A SYSTEMS APPROACH TO INVESTIGATING THE EFFECTIVENESS OF USING A WEB PORTAL TO ENHANCE INFORMATION SHARING IN THE UGANDAN CONSTRUCTION INDUSTRY

A Dissertation Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Science in Construction Project Management in the School of Civil Engineering, Surveying, and Construction, Faculty of Engineering, University of KwaZulu-Natal.

Richard Irumba

Supervised by Mr. Keith Rennie

February 2005

Declaration

I hereby declare that this dissertation is my own work and it has not been submitted for a degree at any other University.

RIrumba

Richard Irumba

As the candidate's supervisor I **have/~~have not~~** approved this dissertation for submission.

Signed: Name: K.L. RENNIE Date: 22 MARCH 2005

Dedication

To mum Beatrice Adyeeri, for her understanding, love, care and support for my academic life.

To my little angel, Kathryn, for her beauty, intelligence, and accepting to put up with an always absent Dad.

Richard Irumba.

Acknowledgements

I wish to express my sincere thanks to the many people who have contributed to this dissertation. The following persons, however, deserve special mention and are acknowledged for their co-operation and assistance in different aspects of this study.

To Mr. Keith Rennie, in his capacity as supervisor of this dissertation, my thanks for his guidance and constructive advice.

To Mr. George Mbuthia for providing relevant journal articles and for editing the research proposal.

To Mr. Roger Courau for his constructive comments on the research and for editing this manuscript.

To Engineer Nkya Kiiza for providing relevant articles on the Ugandan construction industry and for establishing contacts with senior officers of the Ugandan Ministry of Works, Housing, and Communications.

To Professor Rob Pearl, Professor Paul Bowen, Associate Professor Jackson Mwakali, Architect Dr. Barnabas Nawangwe, Engineer Patrick Batumbya and Mr. Bert van den Heever for participating in the validation of the conceptual web portal model.

My thanks to Germany Academic Exchange Service (DAAD) in collaboration with African Network of Scientific and Technological Institutions (ANSTI) for sponsoring my studies in South Africa and to Makerere University Kampala for granting me study leave.

May God bless you all.

Abstract

Over the last fourteen years the construction industry in Uganda has experienced an annual average growth rate of 7.8%, markedly higher than the national GDP of 5.5%. However, the disparity between construction information and the lack of an organised system of sharing it between industry partners has resulted in the poor performance of construction projects. This is due to the fact that it is inadequate, inaccurate and inconsistently disseminated.

This research project investigated the effectiveness of using a web portal to enhance information sharing in the Ugandan construction industry. The work is meant as a step towards the establishment of a web portal for the industry. It is envisaged that the web portal will improve construction project planning and management through the provision of basic construction information. The study population consisted of 233 construction and consulting firms. A multi-method approach was employed in the research. This included the conducting of a questionnaire survey of 80 (i.e. sample size) firms, and an interview survey of 9 representatives of key stakeholders in the industry. A systemic approach was used to elicit the perspectives of stakeholders in the industry and to develop a holistic view of the research problem.

The results of the research have shown that the Ugandan construction industry participants have adequate IT infrastructure and Internet access capacity to benefit from the web portal. 97% of the participants have computers and 77% are connected to the Internet. 83% consider the web portal to be an effective means of sharing information and 93% are willing to share the information produced by their organisations. During the study, two conceptual models (a user's information needs model and a data flow model for stages of a construction cycle) were developed and validated by six experts in construction industry practices and communication.

The research underscores the fact that the successful implementation of the web portal will not only depend on the "hard" (or technical) factors but also on the "soft" (or people) factors, such as changing the users' thinking and methods of work, developing trust and building partnerships amongst participants. In essence, the project proposes the establishment of a building information centre to house and coordinate the web portal and its related activities.

Table of Contents

Declaration ii

Dedication iii

Acknowledgements iv

Abstract v

Table of Contents vi

List of Abbreviations x

List of Figures xii

List of Tables xiii

List of Appendices xiii

Glossary of Terms xiv

1 GENERAL INTRODUCTION 1

1.1 Background to the Research 1

1.2 Justification of the Research 3

1.3 Problem Statement 4

1.4 Hypotheses 4

1.5 Research Questions 5

1.6 Aims and Objectives of the Research 5

1.7 Summary of Research Methodology 6

1.8 Scope, Boundary, and Limitations of the Research 7

1.9 Structure of the Dissertation 8

2 LITERATURE REVIEW 10

2.1 Introduction 10

2.2 The Construction Industry in Uganda 10

2.2.1 Overview of the Construction Industry in Uganda 10

2.2.2 The Ugandan Construction Industry Organisation 12

2.2.3 Information and Communication Opportunities and Challenges for the Ugandan Construction Industry 15

2.3 Review of Web Portal Developments in the Construction Industry 17

2.3.1 Manufactured Products Web Portals 18

2.3.2 Project-Based Web Portals 18

2.3.3 Summary 20

2.4 Information Sharing and Exchange Standards 20

2.4.1 Overview of Information Standardisation 20
2.4.2 Types of Information Standards 22
2.4.3 Benefits and Barriers of Information Standardisation 27
2.5 Concluding Remarks 29
3 RESEARCH DESIGN AND METHODOLOGY 30
3.1 Introduction 30
3.2 Sampling 31
3.2.1 The Concept of Sampling 31
3.2.2 Sampling Terminology 32
3.2.3 Sample Frame and Sample Size 33
3.2.4 Sampling Strategy 34
3.3 Research Instruments 36
3.3.1 Questionnaire Survey 36
3.3.1.1 Questionnaire Design 36
3.3.1.2 Questionnaire Piloting 39
3.3.1.3 Questionnaire Administration and Response Rate 40
3.3.2 Interview Survey 41
3.3.3 Literature Review 43
3.3.4 Validity and Reliability of Research Instruments 44
3.3.4.1 The Concept of Validity and Reliability 44
3.3.4.2 Establishing the Validity and Reliability of Research Instruments 46
3.3.4.3 Testing the Reliability of Questionnaire Scales 47
3.4 Methods of Analysis 52
3.4.1 Systemic Analysis 53
3.4.2 Statistical Analysis 53
3.4.2.1 Cross Tabulations 54
3.4.2.2 Chi-square Tests 55
3.4.2.3 Graphic Displays 56
3.4.3 Comparison of Results with Findings of Similar Surveys 57
3.5 Concluding Remarks 57
4 A SYSTEMIC STUDY OF THE WEB PORTAL 59
4.1 Introduction 59
4.2 The Concept of a System 59
4.3 Overview of Hard System and Soft Systems Methodologies 62

4.3.1 Hard Systems Methodology 62
4.3.2 Soft Systems Methodology 63
4.3.3 Comparison of Hard and Soft Systems Methodologies 63
4.4 A Systemic Analysis of the Web Portal 65
4.4.1 Systems Description 65
4.4.2 Systemic Analysis: Sensing Phase 66
4.4.3 Systemic Analysis: Understanding Phase 68
4.4.4 Systems Objectives and Constraints 69
4.5 Concluding Remarks 72
5 ANALYSIS AND DISCUSSION OF RESULTS 73
5.1 Introduction 73
5.2 Respondents' Profiles 73
5.2.1 Category of Respondent Firms 73
5.2.2 Distribution of Respondents by Geographical Region 74
5.2.3 Size Distribution of Respondent Firms 76
5.3 Computer Infrastructure and Internet Access 76
5.3.1 Computer Availability 76
5.3.2 Local Area Network (LAN) Connections 77
5.3.3 Internet Access 78
5.4 Computer Usage 79
5.4.1 Software Usage 79
5.4.2 Computerisation of Business Processes 81
5.4.3 Future Plans Regarding Investments in IT 83
5.5 Status of Information Sharing in the Ugandan Construction Industry 84
5.5.1 Extent of Information Sharing amongst the Industry Participants 84
5.5.2 Category of Shared Information 85
5.5.3 Methods of Sharing Information 86
5.5.4 Weaknesses of the Existing Methods of Information Sharing 86
5.6 Assessment of Users' Information Needs 88
5.7 Viability and Management of the Web Portal from the Users Perspective 89
5.7.1 Users Views on the Viability and Benefits of the Web Portal 89
5.7.2 Management of the Web Portal 91
5.8 Challenges of Establishing a Web Portal 91
5.9 Concluding Remarks 92

6 CONCEPTUAL MODELLING AND SYSTEM SPECIFICATION 93
6.1 Introduction 93
6.2 Conceptual Modelling 93
6.2.1 Structured Modelling Approach 94
6.2.1.1 The Concept of Structured Modelling 94
6.2.1.2 Overview of Data Flow Diagrams 94
6.2.2 Construction of Conceptual Models 96
6.2.2.1 The Users' Information Needs Model 97
6.2.2.2 Data Flow Model for the Stages of a Construction Cycle 97
6.2.3 Validation of Conceptual Models 100
6.3 Web Portal Specifications 101
6.3.1 Web Portal Interface 102
6.3.2 System Security 103
6.3.3 Web Portal Architecture and Programming 105
6.3.4 System Reliability 106
6.3.5 Applications Integration 107
6.4 Concluding Remarks 108
7 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS 109
7.1 Summary of Research Findings 109
7.2 Conclusions 112
7.3 Recommendations 113
References 115
Appendices 130

List of Abbreviations

AEC/FM	Architecture, Engineering, Construction/Facilities Management
aecXML	Extensible Mark Up Language for the Architecture, Engineering and Construction Industry
AP	Application Protocol
API	Applications Programming Interface
ARB	Architects Registration Board
bcXML	Building Construction Extensible Mark Up Language
CAD	Computer Aided Design
CAP	Research Group of IT global future
CPD	Continuous Professional Development
CIB	International Council for Innovation and Research in Building and Construction
CITE	Centre for E-Business in Construction
CORBA	Common Object Request Broker Architecture
DFD	Data Flow Diagrams
EDI	Electronic Data Interchange
EMP	Environmental Management Plan
ERB	Engineers Registration Board
ERM	Entity Relationship Modelling
GDP	Gross Domestic Product
HSM	Hard Systems Methodology
HTML	Hyper Text Mark up Language
HVAC	Heating, Ventilation, and Air Conditioning
IAI	International Alliance for Interoperability
ICT	Information and Communications Technology
IFC	Industry Foundation Classes
ifcXML	Extensible Mark Up Language based on the IFC data model
ISO	International Standards Organisation
ISP	Internet Service Provider
ISU	Institution of Surveyors of Uganda
IT	Information Technology
Kbps	Kilo Bytes Per Second

Mbps	Mega Bytes Per Second
MOWHC	Ministry of Works, Housing, and Communications-Uganda
OLE	Microsoft Object Linking
OMG	Object Management Group
PKI	Public Key Infrastructure
RAFU	Road Agency Formation Unit
RCDF	Rural Communications Development Fund
RFC	Request for Change
RFI	Request for Information
RSDP	Road Sector Development Programme
SGML	Standard Generalised Mark up Language
SPSS	Statistical Package for Social Sciences
SRB	Surveyors Registration Board
SSM	Soft Systems Methodology
STEP	Standard for Exchange of Product Model Data
UACE	Uganda Association of Consulting Engineers
UCC	Uganda Communications Commission
UIPE	Uganda Institution of Professional Engineers
UNABCEC	Uganda National Association of Building and Civil Engineering Contractors
URL	Universal Resource Locator
USA	Uganda Society of Architects
UTL	Uganda Telecommunications Limited
VSAT	Very Small Aperture Terminal
W78	Working Commission 78 of CIB concerned with IT for construction
XML	Extensible Mark up Language

List of Figures

Figure 1-1: Scope and boundary of the research ... 7
Figure 2-1: The Ugandan construction industry organisation ... 14
Figure 4-1: A general conception of a system ... 60
Figure 4-2 Two paradigms of inquiry: HSM and SSM ... 64
Figure 4-3: Objective tree diagram ... 70
Figure 5-1: Distribution of responses among the categories of firms surveyed ... 74
Figure 5-2: Distribution of responses by geographical region ... 75
Figure 5-3: Size distribution of respondent firms in terms of number of employees . 76
Figure 5-4: Computer availability ... 77
Figure 5-5: Software usage amongst the respondent firms ... 81
Figure 5-6: Extent of computerisation of business processes ... 82
Figure 5-7: Future plans regarding investments in IT ... 84
Figure 5-8: Category of shared information ... 85
Figure 5-9: Existing means of information sharing ... 86
Figure 5-10: Weaknesses of existing methods of information sharing ... 87
Figure 5-11: Challenges of establishing a web portal ... 92
Figure 6-1: Notation used in data flow diagrams ... 96
Figure 6-2: Users information needs model ... 98
Figure 6-3: Data flow model for the stages of a construction cycle ... 99
Figure 6-4: Web portal architecture ... 106

List of Tables

Table 1-1: Summary of research methodology 6
Table 2-1: Real factor cost GDP growth rates (1999/00-2003/04) 11
Table 2-2: Uganda construction and consulting firms 13
Table 2-3: Comparative Summary of the Communications Services Sector, 1996-2001 16
Table 2-4: Total data uplink and downlink capacity 17
Table 3-1: List of interviewees 43
Table 3-2: Reliability analysis: software usage 49
Table 3-3: Reliability analysis: computerisation of business processes 50
Table 3-4: Reliability analysis: existing means of information sharing 51
Table 3-5: Reliability analysis: assessment of information needs 52
Table 4-1: Comparison of HSM and SSM 64
Table 5-1: Distribution of categories of firms by geographical region 75
Table 5-2: Statistics of LAN connections for the categories of firms surveyed 78
Table 5-3: Comparative statistics on software usage 80
Table 5-4: Chi-square test on the weaknesses of the existing methods of information sharing 87
Table 5-5 Information needs assessment: ranking by respondent firms 88
Table 5-6: Chi-square test on the benefits of the web portal 90

List of Appendices

Appendix A: Sample Questionnaire 131
Appendix B: Interview Guide 139
Appendix C: Validation of Conceptual Models 142
Appendix D: Systems Diagrams 147

Appendix D 1: Spray diagram of the web portal system 148
Appendix D 2: Rich Picture of the web portal system 149
Appendix D 3: Systems Map of the web portal 150
Appendix D 4: Influence Diagram of the web portal system 151
Appendix D 5: Multiple cause diagram of the web portal system 152
Appendix D 6: Sign graph of the web portal system 153

Glossary of Terms

Authentication:

This is a mechanism that determines the credibility and identity of users. It involves verifying security access via passwords, voice, digital certificates, *etc.*

Communication Technology (CT):

The hardware, the know-how, the programs and the methods used, in ensuring that the message is transmitted correctly, efficiently and cost-effectively.

Conceptual Modelling:

A process of representing a user's information view in some formal definition form.

Hard System:

One perceived to have well-structured components and definable, quantifiable attributes, which lend themselves to prediction and control.

Hard Systems Methodology (HSM):

A systems methodology which assumes that a perceived problem exists to be solved, or an unmet need or opportunity fulfilled; analysis involves detailed description of systems and a rigorous evaluation of potential strategies; client-set world view is relevant throughout.

Information and Communication Technology (ICT):

ICT is a convergence of information and communication technologies. There is no point in gathering and rapidly processing information that cannot be transmitted as fast. Similarly, there is no point in having high capacity channels if they cannot be used to full capacity.

Information System:

A set of interrelated components that collect (or retrieve), process, store, and distribute information to support decision-making, coordination, and control in an organisation; helps managers and workers analyse problems, visualise complex subjects, and create new products.

Information Technology (IT):

The hardware, software, methods, and know-how required or used in acquiring, storing, processing, and displaying data and information.

Internet:

A global network of networks, providing a highly flexible platform for information-sharing. It permits digital information to be distributed to millions of people throughout the world.

Interoperability:

The ability of technology components to work with each other seamlessly without building significant interfaces. In computer systems, interoperability is a term used to define the ability for information to flow from one computer application to another. Interoperability relies on the development and use of common data interchange standards.

Non-repudiation:

A property achieved through cryptographic methods which prevents an individual or entity from denying having performed a particular action related to data. It involves mechanisms such as non-rejection, proof of obligation, intent or commitment, or proof of ownership.

Soft System:

A system that relates to human activity.

Soft Systems Methodology (SSM):

A systems methodology intended for use where a human activity system exhibits crisis, conflict, uncertainty, or unease among the social actors; also called the 'Checkland' methodology.

System:

A group of elements, either human or non-human, that is arranged and organised in such a way that the elements can act as a whole toward achieving some common goal or objective.

Systems Analysis:

Analysing in detail the components and requirements of a system; analysing in detail the information needs of an organisation, the characteristics and components of the presently used information systems, and the functional requirements of the proposed information systems.

Systems Approach:

A logical and disciplined process of problem solving that defines the problems and opportunities in a systems context. The systems approach forces review of the relationship of the various subsystems; is a dynamic process that integrates all activities into a meaningful total system; systematically assembles and matches the parts of a system into a unified whole; seeks an optimal solution or strategy in solving a problem; blends systematic and systemic approaches.

Systems Thinking:

Recognising systems, subsystems, components of systems, and systems' interrelationships in a situation; involves a holistic approach that looks at the behaviour of wholes; also known as a systems context or a systemic view of a situation.

Systematic:

A logical and directed way of doing something.

Systemic:

Relates to the notion of a system and implies holism and emergence.

Web Portal:

A web based information system that offers a broad array of information resources to attract and keep a large audience; uses a web site as an interface.

1 GENERAL INTRODUCTION

"A decision maker can't respond to information he or she doesn't have, can't respond accurately to information that is inaccurate, can't respond in a timely way to information that is late" (Meadows, 2002:2).

1.1 Background to the Research

Information Technology (IT) is now widely used in the construction industry (Howard *et al.* 1998; Rivard, 2000; Murray *et al.*, 2001). However companies are not fully benefiting from its implementation because of organisational issues (Markus and Robey, 1988). Whyte *et al.* (2002), citing Wroe (1986), argue that it is a combination of organisational and technological factors that affect the implementation of IT in the construction industry.

The construction industry is information intensive as it requires accurate, reliable, and promptly-provided information; ranging from legal requirements, building codes and standards, construction industry research results, manufactured product specifications and site specific data about past and present construction projects (Mathur *et al.*, 1993). Mbadhwe (2000) argues that construction is one of the most information-dependant industries with various forms of necessary data, including detailed drawings, images, photographs, cost analysis sheets, budget reports, risk analysis charts, contract documents and planning schedules. Therefore, for the construction industry to fully progress towards the knowledge society and economy, it must build upon its existing information base. This is widely spread, though unique within individual countries, although there may be significant overlaps between some countries. Drawing together the already mentioned information resources and connecting them to each other enables a more effective, coordinated, informed and intelligent industry (Bloomfield and Amor, 2001).

The Ugandan construction industry is geographically diverse with a sizable number of construction firms, ranging from small to larger concerns. The industry possesses a variety of participants, including Architects, Engineers, Project Managers, Quantity

Surveyors, Contractors, to the Government and Property Developers; each of these actors has specific information needs. Thus, a web-based information portal can serve as a centrally-accessible system, where industry participants can access and use construction information.

Accordingly, Detlor (2003:122) defines a web portal as "a single website that orients users within an organisation to various internal and external information sources such as department websites, external websites, databases, and electronic documents", while. Rivard *et al.* (2004:30) see it as "a website that offers a broad array of resources and services to attract and keep a large audience and aims to become its main entrance to the Internet". From these definitions, it can be deduced that a web portal is a *source*, a *provider* of information resources, and a *gateway* to other forms of data.

The development of the web portal for the Ugandan construction industry requires effective participation of its actors. User participation in IT implementation improves the requirements determination process, leads to greater buy-in, and keeps users informed about progress (Newman and Sabherwal, 1996; Hunton and Beeler, 1997). This results in higher levels of user satisfaction, system quality, and system usage (Gallivan and Keil, 2003, citing Hwang and Thorn, 1999). Similarly, it can be argued that user-developer interaction encourages the users to "own", to take possession of the system in a proactive, positive way, and this contributes to its acceptance during implementation. Whyte and Bouchlaghem (2001) and Whyte *et al.* (2002) conclude that user-developer interaction is critical for the successful implementation of IT in the construction industry, and successful uptake of IT requires involvement of both upper management and technical managers in strategic decision-making.

The web portal is accessed through the Internet by its users. The internet provides a highly flexible platform for information sharing (Laudon and Laudon, 2002). Armstrong (1996) argues that from the users' perspective the main attraction of the web is its ease of use, common interface, initial low entry cost and the notion that information is immediately accessible. The Internet is completely changing the way people (or organisations) work together; it bridges geographic distances and time differences with instant global communication, enabling people and organisations to share information in real time, while providing a virtually unlimited knowledge base (Augenbroe *et al.*, 2002). All of these positive traits make the Internet a perfect medium for the disparate construction industry participants in Uganda to disseminate construction information.

1.2 Justification of the Research

As has been noted already, the construction industry in Uganda is very diverse, and possesses no organised system of sharing information among its members. As noted by Latham (1994) in the United Kingdom, such widely dispersed, uncoordinated information, makes such an industry susceptible to low productivity, cost and time overruns, conflicts and disputes, resulting in unnecessary claims and time consuming litigation.

The major premise of this research is that the web portal will improve construction project planning and management through the provision of basic construction information, for effective management is about making decisions based on experience, knowledge, and information (Mbadhwe, 2000). (In other words, the more informed a manager is the greater the chances for a project's success.)

The Ugandan construction industry lacks cost and resource databases. This makes monitoring of project cost performance very difficult if not impossible (Tindiwensi, 2000). To achieve effective project cost control, contractors need to have a good grasp of measured works i.e. concrete, reinforcement, and formwork, and also require access to labour rates (*ibid.*). Such basic data is not available in an organised database in Uganda.

Amor and Betts (2001) and Sarshar *et al.* (2002) indicate that in the construction industry it is essential to rely on past knowledge and information when dealing with new projects. The implication of this is that the construction industry requires systems that can capture historical data. In a case study dealing with Ballast Construction Company, Sarshar *et al.* (2002) suggest that construction portals and the web will improve information sharing between construction parties, while Rivard *et al.* (2004) assert that web portals allow collaboration and information exchanges in the AEC/FM industry in a fast and efficient manner regardless of distance. Thus, a web portal will serve as a centrally-accessible system providing information to the Ugandan construction industry parties. Sulankivi (2004) observes that the use of a centralised information system in construction information sharing leads to qualitative as well as quantifiable benefits measured in terms of time and money. Having already mentioned that information needs vary from country to country, and from region to region (Bloomfield and Amor, 2001), it is clear that the Ugandan construction industry web portal may in most aspects be different from existing construction portals.

1.3 Problem Statement

The construction industry information in Uganda is disparately organised, and there is no coordinated system of sharing information amongst its participants. This has resulted in the poor performance of construction projects due to inadequate, insufficient, inaccurate, inconsistent and late provision of construction information. The construction portals that have been developed elsewhere in the construction industries of other countries as a means of information sharing, lack effective user-developer interaction in their development methodology. Therefore, through interaction with industry participants, this research sets out to investigate the effectiveness of using a web portal to enhance information sharing in the Ugandan construction industry.

1.4 Hypotheses

Having stated the research problem, studied possible solutions, and reviewed the relevant literature (Kerlinger, 1986), the main hypothesis tested in the research is that:

"A Web Portal developed through effective user-developer interaction is a feasible means of information sharing in the Ugandan Construction industry".

In the context of this research, a feasible system of information sharing is considered to be a system that is acceptable to users and serves their basic information needs.

The above main hypothesis was investigated further by testing the following sub-hypotheses.

1. The Ugandan construction industry participants have the capacity and relevant infrastructure to utilise a web portal.
2. The existing means of information sharing in the Ugandan construction industry do not adequately serve the information needs of industry participants.

1.5 Research Questions

The main research questions considered by this study are:

1. Existing means of information sharing by construction industry participants.
2. Information needs of construction industry participants.
3. The availability of computers and access to Internet by industry participants.
4. The willingness of construction industry participants to provide construction information.
5. The challenges of sharing information using a web portal
6. The management and maintenance of the web portal

1.6 Aims and Objectives of the Research

Aim

The overall aim of this research is to investigate the effectiveness of using a web portal to enhance information sharing in the Ugandan construction industry. The research is a step toward the establishment of a web portal for the local industry.

Research Objectives

1. To study the existing means of information sharing by the construction industry participants in Uganda.
2. To assess the information needs of the Ugandan construction industry participants.

3. To assess the capacity of the Ugandan construction industry participants to utilise a web portal.
4. Based on the results of objectives 1 to 3, to develop a conceptual model of the web portal system.

1.7 Summary of Research Methodology

The summary of the work undertaken to meet the requirements of the objectives outlined in section 1.6 is given in Table 1.1 below. The detailed discussion of the research methodology is given in chapter three of this report.

Table 1-1: Summary of research methodology

Research Stage	Methods	Output
Conceptualisation	➢ Literature review	➢ Research proposal
Data collection	➢ Questionnaires ➢ Interviews ➢ Literature review	➢ Defined existing means of information sharing ➢ Defined user information needs ➢ Assessment of the capacity of the participants to use the portal
Data processing	➢ Systemic analysis ➢ Statistical analysis ➢ Comparison of results with findings of similar surveys	➢ Systems diagrams ➢ Descriptive and inferential statistics ➢ Graphs and Charts.
Conceptual modeling and system specification	➢ Structured modeling using Data Flow Diagrams ➢ System requirements specification	➢ A users information needs model ➢ A data flow model for the stages of a construction cycle ➢ Web portal specifications

1.8 Scope, Boundary, and Limitations of the Research

The research involved the collection, processing, and analysis of construction information from Architecture, Quantity Surveying, Project management and Contracting, Consulting Engineering firms, and the Ugandan Government Ministry of Works, Housing and Communications. However, because of limitations of time and resources, the research did not address the information needs of construction researchers, and the public or facility users.

Additionally, the research did not consider the economic feasibility of the web portal and other technical requirements of detailed design, implementation, and maintenance. However the research findings (chapter five) and the conceptual web portal model (chapter six) provide a sound basis for detailed design and implementation of the system.

The scope and boundary of the research is summarised in Figure 1.1 below.

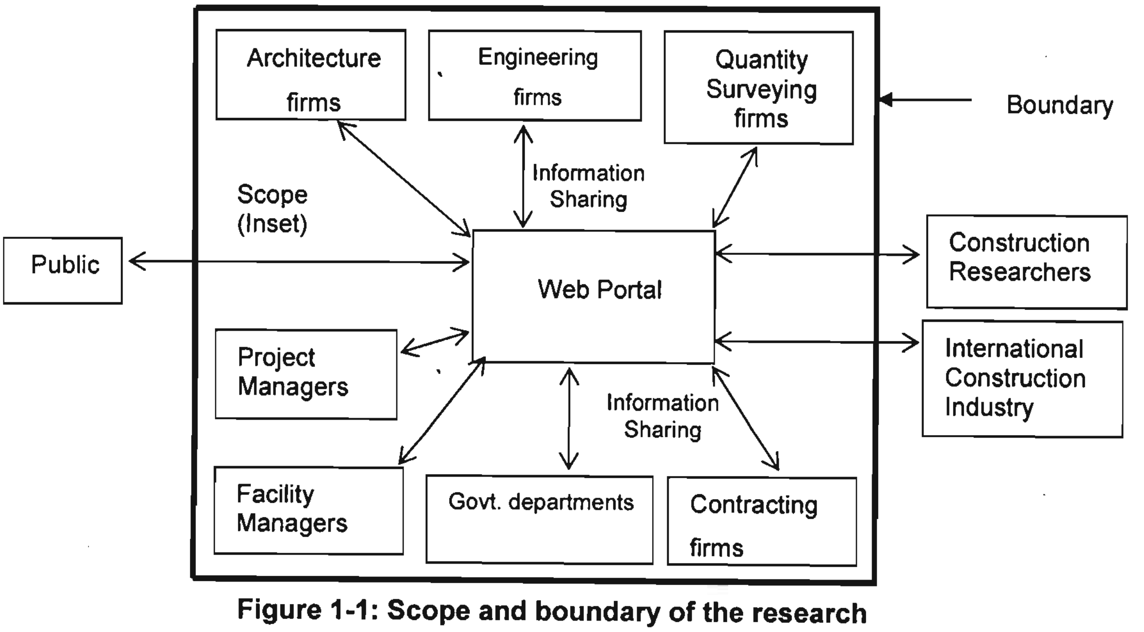


Figure 1-1: Scope and boundary of the research

1.9 Structure of the Dissertation

The schema behind the structure of the dissertation is obviously a logical flow of research ideas and arguments. The dissertation is divided into chapters which build upon what has already been considered, while this sense of conceptual connectivity helps to provide a complementary structure that reinforces the central argument. A brief summary of the contents of each chapter is given below, consistent with the format recommended by Melville and Goddard (1996).

Chapter one: General Introduction

This introductory chapter establishes the theoretical background and justification for the research. The chapter explores the research problem and presents the aims and objectives of the research, hypotheses, the scope and limitations of the research.

Chapter two: Literature Review

This review of the relevant literature on related research on the construction industry in Uganda, discusses the web portal development projects that have been implemented elsewhere in the construction industry, thus establishing for the reader a sense of precedence. A survey of the relevant information sharing and exchange standards is presented, while within the body of the chapter, gaps in current research are identified and what the contribution of this research project will achieve in resolving the central research problem.

Chapter three: Research Design and Methodology

Here, the approach to the research survey and sampling process is explored, and a detailed explanation of the research instruments including Questionnaires, Interviews, and Literature Review is provided. The chapter also gives an overview of the methods of analysis used in the study.

Chapter four: A Systemic Study of the Web Portal

This substantive chapter discusses the systemic approach to studying the web portal, and develops a theoretical framework on systems and the systemic approach, applying the hard and soft system methodologies to study the problem situation.

Chapter five: Analysis and Discussion of Results

Here, a thorough analysis of the data collected from construction industry participants in Uganda is set out. The results of the research are discussed in order to affirm or not affirm the original thoughts presented in the introductory chapter, and whether the research results reaffirm or reject what other researchers have determined. The data is processed and presented in a form suitable for the subsequent stage of conceptual modelling and system specification.

Chapter six: Conceptual Modelling and System Specification

This chapter, engaging with Conceptual Modelling and System Specification, builds on the analysis and discussion of results presented in the previous chapter, and is intended to develop a conceptual design of the web portal and to compile a set of web portal specifications.

Chapter seven: Summary, Conclusions and Recommendations

As proposed by Holt (1998), in this concluding section, a critical relationship is established between the hypotheses stated in the introductory chapter one, and the results of this research project. While a summary of the research findings and the conclusions drawn from the research is considered, in addition, recommendations are made on the efficacy of establishing an administrative framework of the web portal and for further work on the system.

2 LITERATURE REVIEW

2.1 Introduction

The purpose of this literature review is to explore the available body of knowledge on the research topic (Leedy and Ormrod, 2001; Mouton, 2001). As suggested by Holt (1998), in order to fully understand the status of the research topic and particularly the study area, section 2.2 is included. This section provides an overview of the status of the construction industry in Uganda and also reviews the local research that has been conducted on related topics. Section 2.3 reviews the web portal developments that have taken place in the construction industry with the view of discovering their strength and weaknesses, while Section 2.4 explores information sharing and exchange standards. Finally, section 2.5 presents a summary of the gaps identified during literature review and develops an argument on how the research attempts to fill these gaps.

2.2 The Construction Industry in Uganda

2.2.1 Overview of the Construction Industry in Uganda

The construction industry encompasses the sectors of building and civil engineering works (Hauptfleisch and Sigle, 2004), and is concerned with the planning, regulation, design, manufacture, installation, and maintenance of buildings and other structures (Harvey and Ashworth, 1993; Ashworth, 1994). All of these elements are important in developing countries such as Uganda.

The benefits that accrue from the Ugandan construction industry are extensive, for it is the largest absorber of local artisans, technicians, and construction professionals (Lore, 2001). It has been instrumental in the development of the country's infrastructure; in the construction of facilities for housing, roads, and other infrastructure (*ibid.*). The industry is the market outlet for hardware business, building materials, and the transport industry, and it offers employment opportunities to many individuals, especially those in the lower income bracket, through the adoption of the now popular Labour-based technology. Labour-based technology refers to "a structured method of providing or maintaining infrastructure to a specific standard, while optimising the use of labour, and employing people with fair working conditions" (Higenyi, 2000:2), and in Uganda, approximately 30% of the rehabilitation of feeder roads, 99% of routine maintenance on feeder roads, and 5,500km on trunk roads is conducted through these methods (Higenyi, 2000).

Over the past fourteen years, the Ugandan construction industry has thrived as a result of the liberalisation of the economy which has attracted both local and foreign investors. From 1991 to 1997, construction work increased by 38%, while the Gross Domestic Product (GDP) on average increased by 25% (Charlotte *et al.* 1997). The annual average growth rate of the Ugandan construction industry is 7.8% (Lubega *et al.*, 2000), while the average GDP growth is 5.5%, and the average annual per capita GDP growth was 3.9% in the past decade (World Development Report, 2004). These statistics clearly indicate that the construction industry in Uganda is growing at a more rapid rate than the wider economy. Economists often express the relative performance of sectors in the economy in terms of multiplier effects (Snyman and Langenhoven, 1998). In other words, the growth in the Ugandan construction industry could be a multiple of the growth in the economy; the number of house holds living in permanent houses has increased from 25% (1986) to 60% (2003) in urban areas, and from 2% to 10% in rural areas, during the same period (Matovu, 2003). In Table 2.1 below, are set out the statistics on the performance of the construction industry in relation to the economy over the period 1999/00 to 2003/04. The construction industry experienced a recession in 2000/01, but since then it has steadily recovered.

Table 2-1: Real factor cost GDP growth rates (1999/00-2003/04)

	1999/00	2000/01	2001/02	2002/03	2003/04
Construction Industry GDP growth (%)	7.1	1.8	12.5	12.9	8.1
Total GDP (%)	6.2	5.3	6.3	4.9	5.8
GDP per capita (%)	2.6	1.8	2.8	1.4	2.2

Source: National Budget (2004)

The construction industry enjoys an amicable relationship with the Ugandan government. The Ministry of Works, Housing, and Communications (MOWHC) is committed to strengthening and facilitating the local construction industry by increasing opportunities for the involvement of indigenous private contractors and consultants, and offering training through capacity building programmes (Ministry Policies, 2003). The involvement of the private sector is the only way of building a sustainable construction industry that will in turn viably underpin the economy (*ibid.*).

2.2.2 The Ugandan Construction Industry Organisation

The Ugandan construction industry consists of government departments, contractors, consultants, manufacturers of raw materials, and other parties, who are involved in the delivery of building and civil engineering services (Bagonza, 2000). The Ministry of Works, Housing, and Communications (MOWHC) is the main government department responsible for the local construction industry. However, as a result of the government's decentralisation policy, low scale construction works, including the development and maintenance of feeder roads, have been transferred to the Ministry of Local Government. MOWHC has two directorates; namely, the Directorate of Engineering, and Directorate of Transport and Communications, which operates in consultation with the Department of Finance and Administration. MOWHC operates a special unit called the Road Agency Formation Unit (RAFU), which was established to manage the ten year (1997-2006) Road Sector Development Programme (RSDP) (Bagonza, 2000). The RSDP requires US $1.5 billion worth of investment to operate successfully over the ten year period, and is mainly funded by the international donor community (MOWHC, 2002). RSDP covers main roads maintenance and improvement, institutional capacity building and studies, and related district and urban road sector developments (*ibid.*).

The Ministry's communication department is responsible for formulating and monitoring the implementation of communication policies, ensuring provision of efficient and affordable communications services, and ensuring efficient and affordable advanced Internet-based services, including e-business, e-governance and other services (Ministry Policies, 2003). In sum, Bagonza (2000) indicates that the organisational structure of the MOWHC, as outlined above, is responsible for the overall planning, policy formulation and implementation, inspection, and advocacy.

The construction professionals and contractors are organised into professional bodies, namely the Ugandan Institution of Professional Engineers (UIPE), the Ugandan National Association of Building and Civil Engineering Contractors (UNABCEC), the Ugandan Society of Architects (USA), the Institution of Surveyors of Uganda (ISU), and the Ugandan Association of Consulting Engineers (UACE). In terms of the general premise of this research project, it is clear that these professional and industrial associations would benefit greatly from the web portal.

Provided in Table 2.2 below, then, is a summary of the construction and consulting firms registered with the above professional and industry bodies. The total Engineering population is estimated to be 1500, with UIPE having a total of 500 corporate members, and the Engineers Registration Board (ERB) having approximately 300 Engineers registered with them (Crossley and Hollway, 2000).

Table 2-2: Uganda construction and consulting firms

Type of Firm	Number of Firms
Architectural firm	52
Quantity Surveying firm	12
Consulting Engineers	19
Contractors	150
Total	**233**

Source: Secretariats for UACE, UIPE, USA, UNABCEC, ARB, SRB, ISU and MOWHC.

The Ugandan construction industry is characterised by typically informal construction business; Charlotte *et al.* (1997) accordingly highlight that the informal construction sector accounts for up to 70% of all construction in Uganda. Lubega *et al.* (2000), (citing the chairman of UNABCEC, as quoted in the Journal of UIPE of April/May 1999), indicate that there are approximately 250-300 contractors in Uganda. Therefore, in relation to UNABCEC records, it can be determined that there are approximately 100-150 contractors conducting informal construction business in Uganda. In drawing together the aforementioned information, a summary of the Ugandan construction industry organisation structure presented as Figure 2.1 below:

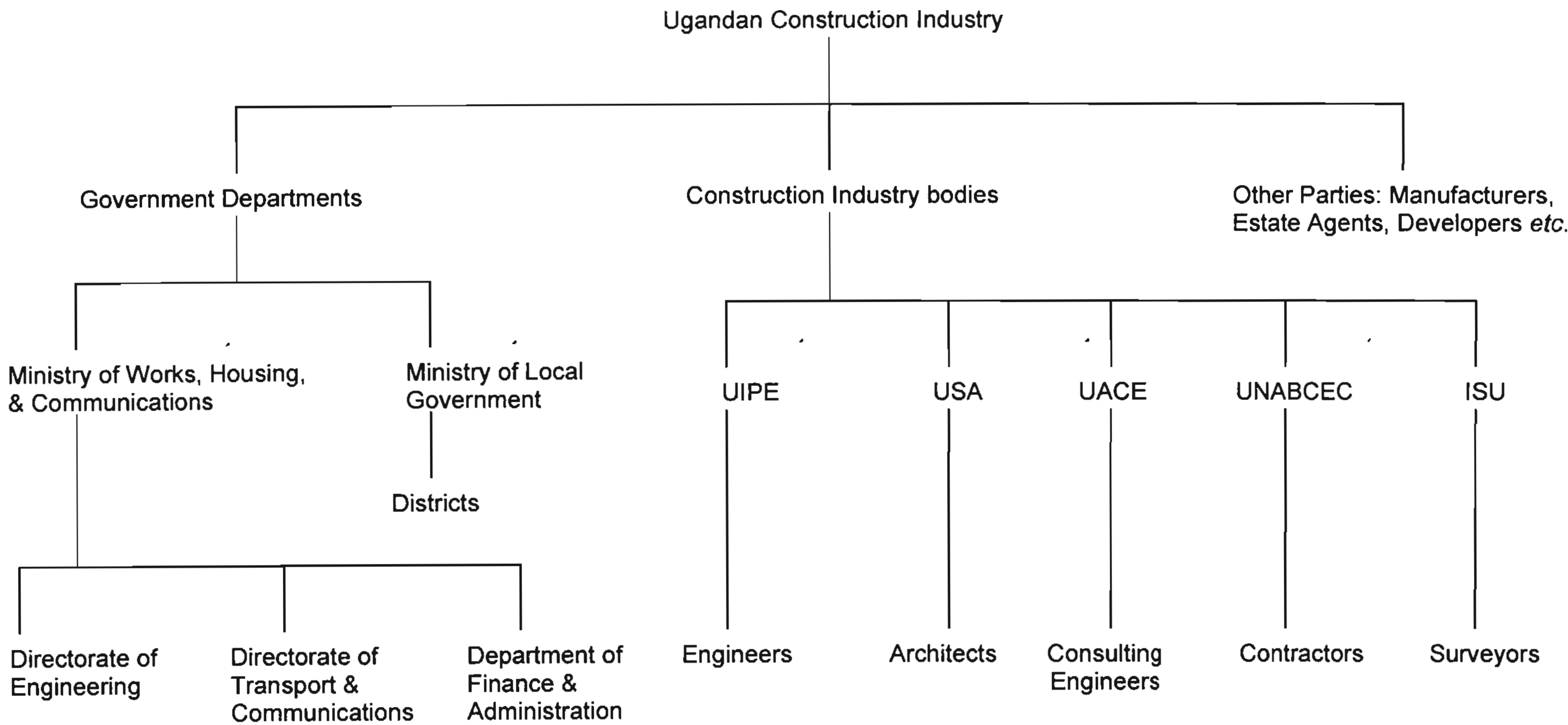


Figure 2-1: The Ugandan construction industry organisation

2.2.3 Information and Communication Opportunities and Challenges for the Ugandan Construction Industry

Information and Communications Technology (ICT) is a vital tool in Uganda's modernisation plans (Tusubira *et al.*, 2001), and therefore, the local construction industry, as a major player in the economy, must be an active participant in this modernisation effort. Tusubira *et al.* (2001) argue that it is important to acknowledge that it is not a question of using ICT for the sake of it, but more of using it in instances where it can increase the pace of modernisation; this means that in order to maximise the benefits of ICT use in the construction industry, there is a need to identify applications where ICT will have the greatest leveraging effect. ICT is a means that one can use to achieve more with the same resources or, better still, achieve more with less resources (*ibid.*).

Mbadhwe (2000) observes that although the construction industry has traditionally been slow to accept new technology, many users have now recognised the superiority of the Internet and are prepared to invest in it. Additionally, Mbadhwe (2000) argues that although the implementation of IT in Uganda has been staggered, the use of the Internet can facilitate effective communication in the local construction industry. Tindiwensi (2000) identifies an information gap in the Ugandan construction industry and particularly, the lack of construction cost and resource databases. The result of this has been the problems, and sometimes interruptions, that construction parties face when monitoring and controlling costs during project implementation (Tindiwensi, 2000).

One of the biggest challenges to ICT implementation in Uganda is the limited availability of infrastructure, especially in rural areas (Tusubira *et al.*, 2001). However, Tusubira *et al.* (2001) indicate that the above challenge is being addressed through enabling regulation, through roll-out obligations for the national operators, and through the Rural Communications Development Fund (RCDF); results of a baseline survey for RCDF conducted by the Uganda Communications Commission in 2000 show that the rural population are willing to pay, and indeed to pay above the normal rates, for access to ICT services.

In this regard, Table 2.3 below provides comparative figures of service providers, customer bases and service coverage between 1996 and 2001, and Table 2.4 sets out the growth in Internet access based on the available international data capacity. Interpretation of the figures presented in these Tables reveals that gateway operators increase Internet access according to the local demand for services.

Table 2-3: Comparative Summary of the Communications Services Sector, 1996-2001

	Service Provided	Dec 1996	Oct 1998	Dec 1999	Feb 2001
1	Wired Telephone lines (UTL)	45,145	55,749	57,913	58,880
2	Fixed wireless lines (MTN)	-	447	148	932
3	Fixed wireless pay phones (MTN)	-	-	200	1,650
4	Cellular subscribers (MTN, CELTEL, UTL)	3,000 CELTEL:3,000	12,000 CELTEL: 8,100 MTN: 3,900	72,602 CELTEL: 19,074 MTN:53,528	188,568 MTN: 146,634 CELTEL: 32,934 UTL: 10,000
5	Internet/ E-mail subscribers (dial up)	500	1,300	4,150	4,469
6	Internet/ E-mail subscribers (wireless)	4	8	98	1,229
7	National Telecommunications Operators	1	2	2	2
8	Mobile Cellular Operators (CELTEL, MTN, UTL)	1	2	2	3
9	VSAT International data Gateways (includes UTL and MTN)	2	3	7	8
10	Internet Service Providers	2	7	9	11
11	Public Internet Access Providers (cafes)	-	3	18	24
12	National Postal Operator	1	1	1	1
13	Courier Service Providers	2	7	11	10

Source: Tusubira *et al.* (2001:20)

Table 2-4: Total data uplink and downlink capacity

Year	Uplink	Downlink
1998	256 Kbps	384 Kbps
1999	640 Kbps	768 Kbps
Feb 2000	1.2 Mbps	1.7 Mbps
Feb 2001	4.088 Mbps	5.216 Mbps

Source: Tusubira *et al.* (2001:20)

2.3 Review of Web Portal Developments in the Construction Industry

Many construction portals have been developed both at commercial and research levels, especially in Europe. Several of these portals failed after a short period of time, mainly because of tight market competition, and the lack of known business models for successful systems (Bloomfield and Amor, 2001). It seems cogent at this point, to consider a several examples of construction portals. Firstly, one might suggest the moderately successful I-SEEC/CONNET project from Europe. It is a collaborative project funded by the European Union with the overall goal of creating an infrastructure to enable and link high quality commercial electronic information services throughout its member countries of Belgium, Finland, Germany, Iceland, Italy, Netherlands, Slovenia, Spain, and the United Kingdom (Bloomfield and Amor, 2001; CONNET, 2004). However despite its achievements, the I-SEEC/CONNET project presents information at the highest level of aggregation, leaving out certain basic construction data. This may be attributed to the large size of its target market.

Another example of a web portal is the Construction and Real Estate Network (CORENET), an IT project undertaken by the government of Singapore through its Ministry of National Development, in collaboration with other public and private organisations. The aim of the project is to improve productivity and performance of the construction and real estate sectors (Sing and Zhong, 2001; CORENET, 2004). The CORENET project involves developing IT systems and key infrastructure to integrate the four processes of a building project life cycle; i.e. design, procure, build, and maintain (CORENET, 2004). Sing and Zhong (2001) indicate that successful implementation and acceptance by users of the CORENET system will lead to compression of project time and processes, improving the knowledge base of the users and will lead to the emergence of a new business model, and the creation of ample business opportunities. The other construction portals that have been launched may be categorised as manufactured products web portals and project-based web portals (Bloomfield and Amor, 2001).

2.3.1 Manufactured Products Web Portals

Manufactured products web portals form the majority of existing portals. They tend to duplicate paper-based catalogues, and in many cases resort to merely scanning the catalogue to provide the service (Bloomfield and Amor, 2001), and in this light add no value to the information they present to users. Bloomfield and Amor (2001) observe that these web portals lack comprehensiveness and often tie in a selected set of related information services, such as standards documents, industry news, and the databases of selected professionals in the industry. Examples of this category of portal include:

- Bricsnet: Operates in six European countries and provides information on design, construction, operation, and maintenance of commercial building property (Bricsnet, 2004).
- Buildonline: Conducts business in seven European countries and deals in Internet-based collaboration, software and supplier relationship management tools (Buildonline, 2004).
- Causeway Technologies: Deals in collaborative, commercial, and supply chain solutions (Causeway, 2004).
- HouseBuilderXL, HBXL: Provides house builders with information on building materials, soft ware, properties, book stores, estimating services, and manufactured products (HBXL, 2004).

2.3.2 Project-Based Web Portals

Project-based web portals allow virtual teams of project participants to be formed so that project documents are shared across the electronic media (Bloomfield and Amor, 2001). These portals offer dedicated collaboration and information-sharing functions to widely dispersed members of design, engineering, and manufacturing teams (Augenbroe *et al.*, 2002). Project-based web portals aim at minimising the potential inefficiencies associated with the traditional means of information exchange (*ibid.*). An example of such inefficiency is the extensive and lengthy RFC (Request for Change) and RFI (Request for Information) cycles in the construction phase. Augenbroe *et al.* (2002) argue that the fact that change orders and errors are unpredictable and stochastic in nature, justifies the need for a dynamic and flexible project management style.

The greatest contribution of project-based web portals is the faster exchange of digital information, especially CAD drawings (Andresen *et al.*, 2003). However, an important constraint on them is that paper versions are still considered as legally-binding documents, and therefore there is a need to change working procedures and particularly to make use of digital signatures (*ibid.*). Additionally, Andresen *et al.* (2003) observe that project-based portals are used to carry out the existing procedures more efficiently, rather than changing them, and this has often led to users discarding project web portals in preference to traditional methods. Project-based web portals should be accompanied by changing working procedures in order to provide better and more efficient services (*ibid.*), for these portals enhance collaboration by providing a single source of up-to-date project information. However, the computer interprets most of this information as black boxes, without a provision for relating similar information from varied sources (Mokhtar, 2002). Examples of project-based portals include:

- AutoDesk Buzzsaw: Deals in online collaboration and project management services (Buzzsaw, 2004).
- BIW Technologies Ltd: Conducts business in systems designed to foster collaborative working in the life cycle of projects (BIW, 2004).
- Cadweb: Deals in project information exchange, management, and collaboration on the web (Cadweb, 2004).
- Citadon: Provides online software solutions for collaboration on design, construction, and operation of projects (Citadon, 2004).

2.3.3 Summary

The majority of construction portals are privately owned and commercially operated. This material fact contradicts Bartholomew's (2000) assertion that government-owned construction portals should serve as the basis for the United Kingdom construction industry. In a similar light, most of the project-based construction portals in the Unites States were established for E-business and are currently facing fierce competition (Rivard *et al.*, 2004). However, there is evidence that users acknowledge the benefits of web portals in terms of the easy update and coordination of drawings, easy access to project information, and improved construction management capabilities (Rivard *et al.*, 2004). Most construction portals do not, however, offer information on tacit and hidden knowledge, legislation and regulations, overseas markets, and online training courses as recommended by Bartholomew (2000). There is little evidence of effective user-developer interaction in the web portal development process as recommended by Whyte and Bouchlaghem (2001) and Whyte *et al.* (2002).

2.4 Information Sharing and Exchange Standards

2.4.1 Overview of Information Standardisation

The ability to share information between computer systems is an important capability for computer-based tools and their application in the construction industry. A primary mechanism for enabling information sharing and exchange is the use of standards for representing information (Froese, 1996). Data standards provide a common language through which users of integrated computer applications can converse (*ibid.*).

The current Architecture, Engineering, Construction, and Facilities Management (AEC/FM) industry is comprised of many, diverse disciplines. Each of these uses its own unique processes and terminologies whilst working together to accomplish a common goal, which is the physical realisation of a building or civil engineering structure (Howell, 1996). A typical construction project involves the collaboration of a number of organisations, varying in size, IT capabilities, computer platform, and physical location, but which need to work collaboratively and share the same project data (Alshawi and Faraj, 2002). The information authored by the organisations is highly fragmented in its location and has limited standardisation of data representation or data delivery (Armstrong, 1996). Howell (1996) observes that sharing and exchange of information between the parties working on a construction project is not well managed, and results in excessive duplication of information, with inconsistencies and contradictions. This results in time delays, added costs, or both.

The AEC/FM industry is information-intensive and increasingly dependent upon effective Information Technologies. Various computer tools are used in this industry. However, the manner in which they have been introduced and used has resulted in a broad spectrum of isolated applications that are incompatible, and hence difficult to integrate (Alshawi and Faraj, 2002). Alshawi and Faraj (2002) suggest that there is an increasing need for these disparate construction applications to communicate with each other, as more processes are becoming computerised, and the pressure on the industry to cut down costs while at the same time increasing quality and productivity, is escalating. Froese (2003) indicates that information is passed on from one tool to the next by producing paper-based or electronic documents which can only be interpreted by individuals, who must re-enter relevant information into the next computer tool. Similarly, this manual data re-interpretation and entry is a non-value adding activity, can often introduce errors into the project, and inhibits the use of better computation tools (*ibid.*).

The problems associated with information communication and exchange across computer applications have compelled the industry to focus on the issue of interoperability (Howell, 1996; Froese, 2003). It is important to realise that interoperability; i.e. the ability for information to flow from one computer application to the next throughout the life cycle of a project, relies on the development and use of common information sharing and exchange standards (Froese, 2003). The challenge of interoperability and its resolution is currently being pursued by the International Alliance of Interoperability (IAI). It is a global industry-based consortium, established to assist AEC/FM industry practitioners, software vendors, and researchers. They are working to support interoperability by developing the Industry Foundation Classes (IFC) as a universal language to improve communication, productivity, delivery time, cost, and quality throughout the life cycle of construction projects (Froese, 1999; Froese *et al.*, 1999; Sun and Aouad, 2000; Mokhtar, 2002; Froese, 2003).

2.4.2 Types of Information Standards

Information sharing and exchange across AEC/FM applications often take place using neutral format files. A sending application translates data from its internal format and encodes it into an established neutral format (Sun and Aouad, 2000). Sun and Aouad (2000) further indicate that this file is then transferred to the receiving application where the data is translated into the internal format of the receiving system. These neutral formats for information exchange can collectively be referred to as information standards. A variety of information standards are available in the computer industry, but the discussion that follows is for the common standards applicable to the construction industry:

File Transfer Using DXF and DWG Formats

Traditionally, participants in the construction industry who use CAD-based software to design building and civil engineering structures use DXF and DWG file formats to transfer design details and drawings electronically (Sun and Aouad, 2000; Ingirige *et al.*, 2001). Ingirige *et al.* (2001) underscore the fact that DXF and DWG file formats marked the beginning of information sharing and exchange in the construction industry, but observe that very little integration is brought about by these electronic transfers. The problems encountered in file transfers based on traditional methods have necessitated other standards to be developed (Wix and Bloomfield, 1997; Ingirige *et al.*, 2001).

Electronic Data Interchange (EDI)

EDI is the electronic transfer of business data between independent computer systems using standard data formats (Froese, 1996). The essential feature of EDI is that the structured nature of data transfer enables the data to be integrated into the recipients' internal database system with no manual intervention (Baldwin *et al.*, 1996a).

EDI has been successful in a number of industries including banking, retail, and manufacturing that have very high transaction volumes (Ingirige *et al.*, 2001). Froese (1996) indicates that EDI is well established with some common business operations such as purchasing, and is now moving into technical areas such as CAD data, product catalogues, and other areas. However, Ingirige *et al.* (2001), citing Grilo (1998), note that the impact of EDI on construction has been limited to exchange of one or two types of information with very limited integration, and the largest users of EDI in the construction industry have been builders, merchants, material suppliers and manufacturers. The majority of these construction parties use EDI as a mechanism to establish links with other firms outside the construction industry (Ingirige *et al.*, 2001).

Standard for Exchange of Product Model Data (STEP)

STEP is part of the effort by the International Standards Organisation (ISO) to develop standards for representing information about products in many different industries, including the AEC/FM industry. The formal name for STEP is ISO 10303 Industrial Automation Systems: Product data representation and exchange.

STEP is based on object-oriented technology, and it provides a framework and implementation technologies for representing product design and production data in a form that can be exchanged between computer systems as files or direct online access (Froese, 1996). Sun and Aouad (2000) indicate that STEP seeks to define not only standard data models to facilitate information exchange but also standard methodologies for data modelling and data exchange. STEP does not attempt to produce a single standard model that applies across disciplines; rather the intent is to produce standard data models [called Application Protocols (AP)] for use with specific areas of application, and to strive to harmonise and coordinate these models across application areas to the greatest extent possible (Froese, 1996). STEP efforts in the AEC/FM industry have led to the development of the Building Elements Application Protocol that is aimed at representing buildings as assemblies of elements, including beams, columns, and windows; the Structural Frame Application Protocol for information integration within the steel industry, and the Building Services Application Protocol, that focuses on HVAC building services (Froese, 1996).

STEP is not only suitable for neutral format information exchange, but can also serve as a means for implementing and sharing product databases and archiving. STEP will enable product data sharing between software applications throughout a product's lifecycle, the different organisations involved in its lifecycle and the physically dispersed sites within an organisation.

Industry Foundation Classes (IFC)

Industry Foundation Classes (IFC) were developed by the International Alliance for Interoperability (IAI), and are general models for a building project that support project information sharing and exchange amongst different types of computer applications used in the project (Froese, 1999). Employing object-oriented and component software technologies, IFC provides customised, industry-based object definitions that bring together information about building elements, as well as design, construction, and management concepts (Howell, 1996). Howell (1996) indicates that there is an important difference between IFC and the other exchange standards. These are both open and proprietary, for IFC captures relationships amongst the building elements, which makes the objects act intelligently and facilitates the capturing of design content at each stage of the building process. IFC is compatible with existing data formats, including STEP, and does not seek to prevent the use of existing data mechanisms (Howell, 1996).

Owolabi *et al.* (2003) indicate that the IFC platform specification provides data structures for the AEC/FM industry shared project model, and seeks to enable data sharing across heterogeneous applications, by representing building products and their information requirements in a neutral computer language; the EXPRESS modelling language. Owolabi *et al.* (2003) extend the argument further by using an example of how IFC would enable a window manufacturer to provide its product data in a format that can simply be inserted into a CAD design program with embedded properties, such as dimensions, materials, strength, energy performance, fire rating, code compliance, applicability, cost, availability and source. It is also further stated that appropriate data about the window can then be exchanged with down stream applications such as cost estimating, and energy analysis (*ibid.*).

IFC, as an emerging information standard for the building industry, faces a number of challenges. Froese *et al.* (1999) indicate that much of IFC focus has been on representing the facilities that are being designed, but the IFC's scope of concern also includes project management information, such as costs, schedules, work tasks, and resources, though limited attempts have been made to implement and test these options. The IFC model specifically addresses building construction. However, this is an arbitrary boundary to the scope of the standard, and much value could be found in extending the scope to include the entire built environment.

Yang (2003) highlights the fact that although IFC development and implementation efforts have generated critical impacts on the conventional ways of representing and exchanging application specification information between AEC/FM software systems, the IFC model has not achieved widespread adoption on a general level in the industry.

Common Object Request Broker Architecture (CORBA)

CORBA and Microsoft Object Linking (OLE) are two emerging standards for distributed object technology (Brown *et al.*, 1996). CORBA has more to offer projects aimed at computer integrated construction and it fully supports the principles of object orientation compared to OLE, which does not support inheritance (Brown *et al.*, 1996). CORBA has been recommended by the Object Management Group (OMG, 2004) and has facilitated the development of distributed object environments where users can run and access applications on different servers without knowing where the objects are stored (Alshawi and Faraj, 2002).

One advantage that CORBA frameworks have over many existing methods of integration is that they are highly flexible and designed for re-use (Brown *et al.*, 1996). The business objects are capable of recognising their environment, interacting with other business objects, and can therefore operate throughout a wide range of integration scenarios, perhaps across industrial sectors (*ibid.*). CORBA frameworks can be easily specialised to meet the needs of the particular organisations or projects, and this is of particular relevance to the construction industry, where organisational structures and processes vary greatly from one project to another (Brown *et al.*, 1996).

A typical large-scale construction project involves many parties, a high number of decisions, and large volumes of data. Clearly, centralising such large amounts of data in a single database poses technical difficulties and hence, the rising need of distribution technology. Brown *et al.* (1996) indicate that distribution technology provides network efficiency in such a way that data in a single logical repository may be physically stored in many different locations.

Extensible Mark up Language (XML) and Web Standards

XML has been developed by the worldwide web consortium, W3C (CITE, 2004). It integrates data from different sources that are widely dispersed, exist in a variety of formats, and maintains the integrity of the data throughout the processing chain (Ingirige *et al.*, 2001). Therefore, data can be retrieved from several sources, combined and customised, and sent to another level of processing (Ingirige *et al.*, 2001).

XML provides a structured data format that can be interpreted and displayed using a simple web browser, such as Microsoft Internet Explorer or Netscape Navigator, and is rapidly becoming accepted as a universal product independent format for data exchange between computer systems (CITE, 2004). XML allows data to be freely exchanged between different software platforms and applications, allows data to have a long life span since the same data can be re-used by other applications for different purposes, and combines the power of the internet with the benefits of structured data to facilitate process integration on a much greater scale than was previously possible (CITE, 2004).

Like Hyper Text Mark-up Language (HTML), which is the design language of web pages, XML is based on Standard Generalised Mark up Language (SGML), and it therefore not only fits well within existing Internet-based services, but can also link together images and other Internet resources through embedded links (CITE, 2004). XML is not a replacement of HTML; rather, it uses style sheets which determine how information is presented, to blend its data within the HTML web page (CITE, 2004).

Research efforts into the development of XML for construction have led to the arising of three major web standards. They are ifcXML (based on the IAI-IFC data model); bcXML (building construction Extensible Mark up Language), and aecXML (XML language for the Architecture, Engineering, and Construction industry), (Amor and Faraj, 2001; Ingirige *et al.*, 2001). XML technologies provide exciting prospects when compared with the high cost and complexity of implementing interfaces to products for the ISO and IAI standard formats (Amor and Faraj, 2001). Froese (2003) indicate that XML, together with other emerging technologies in web services, may lead the way to a more widely-adopted applications interface standard for the AEC/FM industry.

2.4.3 Benefits and Barriers of Information Standardisation

The development of standards for information exchange and sharing should support the business goals of the participants in the AEC/FM industry. Wix and Bloomfield (1997) indicate that these goals are concerned with making the construction process more efficient and in so doing produce greater returns on investment for the organisations concerned. Howell (1996) argues that information sharing will allow the creation of a dynamic project model that will grow and change throughout a building's design, construction and operation phases. Using this project model will bring about cost savings and flexibility during procurement, and continued operating savings from effective facilities management (Howell, 1996). Wix and Bloomfield (1997) indicate that the use of common standards can reduce a significant part of cost and it is estimated that reductions of 10%-35% of design time and cost, and 5%-15% of facility maintenance costs, are achievable by standards based approaches. Wix and Bloomfield (1997) also state that ineffective data exchange and re-keying of information within a contracting organisation can account for up to one sixth of the available project time, and assuming a direct correlation between time and cost, then around 16% of project value could be available to a contracting organisation as profit with the use of standards based product model technology.

Thus, the use of information standards in the AEC/FM industry, among other benefits, leads to savings in time and cost due to elimination of rework during design and construction phases, increases productivity due to improved project communication, leads to efficient working of distributed virtual project teams, results in the reduction of software development costs, and leads to improved quality of decision-making and organisational learning (Ingirige *et al.*, 2001). Baldwin *et al.* (1996a) emphasise these benefits of information exchange to construction projects partnerships and alliance relationships; they mention the guaranteed delivery of data, improved quality of data, reduced data handling, improved communication between alliance partners, and reduced risk of project delay. Given the lack of enthusiasm for information exchange amongst the construction organisations, partnering may therefore be seen as a catalyst for a change in attitude towards information exchange (*ibid.*).

However, the implementation of information sharing and exchange standards in the AEC/FM industry faces a number of distinct challenges. One of the most significant is the low uptake of the technology. This may be a result of the industry lacking a proper understanding of the subject and is unaware of the benefits (Ingirige *et al.*, 2001). Wix and Bloomfield (1997) raise a similar point by stating that as much as the construction industry has been criticised by academics and software vendors as resistant to change, the participants will not take on technology because it is new, and but because it is beneficial.

Ingirige *et al.* (2001) present a summary of barriers to information sharing and exchange, and mention the uncertainty surrounding the legal position of information sharing and exchange, poor communication on the need for standardisation, short term project focus and varying client requirements, company size particularly large companies because of large volumes of procedure that are in place, technical issues related to hardware and software, and the lack of appropriate business processes to support information standardisation in the construction organisations.

2.5 Concluding Remarks

This chapter has discussed the status of the Ugandan construction industry, web portal developments in the construction industry, and information standardisation. The Ugandan construction industry, like similar sectors in other developing countries, is small in size, but given the rate of development in the recent past, there is a potential for growth in terms of size. The challenges of information sharing are not unique to the local industry, but are similar to those faced elsewhere. The greatest incentive for IT implementation in the local industry is the availability of ICT infrastructure, and the commitment of the government to expand the ICT infrastructure, and to conduct business with industry partners.

Most of the portals that have been developed for the construction industry do not serve the business interests of the industry participants, and this could partly explain the low uptake of the technology. Owing to the fact that projects are time-bound with a finite start- and end-date, project-based web portals are only fully utilised during the project's lifecycle. Project-based web portals are established to solely serve the interests of the project parties, and this arrangement helps to meet the project objectives, but limits the scope of information sharing, thus ignoring the other parties in the industry. After the completion of the project, the information generated during the project lifecycle is either lost, or remains in the hands of a few. Therefore, a web portal system that preserves such information and allows easy access to the information at any time would be a positive contribution to the industry.

The technologies of information standardisation have changed so rapidly in the last ten years or so, and some of the standards are still under development and being tested. Therefore, the industry users and software developers face a challenge in how well they are able to adopt and exploit the potential of these upcoming models and standards to increase productivity and effectiveness in the construction industry.

3 RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

The methodology employed in this research project involves a "multi-method approach" (Gillham, 2000: 81), which applies both quantitative and qualitative research methodologies. Quantitative research is used to answer questions about relationships among measured variables with the purpose of explaining, predicting, and controlling phenomena, and in contrast, qualitative research is typically used to answer questions about the complex nature of phenomena, often with the purpose of describing and understanding the phenomena from the participants' point of view (Leedy and Ormrod, 2001). Quantitative and qualitative research designs are appropriate for answering different kinds of questions and as a result we learn more about the world when we use both methodologies at our disposal, than if we reductively limited ourselves to one or the other (Creswell, 1998; Moore, 1987; Taylor, 2000). This research project followed a scientific approach, one which Kerlinger (1986) describes as a systematic process, involving reflective thinking and enquiry. This approach follows the sequential steps of problem identification and definition, hypothesis development, survey design, deductive reasoning, collection and analysis of data, and confirmation or rejection of the hypothesis (Taylor, 2000).

As has been mentioned, a multi-method approach to real-world situations is important, because one approach is rarely adequate and if the results of different methods converge then we can have greater confidence in the findings (Gillham, 2000). The purpose of the multi-method approach is to bring different viewpoints to the research which may ultimately influence its findings (Brannen, 1992). Different research methods have different, even if overlapping, strengths and weaknesses, and therefore if you use a range of methods you can construct a much more adequate sense of a real-world situation (Gillham, 2000). The multi-method approach has the potential of enriching as well as cross-validating the research findings (*ibid.*). Data sources such as interviews and demographic information may yield qualitative data that serve to enhance quantitative data reported in the research (Taylor, 2000).

Indeed,

> "There is no single way that leads us exclusively toward a better understanding of the unknown. Many highways can take us in that direction. They may traverse different terrain, but they all converge on the same destination: the enhancement of human knowledge" (Leedy and Ormrod, 2001:100).

During the research, questionnaires were employed to collect quantitative data on the sample, and interviews were used to gather qualitative data, aiding to reinforce the contextual substance of the questionnaire surveys. The literature review was used as a means to develop a theoretical framework for the research, as well as to give context to the subject and systems methodologies were employed to develop a holistic understanding of the problem situation.

Section 3.2 of this chapter explores the selection of the sample from the study population, and section 3.3 discusses the research instruments (i.e. questionnaires, interviews, and literature review). Section 3.4 considers the methods of data collection and finally, section 3.6 presents a summary of the conclusions drawn from the discussions of this chapter.

3.2 Sampling

3.2.1 The Concept of Sampling

Sampling is an essential aspect of research design, typically because it is seldom possible or practical to survey the complete population. A sample is a group selected from the complete population to make the task of research surveying less costly and more manageable, and the best approach is to select a sample that will represent, or have the same characteristics, as the overall population which is under general examination (Moore, 1987). The process of selecting a sample from the total population possesses both problems and benefits. Kumar (1999) indicates that the advantages of sampling are that it saves time as well as financial and human resources, but equally argues that the disadvantage is that the researcher does not find out the facts about the populations' characteristics of interest, but only estimates or predicts them. Hence, the possibility of an error in the estimation process exists.

Kumar (1999) further lists three principles of sampling:

Principle one: In a majority of cases where sampling is done there will be a difference between the sample statistics and the true population parameters which is attributable to the selection of the units in the sample.

Principle two: The greater the sample size, the more accurate will be the estimate of the true population parameters.

Principle three: The greater the difference in the variable under study in a population, for a given sample size, the greater will be the difference between the sample statistics and the true population parameters.

Samples must be representative of the population being studied or no general observations about the population can be made from studying the sample (Goddard and Melville, 2001). How well a sample represents a population depends on the sample frame, the sample size, and the specific design of the selection procedures (Fowler, 1984). Sample bias is another key feature that determines how representative of the population the samples are. A sample is said to be biased if it represents only a specific subgroup of the population or if particular subgroups are over or under represented in it (Goddard and Melville, 2001). Kerlinger (1986) indicates that sample bias can be avoided by using random sampling techniques (see section 3.2.4 for details on random sampling). In addition to using random sampling techniques, sample bias can be avoided by having a sample frame that covers the population accurately and completely or comprehensively (Kumar, 1999).

3.2.2 Sampling Terminology

Population. "Any group that is the subject of research interest" (Goddard and Melville, 2001:34) or "a theoretically specified aggregation of study elements" (Babbie and Mouton, 2001:173).

Study Population. "A study population is that aggregation of elements from which the sample is actually selected" (Babbie and Mouton, 2001:174).

Sample. "A smaller group, usually but not always a representative one, within a population" (Oppenheim, 1992:38).

Sampling. "The process of selecting individual units from a larger population with the purpose of investigating features of that population in greater detail" (Coombes, 2001:34).

Sample Size. "The number of respondents from whom the researcher obtains the required information" (Kumar, 1999:149) or "the fraction of the population included in the sample" (Fowler, 1984:40).

Sampling Design/Strategy. "The way the researcher selects the respondents" (Kumar, 1999:149).

Sampling Unit/Element. "An element or set of elements considered for selection in some stage of sampling" (Babbie and Mouton, 2001:174).

Sample Frame. "A more or less complete list of members of the population to be studied" (Fowler, 1984:20) or "the actual list of sampling units from which the sample, or some stage of the sample, is selected" (Babbie and Mouton, 2001:174).

Sample Statistics. "Research findings on the basis of the information obtained from the respondents (sample)" (Kumar, 1999:149). The sample characteristics become the basis of estimating the prevalence of a characteristic in the study population.

Population Parameters. "The population characteristics which the researcher wants to investigate" (Kumar, 1999:149).

3.2.3 Sample Frame and Sample Size

The sample frame for this research project was a total of 233 construction and consulting firms consisting of 52 Architectural firms, 12 Quantity Surveying firms, 19 Consulting Engineering firms, and 150 Contracting firms (see Table 2.2 for details). The sample frame was compiled using lists of firms and professionals registered with the Ugandan Association of Consulting Engineers (UACE), the Ugandan Institution of Professional Engineers (UIPE), the Ugandan Society of Architects (USA), the Ugandan National Association of Building and Civil Engineering Contractors (UNABCEC), the Architects Registration Board (ARB), the Surveyors Registration

Board (SRB), the Institution of Surveyors of Uganda (ISU), and the Ministry of Works, Housing and Communications (MOWHC).

The sample size adopted for the research, of 80 firms consisting of 20 Architectural firms, 12 Quantity Surveying firms, 19 Consulting Engineering firms, and 29 Contracting firms, was considered adequate for the statistical analysis of the research data and for prediction of population parameters. Pallant (2001:136), citing Tabachnick and Fidell (1996:132), gives a formula for calculating the sample size, taking into account the number of independent variables in the research as: $n > 50+8m$ (where n is the sample size and m the number of independent variables). Three independent variables (i.e. type of firm, geographical location, and size of firm) were used in the research, suggesting that $n > 50+(8x3)$ or $n>74$. Kerlinger (1986) argues that with samples sizes of 30 or more, there is less of a danger of biasness of the sample to represent the characteristics of the population; additionally, Holt (1998) suggests that as a "general" rule the minimum sample size should be 30.

3.2.4 Sampling Strategy

The sampling strategy adopted for this research was random (or probability) sampling and, more specifically, stratified random sampling. In a random sample, each member in a given population has an equal and independent chance of being selected (Fink and Kosecoff, 1985; Kumar, 1999; Taylor, 2000; Coombes, 2001; Goddard and Melville, 2001; Leedy and Ormrod, 2001; Mitchell and Jolley, 2001). Equal chance implies that the choice of an element in the sample is not influenced by other considerations such as personal preference, and the concept of independence implies that the selection of one member has no influence on the selection or exclusion of other members of the population from the sample (Kumar, 1999; Mitchell and Jolley, 2001). When a random sample is selected, the researcher may assume that the characteristics of a sample approximate the characteristics of the total population (Leedy and Ormrod, 2001).

In stratified random sampling, the population is divided into non-overlapping subgroups (or strata), and respondents are selected from each stratum using random sampling techniques to acquire a sample (Fink and Kosecoff, 1985;

Kerlinger, 1986). The population is divided into strata in order that each stratum is delineated by a known characteristic, and it is important that such a characteristic is easily identifiable in the study population (Goddard and Melville, 2001). Kumar (1999) emphasises that it is important that the characteristic that becomes the basis of stratification be selected to be related to the main variable(s) explored by the research. As discussed earlier in section 3.2.1, under the third principle of sampling, sample accuracy depends on the extent of variability, or heterogeneity in the population, and therefore it follows that if by some means the heterogeneity in the population may be reduced for a given sample size, then greater accuracy in the estimation may be achieved. In stratified random sampling, the researcher attempts to divide the population in such a way that the population within a stratum is homogenous with respect to the characteristic on the basis of which it is being stratified (Kumar, 1999). Thus, Babbie and Mouton (2001) assert that the ultimate function of stratification is to organise the population into homogeneous subsets (with heterogeneity between subsets) and to select the appropriate number of elements from each subset.

During sampling design, the population of the Ugandan construction industry participants was divided into four strata on the basis of type of firm: Architectural firms, Quantity Surveying firms, Consulting Engineering firms and Contracting firms. These four strata constitute the categories of firms exclusively recognised by construction professional associations and the Ministry of Works, Housing and Communications. Because of the small number of members in the strata of Quantity Surveying and Consulting Engineering firms, all 12 and 19 members of the strata respectively, were included in the sample. 20 Architectural firms and 29 Contracting firms were included in the sample, in proportion to the corresponding number of firms in the sample frame. The combination of these four strata constitutes a sample of size of 80. During sampling design, allowance was made for the geographical location of the firms. Six geographical regions were defined: Kampala City, Central Uganda, Western Uganda, Northern Uganda, Eastern Uganda, and Southern Uganda. However, no allowance was made for sampling on the basis of size of firm because accurate data on the variable could not be obtained *a priori* to sample design. The decision to exclude the above characteristic during sample design was meant to avoid the potential risk of biasness in the sample. Having defined the strata, random sampling using a table of random numbers was used to select the sample units for the Architectural and Contracting firms' strata. The procedure followed to this effect is the one recommended by Leedy and Ormrod (2001:212).

3.3 Research Instruments

A good research design should be supported by appropriate research instruments. Research instruments provide a basis on which the entire research effort rests (Leedy and Ormrod, 2001). The design of a research instrument is an important aspect of a research project because the findings of the research are based on the type of information collected, which is entirely dependent upon the research instruments (Kumar, 1999). Research instruments provide the input into a study and therefore the quality and validity of the output, the findings, are solely dependent upon them (Kumar, 1999).

In order to achieve the objectives of the research, three methods of data collection were used: questionnaires, interviews, and literature review. Questionnaires and interviews served as primary sources of data and literature review as a secondary source of data. Section 3.3.1 of this chapter discusses data collection using questionnaires and section 3.3.2 discusses the interview surveys. Section 3.3.3 gives an overview of the data collected through literature search, and section 3.3.4 discusses the validity and reliability of research instruments.

3.3.1 Questionnaire Survey

Questionnaires were used to collect quantitative data for the research. Given the geographical diversity and multiplicity of construction industry participants in Uganda, questionnaires were considered the appropriate tool for data collection. Semi-structured questionnaires were used in the research, allowing statistical analysis of the data so that inferences can be made about the study population.

3.3.1.1 Questionnaire Design

Designing a good questionnaire involves selecting the appropriate questions needed to meet the research objectives, testing them to make sure they can be asked and answered as planned, and then putting them into a format that maximises the ease with which respondents and the researcher can do their job (Fowler, 1984).

Form of Questions

The form and wording of questions is extremely important in a research instrument as they have an effect on the type and quality of information obtained (Kumar, 1999). The questionnaire consisted of close-ended questions, open-ended questions as well as rating scales.

The close-ended questions included in the questionnaire provided structured responses in which respondents were asked to choose from the given alternatives. The structured responses adopted for questionnaires evolved through the literature review and pilot surveys of the questionnaire. Close-ended questions are extremely useful for eliciting factual information (Kumar, 1999). Similarly, Moore (1987) argues that close-ended questions are easy to complete and analyse, that they provide a range of answers, and therefore reduce the chances of the respondents overlooking some alternatives. They reduce the possibility of obtaining ambiguous answers, enable data to be coded, allowing statistical analysis to be carried out on the whole group or over any subgroup of participants, and this enhances the interpretation of results in an efficient and effective manner.

The close-ended questions were supplemented by selected open-ended questions intended to seek opinions, beliefs, and perceptions behind the respondents' answers. Although open-ended questions are difficult to analyse, they permit the researcher to obtain qualitatively-defined answers that were unanticipated and may describe more closely the real views of the respondent (Fowler, 1984). In order to capture the responses not included on the list of alternatives, the "other" option was added with sufficient space for the respondents to express their opinion. Mitchell and Jolley (2001) argue that including the "other" option allows the respondents not to be forced into an answer that doesn't reflect their true position.

The design of the questionnaire incorporated rating scales whose aim was to ask respondents to make comparisons in the form of ranks (for example 3= Most

Important, 2= Important, 1= Least Important), or continuums (for example 4=Most Used, 3= Used, 2= Less used, 1= Not Used). Rating scales were used, particularly, to ascertain the extent of software usage (i.e. CAD, databases, project planning software, spreadsheets and other software), level of computerisation of business processes (i.e. purchasing, scheduling, tendering, bills of quantities, costing and budgeting, materials control and others), existing means of information sharing among the industry participants (i.e. e-mail, postage, hand delivery, telephone and other means), and categorisation of construction information (i.e. information on: past projects, building codes and standards, labour rates, materials and costs, construction machinery and equipment, and other information) according to its importance to the participants. The discussion on the statistical tests for the reliability of the above rating scales is presented in section 3.3.4.3 of this chapter.

Questionnaire Structure

The intent behind the structure of the questionnaire was to reinforce the clarity of questions, and to facilitate continuous communication between the researcher and respondent throughout all sections of the questionnaire. The questionnaire was divided into four sections. The beginning of each section had remarks highlighting the content and relevancy of the questions in the section. This was intended to maintain the respondent's interest in answering the questions and to keep track of the progress on the data provided to the researcher. The choice of the questions to include in the questionnaire were guided by the desire of this research to achieve its objectives and to provide answers to the research questions as set out earlier in chapter one of this report. Given below is a brief description of the contents of the four sections of the questionnaire.

Section I: About the Organisation

This section was employed to collect demographic data about the respondents. Particularly, questions on the type of organisation were asked (i.e. Architectural, Quantity Surveying, Consulting Engineering, Facility Management, Contracting, Project Management firm, and "other" type of firm), geographical location of the firm, and the size of fulltime staff in the organisation. The above three categories of data were used to define the independent variables used during statistical analysis of the research data.

Section II: About the IT infrastructure

Here, the intention was to assess the extent of IT use in the Ugandan construction industry and particularly the computer infrastructure, Internet access, software usage, size of staff able to use computers, computerisation of business processes, and the future plans of construction organisations regarding investment in IT.

Section III: Existing Means of Information Sharing

This section of the questionnaire was employed to study the existing means of information sharing amongst the industry parties, the types of information shared, and the perceptions of industry parties on the benefits and weaknesses of information sharing.

Section IV: Assessment of Information Needs

The intent here, was to assess the information needs of industry participants, the willingness of the participants to provide construction information, the challenges of sharing construction information using a web portal, and the management of the web portal for the Ugandan construction industry.

3.3.1.2 Questionnaire Piloting

A pilot study is a small scale study undertaken to decide if it is worth carrying out a detailed investigation (Kumar, 1999). It is most correctly conducted when the researcher simulates the main study and involves fewer respondents, though they will be of the same kind as the final target group (Gillham, 2000). A pilot study should be undertaken to ascertain if the larger study can be administered and produce the information that is required by the researcher (Fink and Kosecoff, 1985). Additionally, Fink and Kosecoff (1985) assert that the main goal of piloting a research study is to ensure a reliable and valid survey (see section 3.3.4 for more details on validity and reliability of a survey), and is an excellent way to determine the feasibility of the study (Leedy and Ormrod, 2001).

Pilot testing a questionnaire will reveal any operational difficulties, ambiguous questions, and gaps which have previously been overlooked (Moore, 1987). Oppenheim (1992) argues that piloting not only helps with the wording of the questions but also with procedural matters, such as the design of a letter of introduction, the ordering of question sequences, and the reduction of non-response rates.

During the research, the questionnaire was piloted and involved ten construction industry participants in the city of Durban, South Africa. The sample consisted of 2 Quantity Surveyors, 2 Architects, 2 Contractors, 2 Structural Engineers, and 2 Project Managers. The above sample was considered adequate for the pilot survey since it is similar to the study population, and this premise is supported by Kumar (1999:19) who states that as a rule "pilot testing should not be carried out on the sample of the study but on a similar population". The comments, opinions, and observations made during the pilot survey were incorporated into the design of the final form of the questionnaire used in the research.

3.3.1.3 Questionnaire Administration and Response Rate

While sending out questionnaires was one step towards data collection, it was also problematic to ensure that all of them were returned, and to avoid this, during the survey, self-administered questionnaires were "personally" delivered to the respondents. A self administered questionnaire is completed by participants in the absence of an investigator, is distributed to a large number of participants, and often allow anonymity (Mitchell and Jolley, 2001). This ensures accurate sampling and minimum interviewer bias (Oppenheim, 2000). However, Fink and Kosecoff (1985) and Mitchell and Jolley (2001) observe that self-administered questionnaires usually suffer a low response rate. The objective of personal delivery of questionnaires was to increase the response rate and to explain to participants the purpose and relevance of the research, and in this regard, both Oppenheim (1992) and Gillham (2000) recommend personal delivery as an effective way of increasing the response rate.

The quality of a cover letter to a questionnaire is a significant factor that determines the response rate (Kumar, 1999; Leedy and Ormrod, 2001). To that effect, questionnaires were accompanied by a letter that clearly stated the purpose and relevance of the research, and assured the respondents of the high degree of confidentiality attached to the information they provided. The authenticity of a cover letter is equally important; an official headed letter and signatory can suffice. As an incentive aimed at boosting response rates, an offer was made by the researcher and explicitly stated in the questionnaire, to send a summary of the results to the respondents. This strategy is recommended by Fink and Kosecoff (1985) and Leedy and Ormrod (2001).

This research registered a response rate of 88%, with 70 out of 80 questionnaires returned; Gillham (2000) indicates that a response rate of more than 50% can be regarded as reasonably satisfactory. A high response rate of 88% is testimony to effective questionnaire development and administration, and the perceived importance of the research. Therefore, as argued by Gillham (2000), this high response rate is a significant outcome for the research. The low response rates are potentially one of the most important sources of systematic errors, and it is likely to be one of the most problematic concerns regarding the accuracy of sample estimates (Fowler, 1984); hence, attention to minimising its occurrence and effects deserve high priority in the total design of surveys.

3.3.2 Interview Survey

Interviewing is a commonly-used method of collecting information from people. An interview is "any person-to-person interaction between two or more individuals with a specific purpose in mind" (Kumar, 1999:109). During the research, interview surveys were used to acquire qualitative information to supplement quantitative data from questionnaires. In line with what has previously been considered in this report, Moore (1987) suggests that supplementing questionnaires with some in-depth interviews of a smaller sample gives the research the required scope and depth, without resorting to the very costly interviewing of large numbers of people. Through probing (i.e. asking the respondent to explain an answer in a little more depth) and prompting (i.e. an attempt to ensure that the respondent has considered all possibilities when replying to a question), interviews provide an opportunity to obtain qualified answers (Moore, 1987). Similarly, Gillham (2000) states that interviews seem to gain the in-depth and validity required of a survey research.

Face-to-face, semi-structured interviews were used in this research. Face-to-face interviews have the distinct advantage of enabling the researcher to establish a rapport with potential participants, and therefore gain their cooperation (Leedy and Ormrod, 2001). They allow the researcher to clarify ambiguous answers, and when appropriate, seek follow-up information (Leedy and Ormrod, 2001). Semi-structured interviews follow a standard set of questions, with one or more individually tailored questions to maintain clarity, probe a person's reasoning, or to follow up on any interesting or unexpected answers to the standard questions (Leedy and Ormrod, 2001; Mitchell and Jolley, 2001). They are useful research instruments that collect discursive information, qualitative as opposed to quantitative, and this information usually contains a high degree of opinion or expression of attitudes, and they provide a much wider scope for the discussion and recording of respondents' opinions and views (Moore, 1987).

As recommended by Gillham (2000), interviewees should be selected according to their representative characteristics of the population; nine interviewees representing the key stakeholders in the Ugandan construction industry were selected for the research. This number was considered a substantial backup for the 80 questionnaires (i.e. sample size), a ratio of one to nine. Gillham (2000) argues that for interview surveys, quality counts more than quantity, and therefore recommends a simple ratio of one interview for every ten questionnaires as substantial backup. The full list of interviewees is given in Table 3.1 below.

The structure and design of the interview schedule (attached as Appendix B) and particularly the objective of the questions were similar to those of the questionnaire. This was aimed at allowing comparability and cross-validation of the interview and questionnaire data.

Table 3-1: List of interviewees

Number	Interviewee	Organisation
1	Chairman, Ugandan National Association of Building and Civil Engineering Contractors (UNABCEC)	UNABCEC
2	President, Ugandan Society of Architects (USA)	USA
3	General Secretary, Ugandan Association of Consulting Engineers (UACE)	UACE
4	Honorary Secretary, Ugandan Institution of Professional Engineers (UIPE) / Principal Public Works Training Centre, Kyambogo	UIPE
5	Honorary Secretary, Ugandan Society of Architects (USA)	USA
6	Commissioner Buildings, Ministry of Works, Housing and Communications (MOWHC)	MOWHC
7	Commissioner Roads, Ministry of Works, Housing and Communications (MOWHC)	MOWHC
8	Head, School of Building and Civil Engineering, Kyambogo University	Kyambogo University
9	Dean, Faculty of Technology, Makerere University / Past President, Uganda Society of Architects (USA)	Makerere University

Source: Field survey data (2004)

3.3.3 Literature Review

The review of existing information has been a vital part of this research. It not only summarises previous work, but also sets the context for the study by showing how the study finds solutions for problems in previous research, or shows that the research builds on, and extends the work of, previous researchers (Mitchell and Jolley, 2001). The literature review brings both clarity and focus to the research problem, improving the research methodology by studying the procedures and methods used in other studies, and broadens the knowledge base of the researcher in the area of study (Kumar, 1999).

During the research, the literature review focused on three key topics:

- The study area, i.e. the construction industry in Uganda
- Web portal developments in the international construction industry
- Information sharing and exchange standards

The detailed discussion of the above key topics is presented in chapter two of this report, and as stated earlier in section 3.3.1.1 of this chapter, the literature review was the major source of structured responses adopted during questionnaire design.

3.3.4 Validity and Reliability of Research Instruments

3.3.4.1 The Concept of Validity and Reliability

Research planning and design requires many decisions that will ultimately bear upon the data collected and the credibility of the findings (Locke *et al.*, 1998). Validity and Reliability are concepts used to express the accuracy and quality of a research survey (Kumar, 1999). In terms of measurement procedures, validity is the ability of an instrument to measure what it is designed to measure (Kerlinger, 1986; Oppenheim, 1992; Kumar, 1999; Coombes, 2001). Therefore, the term validity implies that the measurements are correct; i.e. the instrument measures what it is intended to measure and measures it correctly (Goddard and Melville, 2001). Validity can be used in two different aspects of the investigation: internal validity and external validity. Internal validity determines whether the findings are truthful about the questions posed in the study and is concerned with whether the research has been designed so that it truly deals with what is being examined (Locke *et al.*, 1998). Kerlinger (1986) indicates that anything affecting the controls of a design, including the controls of extraneous variables and measurement errors, becomes a problem of internal validity. External validity answers the question whether the findings tell the truth about the questions when they are situated outside the scope of the study (Locke *et al.*, 1998); Similarly, Kerlinger (1986) and Mitchell and Jolley (2001) indicate that external validity means representativeness or generalizability outside the study.

Oppenheim (1992) and Kumar (1999) give effective summaries of the types of validity as:

Face and Content Validity

- Face validity is concerned with establishing a logical link between the questions and objectives of the study.

- Content validity seeks to establish that the questions are a well balanced sample of the content domain to be measured.

Concurrent and Predictive Validity

- Concurrent validity shows how well the test correlates with other, well validated measures of the same topic, administered at about the same time.
- Predictive validity shows how well the test can forecast some future criterion.

Construct Validity

Construct validity shows the researcher how well the test links up with a set of theoretical assumptions about an abstract construct. It is based upon statistical procedures and is determined by ascertaining the contribution of each construct to the total variance observed in a phenomenon.

The concept of reliability to a research instrument is the extent to which the instrument yields consistent results when the characteristic being measured has not changed (Oppenheim, 1992; Coombes, 2001; Goddard and Melville, 2001; Leedy and Ormrod, 2001). Like validity, reliability takes different forms in different situations. Leedy and Ormrod (2001) set out a summary of the forms of reliability as:

Inter-rater reliability i.e. the extent to which two or more individuals evaluating the same product or performance give identical judgements.
Internal consistency reliability i.e. the extent to which all items within a single instrument yield similar results.
Equivalent forms reliability i.e. the extent to which two different versions of the same instrument yield similar results.
Test-Retest reliability i.e. the extent to which the same instrument yields the same result on two different occasions.

Validity and reliability are interrelated. A research instrument can measure accurately only when it can measure consistently; however, when a research instrument measures consistently, this does not necessarily mean that it measures accurately (Leedy and Ormrod, 2001). Therefore, reliability is a necessary, though not a sufficient condition for validity (Oppenheim, 1992; Leedy and Ormrod, 2001).

3.3.4.2 Establishing the Validity and Reliability of Research Instruments

Validity and reliability need to be carefully considered during research design so that the eventual analysis of data and presentation of findings can be meaningful and of desired quality. During the research, qualitative and quantitative approaches were used to establish validity and reliability.

As discussed earlier (section 3.1), this research employed a multi-method approach that is based on established theory and supported by authors such as Brannen (1997), Creswell (1998), Gillham (2000), and Taylor (2000). Reliable and valid surveys are obtained by ensuring that the process of enquiry is based on established theory or experience (Fink and Kosecoff, 1985). Therefore, it can be argued that the multi-method approach adopted for the research based on established theory set the context for the validity and reliability of the research. Proponents of the multi-method approach argue that this technique offers the opportunity to increase the internal validity of the data and is one way to strengthen confidence in the research findings (Brannen, 1992; Arksey and Knight, 1999).

The design of research instruments and particularly questionnaires was followed by careful pilot testing (see section 3.3.1.2 for details). As argued by Fink and Kosecoff (1985), pilot testing ensures reliability by clarifying questions and the general format of the survey. Similarly, Fink and Kosecoff (1985) argue that pilot testing bolsters validity by helping to ensure that all topics are included and that sufficient variety in responses is available.

As discussed earlier (section 3.3.4.1), external validity means representativeness or generalizability of the study to other situations or participants. The random sampling strategy adopted during research design ensures that sample estimates can be generalised to represent the population parameters. This, in itself, can be considered as a measure of external reliability of the study.

The most direct form of validation is to compare measures obtained by a particular test with those obtained using a similar device (Ireland, 1983). However, as no similar tests have been constructed to measure the items of the research, this approach is not possible. However, the process of pilot testing the research instruments to determine the items to include, or exclude, from the research instruments, provides some assurance of face and content validity.

Statistical techniques were used to establish the reliability of the rating scales used during questionnaire design. Details of the techniques used are presented in section 3.3.4.3 below.

3.3.4.3 Testing the Reliability of Questionnaire Scales

The reliability of a scale is indicative of how free it is from random errors (Pallant, 2001), and influences the quality of the data obtained using the scale. The aspect of reliability assessed in this section of the report is of the internal consistency of the questionnaire scales, and refers to the degree to which the items that make up the scale are all measuring the same underlying attribute (Pallant, 2001). The internal consistency method is based on the classical scaling theory, which presupposes that if a scale is expected to measure a single underlying continuum, then the items should have strong relationships both with that continuum, and with each other (Oppenheim, 1992). Oppenheim (1992) argues that while we cannot observe the former, a scale will be internally consistent if the items correlate highly with each other, in which case they are also more likely to measure the same homogenous variable. Therefore, the internal consistency method measures reliability in the form of correlation coefficients (Oppenheim, 1992; Pallant, 2001).

The most commonly used statistic for measuring internal consistency is the Cronbach's alpha coefficient and its variants (Oppenheim, 1992; Pallant, 2001). This statistic provides an indication of the average correlation among all the items that make up the scale (Pallant, 2001). Cronbach alpha values are dependent on the number of items on the scale, with a small number of items (i.e. less than ten) leading to small alpha values (Pallant, 2001). The values of the statistic range from 0 to 1, with higher values indicating greater reliability.

The Cronbach's alpha coefficient is based on the formula:

$$\alpha = n/(n-1)\{1 - (\Sigma V_i)/V_t\}$$ (adapted from Ireland, 1983:88)

Where, α is Cronbach's alpha coefficient

n is the number of items

V_i is the variance of item i

V_t is the variance in the total test scores

Given below are the results of the Cronbach's alpha coefficient and its variants, obtained using the Statistical Package for Social Sciences (SPSS) Version 11.5, based on the field questionnaire data coded into the program.

Scale One

Purpose of the scale: To assess the extent of software usage by the Ugandan construction industry participants.

Scale continuum: 5=Most used, 4=Used, 3=Not Used, 2=Not Applicable, 1=Don't Know (for more details see question 7 of the sample questionnaire attached as Appendix A).

Reliability analysis results: (see Table 3.2 below).

Interpretation of results:

According to Pallant (2001), the Cronbach alpha coefficient of a scale should ideally be above 0.70. The computed alpha coefficient of the scale on software usage is 0.33, and is less than the ideal value. However, Pallant (2001) indicates that with short scales (i.e. with less than ten items) it is common to find Cronbach values less than 0.50.Therefore the small number of items (in this case 5) can be used to explain the relatively low alpha value of 0.33. This behaviour is expected and should therefore not be used to qualify the scale as unreliable.

Table 3-2: Reliability analysis: software usage

Variable	Label	Mean	Std Dev	Corrected Item Total Correlation	Alpha if Item is Deleted
SW_WORD	Word processing usage	4.79	0.41	0.06	0.34
SW_SHEET	Spread sheet usage	4.36	0.70	0.06	0.36
SW_DBASE	Database software usage	3.29	0.87	0.20	0.25
SW_PPLAN	Project planning software usage	3.57	0.63	0.50	0.03
SW_CAD	Computer Aided Design Usage	3.84	1.12	0.09	0.41
Statistics for the Scale:					
Mean= 19.84	Variance= 4.19	Std Dev=2.05	Number of Variables= 5		
Reliability Coefficients:					
Number of cases=70	Number of Items=5	**Alpha=0.33**			

Source: SPSS 11.5 Analysis of questionnaire data (2004)

Scale Two

Purpose of the scale: To assess the level of computerisation of business processes for the Ugandan construction industry participants.

Scale continuum: 6= Highly Computerised 5=Computerised, 4=Less Computerised, 3=Not Computerised, 2=Not Applicable, 1=Don't Know (for more details see question 10 of the sample questionnaire attached as Appendix A).

Reliability analysis results: (see Table 3.3 below).

Interpretation of results:

According to Pallant (2001), the Cronbach alpha coefficient of a scale should be ideally above 0.70. The computed Cronbach alpha coefficient of the scale on assessing the level of computerisation of business processes is 0.85. Therefore, the scale can be qualified as highly reliable.

Table 3-3: Reliability analysis: computerisation of business processes

Variable	Label	Mean	Std Dev	Corrected Item Total Correlation	Alpha if Item is Deleted
PURCHASE	Computerisation of purchasing	3.36	1.09	0.57	0.83
SCHEDULE	Computerisation of scheduling	3.94	1.25	0.60	0.83
TENDER	Computerisation of tendering	4.20	1.21	0.43	0.85
BOQCOMP	Computerisation of bills of quantities	4.61	1.33	0.49	0.84
COSTBUDG	Computerisation of costing & budgeting	4.30	1.16	0.72	0.82
MATCONTR	Computerisation of materials control	3.27	1.17	0.55	0.83
BOOKKEEP	Computerisation of book keeping	4.51	1.06	0.55	0.83
INVOICE	Computerisation of invoicing	4.11	1.06	0.70	0.82
TECHCALC	Computerisation of tech. calculations	4.23	1.42	0.54	0.84
Statistics for the Scale:					
Mean= 36.54	Variance= 52.66	Std Dev=7.26		Number of Variables= 9	
Reliability Coefficients:					
Number of cases=70	Number of Items=9			**Alpha=0.85**	

Source: SPSS 11.5 Analysis of questionnaire data (2004)

Scale Three

Purpose of the scale: To study the existing means of information sharing

Scale continuum: 4=Most used, 3=Used, 2=Less Used, 1=Not Used

(for more details see question 15 of the sample questionnaire attached as Appendix A).

Reliability analysis results: (see Table 3.4 below).

Interpretation of results:

According to Pallant (2001), the Cronbach alpha coefficient of a scale should be ideally above 0.70. The computed alpha coefficient of the scale on studying the existing means of information sharing is 0.63. The computed alpha value is less than the ideal value. However, following the argument by Pallant (2001) that for small scales, with less than ten items (in this case four items), the alpha values are expected to be as low as 0.50, it can be determined that the scale is reliable.

Table 3-4: Reliability analysis: existing means of information sharing

Variable	Label	Mean	Std Dev	Corrected Item Total Correlation	Alpha if Item is Deleted
EMAILUSE	E-mail usage	2.74	1.20	0.21	0.73
POSTAGE	Postage usage	2.34	0.96	0.48	0.52
HANDELIV	Hand delivery	3.21	0.95	0.42	0.56
TELEPHON	Telephone usage	3.29	0.98	0.61	0.42
Statistics for the Scale:					
Mean= 11.59	Variance=8.04		Std Dev=2.84		Number of Variables= 4
Reliability Coefficients:					
Number of cases=70		Number of Items=4			**Alpha=0.63**

Source: SPSS 11.5 Analysis of Questionnaire Data (2004)

Scale Four

Purpose of the scale: To assess the information needs of the Ugandan construction industry participants.

Scale continuum: 3=Most Important, 2=Important, 1=Least Important (for more details see question 18 of the sample questionnaire attached as Appendix A).

Reliability analysis results: (see Table 3.5 below).

Interpretation of results:

According to Pallant (2001), the Cronbach alpha coefficient of a scale should be ideally above 0.70. The computed Cronbach alpha coefficient of the scale for assessing the information needs of the Ugandan construction industry participants is 0.73. Therefore, the scale can be qualified as reliable.

Table 3-5: Reliability analysis: assessment of information needs

Variable	Label	Mean	Std Dev	Corrected Item Total Correlation	Alpha if Item is Deleted
LAWSINFO	Information on laws and legislation	2.19	0.64	0.47	0.70
PROJINFO	Information on successful & failed projects	1.86	0.64	0.38	0.71
MATCOST	Information on constr. materials & costs	2.53	0.61	0.28	0.72
CODES	Information on building codes& standards	2.54	0.58	0.33	0.72
TENDEINF	Info. on tender processes & procedures	2.39	0.69	0.49	0.70
LABORATE	Information on labour rates	2.06	0.76	0.01	0.75
INTERINF	Developments in the intern. Constr. industry	1.96	0.62	0.28	0.72
OPORTUNE	Opportunities for service delivery	2.39	0.75	0.22	0.73
EQUPMENT	Information on constr. machinery & equip.	1.94	0.80	0.29	0.72
CAPAXBDG	Opportunities for capacity building & training	2.07	0.69	0.36	0.71
CONTACTS	Contacts & websites of constr. parties	1.89	0.71	0.52	0.69
PREVPROJ	Documentation of previous projects	2.09	0.65	0.24	0.72
PROFBOD	Information on constr. professional bodies	1.87	0.61	0.55	0.69
RESEARCH	Local industry research results	2.11	0.69	0.43	0.70
Statistics for the Scale:					
Mean= 29.87	Variance= 19.91		Std Dev=4.46	Number of Variables= 14	
Reliability Coefficients:					
Number of cases=70	Number of Items=14			**Alpha=0.73**	

Source: SPSS 11.5 Analysis of Questionnaire Data (2004)

3.4 Methods of Analysis

Analysis means categorising, ordering, manipulating, and summarising data to obtain answers to research questions (Kerlinger, 1986). The purpose of analysis is to reduce data to intelligible and interpretable form so that the relations of research problems can be structured and tested (*ibid.*). Analysis consists of constructing generalisations and offering explanation of the research data (Fielding and Gilbert, 2000).

This section of the chapter on research design and methodology gives an overview of the methods of analysis used in the study. Section 3.4.1 examines systemic analysis and section 3.4.2 briefly discusses statistical analysis and particularly descriptive statistics, inferential statistics, and the graphic display techniques used in the study. Section 3.4.3 summarises related research whose results were adopted for the purposes of comparative analysis. The detailed analysis and discussion of results is presented in chapters four and five of this report.

3.4.1 Systemic Analysis

Systemic analysis has its foundation in the field of systems thinking. Systems thinking is a way of viewing world (Nicholas, 2001) and it is a framework of thought that helps us to deal with complex things in a holistic way (Flood and Carson, 1988). Systems thinking attempts to solve problems by looking at the total picture rather than through analysis of individual components (Kerzner, 2003), and in this regard, Nicholas (2001) argues that systems thinking means being able to perceive the "system" in a situation. It implies the ability to take a confused, chaotic situation and perceive some degree of order and interrelationship (*ibid.*), and focuses on the feedback relationships between what is being studied and the other parts of the system (Aronson, 1996). It involves taking a broader view, looking at larger and larger numbers of interactions, and in this way it creates a better understanding of the larger picture (*ibid.*). The fundamental issue within systems thinking is that of leverage, in other words seeing where actions and changes in structures can lead to significant, enduring improvements (Senge, 1990).

During the study, systemic analysis was carried out using the hard and soft system methodologies, and particularly, employing systems diagrams. A detailed discussion on the systemic approach is given in chapter four of this report.

3.4.2 Statistical Analysis

Statistics in research provide a set of tools that assist with the organisation, analysis, and interpretation of data (Newton and Rudestam, 1999). Statistical analysis plays an important role in answering research questions, in understanding the relationship between variables particularly when there are more than two, in ascertaining the magnitude of an existing relationship or interdependence, and to place confidence in research findings (Kumar, 1999). It can be viewed as primarily concerned with two foci; the description of sample information or descriptive statistics, and the generalisation of sample information to a population or statistical inference (Newton and Rudestam, 1999). Descriptive statistics are used to present quantitative descriptions in a manageable form (Babbie and Mouton, 2001), and aim at summarising large quantities of data down to a few numbers, in a way that highlights the most important numerical features of the data (Antonius, 2003). On the other hand, inferential statistics assists in drawing conclusions from research observations and this typically involves drawing conclusions about a population from the study of a sample drawn from it (Babbie and Mouton, 2001).

During the research, frequencies, cross tabulations (see section 3.4.2.1), chi-square tests (see section 3.4.2.2) and graphic displays (see section 3.4.2.3) were used as descriptive statistics and percentages, as both descriptive and inferential statistics. The choice of the above techniques was determined through the type of data collected, which was basically nominal (categorical) and ordinal (ranked). However, it should be noted that the sample estimates can only be generalised to represent the parameters of the study population which was constituted by licensed practitioners.

3.4.2.1 Cross Tabulations

A cross tabulation (also referred to as cross breaks or contingency tables) is a numerical tabular presentation of data, usually in frequency or percentage form, in which variables are cross-partitioned in order to study the relations between them (Kerlinger, 1986). Cross tabulations are also used in descriptive ways, when the researcher is not interested in relations (Kerlinger, 1986). Kumar (1999) and Babbie and Mouton (2001) indicate that cross tabulations are commonly used in the analysis of independent and dependent or attribute and dependent variables for nominal and ordinal data. In cross tabulation analysis, the absolute number of respondents, and the row and column percentages, usually give a reasonably good idea as to the possible association (Babbie and Mouton, 2001).

A cross tabulation contains the joint distribution of variables under study (Newton and Rudestam, 1999). The variables are set out in the form of a square or rectangle with cell frequencies occupying each tabular cell and total frequencies (also referred to as marginal frequencies) at the end of each row or column. The total of row marginal frequencies or column marginal frequencies are equal to the sample size (Newton and Rudestam, 1999). The conventional way of constructing cross tabulations is with the independent variable at the top and the dependent variable at the side of the table (Newton and Rudestam, 1999).

During analysis, cross tabulations were used to study possible relations between the independent variables of type, location, and size of firm, and selected dependent variables including information needs, software usage, computerisation of business processes, existing means of information sharing, and future investments in IT.

3.4.2.2 Chi-square Tests

The chi-square test is probably the most widely used non-parametric test of significance (Newton and Rudestam, 1999), and can be employed when data is qualitative or discrete, as they do not make assumptions about the underlying population distribution (Goddard and Melville, 2001; Pallant, 2001). The test is used to determine how closely observed frequencies match the frequencies expected by chance (Kerlinger, 1986; Leedy and Ormrod, 2001).

The chi-square test is based on the null hypothesis: the assumption that there is no relationship between the two variables in the population (Babbie and Mouton, 2001). The Chi-square test statistic (χ^2) is given by the formula:

$$\chi^2 = \Sigma(o_{ij} - e_{ij})^2 / e_{ij}$$ (adapted from Goddard and Melville, 2001:80).

Where o_{ij} denotes the observed frequency in row i, column j, e_{ij} the expected frequency in row i, column j and the summation (Σ) is over all entries in the contingency table. The value of the chi-square test statistic is the overall discrepancy between the observed distribution in the sample and the distribution expected if the two variables were unrelated to one another (Babbie and Mouton, 2001). Babbie and Mouton (2001) assert that the mere discovery of a discrepancy does not prove that the variables are related, since normal sampling error might produce discrepancies even when there is no relationship in the total population. However, the value of χ^2 permits the estimation of the probability that a relationship exists.

To determine the statistical significance of the observed relationship, a standard set of chi-square values are used, and this requires the computation of the degrees of freedom. Degrees of freedom refer to the possibilities of variation within a statistical model (Kerlinger, 1986; Babbie and Mouton, 2001). The degrees of freedom for a chi-square test are given by (r-1)(c-1), where r and c is the number of rows and columns of the contingency table respectively (Goddard and Melville, 2001). Testing the significance of a relationship also requires knowledge of the possible levels of significance which are usually expressed as a percentage, e.g. 5% or 1%. The interpretation of chi-square results is such that the higher the chi-square value in relation to the values obtained from the standard χ^2–distribution, the less probable it is that the value could be attributed to the sampling error alone.

During analysis, chi-square tests were used to test the significance of the observed relations on weaknesses of the existing methods of information sharing in the Ugandan construction industry and on the perceived benefits of the web portal.

3.4.2.3 Graphic Displays

Graphic displays are one of the most powerful tools of analysis (Kerlinger, 1986). A graph is a two dimensional representation of a relation or relations, and it exhibits pictorially sets of ordered pairs in a way no other method can (*ibid.*). The main objective of a graph is to present data in a way that is easy to understand and interpret and interesting to look at (Kumar, 1999).

The graphic display methods adopted for the study include bar-charts and pie-charts. The bar chart is used to display categorical data (Kumar, 1999; Pallant, 2001). It is used for variables measured on nominal and ordinal scales (Kumar, 1999). Bar charts were used to display variables such as software usage, computerization of business processes, existing methods of information sharing, benefits, and weaknesses of information sharing among others.

Pie charts provide a good way of displaying percentages and of comparing different groups or changes over time (Gillham, 2000), and were used to display respondents profiles including firm type, location and size.

3.4.3 Comparison of Results with Findings of Similar Surveys

The results of the research were compared with results of similar surveys conducted in Canada, Sweden, New Zealand, Turkey, and Malaysia. The aim of making these comparisons was to identify similarities and differences in the area of information sharing between the Ugandan construction industry and other industries. The surveys conducted in the above countries were not explicitly designed to measure the same items. However, they present quantitative data and qualitative arguments on different aspects of information sharing including computer availability, Internet access, software usage, computerisation of business processes, computer networking, and E-mail usage, amongst others. The following articles were used in making comparisons of results:

Article 1: A survey on the impact of information technology on the Canadian Architecture, Engineering and Construction industry (Rivard, 2000).

Article 2: IT-Barometer 2000: The Use of IT in the Nordic construction industry (Samuelson, 2002).

Article 3: A survey of computer use in the New Zealand Building and Construction industry (Doherty, 1997).

Article 4: A survey of IT use in the Turkish construction industry (Isikdag, 2002).

Article 5: A survey of Internet Usage in the Malaysian construction industry (Mui *et al.*, 2002).

3.5 Concluding Remarks

The chapter on research design and methodology has discussed the research approach, the sampling process, research instruments, and methods of analysis. The discussions and arguments raised in this chapter point to the fact that there is no single approach that exclusively leads to the achievement of research objectives.

The multi-method approach, as used in the research, blends analysis and synthesis, and permits a much more adequate understanding of the problem situation. Through careful planning, design, and administration of a research study, respondents are encouraged to participate and this bolsters the response rate. The 88% response rate, as has been mentioned, is a significant outcome of the research, and particularly of the questionnaire survey, more especially given the low response rate characteristic of the method.

Research design should incorporate measures that enhance the quality of a research, and indeed researchers need to be aware of the benefits of setting measures of quality. The qualitative and quantitative approaches of determining the validity and reliability of a research not only improve the quality of findings for the current study but also of other studies that make use of them.

4 A SYSTEMIC STUDY OF THE WEB PORTAL

4.1 Introduction

The systemic approach adopted in this research project provides an effective means for eliciting the responses and perspectives of stakeholders in the Ugandan construction industry with the aim of developing a holistic view of the research problem. It serves as a means of qualitatively putting together the captured data through questionnaire and interview surveys. In this regard, systems thinking has been a powerful tool employed in studying innovation efforts so that they result in innovations that are more strategically useful and thus have greater benefits to stakeholders (Aronson, 1996). Therefore, they can be considered as appropriate tools to study a web portal as a strategic innovative effort for the Ugandan construction industry.

Section 4.2 discusses the concept of a system, while section 4.3 explores the Hard and Soft Systems methodologies. Section 4.4 applies the above methodologies to develop an understanding of the wider picture of the system, while section 4.5, finally, presents a summary of the conclusions drawn from the discussions of this chapter.

4.2 The Concept of a System

A General Conception of the System

Meadows *et al.* (1992:278) define a system as "a set of elements that is coherently organised around some purpose", while Kerzner (2003:55) gives a broader definition of the concept, referring to it as "a group of elements, either human or non-human, that is arranged and organised in such a way that the elements can act as a whole toward achieving some common goal or objective". From these definitions, it can be deduced that systems are collections of elements whose interactions determine the behaviour of the system. Similarly, it can also be argued that it is this resultant behaviour that allows a system to achieve its intended purpose. Of course, any system possesses subsystems which are part of the larger system. A system receives input from its environment, and through a process of transformation, generates output. The system output dissipated to the environment, or used as input into the system is referred to as feedback. Ackoff (1974) and Nicholas (2001) indicate that the elements of a set and the set of elements that form a system exhibit the following three properties:

i. Parts of a system are affected by being in the system and are changed if they leave it. This means that the whole is more than the sum of parts.
ii. The assembly of parts does something, i.e. systems are dynamic and exhibit some kind of behaviour.
iii. The assembly of parts is of particular interest, i.e. systems are conceived by people examining them.

The central aspects of a generalised conception of a system are presented in Figure 4.1 below:

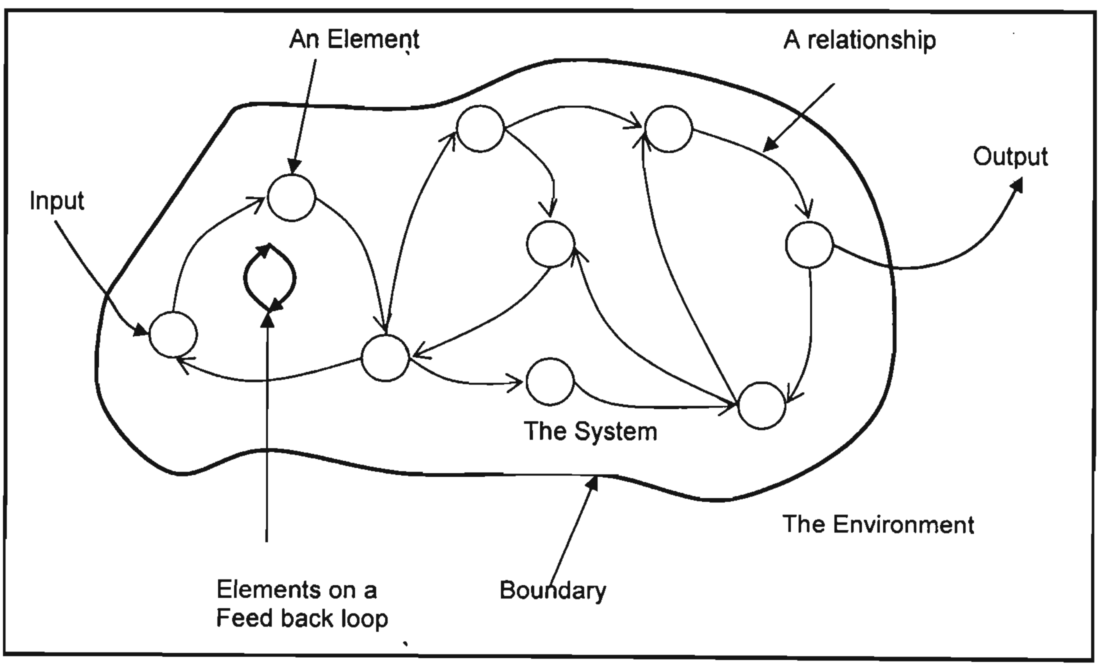


Figure 4-1: A general conception of a system (adapted from Flood and Jackson, 1991:6)

The System Environment

Systems are not independent entities but exist within the context of an environment. This environment affects the functioning and the performance of the system (Sommerville, 1995), and it may be thought of as a system in its own right *(ibid.)*, and comprises those elements, activities, people, ideas and so on, that are not part of the system but which may nevertheless be important in understanding it (Lane, 2000:41). Therefore, a system is the foreground and the environment is the background; the relevant context of the system (*ibid.*). Ackoff (1974) indicates that in systems thinking every purposeful system is considered to have an environment and to be part of one, or more larger, (supra) systems. In essence, a system can be considered to have an effect on, and to be affected by, at least one system of which it is part (*ibid.*). The system also interacts with the other systems in its supra-system. Ackoff (1974) asserts that the system environment consists of all those things, physical and social, man made and natural, that are external to it and either affect or are affected by its behaviour and defines environmentalisation as the process of putting into a system's mind its relationship to the whole of which it is part.

The System Boundary

Lane (2000:41) defines a systems boundary as "basically where the system ends and the environment begins". Thus, constructing a boundary around this organised assembly of components distinguishes it from its context or environment. A common challenge in systems thinking is the task of boundary identification, and in some situations it may appear straightforward to delineate it, while others not. Flood and Carson (1988) indicate that the first step in system identification is to choose between a structural or behavioural modelling approach. A structural approach is where a set of elements is assumed in advance of any search for processes. The structural modelling approach is more applicable to hard situations. Conversely, the behavioural approach is fundamentally different in that structure is not assumed *a priori* (Flood and Carson, 1988). The behavioural approach is more applicable to soft situations, especially those considered to be erratic and ill-defined.

4.3 Overview of Hard System and Soft Systems Methodologies

Soft Systems Methodology (SSM) emerged as a result of dissatisfaction with the limitations of traditional Hard Systems Methodology (HSM) (Khisty, 1995). It was felt that the original intention of a holistic, interdisciplinary, experimental discipline addressed to human activity systems was being betrayed (*ibid.*). Checkland (1981) argues that HSM tackles the question of, "How?"; by definition if objectives are themselves problematical and the questions to be answered are, "What?"; as well as, "How?" then the approach must be modified. HSM is a useful methodology to employ when tackling a relatively well-structured problem situation in which there is virtually common agreement on what constitutes the problem and what merely remains is to organise how to deal with it.

4.3.1 Hard Systems Methodology

The Hard Systems Approach was developed for designing and managing change. From a functionalist perspective, the properties of Hard Systems typically have (or are perceived to have) a higher degree of predictability and attributes which are readily quantifiable and measurable than that of Soft Systems (Waring, 1996). Khisty (1995) asserts that essentially, the Hard Systems approach defines the objectives to be achieved, then engineers the system to achieve these objectives. Fortune *et al.* (2002) indicate that the approach provides a rigorous and systemic way of thinking through a range of options, and then tests those options against a set of explicit criteria. The methodology uses quantitative criteria to test options for change and its roots lie in the work on complex operational problems and the quantitative techniques associated with operational research (*ibid.*).

Flood and Carson (1988) outline the fact that the HSM which set out to select an efficient means of achieving a known and defined end can conveniently be considered under the headings of 'systems analysis' and 'systems engineering'. Flood and Carson (1988:108) define systems analysis as "the systematic appraisal of costs and other implications of meeting a defined requirement in various ways" and they also define systems engineering as "a set of activities that together lead to the creation of a complex man made entity and/or the procedures and information flows associated with the operation" (1988:108).

HSM promotes a sequential, staged approach to change. However, going back to a previous stage and re-iteration is possible, if environmental influences or interaction with the client invalidates certain assumptions or subsequent work introduces uncertainty which had not been taken into account at the beginning (Fortune *et al.*, 2002).

4.3.2 Soft Systems Methodology

SSM was developed in order that problematic situations of purposeful human activity might be investigated (Flood and Carson, 1988). The methodology is best suited for understanding messes i.e. sets of interlinked problems. Khisty (1995) argues that human activity systems are usually messy, ill-defined, and cannot be accurately delineated in terms of their state and therefore, the analyst must concede to their purposeful activity, human values, and non-physical relationships. Khisty (1995) further argues that human activity systems can be expressed only as perceptions of people who attribute meaning to what they perceive, and concludes that, therefore, there is no single "testable" account of a human activity system; the only possible accounts are valid according to a particular "world view" (or *Weltanschauung).*

4.3.3 Comparison of Hard and Soft Systems Methodologies

The aim of SSM is to seriously account for the crucial element of subjectivity embedded in human activity systems. In comparison to HSM, SSM does not seek to mechanically design a solution as much as it orchestrates a process of learning (Khisty, 1995). Some of the similarities and differences between HSM and SSM are summarised in Figure 4.2 below.

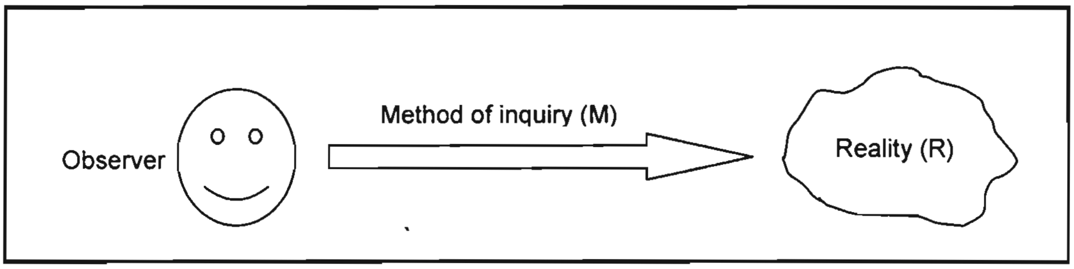


Figure 4-2 Two paradigms of inquiry: HSM and SSM
(HSM: R is systemic, M can be systematic; SSM: R is problematic, M can be systemic. adapted from Khisty, 1995:92)

The essential output of SSM is that, by employing a variety of perspectives, a set of relevant systems may be identified and this strongly contributes to the success of the methodology as a rigorous learning exercise (Flood and Carson, 1988). Khisty (1995) states that the main difference between HSM and SSM is that HSM considers goal-seeking to be an adequate model of human behaviour and relies heavily on the language of 'problems' and 'solutions' to eliminate problems, while SSM does not consider goal seeking to be an adequate model for representing and solving human activity problems. Therefore, SSM is relevant to arguing and debating about real world problems, not models of the world.

The main differences between HSM and SSM are summarised below in Table 4.1 below.

Table 4-1: Comparison of HSM and SSM

Attributes	HSM	SSM
Orientation	Systematic goal seeking	Systemic learning
Roots	Simplicity paradigm	Complexity paradigm
Belief	Systems can be 'engineered'	Systems can be explored
Belief	Models are of the world (ontologies)	Models are intellectual constructs (epistemologies)
Belief	Closure is necessary	"inquiry" is never ending
Human content	Non existent	High
Question(s)	How?	What and how?
Suitability	Well structured problems	Ill structured problems

Source: Khisty (1995:97)

4.4 A Systemic Analysis of the Web Portal

The problem situation under study is a web portal and can be described as structured and the purpose of the system solution clearly defined. This implies that the Hard Systems approach would be the appropriate methodology to study the system. However, Khisty (1995) indicates that in practice (in real world situations) Hard Systems Methodology (HSM) and Soft Systems Methodology (SSM) complement and supplement each other. Therefore, the systemic study of the web portal for the Ugandan construction industry employs both the Hard Systems and Soft Systems methodologies.

Fortune *et al.* (2002) indicate that HSM and SSM are associated with particular types of systems diagrams. They state that systems maps, influence diagrams, multiple cause diagrams, and sign graphs are most commonly associated with the Hard Systems approach, where as the rich picture is more often used in soft analyses. The systemic study of the above problem situation was carried out using systems diagrams. Based on the results of the analysis, an attempt was made to identify the systems objectives and associated constraints.

4.4.1 Systems Description

Semi-structured interview sessions and questionnaire surveys were conducted with key stakeholders in the Ugandan construction industry in order to gain an understanding of their perspectives towards the proposed system. The field survey data revealed that construction information is presently being shared amongst the industry parties via E-mails, fax, telephone, and hand delivery. The type of information shared ranges from computer aided drawings (CAD), word processed documents, spreadsheet data, hard copy drawings, to cost and budget estimates. Information sharing in the Ugandan construction industry can be improved by either strengthening the existing means of information sharing or developing alternative means of information sharing. The focus of this study was on the latter option and particularly on developing a web portal.

4.4.2 Systemic Analysis: Sensing Phase

In order to explore the problem situation, a spray diagram and rich picture were drawn. Diagramming techniques were considered appropriate for this study, because they clarify thinking, convey the analysts' thought to other readers, and can capture and represent interconnectedness in a way that is usually impossible in linear text (Waring, 1996; Fortune *et al.*, 2002).

Spray diagrams are used to show simple relationships of ideas (Fortune *et al.*, 2002). Flood and Carson (1988:48) define a rich picture as "one that expresses, in as rich a manner as possible, a person's general appreciation of a perceived problematic situation". The spray diagram (attached as Appendix D1) and rich picture (attached as Appendix D2) were used to diagrammatically capture ideas generated through the literature review and the interview sessions with the Ugandan construction industry participants. The spray diagram and rich picture were also employed to identify themes that emerge from the problem situation as well as the stakeholders involved.

The following two themes were identified:

- The desire to improve the existing means of information sharing
- The desire to devise alternative means of information sharing using Internet communication technology.

The latter option was selected for the research and further scrutiny, and the understanding is presented in section 4.4.3 of this report.

The following categories of stakeholders were identified:

- Professionals

  The construction professionals i.e. Architects, Engineers, Quantity Surveyors, Facility Managers and Project Managers have been identified as providers and users of construction information.

- Contracting firms

  Contracting firms (contractors) implement construction projects. They are therefore providers and users of construction information.

- Government

  The Ugandan government through the Ministries of Works, Housing, and Communication, and Local government, is the biggest client of the construction industry. Interviews with professionals revealed that information generated during planning, design, procurement/construction and facility management phases of a construction cycle belongs to the client. Therefore, it can be deduced that the government is the biggest provider of construction information. Interviews with industry participants revealed that the government is a potential owner and/or funder of the web portal, and the appropriate stakeholder to spearhead enactment of the relevant legislation for information sharing and exchange.

- Professional bodies

  The Ugandan construction industry professional bodies including the Ugandan Society of Architects (USA), the Ugandan Institution of Professional Engineers (UIPE), the Institution of Surveyors of Uganda (ISU), the Ugandan Association of Consulting Engineers (UACE), the Ugandan National Association of Building and Civil Engineering Contractors (UNABCEC), are providers and users of information, and potential funders of the portal.

- Academic and Research Institutions

  These have been identified as providers and users of construction information.

Other stakeholders:

- Manufacturers of building materials
- Service providers (Internet, telephone, E-mail, etc.).

The research largely deals with "hard" issues. However, the conceptualisation of the problem situation using a rich picture and spray diagram, suggests that in order to fully benefit from the web portal and other digital technologies, there is a need to consider "soft" issues, particularly, the challenge for the users to change their thinking and methods of work, developing trust among parties, and building partnerships amongst the industry participants.

4.4.3 Systemic Analysis: Understanding Phase

This is a diagnostic phase for comprehending the problem situation using the systemic approach. The systems diagrams presented at this stage of analysis aim at mapping out the structure of the system. The components of the system, the system environment and their interrelationships are discussed. Systems diagrams are particularly helpful in showing how a change in one factor may impact else where. They are important tools for identifying the long term effects of change and studying the feed back behaviour. Feedback will either reduce or amplify the impact of change. Systemic analysis leads to identification of points of leverage so that any systems intervention can produce the desired effects. In trying to understand the situation, various systems diagrams were employed, including a systems map, influence diagram, multiple cause diagram and sign graph.

The systems map (attached as Appendix D3) is essentially a snapshot indicating structure (Fortune *et al.*, 2002). The following systems components have been identified:

- Construction information i.e. Building materials, past records, cost data *etc.*
- Building information centre (Housing the web portal, ICT staff and construction databases).
- Construction professional bodies
- Construction parties i.e. Architects, Engineers, Quantity Surveyors, Facility Managers, Project Managers, Contractors, and Property Developers.
- Communication services i.e. Internet, E-mail, meetings, and others.
- Service providers for Internet, telephone, and E-mail services.
- Academic and research institutions
- Construction infrastructure i.e. Buildings, Roads, dams, and others.
- Ugandan government, particularly the Ministry of Works, Housing, and Communication, Ministry of local government, and the legislature.

The systems environment consists of:

- Ugandan government departments with the exception of those mentioned above (see systems components).
- The international construction industry.
- Funding organisations.

The influence diagram (attached as Appendix D4) represents the main structural elements and the important influences that exist among them (Fortune *et al.*, 2002). The multiple cause diagram (attached as Appendix D5) explores why certain changes in the system tend to occur (Fortune *et al.*, 2002). In order to represent and investigate relationships between variables in the system, a sign graph was used (attached as Appendix B6). In this light, Fortune *et al.* (2002) argue that a sign graph is a useful tool for thinking about the likely effects of changes, and in particular, interventions in systems.

Systemic analysis of the situation suggests that developing a centralised system of information-sharing will provide sufficient, consistent, and timely construction information contributing to construction projects to be completed on schedule and to desired quality. This will improve the performance of the construction industry, attracting high rates of return on investment, and hence encouraging investment in property development.

4.4.4 Systems Objectives and Constraints

The understanding of the problem situation developed through the process of systemic analysis (see sections 4.4.2 and 4.4.3) led to the definition of systems objectives (see Figure 4.3 below) and the identification of constraints.

An analysis and understanding of the objective tree diagram reveals two categories of objectives; firstly, the lower-level objectives that must be achieved in order to achieve the higher order objectives and, secondly, the "either ... or...." objectives which means that part of the lower level objectives should be achieved in order to accomplish the higher order objectives. The tactical objective of developing a web portal and the corresponding lower level objectives fall within the first category, whereas the management objectives of strengthening the existing means of information sharing, fall in the second category of objectives.

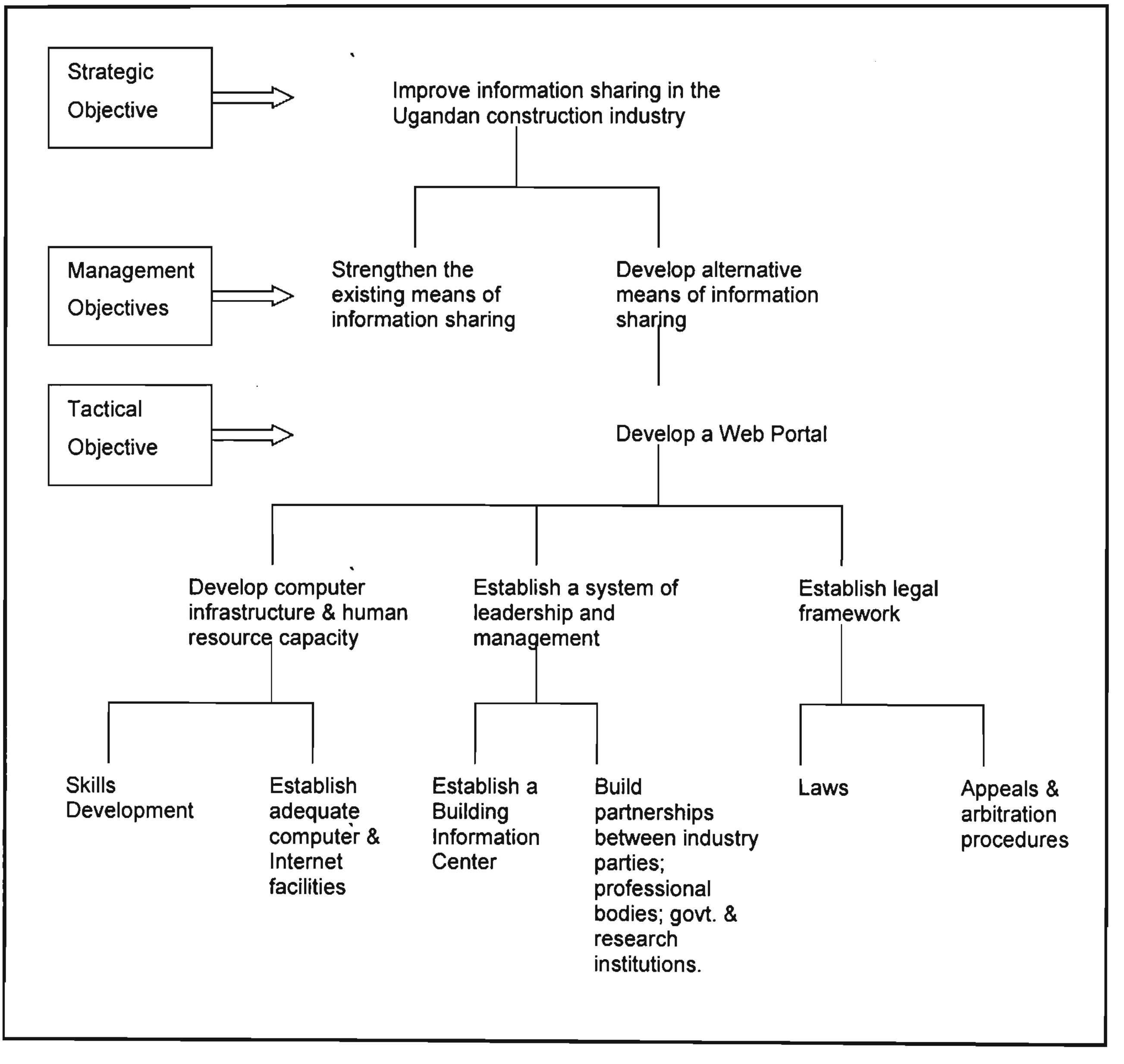


Figure 4-3: Objective tree diagram

Constraints

The following constraints were identified:

Capital and maintenance costs

Establishing a web portal is a capital-intensive investment, requiring inputs of computer and Internet infrastructure, as well as skills development. The web portal system also requires the establishment a building information centre to house the portal and construction databases, and to coordinate the various stakeholders.

Legal framework

A web portal needs a legal framework constituted by relevant laws and regulations on information sharing and exchange. Requirements of information authentication and non-repudiation are crucial to any information sharing system. The web portal system must also establish procedures for appeals and arbitration in the case of disputes and conflicts arising from the information sharing and exchange processes.

Change of users thinking and methods of work

Establishing a web portal for the Ugandan construction industry demands a change in users' thinking, and particularly, the importance they attach to information. The information presented on the web portal would be of little use if not fully utilised by users. The system requires users to change their methods of work, and especially implies a shift from paper-driven methods to computer-driven (or digital) approaches.

Data requirements

Data presented on a web portal must meet certain standards; typically the Industry Foundation Classes (IFC), web authoring standards, and other data standards applicable to the construction industry. Procedures that ensure data integrity and data security are crucial. One must build safeguards against illegitimate use and privacy protection into the design of information systems (Churchman, 1968).

4.5 Concluding Remarks

This chapter has developed a theoretical framework on systems and systems methodologies within the context of the study of the web portal. This theoretical framework served as a basis for the carrying out of a systemic analysis of the web portal. The analysis was set out using systems diagrams that relate to HSM and SSM.

The systematic study of the web portal suggests that successful implementation of the system will not only depend on the "hard" (or technical) factors but also on the "soft" (or people) factors, such as changing the users' thinking, methods of work, developing trust, and building partnerships amongst the industry participants. It is envisaged that establishing a web portal will bridge an information gap in the Ugandan construction industry. This will contribute to effective management of construction projects.

5 ANALYSIS AND DISCUSSION OF RESULTS

5.1 Introduction

The analysis and discussion of the research findings presented in this chapter are based on the quantitative data collected through questionnaires and processed using SPSS 11.5, and the qualitative data collected through interviews. The interview survey data was used to explain trends in the results of the questionnaire survey, a dynamic which has already been explored. The analysis and discussion of findings build on the earlier discussion on systemic analysis (see chapter 4), typically by quantifying the findings, studying associations between variables, and testing the significance of the relationships observed in the study. The focus of the analysis and discussion of findings was to study the existing methods of information sharing, assess the capacity of the participants to utilise the web portal, study the users' information needs, and to assess the viability of the web portal from the users' perspective.

Section 5.2 of this chapter discusses the respondents' profiles, section 5.3 discusses computer infrastructure and Internet access, and section 5.4 presents a discussion on computer usage. Section 5.5 discusses the status of information sharing in the Ugandan construction industry and section 5.6 details the users' information needs. Section 5.7 discusses the viability and management of the web portal from the users' perspective and section 5.8 highlights the challenges of establishing a web portal. Finally, section 5.9 provides a summary of the conclusions drawn from the discussions of this chapter and therefore serves as the background for the conclusions and recommendations of the research presented in chapter seven of this report.

5.2 Respondents' Profiles

5.2.1 Category of Respondent Firms

Respondents consisted of Architectural firms, Quantity Surveying firms, Consulting Engineering firms, Contractors, Project Management firms and the more loosely-defined, "other type" of firm. Project Management is still a youthful discipline in

Uganda and is yet to be recognised as an independent discipline by the existing professional bodies and the government Ministry of Works, Housing, and Communications. However, a few formerly Quantity Surveying and Architectural firms are practising as Project Managers. The "other type" refers to categories of firms which do not fall in any of the above categories, mainly because of the multi-disciplinary nature of their operations. No respondents classified themselves as Facility Management firms. Figure 5.1 below shows the distribution of responses amongst the categories of firms surveyed.

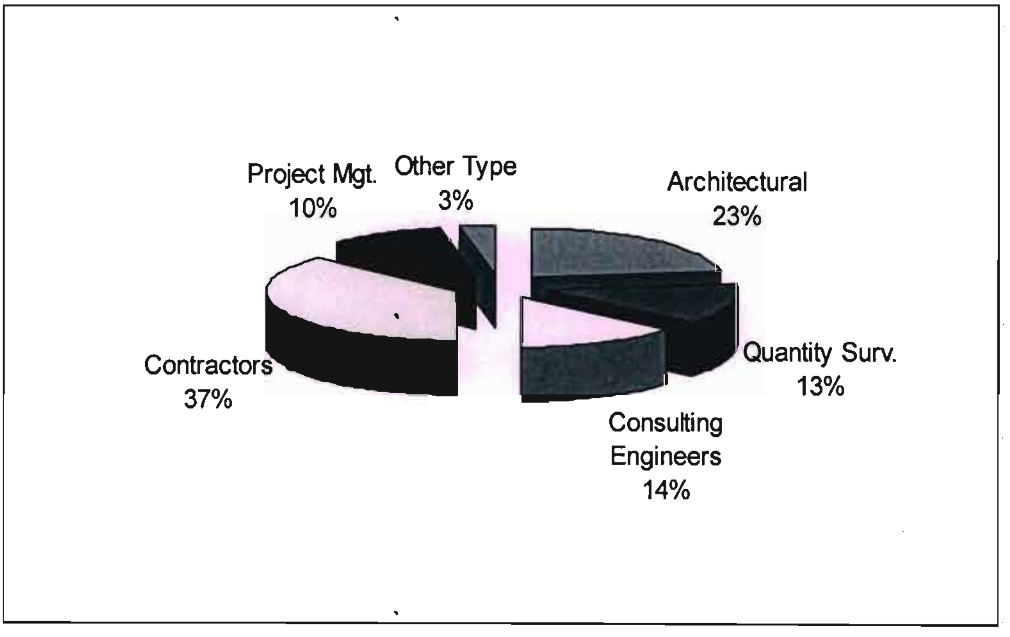


Figure 5-1: Distribution of responses among the categories of firms surveyed

5.2.2 Distribution of Respondents by Geographical Region

The majority of the respondent firms have offices in Kampala city (74%). Northern, Eastern, and Southern Uganda had an almost equal number of responses. Central and Western Uganda registered the smallest number of responses (3%). All Quantity Surveying firms, 90% of Consulting Engineering firms, 94% of Architectural firms, and 46% of contractors have offices in Kampala city. In comparison to 95% of Architectural firms that were operating in Kampala by 1997 (Charlotte, *et al.*, 1997), the proportion of Architectural firms operating in the city has not changed significantly in the last seven years. Central Uganda is characterised by high construction business but because of its proximity to Kampala city, few firms have their offices in the region. Figure 5.2 below shows the distribution of responses by geographical region and Table 5.1 shows the distribution of different categories of firms by geographical region.

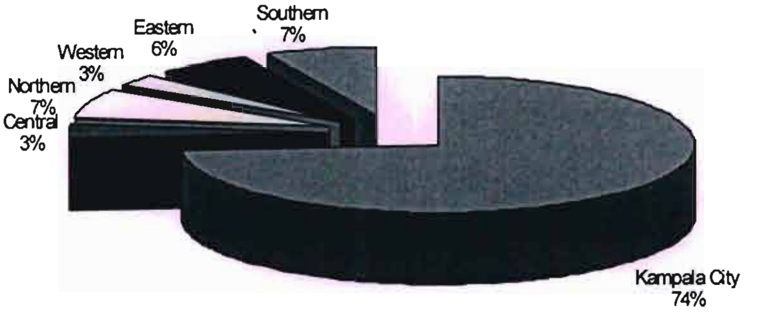


Figure 5-2: Distribution of responses by geographical region

Table 5-1: Distribution of categories of firms by geographical region

	Category of Firm						Total
	Architectural	Quantity Surveying	Consulting Engineers	Contractor	Project Mgt.	Other type	
Region: Kampala City	15(94%)	9(100%)	9(90%)	12(46%)	6(86%)	1(50%)	**52(74%)**
Central Uganda	-	-	-	2(8%)	-	-	**2(3%)**
Western Uganda	-	-	-	2(8%)	-	-	**2(3%)**
Northern Uganda	-	-	-	5(19%)	-	-	**5(7%)**
Eastern Uganda	-	-	1(10%)	3(11%)	-	-	**4(6%)**
Southern Uganda	1(6%)	-	-	2(8%)	1(14%)	1(50%)	**5(7%)**
Total	**16(100%)**	**9(100%)**	**10(100%)**	**26(100%)**	**7(100%)**	**2(100%)**	**70(100%)**

Remark: The values shown in brackets are column percentages.

Source: SPSS 11.5 Analysis of Questionnaire Data (2004)

5.2.3 Size Distribution of Respondent Firms

The majority of respondent firms can be categorised as medium-size with fulltime staff of between 5 and 25. Most of the consulting firms have more than 5 fulltime staff with only 25% of Architectural firms, 22% of Quantity Surveying firms, 30% of Consulting Engineering firms, and 14% of Project Management firms, having less than 5 fulltime staff. Most of the Contractors (57%) have between 5 and 25 fulltime staff. The survey results also show that, in comparison to other categories of firms, Contractors constitute the majority of firms with 26 up to 50 and with more than 50 fulltime staff at 12% and 15% respectively. Figure 5.3 below shows the size distribution of respondent firms in terms of number of employees.

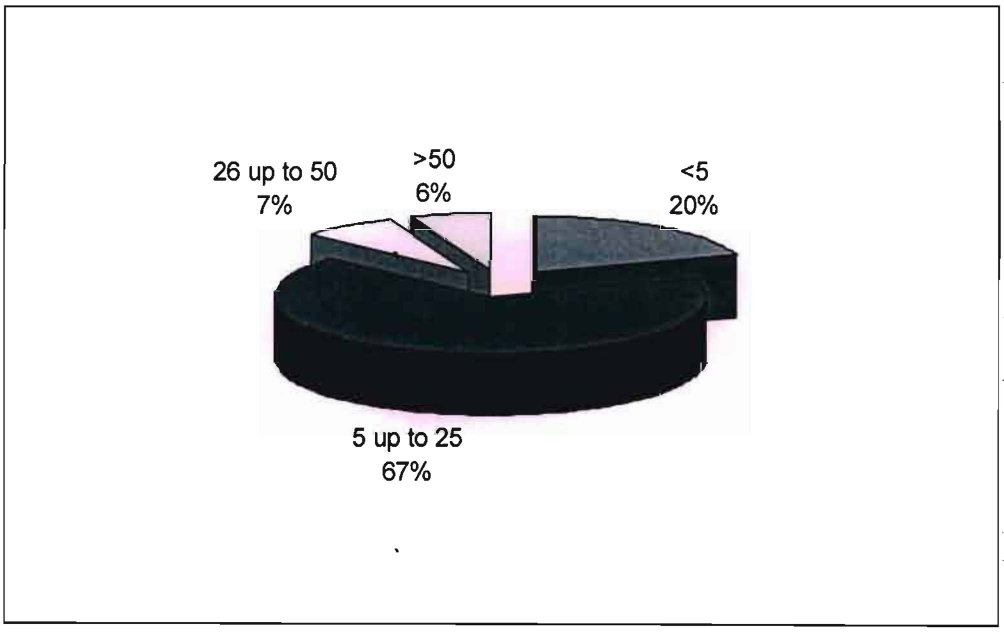


Figure 5-3: Size distribution of respondent firms in terms of number of employees

5.3 Computer Infrastructure and Internet Access

5.3.1 Computer Availability

Almost all of the respondents (97%) have computers and even the 3% who do not own computers have access to commercial computer services. Access to computer services is not influenced by geographical location, with both firms in Kampala city as well as those in the rural areas having access to computer facilities. The high level of access to computer services can be attributed to the relatively low price of computers, their usefulness and popularity, and the continued demand for computer processed presentations by clients. The 97% computer availability rate in the Ugandan construction industry compares with that of Canada's 99% (Rivard, 2000), is higher than the 88% availability in Sweden (Samuelson, 2002) and 86% in New Zealand (Doherty, 1997); the survey on computer usage in the New Zealand building and construction industry was carried out in 1997, and therefore it is possible that the statistics cited above have significantly changed in the last seven years. Figure 5.4 below shows the availability of computers among the respondent firms. 63% of the respondent firms use less than 5 computers and only 7% use more than 15 computers.

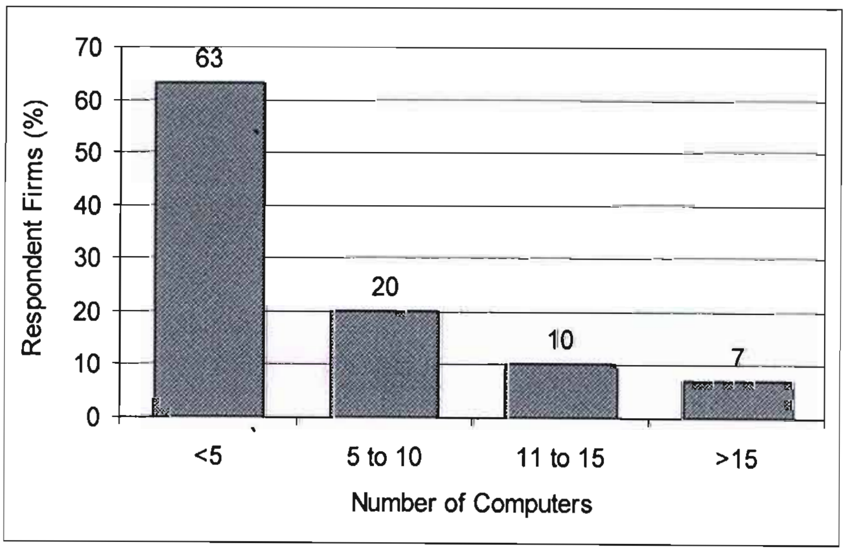


Figure 5-4: Computer availability

5.3.2 Local Area Network (LAN) Connections

43% of respondent firms have their computers connected by a Local Area Network (LAN). A LAN is an association of computers connected by less than 1,000feet of cable (Rivard, 2000). A LAN provides an easy way to coordinate and exchange text documents and large drawing files (Arif and Karam, 2001). Arif and Karam (2001) argue that with a LAN there is less maintenance required for individual computers, software is easy to update, and printing services to common printers are much easier. The proportion of firms (43%) connected to a LAN in the Ugandan construction industry is significantly lower than the 62% LAN connection in Canada (Rivard, 2000) and 60% in New Zealand (Doherty, 1997). In terms of categories of firms, the majority of Architectural firms, Consulting Engineering firms, and Project Management firms have LAN connections (see Table 5.2 for more details). Contractors and Quantity Surveyors have the least LAN connections at 19% and 11% respectively. The comparatively high percentages of LAN connections for Architectural firms, Project Management firms, and Consulting Engineering firms can be partly explained by the fact that most of the firms (70%, 57%, and 51% for Consulting Engineering, Project Management, and Architectural firms respectively) have more than 5 computers and therefore it is considered cost effective to have a LAN connection. Table 5.2 below sets out a summary of the statistics of LAN connections for the categories of firms surveyed.

Table 5-2: Statistics of LAN connections for the categories of firms surveyed

	Category of Firm						Total
	Architectural	Quantity Surveying	Consulting Engineers	Contractor	Project Mgt.	Other type	
Computers on LAN:							
YES	12(75%)	1(11%)	5(50%)	5(19%)	5(71%)	2(100%)	**30(43%)**
NO	4(25%)	8(89%)	5(50%)	21(81%)	2(29%)	-	**40(57%)**
Total	**16(100%)**	**9(100%)**	**10(100%)**	**26(100%)**	**7(100%)**	**2(100%)**	**70(100%)**

Remark: The values shown in brackets are column percentages.

Source: SPSS 11.5 Analysis of Questionnaire Data (2004)

5.3.3 Internet Access

77% of the respondent firms are connected to the Internet. In terms of categories of firms, all Project Management firms, 89% of Quantity Surveying firms, 81% of Architectural firms, 80% of Consulting Engineering firms, and 62% of contractors are connected to the Internet. In comparison to the construction industry in Canada (Internet access of 90% as reported by Rivard, 2000), Malaysia (Internet access of 94% as reported by Mui *et al.*, 2002), Sweden (Internet access of 83% as reported by Samuelson, 2002), Internet access in the Ugandan construction industry can be considered low. However, for a developing country such as Uganda, a 77% access to the Internet should be considered satisfactory. The interview survey revealed that Internet connections in Uganda are relatively slow. The most common means of Internet access are through modem connections to dial-up networks. A dial-up connection may be adequate for simple electronic communications such as e-mail and newsgroups; however, it is not efficient or appropriately fast enough to convey large and complex construction information, such as CAD drawings, or to process requests for large amounts of information online (Nitithamyong and Skibniewski, 2004). A few firms have radio-link connections, but still, Internet access remains relatively slow.

A web portal is a web-based application, and therefore computer availability and Internet access are major considerations for its successful implementation. Local Area Networks are also essential as a means of enhancing intra-organisational information sharing and exchange.

5.4 Computer Usage

Computers have become a ubiquitous presence and can be used for many purposes in the construction industry. They are now a vital part of all effective businesses (Doherty, 1997). In the Ugandan construction industry, computers have been fully utilised in some areas and under-utilised in others. This section of the report discusses computer usage in terms of type and extent of software usage, level of computerisation of key business processes and also presents a discussion on the future plans of industry participants regarding investments in IT.

5.4.1 Software Usage

The survey on the extent of software usage looked at general purpose applications, i.e. word processors and spread sheets, and the specialised applications of databases, project planning, and Computer Aided Design (CAD). All firms that have computers use word processors and most of them use spreadsheets. In the category of specialised software, CAD is most prevalent. Databases and project planning packages are the least used software by the participants. Construction work is highly dependent on drawings production and this explains the dominance of CAD. The high usage of CAD is also an indicator of a shift from the traditional paper-driven design approaches to digital design approaches, especially amongst Architects and Consulting Engineers. The most commonly used CAD software are AutoDesk products, including AutoCAD, AutoCAD LT, ArchiCAD, Architectural Desktop, and AutoCivil, among others.

In comparison to the construction industry in other countries, the usage of office software in Uganda is comparable to Sweden, Canada, and Turkey, while the usage of project planning packages in Uganda is comparable to the industries in Sweden and Canada. However, the usage of CAD and databases is notably lower than in the aforementioned countries. Table 5.3 below gives comparative statistics on software usage.

Table 5-3: Comparative statistics on software usage

	Construction Industry			
	Uganda	Turkey	Sweden	Canada
Software:				
Word Processor	**97%** 100% (Architectural firms) 100% (Quantity Surv.) 100% (Consult. Eng.) 92% (Contractors) 100% (Project Mgt. firms) 100% (Other type of firm)	86%	97%	99%
Spread sheets	**86%** 75% (Architectural firms) 100% (Quantity Surv.) 100% (Consult. Eng.) 77% (Contractors) 100% (Project Mgt. firms) 100% (Other type of firm)	86%	90%	92%
CAD	**60%** 100% (Architectural firms) 11% (Quantity Surv.) 100% (Consult. Eng.) 31% (Contractors) 71% (Project Mgt. firms) 100% (Other type of firm)	-	77% (Architects) 89% (Engineers)	76%
Project Planning	**49%** 50% (Architectural firms) 22% (Quantity Surv.) 60% (Consult. Eng.) 43% (Contractors) 71% (Project Mgt. firms) 100% (Other type of firm)	-	49% (Architects) 46% (Engineers) 34% (Contractors)	47%
Database	**37%** 31% (Architectural firms) 0% (Quantity Surv.) 50% (Consult. Eng.) 47% (Contractors) 57% (Project Mgt. firms) 0% (Other type of firm)	50%	74%	65%

Source: Rivard (2000); Isikdag (2002); Samuelson (2002); Field survey data (2004)

The other software employed in the industry include WinQS and Masterbill Elite quantity surveying software, Ledger works and Tally accounting software, and CUSTIMA for accounting and human resource management. Oracle, my SQL, Microsoft Access and Microsoft SQL, are the most widely-used database software. Microsoft Project is the most widely used project planning software software and a few firms use Primavera project planner. STAAD III for Windows is used by Consulting Engineers as structural engineering software. Although not widely used, a few firms (mainly Contractors) use document imaging software for document management, including scanning, storage, indexing, and retrieval. Geographical Information Systems (GIS) software is also used in the industry, mainly by Consulting Engineering firms. A GIS is an integrated software application devised to capture, store, edit, analyse, and display geographic information and is typically used in land use planning, infrastructure management, environmental engineering, natural resources planning and management (Rivard, 2000). GIS is also used in site selection and management, and in surveying and mapping practice (Isikdag, 2002). Figure 5.5 below shows the extent of software usage amongst the respondent firms.

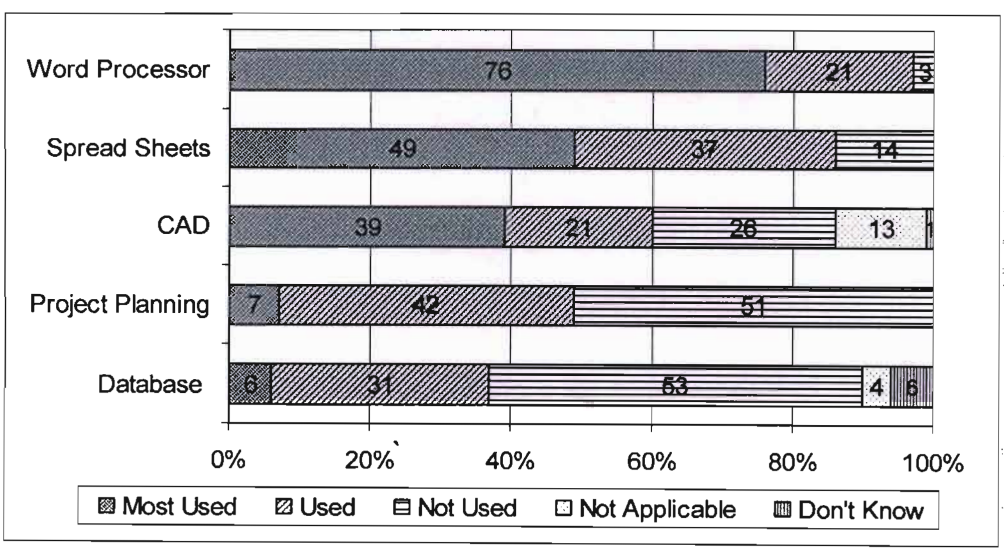


Figure 5-5: Software usage amongst the respondent firms

5.4.2 Computerisation of Business Processes

The survey evaluated the extent of computerisation of the common business processes in the Ugandan construction industry, using a rating scale consisting of the elements: Highly Computerised, Computerised, Less Computerised, Not Computerised, Not Applicable, and Don't Know (see Table 3.3 for details on the reliability analysis of the scale). The results of the survey show that bills of quantities, technical calculations, book keeping (accounting), costing and budgeting, and tendering processes are highly computerised. The results also indicate that invoicing, and scheduling processes are computerised. Purchasing and materials control are amongst the processes that are the least computerised in the industry. The lack of computerisation for some of the processes could be a result of lack of appropriate software or inadequate skills by staff. The survey revealed that in medium-sized firms (5 up to 25 fulltime staff), which are the majority, 36% of the firms have less than 5 fulltime staff able to use computers. Figure 5.6 below shows the extent of computerisation of business processes amongst the respondent firms.

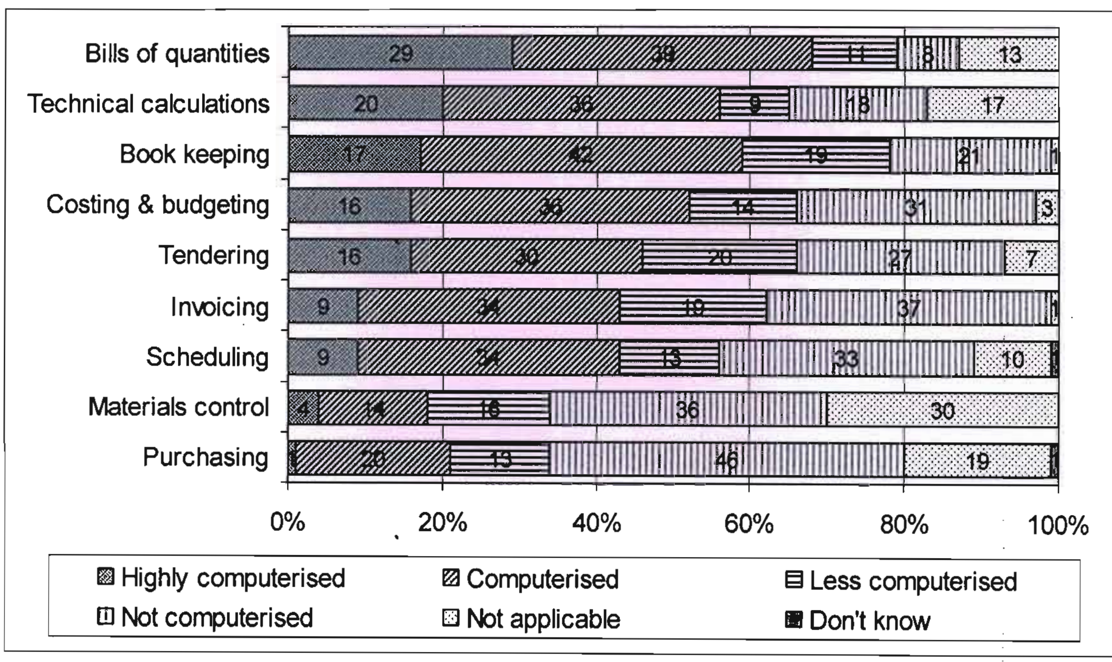


Figure 5-6: Extent of computerisation of business processes

In terms of categories of firms, 58% of Contractors have their tendering process computerised. Surprisingly, Contractors have a low level of computerisation of materials control, and purchasing processes at levels of 19% and 38% respectively, considering that these are important processes in their business. The same trend was observed in Sweden (Samuelson, 2002). However, bills of quantities were surprisingly more computerised amongst Contractors (73%) than Quantity Surveyors

(56%). Costing and budgeting, and bookkeeping (accounting) are more computerised amongst the Project Management firms at 86%. All Consulting Engineering firms have technical calculations, 70% of invoicing and 60% of scheduling processes computerised.

5.4.3 Future Plans Regarding Investments in IT

During the questionnaire survey, respondent firms were asked to indicate the key areas of their future investments in IT. The results of the survey have shown that about the same number of respondent firms (51%) plan to invest in Computer Aided Design (CAD), project management systems, and bills of quantities software. A low number of firms (30%) plan to invest in document handling systems. This could probably be the result of lack of awareness on the existence and/or benefits of such systems. 50% of the respondent firms plan to invest in Internet services, while the majority of the firms (87%) that plan to invest in Internet services are not connected to the Internet. This is an indicator that in the near future, access to Internet is likely to increase and more participants will benefit from the envisaged web portal system.

In terms of categories of firms, 80% of Consulting Engineering firms plan to invest in CAD, followed by Architectural firms at 56%. 62% and 60% of Contractors and Consulting Engineers respectively, plan to invest in Internet services and accounting systems. 60% of Consulting Engineers plan to invest in project management systems, followed by Architectural firms at 56%. Surprisingly, a meagre 28% of Project Management firms plan to invest in project management systems. This can be explained by the fact that these firms were satisfied with their present investments in IT and prefer to focus more on the maintenance and updating of the systems. 90% of Quantity Surveyors plan to invest in bills of quantities followed by Contractors at 58%. This is expected because Quantity Surveyors and Contractors make use of bills of quantities more than any other category of firm. 70% of Consulting Engineering firms plan to invest in technical calculations followed by Project Management firms at 57%. Overall, it can be deduced from the above statistics that Consulting Engineering firms are more keen to future investments in IT than any other category of firm. Figure 5.7 shows the survey responses on the future investments in IT.

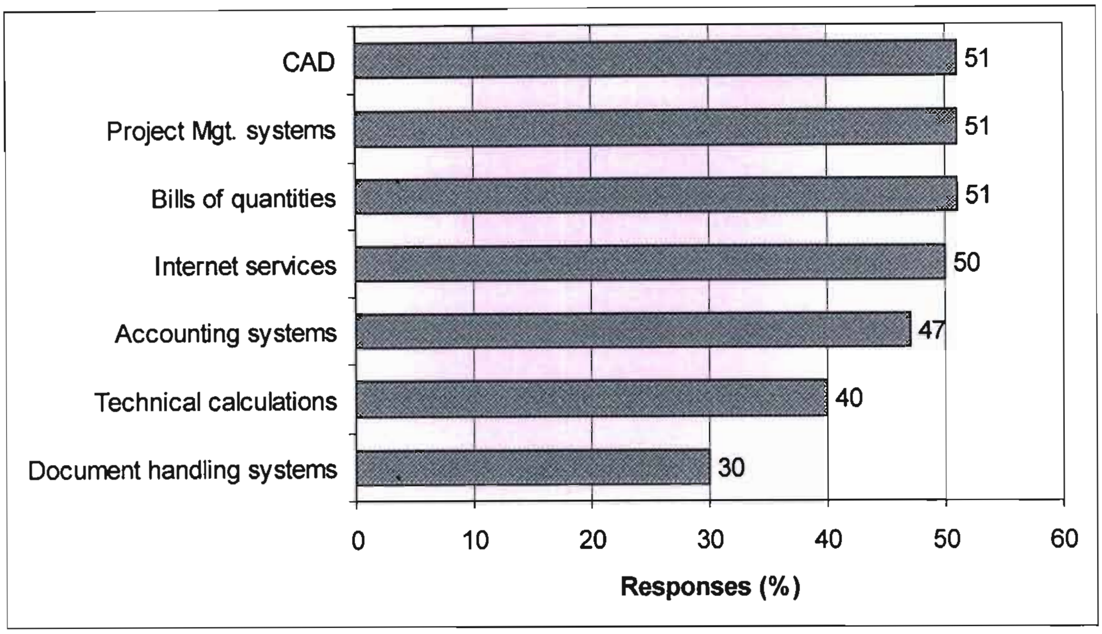


Figure 5-7: Future plans regarding investments in IT

5.5 Status of Information Sharing in the Ugandan Construction Industry

During the questionnaire survey, respondent firms were also asked to indicate whether or not they are involved in information sharing. Follow-up questions were employed to probe the participants on how they are involved in information sharing, with whom they share information, the type of information shared, the methods of sharing information, and the challenges they face during the information sharing process.

5.5.1 Extent of Information Sharing amongst the Industry Participants

The majority of respondent firms (93%) are involved in some form of information sharing with other parties in the industry, though it is most prevalent amongst Architectural firms (100%), between Quantity Surveying and Architectural firms (100%), amongst Consulting Engineering firms (90%), between Consulting Engineering firms and Contractors (90%), between Quantity Surveying and Consulting Engineering firms (89%), and between Architectural and Consulting Engineering firms (88%). The lower levels of instances of information sharing were reported between Contractors and Project Management firms (23%). This can be attributed to the fact that project management is still a youthful discipline in Uganda (see section 5.2.1) and therefore very few projects are delivered under the leadership of project managers.

As has been noted overall, Architectural firms are more involved in information sharing than any other category of firm. This can be attributed to their central role in the procurement process, especially at the design stage and the fact that on most building projects in Uganda, an Architectural firm is the principal agent of the client. The statistics have also shown that information sharing is more prevalent amongst construction consultants than between construction consultants and contractors or amongst contractors.

5.5.2 Category of Shared Information

Most of the information shared amongst participants is in form of Computer Aided Drawings (CAD), estimates, word processed documents and paper drawings. Database and project management information are amongst the least-shared information. This could be partly explained by the fact that database systems and project planning packages are not widely used in the industry (see section 5.4.1). Figure 5.8 below presents a summary of the category of information shared amongst the industry participants.

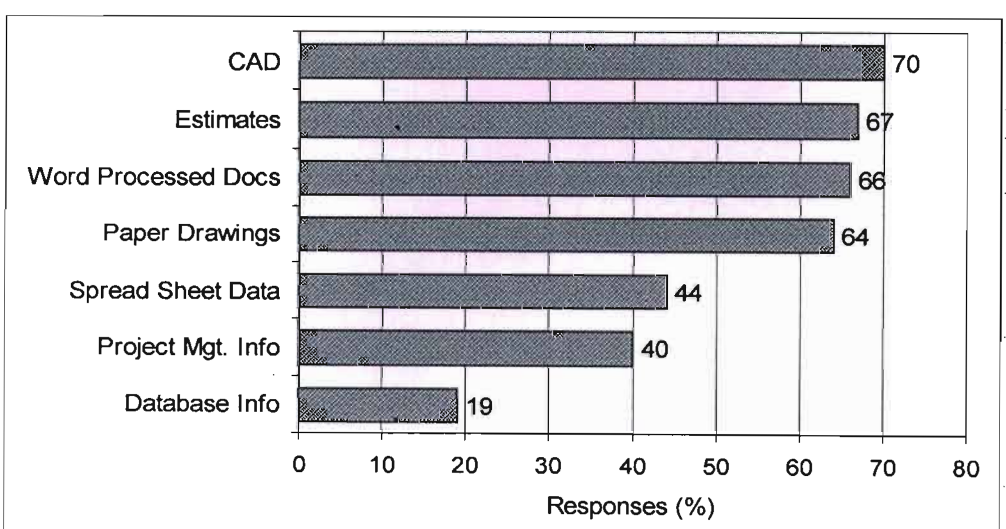


Figure 5-8: Category of shared information

5.5.3 Methods of Sharing Information

Hand delivery is the most commonly used means of sharing and exchanging information, with 90% usage by the respondent firms. 88% of respondent firms use telephone as a means of sharing information, 77% use postage and 74% employ E-mail. The interview survey revealed that project meetings are a common means of sharing information and storage devices such as CDs and Floppy disks are commonly used to exchange information. Figure 5.9 below presents a summary of the existing means of information sharing.

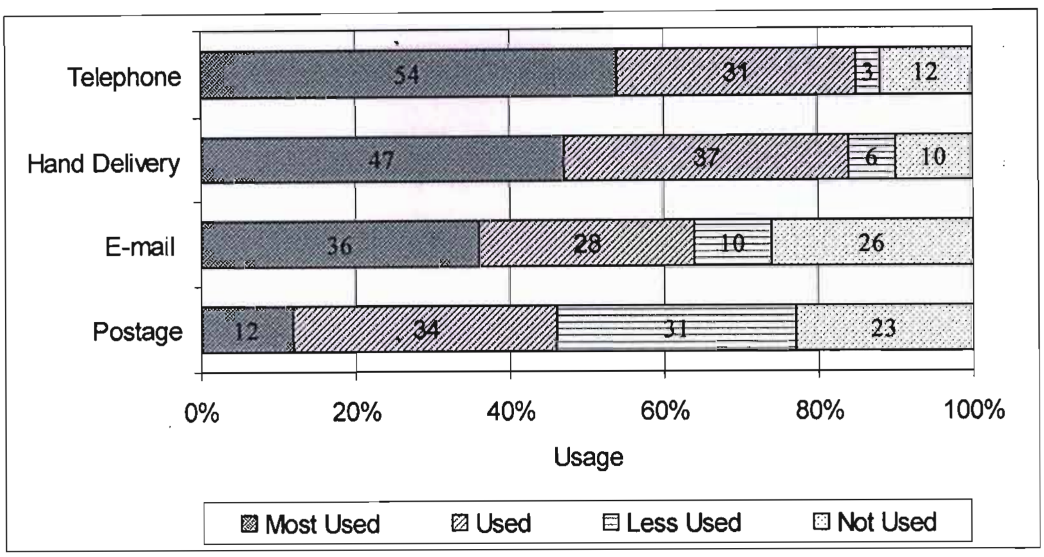


Figure 5-9: Existing means of information sharing

5.5.4 Weaknesses of the Existing Methods of Information Sharing

50% of the respondent firms indicated that threats to the integrity and safety of shared information is a major weakness of the existing means of information sharing, 47% consider delays in information delivery as another hindrance, while the apparent lack of trust between the participants was also cited by 36% of the respondent firms as a limitation. Figure 5.10 below presents a summary of the weaknesses of the existing means of information sharing.

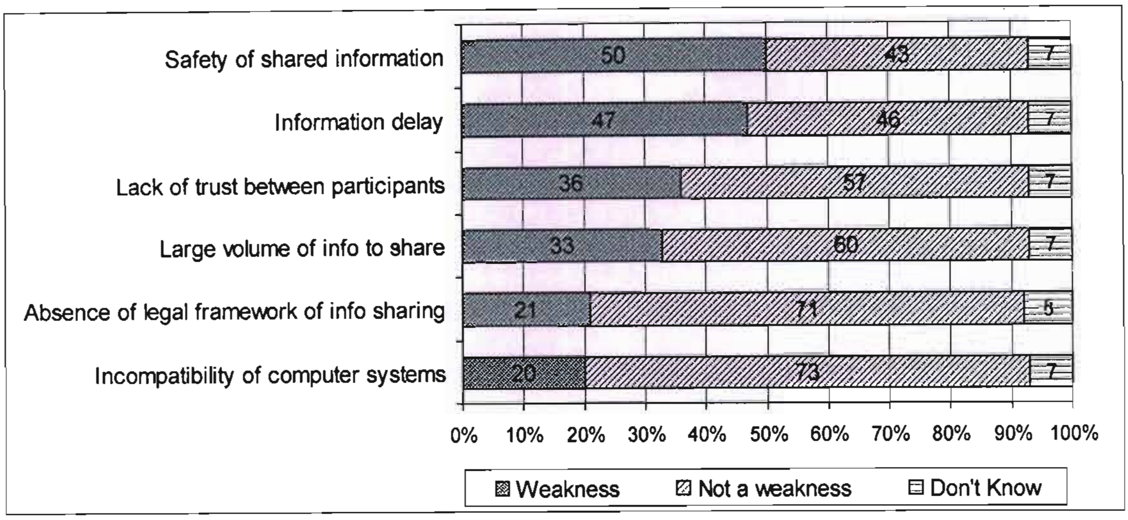


Figure 5-10: Weaknesses of existing methods of information sharing

The statistics provided above (Figure 5.10) emphasise the fact already noted that respondent firms acknowledge the weaknesses of the existing means of information sharing. However, the statistics do not reveal that the perceived weaknesses are significant enough to require an intervention. To that effect, a chi-square test was carried out. The results of the test are given in Table 5.4 below.

Table 5-4: Chi-square test on the weaknesses of the existing methods of information sharing

	Information delay is a weakness	Large volume of info to share is a weakness	Safety of shared info is a weakness	Compatibility of digital information is a weakness	Lack of trust between parties is a weakness	Uncertainty surrounding the legal framework of info sharing Is a weakness
Chi-Square [a]	21.629	29.343	22.143	50.943	26.429	47.857
Df	2	2	2	2	2	2
Asymp. Sig.	.000	.000	.000	.000	.000	.000

a. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 23.3.

Source: SPSS 11.5 Analysis of questionnaire data (2004)

The Chi-square test technique used is the Chi-square for goodness of fit. The test explores the proportion of cases that fall into the various categories of a single variable, and compares these with hypothesised values (Pallant, 2001). Chi-square tests require expected frequencies above 5 (Goddard and Melville, 2001). As shown in Table 5.4 above (see table footnote), all expected frequencies were above 5. To be significant, the significant values (represented as asymp. sig. in Table 5.4) needs to be 0.05 or smaller (Pallant, 2001). All significant values are less than 0.05, suggesting that the perceived weaknesses of the existing methods of information sharing are significant enough to require an intervention.

5.6 Assessment of Users' Information Needs

The users' information needs were assessed through a questionnaire survey by asking respondent firms to rank different categories of information according to their importance to the firm. Information on construction materials and costs, building codes and standards and opportunities for service delivery, were considered the most relevant by the majority of respondent firms. Information on construction professional bodies, developments in the international construction industry, documentation of previous projects, laws and legislation, opportunities for capacity building and training, and research results from the local construction industry, were regarded as important by the majority of respondent firms. Below, Table 5.5 sets out the ranking of different categories of information by the respondent firms.

Table 5-5 Information needs assessment: ranking by respondent firms

	Rank		
	Most Important	Important	Least Important
Information Need:			
Information on construction laws and legislation	31%	56%	13%
Information on construction materials and costs	59%	36%	5%
Building codes and standards	59%	37%	4%
Tender processes and procedures	50%	39%	11%
Labour rates	31%	43%	26%
Developments in the international construction industry	17%	62%	21%
Opportunities for offering construction services	54%	30%	16%
Information on construction machinery and equipment	29%	37%	34%
Opportunities for capacity building and training	27%	53%	20%
Contacts and websites of construction parties	20%	49%	31%
Documentation of previous projects	26%	57%	17%
Information on construction professional bodies	13%	61%	26%
Local industry research results	30%	51%	19%

Source: SPSS 11.5 Analysis of questionnaire data (2004)

A common set of needs was expressed by the categories of firms, and they individually expressed what was most important to them. Contractors consider information on construction materials and costs (73%), tender processes and procedures (65%), opportunities for service delivery (65%), and construction machinery and equipment (62%) as most important. Architectural firms consider information on building codes and standards (69%) as most important and documentation of previous projects (69%) as important. Quantity Surveyors consider documentation of previous projects (78%), information on professional bodies (78%), machinery and equipment (67%), and contacts and websites of participants (67%) as important. Consulting Engineering firms consider contacts and websites of participants (80%), information on previous projects (70%), and professional bodies (70%) as important to their needs. A conceptual model of the users' information needs is given as Figure 6.2 in Chapter 6 of this report.

5.7 Viability and Management of the Web Portal from the Users Perspective

5.7.1 Users Views on the Viability and Benefits of the Web Portal

The viability of the web portal was assessed through questionnaire and interview surveys by seeking respondents' views on using a web portal as means of enhancing information sharing, the willingness of the participants to share the information produced by their organisations, and the perceived benefits of sharing information by the participants.

83% of respondent firms consider the web portal to be an effective means of sharing information, 3% do not consider it effective, and 14% were not certain. 93% of the respondent firms are willing to share the information produced by their organisations, while 7% are not. The argument raised by most of those not willing to share construction information is the fear of competition. This category of participants argue that certain types of information such as estimates and designs should not be shared and indicate that, in the event that such information is shared, copyright should remain with the producer of information. The above argument points to the fact that there is a stigma attached to information sharing amongst some participants and this also acknowledges the fact that there are legal implications related to information sharing.

Respondents were optimistic about the benefits of using a web portal to enhance information sharing. 80% of the respondent firms indicated that information sharing will result in savings in time and cost during design, construction and maintenance phases and 73% indicated that information sharing will improve the quality of decision-making due to availability of information. 73% of the respondents indicated that information sharing and exchange will lead to improved teamwork on projects and 56% indicated that information sharing and exchange will lead to efficient working of dispersed construction parties. These statistics suggest that users acknowledge the benefits of setting up a web portal. However, they do not show that the benefits are significant enough to justify the initiative. To that effect, a Chi-square for goodness of fit test was carried out. The results of the test are given in Table 5.6 below.

Table 5-6: Chi-square test on the benefits of the web portal

	Saving time & cost is a benefit of info sharing	Improved teamwork is a benefit of info sharing	Improved quality of decision-making is a benefit of info sharing	Efficient working of dispersed parties is a benefit of info sharing
Chi-Square [a]	25.200	14.629	14.629	.914
Df	1	1	1	1
Asymp. Sig.	.000	.000	.000	.339

a. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 35.0.

Source: SPSS 11.5 Analysis of questionnaire data (2004)

The test results data meets the minimum requirements of expected frequencies above 5 (as quoted by Goddard and Melville, 2001). To be significant, the significant values (represented as asymp. sig. in Table 5.6) need to be less than or equal to 0.05 (Pallant, 2001). All significant values are less than 0.05, suggesting that the perceived benefits are significant enough to justify the development of the web portal.

5.7.2 Management of the Web Portal

During the questionnaire survey, respondents were asked to indicate the industry body considered best placed to manage and maintain the web portal. 56% of the respondent firms consider professional bodies to be best placed to manage and maintain the portal. 40% and 24% consider academic and research institutions, and the government ministry of works and communications, respectively, to be the more viable bodies to manage and maintain the web portal. A common opinion expressed throughout the interviews was that the web portal should be managed by an independent body, constituted by all of the stakeholders in the industry.

5.8 Challenges of Establishing a Web Portal

Participants in the Ugandan construction industry acknowledge the fact that establishing a web portal poses a number of challenges. The majority of the respondent firms consider regular updating of information, failure of participants to provide accurate information, and the need of participants to change work methods as the biggest challenges of establishing a web portal. Less than 50% of the respondent firms consider high capital and maintenance costs and the failure of participants to access Internet services as serious challenges. Additionally, respondent firms did not consider access to the Internet a serious hindrance because the majority of them have access to that service.

The fundamental requirements for establishing the web portal include adequate computer infrastructure, skills development, and an effective administrative system. As has been mentioned, the web portal also requires establishing a legal framework for information sharing and exchange, and the data presented on the web portal must meet certain standards such as STEP, IFC and web authoring standards. A detailed discussion of the challenges of establishing a web portal is given in section 4.4.4 of this report. Figure 5.12 below illustrates the respondents' assessment of the challenges of establishing a web portal.

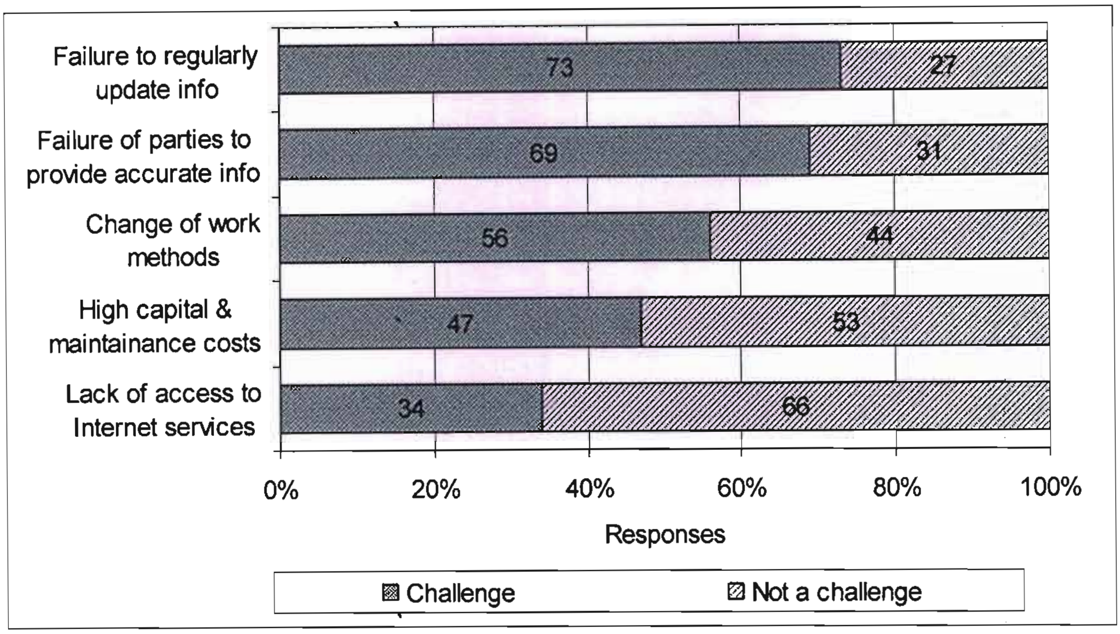


Figure 5-11: Challenges of establishing a web portal

5.9 Concluding Remarks

The analysis and discussion of results has shown that the Ugandan construction industry participants have adequate IT infrastructure and Internet access capacity to benefit from the web portal. The high number of participants willing to share the information produced by their organisations represents a great potentiality for the establishing of the system. The participants acknowledge the benefits of the web portal in terms of savings in time and cost, improved quality of decision-making, improved teamwork on projects, and efficient working of dispersed parties. The existence of challenges facing the implementation of the web portal should not be a reason to thwart its establishment. Rather, these challenges should be understood as the unavoidable socio-technical factors which can be met by the beneficiaries of the system including construction professionals, professional associations, the government and property developers.

6 CONCEPTUAL MODELLING AND SYSTEM SPECIFICATION

6.1 Introduction

This chapter builds upon the analysis and discussion of results presented in chapter 5 of this report. The conceptual model of the web portal was developed through the modelling of users' information needs and mapping of data flows within the system. As defined by Konsynski (1981:265), conceptual modelling refers to the "process of representing a user's information view in some formal definition form". A good conceptual model allows complete and natural representation of a user's world (*ibid.*). The conceptual models presented in this chapter are based on the users' expectations of the system within the context of the best practice in the design of web portals and related web-based information systems.

In this chapter, conceptual modelling is discussed in section 6.2 and section 6.3 presents the web portal specifications. The discussion on web portal specifications cover web portal interface, system security, web portal architecture and programming, system reliability, and applications integration. Finally, section 6.4 sets out a summary of the conclusions drawn from the discussion on conceptual modelling and web portal specifications.

6.2 Conceptual Modelling

During the study, two conceptual models were developed, and they included a users' information needs model, and a data flow model for the stages of a construction cycle. The users' information needs model evolved from the assessment of the users' information needs discussed in chapter 5 of this report. The data flow model for the stages of a construction cycle was developed using the structured modelling approach. The data flow model enhances the users information needs model by mapping out the flow of data in the system, defining the data transformation processes, and also graphically depicting the key sources of information in the system.

6.2.1 Structured Modelling Approach

6.2.1.1 The Concept of Structured Modelling

Structured modelling is associated with structured analysis, and has had widespread use in systems analysis. In the construction industry, structured modelling has found extensive user acceptance (Hiremath and Skibniewski, 2004). In structured modelling, primary priority is given to the various processes in the system domain. The whole system is analysed in terms of functional processes and each process is designed and implemented accordingly. Data flow diagrams are used to model these processes.

In the current systems paradigm, structured modelling can be defined as a hard system (Checkland, 1981; Fisher and Yin, 1992). The structured modelling approach necessitates considering the whole system in its entirety (Hiremath and Skibniewski, 2004), and from a holistic view, it is easier to locate errors of logic, gaps, and any considerable redundancy built into the system (Fisher and Yin, 1992). These arguments on systems thinking are particularly important to this study because they emphasise the fact that structured modelling enhances the systemic approach adopted earlier during analysis (see chapter 4 for details).

In structured modelling, the system is divided into sub-systems, which are further partitioned into sub-sub-systems until they cannot be deconstructed any further. The diagrams are simply-structured with minimal modelling elements and are easy to comprehend (Hiremath and Skibniewski, 2004). Thus, it can be argued that this has contributed to its wider user acceptance.

6.2.1.2 Overview of Data Flow Diagrams

Data Flow Diagrams (DFD's), associated with structured analysis, are popular and arguably the most popular structured modelling technique (Barros and Hofstede, 1998). A data flow diagram is a network of interrelated processes expressed graphically and follows the convention of showing the flow of data, but not control (DeMarco, 1978; Fisher and Yin, 1992). Data flow diagrams map the journey of information through a system, recording its transformations and co-ordinations (Baldwin *et al.*, 1996b). Data is transformed at each step before moving onto the next stage (Sommerville, 1995).

A data flow diagram portrays the system in terms of its component pieces, with all interfaces among the components indicated (DeMarco, 1978). It is the documentation of a situation from the point of view of data and can be used as a model of a real situation (*ibid.*). DeMarco (1978) asserts that studying a situation from the perspective of data presents an opportunity for seeing a big picture rather than a specific portion of ontological reality. The latter is a common characteristic of various people and machines that handle data. Data flow diagrams have the advantage that, unlike some other modelling notations, they are simple and intuitive (Sommerville, 1995). Together with the decomposition feature, the simplicity, and general concepts associated with data flow diagrams, they allow effective comprehensibility, which is useful for the early phases of analysis where the broader functionality of a system is still being determined (Barros and Hofstede, 1998), and they permit process interaction with the environment and hence incorporating some treatment of external interaction (*ibid.*). They also indicate that this assists in the validation of large, cumbersome data flow diagrams.

Definitions and Terminology

A data flow diagram depicts the passage of data through the system using four basic symbols. Different authors have suggested alternative notations and the one presented here is that adopted by DeMarco (1978) and Yourdon (1989). The symbols are shown in Figure 6.1 below.

Data Flow

Flows are shown by curved, directed arrows. They are the connections between the processes (systems functions) and they represent the information that the processes require as input and/or the information they generate as output (Yourdon, 1989).

Process

Processes invariably show some amount of work performed on data (DeMarco, 1978). They are indicated by circles or bubbles in the diagram. They represent the various individual functions that the system carries out (Yourdon, 1989). Functions transform inputs into outputs (*ibid.*).

Data Store

A data store is a temporary repository of data (DeMarco, 1978). Data stores are shown by two parallel lines. They indicate collections (aggregates) of data that the system must remember for a period of time (Yourdon, 1989). When system designers and programmers finish building the system, the stores will typically exist as files or databases (*ibid.*).

Source or Sink

A source, or sink, is a person or organisation, lying outside the context of a system that is a net originator or receiver of system data (DeMarco, 1978). They are shown in the diagram by rectangles or squares.

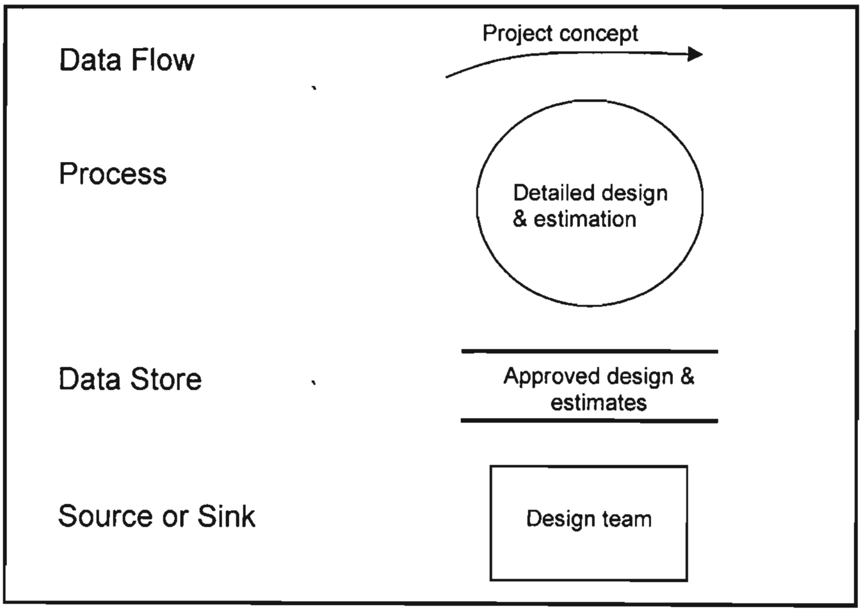


Figure 6-1: Notation used in data flow diagrams

6.2.2 Construction of Conceptual Models

This section considers the construction of two conceptual models. The development of the users' information needs model is discussed in section 6.2.2.1 below, and the construction of the data flow model for the stages of a construction cycle is discussed in section 6.2.2.2.

6.2.2.1 The Users' Information Needs Model

The users' information needs model was constructed based on the assessment of the users' information needs (see section 5.6 for details). Different participants in the construction industry have common information requirements. Therefore, to reduce the possibility of data redundancy in the model, it was considered unfeasible to classify information according to the categories of participants in the industry. Categorisation of information according to the four main stages of a construction cycle i.e. planning, design, procurement/construction, and post-construction (facility management) minimises data redundancy in the model. The notation used was adapted from Sing and Zhong (2001). A web portal is placed at the centre of the users' information needs model, receiving and providing information at various stages of a construction cycle. The users information needs model is presented as Figure 6.2 below.

6.2.2.2 Data Flow Model for the Stages of a Construction Cycle

The data flow model for the stages of a construction cycle illustrates the flow of data and functional processes across the different stages of the construction cycle. The notation used in the model was adapted from DeMarco (1978) and Yourdon (1989), while the details of the notation are explained in section 6.2.1.2. The model develops from the users information needs model by introducing the industry participants into the system. Industry participants are the primary "sources" and "consumers" of information presented on the web portal. The model defines the data output for the various stages of a construction cycle: a refined project concept, approved design and estimates and environmental management plan, a construction product (i.e. building or civil engineering structure), and property demolitions and/or redevelopment were identified as outputs for the planning, design, construction, and facility management stages respectively. The model follows the project management delivery system, whereby a project manager is the principal agent for the client (property developer). As illustrated in the model, the project manager's roles cut across the planning, design, and procurement/construction stages of the construction cycle. The data flow model for the stages of a construction cycle is presented as Figure 6.3 below.

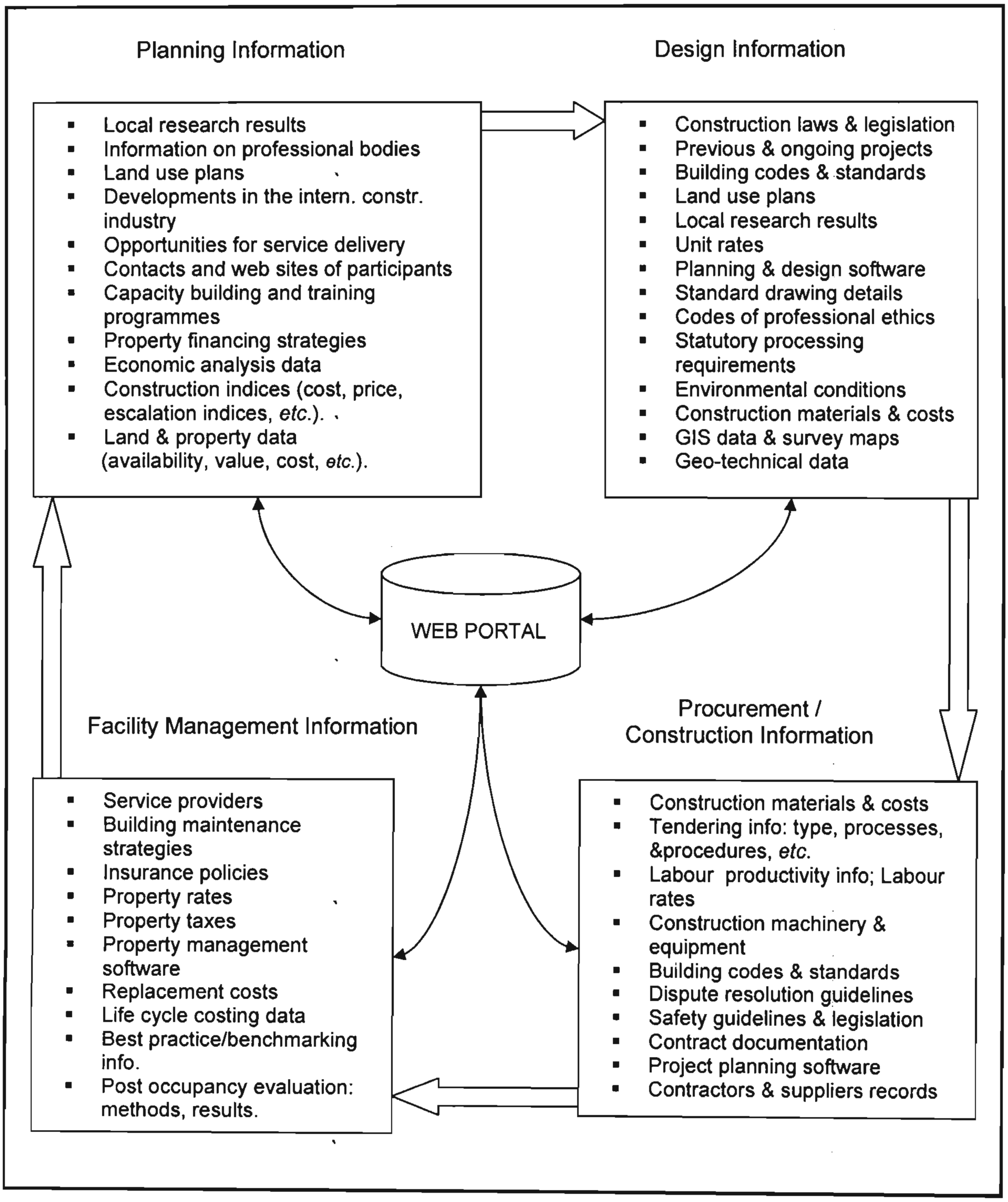


Figure 6-2: Users information needs model

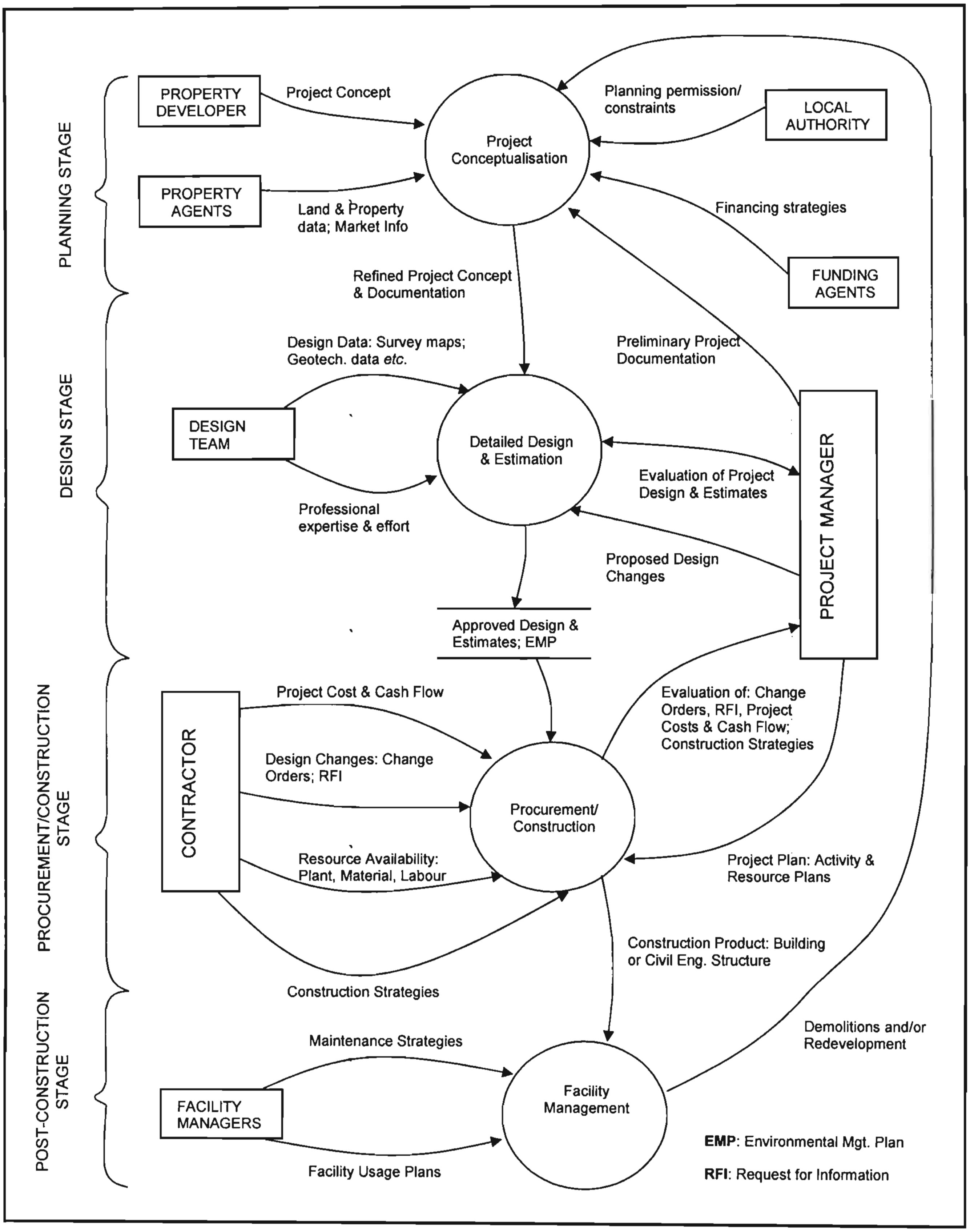


Figure 6-3: Data flow model for the stages of a construction cycle

6.2.3 Validation of Conceptual Models

The validation of the conceptual models was carried out in order to test the quality of the conceptual design. As argued by Knutson and Carmichael (2001), quality must be designed into the system and the underlying assumption is that the quality of the development process directly affects the quality of delivered products. Quality is not a feature that can be added to a system in use, for it is a process that begins with system conceptualisation and continues long after the system is in use (Knutson and Carmichael, 2001). Validation is concerned with building the right product (Sommerville, 1995; Knutson and Carmichael, 2001), and involves checking that the system meets the needs of the user (Konsynski, 1981; Sommerville, 1995; Knutson and Carmichael, 2001).

During the study, the approach used to validate the conceptual models is that recommended by Tuzmen (2002), whereby the conceptual models were validated by a panel of six experts in construction industry practices and communication. Three experts were drawn from the Ugandan construction industry and the other three from the South African. The inclusion of experts from the Ugandan construction industry was primarily aimed at validating the models to suit the local construction industry needs. It can be argued that appraising the models by experts from the South African construction industry helps to demonstrate that the conceptual models can be adopted elsewhere with minor modifications to suit local conditions.

During the validation process, the experts were asked to critically appraise the model in terms of structure, content, and any other aspects of the model which they considered necessary for refinement. There was general agreement among experts of the validity of the structure and content of the conceptual models. However, a few suggestions were made, especially relating to economic analysis and the role of local authority in granting planning permission, setting planning constraints during the planning stage, environmental considerations during the design stage and lifecycle costing during the facility management stage. The comments made by experts were used to refine the preliminary conceptual models. Figure 6.2 and Figure 6.3 represent the final versions of the conceptual models. A copy of the validation form is attached as Appendix C.

6.3 Web Portal Specifications

This section describes in general terms the specifications of the web portal system. The system specifications were defined and deduced from the study of users' expectations of the system, from the conceptual models of the system, and from the established best practice for web based information systems.

The proposals put forward in form of system specifications offer the following features:

i. Support the detailed design and implementation of the web portal.
ii. Present the user with an understandable and helpful dialogue mode (i.e. user interface).
iii. Enable effective control and management of the system.
iv. Ensure the security and integrity of the information presented on the web portal.
v. Support up-to-date technology for web based information systems.
vi. Support integration with other applications by adopting standards for information sharing and exchange.

Thorpe (1992), citing Cusack (1987), identifies five general criteria which should be followed when designing a computer-based information system:

i. The system must meet the requirements of the potential users and the temptation to design and implement a sophisticated system which is not understandable must be avoided.
ii. The system should make as much use as possible of the exception principle, highlighting deviations from expected behaviour thus keeping the amount of routine information to a minimum; although this must be available for checking if required.
iii. The computer provides information by transforming data input. The accuracy of this information is dependent on the availability of pertinent data, which must normally be input in a specified format. Accordingly, the technique used to enter the data must be accurately described with a general data validation

procedure which will check and reject unsuitable information. Thus the system should request the operator to re-enter incorrect data items or enter missing data. It is important to ensure that existing data is not inadvertently destroyed when new data is entered.

iv. The system should be designed to allow additional modules to be added at a later date.

v. The level of skill, quality, potential and responsibility of the ultimate users should be taken into account, particularly in an interactive system where the users can enter and retrieve information.

The above factors were considered and incorporated when developing specifications of the web portal. These specifications are described in sections 6.3.1 to section 6.3.5 below.

6.3.1 Web Portal Interface

A web portal is a centrally-accessible system that provides information resources to its users. A web portal interface is crucial because it provides a means by which users can access information resources. A web portal interface manages the look and feel of the web portal, and it is a layer where text, images, audio, video and other data requested by the user are assembled into a coherent picture and then rendered for viewing (Murray, 2002).

An interface is a critical factor that determines the success of a system (Thorpe, 1992). To meet the expectations of the user, a web portal interface must be "user-friendly", and implies an understandable user interface, that provides meaningful error messages, traps and checks, thorough validation of data entry, sufficient control on access to protected data, adequate back-up facilities to restore data in case of a system failure or mistake, and thorough and understandable user documentation (*ibid.*). These features collectively determine the versatility of an interface.

The presentation of information resources using a web portal is generally via a web browser. Browser access allows for the spawning of a new window for each application or the partitioning of the screen into frames allocated to individual applications (Murray, 2002). The design of a web portal interface should be compatible with the different browsers on the market, the most popular ones being Internet Explorer and Netscape Navigator. The speed of operation is another important factor in the design of an interface especially of a web based system, and is determined, among other factors, by the source data formats, the balance between text and image formats, and the choice of the web portal programming environment. More details on web portal programming are given in section 6.3.3.

6.3.2 System Security

Data is a valuable resource that must be strictly controlled and managed. The term 'security' refers to the protection of a system against unauthorised access, either intentional or accidental (Connolly and Begg, 2004). Security considerations apply not only to the system but also to its environment. Broadly defined, system security encompasses both physical security and logical security.

Physical security involves consideration of the physical location and environment in which the computer system and its components are installed. Potential threats include theft, vandalism, accidental damage, water, or other liquid, fire, dust, electromagnetic interference, humidity, and exposure to high or low temperatures. In addition, weather conditions such as lightning can damage a system if not properly protected. Physical security largely involves safeguarding the system against unauthorised physical access. In this regard, the best security option is to maintain controlled access to all buildings housing the system infrastructure, during and after working hours.

Logical security refers to the policies, procedures, and mechanisms that control access to the system. Connolly and Begg (2004) outline the key aspects of logical security, referring to protection against theft and fraud, loss of confidentiality (secrecy), loss of privacy, loss of integrity and loss of availability as important factors. Some aspects of security such as theft and fraud do not necessarily alter the data as is the case with the resultant loss of confidentiality or privacy. Confidentiality refers to the need to maintain secrecy over data, whereas privacy refers to the need to protect data about individuals (Connolly and Begg, 2004). It is important to note that breaches in security, particularly resulting in loss of privacy, could lead to legal action being taken against the owner of the system. Loss of data integrity results in invalid or corrupted data, and loss of availability means that the data, or the system, or both cannot be accessed (Connolly and Begg, 2004). All of these aspects of security greatly affect the performance of the system.

The greatest logical security threats are unauthorised access, and loss or corruption of data through accidental or deliberate means. Viruses are a major threat that must be carefully considered. Unauthorised access from sources internal and external to the organisation must be addressed. Logical security encompasses the use of passwords, user names, encryption, system monitors, virus scanners, access privilege controls and similar measures. A firewall should be installed on all web portal servers. This program will protect against any unauthorised access by hackers or other outsiders.

Passwords and user names can be installed at different levels of access including log on, application access, and database or file access among others. Periodic changing of passwords can also enhance system security. As noted by Murray (2002), the security of web portal systems should go beyond user names and pass words, and adopt alternative authentication methods such as Public Key Infrastructure (PKI) that use digital signatures, digital certificates, and similar devices. However, in the Ugandan context, in order to attract wider user acceptance, the adoption of such technologies should match related ICT advancements in the construction sector.

In sum, system security aims to minimise losses caused by anticipated events in a cost effective manner, without unduly constraining the users. In recent times, computer-based criminal activities have significantly increased and are forecast to continue to rise over the next few years (Connolly and Begg, 2004). Therefore, adequate security procedures are crucial for successful implementation of a web portal system.

6.3.3 Web Portal Architecture and Programming

The proposed architecture of the web portal is a modified client/server architecture that is referred to as the n-tier architecture. Early client/server models were classified as two-tier (Murray, 2002), as desktop clients processed the user interface and database servers handled data management. Application logic was processed either through the client or the server, depending upon the platform and requirements of the task at hand. As client/server systems were applied to more complex business problems, the architecture evolved into three or more tiers referenced as n-tier architecture (Murray, 2002). The n-tier architecture has been found effective for web portals and separates applications into layers that handle presentation services, business processes and rules, and data management services (Murray, 2002). Desktop clients process the user interface, the database servers handle data management, and a business services tier provides support for the processing of the application logic using appropriate software. The proposed architecture of the web portal is illustrated as Figure 6.4 below.

Because of the diversity and multiplicity of construction information, a web portal for the construction industry is a complex information system. Hiremath and Skibniewski (2004) indicate that web based complex information systems should be developed using object-oriented programming languages. Java is, arguably, the most widespread web application development programming language that supports cross-platform portability, such that new applications can be developed and added to existing environments (Murray, 2002). Other modern web programming environments such as dynamic HTML and XML can be adopted. Most web portal software available on the market offers content management services, a search engine, and Applications Programming Interfaces (APIs) to commonly-used applications (Murray, 2002). However, such software requires additional development efforts to tailor them to specific users' needs. These middleware technologies are seen as key to successful web portal implementation (Murray, 2002).

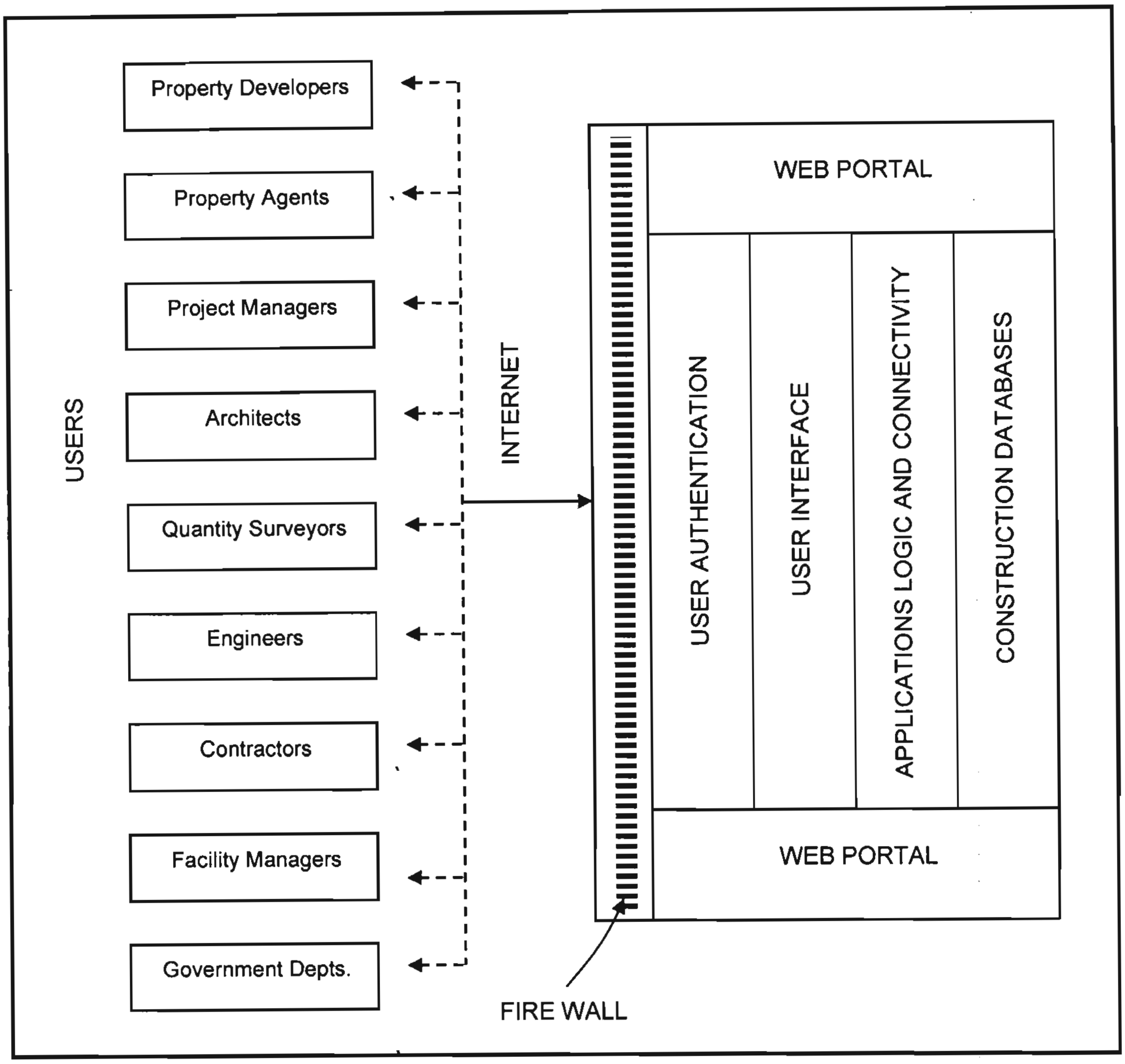


Figure 6-4: Web portal architecture

6.3.4 System Reliability

Ideally, a system should be available to users at all times to ensure its high reliability. However, this is rarely the case (Nitithamyong and Skibniewski, 2004). Reliability is closely related to consistency. System reliability and consistency must be maintained in the presence of failures of both hardware and software components, and when multiple users are accessing the system (Connolly and Begg, 2004). When system failures occur, data can be lost if the system is not backed up or is improperly housed (Nitithamyong and Skibniewski, 2004).

System reliability can be achieved by ensuring three closely-related functions. Connolly and Begg (2004) define these functions as concurrency control services, recovery services, and transaction support. Both concurrency control and recovery are required to protect the system from data inconsistencies and data loss. Web portals, like any other information systems, allow users to undertake simultaneous operations on the system. If these operations are not controlled, accesses may interfere with one another and the system can become inconsistent. To overcome this, systems implement a concurrency control protocol that prevents systems accesses from interfering with one another (Connolly and Begg, 2004).

System recovery is the process of restoring the system to a correct state following a failure (Connolly and Begg, 2004). To mitigate the effects of systems failures, organisations require having an effective disaster recovery plan. A disaster recovery plan should spell out the back-up policy including back-up procedures, back-up intervals, and responsible personnel, and alternative arrangements for accessing data resources in the event of the existing system crashing. All system recovery policies, procedures, and control mechanisms must be documented, and copies of this documentation should be kept in a secure place.

6.3.5 Applications Integration

The ability to exchange data between applications and to provide applications integration is a fundamental component of a successful web portal (Murray, 2002). A fully functional web portal should bring together both structured data such as database data and unstructured data such as e-mails, and user comments. A web portal for the construction industry should provide access to data from multiple sources including databases, spread sheets, word processed documents, and computer aided drawings among others. The above information has varying data formats, and can reside on varying hardware and software platforms. This raises the need for an appropriate applications integration environment.

The web portal should adopt data interchange standards applicable in the construction industry such as IFC, aecXML, bcXML, ifcXML, and STEP standards.

As much as these standards are still emerging, their adoption will set the pace for the integration of the web portal with other construction information systems.

6.4 Concluding Remarks

It is clear from the discussions of this chapter that the quality of a high level design and the final product are highly dependent upon the quality of a conceptual design. A common question is, "How do you assess the quality of a theoretical model?" The easiest answer is to thoroughly examine it, talk about it, and ascertain if its contents are traceable from its source. Thus, it can be said that the process is one of review and inspection. Treading between analysis and discussion of results, and conceptual design processes, together with the validation of conceptual models by experts, was an attempt to achieve this goal.

Establishing a web portal is a major undertaking. Its full deployment should be evolutionary. A web portal is an emerging technology in the Ugandan construction industry, and therefore an evolutionary approach will leverage ICT resources and provide a mechanism for developing a greater understanding of the technology. As noted by Murray (2002), developing a web portal with the level of sophistication that meets the users' needs is a long and hard process. The planning for web portal implementation should be seen as a process of building an infrastructure, a foundation for the future, and not as the development of a single, all-encompassing solution.

7 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter contains a summary of the research findings, conclusions, and proposals for establishing an administrative framework for the web portal and for further work on the system.

7.1 Summary of Research Findings

The summary of research findings are set out below and derive from the discussions in chapters 4, 5, and 6.

Availability of Computer Infrastructure and Internet Access

The results of the research have clearly indicated that the Ugandan construction industry participants have adequate computer infrastructure and Internet access capacity to benefit from the web portal. 97% of industry participants have computers and the remaining 3% who do not own computers, have access to commercial computing services; the majority of participants (77%) are connected to the Internet. At a national level, there is increased availability of Internet services as demonstrated by an increase in the number of Internet Service Providers (ISPs) and VSAT international data gateways in the recent past (see Table 2.3 for details). However, the industry still faces the challenges of limited permeation of LAN connections as a means of enhancing intra-organisation information sharing and the low speed of Internet access that is mainly constituted by modem connections to dial-up networks.

Computer Usage

The study assessed computer usage in terms of the extent of software usage, level of computerisation of key business processes, and future plans regarding investments in IT. The results of the study show that all firms that have computers use word processors and most of them (86%) use spreadsheets. Computer Aided Design (CAD) is the most prevalent (60% usage) specialised software used by industry participants, while project management packages and database systems are the least used specialised software at 49% and 37% respectively.

In considering the levels of computerisation of common business processes, it was found that bills of quantities, book keeping (accounting), technical calculations, costing and budgeting, and tendering processes, are the most computerised processes at 68%, 59%, 56%, 52%, and 46% respectively. 51% of industry participants plan to invest in CAD, project management systems, and bills of quantities in the future. 50% of respondent firms plan to invest in Internet services, while 87% of the firms that plan to invest in Internet services are not connected to the Internet. This is an indicator that in the near future Internet access is likely to increase and more participants will benefit from the web portal.

Status of Information Sharing

The results of the study have shown that the majority (93%) of construction industry participants in Uganda are involved in some form of information sharing. Most of the information shared among participants is in the form of computer aided drawings, estimates, word processed documents, and paper drawings. Database and project management data have been shown to be the least shared information. This can be attributed to the low uptake of database and project management systems. Hand delivery is the most popular method of sharing and exchanging information with 90% usage by participants. This trend is undesirable, especially given the available ICT infrastructure and Internet access capacity; Telephone and E-mail are also used to share construction information.

The most citable weaknesses of the existing methods of information sharing include the safety of shared information, information delays, lack of trust between participants, large volumes of information to share, absence of relevant legal framework of information sharing, and the incompatibility of computer systems. Statistical tests on the results show that the perceived weaknesses of the existing methods of information sharing are significant enough to justify an intervention. The focus of this study was on the use of a web portal as an alternative method of sharing construction information.

A Study of the Users' Information Needs and Conceptual Modelling

During the study, the users' information needs were assessed through interview and questionnaire surveys. The results of the survey led to the development of a users' information needs model. This model is presented as Figure 6.2. The users' information needs model categorises information according to the main stages of a construction cycle, i.e. planning, design, procurement/construction, and facility management. A web portal is placed at the centre of the users' information needs model serving as a source and provider of construction information. In order to study the flow of data in the system, and to identify and map the key sources of information, a data flow model for the stages of a construction cycle was constructed. The latter model is presented as Figure 6.3.

Viability and Management of the Web Portal from the Users Perspective

The majority of industry participants (83%) consider the web portal to be an effective means of information sharing. 93% of participants are willing to share the information produced by their companies, though a common argument raised by those not willing to share construction information is the fear of competition.

The construction industry participants in Uganda are optimistic about the benefits of establishing a web portal for the industry, and those identified during the study include savings in time and cost during the different phases of a construction cycle, improved quality of decision-making due to availability of information, improved teamwork on projects, and efficient working of dispersed construction parties.

A common opinion expressed through interview and questionnaire surveys was that a web portal should be managed by an independent body constituted by stakeholders in the industry.

Challenges of Establishing a Web Portal

Establishing a web portal for the Ugandan construction industry is an exigent innovation that raises a number of challenges, a fact also acknowledged by industry participants. The major challenges identified during the study include high capital and maintenance costs, and a need for an appropriate legal framework constituted by relevant laws and regulations on information sharing. The requirements of maintaining data integrity, data security, and data standardisation are crucial for a web portal system. The industry participants need to change their "thinking", particularly on the value and importance of information. The industry participants also need to alter their work methods, especially regarding the shift from paper-driven methods to digital approaches. There is a need to develop trust, and to build partnerships among industry participants. These "soft" issues are seen as key to successful implementation of the web portal.

7.2 Conclusions

The main hypothesis tested in this research is:

"A Web Portal developed through effective user-developer interaction is a feasible means of information sharing in the Ugandan Construction industry".

A feasible system in the context of this research is defined as a system that is acceptable to users and serves their basic information needs. In an attempt to confirm or reject the above hypothesis, this research set out to achieve the following four objectives i.e.

1. To study the existing means of information sharing by the construction industry participants in Uganda.
2. To assess the information needs of the Ugandan construction industry participants.
3. To assess the capacity of the Ugandan construction industry participants to utilise a web portal.
4. Based on the results of objectives 1 to 3, to develop a conceptual model of the web portal system.

Through interviews and questionnaire surveys, this research has demonstrated that a web portal system is acceptable to the majority (93%) of participants in the Ugandan construction industry. The existing means of information sharing do not adequately serve the information needs of industry participants (see section 7.1 and chapter 5 for details). This justifies the need to establish a web portal as a means of enhancing information sharing in the Ugandan construction industry. As has been noted, the industry participants have the necessary IT infrastructure and Internet access capacity to benefit from the web portal (see section 7.1 and chapter 5 for details). The users' information needs were assessed through interview and questionnaire surveys (see chapters 3 and 5 for details). Results of the survey led to the development of a conceptual model of the system (see chapter 6 for details), and the conceptual model was validated by a panel of experts in construction industry practices and communication (*ibid.*).

From the above extended deliberation, it is clear that all the four objectives of this study were achieved. The arguments posed in this part of the report and supported by the analysis and discussion of results (chapter 5), and conceptual modelling processes (chapter 6), demonstrate that a web portal is a feasible means for information sharing in the Ugandan construction industry. Therefore, the findings of this study confirm the hypothesis as stated at the beginning of this section and in chapter 1 of this report.

7.3 Recommendations

Based on the results of this study, two recommendations were made and are discussed below:

1. Establishment of a building information centre

This research recommends the establishment of a national building information centre to house and coordinate the web portal and related activities. It is envisaged as a hub of information and knowledge in the construction sector. The management board of the information centre should be constituted by representatives of all stakeholders in the Ugandan construction industry. It is important that the information centre remain objective, impartial, and efficient. It should fulfil the following roles:

i. Coordinate the functions of a web portal, including data collection, data processing, quality assurance, and information dissemination to targeted users.

ii. Coordinate all of the communication between stakeholders in the web portal system, including government departments, professional bodies, professionals, property developers, property agents, research institutions, and contracting firms.
iii. Establish the relevant ICT infrastructure and Internet access facilities for the implementation and maintenance of the web portal. The information centre should also guide industry participants on the appropriate hardware and software required in order to fully benefit from the web portal.
iv. Coordinate didactic programmes, including sensitisation on the importance and value of information, developing trust among parties, change of work methods from paper driven to digital approaches, and building partnerships among participants. A key message to participants should be that in today's business environment, it is wise to work as partners, rather than as competitors. This requires maximum utilisation of the available information resources.
v. Establish alternative methods of information dissemination such as CD-ROMS, seminars, workshops, and any relevant documentation.
vi. Spearhead the implementation (in Uganda) of data interchange standards applicable in the construction industry such as IFC, aecXML, bcXML, ifcXML, and STEP standards.
vii. Coordinate research efforts in the construction sector.
    The building information centre has the potential of taking a lead in the establishment of refereed journals for dissemination of research data considered appropriate to local construction industry needs.

2. Further Work

This research has assessed the viability of the web portal system from the users' perspective and to a given extent, IT infrastructure. However, there is a need to assess the economic feasibility of the system, and other technical factors of detailed design, implementation, and maintenance. Based on established best practice for web portal systems, object-oriented methods appear to hold the future for detailed web portal design and implementation.

References

Ackoff, L. R. (1974) *Redesigning the Future: A Systems Approach to Societal Problems.* New York: John Wiley & Sons.

Alshawi, M. and Faraj, I. (2002) Integrated Construction Environments: Technology and Implementation. *Journal on Construction Innovation*, Volume 2, pp 33-51.

Amor, R. and Betts, M. (2001) *Information Technology for Construction: Recent Work and Future Directions*, Proceedings of the CIB Triennial Conference, Wellington, New Zealand, 2-6 April 2001, Volume 1, pp 54-63.

Amor, R., and Faraj, I. (2001) Misconceptions about Integrated Project Databases. *Electronic Journal of Information Technology in Construction (ITcon)*, Volume 6, pp 57-67.

Andresen, J. L., Christensen, K., and Howard, R. W. (2003) Project Management with a Project Web. *Electronic Journal of Information Technology in Construction (ITcon)*, Volume 8, pp 29-41.

Antonius, R. (2003) *Interpreting Quantitative Data within SPSS.* London: Sage Publications Ltd.

Arif, A. A. and Karam, A. H. (2001) Architectural Practices and Their Use of IT in the Western Cape Province, South Africa. *Electronic Journal of Information Technology in Construction (ITcon)*, Volume 6, pp 17-33.

Arksey, H. and Knight, P. (1999) *Interviewing for Social Scientists.* London: Sage Publications Ltd.

Armstrong, S. G. (1996) *Construction Information Highway*, Proceedings of the International Construction Information Technology Conference (INCIT 96), Sydney, Australia, 18-19 April 1996, pp 183-192.

Aronson, D. (1996) Targeted Innovation: Using Systems Thinking to Increase the Benefits of Innovation Efforts. *Journal on Innovation Leader*, Volume 6, Issue 2, pp 1-3.

Ashworth, A. (1994) *Cost Studies of Buildings*, 2nd Edition. United Kingdom: Longman Scientific & Technical.

Augenbroe, G., Verheij, H. and Schwarzmuller, G. (2002) Project Websites with Design Management Extensions. *Journal on Engineering, Construction and Architectural Management*, Volume 9, Issue 3, pp 259-273, June 2002.

Babbie, E. and Mouton, J. (2001) *The Practice of Social Research*. Cape Town: Oxford University Press Southern Africa.

Bagonza, S. (2000) The Role of Ministry of Works, Housing, and Communications Quality Management Department in the Local Construction Industry. *Journal of the Uganda Institution of Professional Engineers*, Volume 6, Issue 4, August/September 2000, pp 7-10.

Baldwin, A. N., Thorpe, A., and Carter, C. (1996a) *The Construction Alliance and Electronic Information Exchange: A Symbolic Relationship*. In the Organisation and Management of Construction, Langford, D. A., and Retik, A (eds.). United Kingdom: E & FN SPON, pp 23-32.

Baldwin, A. N., Thorpe, A., and Carter, C. (1996b) *Simulating the impact of Electronic Commerce*, Proceedings of the International Construction Information Technology Conference (INCIT 96), Sydney, Australia, 18-19 April 1996, pp 199-203.

Barros, A.P. and Hofstede, A.H.A (1998) Towards the Construction of Work Flow Suitable Conceptual Modelling Techniques. *Information Systems Journal*, Volume 8, Issue 4, pp 313-337.

Bartholomew, D. (2000) *Information and Communications Technologies: CAP issues group working paper- Final report,* Research Group of IT Global Future, United Kingdom, pp 1-18.

BIW (2004) *BIW Technologies: Building Value by Extending Knowledge,* http://www.biwtech.com, accessed on 12th August 2004.

Bloomfield, D. and Amor, R. (2001) *I-SEEC: An Internet Gateway to European Construction Resources,* Proceedings of the CIB W78 Conference, Mpumalanga, South Africa, 30 May – 1June 2001, pp 12.1 -12.14.

Brannen, J. (1992) *Combining Qualitative and Quantitative Approaches: An Overview,* cited in Mixing Methods: Qualitative and Quantitative Research, ed Brannen, J. United Kingdom: Averbury, pp 3-37.

Bricsnet (2004) *Bricsnet: A Resource for Building Product Information,* http://www.uk.bricsnet.com, accessed on 12th August 2004.

Brown, A., Rezgui, Y., Cooper, G., Yip, J. and Brandon, P. (1996) Promoting Computer Integrated Construction Through the Use of Distribution Technology. *Electronic Journal of Information Technology in Construction (ITcon)*, Volume 1, pp 1-16.

Buildonline (2004) Buildonline: *Collaboration Software Provider for Construction, Utility and Transport Projects,* http://www.buildonline.com , accessed on 12th August 2004.

Buzzsaw (2004) *Autodesk Buzzsaw: Online Project Collaboration Service,* http://usa.autodesk.com, accessed on 12th August 2004.

Cadweb (2004) *Cadweb: Electronic Project Management,* http://www.cadweb.co.uk, accessed on 12th August 2004.

Causeway (2004) *Causeway Technologies: Connecting People, Projects and Partners through IT*, http://www.causeway-tech.com , accessed on 12th August 2004.

Charlotte, B., Lasse, P., and Ørjan, T. (1997) *Construction Industry in Uganda-Some Factors Significant for the Quality and Sustainability of the Construction Industry*, Masters Thesis in Civil Engineering, Norwegian University of Science and Technology, April 1997.

Checkland, P. B. (1981) *Systems Thinking, Systems Practice.* Chichester: John Wiley & Sons.

Churchman, C. W. (1968) *The Systems Approach.* New York: Dell Publishing Co. Inc.

Citadon (2004) *Citadon: Delivering Project Collaboration and Business Process Management Solutions*, http://citadon.com, accessed on 12th August 2004.

CITE (2004) *E-Business: Emerging Technologies-XML*, The Centre for E-Business in Construction, http://www.cite.org.uk, accessed on 21st June 2004.

CONNET (2004) *CONNET-European Gateway: Linking European Construction*, http://www.connet.org, accessed on 12th August 2004.

Connolly, T. M., and Begg, C. E. (2004) *Database Systems: A Practical Approach to Design, Implementation, and Management*, 4th edition. London: Addison-Wesley.

Coombes, H. (2001) *Research Using IT.* New York: Palgrave.

CORENET (2004) *The Construction and Real Estate Network*, http://www.corenet.gov.sg/corenet, accessed on 12th August 2004.

Creswell, J. W. (1998) *Qualitative Inquiry and Research Design: Choosing Among Five Traditions.* Thousand Oaks, California: Sage Publications.

Crossley, B. and Hollway, A. M. (2000) Structured Training for Engineers and Continuing Professional Development (CPD). *Journal of the Uganda Institution of Professional Engineers*, Volume 6, Issue 4, August/September 2000, pp 10-20.

Currie, W.L. (1989) Investing in CAD: A case Study in adhoc decision-making. *Journal on Long Range planning*, Volume 22, pp 85-91.

Cusack, M. M. (1987) *Computer Based Production Systems as a Basis for Decision-Making*. In Managing Construction World Wide, Lansley and Harlow (eds.), Volume 1, Systems for Managing Construction. London: E and FN SPON.

DeMarco, T. (1978) *Structured Analysis and System Specification*. New York: Yourdon Inc.

Detlor, B. (2003) Internet – Based Information Systems Use in Organisations: an Information Studies Perspective. *Information Systems Journal*, Volume 13, Issue 2, pp 113-132, April 2003.

Doherty, J. M. (1997) A Survey of Computer Use in the New Zealand Building and Construction Industry. *Electronic Journal of Information Technology in Construction (ITcon)*, Volume 2, pp 1-13.

Fellows, R. and Liu, A. (1997) *Research Methods for Construction*. United Kingdom: Blackwell Science.

Fielding, J. and Gilbert, N. (2000) *Understanding Social Statistics*. Thousand Oaks, California: Sage Publications Ltd.

Fink, A. and Kosecoff, J. (1985) *How to Conduct Surveys: A step by step Guide*. Beverly Hills, California: Sage Publications.

Fisher, N. and Yin, S. L. (1992) *Information Management in a Contractor: A model of the Flow of Project Data*. London: Thomas Telford.

Flood, L. R. and Carson, R. E. (1988) *Dealing with Complexity: An Introduction to the Theory and Application of Systems Science.* New York: Plenum Press.

Flood, L. R. and Jackson, C: M. (1991) *Creative Problem Solving: Total Systems Intervention.* Chichester: John Wiley & Sons.

Fortune, J., Bell, S., Reynolds, M., Wright, T., Thomas, A., Mynors, L., and Morgan, C. (2002) *TXR 248 Experiencing Systems.* United Kingdom: The Open University.

Fowler, F. J. (1984) *Survey Research Methods.* London: Sage Publications.

Froese, T. (1996) *STEP Data Standards and the Construction Industry*, Proceedings of the 1996 Annual Conference of the Canadian Society for Civil Engineering, Edmonton, Alberta, May 29-June 1 1996, CSCE, Montreal, Canada, 1996, Volume 1, pp 404-415.

Froese, T. M. (1999) *Industry Foundation Class Modelling for Estimating and Scheduling*, 8th International Conference on Durability of Building Materials and Components, May 30 – June 3 1999, Vancouver, Canada.

Froese, T. (2003) Future directions for IFC-Based Interoperability. *Electronic Journal of Information Technology in Construction (ITcon)*, Volume 8, pp 231-246.

Froese, T., Fisher, M., Grobler, F., Ritzenthaler, J. and Yu, K. (1999) Industry Foundation Classes for Project Management: A Trial Implementation. *Electronic Journal of Information Technology in Construction (ITcon)*, Volume 4, pp 17-36.

Gallivan, M.J. and Keil, M (2003) The User-Developer Communication Process: a Critical Case Study. *Information Systems Journal*, Volume 13, Issue 1, pp 37-68.

Gillham, B. (2000) *Developing a Questionnaire.* London: Continuum.

Goddard, W. and Melville, S. (2001) *Research Methodology: An introduction*, 2nd edition. South Africa: Juta.

Grilo, A. (1998) *Development of Electronic Trading between Construction Firms*, PhD Thesis, University of Salford, United Kingdom.

Harvey, R. C. and Ashworth, A. (1993) *The Construction Industry of Great Britain*. London: Butterworth-Heinemann Ltd.

Hauptfleisch, A. C. and Sigle, H. M. (2004) *Structure of the Built Environment in South Africa*, 3rd edition. Hatfield, South Africa: CONQS Publishers.

HBXL (2004) *HouseBuilderXL: Construction Software and Services for the Small Builder, Residential Developer and Self Builder,* http://www.housebuilderxl.co.uk, accessed on 12th August 2004.

Higenyi, W. F. M. (2000) *Labour Based Technology in Road Works*, Publication on Labour Based Technology: A Step on the Road to Poverty Reduction, Ministry of Works, Housing, and Communications-Uganda, June 2000, pp 1-3.

Hiremath, H. R., and Skibniewski, M. J. (2004) Object-Oriented Modelling of Construction Processes by Unified Modelling Language. *Automation in Construction*, Volume 13, pp 447-468.

Holt, G. (1998) *A guide to Successful Dissertation Study for Students of the Built Environment*, 2nd edition. United Kingdom: University of Wolverhampton.

Howard, R., Kiviniemi, A. and Samuelson, O. (1998) Surveys of IT in the Construction Industry and Experience of the IT Barometer in Scandinavia. *Electronic Journal of Information Technology in Construction (ITcon)*, Volume 3, pp 47-59.

Howell, I. (1996) *The Need for Interoperability in the Construction Industry*, Proceedings of the International Construction Information Technology Conference (INCIT 96), 18-19 April 1996, Sydney, Australia, pp 43-47.

Hunton, J.E. and Beeler, J.D. (1997) Effects of User Participation in Systems Development: A Longitudinal Field Experiment. *MIS Quarterly*, Volume 21, Issue 4, pp 359-388.

Hwang, M.I. and Thorn, R.G. (1999) The Effect of User Engagement on System Success: a Meta-analytical Integration of Research Findings. *Information and Management*, Volume 35, Issue 4, pp 229-236.

Ingirige, B., Aouad, G., and Sun, M. (2001) *Awareness of Information Standardisation in the UK Construction Industry: A Preliminary Survey by the SIENE Network*, Proceedings of the CIB W78 Conference, Mpumalanga, South Africa, 30 May-1 June 2001, pp 6.1 – 6.9.

Ireland, V. B. E. (1983) *The Role of Managerial Actions in Cost, Time, and Quality Performance of High-Rise Commercial Building Projects.* PhD Thesis, University of Sydney, Australia.

Isikdag, U. (2002) *A Survey of IT Use in the Turkish Construction Industry.* Proceedings of the Second International Postgraduate Conference in the Built and Human Environment, University of Salford, United Kingdom, April 11th -12th 2002, pp 334-341.

Kerlinger, F.N. (1986) *Foundations of Behavioral Research*, 3rd edition. Fort Worth, TX: Holt, Rinehart, and Winston.

Kerzner, H. (2003) *Project Management: A Systems Approach to Planning, Scheduling, and Controlling*, 8th Edition. Canada: John Wiley & Sons.

Khisty, C. J. (1995) Soft Systems Methodology as Learning and Management Tool. *Journal of Urban Planning and Development*, Volume 121, Issue 3, pp 91-107, September 1995.

Knutson, C. and Carmichael, S. (2001) Verification and Validation. *Embedded Systems Programming*, Volume 14, Issue 6, pp 24-32.

Konsynski, B. R. (1981) *Database Driven System Design*. In Systems Analysis and Design: A Foundation for the 1980's, Cotterman, W., Couger, D. J., Enger, N. L., and Harold, F. (eds.). New York: Elsevier North Holland Inc., pp 252-278.

Kumar, R. (1999) *Research Methodology: A Step by Step Guide for Beginners*. London: Sage Publications.

Lane, A. (2000) *T551 Systems Thinking and Practice: A Primer*. United Kingdom: The Open University.

Latham, M. (1994) *Constructing the team: Final Report of the Government/ Industry Review of Procurement and Contractual Arrangements in the UK Construction Industry*. United Kingdom: HMSO Publication.

Laudon, K.C. and Laudon, J.P. (2002) *Management Information Systems: Managing the Digital Firm*, 7th edition. New Jersey: Prentice Hall.

Leedy, P. D., and Ormrod, J. E. (2001) *Practical Research: Planning and Design*, 7th Edition. United States of America: Prentice Hall.

Locke, L. F., Silverman, S. J., and Spirduso, W. W., (1998) *Reading and Understanding Research*. Thousand Oaks, California: Sage Publications.

Lore, C. (2001) Private Sector Involvement in Ugandan Road Construction. *Construction Review: Journal of the Construction Industry*, Volume 12, Issue 10, August 2001, pp 56.

Lubega, H. A., Kiggundu, B. M., and Tindiwensi, D. (2000) *An Investigation of the Causes of Accidents in the Construction Industry in Uganda*, 2nd International Conference on Construction in Developing Countries: Challenges Facing the Construction Industry in Developing Countries, 15-17 November 2000, Gabarone, Botswana, pp 1-12.

Markus, M.L. and Robey, D. (1988) Information Technology and Organisational Change: Causal Structure in Theory and Research. *Management Science*, Volume 34, Issue 5, pp 583-598.

Mathur, K.S., Betts, M.P. and Tham, K.W. (1993) *Management of Information Technology for Construction*. Singapore: World Scientific & Global Publications Services.

Matovu, J. (2003) Finance and Administration: Mid Term Performance Review, *The Uganda Ministry of Works, Housing, and Communications Bi-Annual Bulletin*, Volume 8, January- June 2003, pp 2.

Mbadhwe, J. (2000) Improving Communication in the Construction Industry Using the World Wide Web. *Journal of the Uganda Institution of Professional Engineers*, Volume 4, Issue 4, pp 25-30, September 2000.

Meadows, D. (2002) Dancing With Systems. *The Systems Thinker*, Volume 13, Issue 2, March 2002, pp 1-5.

Meadows, D.H., Meadows, D.L., and Randers, J. (1992) *Beyond the Limits: Global Collapse or A Sustainable Future.* London: Earth Scan Publications Limited.

Melville, S. and Goddard, W. (1996) *Research Methodology: An Introduction for Science and Engineering Students*, 1st edition. South Africa: Juta & Co. Ltd.

Ministry Policies (2003) *The Uganda Ministry of Works, Housing, and Communication Budget Policy Statement for Financial Year 2003/2004*, In the Ministry of Works, Housing, and Communication Bi-Annual Bulletin, Volume 8, January-June 2003, pp 3-8;11-18.

Mitchell, M. and Jolley, J. (2001) *Research Design Explained*, 4th edition. New York: Harcourt College Publishers.

Mokhtar, A. H. M. (2002) Coördinating and Customising Design Information through the Internet. *Journal on Engineering, Construction and Architectural Management*, Volume 9, Issue 3, pp 222-231, June 2002.

Moore, N. (1987) *How to Do Research*, 2nd edition. London: Library Association Publishing Ltd.

Mouton, J. (2001) *How to Succeed in Your Masters & Doctoral Studies: A South African Guide and Resource Book.* South Africa: Van Schaik Publishers.

MOWHC (2002) The Uganda Ministry of Works Housing and Communications: Road Programmes and Projects Managed by the Road Agency Formation Unit, *Industrial Review*, Volume 6, Issue 1, January-February 2002.

Mui, L.Y., Aziz, A.R.A., Cheng, A., Yee, W.C., and Lay, W.S. (2002) A Survey of Internet Usage in the Malaysian Construction Industry. *Electronic Journal of Information Technology in Construction (ITcon)*, Volume 7, pp 259-269.

Murray, M., Nkado, R. and Lai, A. (2001) *The Integrated Use of Information and Communications Technology in the Construction Industry,* Proceedings of the CIB W78 Conference, Mpumalanga, South Africa, 30 May – 1 June 2001, pp 39.1- 39.13.

Murray, M. (2002) *An Investigation of Specifications for Migrating to a Web Portal Framework for the Dissemination of Health Information Within a Public Health Network*, Proceedings of the 35th Hawaii International Conference on Systems Sciences, 7-10 January 2002, Island of Hawaii.

National Budget (2004) *Background to the Republic of Uganda Budget 2004/5: Promoting Economic Growth and Reducing Poverty Through Public Expenditure*, Ministry of Finance Planning and Economic Development, Kampala, Uganda.

Newman, M. and Sabherwal, R. (1996) Determinants of Commitment to Information Systems Development: A Longitudinal Investigation. *MIS quarterly*, Volume 20, Issue 1, pp 23-54.

Newton, R. R. and Rudestam, K. E. (1999) *Your Statistical Consultant: Answers to Your Data Analysis Questions*. Thousand Oaks, California: Sage Publications.

Nicholas, J.M. (2001) *Project Management for Business and Technology*, 2nd Edition. USA: Prentice Hall.

Nielsen, J. (2000) *Designing Web Usability.* United States of America, Indianapolis, Indiana: New Riders Publishing.

Nitithamyong, P. and Skibniewski, M. J. (2004) Web-based Construction Project Management Systems: How to make them Successful? *Automation in Construction*, Volume 13, pp 491-506.

OMG (2004) *Object Management Group*, http://www.omg.org/, accessed on 21st June 2004.

Oppenheim, A. N. (1992) *Questionnaire Design, Interviewing and Attitude Measurement*, New edition. London: Sage Publications.

Owolabi, A., Anumba, C. J., Hamalawi, A. (2003) Architecture for Implementing IFC-Based Online Construction Product Libraries. *Electronic Journal of Information Technology in Construction (ITcon)*, Volume 8, pp 201-217.

Pallant, J. (2001) *SPSS Survival Manual: A Step by Step Guide to Data Analysis for Windows (Version 10)*. United Kingdom: Open University Press.

Rivard, H. (2000) A Survey on the Impact of Information Technology on the Canadian Architecture, Engineering, and Construction Industry. *Electronic Journal of Information Technology in Construction (ITcon)*, Volume 5, pp 37-56.

Rivard, H., Froese, T., Waugh, L. M., El-Diraby, T., Mora, R., Torres, H., Gill, S. M., and O'Reilly, T. (2004) Case Studies on the Use of Information Technology in the Canadian Construction Industry. *Electronic Journal of Information Technology in Construction (ITcon)*, Volume 9, pp 19-34.

Samuelson, O. (2002) IT Barometer 2000: The Use of IT in the Nordic Construction Industry. *Electronic Journal of Information Technology in Construction (ITcon)*, Volume 7, pp 1-25.

Sarshar, M., Tanyer, M., Aouad, J. and Underwood, J. (2002) A Vision for construction IT 2005-2010: two case studies. *Journal on Engineering, Construction and Architectural Management*, Volume 9, Issue 2, pp 152-160, April 2002.

Schaffitzel, W. and Kersten, U. (1985) Introducing CAD Systems: Problems and the Role of User Developer Communication in their Solution. *Behaviour and Information Technology*, Volume 4, pp 47-61.

Senge, P.M. (1990) *The Fifth Discipline: The Art and Practice of the Learning Organisation.* USA: Doubleday Dell Publishing Group, Inc.

Sing, T.F. and Zhong, Q. (2001) Construction and Real Estate Network (CORENET). *Facilities*, Volume 19, Issue 11/12, pp 419-427.

Snyman, J. and Langenhoven, H. (1998) The Building Industry in Paralysis: Who is to blame? *Civil Engineering and Building Contractor,* Volume 32, Number 5, Johannesburg, March 1998.

Sommerville, I. (1995) *Software Engineering*, 5th edition. UK: Addison-Wesley Publishing Company.

Sulankivi, K. (2004) Benefits of Centralised Digital Information Management in Multi-Partner Projects. *Electronic Journal of Information Technology in Construction (ITcon)*, Volume 9, pp 35-63.

Sun, M., and Aouad, G. (2000) *Integration Technologies to Support Organisational Changes in the Construction Industry*, 7th ISPE Internal Conference on Concurrent Engineering, Lyon, France, 17-20 July 2000, pp 596-604.

Tabachnick, B. G. and Fidell, L. S. (1996) *Using Multivariate Statistics*, 3rd edition. New York: HarperCollins.

Taylor, G. R. (2000) *Integrating Quantitative and Qualitative Methods in Research.* United States of America: University Press of America.

Thorpe, A. (1992) *Information Flow in House Building Organisations*, PhD Thesis, Loughborough University of Technology, United Kingdom.

Tindiwensi, D. (2000) *Development of a Building Cost Control Model for the Ugandan Construction Industry*, Unpublished Research Findings, Faculty of Technology, Makerere University, Kampala.

Tusubira, F. F., Bugaba, S., Kaggwa, I., and Tibenderana, C. (2001) *Information and Communication Technology as a Tool for Modernisation*, Proceedings of the Uganda Institution of Professional Engineers 6th National Technology Conference, Nile International Conference Centre, Kampala, 3-4 May 2001, pp 8-24.

Tuzmen, A. (2002) A Distributed Process Management System for Collaborative Building Design. *Engineering, Construction and Architectural Management*, Volume 9, Issue 3, pp 209-221.

Waring, A. (1996) *Practical Systems Thinking*. London: International Thomson Business Press.

Whyte, J. and Bouchlaghem, D. (2001) *IT Innovation Within the Construction Organisation,* Proceedings of the CIB W78 Conference, Mpumalanga, South Africa, 30 May- 1 June 2001.

Whyte, J., Bouchlaghem, D. and Thorpe, T. (2002) IT Implementation in the Construction Organisation. *Journal on Engineering, Construction and Architectural Management*, Volume 9, Issue 5-6, pp 371-380, October 2002.

Wix, J., and Bloomfield, D. (1997) *Standards for Information Exchange and Sharing: Business Benefits*. Department of the Environment (DoE) Construction Directorate, London, United Kingdom, pp 409-417.

World Development Report (2004) *Making Services Work for Poor People*. Washington, DC: World Bank Publications.

Wroe, B. (1986) *Contractors and Computers: Why Systems Succeed or fail.* PhD Thesis, Loughborough University, Loughborough.

Yang, Q. Z. (2003) IFC- Compliant Design Information Modelling and Sharing. *Electronic Journal of Information Technology in Construction (ITcon)*, Volume 8, pp 1-14.

Yourdon, E. (1989) *Modern Structured Analysis*. New Jersey, USA: Prentice Hall, Inc.

Appendices

Appendix A: Sample Questionnaire

Ms......................

DEVELOPING A WEB PORTAL FOR THE UGANDAN CONSTRUCTION INDUSTRY- A COVER LETTER

Thank you for agreeing to participate in a questionnaire survey to discuss your experiences in the Ugandan construction industry.

The aim of this research is to develop a web portal (i.e. a detailed web based information system) to facilitate information sharing in the Ugandan construction industry. The researcher, Mr. Richard Irumba, is a student of the Masters Programme in Construction Project Management at the University of KwaZulu-Natal, South Africa.

All responses to this questionnaire survey are treated as confidential.

Yours sincerely,

Keith Rennie,
Supervisor/Programme Director,
Property Development Programme,
School of Civil Engineering, Surveying, and Construction,
University of KwaZulu-Natal,
Durban 4041, South Africa.

DEVELOPING A WEB PORTAL FOR THE UGANDAN CONSTRUCTION INDUSTRY- A QUESTIONNAIRE SURVEY

Guidelines:

Write in the provided space and/or tick (✔) the appropriate choice(s).

SECTION I: ABOUT THE ORGANISATION

To allow the best analysis of your responses, the researcher would like to know more about your organisation.

1. Which category best describes the type of your organisation?

- ☐ Architectural Firm
- ☐ Quantity Surveying Firm
- ☐ Consulting Engineers
- ☐ Facility Managers
- ☐ Contractor
- ☐ Project Management Firm
- ☐ Other: please specify……………………………………………………

2. Indicate the district (s) where the offices of your organisation are located.

……………………………………………………………………………………………

3. What is the size of full time staff in your organisation?

☐ Less than 5 ☐ 5 up to 25 ☐ 26 up to 50 ☐ More than 50

SECTION II: ABOUT THE INFORMATION TECHNOLOGY (IT) INFRASTUCTURE

This research is about using IT tools in construction information sharing and therefore in this section of the questionnaire, the researcher would like to assess the extent of IT use in your organisation

4. Do you use any computers in your organisation?

☐ YES ☐ NO

If the answer is NO go to Question 11.

5. How many computers do you use in your organisation?

☐ Less than 5 ☐ 5 up to 10 ☐ 11 up to 15 ☐ More than 15

6. Do the computers in your organisation run on a network?

☐ YES ☐ NO ☐ Don't Know

7. Which office software(s) do you use in your organisation?

SOFTWARE	LEVEL OF USE				
	Most Used	**Used**	**Not Used**	**Not Applicable**	**Don't Know**
Word Processing					
Spread Sheet					
Database					
Project Planning					
Computer Aided Design (CAD)					
Other: Please specify					

8. Do you have access to Internet services in your organisation?

☐ YES ☐ NO ☐ Don't know

9. What is the size of full time staff in your organisation able to use computers?

☐ Less than 5 ☐ 5 up to 25 ☐ 26 up to 50 ☐ More than 50

10. Which of the following processes are computerised in your organisation?

PROCESS	**LEVEL OF COMPUTERISATION**					
	Highly Computerised	**Computerised**	**Less Computerised**	**Not Computerised**	**Not Applicable**	**Don't Know**
Purchasing						
Scheduling						
Tendering						
Bills of Quantities						
Costing and Budgeting						
Materials Control						
Book Keeping						
Invoicing						
Technical Calculations						
Other: Please Specify						

11. What is the future plan(s) of your organisation regarding investment in Information Technology?

- ☐ Computer Aided Design
- ☐ Internet Services
- ☐ Accounting Systems
- ☐ Project Management
- ☐ Document Handling
- ☐ Bills Of Quantities
- ☐ Technical Calculations
- ☐ No Future Plan
- ☐ Other: Please Specify ....
  ....
  ....
  ....

SECTION III: EXISTING MEANS OF INFORMATION SHARING

In this section of the Questionnaire, the researcher would like to identify the existing means of information sharing and to assess their strength and weaknesses.

12. Does your organisation share information with other parties in the Construction industry?

☐ YES ☐ NO

If NO go to Question 17.

13. Which are the construction parties with whom you share information?

- ☐ Architectural Firms
- ☐ Quantity Surveying Firms
- ☐ Construction Engineers
- ☐ Facility Managers
- ☐ Contractors
- ☐ Project Management Firms
- ☐ Other: Please Specify…………………………………………………………………
…………………………………………………………………………………………………

14. What type of information do you share with the construction parties you have identified in question 13 above?

- ☐ Computer Aided Drawings
- ☐ Word Processed Documents
- ☐ Database Information
- ☐ Graphics
- ☐ Spread Sheet Data
- ☐ Estimates
- ☐ Project Management Data
- ☐ Paper Drawings
- ☐ Other: Please specify…………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

15. What are the means that your organisation use to share construction information?

MEANS OF INFORMATION SHARING	LEVEL OF USE			
	Most Used	**Used**	**Less Used**	**Not Used**
Electronic mail				
Postage				
Hand delivery				
Telephone				
Other: Please Specify				

16. What do you perceive as the weaknesses of the existing means of information sharing in your organisation?

- ☐ Delay in information delivery
- ☐ Large volumes of information to share
- ☐ Safety of shared information
- ☐ Digital information not compatible with different computer systems
- ☐ Lack of trust between construction parties
- ☐ Uncertainty surrounding the legal position of information sharing
- ☐ No weaknesses
- ☐ Others: Please specify...
....
....

17. What do you perceive as the benefits of sharing information to your organisation?

- ☐ Savings in time and cost during design, construction, and maintenance phases
- ☐ Improved teamwork on projects
- ☐ Improved quality of decision-making due to availability of information
- ☐ Efficient working of dispersed construction parties
- ☐ No benefits
- ☐ Other: Please specify ....
....
....

SECTION IV: ASSESSMENT OF INFORMATION NEEDS

In this section of the questionnaire, the researcher would like to assess the information needs of your organisation and to seek your opinion on the management of the web portal for the Ugandan construction industry.

18. Rank the following information needs according to their importance to your organisation.

INFORMATION NEED	RANK		
	Most Important	Important	Least Important
Information on construction laws and legislation			
Information on successful and failed projects			
Information on construction materials and costs			
Building codes and standards			
Tender processes and procedures			
Labour rates			
Developments in the international construction industry			
Opportunities for offering construction services			
Information on construction machinery and equipment			
Opportunities for capacity building and training			
Contacts and websites of construction parties			
Documentation of previous projects			
Information on construction professional bodies			
Results of research carried out in the Ugandan construction industry			
Other: Please specify			

19. Do you think this information would best be shared using a Web Portal (i.e. a detailed web based information sharing system)?

☐ YES ☐ NO ☐ Don't know

20. Would you be willing to share construction information with other parties?

☐ YES ☐ NO

If NO, please explain why...
....

21. What challenges do you foresee with sharing construction information using a Web Portal in Uganda?

- ☐ High capital and maintenance costs
- ☐ Failure to regularly update information
- ☐ Failure of construction parties to provide accurate information
- ☐ The challenge for construction parties to access Internet Services
- ☐ Failure of construction parties to utilise digital information in preference to paper documents
- ☐ No problems
- ☐ Other: Please specify……………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

22. Who do you think would be best placed to manage and maintain the Web Portal for the Ugandan construction industry?

- ☐ Government ministry of works and communications
- ☐ Construction professional institutions
- ☐ Academic and research institutions
- ☐ Other: Please specify……………………………………………………………………

Give reasons to support your choice:…………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

Optional: For future correspondences, please indicate the name and contacts of your organisation.

……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

The Researcher will come back to your organisation with the results of the Research.

THANK YOU FOR CO-OPERATION.

Appendix B: Interview Guide

DEVELOPING A WEB PORTAL FOR THE UGANDAN CONSTRUCTION INDUSTRY- INTERVIEW GUIDE

Introductory Remarks

Thank you for agreeing to participate in an interview survey to discuss your experiences in the Ugandan construction industry.

The aim of this research is to develop a web portal to facilitate information sharing in the Ugandan construction industry. The web portal will provide a platform for construction information sharing and serve as a step toward bridging the gap of information sharing by the different construction parties in Uganda.

The author, Mr. Richard Irumba is a student of the Masters Programme in Construction Project Management at the University of KwaZulu-Natal, South Africa. All responses to this interview are treated as confidential.

SECTION I: ABOUT THE INTERVIEWEE

To allow the best analysis of your responses, the researcher would like to know more about you and your organisation.

1. What is the name of your organisation?

2. What is the title of the position you hold in the organisation?

SECTION II: ABOUT THE INFORMATION TECHNOLOGY (IT) INFRASTUCTURE

This research is about using IT tools in construction information sharing and therefore the researcher would like to assess the extent of IT use in the Ugandan construction industry.

3. Do you consider the Ugandan construction industry parties (i.e. Architects, Quantity surveyors, Contractors, Civil engineering consultants, Facility managers, Project managers, the Government line Ministries, and Property developers) to be at the right stage of using computers?

4. Do you think the construction parties have the necessary infrastructure (i.e. computers, internet access, and knowledge) to utilise a Web Portal (i.e. a detailed web based information sharing system)?

5. Do you think construction information would best be shared using a Web Portal? Give reasons to support your position.

6. Do you think the construction parties would be willing to provide and utilise construction information on a Web Portal? Explain your position.

7. What challenges do you foresee with sharing construction information using a Web Portal in Uganda?

8. What do you consider to be the appropriate investment in Information Technology for the construction industry in Uganda?

SECTION III: EXISTING MEANS OF INFORMATION SHARING

At this stage of the interview, the researcher would like to identify the existing means of information sharing and to assess their strength and weaknesses.

9. What are the means that construction parties in Uganda use to share construction information?

10. What do you perceive as the weaknesses of the existing means of information sharing in the Ugandan construction industry?

11. What do you perceive as the benefits of sharing construction information by the construction parties in Uganda?

SECTION IV: ASSESSMENT OF INFORMATION NEEDS

This is the last stage of the interview and the researcher would like to assess the information needs of the construction industry in Uganda and to seek your opinion on the management of the Web Portal for the Ugandan construction industry.

12. What type of information do the construction parties in Uganda share?

13. Who do you think would be best placed to manage and maintain the Web Portal for the Ugandan construction industry? Briefly explain why?

14. What are the possible sources of funding (capital and maintenance costs) for the Ugandan construction industry Web Portal?

Thank you for participating in this interview, the researcher will come back to you and your organisation with the results of the research.

Appendix C: Validation of Conceptual Models

Dear ....,

DEVELOPING A WEB PORTAL FOR THE UGANDAN CONSTRUCTION INDUSTRY- VALIDATION OF THE CONCEPTUAL MODEL

Based on your experience and knowledge of construction industry practices, you have been selected to participate in the validation of the conceptual web portal model for the Ugandan construction industry.

The aim of the web portal (i.e. a detailed web based information system) is to facilitate information sharing among the construction industry participants. The attached models were developed after a detailed questionnaire and interview survey with key stakeholders in the Ugandan construction industry.

Please, we request you to give your humble and genuine opinion by 7th December 2004. For any clarification on the models, feel free to contact the principal author at E-mail irumbar@ukzn.ac.za. E-mail your responses to the same address.

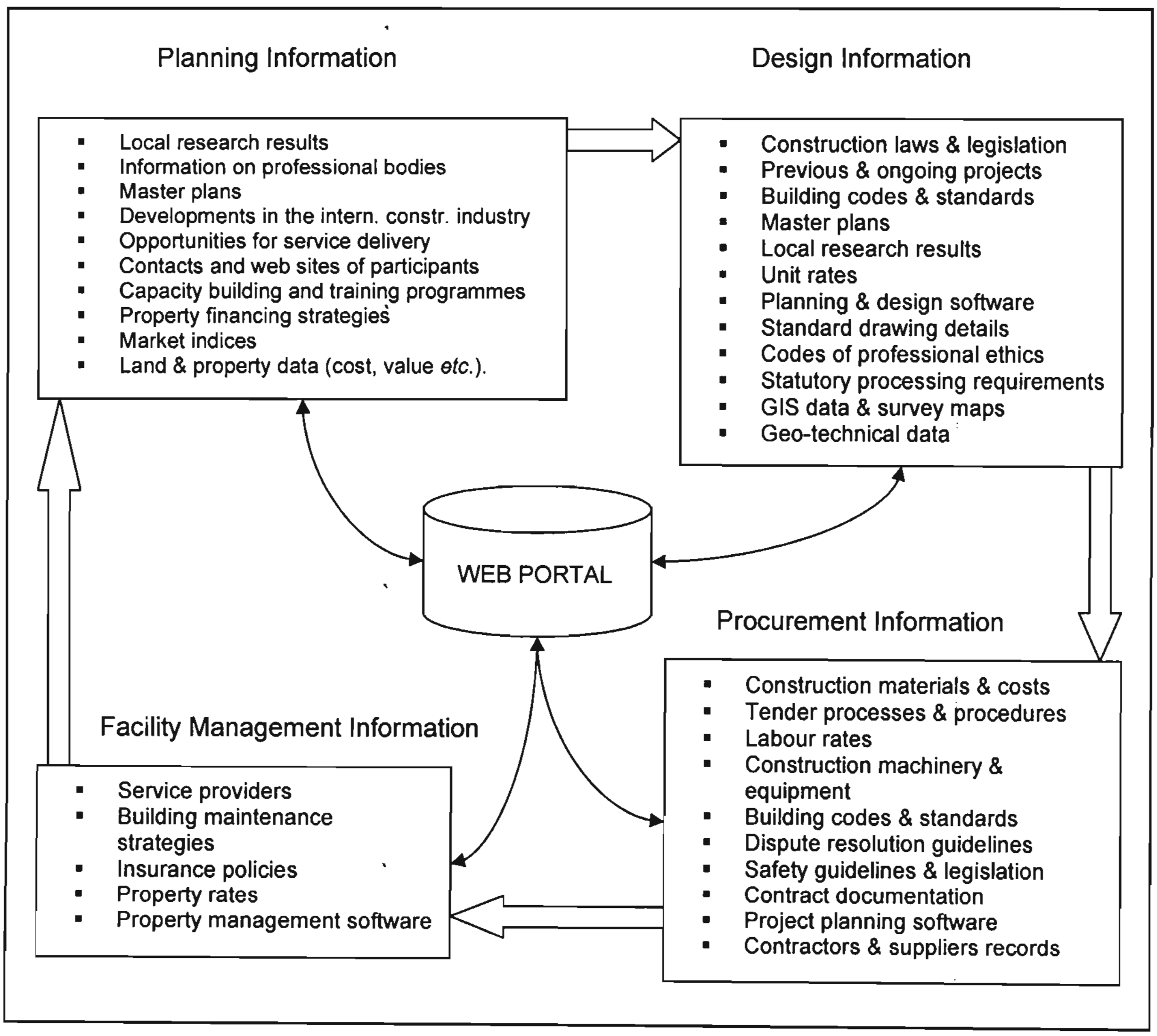
Yours sincerely,

Irumba, R. and Rennie, K.,
Property Development Programme,
School of Civil Engineering, Surveying, and Construction,
University of KwaZulu-Natal,
Durban 4041, South Africa.

Guidelines:

Write your responses in the provided space, save the changes and E-mail the document to irumbar@ukzn.ac.za

PART I: VALIDATION OF THE USERS INFORMATION NEEDS MODEL



Critically appraise the above model in terms of:

I. **Structure:** Does the proposed model structure (i.e. planning info, design info, procurement info, and Facility management info) span a complete construction cycle?

(Write your comments here)

II. **Content:** Study the users information needs presented in the above model and indicate in Table 1 below any other user information needs that you consider appropriate for the system.

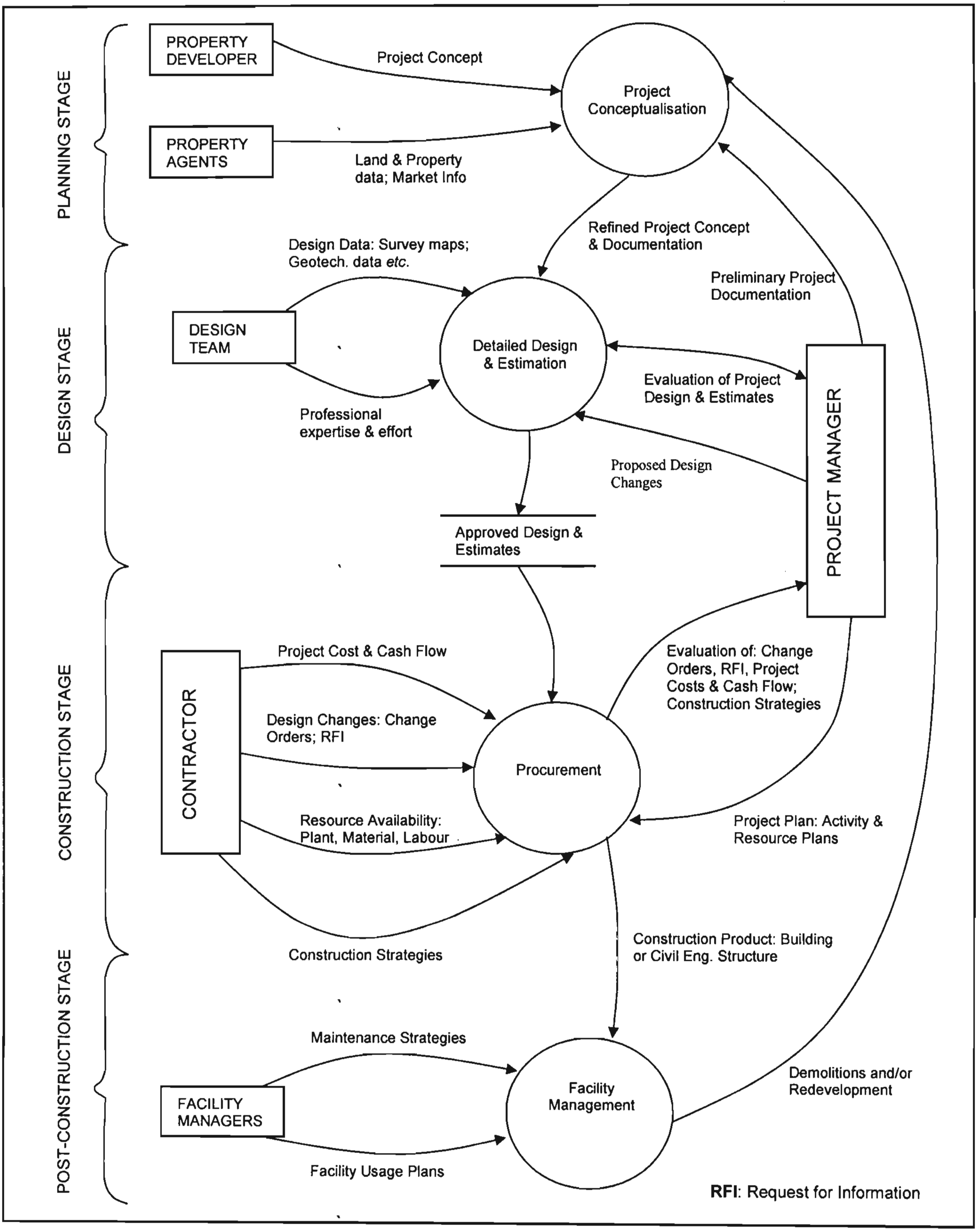
Table 1: Additional Users Information Needs

	Planning Info	Design Info	Procurement Info	Facility Mgt. Info
1				
2				
3				
4				
5				

III. Any other comments on the users information needs model.

(Write your comments here)

PART II: VALIDATION OF THE DATA FLOW MODEL FOR THE STAGES OF A CONSTRUCTION CYCLE



The above model is based on the project management delivery system whereby a project manager is the principal agent of the client. Critically appraise the model in terms of:

I. **Roles played by industry participants**

Comment on the correctness and completeness of the roles played by industry participants (i.e. property developers, property agents, project managers, design team, contractor, and facility managers) in the construction process.

(Write your comments here)

II. **Functional processes**

Four functional processes (i.e. project conceptualisation, detailed design & estimation, procurement, and facility management) are defined in the model. Comment on the correctness of the outputs (i.e. refined project concept and documentation, approved design & estimates, construction product, and demolitions/redevelopment respectively) for the above processes.

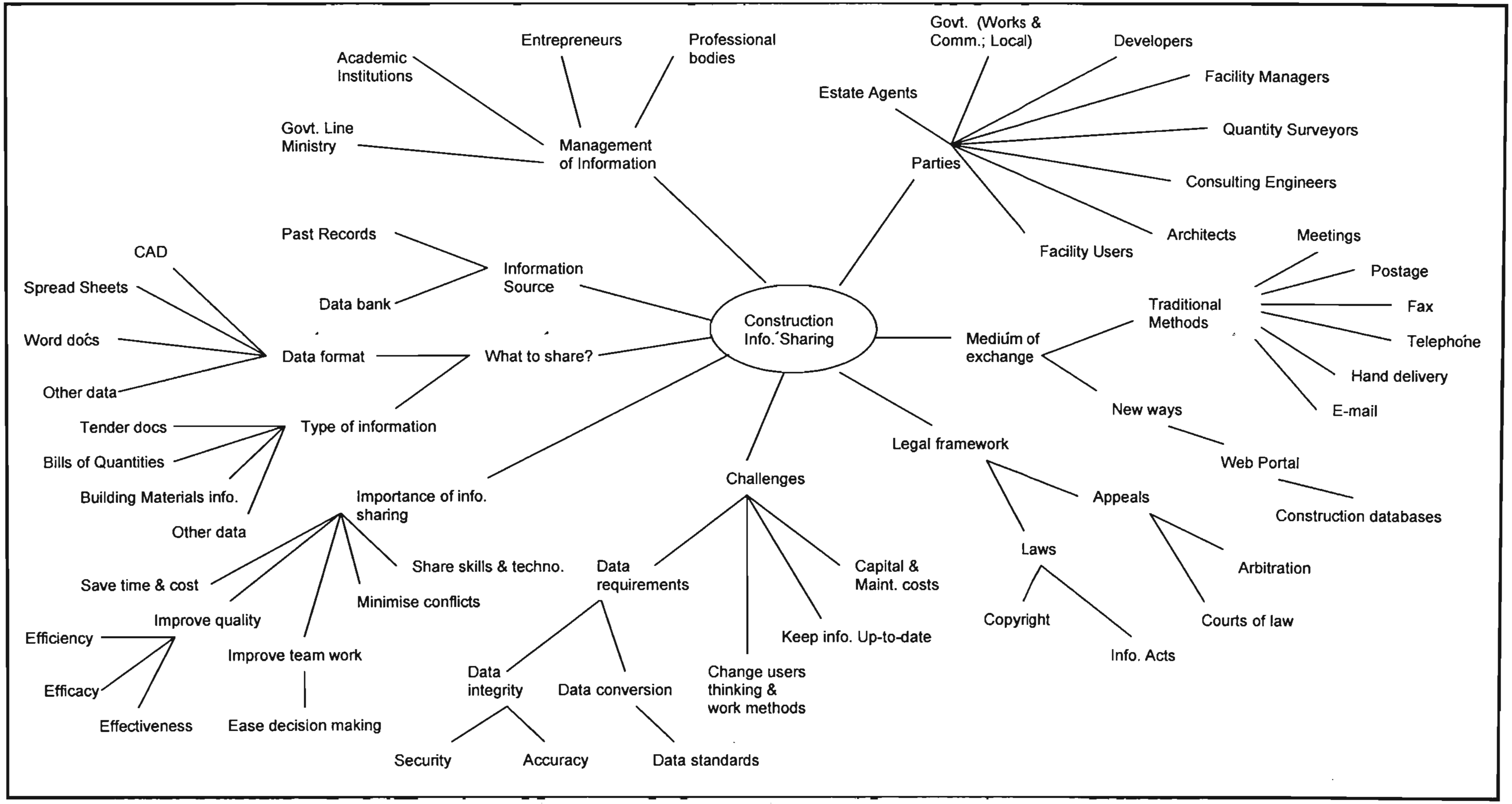
(Write your comments here)

III. Any other comments on the data flow model for the stages of a construction cycle.

(Write your comments here)

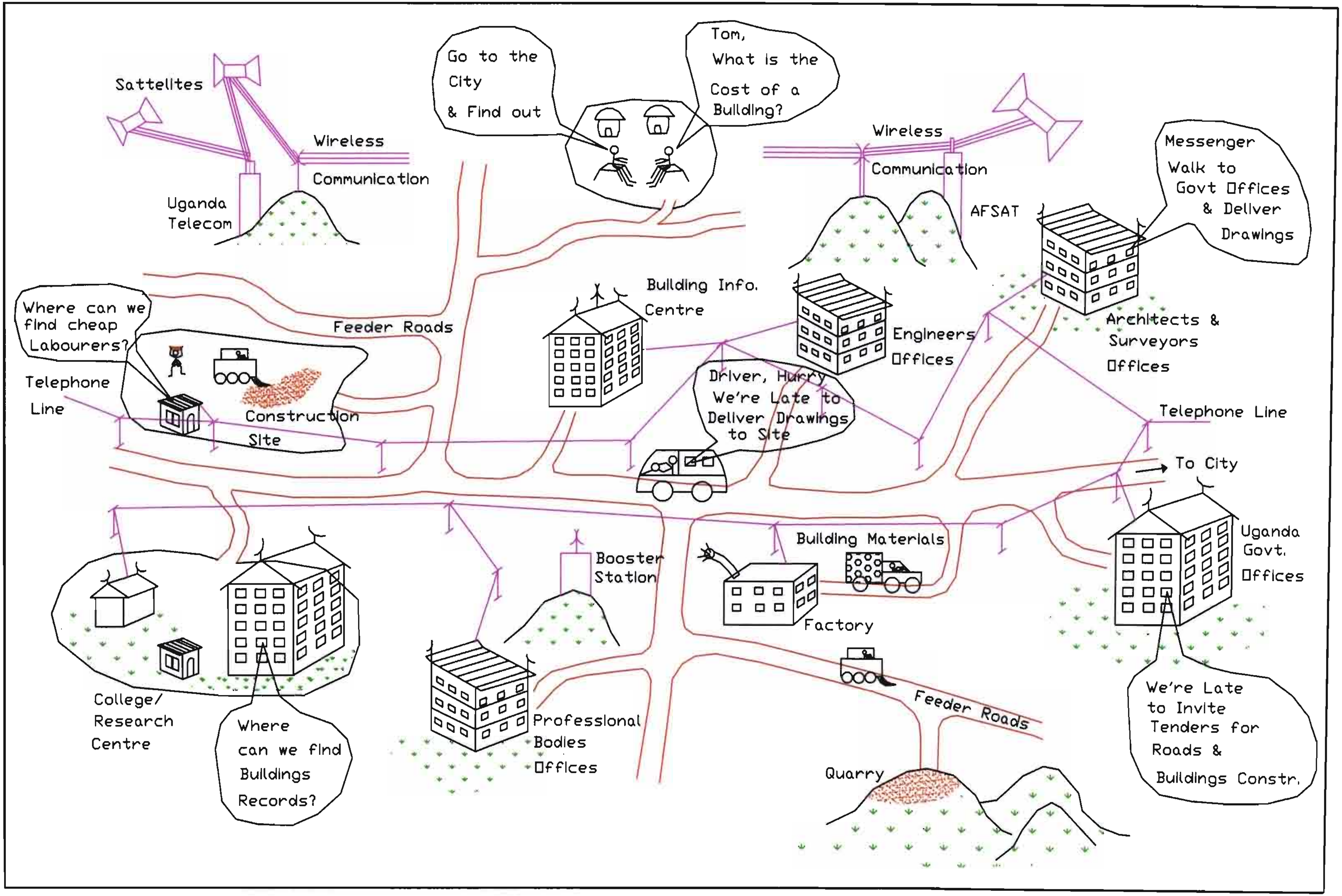
Appendix D: Systems Diagrams

Appendix D 1: Spray diagram of the web portal system

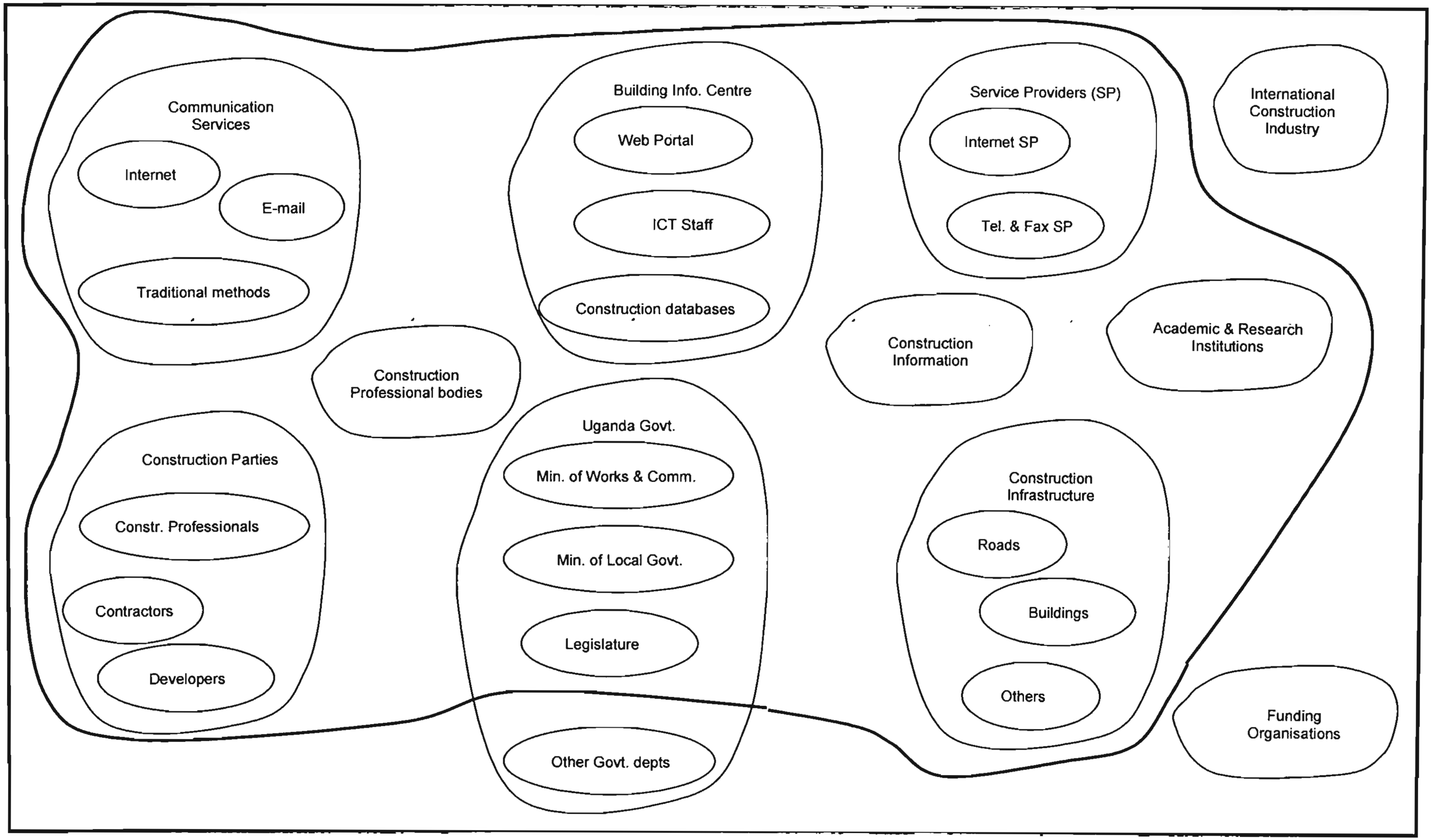


Appendix D 2: Rich Picture of the web portal system

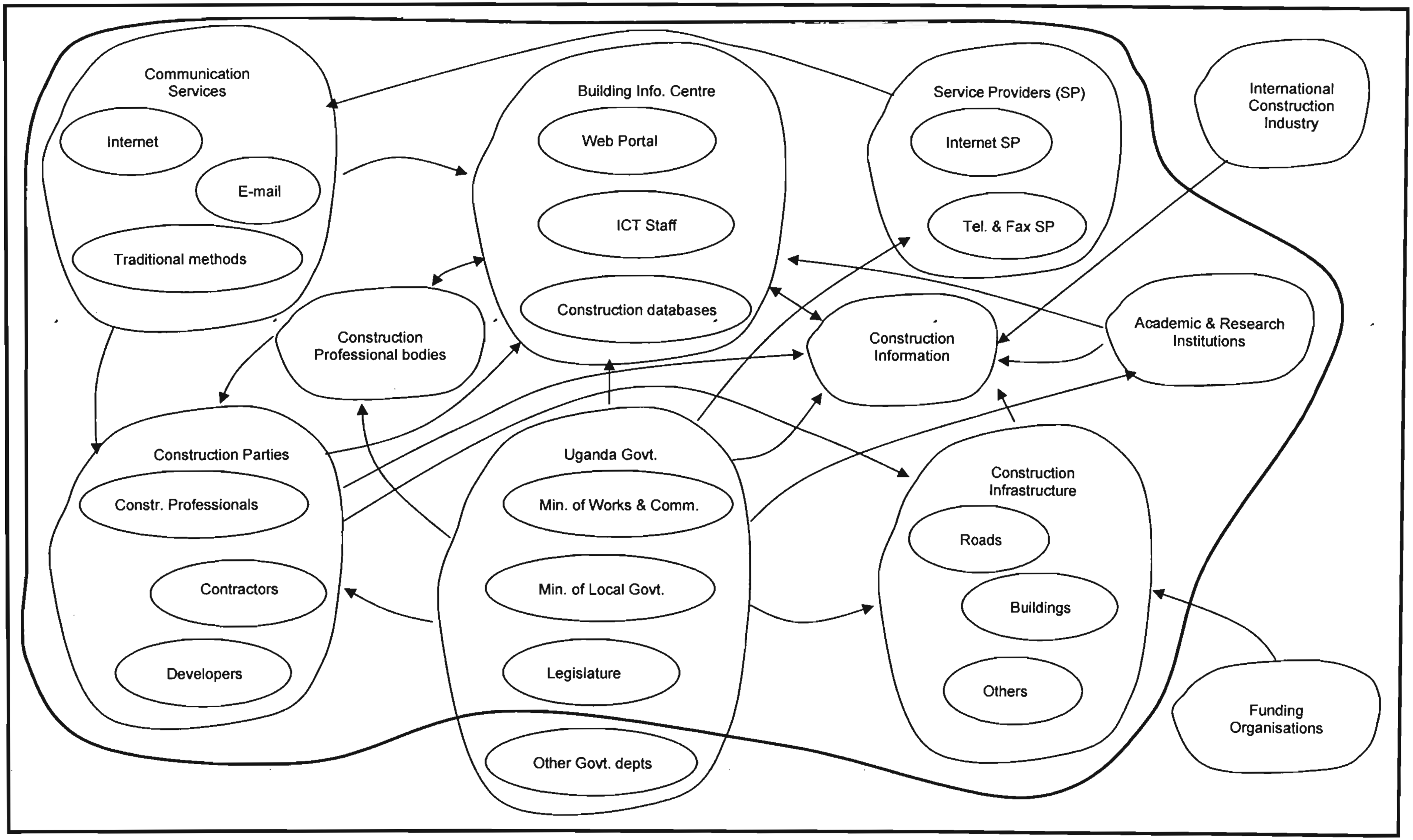
RICH PICTURE OF THE WEB PORTAL FOR THE UGANDAN CONSTRUCTION INDUSTRY



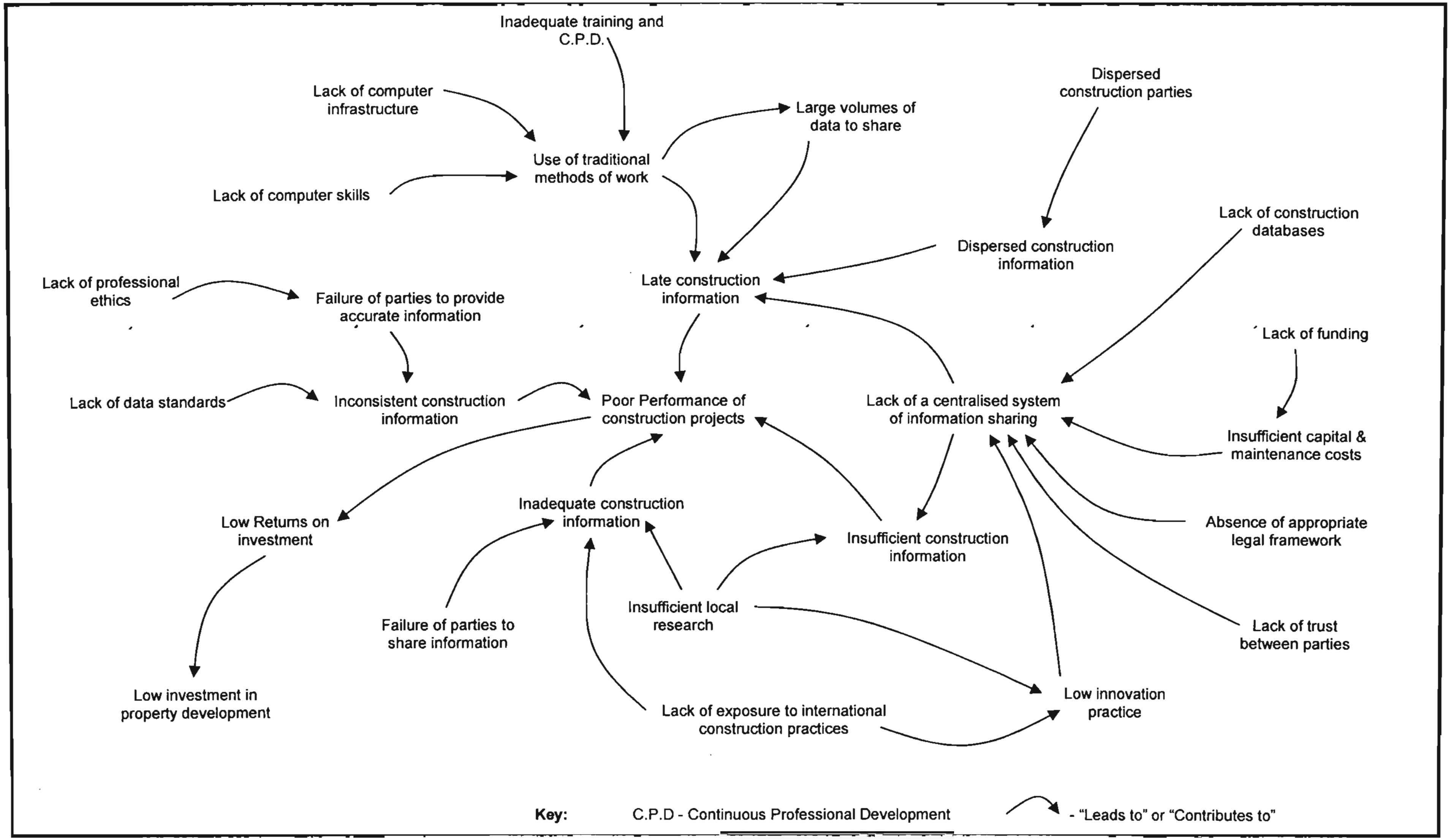
Appendix D 3: Systems Map of the web portal



Appendix D 4: Influence Diagram of the web portal system



Appendix D 5: Multiple cause diagram of the web portal system



Appendix D 6: Sign graph of the web portal system