☐
05. HardwareMaintenance ☐
06. SoftwareSupport Services ☐
07. SoftwareMaintenance ☐
08. Other (Pls. specify……..) ☐

2.4.3 Please indicate which of the following services is/are outsourced (Pls. tick relevant box/es)

☐
☐
☐
☐
☐

01. Desk sidesupport
02. Internet & e-Mail support
03. DatabaseMaintenance
04. Networking
05. HardwareMaintenance
06. SoftwareSupport Services
07. SoftwareMaintenance
08. Other(Pls. specify……..)

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2.4.4 What isthe current averagestaff to computer ratioin your organization?(Pls. tick relevant box)
(NOTE: **Ratio= No. of staff ÷ No of Computers)**

1:1	2:1	3:1	4:1	Other (please specify)

2.4.5 What minimum **academic qualifications** do current users of computer in your organization have?

Academic Qualification	**IT Qualification**	**Non IT Qualification**
Masters		
Degree		
Diploma		
Certificate		
Other(Pls. specify……..)		

SECTION III:Level of usage of Information and Communication Technology(ICT) in organisation

3.1 Please indicatethe **extent**of **Computerisation** or **usage of computer softwares** for the following **activities**in your organization.**(**Note**: 1= Never; 2=Not always;3=Average; 4=Quiet always; 5=Always.)**

☐1	☐2	☐3	☐4	☐5

Activity					
01. Book-keeping					
02. ProjectDrawings					
03. Purchases and Invoicing					
04. Technical Calculations					
05. Costing and budgeting					
06. Estimating					
07. ResourcesManagement (Labour, Material and Equipment)					
08. Scheduling and works planning					
09. Accounting/payroll					
10. ProjectRecords					
11. Taken- off					
12. Progress reports					
13.Financial management					
14.Site management and security					
15. Project Cost control					
16.Subcontractors and suppliers information					
17.Communication (with project sites and external Parties)					
18.Distributionsof project Documents.					

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3.2 Please indicate the **extent of usageor application**of the following ICT **tools**in your company
(Note: 1= Never; 2=Not always;3=Average; 4=Quiet always; 5=Always.)

☐**1**	☐**2**	☐**3**	☐**4**	☐**5**

ICT Application

01.E-mailand Short Message Services (SMS)
02. Mobile internet
03. Videoconferencing
04. Electronic purchasing (E-purchasing)
05. Teleconferencing
06. Global Positioning Systems (GPS)
07. Geographic information Services (GIS)
08. Radio Frequency Identification (RFID) and barcodes
09. Project specific websites (Extranets)
10. Site surveillance Technologies (e.g CCTV etc)
11. Electronic tendering (E-tendering)
12. Modeling and visualization (eg.3D-CAD, 4D-CAD etc)
13. Electronic document management systems (EDMS)
14. Integrated software (e.gEnterprise Resource Planning; ERP)

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3.3 General and Technical Software Usage

3.3.1 Please indicate usage of the following commercially available software in your organization.(Pls. tick relevant box/es)

General Administration/Business Systems	Never Used	Daily Use
Word Processors (e.gMs Word)		
Spreadsheets (e.gMs Excel)		
Presentations (e.gMs Power Point)		
Databases (e.gMs Access)		
Other (Pls. Specify……)		
Project Planning and Scheduling		
Microsoft Project		
Primavera		
Power Project		
PMSystems,		
Other (Pls. Specify……)		
QS,Estimating and Cost calculations		
WinQS		
Esti-mate,		
Manifest,		
Buildsoft,		
Masterbill,		
Other (Pls. Specify……)		
Computer Aided Design (CAD)		
AutoCAD		
ArchiCAD,		
Other (Pls. Specify……)		

3.3.4 Does your firm have some proprietary or in-house software designed for your own office use?

☐Yes ☐No

3.3.5 Would your organisation be interested to support a Ghanaian IT company that want to offer such proprietary software services? ☐Yes ☐No

SECTION V:Reason hindering useof ICT in your organisation.

5.1 Which of the following statements in your opinion, best describe reasons hindering the use of ICT in your organization.(Pls. tick) (**Note: 1=Very Weak; 2=Weak;3=Average;4=Strong;5=Very Strong.)**

☐1	☐2	☐3	☐4	☐5
☐1	☐2	☐3	☐4	☐5
☐1	☐2	☐3	☐4	☐5

☐1	☐2	☐3	☐4	☐5
☐1	☐2	☐3	☐4	☐5

Reasons

Financial Reasons

01.Budget constraint for ICT investment

02. Cost of training professionals in ICT

03. Limited benefits/Low return on investment in ICT.

04. High cost of employing ICT professionals

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Human Reasons

05. Inadequate ICT content of construction education

06. Lack of commitment by firm's management towards ICT

07. Inadequate knowledge about return on ICT investment

08. Lack of staff with appropriate skill and knowledgein ICT

09. Fear of job losses /making professionals redundant.

10. Satisfaction with existing method of working.

Technical Reasons

11. Rapid changes in ICT technologies

12. Problem of ICT integration/compatibility in the organization

13. Software and hardware reliability problems

15. Security concerns/privacy fears

14. High rate of obsolescence ICT products in the Ghanaian market

15. Access to relatively cheap work force

EnvironmentalReasons

16. Majority of client not interested in firms ICT base

17. Lack of adequate jobs in the market

Legal Reasons

18. Risks for liability

19. Lack of legal support for use of ICT

20. Securityimplications of ICT transactions					

THANK YOU

Your final comments (if any)…….....

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