KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,
KUMASI
COLLEGE OF PLANNING AND ARCHITECTURE
FACULTY OF ARCHITECTURE & BUILDING TECHNOLOGY
DEPARTMENT OF BUILDING TECHNOLOGY

THE DEVELOPMENT OF AN INFORMATION MANAGEMENT SYSTEM FOR MATERIALS MANAGEMENT IN LARGE CONSTRUCTION COMPANIES OPERATING IN THE GHANAIAN CONSTRUCTION INDUSTRY

BY

ERIC KOFI MANTEAU

A PROJECT REPORT PRESENTED TO THE DEPARTMENT OF BUILDING TECHNOLOGY OF THE FACULTY OF ARCHITECTURE AND BUILDING TECHNOLOGY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR A DEGREE OF MASTER OF SCIENCE IN CONSTRUCTION MANAGEMENT

AUGUST 2007

DECLARATION

I declare, that this project except where references are made, has been wholly undertaken by me, duly supervised and submitted herein:

Date: 30/06/09 ……

Signed ……

Eric Manteau
(Student)

I declare that, I have supervised this project and I am satisfied, that the student has wholly undertaken it and therefore has my permission to submit it.

Date 13/07/09 ……

Signed……

Dr. Theophilus Adjei-Kumi
(Supervisor)

DEDICATION

To My Parents;
Dr. & Mrs. Manteau

ABSTRACT

Materials are one of the resources that require special attention while creating a project's master plan as well as during the daily construction progress. The absence of materials when needed is one of the main causes of loss of productivity at a jobsite. Inefficient materials management can lead to an increase of 50% in work hours. As a result, a detailed plan for the materials management of each construction project is necessary.

The critical role of materials management in the success of a construction project motivates the development of a new model for the process of materials management for the construction industry. Materials management problems have a great impact on general contractors. It was based on these preliminary findings that the researcher decided to carry out the research.

Currently, materials management functions in the construction industry are often performed on a fragmented basis with minimal communication and no clearly established responsibilities among the parties involved. In addition, the collaboration required among departments has not been considered and implemented. This fragmentation creates gaps in information flow, which leads to delays in material ordering and receiving, expediting costs, excessive inventories of some items and project delays. However, model-based, computerised solutions to materials management problems is the way forward in summarising the duties of the materials manager at the same time bridging the information gap that exists between these departments and providing synergy amongst the departments. The objectives of the research were the following:

- To undertake a comprehensive study and documentation of the current materials management systems in the Ghanaian construction industry.
- To identify the major factors that influence the dissemination of information for the efficient and effective management of materials within construction companies in Ghana
- To develop information management system for the efficient Management of materials for Construction firms in Ghana.

The researcher used purposive sampling in obtaining the population (36 D1 contractors) as provided by the ABCCG, it was deemed that these contractors (D1) would have an outfit capable of having a structured organisational hierarchy, thus giving the researcher credible information for the research.

Some of the major findings in the study brought out interesting facts and solution to these problems; these problems were directly tied to the objectives of the study. The researcher noticed that in general the construction industry is not paying enough attention to materials management rather focusing on labour to make savings.

The next finding was in respect to information creation, dissemination and destination in the area of materials management it was the authors observation that the information flow was fragmented and open for errors due to double-entry and mismanagement of the information created, this was further compounded by the problem of easy accessibility since 36% of the information existed in a locked paper environment, 42% of the information generated went home with the personnel in charge of the creation of the information and the final 22% existed in personal devices such as office computers, PDA's and mobile phones. This made accessing the information time consuming.

The study developed a computer based model for materials management practises which runs through five phases of the materials management practised in Ghana and developed in the study namely *bidding, sourcing, material procurement, construction phase and post- construction phase,* it is the authors hope the model will bring about standardisation in the industry which may pave the way forward.

In conclusion the primary goal is to have the material needed, in the amount needed with the quality required, and the time that they are needed at the right cost. Most companies have a materials management system that serves their needs, although it could be improved. Standardisation of the materials management system could be a step forward in improving the system and eliminating some of the challenges. The research presented in this document is aimed at designing an integrated system for materials management. A fully integrated and standardised approach will better improve communication and minimise gaps in information flow among all the parties and departments involved.

The research derives the optimal integration of people, decision processes, information support systems and data that are required to support efficient and effective systems for acquisition, procurement, transport, storage and allocation of materials in the construction industry.

"The- construction industry is as much a manager of information as it is a manager of materials"

John Hollingworth

(Building Centre Trust, 1990)

ACKNOWLEDGEMENTS

First of all I would like to thank God for what I am, for everything I have, for taking care of my family and for being everything.

Special thanks to my supervisors who assisted and guided me to complete this work. The guidance, inspiration and encouragement of Drs. Theo Adjei-Kumi and K.A. Manteau are greatly appreciated. The continued interest, assistance, and inspiration of the staff of the Department of Building Technology, K.N.U.S.T, Kumasi, are deeply appreciated. Thank you for being part of my work and for the great relationship that grew among us. I would say that I consider you my friends.

I would like to extend my gratitude to my friends and colleagues from the Department of Building technology, you always had words of encouragement when things were rough.

The support of the University is deeply appreciated. The support of the Association of Building Contractors and Civil Engineers of Ghana (ABCCG), Ministry of Works and Housing, Registrar Generals Department, is deeply appreciated.

Thanks to all the companies that allowed me to collect data through interviews and site visits

Thanks to Naa Okailey Adamafio for being there for me when I needed her the most. Your encouragement and friendship helped me through this period

I would also like to thank my parents Dr. and Mrs Manteau and my siblings Dela and Dzifah for their unconditional support, encouragement and love for me.

This work is dedicated to you.

LIST OF TABLES

Page

LIST OF FIGURES

Page

APPENDICES

TABLE OF CONTENTS

CHAPTER ONE
INTRODUCTION

1.0 GENERAL

Materials management can be defined as the process to provide the right materials at the right place at the right time and at the right price in order to maintain a desired level of production at minimum cost. (Carter and Price, 1993)

The purpose of materials management is to control the flow of materials effectively. This comprises of managerial decisions; among these decisions are sourcing, forecasting, safety-stock setting, order timing and locating stock. In recent years, materials management has emerged as a critically important aspect of a contractor's business viability. Competitive advantage can be achieved through: (Carter and Price, 1993)

1. Reducing or avoiding material shortages that delay projects and degrade the reputation of the contractor, and
2. Reducing or avoiding excess material stock that is costly to store, transport and finance.

Although material management problems highly impact general contractors all over the world, they are more critical for Ghanaian contractors. Most Ghanaian contracting companies are small in size. Therefore, they have to efficiently manage their materials to lower cost in order to remain in business. Because of the risk that these contractors undertake in every construction job, they are constantly tracking their resources

planning of the materials requirements resulted in the materials ordered either being inadequate quality-wise or quantity-wise.

3. **Unrealistic lead times or ordering materials on short notices.** Lead time is the period from which a firm decides to order for materials till the time the time the materials are brought to the site and ready to be used. A majority of the firms did not pay adequate attention to this, which resulted in delayed deliveries or early deliveries.
4. **Manual information management procedure.** Collection, processing and packaging of information was done manually and this required high and frequent inputting of data into the materials management system, with its concomitant errors and reduction in the productivity of the materials management system. As a result the companies were unable to meet project delivery deadlines, information was not updated quickly and frequently enough, and obsolete data were frequently used with disastrous consequences.

Current materials management practices in the construction industry are performed on a fragmented basis with unstructured communication and no clearly established responsibilities between the parties involved. This fragmentation creates gaps in information flow, which affects the decision making process and leads to delays in material ordering and receiving, among other problems. The material manager needs to realise that decisions taken at one stage in the process will certainly impact other activities and processes in the supply chain, a problem not realised due to this fragmentation.

The initial phase of this research will investigate current material management practices in the Ghanaian Construction industry. The investigation will consider the entire range of activities necessary for procuring the needed materials, starting from the estimating process and ending with site delivery, distribution and storage logistics. The research will include documenting the problem bottlenecks in the materials management system as well as identifying and classifying the various criteria that influence the decision process for procuring materials. A comprehensive flowchart describing the materials management process will be developed based on various discussions and interviews with several Ghanaian construction firms. The flowchart will consider many decision alternatives including material type, supplier availability and relationship, procurement options and incentives, quantities needed, delivery dates, storage alternatives, and project schedules.

1.2 Aim of Study

To develop a materials management information system for D1 construction companies operating in Ghana

1.3 Research Objectives

The objective of this research is to develop a materials management information system to improve the decision making process for materials management in the construction industry. In order to achieve this objective it will be broken down into the following sub objectives:

- To undertake a comprehensive study and documentation of the current materials management systems in the Ghanaian construction industry.

- To identify the major factors that influence the dissemination of information for the efficient and effective management of materials within construction companies in Ghana
- To develop a management information system for the efficient management of materials within construction firms in Ghana.

1.4 Justification of Topic

The success of a construction project resides in the ability of all stakeholders to plan effectively, as well as properly manage the resources for the project. This grand plan includes the determination of the tasks to be performed, their sequence and strategies for allocation of resources among them. The grand plan is subdivided into smaller plans to facilitate managing the entire project. The quality and effectiveness of the grand plan or individual plans can be measured, among other things, by the variability of the actual time and cost required to complete it, compared to the original estimates.

Construction projects are subjected to continuous variability. This variability can be traced to the dependency of the general contractor on other parties such as suppliers and subcontractors. As a result of deviations from the plan, decreases in productivity and subsequent increases in cost and time required to finish the project can be expected. Materials are one of the areas that require special attention while creating the grand plan for the project. Materials account for more than 50% of the total cost of a construction project. In addition, materials are essential for the daily progress of a construction project. The absence of materials when needed is one of the main causes of loss of productivity on a jobsite. As a result, an elaborate plan for materials management

becomes mandatory. The formulation of a plan for materials management involves the development of strategies for the integration and monitoring of the entire process and the implementation of those strategies. This plan should consider, among other things, the flow of materials through all the phases of the project starting from the estimating phase, through procurement, purchasing, delivery, installation and disposal of surpluses as shown in Figure 1.1. General activities that should be considered in preparing the plan for materials include the determination of materials needed (i.e. quantity, type, sizes, colour, etc.), specific dates when the materials are needed, procurement, expediting, receiving, storage, usage, disposal and provisions for contingencies.

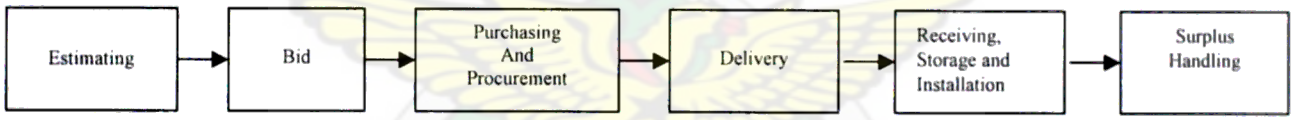


Figure1.1: Material Phases on a Construction Project

The accuracy of the plan is evaluated by variations from the estimated cost, variations on the delivery date, and effects of the variations in times of material management related activities on the overall project duration (i.e. on time vs. delayed). Based on the deviations observed, the materials manager may decide to modify certain decisions or strategies or formulate a new plan. This comparison of planned strategies vs. actual results is essential to refine and update the materials management plan. In addition, during the material cycle on the construction project, the project team faces decisions

about deliveries, suppliers, among others.

Better materials management practices or models could increase efficiency in operations and reduce overall costs. There is a growing awareness in the construction industry that materials management needs to be addressed as a comprehensive integrated management activity (Ammer, 1980). Increasing pressures on project costs and completion times are motivating the need to make materials management decisions in a coordinated fashion and in consideration of minimizing total supply-chain cost without causing shortages. The performance of these decisions is heavily dependent on the combination of the different alternatives listed in every phase of the materials management process. Currently, there is no structured approach to identifying the optimum combination of decisions that will lead to processing the needed material with the least total costs. Fortunately, model-based, computerised solutions to materials management problems are proliferating (Dos Santos, 1996). However, the typical Ghanaian contractor may be overwhelmed by the technology embodied by these solutions and the challenges of integrating this knowledge into business practices. A definition of the data, models, decision makers and procedures that make up this knowledge and a mapping of their relationships and uses is a vital first step towards building integrated decision support for the Ghanaian contractor.

It is clear that effective planning is required to keep costs to a minimum and to insure that the material is on site when needed. Poor planning of materials will increase indirect costs associated with delivery and use of materials. In addition, losses in productivity, delays, re-handling, and duplicate orders among other factors can be expected when

there is a poor materials management system. Contractors need to realise that by improving their material management systems, improvements could be achieved in other areas such as in the labour force. The effects of not having material available when needed could be difficult to measure, but the impact in labour productivity could be noticed and quantified. Indirect labour costs due to absence of materials could be significant. Increases in idle time or unproductive time should be expected. Gang members will pretend to be busy even if there is no material to install, which increases the labour cost. Stukhart, G. and Bell, L.C. (1987) conducted a study of twenty heavy construction sites in the U.S.A where the following benefits from the introduction of materials management systems were noted:

- In one project, a 6% reduction in craft labour costs occurred due to the availability of materials on site when needed. On some other projects, an 8% savings was estimated by reducing the delay for materials.
- Two projects, with and without a materials management system, were compared and the comparison revealed a change in productivity from 1.92 man-hours per unit without a system to 1.14 man-hours per unit with a new system. Much of the difference can be attributed to the .timely availability of materials.
- Warehouse costs were found to decrease 50% on one project with the introduction of improved inventory management, representing a savings of $92,000. Interest charges for inventory also declined, with one project reporting a cash flow savings of $85,000 from improved materials management.

Other issues that could be a consequence of a bad material management system include

disruptions of work flow, time lost due to relocation of the work force, changing set ups to new locations where material is available, even if it is a different activity, de-motivation of supervisors and possibly labour force. On the other hand, excess of material due to early deliveries could disrupt the work flow, require re-handling material to free up space for other gangs to work, which requires time, the possibility of material being damaged increases and there is a greater probability of having accidents due to extra material on the jobsite.

All sectors of the construction industry share a common ground for material management and control. Thus, the discussion presented although it is directed towards the general contracting industry could be applied to any sector. Material management activities are required throughout a construction project and in every construction project. Moreover, the success of the project is highly dependent on the successful management of the materials required. Hence, managing the materials in an effective way is very critical to all parties involved not only in the construction industry but also in other industries.

The research work is expected to provide the following benefits to the industry:

- Improve the management of materials for the construction industry.
- Provide guidelines to assist in the materials management learning process.
- Standardisation of the material management practices within a company.
- Investigate state of the art tools and technologies that could be helpful in managing and monitoring material and control its quality.
- With the development of a structure for a material management information

system, facilitated through a management database, the following benefits are expected:

- Minimization of the repetition of past failures.
- Sharing of successful experiences.
- Learning from other people's experiences to avoid pitfalls and to minimize the repetitions of errors.
- Identifying specific design, process, or decision that reduces or eliminates the potential for failures
- Availability of corrective actions for typical problems that might impact the cost of a project

1.5 Research Methodology

The approach to do this work was broken down into desk study through literature search, field survey through administering of questionnaire and interviews, observation and analyses of results.

The Desk Study Through Literature

This was done by means of a systematic literature review of text books, institutional and statutory publications, periodicals, trade/academic journals, seminar and conference papers some of which were undertaken over the internet.

Survey Design

To achieve the aim and objectives of the research, structured questionnaires and semi-structured interviews were used as tools of data collection. The target group of the questionnaires were contractors and personnel of D1 contractors.

Questionnaires Administration

Questionnaires were developed with the aim of identifying, investigating, and analysing the materials management systems of contractors, currently in use at the pre and post contract periods. The developed questionnaires were distributed to selected category D1 construction firms in the Greater Accra, Ashanti, Central and Western Regions of Ghana.

Sampling Design

The questionnaires were distributed to selected contractors in D1 category. Purposive or judgmental method of sampling was used for the sample size selection.

Treatment of Questionnaires

The questionnaires were personally distributed to respondents and collected personally. Respondents were briefed on the objective of the survey so as to ensure that their responses would be realistic and as objective as possible. Each respondent was expected to take a maximum of forty-five minutes to complete the questionnaire after which they were collected.

Interviews

Interviews were conducted with respondents and other stake holders during the collection of data to allow supplementary information to be collected on areas not clearly covered by the questionnaires. The selection of respondents for the interviews was purely by a judgmental system.

1.6 Scope and Limitations of Study

The scope of works will be limited to:

- **Location and industry**

  Ghanaian Construction Industry, and limited to the Greater Accra, Ashanti, Western and Central regions of Ghana.

- **Contractor classification**

  D1 construction companies

- **Materials Management function**

  Purchasing

  Receiving and Stores

  Materials control

1.7 Organisation of the Research

The organisation of the chapters is as follows:

Chapter 1: The General Introduction of study, the Problem Statement, Aim and Objectives, Industrial Relevance, Justification of the Research, Scope of Study and Research Methodology.

Chapter 2: The Literature Review of the research under study; thus, Materials Management and Information Technology. Here, Materials Management is discussed in detail and Computer Applications to Materials Management is also dealt with.

Chapter 3: This chapter looks at the methodology applied in the research, survey design, sampling technique, questionnaire development and questionnaire administration

Chapter 4: Data Presentation and Analysis. This deals with the analytical phase of the report based on the case study. It looks at Materials Management; specifically, Production Planning, Materials Scheduling and Purchasing, as well as some of the Computer Applications available for use.

Chapter 5: This chapter dwells on the development of the model, testing and validation and the operation of the model

Chapter 6: Summary of the entire Research, Conclusions and Recommendations.

CHAPTER TWO
MATERIALS MANAGEMENT AND MANAGEMENT INFORMATION SYSTEMS

2.0 General

This chapter defines what a material management system is and typical materials used in the construction industry, why it is important to have a material management system and the advantages of having it. This chapter also presents the current state of knowledge in materials management for construction. The studies are classified in materials management and project management, benefits and the costs of a materials management system, role of the supplier, models developed and studies of effectiveness of materials management, use of technology for materials management, and other research related to materials management.

2.1 INTRODUCTION TO MATERIALS MANAGEMENT

Construction materials constitute a major cost component on any construction project. The total cost of installed materials (or *Value of Materials)* may be 50% or more of the total cost of a project (Stukhart 1995, Bernold and Treseler 1991), even though the factory cost may be a minor part of the total, probably less than 20-30%. This is because the manufactured item must be stored, transported, and restored before it is put in place or "consumed" at the site. The total cost of materials will include, in addition to the manufacturer's selling price, the cost of procurement (cost of placing processing and paying for the material, physical distribution, the distributor's cost, and the transportation of materials), and the site-handling costs (cost of receiving, storage, issuing, and

disposal). The efficient procurement and handling of material represent a key role in the successful completion of the work. It is important for the contractor to consider that there may be significant difference in the date that the material was requested or date when the purchase order was made, and, the time at which the material will be delivered. These delays can occur if the contractor needs a large quantity of material that the supplier is not able to produce at that time or by any other factors beyond his control. The contractor should always consider that procurement of materials is a potential cause for delay (Willis, 1986).

Poor planning and control of materials, lack of materials when needed, poor identification of materials, re-handling and inadequate storage cause losses in labour productivity and overall delays that can indirectly increase total project costs. Effective management of materials can reduce these costs and contribute significantly to the success of the project.

2.1.1 Background

The Webster's dictionary defines materials as *"the elements, constituents, or substances of which something is composed or can be made."* Ballot (1971) defines materials as "the physical materials that are purchased and used to produce the final product and does not suggest that materials are the final product". In other words, materials are the parts used to produce the final product. Bailey and Farmer (1982) define materials as "the goods purchased from sources out of the organisation that are used to produce finished products". Stukhart (1995) defines materials as "the items that are used to produce a

product and which include raw materials, parts, supplies and equipment items".

Dobler and Burt (1996) classify manufacturing materials into five categories. These categories are:

- Raw materials- materials that the company converts into processed parts. This might include parts specifically produced for the company and parts bought directly off the shelf (i.e. bolts, nuts).
- Purchased parts- parts that the company buys from outside sources (i.e. rubber parts, plastic parts).
- Manufactured parts- parts built by the company (i.e. tower case for a computer)
- Work in process- these are semi-finished products found at various stages in the production process (i.e. assembled motherboard).
- Maintenance, repairing, and operating (MRO) supplies- MRO supplies used in the manufacturing process but are not part of the final products (i.e. detergents, lubricating oil).

Chandler (1978) states that construction materials can be classified into different categories depending on their fabrication and in the way that they can be handled on site. He classifies the materials into five categories. These categories are:

- Bulk materials- these are materials that are delivered in mass and are deposited in a container.
- Bagged materials-these are materials delivered in bags for ease of handling and controlled use.
- Palette materials- these are bagged materials that are placed in pallets for

delivery.

- Packaged materials- these are materials that are packaged together to prevent damage during transportation and deterioration when they are stored.
- Loose materials- these are materials that are partially fabricated and that should be handled individually.

Table 2.1 presents some examples of commonly used materials in construction and their classification.

Table 2.1: Classification of Materials (Adopted from Chandler, 1978)

Material	Bulk	Bagged	Palleted	Packaged	Loose
Sand	X				
Gravel	X				
Topsoil	X				
Paving Slabs					X
Structural Timber					X
Cement	X	X	X		
Concrete	X				
Pipes				X	X
Tiles				X	
Doors			X		
Electrical Fittings				X	

Stukhart (1995) states that the main categories of materials encountered in a construction project are engineered materials, bulk materials, and fabricated materials.

- Bulk materials- these are materials manufactured to standards and are purchased in quantity. They are bought in standard lengths or lot quantities. Examples of such materials include pipes, wiring, and cables. They are more difficult to plan because of uncertainty in quantities needed.
- Engineered materials- these materials are specifically fabricated for a particular project or are manufactured to an industry specification in a shop away from the site. These materials are used for a particular purpose. This includes materials that require detailed engineering data.
- Fabricated materials- these are materials that are assembled together to form a finished part or a more complicated part. Examples of such materials include steel beams with holes and beam seats.

2.1.2 Importance of Materials on a Project

Problems related to managing the flow of materials can be found in every organisation. The efficient management of materials plays a key role in the successful completion of a project. The control of materials is a very important and vital subject for every company and should be handled effectively for the successful completion of a project. Materials are critical in the operations in every industry since unavailability of materials can stop

production. In addition, unavailability of materials when needed can affect productivity, cause delays and possible suspension of activities until the required material is available. It is important for a company to consider that even for standard materials, there may be significant difference in the date that the material was requested or date when the purchase order was made, and the time in which the material will be delivered. These delays can occur if the quantities needed are large and the supplier is not able to produce those materials at that time or by any other factors beyond the control of the company. The company should always consider that purchase of materials is a potential cause for delay (Willis, 1986). Unavailability of materials is not the only aspect that can cause problems. Excessive quantities of materials could also create serious problems to managers. Storage of materials can increase the costs of production and the total cost of any project. When there are limited areas available for storage, the managers have to find other alternatives to store the materials until they are needed. Some of these alternatives might require re-handling of materials, which will increase the costs associated with them. Provisions should be taken to handle and store the materials adequately when they are received. Special attention should be given to the flow of materials once they are procured from suppliers.

It is obvious that materials should be obtained at the lowest cost possible to provide savings to the company (Damodara, 1999). In the late 1970's, construction companies experienced an increase in costs and a decrease in productivity. Owners of these companies thought that these increases in cost were due to inflation and economic problems. Further research concluded that these companies were not using their resources efficiently and that the decrease in productivity was also attributable to poor

management (Stukhart, 1995). Material management has been an issue of concern in the construction industry. 40% of the time lost on site can be attributed to bad management, lack of materials when needed, poor identification of materials and inadequate storage (Baldwin et. al, 1994).The need for an effective materials planning system becomes mandatory. Some companies have increased the efficiency of their activities in order to remain competitive and secure future work. Baldwin et. al, also stated that many other firms have reduced overheads and undertaken productivity improvement strategies. Considerable improvement and cost savings would seem possible through enhanced materials management. Timely availability of materials, systems, and assemblies are vital to successful construction. Materials management functions are often performed on a fragmented basis with minimal communication and no clearly established responsibilities assigned to the owner, engineer or contractor. Better material management practices could increase efficiency in operations and reduce overall cost. Top management is paying more attention to material management because of material shortages, high interest rates, rising prices of materials, and competition. There is a growing awareness in the construction industry that material management needs to be addressed as a comprehensive integrated management activity

2.1.3 What is material management?

Different researchers provide different definitions for material management, therefore different definitions can be found in different references. Basically, material management is concerned with the planning, identification, procuring, storage, receiving and distribution of materials. The purpose of material management is to assure that the

right materials are in the right place, in the right quantities when needed. The responsibility of one department (i.e. material management department) for the flow of materials from the time the materials are ordered, received, and stored until they are used is the basis of material management.

- Ballot (1971) defines material management as the process of planning, acquiring, storing, moving, and controlling materials to effectively use facilities, personnel, .resources and capital.
- Tersine and Campbell (1977) define material management as the process to provide the right materials at the right place at the right time in order to maintain a desired level of production at minimum cost. The purpose of material management is to control the flow of materials effectively.
- Beekman-Love (1978) states that a material management structure should be organized in such a way that it allows for integral planning and coordination of the flow of materials, in order to use the resources in an optimal way and to minimize costs.
- Chandler (1978) states that material management systems should be implemented to plan, order, check deliveries, warehousing, controlling the use of materials, and paying for materials. He adds that these activities should be interrelated.
- Ammer (1980) defines material management as the process in which a company acquires the materials that it needs to achieve their objectives. This process usually begins with the requisition of materials from the supplier until the material is used or incorporated into a product.
- Bailey and Farmer (1982) define material management as a concept concerned

with the management of materials until the materials have been used and converted into the final product. Activities include cooperation with designers, purchasing, receiving, storage, quality control, inventory control, and material control.

- Gossom (1983) indicates that a material management system should have standard procedures for planning, expediting, transportation, receipt, and storage to ensure and efficient system for materials control.
- Cavinato (1984) states that material management involves the control of the flow of goods in a firm. It is the combination of purchasing with production, distribution, marketing and finance.
- Arnold (1991) states that material management is a function responsible for planning and controlling of materials flow. He adds that a materials manager should maximize the use of resources of the company.
- Stukhart (1995) defines material management as the activities involved to plan, control, purchase, expedite, transport, store, and issue in order to achieve an efficient flow of materials and that the required materials are bought in the required quantities, at the required time, with the required quality and at an acceptable price.
- Plemmons and Bell (1995) define material management as the plan and control of all activities to ensure the correct quality and quantity of materials and equipment to be installed are specified in timely manner, obtained at reasonable cost and are available when needed.
- Dobler and Burt (1996) state that material management is designed to improve the activities related to the flow of materials. They add that material

management should coordinate purchasing, inventory control, receiving, warehousing, materials handling, planning, and transportation.

The role that a materials manager plays in an organisation is strictly economical since the materials manager should keep the total cost of materials as low as possible. The person in charge of handling materials should keep in mind the goals of the company and insure that the company is not paying extra money for materials. The goal of every company is to make a profit. This is the basis for company survival, costs should not exceed income, but keeping in mind customer's expectations.

The typical tasks associated with a material management system are (Tersine and Campbell (1977), Ammer (1980), Stukhart (1995)):

- Procurement and purchasing
- Expediting
- Materials planning/ Materials handling
- Distribution
- Cost control
- Inventory management / Receiving/ Warehousing
- Transportation

Purchasing and procurement deals with the acquisition of materials to be used in the operations. The primary function of purchasing and procurement is to get the materials at the lowest cost possible, but keeping in mind quality requirements. Expediting is the

continuous monitoring of suppliers to ensure on time deliveries of materials purchased. The purpose of materials planning is to procure the materials for the dates when they are needed, storage facilities, and handling requirements. The primary function of materials handling is to manage the flow of materials in the organisation. The manager has to assure that the costs associated with handling materials are kept to a minimum. In cost control, the manager has to insure that the costs to buy materials are kept to a minimum. In other words, the manager has to insure that he is buying the products at the lowest possible price. The inventory management deals with the availability of materials. Transportation involves using the safest most economical means to transport the materials to the site where they are needed.

Figure 2.1 depicts the different phases of the material management process including the relationship and interdependency between the different activities in each phase. From this figure it can be seen that decisions taken at each phase in the system, directly affect the activities of the phases that follow.

costs associated with personnel, equipment and plant and little attention has been given to materials. For manufacturing organisations, the costs related to materials have increased and had become the largest expenditure of the organisation; therefore more attention has been placed into activities related to materials (Tersine, 1978). The cost of materials has escalated to twice the cost of labour between 1975 and 1980 inducing companies to pay more attention to activities related to materials (Bernold and Treseler, 1991).

Traditionally the responsibilities for activities related to materials flow have been divided between different departments. Figure 2.2 depicts the division of responsibilities for material management. The activities related to material management are divided between different departments. For example, the finance department is in charge of the purchasing activities while the manufacturing department is in charge of the control of materials during production. This division of responsibilities makes it difficult to coordinate the activities related to materials. In addition, this division can make the control and identification of materials extremely difficult.

The integration of the functions related to materials into a single department makes it easier to control and identify all the activities related to material flow and costs. Figure 2.3 depicts the integrated approach for material management. Material management is designed to coordinate and control the materials needed and activities related to those materials. In a typical organisation, the material activities are interrelated (Dobler and Burt, 1996).

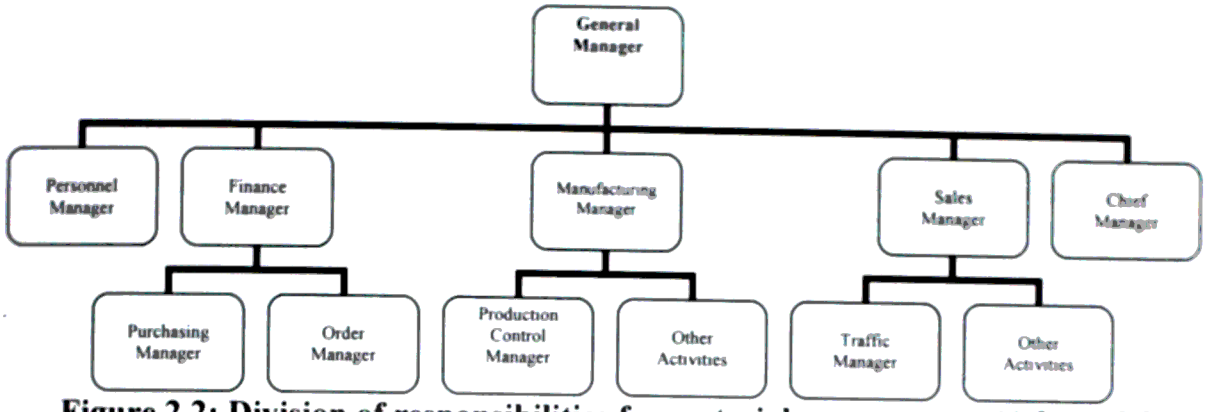


Figure 2.2: Division of responsibilities for material management (Adopted from Ammer, 1981)

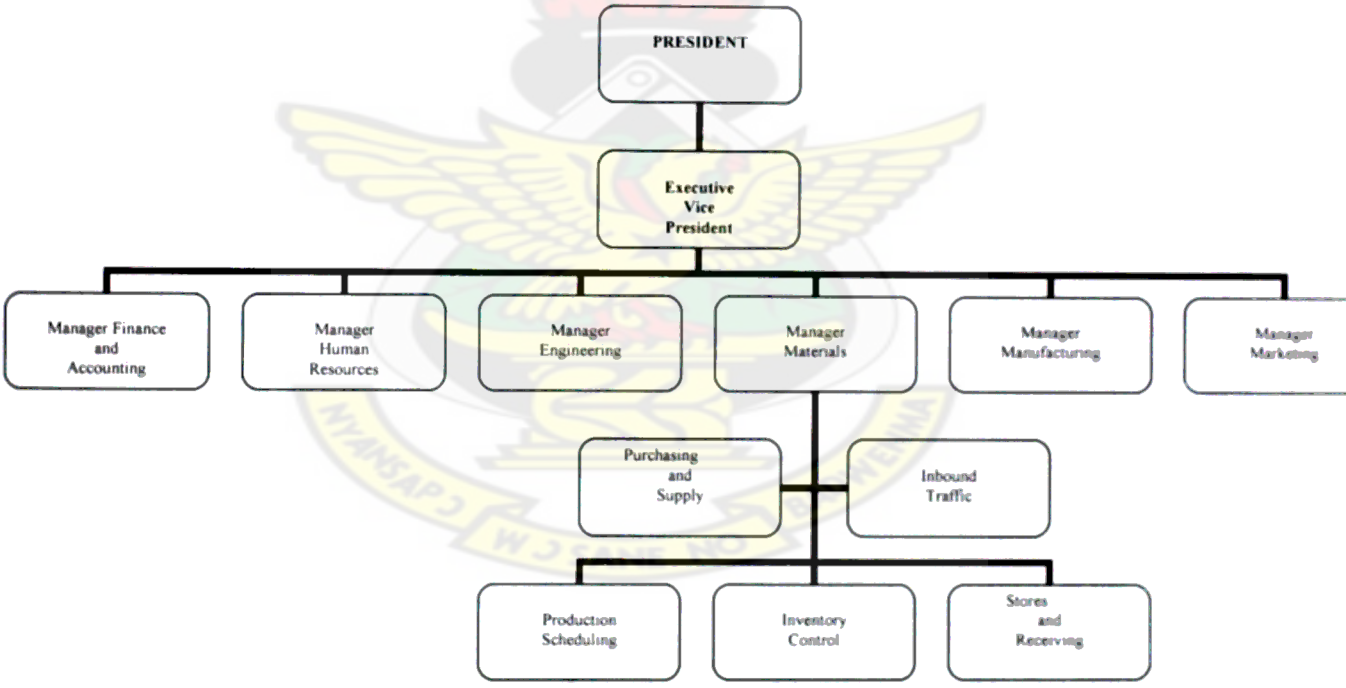


Figure 2.3: General Structure of a Material Management System in a Company (Adopted from Dobler and Burt, 1996)

Figure 2.4 illustrates a typical flow of materials, and material activities in an organisation. From the figure, it can be seen that decisions taken at early stages in the material management flow might affect other activities and decisions to be made in later stages. For example, if the proposals from suppliers are not analyzed (i.e. step 6 in the purchasing activities), then the selection of suppliers might be affected (i.e. step 3 in the supply management activities).

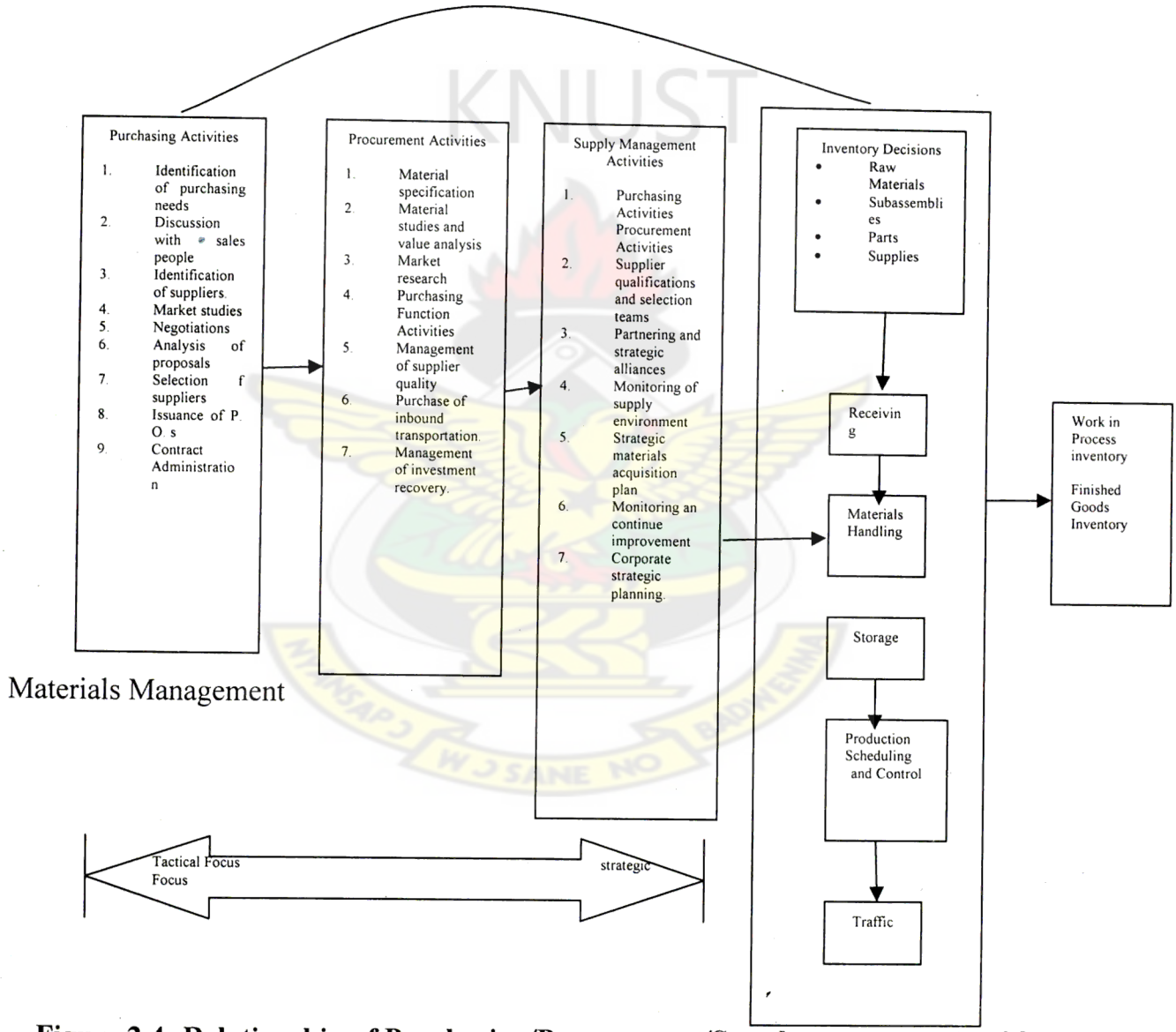


Figure 2.4: Relationship of Purchasing/Procurement/Supply management with Material Management (Adopted from Dobler and Burt, 1996)

Coordination is needed in order to reduce the impact that a decision at a certain stage

might have in other activities. Communication is essential among members of the team to avoid conflicts and to take the better decisions regarding materials flow. The flow of information is another aspect of the materials management system which is often overlooked by senior management.

2.1.5 Benefits of Materials Management

An effective materials management system can bring many benefits for a company. Previous studies by the Construction Industry Institute America (**CIIA**) concluded that labour productivity could be improved by six percent and can produce 4-6% in additional savings (Bernold and Treseler, 1991). Among these benefits are:

- Reducing the overall costs of materials by better handling of materials.
- Reduction in duplicated orders.
- Materials will be on site when needed and in the quantities required.
- Improvements in labour productivity.
- Improvements in project schedule.
- Quality control.
- Better field material control.
- Better relation with suppliers.
- Reduction of materials surplus.
- Reduction in the storage of materials on site.
- Labour savings.
- Stock reduction.
- Purchase savings.
- Better cash flow management

This chapter provided an introduction to materials management and the benefits that could be realized by having an effective materials management system. The basic knowledge needed to understand the basis of the research and why it is important to undertake this research work were presented. The next chapter will present the current state of knowledge in materials management, particularly for the construction industry. In addition, areas related to materials management that are particularly important for this research work, such as cultural change and knowledge management, are also described.

2.2 Management Information Systems (MIS)

Every aspect of management in the modern age relies heavily on information to thrive. Nothing moves without information and it is generally believed that information is power and that he who has it has power. It is an important resource needed to develop other resources. Changing circumstances and environments have necessitated the need for the proper dissemination of information at various levels of management. The development and use of management information systems (MIS) is a modern phenomenon concerned with the use of appropriate information that will lead to better planning, better decision making and better results. There is no universally accepted definition of MIS and those that exist reflect the emphasis and perhaps prejudices of their authors. However, the term "management information system" can be seen as a database management system tailored to the needs of managers or decision makers in an organisation. MIS is a system using formalised procedures to provide management at all levels in all functions with appropriate information based on data from both internal and

external sources, to enable them to make timely and effective decisions for planning, directing and controlling the activities for which they are responsible (Argyris, 1991).

It will be noted from the above definition that the emphasis is on the uses to which the information is put. Planning, directing and controlling are the essential ingredients for management.

In essence the processing of data into information and communicating the resulting information to the user is the key function of MIS. It should, therefore, be noted that MIS exist in organisations in order to help them achieve objectives, to plan and control their processes and operations, to help deal with uncertainty, and to help in adapting to change or, indeed initiating change.

2.2.1 The importance of MIS to management

In all but the smallest organisations management rarely observe operations directly. They attempt to make decisions, prepare plans and control activities by using information which they obtain from formal sources - for example, the organisation's MIS - and also by informal means such as face-to-face conversations, telephone calls, through social contacts, and so on.

A management information system is generally thought of as an integrated, user-machine system providing information to support operations, management and decision-making functions in an organisation. As a matter of fact, an MIS is a special-purpose

system useful for management in an organisation. MIS is an accessible and rapid conveyor belt for appropriate high quality information from its generation to its users. The heart of an effective MIS, therefore, is a carefully conceived, designed and executed database. Its level corresponds to adaptive decisions. The characteristics of MIS in practice include:

- an information focus, designed for managers in an organisation;
- structured information flow;
- integration of data processing jobs by business function, such as production of MIS personnel and so on; and
- Inquiry and report generation, usually with a database.

The MIS era has eventually contributed a new level of needed management information. The increasing interest in MIS had led to much activity in developing techniques and software for data management. However, it should be noted that the new thrust in MIS is on the uses to which the information is put and not how it is processed. The emphasis is on managing the information as a resource, which is important, and not on the intermediate processing stage. Managements are faced with an accelerating rate of change and an ever more complex environment.

Managers need relevant information, which is information that increases their knowledge and reduces their uncertainty. Thus it is usable by the manager for its intended purpose. Without relevant information, no manager can function effectively. A worthwhile extension to the well-known adage that "management get things done through people," would be that management get things done through people, by using relevant information retrieved from MIS. It is not an exaggeration to state that MIS is the lifeblood of management.

2.2.2 Problems with MIS

There is abundant evidence from numerous surveys conducted in developed countries, particularly in the UK and USA, that existing MIS, often using advanced computer equipment, have had relatively little success in providing management with the information it needs. Reasons discovered by (Nigel Craig and James Somerville, 2003) include the following:

- lack of management involvement with the design of the MIS;
- narrow or inappropriate emphasis of the computer system;
- undue concentration on low-level data processing applications particularly in the accounting area;

- poor appreciation by information specialists of management's true information requirements and of organisational problems; and

- Lack of top management support.

To be successful, an MIS must be designed and operated with due regard to organisational and behavioural principles as well as technical factors. Management must be informed enough to make an effective contribution to system design, and information specialists (including systems analysts, accountants and operations researchers) must become more aware of managerial functions and needs so that, jointly, more effective MIS are developed. Management do not always know what information they need and information professionals often do not know enough about management in order to produce relevant information for the managers they serve. There is no doubt that better communication between management and information professionals and a wider knowledge by both groups of MIS principles would greatly facilitate the task of developing relevant and appropriate information systems. It should be noted, however, that there is no simple checklist of essential features which, if followed, will automatically produce the perfect MIS. What is required is an awareness and understanding of key principles and functions so that the design, implementation and operation of the MIS is the result of informed decisions and judgement rather than haphazard development without regard to real organisational requirements.

2.3 The Materials Management Practice and Management Information Systems (MIS)

In essence, a MIS provides a highly structured system focused around a construction project: such a tool will create a central repository for information within a secure environment that facilitates all materials management functions/departments transferring project information electronically. However, many construction organisations still have not taken the initial steps towards the adoption and implementation of IT (for now they can exist and compete without using this type of technology) (Anderson, 2000).

Perhaps though, the most compelling reason why the Ghanaian construction industry is not moving as swiftly as it should towards IT implementation is the lack of robust industry-specific systems that can be adopted at the lower end of the supply chain. Development of MIS and the pan-global nature of the construction industry are driving forward the issue of integration and making it all the more critical. Software and systems development within the construction industry is still highly centric to fine tuning the established systems. What is required is a wider, more holistic, perspective which looks beyond the needs of individual and singular organisations and examines the specific needs of the industry: this will result in competitive advantages for firms as it has in other industries, e.g. manufacturing.

MIS will facilitate the existence of multiple real and virtual organisations that work co-operatively and will also facilitate organisations in their drive for improved operational

efficiency. MIS enable inter-organisational integration of information and achieve reductions in processing of project critical information (Molad and Back, 1995).

2.4 Current State of Knowledge in Materials Management for Construction

A successful construction company meets the customer's needs effectively and in the process makes a profit. Owners are looking for construction companies that can deliver the project at low cost, with the required standards of quality and in a reasonable time. Similar to other industries, the cost of materials in construction accounts for a considerable part of the project cost. Some studies concluded that materials account for around 50-60% of the project cost (Stukhart (1995), Bernold and Treseler (1991)). It is obvious that materials should be obtained at the lowest cost possible to provide savings to the company (Damodara, 1999). Materials management has been an issue of concern in the construction industry. In addition, 40% of the time lost on site can be attributed to bad management, lack of materials when needed, poor identification of materials and inadequate storage (Baldwin et. all. 1994).

Some studies have shown that an effective material management system can produce 6% improvement in labour productivity and a computerized system can produce additional 4-6% in savings (Stukhart, 1995). There is a growing awareness in the industrial construction industry that material management need to be addressed as a comprehensive integrated management activity. Researchers have acknowledged the

importance of materials and the impact that these have in the total project cost, plans and operations. This chapter presents an overview of some of the aspects considered in previous and ongoing research in materials management in construction.

2.4.1 Materials Management and Project Management

Different authors define the concept of materials management in different ways. However, all the researchers point out that materials management is extremely important for a successful project completion. The basic idea behind materials management is that the materials and/or equipment needed, in the quantities needed, meeting the standards of quality specified, are obtained at a reasonable cost and are available when needed on the construction site. The process of materials management should integrate planning, purchasing, expediting, and inventory control. The benefits of implementing a materials management system have not been recognized by senior management. A well managed materials management system can contribute to the cost effectiveness of a project. In .order for a company to implement a successful materials management system, top management support is required.

Damodara (1999) identifies seven stages in which the project management team must ensure a materials management focus. These seven stages are: Planning, Preliminary Design, Final Design, Procurement, Supplier Control, Construction and Closeout. A description on the tasks of managers in each stage follows.

In the Planning stage the project management team develops the materials management

team and the functional relationship among members of the team in order to develop a team that is united and working towards the same goal. In this stage the materials management focus should be defined and adapted to the mission, which is to complete the project at the lowest cost possible. In the preliminary design phase the materials to be used in the project are defined. This definition of materials should minimize the cost of the design, but assuring that the materials and equipment selected meet the client's requirements. Once materials are defined, the project team starts to inquire from suppliers for information about the materials needed and possible delivery dates. In the final design stage the team should develop specifications for equipment and materials to be used in order to request and obtain competitive proposals. In the procurement stage the team should consider to use standard materials that meet the specifications and requirements. In addition, the submittals should be kept to minimum level. This might ensure more reliable delivery dates. The team should not buy materials in advance. Buying materials earlier than needed may require re-handling which will increase costs. In addition, the team has to put in place a plan to expedite the orders so that the materials are delivered according to the schedule. In the construction stage the team should account for all materials and equipment received. This practice will be useful to avoid duplicated orders. These materials and equipment should be available when needed on site to avoid delays. In the closeout stage the project team should dispose of any surplus materials. The disposal process can be simplified if the team uses standard materials. The team can identify any pitfalls in the materials management process and identify areas of improvement. The success of a project depends greatly in the effective implementation of materials management system.

2.4.2 Benefits and Costs of a Materials Management System

The Construction Industry Institute (CII) created a materials management task force in the middle 1980s. This task force was comprised by clients, contractor and people from academia. The first research conducted was to examine the attributes of a materials management system. Bell and Stukhart (1986) presented the attributes of a materials management system that they identified as part of a research work. The attributes identified were: Planning and Communications. Material Take-off and Engineering Interface, Supplier Inquiry and Evaluation, Purchasing, Expediting and Shipping, Warehousing, Receiving and Materials Distribution, Materials Control, and Computer Systems

Bell and Stukhart (1986) completed another study to identify the costs and benefits of a materials management system. They stated that the development of some materials management systems that combine takeoff, expediting, purchasing and supplier evaluation, among other factors, can produce benefits in productivity, cash now and reductions in inventory. The benefits identified by Bell and Stukhart were:

- Improved Labour Productivity.
- Reduced Bulk Materials Surplus.
- Reduced Materials Management Manpower.
- Improved Supplier Performance.
- Other benefits, namely;
    - Timely materials procurement results in reduced requirement for physical

warehouse facilities;

- Other benefits are those associated with timely materials purchases;

Some of the factors that might impact the benefits of a materials management system were also identified. Among these factors, inadequate training, insecure or poorly designed warehouse and lay down areas are included.

Wong and Norman (1997) stated that benefits of implementing materials planning software packages in the manufacturing industry include labour savings, stock reduction, purchase savings and better cash flow management. They suggested implementing a construction materials planning system (CMPS) to determine what components were needed. In addition, it should help to determine what to order, order quantity, ordering time, when to schedule delivery. They identified the major costs such as acquisition cost, start-up costs and annual operating costs. Benefits identified include labour savings, stock savings, cost control savings, purchase savings, earnings generated from extra contracts

Tuffour (1987) performed some research in materials management for construction in developing countries. He identified the following as benefits of a materials management system : reduction in paper work, coordination or cooperation among departments, improvement in relations with suppliers, reduction in double handling of materials, assurance of materials availability, and increase in productivity at the job site.

In addition, Tuffour identified the following as costs associated with the development of a materials management system:

- Warehousing
- Personnel
- Computer system development and application

2.4.3 Role of Suppliers

The relationship between the contractor and suppliers is crucial for the success of a project and it is vital in determining whether or not a construction company stays in business. If the contractor has a good relationship with the suppliers, better prices and more reliable delivery dates can be expected. On the other hand, if the relationship with the supplier is not a good one, the contractor can expect higher prices and late deliveries. This section will examine the effects that the Supplier might have in a project as stated by previous research.

Thomas and Sanvido (2000) stated that although suppliers were a critical component for materials management process, their role has not been considered in previous research. Furthermore, they pointed out that they did not find quantitative research studies that studied the impacts on a project due to supplier's performance. They analyzed three case studies to demonstrate the quantitative effect of the supplier on labour productivity.

Agapiou, (1998) investigated the role of merchants/suppliers in the supply process and discussed the changes in their roles. They stated that a materials' scan brought savings in the costs of materials and components and that the supply included price, discounts, reliability and timing of deliveries, credit facilities for payment.

Bernold and Treseler (1991) stated that the performance of suppliers was related to the success of the materials management system, thus selection of suppliers was a very important aspect. They introduced the 'Concept of Best Buy'. 'Best Buy' assumes certain level of suitability, but considers cost and procurability, transportation and disposal. 'Best Buy' not necessarily means best price; procurement and technical specifications should also be considered. In addition, other factors such as specifications, price, delivery time, etc. should be considered.

2.5 Models Developed and Studies of Effectiveness of Materials Management

The delivery of materials to a construction site is a critical aspect. The supply of building materials and components is filled with obstacles that can have a significant effect on levels of productivity if the materials are not available when needed. Therefore, the delivery of materials is an aspect which demands the introduction of a carefully developed system to monitor and control the problems as early as possible. In addition, the conditions in which the materials are kept on site could lead to damage from weather and movement of people, plant and equipment. This aspect could also have an impact on productivity.

Agapiou, (1998) studied the role of logistics in the materials flow process. They defined logistics as the art of moving, lodging and supplying troops and equipment. For the construction industry, logistics comprise planning, organisation, coordination and control of the materials flow from the extraction of raw materials to the incorporation

into the finished building. Logistics spans the organisation, from the management of materials through to the delivery of the final product. They concluded that the success of the model was based on an integrated approach and the roles adopted by the participants during design and construction phases. In addition, they concluded that the primary focus of logistics was to improve communication and coordination between participants during design and construction, particularly in the materials now control. They stated that partnering arrangements could lead to effective materials control through coordination and cooperation.

Proverbs, (1995) examined the materials management procedures and wastage levels of a medium-sized building contractor during the recession in UK. Some comparisons were made with wastage levels prior to the recession to evaluate improvements in materials control procedures. They prepared a structured questionnaire based on materials management practices and distributed them to site managers. Actual site measurement of direct materials wastage was undertaken. The research team concluded that a materials manager could reduce wastage, improve materials control on site and lead to overall improvements in the competitiveness and efficiency of a company. If the site management was motivated, the morale of employees would increase the percentage of time spent doing productive work.

Formoso and Revelo (1996) developed a method for improving the materials supply system in small-sized building firms using Total Quality Management (TQM). The main problems detected while performing the study were: problems related to design, such as delays, incompleteness, lack of details and inconsistencies, lack of planning and

organisation of transportation and delivery of materials, materials ordered on short notice or verbally, incomplete or inconsistent materials specification, lack of estimation of the amount of materials needed, delays in price surveys and in ordering materials, delays in checking stocks. The improvements were mostly related to supply planning, design phase management, qualification of suppliers and designers, and changes in the process flow. They concluded that although quality concepts and techniques seemed easy to understand, their application in complex processes, such as materials supply management, tended to be rather difficult and time consuming.

Abdul-Malak, (2000) investigated policies that could ensure that costs associated with materials purchasing were kept to a minimum. The research investigated the parameters used in characterising construction materials, the contractor's purchasing policies and costs associated with purchasing of and holding materials, and the client's payment policies for purchased materials. They identified three major cost categories associated with procurement and purchasing: purchase cost, holding costs and shortage costs. They identified payment policies from the contractor to supplier and from the client to the contractor. After finishing the research they concluded that the clients should carefully check procurement policies by contractors. Clients should require a procurement schedule of all major materials for which partial payments are made. The contractor should be paid for materials purchased according to the schedule, so as to avoid paying for materials that were prematurely delivered to site. Control should be exercised over the contractor's ordering policies and payments to contractors should be scheduled properly to reduce overall costs of acquiring materials for construction.

Tuffour (1987) developed a materials management model to be used as a guide for contractors in developing countries, especially Ghana. Materials management was divided into three main parts. These parts were: materials management organisation, purchasing procedures and relations with suppliers, and material utilization The materials management organisation presented a role and responsibility matrix that showed the responsibilities of several people from different departments.

Elzarka and Bell (1995) developed a prototype object oriented computer model for piping systems. They wanted to examine and determine potential expert systems applications to materials management. They stated that the model was capable of executing automatic takeoff. Also, the program could generate purchase orders daily and allowed for reduction in paperwork. The object oriented model was integrated with the design and the schedule. This integration allowed updating the material takeoff automatically. In addition, changes in materials were updated automatically. They concluded that expert systems could improve the efficiency of material management systems.

CHAPTER THREE
RESEARCH METHODOLOGY AND DATA COLLECTION

3.0 General

This chapter presents the methodology used in the research, like the questionnaire design, administration and the sampling technique used. The research approach used by the researcher was that of literature review and at the survey design stage, questionnaires, interviews and case studies were developed and analysed.

3.1 Survey Design

This method was used to collect field data for the research.

3.1.1 Stages Involved In the Design of the Survey

It was clear at the initial stages of the research that conducting a survey was not going to be a simple mechanical counting or recording of events, procedures or behaviour patterns. But rather, it was going to involve the researcher going through a planned and structured process to conduct the survey. The various stages of the process are described below.

A. Planning Stage

1) *Definition of the problem to be investigated*: This involved the researcher deciding on the scope of the survey (that is the decision on what to include and to exclude)
2) *Designing the survey:* Here the researcher drew plans on :
    a. what information to collect;
    b. whom to collect the data from (including problems of sampling);

c. method of recording the data;

d. plans and schemes for processing and analysing the data.

3) *Actual selection of the sample:* Here it was the researcher's duty to prepare the instruments to be used in the data collection. It was decided by the researcher that the instruments to be used would be questionnaires and unstructured interviews. This stage was mainly concerned with the preparation and testing of the questions to be asked both in the interview and questionnaire during the survey.

B. Field Operations

1) *Initial Activities*

a) *Preparation of field equipments:* The researcher at this stage prepared all the questionnaires (refer to appendix A) to be distributed, this process included editing and printing. Voice recorders were tested, tapes and batteries purchased.

b) *Informing the sample size of your intentions:* It was at this stage that the researcher made first contacts with the targeted group for the survey; these were mainly through telephone calls to book appointments with a view to discussing the purpose of the survey.

2) *Enumeration:* This was the stage where the researcher conducted the actual interviews with the participants, distributed the questionnaires and undertook critical observations and recorded relevant phenomena under study.

C. Final Stages

1) *Editing and Coding:* The researcher at this stage went through all the completed questionnaires where they were individually checked. Since most of the data collected were qualitative in nature it was necessary for the researcher to develop a coding system to convert the data into quantitative form.
2) *Processing the data:* The coded information were analysed by the researcher and attempts were made to identify patterns of practices that best represented the mode of operation of the population.
3) *Findings:* At this stage certain patterns of operations were identified including other findings relating to the shortcomings of current practices. These pieces of information formed the basis of the proposed model and the recommendations suggested at the end of the work.

The field survey approach used by the researcher is shown below

- Case study approach
- The survey approach

3.1.2 Case Study Approach

Case study is an ideal methodology when a holistic, in-depth investigation is needed (Feagin, Orum, & Sjoberg, 1991). Case studies have been used in varied investigations, particularly in sociological studies, but increasingly, in construction. Yin (1993), and Stake (1995), who have wide experience in this methodology have developed robust procedures, when these procedures are followed, the researcher will be following methods as well developed and tested as any in the scientific field. Whether the study is

experimental or quasi-experimental, the data collection and analysis methods are known to hide some details (Stake, 1995). Case studies, on the other hand, are designed to bring out the details from the viewpoint of the participants by using multiple sources of data. Case study research is not sampling research; that is a fact asserted by all the major researchers in the field, including Yin, Stake, Feagin and others. However, selecting cases must be done so as to maximise what can be learned in the period of time available for the study. It is in this light that the researcher used a non statistical approach in the selection of sample size, by using Purposive/Judgmental Sampling in selected regions of Ghana.

3.1.3 The survey approach

Surveys are used to gather data from a relatively large number of respondents within a limited time frame. It is thus concerned with a generalized result when data is abstracted from a particular sample or population. Two types of surveys are generally noted- descriptive and analytical surveys.

With the survey and the case study approach, the researcher tends not to affect or interfere with that which is being studied.

In the design of the research it was the researcher's aim to define the fundamental objectives in order that the research could be designed and planned to follow logical steps from which credible conclusions could be drawn.

The research was grouped into three phases, this helped in the structured nature of the research which gave the researcher both direction and immediate realistic goals.

The first phase was to undertake an extensive literature search from the Ghanaian construction industry, academic and construction journals worldwide, the use of the World Wide Web (Internet) was also an added plus with the use of e-libraries and journal databases on issues relating to current construction materials management practices.

The second phase was in the form of structured questionnaires which were prepared based on the objectives of the study to solicit information from building construction firms operating in Ghana. In this phase interviews were also used to bring out information that the structured questionnaire could not capture.

The survey was meant to provide data on the current practices of building contractors in Ghana, in the area of materials management. Interviews were held with some top and middle level management staff to solicit their views on issues relating to materials management in their organisation.

Finally, the data obtained was analysed qualitatively to help establish the first and second objectives which were to find the current materials management practices in Ghana and to find the factors that affected the dissemination of information in such organisations. Based on this information the researcher was able to develop an information management system for materials management in Ghana. Fig 3.0 shows a flow chart of the objectives, and how the objectives of the research were able to achieve the researcher's aim.

Recommendations and conclusion were then made based on the findings of the research.

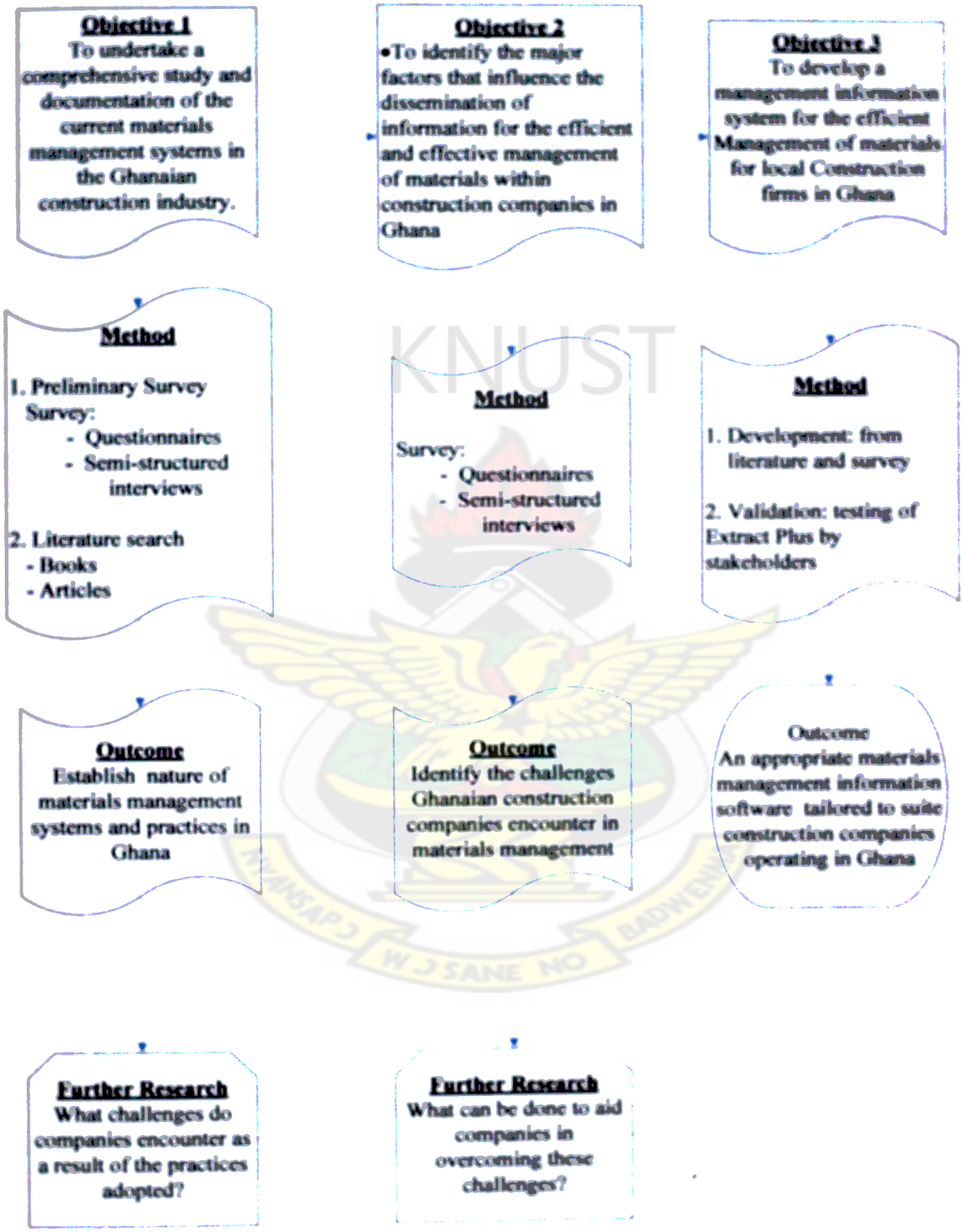


Fig 3.1 Flow chart of objectives

3.2 DATA COLLECTION

In sampling, the main objective is to select a portion of the universe that may, or could be, extended to a whole population. It is in this respect that the representativeness of the universe of which a sample forms part becomes fundamental to sampling. However, certain characteristics of the universe of which a sample forms a part becomes fundamental to sampling. Certain characteristics or phenomena are not distributed randomly or uniformly in a universe. In such cases a representative sample may not at all include a unit typical of the characteristics in question, or it may include so few units that their analysis may not be statistically significant, in such cases, it is more appropriate to identify units of the universe, which satisfy the characteristics of the phenomenon under investigation.

The sample size for Contractors with financial Class D1, registered and working in the selected regions is thirty-six (36).

Table 3.1 Sample Size Distribution

Respondents	**Questionnaires out**
Greater Accra	20
Central region	8
Ashanti region	6
Western region	2
Total	36

Thus the use of this method of sampling (purposive sampling) in the distribution of the researcher questionnaires and interviews. It was known to the researcher that the majority of D1 contractors in Ghana were located in the Greater Accra, Western, Central and Ashanti regions of Ghana. The sample size was established to use D1 contractor in these regions for the study. This selection does not involve the intricate procedures of random sampling. It simply involves picking units on the basis of their known characteristics.

3.2.1 SAMPLE SIZE OF CONTRACTORS

All D1 contractors in the selected regions were targeted.

The above-stratified classes were selected for the following reasons:

- In the classification, D1 contractors were chosen because of the size of their outfits, as they were more likely to have structured organisational systems.
- Limited time and financial resources available for the study could not allow the researcher to tour all the demographic areas or political regions of Ghana.

3.2.2 DESIGN OF QUESTIONNAIRES AND FIELD TESTING

The primary source of data for this research was in the form of a structured questionnaire designed to collect information from D1 contractors, in the Greater Accra, Ashanti Region Central and Western regions.

Guided by the premise that there is paucity of information, a structured questionnaire was prepared to embrace the objectives of the study. A questionnaire was designed for the contractors.

The questionnaire covered five main parts;

- General information on the respondent,
- Materials Control practices in the organisation
- Purchasing practices in the organisation
- Materials inventory and storage control
- Current IT applications in materials management and the dissemination of information in the organisation

The questionnaire also included a list of factors influencing the dissemination of information on materials management that respondents would be required to provide information on. By use of the Likert Principle, respondents were asked to rate the factors using a scale of 1-5, with 1 meaning not important, 2 meaning slightly important, 3 meaning moderately important, 4 meaning very important and 5 meaning extremely important.

The said questionnaires were initially discussed with colleague researchers and lecturers at the Department of Building Technology at a seminar organised for that purpose and then tested using six D1 construction firms from the Ashanti region

The pilot test enabled the author to assess the relevance of the questionnaire, the understanding of the various questions, as well as the availability of the various categories of information needed

The initial questionnaire was thus reviewed based on the suggestions of the various respondents. The necessary corrections, omissions, additions and adjustments were then effected and resulted in the final questionnaire as presented in Appendix A.

This section deals with the detailed analysis of data collected from respondents in relation to questionnaires sent out based on the objective of the above project work in relation to the dissemination of information within the contractor's setup in Ghana.

A total of thirty six (36) questionnaires were sent out; twenty (20) to Greater Accra region, eight (8) to Central region, six (6) to the Ashanti region and two (2) to the western region.

Table 3.2 shows a summary of the responses obtained after distribution of the questionnaires.

Table 3.2 Summary of Responses of Questionnaires sent out

Respondents	**Questionnaires out**	**Response**	**Percentage response (%)**
Greater Accra	20	15	75
Central region	8	5	62.5
Ashanti region	6	6	100
Western region	2	2	100
Total	36	28	80.5

Source: Author's Field Survey, January- April 2007

3.2.3 QUESTIONNAIRE ADMINISTRATION

The author administered all the questionnaires personally to the respondents during which advantage was taken to interview some top and middle level management staff. Respondents were given 45 minutes to fill the questionnaires after which they were personally collected for analysis. Respondents were briefed on the objective of the survey so as to ensure that their responses would be realistic and as objective as possible along the objectives of this thesis. During the collection of these questionnaires interaction with these construction firms allowed supplementary information to be obtained touching on areas which were not covered by the above questionnaires as well as clearing up all clouded areas.

All the respondents were given the freedom to answer the questions, as they deemed appropriate. However, those questions that needed clarification by some of the respondents were attended to, but in a manner that eliminated bias emanating from the researcher's end.

CHAPTER FOUR
THE CURRENT MATERIALS MANAGEMENT PRACTICES IN THE GHANAIAN CONSTRUCTION INDUSTRY

4.0 GENERAL

This chapter presents an overview of materials management practices in the Ghanaian construction industry including services provided by suppliers and materials purchasing. In addition, this chapter describes the current materials management practices in the construction industry. In this chapter, the author was able to develop distinct phases used in current practices in materials management. The different phases included:

- Bidding phase.
- Sourcing phase.
- Material procurement phase.
- Construction phase.
- Post-Construction phase.

The chapter went further to describe the main challenges that are encountered during the five phases of materials management processes.

4.1 Current Materials Management Practises in the Ghanaian Construction Industry

The survey carried out by the researcher investigated current materials management practices in the construction industry. The investigation considered the entire range of activities necessary for procuring the needed material, starting with the estimating process and ending with site delivery, distribution and storage logistics. The survey outcome included documenting the current materials management practices as well as

identifying and classifying the various criteria that influence the decision process for procuring materials. Flowcharts for the material supply chain process was established based on various discussions and interviews with the office and site personnel of construction companies, in selected regions (Greater Accra, Ashanti, Central and Western). From the information acquired from the questionnaire administered and interviews, five distinct phases that complete the process were identified. It must be said that the representation of the phases did not mean that these were practised in every company visited, but represents an overview of the combined representation of companies:

1- *Bidding Phase*,

2- *Sourcing Phase*,

3- *Material Procurement Phase*,

4- *Construction Phase*,

5- *Post- Construction Phase*.

The following subsections will discuss the five phases in more detail.

4.1.1 Phase 1: Bidding

The materials management process starts from the time that the contractor receives the drawings and specifications. The materials takeoff and identification process is the first step in this phase and involves identifying the materials needed as well as any special requirements or special materials to be used in the project. Quantities needed are estimated and a bid package is put together and submitted, typically to the client's team of professionals. Figure 4.1 presents a diagram of the bidding phase.

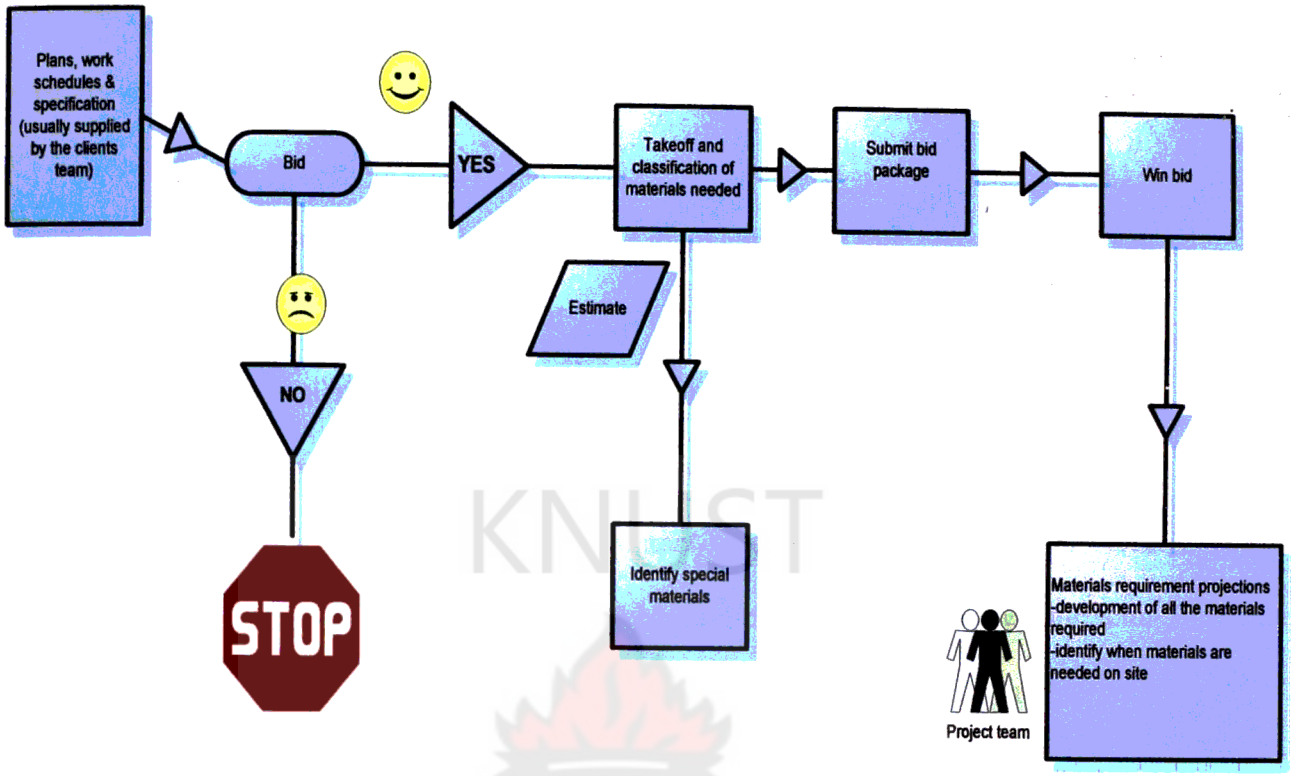


Figure 4.1 Bidding phase flow chart

In general, materials used by contractors can be classified into two categories: off-the-shelf commodities, and customised materials. Customised materials include bulk materials and other items that need to be designed/ fabricated specifically for a given job.

Most contractors prepare manual estimates, which are verified several times prior to submitting the bid for the proposed project. Some contractors use internal cost codes for material takeoff and identification that are assigned to the materials being estimated. Other contractors create "electronic" or computerised estimates or by preparing a

customised program that is suitable for their needs by using a computer application such as Microsoft excel ®.

60% of the companies used in the study, project managers / site managers are involved in the estimating phase. The involvement of the project managers could lead to the preparation of more realistic estimates due to the project manager's knowledge of the materials and equipment. In 20% of companies under study, the estimate was prepared by the estimating department and no site personnel was involved. However, in these companies, the estimate was verified and reviewed by the contractor once the contractor successfully won the bid. A further 20% of the companies under study utilise both methods of estimating.

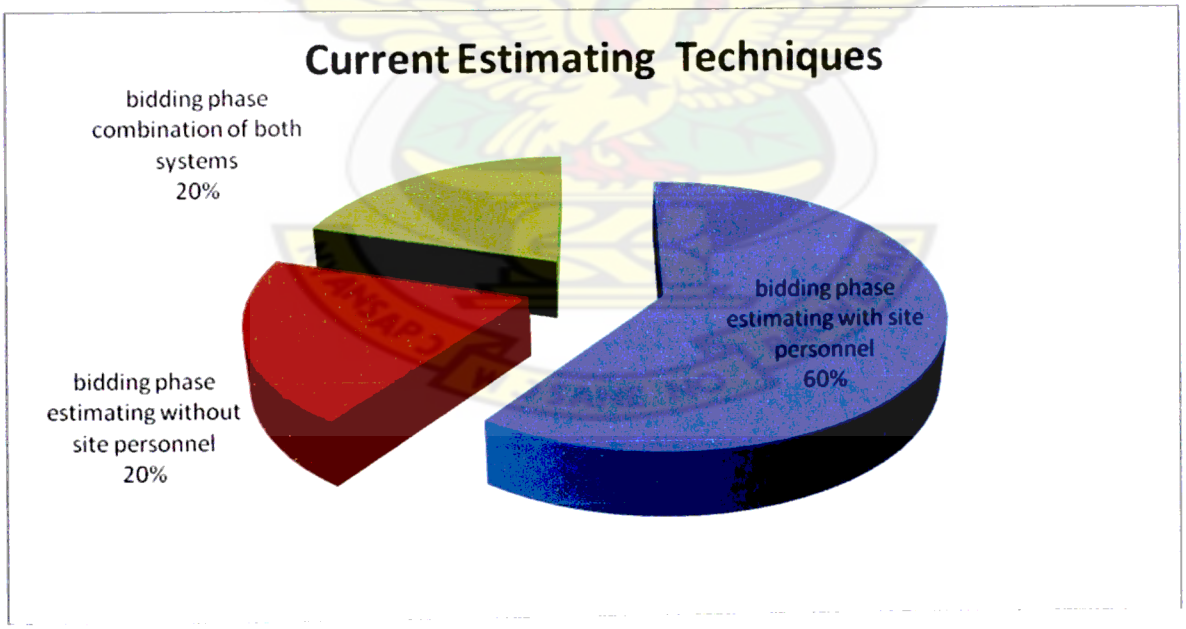


Fig 4.2 current estimating techniques

Typically, databases of historical prices are used to prepare the estimate and subsequent bid packages. For major materials, contractors relied on prices from suppliers or manufacturers or they used prices from a database of historical prices. These databases of prices were updated periodically to reflect current market prices. The person or persons in charge of purchasing verified the prices used in the estimate prior to submitting the bid.

After successfully winning the bid for a particular project, 70% of the companies studied schedule a kick-off meeting that included the general manager, the project manager and all the foremen. At this meeting, the foremen and the project manager re-estimated the quantities for major material and commodities. They generated a material schedule (e.g. release forms) specifying material types, quantities needed, dates when the material should be delivered and any additional information needed for clarification. In addition, any notes related to particular items and the drawings for the job were included. 20% of the companies did not re-estimate the project as long as the quality and clarity of drawings provided was good and no changes were made to the design. In these companies, the initial estimate was verified 2-3 times before submitting the bid.

4.1.2 Phase 2: Sourcing

The first stage in this phase was the selection of reputable suppliers and manufacturers. The selection of suppliers was critical and the contractor needed to verify that the supplier was capable of delivering the right materials (i.e. type, price, quality and quantity) when needed (i.e. at dates specified). In general, most materials (everyday and

major) were purchased through suppliers. 90% of contractors studied prefer to buy materials from their local suppliers and from suppliers with whom they had worked before. The other 10% of the companies had specialised agents within their purchasing setups for supplier selection and procurement. In order to do business with these suppliers, they needed to verify that the supplier was capable of delivering the material when needed. In addition, in order to get reasonably good prices for the material, they requested quotations from different suppliers, suppliers were usually selected based on lowest price, however, contractors might consider suppliers with higher prices but would provide better service or that have a record to supply the right materials in the quantities needed at the times specified. In some situations incomplete proposals from suppliers might delay the selection process.

The purchasing process was different depending on the type of material ordered. For off-the-shelf (commodities) 90% of the contractors selected their suppliers based on a bidding process, unless there were yearly purchase orders for certain types of materials. Under the bidding process, the contractor requested quotations for the materials from suppliers that the contractor had worked with on previous projects. In the case of a yearly contract, the contractor bought the material items under the contract from that particular supplier. Due to high competition in their market areas, some contractors did not use yearly contracts because they were able to get better prices at any time by requesting bids from their suppliers. Typically, the contractor requested prices for an amount of material that was less than the amount that was estimated (e.g. 80% of original estimated material needed). That approach was used to avoid material surplus

on the job site. Based on the quotations submitted, the contractor then selected a supplier.

For major materials, the contractor most often negotiated prices directly with the manufacturer, if the manufacturer was specified in the contract documents. However, the contractor had to buy the materials through the supplier after a mark up had been applied. Otherwise, the contractor requested bids from different qualified manufacturers that produced the required materials. Getting the manufacturers to bid against each other was beneficial for the contractor because he could get better prices. The contract was awarded to a manufacturer after the negotiated or bidding process was completed. As opposed to everyday materials, the contractor typically purchased the total that was originally estimated for major materials. That was because major materials needed to be fabricated and required longer lead times. If the amount requested was less than the amount originally estimated and there were shortages, the contractor would have to wait until more materials were fabricated, which could cause disruptions and delays.

In 70% of the companies used in the study, after the contract had been awarded to the supplier, an agreement was set by the issuance of a temporary purchase order. This temporary purchase order was an assurance to the supplier that the contractor would buy the material from that particular supplier. After the contract was awarded, the supplier would issue submittals for major material and certain everyday materials to the contractor. The temporary purchase order would be approved and would become a purchase order once the submittals have been approved by the contractor. This process is illustrated in Figure 4.3.

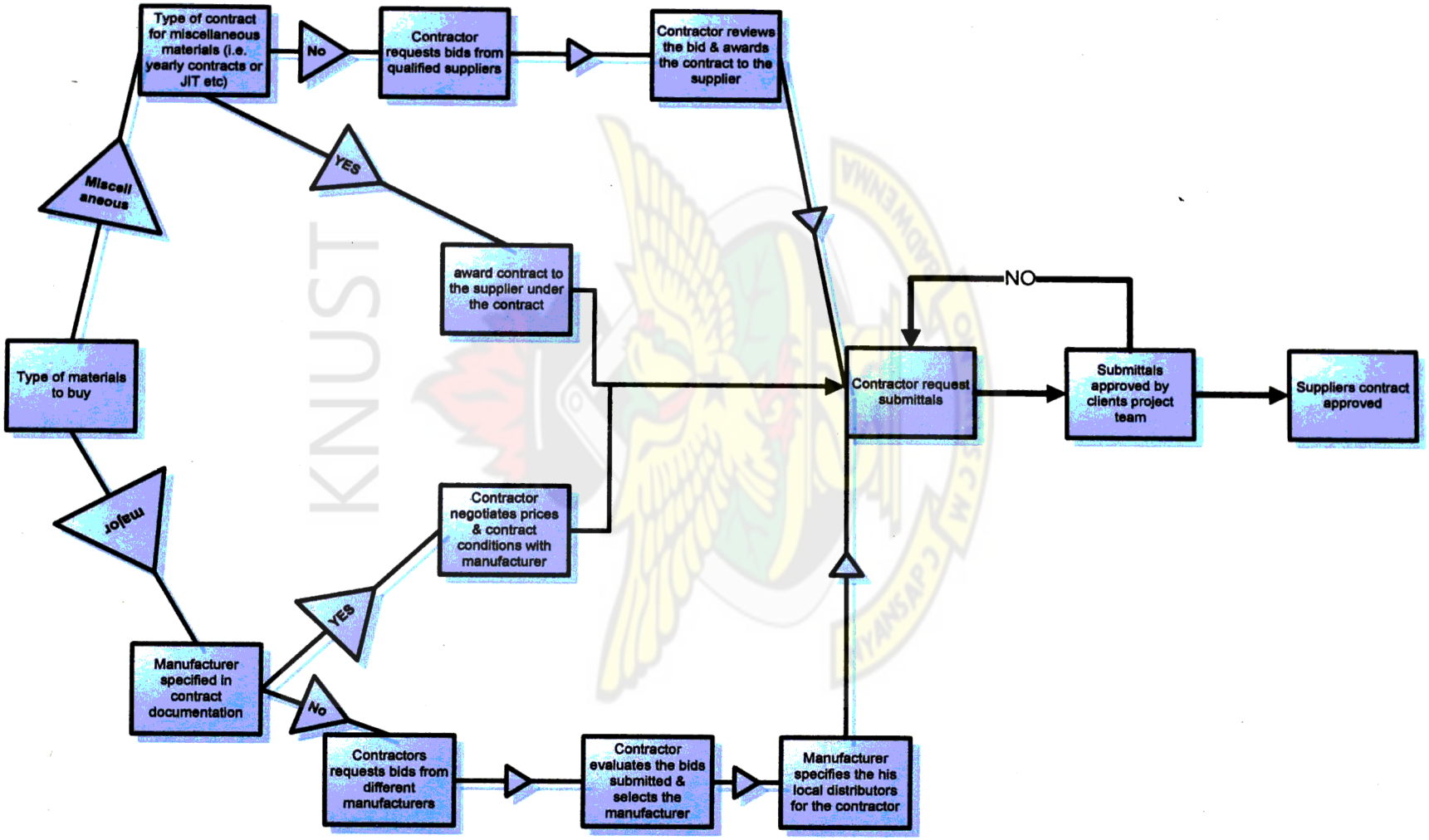


Figure 4.3 Sourcing Phase

4.1.3 Phase 3: Materials Procurement.

The materials requisition and expediting phase was very critical to the success of a materials management process. The person in charge of procuring materials or the purchasing department, in the case of a large company, needed to ensure that the correct materials in the correct quantities were delivered. That person also needed to verify the release dates at which the materials were needed and to clearly specify those delivery dates and the location of delivery to the supplier.

Once a supplier was selected and the materials were ordered, the contractor had to follow up systematically the status of ordered materials to ensure delivery to the jobsite in the quantities needed and within the timeframe specified. In 40% of the companies visited, that process started with the generation of a materials requisition schedule. In large jobs, the schedule was usually prepared by the site staff and then was sent to the purchasing department for materials request from the suppliers under contract. In 60% of the companies visited or on smaller size jobs, material were requisitioned directly by the field personnel. That was the most popular practice in the industry. In companies that had central stores, the purchasing department first verified availability of materials in the central stores before requisitioning any materials from suppliers.

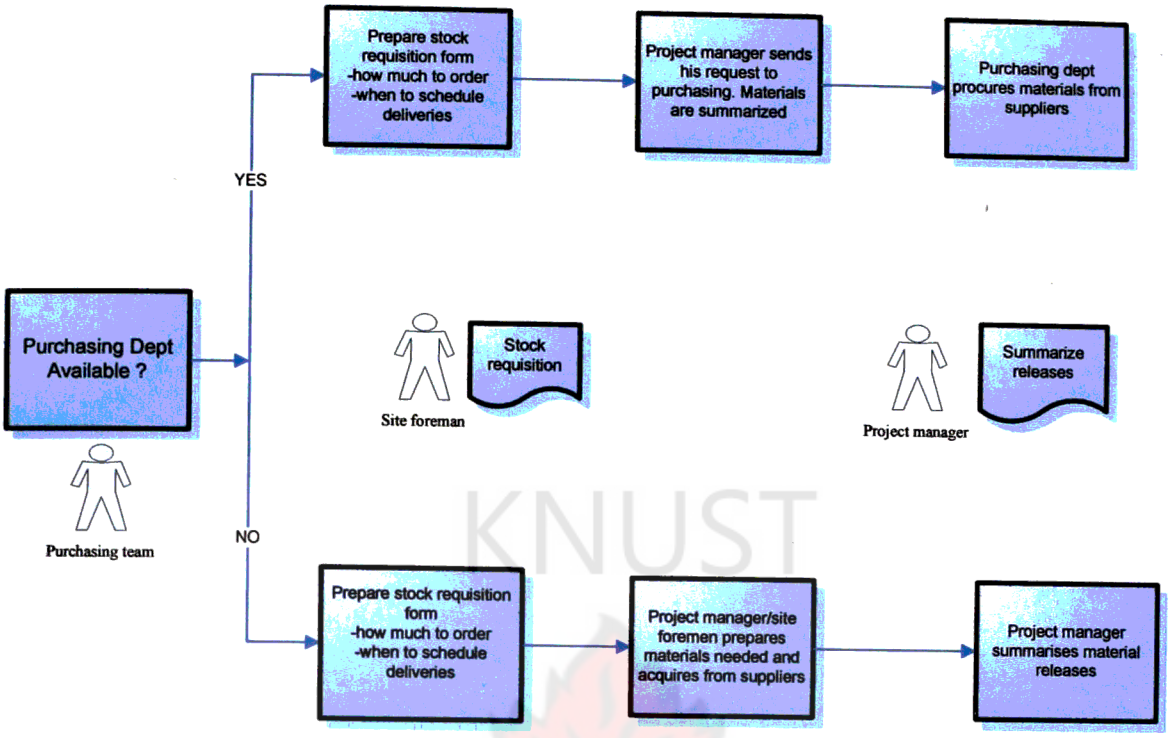


Figure 4.5 Materials Procurement Phase

Once a materials requisition schedule was in place, individual requisitions were generated from the construction site by either the foreman or the project manager. A materials requisition started with the generation of a materials release form. In this form, the type of material needed and the quantities and the dates when the material was needed were specified. In the case that the foreman prepared the material release form, it was sent to the project manager. The project manager was in charge of requesting the material from the purchasing department. The purchasing department requested the material from the supplier specifying the material type, quantity needed, time when the material was to be delivered and instructions on where to deliver it.

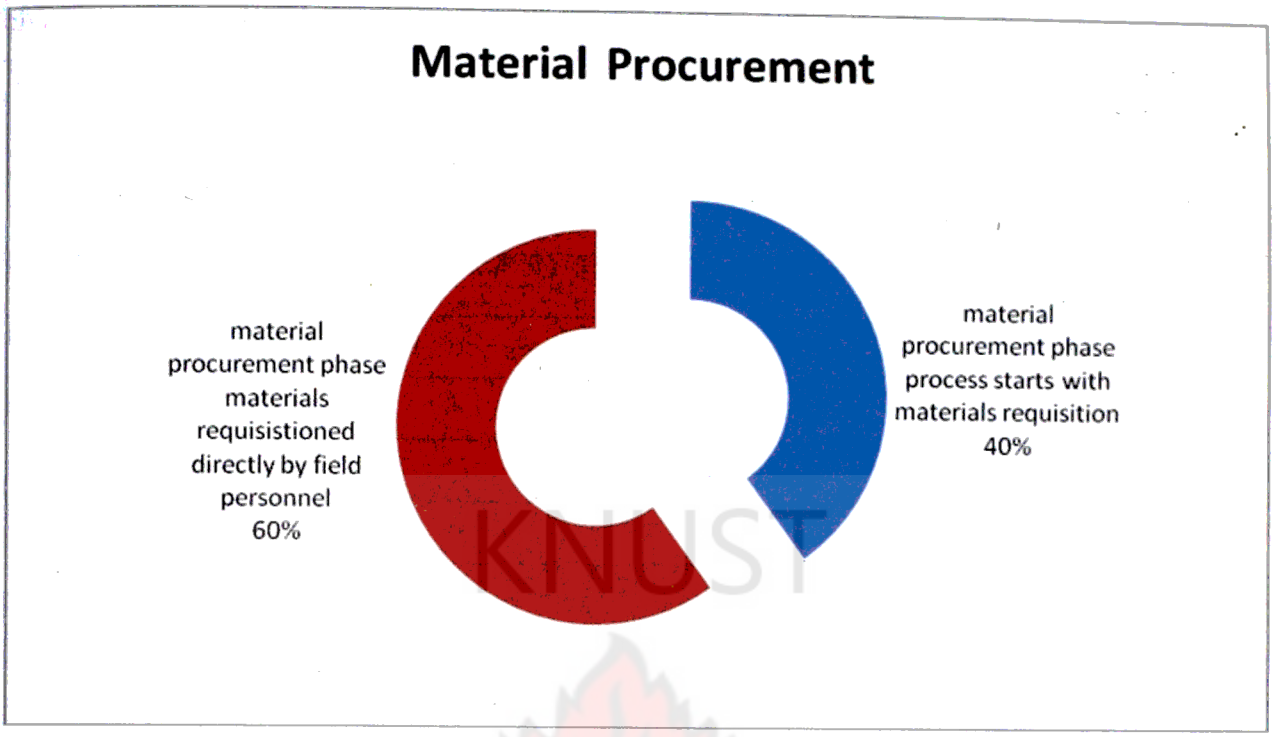


Fig 4.4 Methods in Materials Procurement

Figure 4.5 presents the material procurement (requisition and expediting) phase.

Small companies that did not have a purchasing department had the project manager in charge of procuring the material directly from the supplier. Similar to the case in which there was a purchasing department, the material requisition process started from the construction site by either the foreman or the project manager. Once a release form was generated, suppliers were contacted for procuring the material needed. The type of material needed, quantities and the time when the material was needed were specified to the supplier.

4.1.4 Phase 4: Construction

Material delivery usually occurred during the construction phase. Material was generally requested for delivery to the jobsite. In some instances material delivery to the jobsite might not be feasible due to storage or access limitations. In that case, the material was delivered to other locations, such as the contractor's central stores, or another subcontractor's storage area. Figures 4.6 and 4.7 depict the different material delivery and storage options.

Material was delivered to central stores in cases such as when critical specialty items were ordered early and were not going to be installed immediately, when storage area at the jobsite was unavailable. Storage of the material at the contractor's central stores prior to moving it to the jobsite usually increased indirect costs due to re-handling. Here too, we could see the role of information systems in helping the contractor trade off these costs against the costs of shortages and more orders.

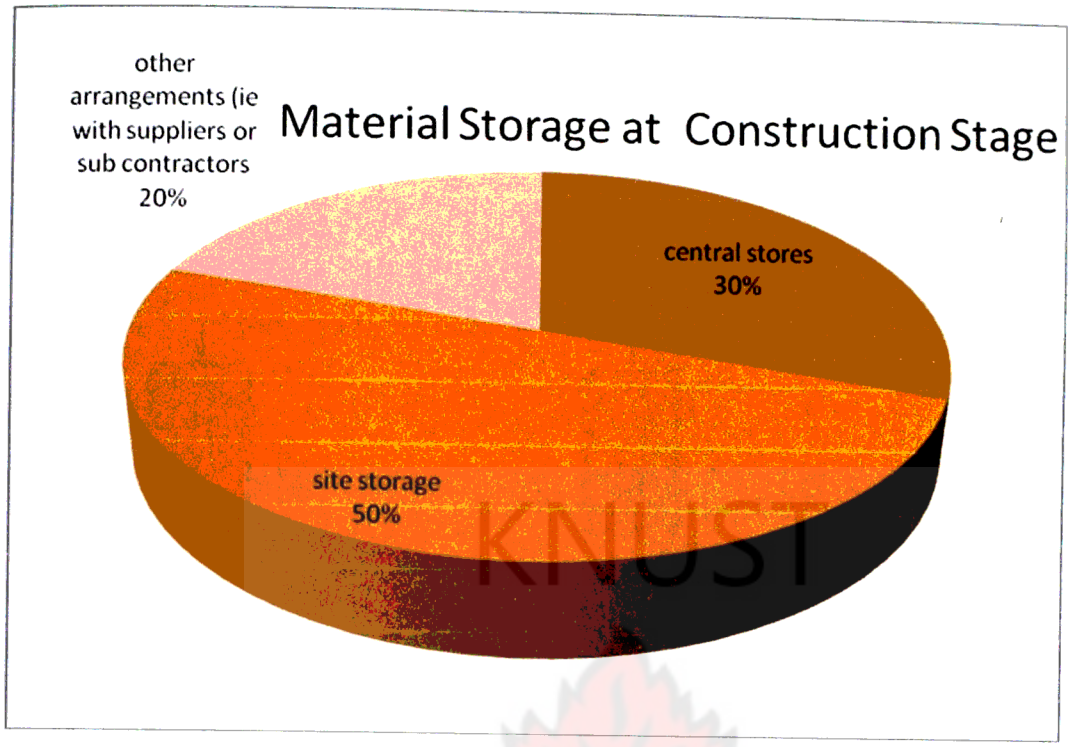


Fig 4.6 Materials Arrangement for Storage

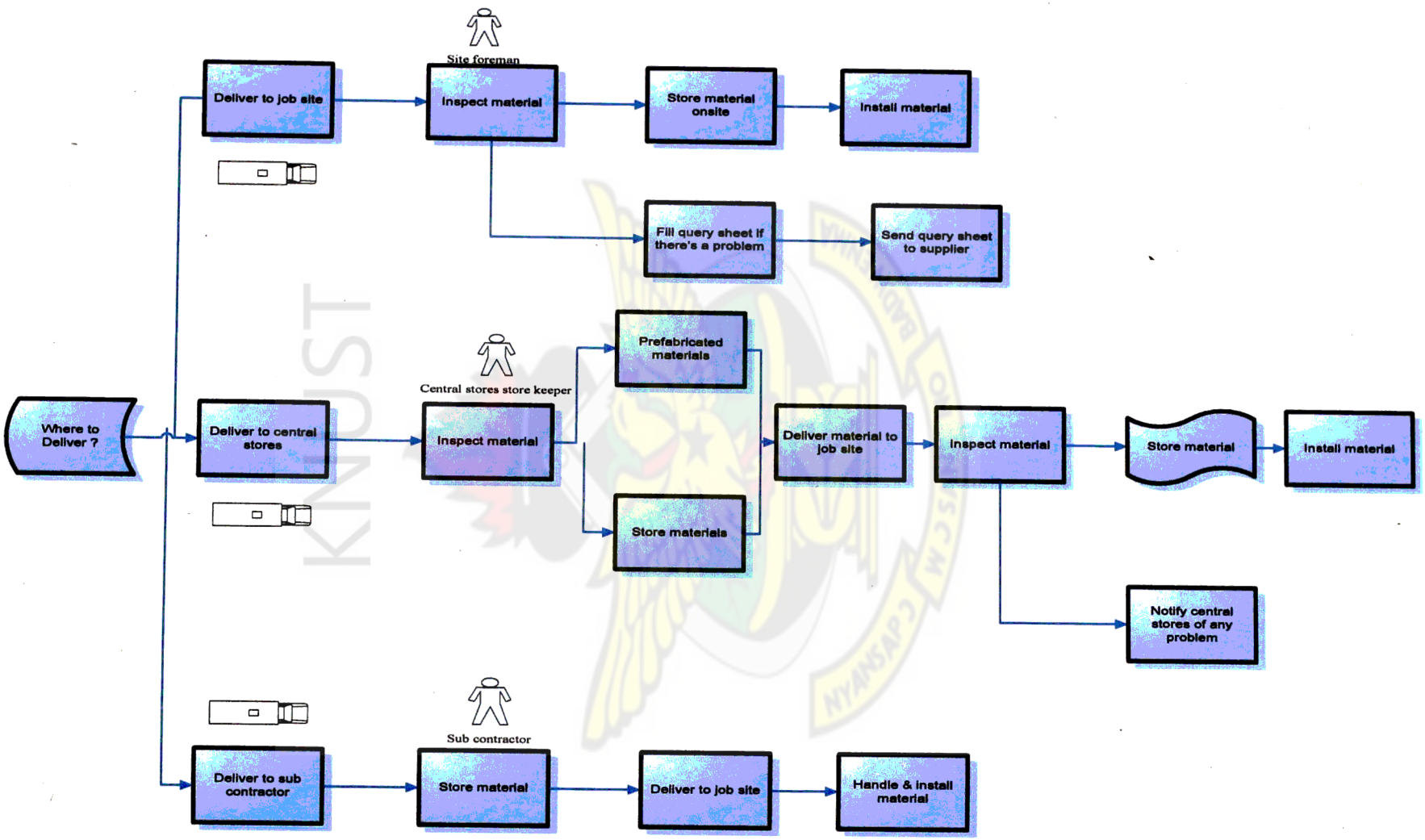


Figure 4.7 Constructions Phase

In other instances, the contractor might utilise a subcontractor's yard for storage and subsequent delivery and installation. A typical example of this situation involved the use of the electrical subcontractor to store large-size materials such as transformers. In addition to being used for installation, the subcontractor provided storage space until his own materials could be delivered to the site and installed. A further benefit to the contractor was the subcontractor's responsibility for any damage to the material stored at his yard. There was an additional fee that the contractor had to pay for the storage space and for the risk taken by the subcontractor with respect to damage to the material. There was a trade off between paying the fee and utilising the contractor's own, limited storage space possibly requiring smaller, more frequent orders. Another consideration was the subcontractor's assurance that the material would retain its quality and that it would be installed when needed.

4.1.4.1 Material Requisition Process

Materials requisition problems greatly affected the construction stage and failure to manage the phase effectively could result in project disruption and possible delays due to late deliveries, stock outs due to small quantities bought, material delivered to the wrong locations, material backordered and effects on overall costs. The requisition process for off-the-shelf often started in the construction phase and was focused on how much material to buy, when to buy that material, where to deliver the material, when to deliver, which supplier to buy from, where to store on site.

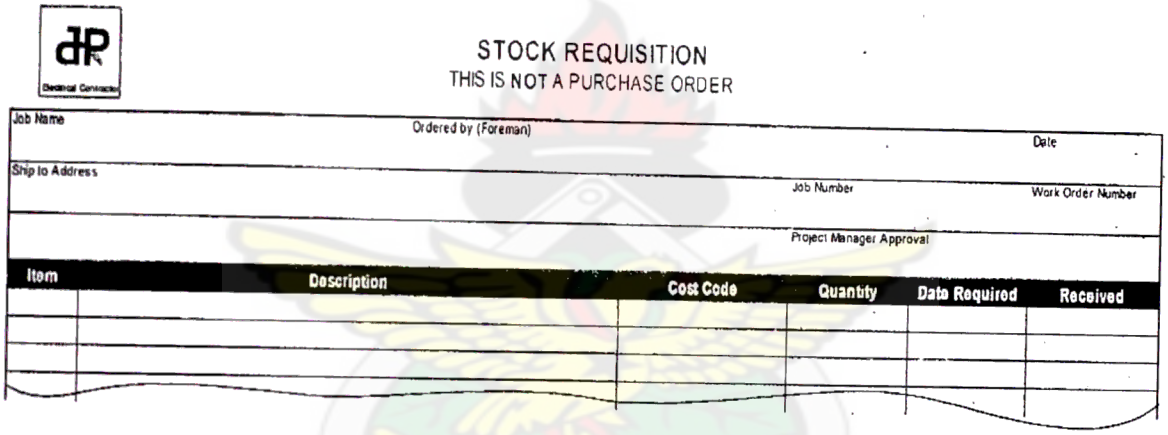
The decision of how much to buy was very important to assure that the quantities needed were available and that there were no material shortages. The decision of when to buy was important to ensure that material was available when needed. The decision of where to deliver the material required space planning and consideration of site limitations. That decision should be made to minimise theft, loss and damage and at the same time considering availability of material when needed. The decision of when to deliver required knowledge of the schedule and actual installation rates. The decision of which supplier to buy from depended on contract agreements, specifications and performance of the supplier. The decision on where to store on site depended on site restrictions and space availability.

Various interviews were conducted by the researcher to investigate the different approaches used by contractors to request material during the construction phase. Based on literature search, questionnaires and interviews, it came out clearly that the process started with the generation of materials release forms by the foreman or the project manager. In this form, the material needed, quantities and the dates when the material was needed were specified. The foreman sent the form to the project manager, who was normally in charge of requesting the material from the purchasing department (or who ever was in charge of purchasing). The purchasing department then requested the material from the supplier and instructs the supplier about material type, quantities, time when the material was needed and instructions for delivery.

Step – 1) Whenever materials were needed at the construction site, a materials requisition process was initiated by site personnel (e.g. foreman or the project manager). The process involved the generation of a stock requisition form, presented in Figure 4.8.

In this form, the material description, quantities needed, dates when the material was needed, and material cost codes were specified.

Other information specific to the job including personnel names and phone numbers, job address and ID, date and signatures were also included when filling the requisition form. The project manager also included a contact name and phone number of a designated site person in charge of receiving the material ordered when it was delivered to the site. Once the form was completed manually, the project manager would send it to the purchasing department.


STOCK REQUISITION
THIS IS NOT A PURCHASE ORDER

Job Name | Ordered by (Foreman) | Date

Ship to Address | Job Number | Work Order Number

Project Manager Approval

Item	Description	Cost Code	Quantity	Date Required	Received

Fig 4.8 Stock Requisition Form

(Step – 2) The project manager would update a material release form (Figure 4.9), based on the new order completed (Step – 1). The purpose of this form was to keep records of the material being used in the project and the balance available for requisition. A copy of the summarised releases would then be sent to the foreman.

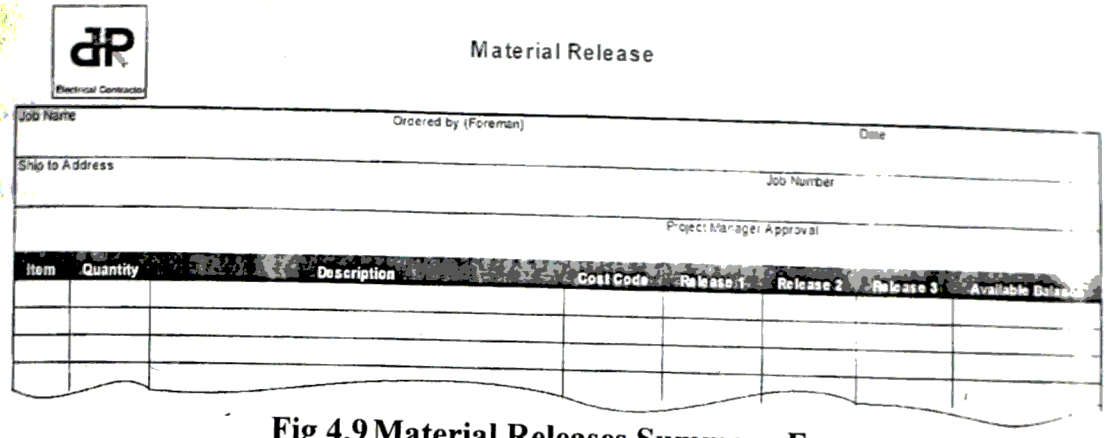


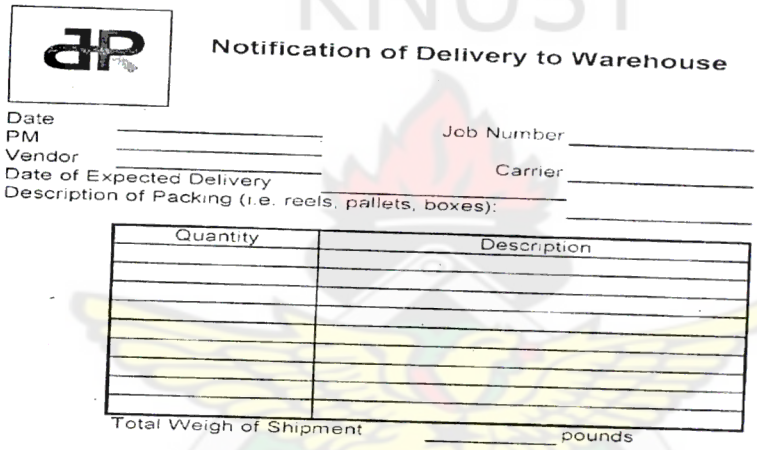
Fig 4.9 Material Releases Summary Form

(Step – 3) Purchasing would request the material from pre-selected suppliers and would then instruct the supplier about material type, quantities needed, time when the material was to be delivered and instructions for delivery (i.e. location and contact person).

Purchasing would forward a copy of Form 1 with this information to each supplier. Material was generally requested for delivery to the job site. In some instances, that might not be feasible due to storage or access limitations. In that case, the material was delivered to other locations such as the contractor's central store or another subcontractor's storage area. Material was delivered to a central store in cases such as when critical specialty items were ordered early and were not going to be installed immediately, when storage area at the jobsite was unavailable. Storage of the material at the central stores prior to moving it to the jobsite would increase indirect costs due to re-handling.

(Step – 4) In 30% of the companies visited the material was delivered to the central stores. The project manager filled a notification of delivery to central stores form (Figure 4.10) to notify the central stores personnel that certain material was to be delivered to the central stores for storage. That form specified the type and quantity of material to be delivered, when it would be delivered, job number, supplier's name, carrier's name, and

holding period for the material. That form was prepared and sent at least 72 hours in advance of delivery. Once delivered, the central stores personnel verified the material received against the notification of delivery to central stores form and stamped the packing slip for acknowledgement that the material was received. The delivery slip was forwarded to purchasing for payment purposes. If there was any damaged material, it was noted on the delivery slip and the purchasing department was notified. The central stores personnel also notified the project manager by phone of all materials received and stored at the central store.



Notification of Delivery to Warehouse

Date
PM
Vendor
Date of Expected Delivery
Job Number
Carrier
Description of Packing (i.e. reels, pallets, boxes):

Quantity	Description

Total Weigh of Shipment _____ pounds

Fig 4.10 Notification Of Delivery To Central Stores

(Step – 5) In the case that the material was delivered to the jobsite, the designated site personnel would verify the materials received against the stock requisition form. Actual quantities received were recorded in the received column in the requisition form. If there were any discrepancies in material quantities, damages to material or items not delivered, the foreman would fill a problem sheet form (Figure 4.11) and forward a copy of this form to the purchasing department. At the time that the material was received, the foreman would also fill a receiving report (Figure 4.12) and forwards this receiving report to the project manager.

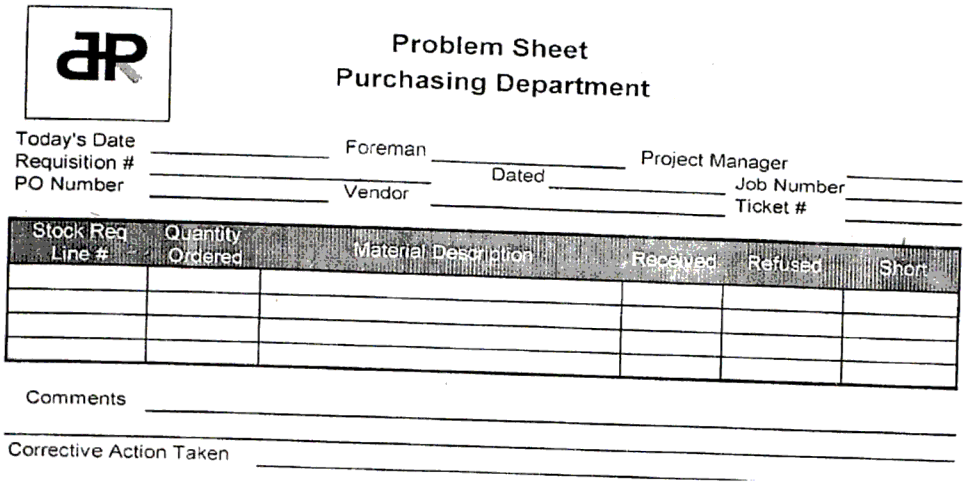


Fig 4.11 Problem Sheet Form

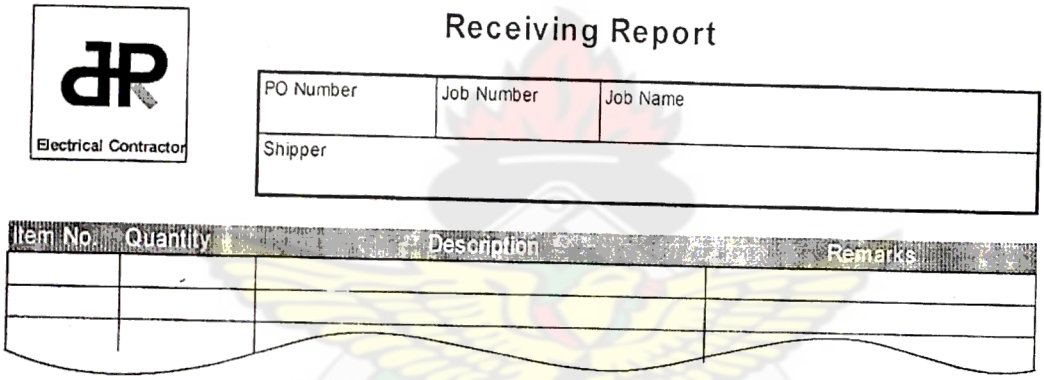


Fig 4.12 Receiving Report

(Step – 6) For payment purposes, a copy of the packing slip was faxed/sent to purchasing, from the central stores or the site, for acknowledgement of delivery of material and payment purposes.

Figure 4.13 illustrates a summary of the information flow between the forms used in requisition process. The stock requisition form, Figure 4.8, is the base form used to input information into the other forms. This information transfer between forms is done

manually, which requires double entry. The process is time consuming and prone to error

due to the manual input of data. From the stock requisition form, the material description and quantity requested in a particular period is input into the material release form. This form is used to keep track of the material ordered in each period and the remaining balance. If there are any problems with the material ordered (e.g. damage material, incorrect quantities) the site personnel writes the material description and the problem encountered into a problem sheet form. Most of this information is coming from the stock requisition form. When an order of material is received, a receiving form is filled. In this form, PO (purchase order) number, job number, job name, material description, and quantity received. All the information, except the quantity received, is obtained from the stock requisition form. It is in this light that 40% of the standard construction companies actually have these processes in place, but do not actually practise them because of their time-wasting nature. The above forms were developed from interviews conducted by the researcher since most of the companies were not willing to show their forms to the researcher for use in the study.

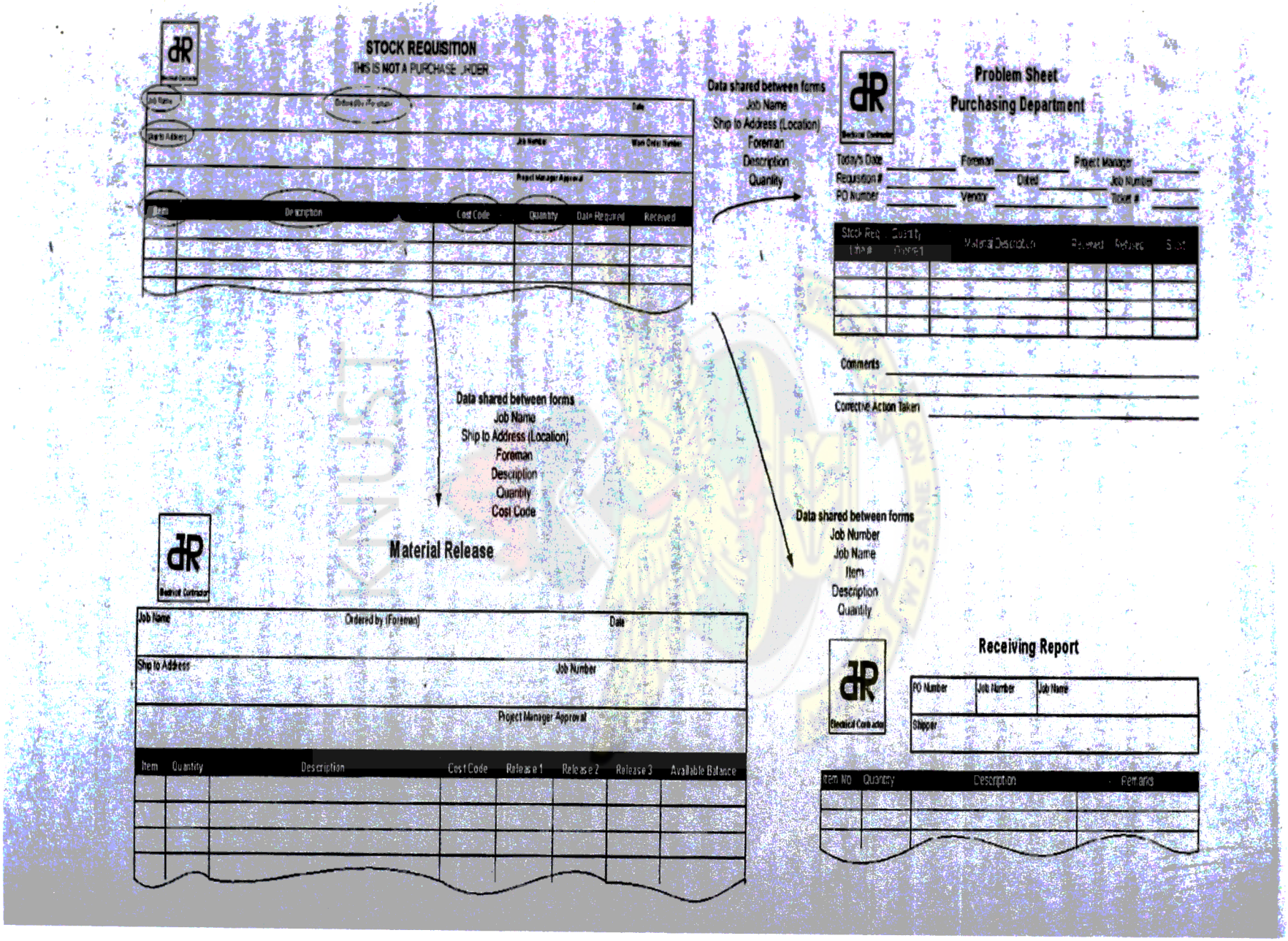


Fig 4.13 Flow of Information Between Paper Forms

4.1.5 Phase 5: Post – Construction

After installation of the materials on the structure, the contractor had to manage any surplus material. The surplus was handled differently depending on the type of material and also whether or not the contractor had a central store. If the company had a central store, the surplus material was stored in the stores for use on future projects. In the case where the contractor was not equipped with a central store the surplus was transferred to another site for use.

An effective materials management system was essential to avoid material shortages, misplacements, loss, and theft which might result in increases in gang idle times, loss of productivity and delay of activities. Contractors should implement an efficient materials management system due to the fact that in most of the cases they were asked to squeeze their bids in order to keep the cost of their projects under budget. In such a case failures to effectively manage materials could result in decreases in the profit or even loss.

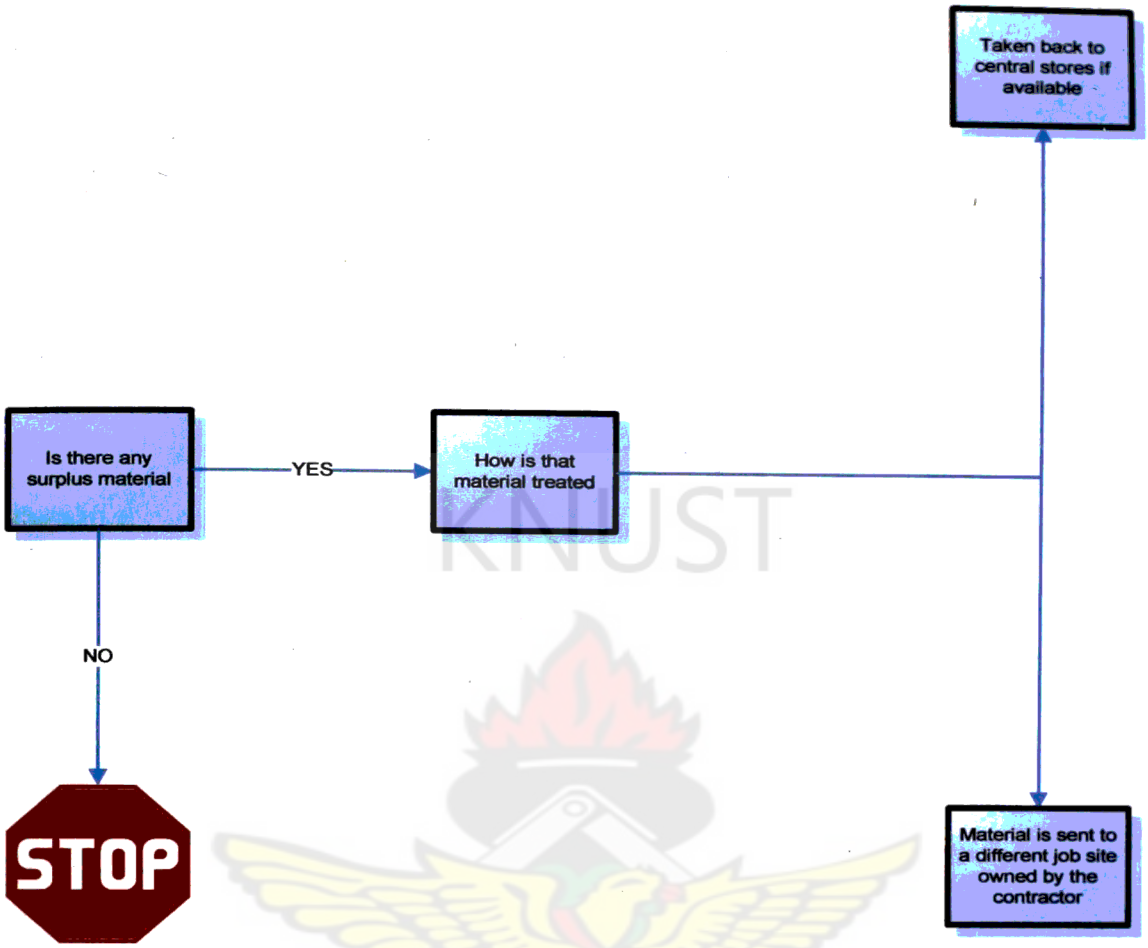


Fig 4.14 Post Construction Stage

The primary goal for these companies was to have the materials needed, in the amounts needed, with the quality required, at the right price and the time they are needed. Based on the interviews conducted, 60% the companies had a materials management system that served their needs, although it could be improved. Standardisation of the materials management system could be a step forward in improving the system for all the companies and eliminating some of the challenges.

The interviews performed allowed collecting data for different contractors in the Ashanti, Greater Accra, Central and Western regions of Ghana. The flowcharts presented represent general flowcharts that describe a compilation of the current materials management practices for the companies visited.

4.2 Material Purchasing by Contractors

Given the change in the roles that contractors play, including non traditional roles, the change in the area of materials purchases is evident. The Contractor Magazine (vol. 13, 2000) conducted a study called profile 2000, where the contractors were asked about their top three concerns when buying material. For the majority, price was the number one concern. However, the study concluded that cost was named first by less than 50% of the respondents, no matter what size of business. As times have changed, apparently, more and more contractors are changing with them. Table 4.1 shows a comparison on the materials purchasing criteria between 1997 and 1999. As can be seen from this table, the *price* criteria was the top priority in 1997, but *availability* was the top priority in 1999 (The Contractor, 2000)

Table 4.1: Materials Purchasing Criteria Priorities 1997 and 1999 (source The Contractor 2000)

1999	1997
1. Availability	1. Cost
2.Quality	2.Quality
3.Cost	3.Availability
4.Service	4. Ease of Placing an Order
5. Ease of Placing an Order	5. Service
6.Brand Name	6. Brand Name
7. Delivery	7.Delivery

A similar survey was carried out in Ghana by the researcher in 2007, it was realised that the trend has not changed much. Contractors were asked to rank these same factors in the previous study and some other factors that the researcher found to be peculiar, to the Ghanaian construction industry in the selection of suppliers. The researcher obtained the following results. Table 4.2 shows the factors and how they ranked.

Table 4.2: Materials Purchasing Criteria Priorities 2007 (Source Field Survey -Eric Manteau)

2007 (Ghana)
1. Availability
2. Competitive cost
3.Quality of Materials
4. Delivery Services
5. Financial Arrangements
6.Continuity of Suppliers
7.Availability of Materials from Different manufacturers
8.Ease of Placing an Order

Contractors rely and buy the majority of their materials from their local suppliers. However, for works involving speciality technology they have to buy materials from other places (manufacturers), because their local distributors are not ready to supply the materials that they needed in this category. The relationship with suppliers can be critical and could decide between a profit and loss. Suppliers offer product capacity, information, availability, and delivery. With this information the contractor can finance his operations and plan the work depending on the time of arrival of materials. Because of the impact that a supplier can have in the financial and production aspects of contractors, contractors prefer to do business with more than one supplier. By having more than one supplier they can avoid product miss pricing (i.e. a supplier charging

more for products and materials), and they could have a bigger selection of products. Most contractors in Ghana are not buying materials using e-commerce. The primary reason is that suppliers do not have the facilities to store all the materials information needed for a project and then deliver them to site as needed. This will require a materials handling system and the majority of contractors are looking to carry less inventory by relying on their local suppliers to deliver the materials when they are needed.

4.3 Current Supplier/ Contractor Arrangements

Unavailability of the materials when needed can greatly affect the productivity of the workforce, thus causing delays to activities, increasing the cost of the project and possibly delaying the completion of the project. There is no doubt availability of materials when needed is critical for the successful completion of the project. The contractor should search for arrangements that will ensure the availability of materials when they are needed. This section presents an overview of the current value added services that suppliers offer to contractors.

4.3.1 Value Added Services

Typically the supplier is viewed by the contractor only as a source that supplies materials needed for construction of the project. Many suppliers are looking for ways to survive in a market full of suppliers. These days it is difficult for a supplier to compete in the market based on product price alone, therefore suppliers are looking for other ways to generate income by providing additional services to their customers. These

services are known as value added services (VAS). Some of the benefits that a contractor can expert when receiving supplier value added services include:

- Quality – the supplier will ensure that the contractor will receive defect free materials.
- Timely deliveries – supplier will ensure timely delivery of materials
- Continuity of supplies – the supplier will ensure supply of materials as needed to reduce risk of shortages of materials

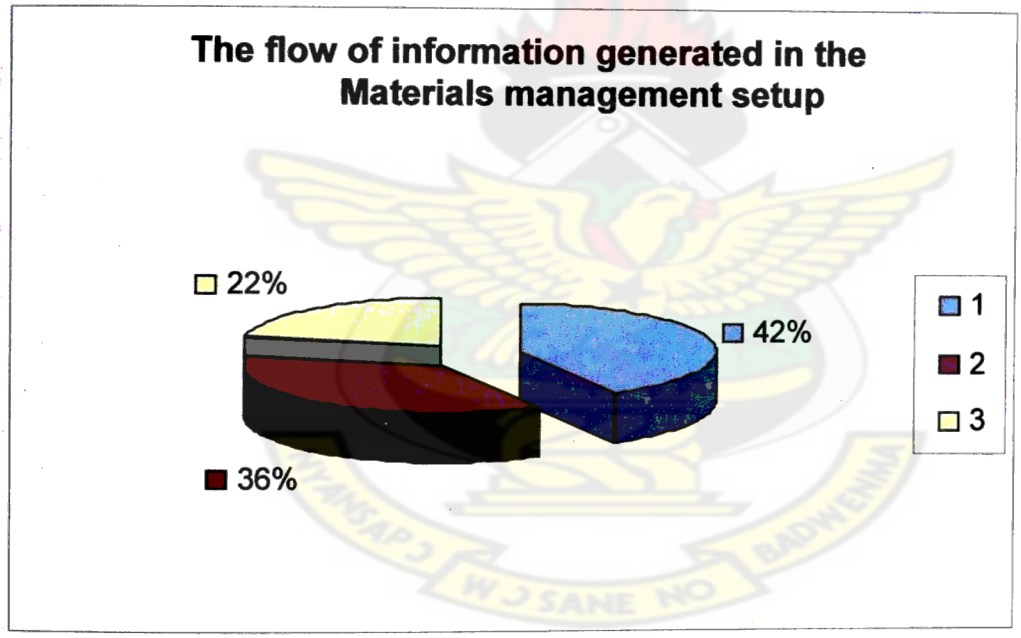
4.4 AN OVERVIEW OF THE FLOW OF INFORMATION WITHIN A COMPANY'S MATERIALS MANAGEMENT SETUP

Construction companies are highly complex organisations to manage due to the collaborative nature of the industry. This arises because projects consist of events involving many different bodies and organisations, e.g. clients, designers, consultants, contractors, and inspectors. Inter- and intra-discipline communication between these distinctive professionals is often problematic. The lack of integration and co-ordination between the industry's professions can be perceived as a major contributory factor to poor dissemination of real time information.

The growing clamour to meet the ever more demanding needs of the client and improve project performance helps drive the construction industry towards fully integrated project teams where project participants have instantaneous access to all project information through the use of information management systems (MIS) (Moore and Dainty, 1999). Over the life of a project, individuals and organisations will accumulate huge amounts of real time information and this coupled with the fluctuating nature of

construction contracts, and the increased vulnerability of project personnel, has often meant that project information is not transferred nor stored in the way it was intended to be.

A survey conducted by the researcher shows in Figure 4.15 that the information generated within a contractor's setting is poorly captured and in many instances the volume of meaningful knowledge exiting the organisation on a daily basis exceeds that available for immediate use within the organisation. The question arises on construction projects as to where the information is generated and by whom.



Legend

1. *knowledge goes home at the end of the day*
2. *knowledge that exists in a locked paper environment*
3. *knowledge that exists in personal devices such as office PC's PDA's*

Figure 4.15 Information Generated within a Contractor's Setting (Source: Survey by Eric Manteau, 2007)

4.4.1 Information creation and destination

As the uptake and usage of information within construction companies spreads, increased quality of documents, integrated and structured communication channels, speed of work and ease of access to project information will become a more common place.

In Ghana within large construction companies, the co-ordination of the numerous project members involved has been viewed as a daunting experience. The parties contracted to a construction project rely on personal contact and the traditional methods of telephone and paper to manage information created within the project environment with overall responsibility historically resting with the main contractor.

As the construction industry begins to support integrated and collaborative ways of working, the change from the traditional ways of communicating to new ways based on electronic means of co-ordination will take time to become fully embedded within the construction process.

Crucial to the running of any major construction project is the movement of project information amongst the professionals, all of whom have conflicting priorities and objectives. The different professions use their own unique processes to undertake tasks but to undertake these tasks efficiently they become reliant on information supplied by others. Generally, information provided is rarely available in a format that is suitable for all users. In effect the different professions seldom, if ever, recognise the needs of others and in some cases the information is so incompatible that the recipient sees the next process as being how to re-construct the information provided. Hence the need for a programme which presents the information needed in an acceptable template.

4.4.2 The flow of data within the construction company

The control of construction project information to a large extent depends on who has created the information. The main controller of information within a construction project can range from the architect, to the contractor or even the client: the end result is often being moderated by the type of contract and procurement route adopted for the project. With regard to the control of information within the traditional procurement route it is the contractor who takes responsibility for the works section and therefore they become responsible for most communication and information flows: although the client can still influence directly. However, under the construction management procurement route, the transfer and channelling of information is not as well defined as overall responsibility, for the control of information within the project may shift during the various phases of the project due, in part, to the nature of the project and the procurement route adopted. This implicit flexibility within the management structure is essential if the contract, and the project, is to be successful. In effect, the rigidity of the contract can often hinder the communication behaviour of the project parties. Communication breakdown may be inevitable and will occur if there are conflicts of interests between the contracting parties the patterns of flow and sharing of information is to become more efficient, and to some extent, automated, then some of the boundaries that currently exist within the industry need to be broken down and removed. Sharing information will go some way to solving the problem of incompatible communication and also help in establishing integration where information is freely exchanged in a disciplined manner amongst the project parties.

4.4.3 Factors that affect the dissemination of information in the materials management setup of an organisation

The questionnaires listed 10 factors that affect the flow of information within the contractors setup and respondents were requested to rate the individual factors separately. Respondents were requested to rate ten (10) factors which were identified to affect the dissemination of information within their setup. Respondents were requested to rate the above factors against a five point scale as

- 1-strongly disagree,
- 2- disagree,
- 3- undecided,
- 4- agree,
- 5- Strongly agree.

Based on the information provided by the contractors, the relative importance indices of the respondents were computed to deduce their rankings are below. The data was analysed by ranking the various factors that affected contractor's information flow in construction project. The ratings of identified factors made by respondents against the five-point scale were combined and converted to deduce the relative importance indices of the various factors as follows,

$$RII = \frac{\Sigma r}{A \times N} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5.1)$$

Where Σr = summation of the weightings given to each factor

A = highest rating and N= Total number of respondents for that factor

Example for lack of information when needed

Weight = 1(0) + 2(2) + 3(2) + 4(10) + 5(14) = 120

Relative Importance Index = $\frac{120}{5(0 + 2 + 2 + 10 + 14)} = 0.857$

The factor with the highest relative importance index was then ranked as 1, and then followed by two as the next higher rank, etc.

Based on the responses from contractors, the following analyses were made with respect to factors that affected the information dissemination of contractors. The researcher noticed that since none of the factors listed below on the table had relative importance less than 0.5, it meant that all the contractors in the survey deemed these factors necessary.

Factors that Affect the Dissemination of Information in the Contractors' setup

Code	Information Dissemination Factors	Frequency of Rankings 1	2	3	4	5	Weighting Sum (∑W)	RII ((∑W)/(A*N))	Rank
I6	The nature of the industry	0	0	0	1	27	139	0.9929	1
I2	Appointing staff with relevant skills and experience	0	0	1	5	22	133	0.9500	2
I4	Management style of the Organisation	3	2	0	8	17	124	0.8857	3
I3	The Channels of communication	0	2	3	5	18	123	0.8786	4
I8	Lack of integration among the various departments	0	0	0	18	10	122	0.8714	5
I7	The Nature of information flow (Vertical/ Horizontal)	0	4	2	4	18	120	0.8571	6
I9	Time taken in the updating of information in real time	0	0	5	10	13	120	0.8571	6
I1	Types of information sources available (internal and external)	0	0	4	20	4	112	0.8000	8
I5	The Objectives and goals of the organisation	2	1	0	18	7	111	0.7929	9
I10	The use of verbal and written communication to send information	5	3	2	16	2	91	0.6500	10

Table 4.3 Source: Researcher's Field Survey, Ranking of the Factors (January- March 2007)

4.5 Materials Management Challenges in Current Practices

In the competitive environment such as the construction industry, it is critical for the contractor to focus all the energies in the efficient and effective execution of all the activities involved in construction. This effort requires the preparation of a plan to delineate the sequence of activities. Some of the resources needed to perform the activities include materials, equipment and labour. In the construction industry, material ordering and delivery are very critical to the successful execution and completion of any project. Special attention should be placed in dealing with the activities related to materials. Furthermore, the contractor needs to anticipate possible problems and provide possible solutions so that the project would not be affected in the case that problems arise. This section will identify problematic issues or challenges in the materials management process for Ghanaian contractor.

Many challenges are encountered during the five phases of the materials management process. These challenges were grouped into two categories: information technology, and implementation.

Challenges - Information Technology

Figures 4.1 to 4.10 and Figure 4.14 illustrate numerous exchanges of information within the five phases of the materials management process. Hence, the efficient operation of the materials management process depends on accurate and timely generation and transfer of information. Not all information that is necessary for the smooth operation of materials management is computerised, but it is safe to say that computerised and

networked information systems offer speed, accuracy and retention of information that few contractors can afford to forego. Some examples of the critical role of advanced information technology within the materials management process are presented in the following sections.

During the Bidding Phase, the contractor may be forced to cut costs to satisfy budget limits of clients while still committing to the same scope of work. The problem could be minimised if these sub-contactors are involved in the pre-construction planning and design phase of the project (see Figure 4.1).

The sub-contractor can provide to the client expertise regarding materials and means and methods for installation, as well as more realistic cost estimates. The sub-contractor could also provide information about the difficulty, cost and time required for installation in order to better assess the effect that the changes in scope could have on overall cost and schedule. The enabling technology for such integration of the sub-contractor in the project's bid estimation is internet-based communications between the contractor and the sub-contractor and the contractor's access to a database of material prices, lead times, wage rates and standard job times.

The Sourcing Phase requires access to data regarding prices, quality, delivery, performance and existing contractual arrangements with manufacturers and suppliers. Typically, prices are requested by a fax transmittal from the contractor to the potential suppliers. Fax technology is becoming more time consuming compared to other recent means of data communication. Fax machines are also more prone to breakdown problems (e.g. paper jams, incomplete transmittal, etc.) compared to other methods (e.g.

email). Furthermore, it could take longer for the fax information to reach the person in charge of providing quotes and for the contractor to get an answer to the request for pricing. There have been some efforts to develop a P2P network pricing system that will allow the contractor's personnel to have immediate access to the current prices of a particular supplier with near real-time updates, therefore reducing the difficulties that the current practice presents. Ideally, the contractor would be able to draw on historical data reflecting experience with different supply sources as well as up-to-date pricing and delivery data. Clearly, a combination of on-line and proprietary data is required.

The Procurement Phase integrates individual orders, and deliveries with the contractor's materials management plan. The person in charge of procuring material or the purchasing department, in the case of a large company, needs to ensure that the correct material in the correct quantities is ordered. This person also needs to verify the dates at which the material is needed and clearly indicate to the supplier where to deliver the material. Ready access to contract data and project scheduling data, as well as a means to communicate delivery instructions to personnel on site is essential to performing these tasks. Material is usually procured by a fax transmittal from the contractor to the supplier indicating the material needed quantities and delivery dates. This process might present the same challenges that are present in the sourcing phase. Similar to the sourcing phase, there have been efforts to develop a peer to peer (P2P) network that will allow the contractor to place orders through a computer. This will accelerate the ordering process and reduce errors that often occur in current practice.

During the Construction Phase and the Post-Construction Phase tracking material is one of the biggest challenges faced by the contractor. Tracking allows for identifying

material not delivered as ordered or if the order was delayed. Tracking is also essential to identify what material is available, to minimise theft or loss, to identify where the material is stored on site and to control inventory costs. In some instances suppliers may deliver wrong material that need to be returned. Design changes may also result in a reduction in requirements for some material and an increase for others, which will also affect the delivery schedule. There is no direct cost to the contractor when design changes are made; however, indirect costs are incurred due to possible delays associated with completing corresponding activities and possibly the overall duration of the project. In other instances, material is misplaced or relocated by central stores personnel or is not properly identified before storage. Material that is lost, damaged or stolen after it is issued is another challenge faced by the contractor that is related to material tracking. If the material is damaged during delivery and the person receiving the material acknowledges the damage, the material is returned at no cost to the contractor. However, this might cause delay if the material is needed immediately. If the person receiving the material does not verify the material and does not identify any damage, the contractor may end up being responsible for the damaged material, which will result in a loss. Similarly, the contractor assumes responsibility for damages to material while it is stored prior to installation. An automated system, such as bar codes, could greatly improve tracking and inventory control and could minimise lost and misplacement of materials.

Challenges - Implementation Management

Changing procedures, installing and using new information technology and elevating managerial practices to the point where new soft wares are in everyday use have been known to be stressful to organisations that pursue such improvements. In many cases,

the inability of the organisation to embrace such changes dooms the improvement initiatives. Advantages of pre-assembly include increased production time and reduced labour costs compared to performing the assembly process in the field where poor weather conditions and space limitations may cause work delays. The increase in productivity and savings in labour costs out weigh additional costs encountered due to pre-fabrication and re-handling. Some site personnel, particularly job foremen, may not favour pre-fabrication due to fear of loss of control on material and installation. Upper management for some companies has developed incentive programs to introduce site staff to the benefits of a change of culture and acceptance of the process.

Better materials management practices and software models could increase efficiency in operations and reduce overall costs. Increasing pressures on project costs and completion times are motivating the need to make materials management decisions in a coordinated fashion and in consideration of minimising total materials management cost without causing shortages. The next chapter will describe the use of information management techniques to design software for an integrated system for materials management.

The following section deals with studies in materials management in relation to technology and MIS.

CHAPTER FIVE
MODEL DESIGN AND IMPLEMENTATION
(EXTRACT PLUS)

5.0 GENERAL

From the appraisal of the current materials management practices phases in chapter four, and the factors that affect the dissemination of information in the construction industry in the same chapter. The need for the third objective for the research was eminent which was to develop a materials management information management system which would address the findings in chapter 4.

The performance of a materials management system involves decisions which are heavily dependent on the combination of the different alternatives associated with every phase of the materials management process and the factors or parameters that influence the selection among the different alternatives for each particular decision. These factors need to be extracted on a regular basis as decisions related to materials management are ever present in a construction project.

The identification of input data is a task that requires more attention, since parameters related to different areas, such as scheduling, suppliers, among others, need to be considered. These data can be acquired from different sources such as historical data on previous similar projects, and suppliers, among others. The identification and extraction process for the data could be tedious and time consuming because the decision maker could be extracting the information from unstructured records that contain vast amounts of data. In addition, important parameters that relate to different categories such as

schedule, storage, cost, among others, need to be extracted and sorted.

5.1 EXRACT PLUS

Currently, there is no structured model to categorise the information that needs to be considered in the materials management decision making process for the contractor. The construction industry needs a structured database design that can allow decision makers to plan, review and implement decisions based on the information generated. This software could facilitate the storage and classification of the information for future extraction and use. As part of this research, a structured approach was defined for information needed. For a more complete system design, a similar approach needs to be developed for output rates and performance measures. This development could be the basis for future research.

Based on the information gathered through interviews with the Ghanaian construction industry personnel and through extensive literature search , a system for scheduling, planning, extraction, purchasing and storage of materials in a construction project was developed . The development of EXTRACT PLUS begins with an architectural framework. This approach conforms to generally accepted methods of structured systems development. Extract Plus will be the basis for future development of a relational database to share and organise information. In addition, the development of Extract Plus could help contractors in understanding how some of the particular computer applications work. For example, Extract Plus could give the contractor an idea of how a MS. Project system works.

5.2 Modelling of Extract Plus

Programming (software development) is a six step procedure for producing a program. A program is a list of instructions for the computer to follow to accomplish the task of processing data into information (Timothy J. O'Leary 1998). The instructions are made up of statements used in programming language, such as BASIC, Pascal, or C**.

The six programming phases are as follows:

1. Program specification
2. Program design
3. Program code
4. Program test
5. Program documentation
6. Program maintenance

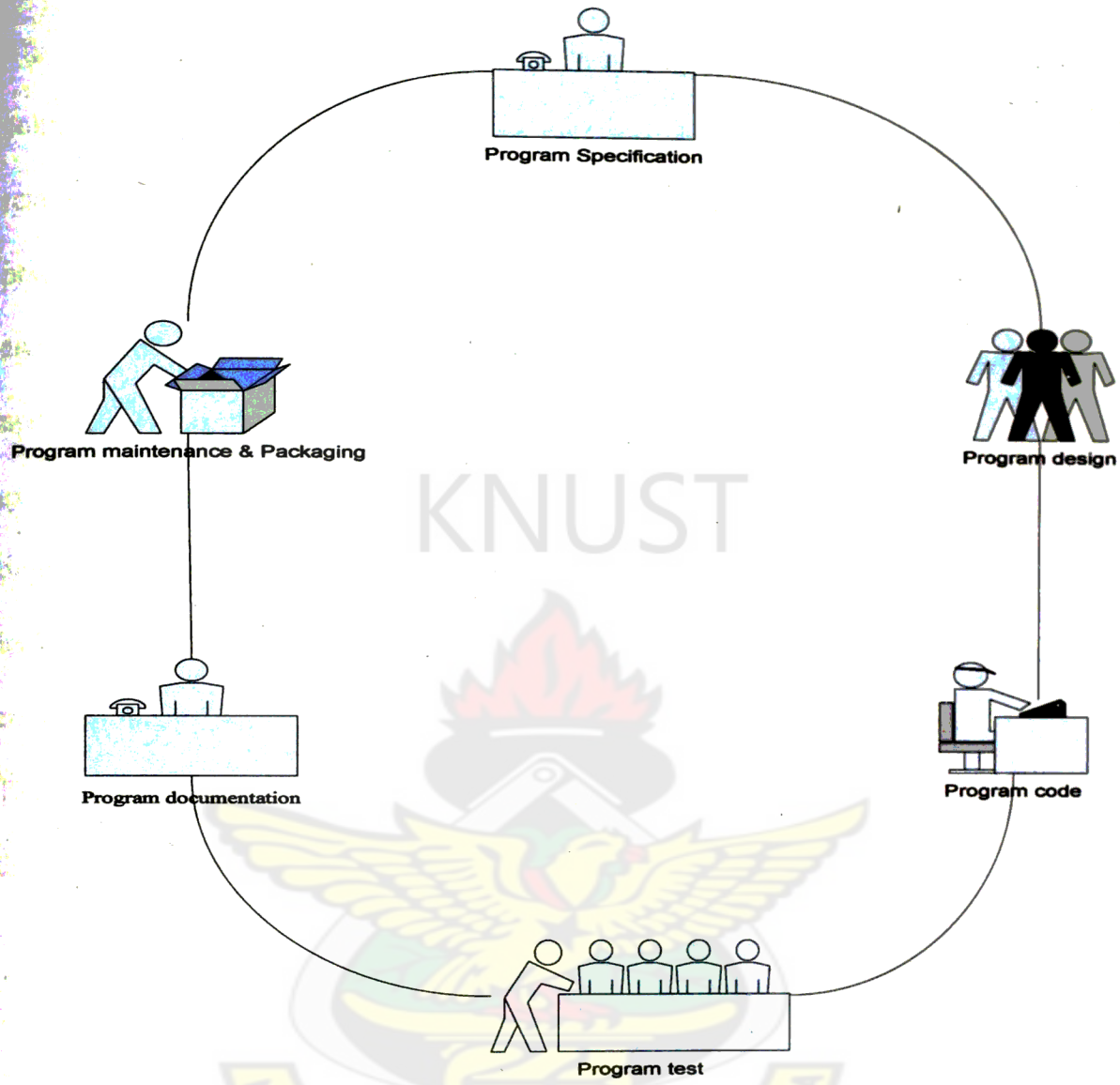


Figure 5.1 Programming Phases

5.3 Model Specification

In the program specification stage of Extract Plus, the objectives, outputs, inputs, and processing requirement were studied and determined.

5.3.1 Objective and Scope of Extract Plus

The objective of this model was to develop a system that would cater for the Ghanaian contractor's needs in terms of materials management. The findings in chapter four in relation to the current materials management practices, gave an indication that these practices actually existed in theory. When it came to these practices being carried out and updated there was a lag between the actual occurrence of a task and it being updated; it was therefore the objective of the researcher to provide a model that expediently transferred materials management information in real time within the organisation. It was also noticed that a lot of the information that existed were in a locked paper environment and made the transfer of materials information tedious and cumbersome.

The model was limited to only building projects. The extraction of materials is limited to the following work groups

- Concrete work
- Reinforcement
- Block walling
- Roofing
- Timber members
- Plumbing
- Rendering
- Painting

The researcher recommends that further research be carried out to create a more complete model that would cater for civil and building works.

5.3.2 Desired Output For Extract Plus

The desired results that were targeted in the development of Extract Plus were the generation of the following reports, which the researcher from his findings felt were key in the development of such a model.

Figures 5.2 – 5.7 show the desired output reports

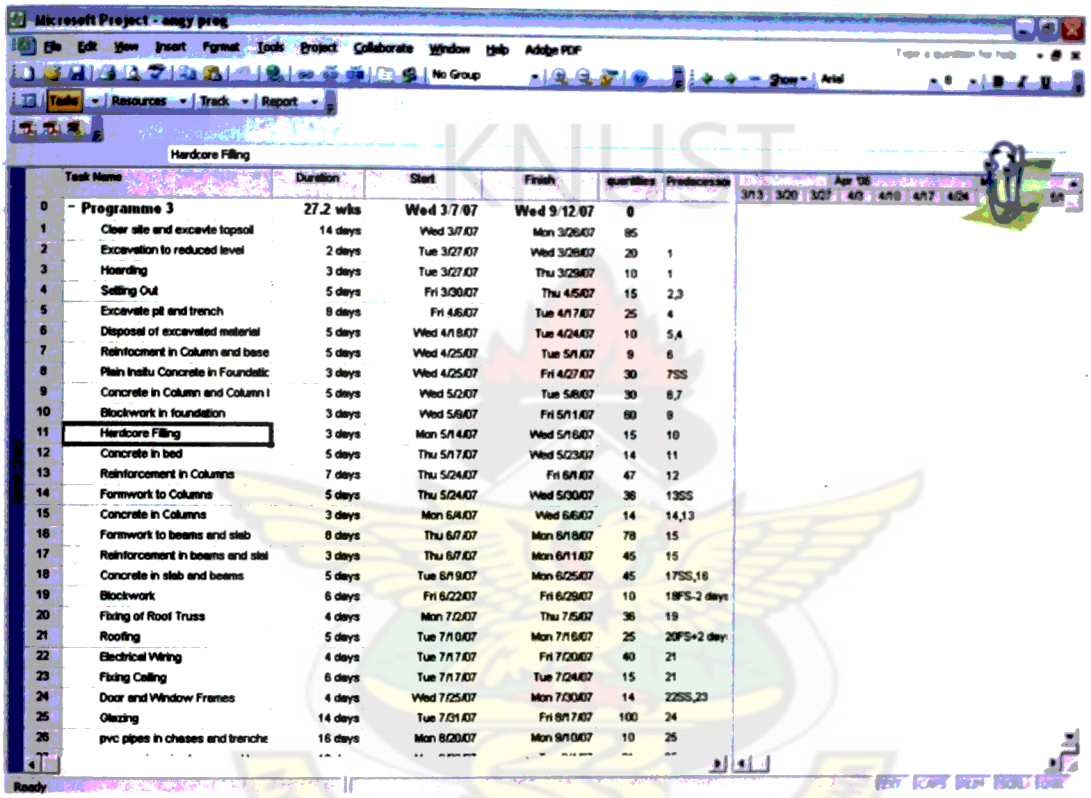


Figure 5.2 Generation of Program Of Works (For Individual Projects)

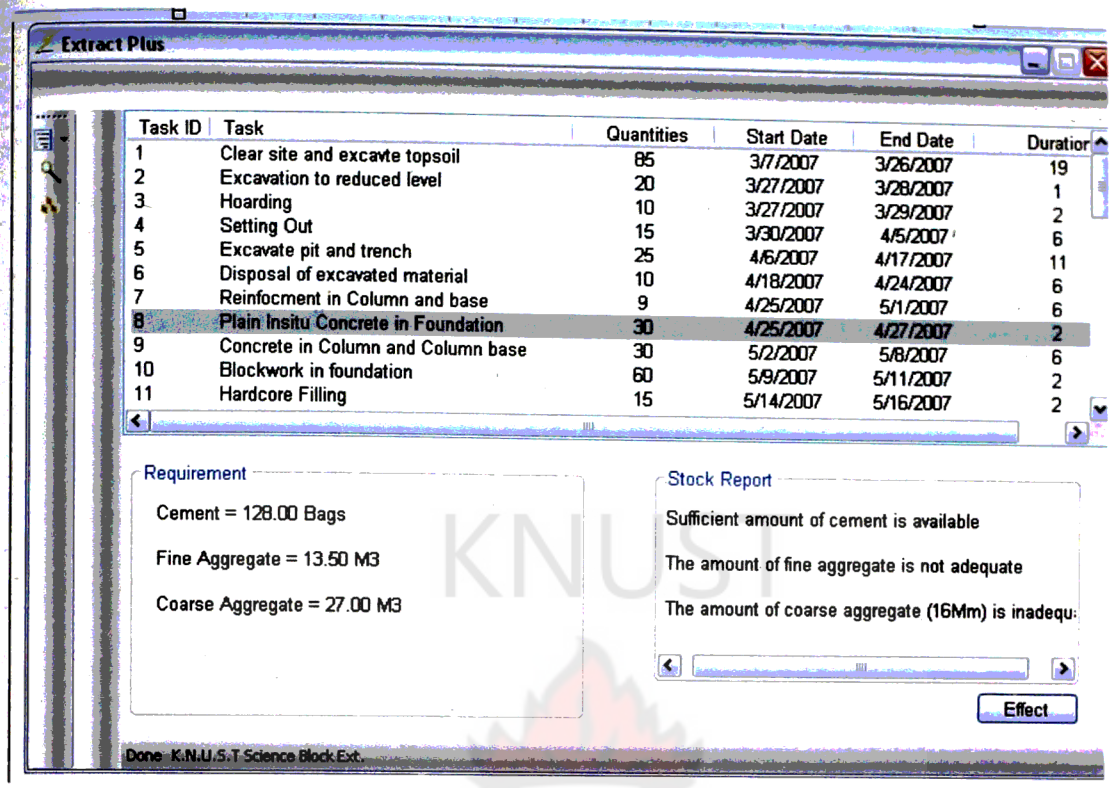


Figure 5.3 Extraction of Material Requirements Necessary for a Particular Task on the Program of Works

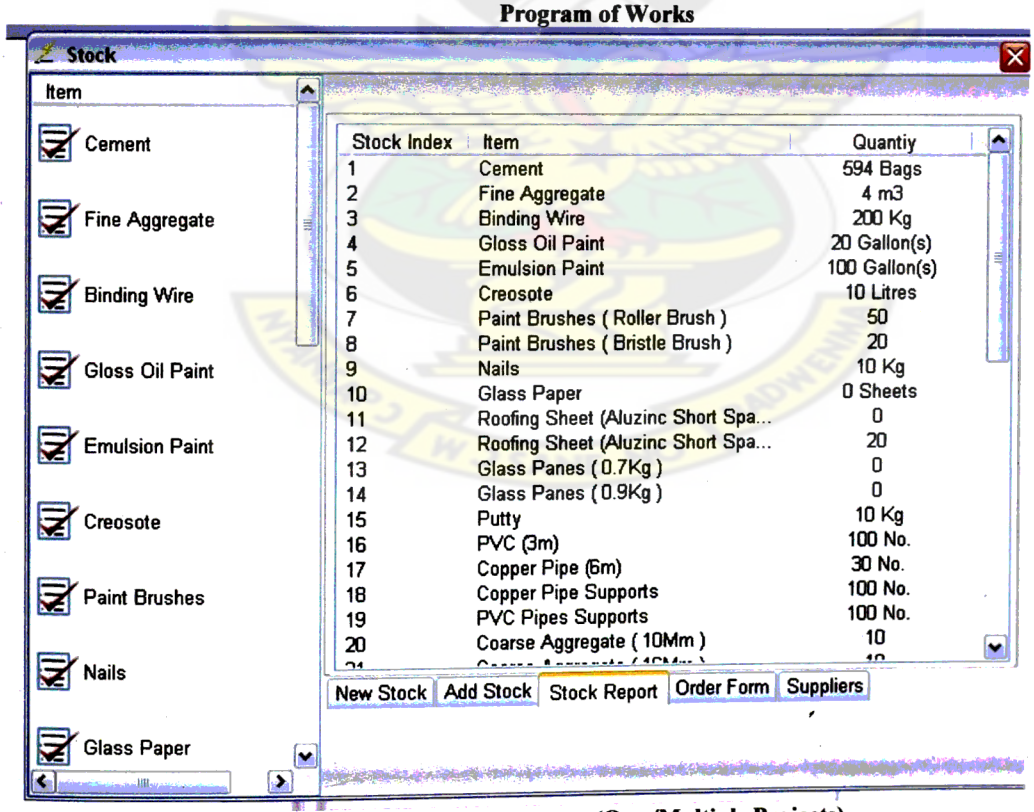


Figure 5.4 Database of Stock Reports (One /Multiple Projects)

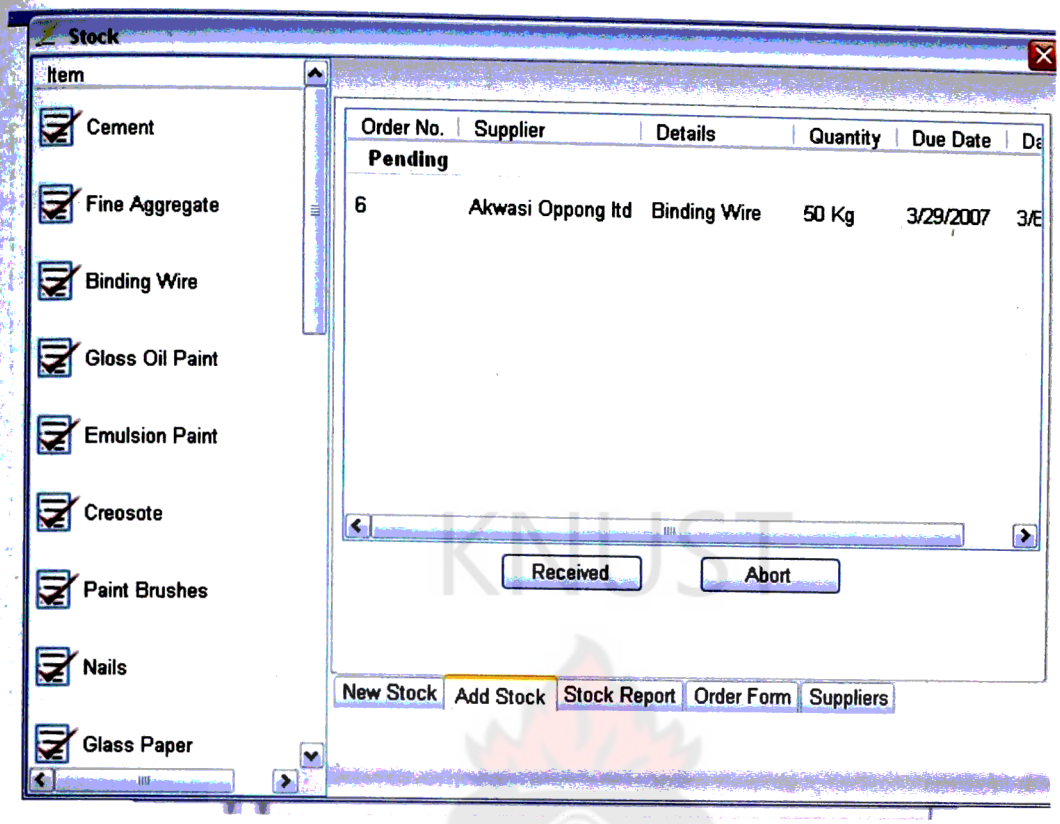


Figure 5.5 Delivery Reports

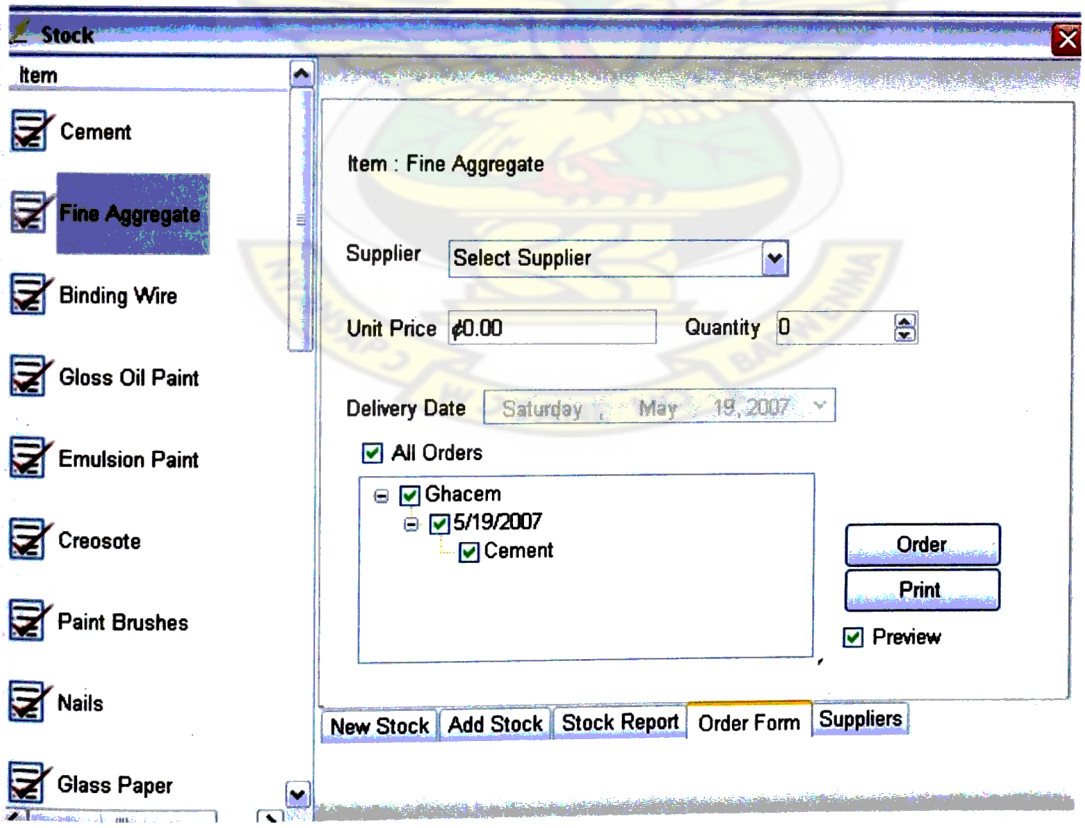


Figure 5.6 Database for all orders made for a Particular Material on that Project

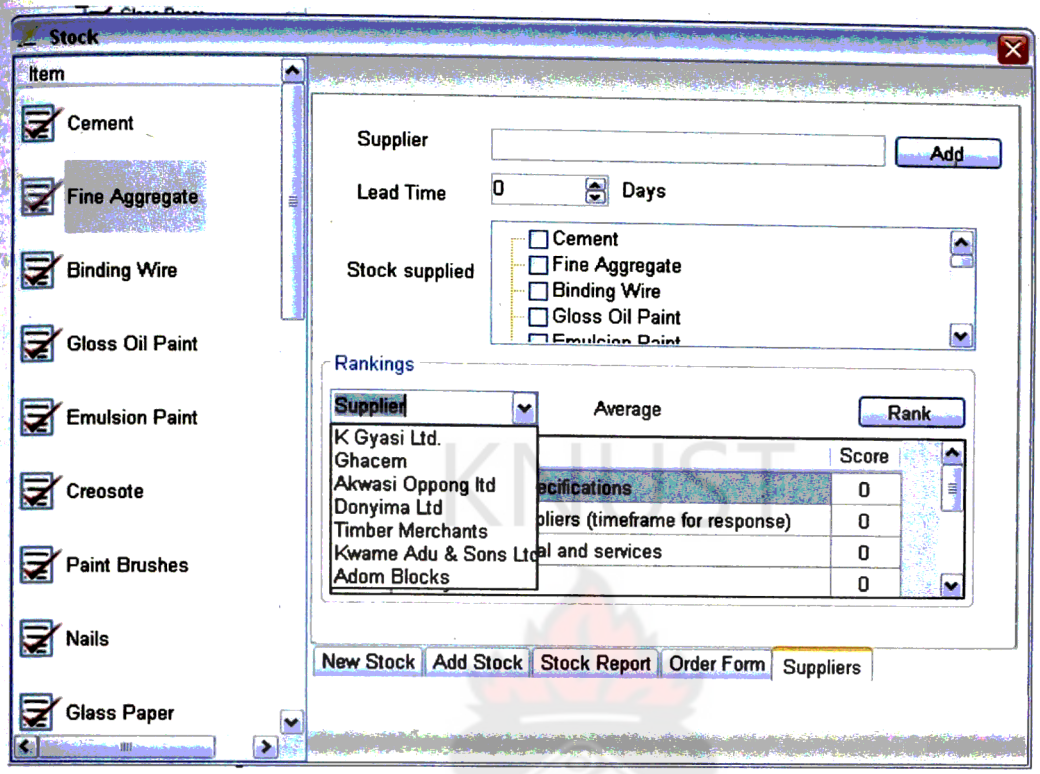


Figure 5.7 Databases for Contractors Suppliers

These were the desired outputs hence the researcher in the following section looks at the input data that were going to generate these outputs.

5.3.3 Extract Plus Input Data

These following windows™ user applications are needed for the input of data for Extract Plus:

- Microsoft Project 2003
- Microsoft Access 2003
- Microsoft Excel 2003

Microsoft Project 2003

Project management encompasses all the stages of a project, from the planning stages through the completion and drafting of final reports that summarise the completion of the project. As soon as a project manager determines his project goals, he can get started with Microsoft Project. Microsoft Project is an invaluable tool for the following works.

- Organising the project plan
- Scheduling the project tasks
- Assigning resources and costs to the tasks
- Fine tuning the project plan to satisfy constraints

After work begins on the project Microsoft Project can be used for the following on going tasks:

- Monitoring actual performance.
- Project the impact on the project schedule when changes occur that threaten the success of the project.
- Revising the plan to meet contingencies .
- Producing final reports on the success of the project

Extract Plus makes use of Microsoft Project in the input of the following information for that particular project:

- Inputting scheduled tasks.
- Inputting the quantities(volume, area weight etc..) of the tasks.

- And the start and finish dates, durations of the tasks of that project.

Hence this is where all the planning is carried out in Extract Plus.

Microsoft Access 2003

Databases are electronic filing systems that store information. A database application goes a step further by allowing you to work with the information, which includes adding to the information, updating it and deleting it. A database application also allows you to create report files. Extract Plus used Microsoft Access in the creation and storage of stock databases, supplier databases and all orders placed on the project. These databases could accommodate any amount of information depending on the end users hard disk space. The use of Microsoft Access made it easy to carry information from one Personal Computer to another and still maintain its structure which made it advantageous to use in Extract Plus.

Microsoft Excel 2003

Excel is a computerised spreadsheet- a spreadsheet is a popular program used to analyse numeric information and help make meaningful business decisions based on the analysis. Spreadsheets are used for a variety of applications ranging from financial analysis of stock portfolios, manufacturing and production quantity assessment, inventory turn over and cost estimation, budgeting and simple household record keeping. Microsoft Excel is a very common spreadsheet application and hence the decision to use it in Extract Plus for all the extractions carried out in Extract plus.

5.3.4 Hardware Requirements for Extract Plus

Extract Plus©2007 requires a minimum operating system of Windows® 98, 2000, Millennium, or XP.

For Extract Plus to operate properly, please verify the following:

• A PC with a minimum of Pentium® III 333 MHz computer,

• Minimum local hard drive with 120MB free space.

• High speed data networks (GPRS, P2P, LAN and WAN) for high speed Internet use; data service is a network and subscription dependant feature that may not be available in all areas. Please contact your wireless service provider for details. **(Optional)**

• Minimum active memory: 128MB of RAM under Windows® 98 and Millennium, 256MB of RAM under Windows® 2000 and XP.

5.4 Model Design

The following sections will spell out the steps followed in designing Extract Plus.

5.4.1 System Architecture of implemented Model

The system architecture of this prototype is shown in Figure 5.8. This basically portrays three (3) sections, the Materials Control Function, the Purchasing Function, Receiving and Stores Function; this is the total representation of Extract Plus. Please find attached from Figs. 5.8-5.10 the system architecture in implemented model

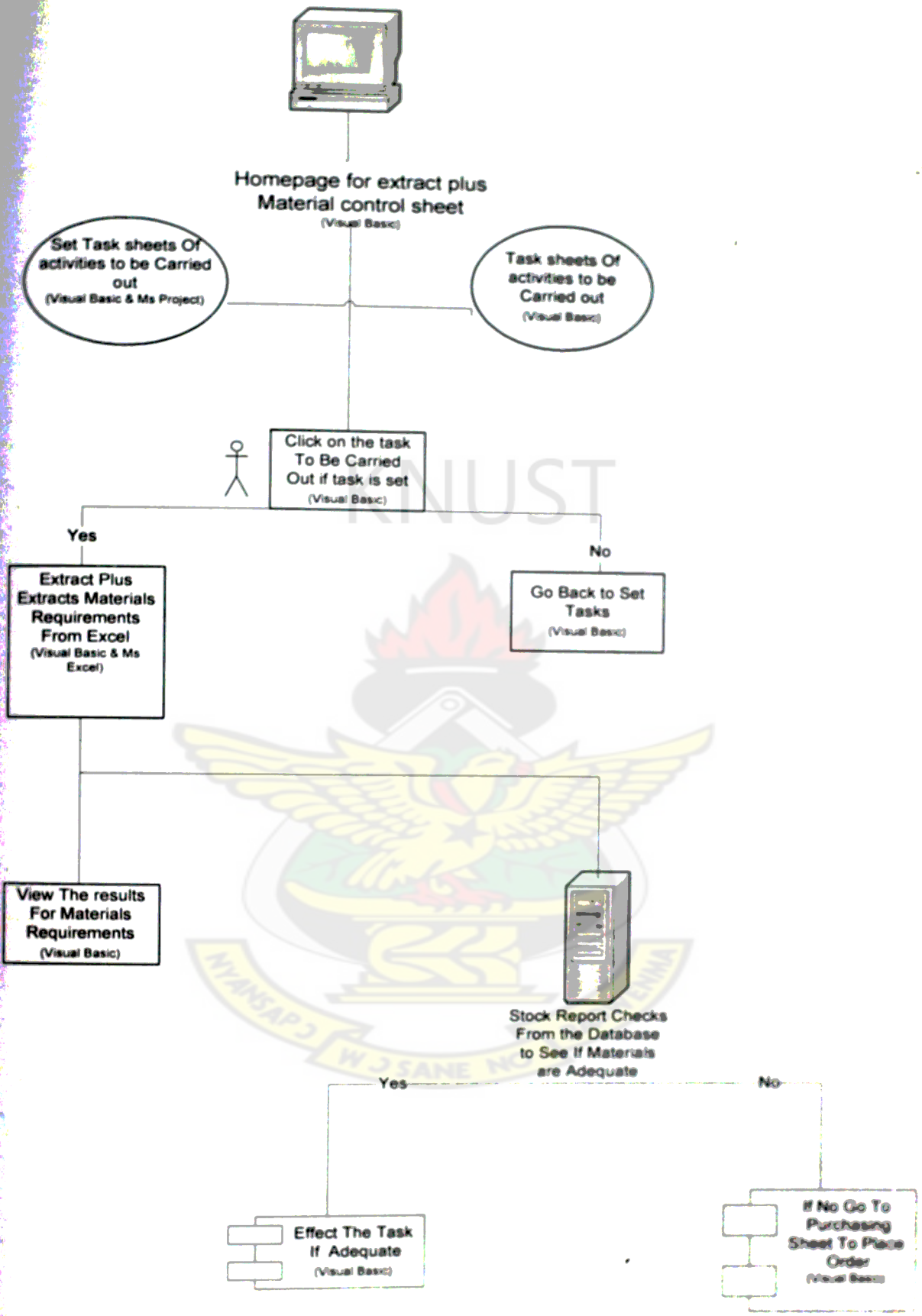


Figure 5.8 System Architecture of Extract Plus (Materials Control)

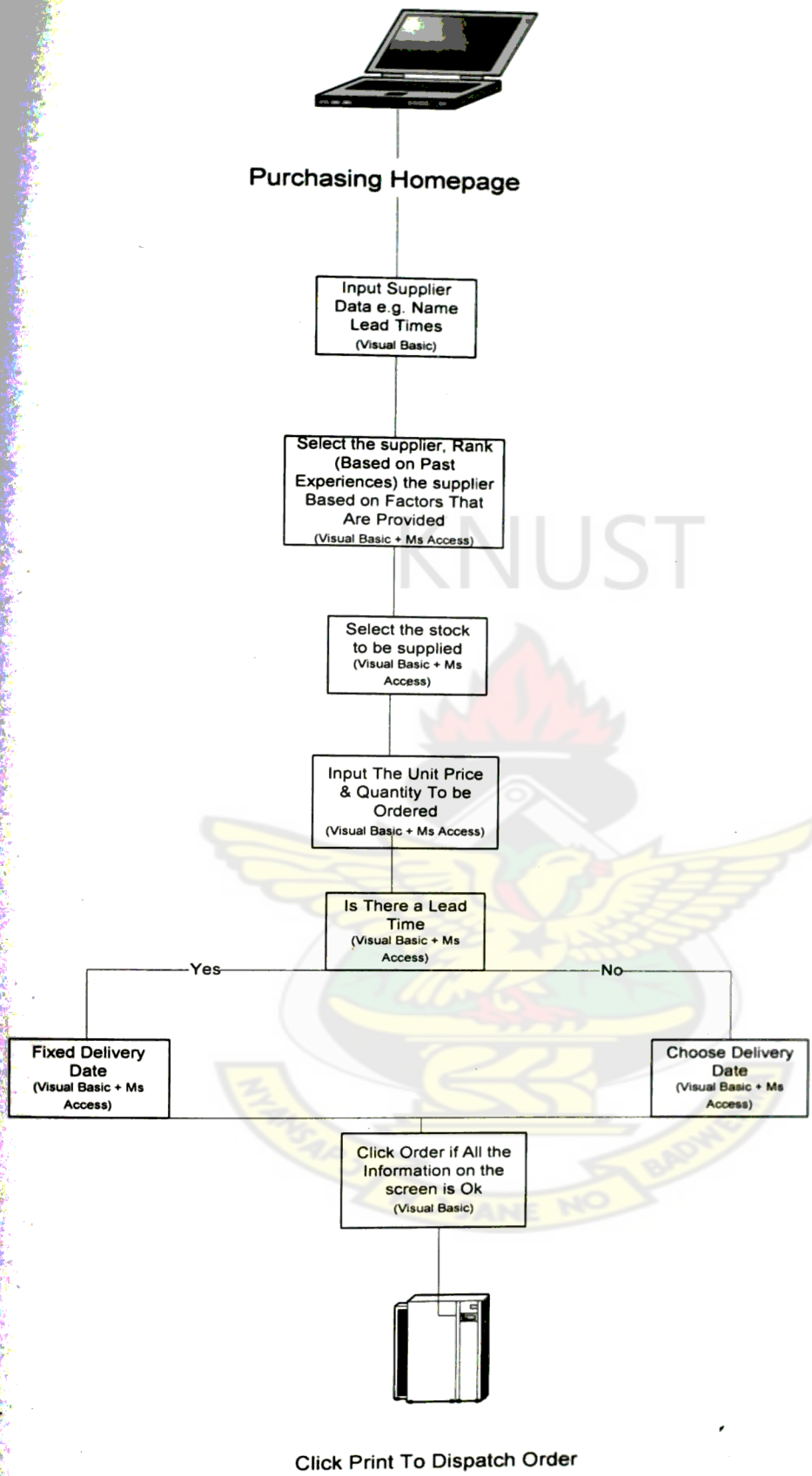


Figure 5.9 System Architecture for Extract Plus cont'd (Purchasing)

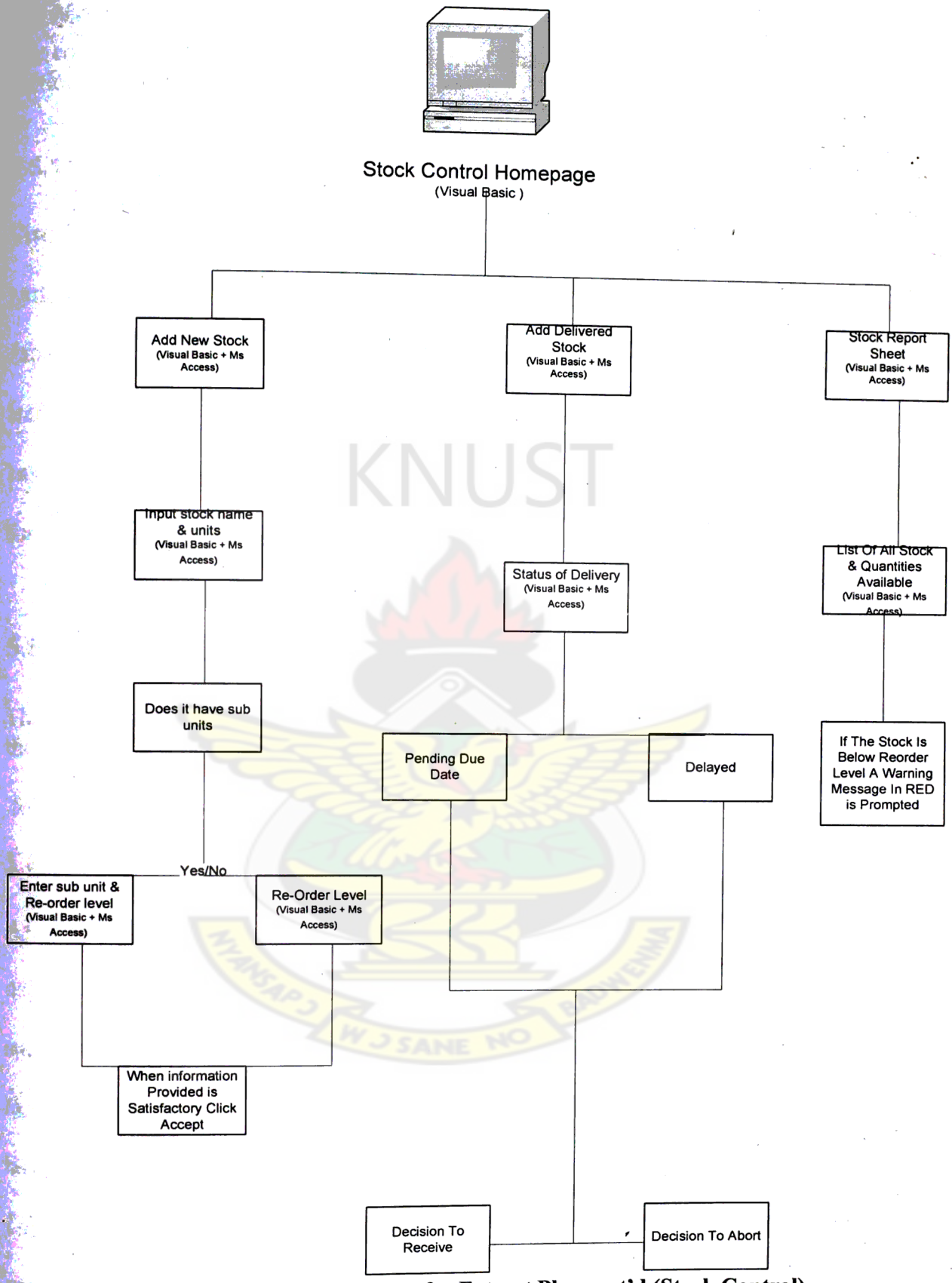


Figure 5.10 System Architecture for Extract Plus cont'd (Stock Control)

5.5 Model Coding

The computer language used for coding Extract Plus, is indicated in the following section of the report.

5.5.1 Visual Basic (.net Studios)

Visual basic is the language that many developers, including Microsoft, are using to write new application softwares. When a closer look is taken at any modern windows database, spreadsheet or word-processing package, whether from Microsoft or another leading software house, you will find that its macro language is either a variety of visual basic, or a language almost identical to it. For this reason Extract Plus used visual basic for all its coding, macros and forms as a template for all its input data and processes.

5.6 Model Test

The procedures followed in testing the developed Extract Plus model are described in the

following sections of this report.

5.6.1 Testing of model

As a means of testing the model after development, it was necessary for the researcher to debug it in order to eliminate errors; the main types of errors under investigation at this stage were syntax errors and logic errors;

Syntax errors are errors that violate the rules of the programming language in use (visual basic).

Logic errors come about when the programmer uses an incorrect calculation or procedure in programming.

In the testing phase several methods were devised by the researcher in finding and removing both types of errors, the first being;

Desk checking: with this type of testing the researcher went through the program line by line looking for syntax or logical errors.

Manual testing with sample data: here the researcher ran the program with both correct and incorrect data; this was to test for the correct processing of the results obtained.

Beta testing: this was the final stage of testing the program, at this stage selected potential end users were asked to test the programme and provide feedback to the researcher.

One of the main objectives of this section is to verify the realism of its practicability and the answers produced by this model. Quite imperatively, this is perhaps one of the most difficult things to measure, since some construction projects are long term and could take years to run through one project let alone getting similar projects to run side by side for testing. On the other hand, it is not difficult to verify how realistic the values are since they were determined by means of mathematical functions and logical reasoning. The difficulty would arise from determining the practicability of the model and its effectiveness in managing materials and information at the same time maintaining all the materials management functions.

5.6.2 Validation of results

In the previous section the researcher made mention of beta testers who were to test the model and provide feedback, this was a daunting task since most project managers were

not willing to go through the hassle of doing things differently. The following was the prefix for carrying out the beta testing and the conditions hold for all test cases.

- Three project managers that agreed to go through with the beta testing all worked on different estate housing projects
- The estate houses had to be similar if not the same for sections under investigation; due to time factor, not all the sections of the build could be tested.
- The notion carried out by the researcher was that estate housing was repetitive in nature and hence could be monitored side by side.
- The project managers were to compare two estate houses similar in design and dimensions, with one scenario being that the project manager used Extract Plus to carry out all the materials management functions from a personal computer; and the other being that, on the other house they went about their materials management functions without the aid of extract plus.
- The beta testing was carried out for two months of construction (April and May 2007)
- After this period the project managers were asked to give their feed backs.

Critical analysis of feedback produced by both methods indicated that calculations with respect to materials extractions were similar with little variations since they were deduced directly from the progress of work.

The project managers before Extract Plus went about their materials management functions as described in the flow charts in chapter four. The management of these companies believed that materials management was a

very important aspect for successful project completion; therefore they focussed greatly on materials issues for cost control. (Hence their willingness to participate) Typically, the project personnel were in charge of buying the materials needed, the foremen for each project were responsible for preparing the list of materials to be requested from the suppliers. The material requisition was sent to the project manager who in turn, sent it to purchasing. This requisition specified the type of material to buy, how much material to buy and where to deliver this material.

The type of material to buy was specified in the material schedule prepared in the pre-planning stage. Usually, the type of materials requested, by the site personnel, were common and readily available materials since major materials were requested early due to the long lead times that it required. The type of materials to buy depended on the type of work expected to be done in the particular period.

All three project managers had their views on Extract Plus and the pro and cons of Extract Plus are discussed below.

Validity of Extract Plus

1. They all agreed that it made their work a lot easier and increased the speed of their work since they felt they were in control of the project at all times by just monitoring progress from behind their personal computers.
2. The use of Microsoft Project also made the scheduling of tasks and the monitoring of progress of work more easy to follow.

3. The project managers realised that with Extract Plus they could tell the exact amount of materials to use for a period and the fact that Extract Plus warned them if they were low on stock was an exciting feature.
4. They were also impressed with the fact that the selection of suppliers had been made so easy that based on a simple ranking procedure Extract Plus would select the most appropriate supplier for that material. This also avoided the repetitive nature of this process explained in chapter four, for materials requisitions and a lot less paper work.
5. They also agreed that Extract Plus made their physical store counts more reliable since they knew exactly what to expect in the stores and discrepancies were easily traced and corrected.
6. It also improved materials handling on site since they were made aware of delivery times and dates.
7. The fact that Extract Plus could be used on several projects at the same time by creating separate project files also meant that with a laptop the project manager could carry project information for various projects to management meetings and show progress of work.
8. The database for Extract Plus was extensive and was able to record all orders made for materials on a particular project and also produce a summary report for all materials used on the project for site meetings
9. The security system for Extract Plus is that of a password known only to the administrator, in this case the project managers.
10. They were pleased with the nature of its user friendly interface.

Shortfalls of Extract Plus

1. They complained that it could not curb late deliveries and such suppliers could only be black listed after the harm was done, the researcher later explained that it was only a guide and not the answer to late or failed delivery problems.
2. They also said that Extract Plus combined all the materials management functions into one practice and put the responsibility on only the end-user, who on large projects might be overwhelmed with his duties.
3. The scope of Extract Plus, they felt was too limited, but felt that if expanded would be great for the industry.

The researcher from the above comments felt the research's third objective had been achieved and recommended that further research be under taken to expand Extract Plus for commercial use.

5.7 Model Documentation

5.7.1 Data Definition for EXTRACT PLUS

A data dictionary is a collection of descriptions of the data items in a data model to facilitate the understanding of such data to users who need to refer to them. In its simplest form, the data dictionary is only a collection of data element definitions or a document prepared by the researcher to describe all items in software.

A Category is the main class used to classify a parameter. Categories were selected

based on the main information components that can be found in a typical construction project. Categories could contain subcategories that are used to further divide the categories into components that could facilitate the classification of the parameters. For example, the cost category can be further divided into two categories: direct cost and indirect cost. The use of sub-categories allows classifying parameters more specifically based on the course that the parameters could have on the overall decision system. For example, a contractor could easily identify that materials not being available when needed creates an indirect cost associated to losses in productivity.

Table 5.1 depicts detailed description of Extract Plus terminologies, including information that is related to all the decisions that were considered in this research.

Categories	Definition	Components
Cost	Total amount of money paid to have materials on site	Direct cost and indirect cost
Type of material	Type of materials to be bought	Major material or off the shelf
Storage	Location/ space where the materials will be placed until installation	On-site / off- site
Schedule	Planned calendar of the work to be performed	Progress of work productivity Uncertainty in schedule Work to be done When to use the material Planned vs. Actual • Extra work • Change Quantity to install Order to install Order to store
Supplier	The source that will supply the material needed	Location Lead time Performance • Ability to supply material

		• Backorders Reliability Specified in documents Bidding process
Specifications	To be given by the client / his representative to the contractor	Brand/ capacity
Other	Use to classify the parameters that don't fit into any of the categories above	Waste (%) How prone to damages Number of trades working on site Storage restrictions Lead times required Critical / speciality materials
Sub-Categories	**Definition**	**Components**
Direct cost	Cost of purchasing and having the materials available on site	Material selling cost procurement costs (cost of placing processing and paying of material, physical distribution, distributors cost, and the transportation costs) and site handling costs (cost of receiving, storage, issuances and disposal)
Indirect cost	Cost due to unavailability of the materials, misplacements and multiple ordering	Loss in labour productivity misidentification, duplicate orders delays etc....
On- site storage	Space available on the job site to store materials	Sea containers lay down areas, work areas
Off – site storage	Space own or rented in a remote location for storage purposes	Warehouses, central stores ,sub contractors yard

5.8 Model Maintenance

It is hoped that the end user would not have much trouble using Extract Plus. This in the researchers view should be the first step in solving materials management problems in

the Ghanaian construction industry. The following chapter deals with the conclusion and recommendations for this research.

CHAPTER SIX
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS.

6.0 Summary of Findings

This chapter presents the major findings, conclusions and recommendations made for this research project. The diagrams below are a pictorial of the major objectives and the major findings of the research.

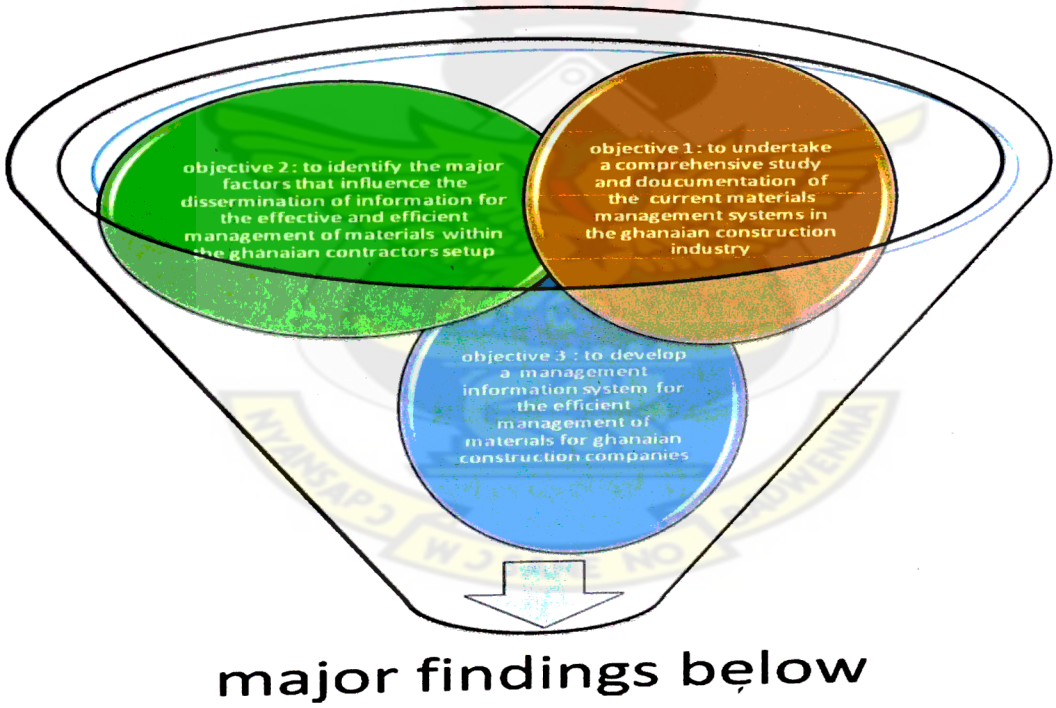


Fig 6.1 Diagram of Major Findings

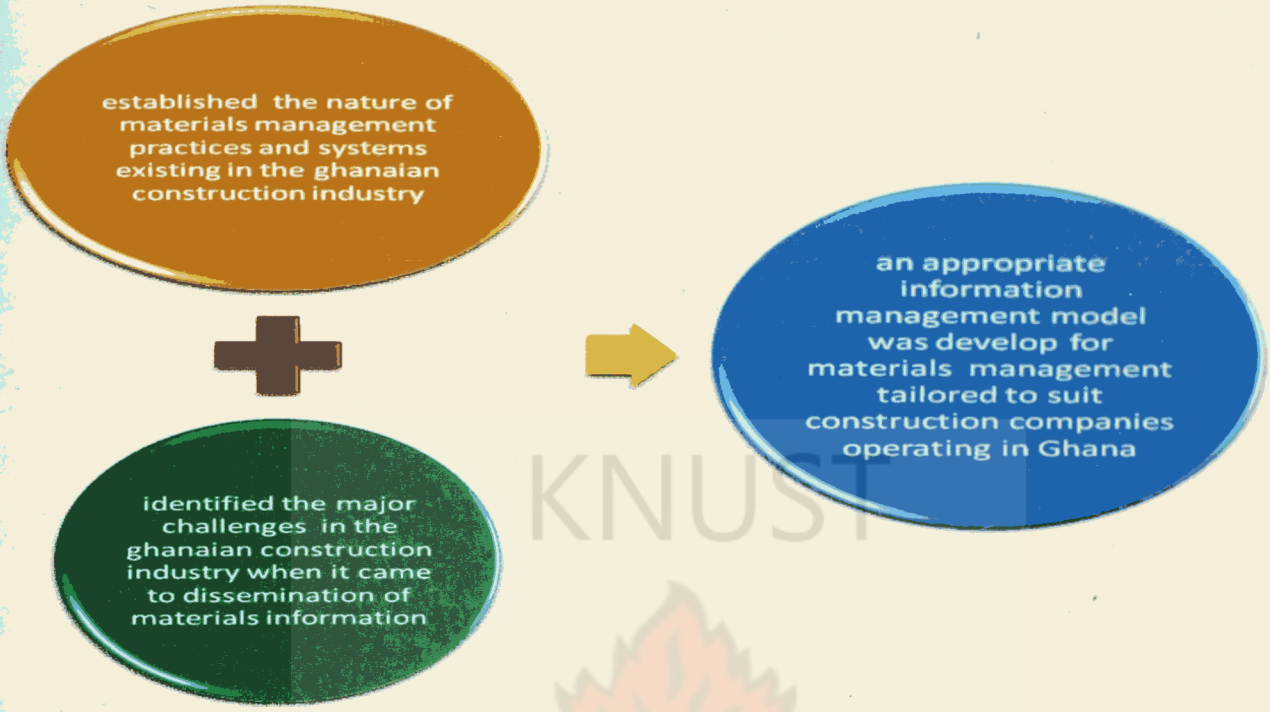


Fig 6.2 Diagram of Major Findings

Objective 1:

Currently, materials management functions in the construction industry are often performed on a fragmented basis with minimal communication and no clearly established responsibilities among the parties involved. This was established in chapter four. The researcher noticed that there were five distinct phases of materials management practised in Ghana, namely; *bidding, sourcing, material procurement, construction phase and post- construction phases.* The researcher found out that these phases existed but were not being practised in the daily set up and running of these companies' materials management outfits.

Objective 2:

The next finding was in respect to information creation, dissemination and destination in the area of materials management. It was the author's observation that the information flow was fragmented and open for errors due to multiple-entry and mismanagement of the information created. This was further compounded by the problem of easy accessibility, since 36% of the information existed in a locked paper environment, 42% of the information generated went home with the personnel in charge of the creation of the information and the final 22% existed in personal devices such as office computers, PDA's and mobile phones. This made accessing the information time consuming, and almost impossible for personnel to access information in real time, since they were always at the mercy of the persons who created the information.

Objective 3:

The study developed a computer based model (Extract Plus) for materials management practice, based on the five distinct phases of the materials management practised in the Ghanaian construction industry. These phases were identified by the researcher as *bidding, sourcing, material procurement, construction phase and post- construction phase.* It is the author's hope the model will bring about standardisation in the industry which may pave the way forward for good materials management practice by helping in eliminating some of the challenges that materials management practitioners faced in Ghana..

The research also derives the optimal integration of people, decision processes, information support systems and data that are required to support efficient and effective systems for acquisition, procurement, transport, storage and allocation of materials in the construction industry.

6.1 Summary of Work

Throughout this research, materials management for the construction industry has been described and analysed. This study was done in an effort to improve the current materials management practices and find the solutions to the factors that affect the dissemination of information in the construction industry.

Chapter 1 presented the research statement. This chapter presented a description of the problem statement, the objective of the research, the methodology for the research work, relevance of this work to the construction industry of Ghana and the limitations of this study.

Chapter 2 presented a general introduction to materials management in construction. This chapter defined what a material management system is and typical materials used in the construction industry, why it is important to have a material management system and the advantages of having it. This chapter also presented the current state of knowledge in materials management for construction.

Chapter three presented the methodology used in the research, like the questionnaire design administration and the sampling technique used.

Chapter four presented an overview of the Ghanaian construction industry including services provided by contractors and materials purchasing. In addition, this chapter describes the current materials management practices in the construction industry. In this chapter, the author was able to identify distinct phases used in the current practices in materials management. The different phases included:

- Bidding phase
- Sourcing phase
- Material procurement phase
- Construction phase
- Post-Construction phase

The chapter went further to describe the main challenges that are encountered during the five phases of materials management processes.

Chapter five also presented the process that the researcher undertook in the development of the materials management information system (Extract Plus). It also looks at its installation and application, system requirements, as well as testing and validation.

Chapter six - this chapter, presents the summary of the major findings, conclusions and recommendations made by the researcher.

6.2 Conclusions

Efficient materials management is crucial for the success of any construction project and can be the deciding factor between a successful project and a project full of delays and claims. Better materials management methods and software models are needed to improve the contractor's current practices, thus increasing efficiency and minimising costs. An effective materials management system is essential to avoid material shortages, misplacements, loss and theft which might result in increase in gang idle times, loss of productivity and delay of activities. Contractors should implement an efficient materials management system due to the fact that in most of the cases, they are asked to squeeze their bids in order to keep the cost of the project under budget. In such

a case, failure to effectively manage materials could result in decreases in profit or even a loss. The primary goal is to have the material needed, in the amount needed with the quality required, and the time that they are needed at the right cost. Most companies have a materials management system that serves their needs, although it could be improved. Standardisation of the materials management system could be a step forward in improving the system and eliminating some of the challenges. The research presented in this document aimed at designing an integrated system for materials management. A fully integrated and standardised approach will better improve communication and minimise gaps in information flow among all the parties and departments involved.

6.3 Recommendations.

The main aim of this research was to develop a materials information management system for the Ghanaian construction industry. The work presented in this document constitutes a contribution to the body of knowledge. This was accomplished by the identification of current materials management practices, the factors that affect the dissemination of information, and the development of a new information management system for the construction industry.

The development of Extract Plus in chapter 5

The research breached some of the barriers to the adaptation of methods and technologies that are emerging in other industries by working with companies of different industries in the design of the software for implementing materials management.

Directions for further research

This research established the knowledge and bases that allow the reengineering the current practices for materials management for the construction industry. The implementation of the software will allow making better decisions on what time to use materials, what quantities of materials to use, what material to buy, when to buy and from the supplier to buy the materials from. This research did not cover construction as a whole; this serves as a basis for future research in the area. This section presents research directions and issues that could be the basis for future research efforts.

Expand the Model (Extract Plus) to Better Represent the Construction Industry

The software designed as part of the research concentrates mostly on construction of buildings. The interviews conducted were focussed on large size construction companies. The software should be expanded to:

- Include other types of work such as civil engineering structures.
- Consider smaller size companies in terms of their classification (D2/K2-D4/K4)
- Include companies from other geographical areas

Study Cultural Change Issues

The construction industry is very resistant to change. The "if it is not broken, don't fix it" attitude is typical in this industry. Implementation of new innovative methods might be difficult in such an environment. Riley and Clare-Brown (2001) cite the Royal Academy of Engineering that states that *"the challenge of changing the culture in the construction*

industry ... is daunting." Therefore a study of the culture encountered in construction is essential for the implementation of the software system in a company. Such a study should develop guidelines to assist with cultural issues that resist change and to incorporate the findings in the construction industry (i.e. what to do, with field/office personnel to adopt the new model).

Incorporate Existing Tools and Technologies to the developed Software

Existing technologies (i.e. web based methods, Pocket PCs. barcodes, RFID) could be very useful to effectively manage the materials management process. Automation of the process can be very beneficial for all parties involved. By automating the process, manual entries can be minimised, thus minimising errors associated with materials inventory and control. This could be accomplished by using bar codes of RFID systems that can automatically gather inventory information in an electronic format, instead of manually registering inventory information. This eliminates the problem of multiple entries. Moreover materials related data can be gathered at a much faster rate using bar codes or RFID, instead of manual methods, and errors in data collection can be greatly reduced. The challenge lies on the implementation of such technologies along with the software (Extract Plus) described in this document.

Implementation of Extract Plus in other Construction Sectors

The construction industry is moving towards fragmentation and it is safe to say that in a typical construction project more than 40% is performed by specialty contractors. All sectors of the construction industry share a common ground for material management

and control. Therefore, Extract Plus described in this document could be easily applied to other sectors to build industry such as specialty contractors (i.e. electrical plumbing and glazing)

REFERENCES.

Ammer, Dean S. (1974) *Materials Management,* Richard D. Irwin, Inc. Homewood, Illinois

Ammer, Dean S. (1980) *Materials Management and Purchasing,* Richard D. Irwin, Inc. Homewood, Illinois

Arnold, J.R. (1991) *Introduction to Materials Management,* Prentice-Hall, Englewood Cliffs, New Jersey

Bailey Peter and Farmer, David (1982) *Materials Management Handbook,* Gower Publishing Company Limited, Aldershot, Hants, England

Ballot, Robert B. (1971) *Materials Management: A Results Approach,* American Management Association Inc., United States of America

Beekman-Love, G.K. (1978) *Materials Management,* Martinus Nijhoff Social Sciences Division, Boston

Bernold, Leonhard E., Treseler, John F., (1991) Supplier Analysis for Best Buy in Construction, *Journal of Construction Engineering and Management,* VoL117, No.4, December 1991, pp. 645-658

Cavinato, Joseph, L. (1984) *Purchasing and Materials Management,* West Publishing Company, Minnesota

Chandler, Ian E. (1978) *Materials Management on Building Sites,* The Construction Press Ltd, Lancaster, England

Construction Industry Institute (1988) *Project Materials Management Primer,* Publication 7-2, Bureau of Engineering Research, The University of Texas at Austin

Construction Industry Institute (1999) *Procurement and Materials Management: A Guide to Effective Project Execution,* Implementation Resource 7-3, Bureau of Engineering Research, The University of Texas at Austin

Damodara, K., (1999) Materials Management: The Key to Successful Project Management, *journal of Management in Engineering,* VoLI5, No.1, January/February 1999, pp. 30-34

Dobler, Donald W., Burt, David N., (1996) *Purchasing and Supply Management: Text and Cases,* McGraw-Hill Series in Management, The McGraw-Hill Companies Inc, USA

Dos Santos, A., Formoso, G.T. & Hinks, J. (1996) Method of intervention on the flow of materials in building processes, in: *Proceedings of the Fourth Annual*

Conference of the International Group for Lean Construction, University of Birmingham, Birmingham, UK. Also at: http:/web.bham.ac.uk/dj.crook/lean

Ericsson, Dag (1974) *Materials Administration*, McGraw Hill Book Company (UK) Limited, England

Gossom, W.J. (1983) *Control of Projects, Purchasing, and Materials*, Penn Well Publishing Company, Tulsa, Oklahoma

Plemmons, James K., Bell, Lansford C. (1995) Measuring Effectiveness of Materials Management Systems, *Journal of Management in Engineering*, Vol. II, No.6, November/December 1995, pp. 26-32

Stukhart, G., (1995) *Construction Materials Management*, Marcel Dekker Inc. New York

Tersing, Richard J., Campbell, John H. (1977) *Modern Materials Management*, North-Holland Publishing Company, Amsterdam, The Netherlands

Thomas, H. Randolph, Sanvido, Victor E. (2000) Role of the Supplier in Labour Productivity, *Journal of Construction Engineering and Management*, Vol.126, No.5, September/October 2000, pp. 358-365

Willis, E. (1986) *Scheduling Construction Projects*, John Wiley and Sons

APPENDIX A

(QUESTIONNAIRE)

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

Department of Building Technology

A questionnaire to Construction companies in Ghana designed to aid in the development of an information management system aimed at enhancing materials management in large construction companies operating in the Ghanaian Construction Industry

INTRODUCTION TO QUESTIONNAIRE

This questionnaire seeks to gather information on the current practices of Materials Management in Ghana. It is part of thesis report which aims at developing a Materials Management Information system for the Construction Industry in Ghana by Eric Kofi Manteau in partial fulfilment of the award of a Masters degree.

Your participation, though voluntary, is very important to the success of this research and the development of the Industry under consideration. The information provided will be considered highly confidential and strictly for academic purposes.

I implore you to spare 30 – 45 minutes to complete this questionnaire.

Thank you.

Respondent Data

Please answer this section to help in the analysis of the data provided.

1. Position Held .....

2. Years of working in the company [ ]

3. Academic Qualification(s) .....

4. Professional Qualification (s) .....

5. How many years have you practiced in materials management [ ]

6. How many years have you worked in the construction industry [ ]

7. Gender a. Male[ ] b. Female [ ]

8. Age of the respondent?

   a. Below 20yrs [ ]

   b. 20 – 30 yrs [ ]

   c. 31 – 40 yrs [ ]

   d. 41 – 50 yrs [ ]

   e. Above 50 yrs [ ]

MATERIALS PLANNING

1. Do you plan materials requirements for projects executed?

   a. Yes [ ] b. No [ ]

   If No Go to Que. 3

2. If yes how do you extract quantities of materials for planning?

   a. Bills of Quantities [ ]
   b. Previous knowledge [ ]
   c. Guess Work [ ]
   d. Program of works [ ]
   e. Other [ ]

   Specify:
   .....

   .....

3. At what stage is the planning done

   a. Pre-Tender Stage [ ]
   b. Contract [ ]
   c. Other [ ]

   Specify:
   .....

   .....

4. Who is responsible for materials planning?

   a. Site foreman [ ]
   b. Site Engineer [ ]
   c. Contracts Manager [ ]
   d. Quantity surveyor [ ]
   e. Other [ ]

   Specify: .....

5. To what degree do you consider the importance of Materials Management in your company?

   a. Very important [ ]
   b. Important [ ]
   c. Moderately important [ ]
   d. Not important [ ]
   e. Indifferent [ ]

6. Who gives final approval to the materials plan?

   a. Managing director [ ]
   b. Contracts manager [ ]
   c. Purchasing manager [ ]
   d. Financial controller [ ]
   e. Site manager [ ]
   f. Committee responsible for procurement [ ]
   g. Other [ ]

   Please state.....

7. Who is responsible for implementing the materials plan?

   a. Managing director [ ]
   b. Contracts manager [ ]
   c. Purchasing manager [ ]
   d. Financial controller [ ]
   e. Site manager [ ]
   f. Committee responsible for procurement [ ]
   g. Other [ ]

   Please state.....

MATERIALS PURCHASING

1. Do you have a purchasing department?

a. Yes [ ] No [ ]

2. Who is responsible for the function of Purchasing in your company?

a. Procurement manager [ ]
b. Stores keeper [ ]
c. The Contract Manager [ ]
d. Site foreman/ agent [ ]
e. Managing director [ ]
f. Other [ ]

Specify:
.....

3. Does your firm prepare a programmed schedule for ordering materials?
a. Yes [ ] b. No [ ]

4. How do you purchase materials for constructional works undertaken by your firm?

a. Open market [ ]
b. Procurement arrangements [ ]
c. From manufacturers [ ]
Others [ ]

Specify:
.....

7 Do you classify materials you purchase?

a. Yes [ ] b. No [ ]

8 What procedures are employed for evaluating potential suppliers?

a. Quotations [ ]
b. Experience of supplier[ ]
c. Reputation [ ]
d. Past experience with supplier [ ]
e. Other (please specify) [ ]

9 How do you typically place an order?
a. Visit the store [ ]
b. Phone [ ]
c. Fax [ ]
d. E-mail [ ]

10 Do you issue purchasing orders to suppliers when ordering for materials?
a. Yes [ ] No [ ]

If no Go to Que. 12

11. If yes does you company have a standard copy?
a. Yes [ ] No [ ]

12. Do you follow up placed orders?
a. Yes [ ] No [ ]

If no Go to Que. 14

13. If yes how are the follow ups done?
a. Visits to suppliers [ ]
b. Telephone calls [ ]
c. E-mails [ ]
d. fax [ ]
e. Others [ ]

Please specify.....
.....

14. Problems associated with the ordering process?
    a. Lost of order [ ]
    b. Fax not received [ ]
    c. Too many papers to fill out [ ]
    d. Not a good definition of what is wanted [ ]
    e. .Poor communication with supplier [ ]
    f. Vaguely stated requirements [ ]
    g. Materials not available [ ]
    Other [ ]
    Please specify.....
    .....

15 Quality is specified in the specifications for a particular project. For approval of the work, the contractor has to meet the quality requirements specified. How are quality issues specified to the supplier?
    a. Copy of specifications [ ]
    b. Orally [ ]
    Other [ ]
    Please specify.....

16. . How often do you experience late deliveries?
    a. Very often [ ]
    b. Often [ ]
    c. Not often [ ]
    d. Rarely [ ]

17. How do you cope with late deliveries?.
    a. Terminate contract with supplier [ ]
    b. Re-negotiate for another date of delivery [ ]
    c. Purchase materials from other source [ ]
    Other [..]
    Please specify.....

18. Who monitors this process to ensure that materials arrive on time?
    a. Site foreman [ ]
    b. Contract Manager [ ]
    c. Stores keeper [ ]
    d. Other [ ]
    Please specify.....

19 How are materials purchased from suppliers transported to site/ company storage?
    a. supplier delivers [ ]
    b. company transport acquires and delivers [ ]
    c. extra is paid for the supplier to deliver [ ]
    d. alternative transport is arranged for [ ]
    e. Other [ ]
    Please specify.....

20. How would you rate the following factors using a scale of 1-5 with 1 meaning strongly disagree, 2 disagree, 3 undecided, 4 agree, 5 strongly agree

Factors Affecting Materials Suppliers Selection	**Please tick in order of importance**				
	5	**4**	**3**	**2**	**1**
Adherence to specifications					

Flexibility of suppliers (timeframe for response)					
Quality of material and services					
Timely deliveries					
Continuity of suppliers supplies					
Financial arrangements offered by supplier (discounts, invoice consolidation)					

Competitive prices					
Availability of materials from different manufacturers (variety)					
Delivery services					

INVENTORY CONTROL STORAGE

1. Does your company have an inventory system?
   a. Yes [ ] No [ ]

If no Go to Que. 3

2. How do you keep track of materials installed against existing stock levels?
   Please state
   .....
   .....
   .....
   .....
   .....
   .....
3. Who receives delivered materials?
   a. Site foreman [ ]
   b. Contract Manager [ ]
   c. Stores keeper [ ]
   d. Other [ ]

Please specify.....

4. Do you carry out inspections on delivered materials?
   [ ] No [ ]

If no Go to Que. 6

5. If yes now is the inspection done?
   a. By physically examining them [ ]
   b. By tests [ ]
   c. Others [ ]
   Please specify.....

6. How do you deal with damaged materials or wrong deliveries?
   a. Returning them [ ]
   b. Disposing them off [ ]
   c. Negotiating for discount of materials [ ]
   d. Other [ ]
   Please specify.....

7. Where are the purchased materials stored When delivered?

a. on-site [ ]
b. company warehouse [ ]
c. Other [ ]
Please specify.....

8. If the materials are stored on site who manages the on-site inventory?
a. site foreman/ agent [ ]
b. stores keeper [ ]
c. site manager [ ]
d. Other [ ]
Please specify.....

9. Which materials are most likely to be stored on site?
Please state

10. What actions are taken if there are problems with material shortages or material damage?
Please state
.....
.....
.....
.....

11. How are surplus materials handled at the post construction stage?
a. returned to supplier at reduced cost [ ]
b. returned to company's main stores [ ]
c. sold off to other contractors [ ]
d. destroyed [ ]
e. Other [..]

12. What do you think are the difficulties in your existing system?
Please state
.....
.....

IT APPLICATION & INFORMATION DISSEMINATION

1. What are the current IT facilities in your organization?
Please state

No.	Material

.....
.....
.....

2. What are they Currently Used for in your organization?
Please State
.....
.....
.....

3. Do you use any IT in materials management as a company?
a. Yes [ ] No [ ]

4. If yes what software applications are used?
Please state
.....
.....
.....
.....

5. How do these systems affect Materials Management?
   a. time saving [ ]
   b. cost effective [ ]
   c. increase in labour productivity [ ]
   d. Other [ ]
   Please specify.....

6. If a system is introduced to cater for Materials Management will it be an added plus to you management process?
   a. Yes [ ] No [ ]

7. What mode should it take?
   a. computer software [ ]
   b. Policy [ ]
   c. Other [ ]
   Please specify.....

8. How does the purchasing process begin in your organization?
   a. By receipt of written/verbal requisition from materials control [ ]
   b. By receipt of written/verbal requisition from the site manager [ ]
   c. By receipt of written/verbal requisition from general manager. [ ]
   d. If other Please Specify
   .....
   .....
   .....

9. What monitory and control measures are put in place during the material plan implementation?

   .....
   .....

.....

10. How would you rate the following factors that affect the dissemination of information, using a scale of 1-5 with 1 meaning strongly disagree, 2 disagree, 3 undecided, 4 agree, 5 strongly agree

Factors Affecting information dissemination	**Please tick in order of importance**				
	5	**4**	**3**	**2**	**1**
Types of Information Sources available(internal and External)					
Channels of communication					
Management style of the organisation					
Objectives of the Company					
Nature of the industry					
Nature of information Flow (Vertical/ Horizontal)					
Lack of adequate information when needed					
Lack of integration amongst Parties					

11. Please add any additional comments that you feel have not being properly captured in the questionnaire above?

.....

.....

.....

.....

Thank you,

APPENDIX B

(HOW TO INSTALL THE MODEL)

(THE MANUAL)

How to Install and Operate Extract Plus

This section of the chapter takes the end user through the installation and basic operations of extract plus for the first time user. Through this section figures of extract plus would be used to make the process more user friendly.

How to Install Extract plus

Step 1

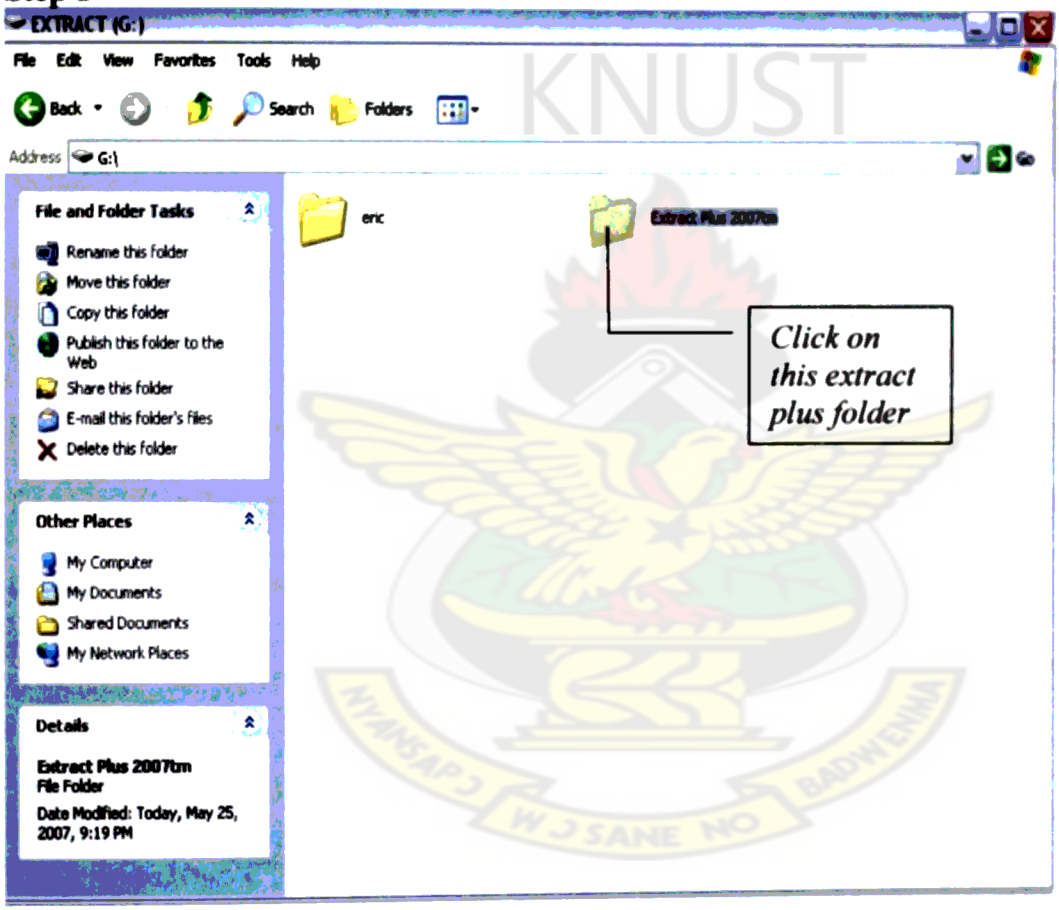


Fig B.1 The Installation of Extract plus

This the firsts window the end user sees when the Cd Rom drive is double clicked,

Step 2

Fig B.2 The Installation of Extract plus

This window comprises of three folders and two types of setup the researcher would recommend that the end-user double clicks and selects the set highlighted since it has being packaged to detect if the end users computer has certain components like the .net framework installed or not, if not it installs all the needed components without asking the end-user to download any components from the internet.

Step 3

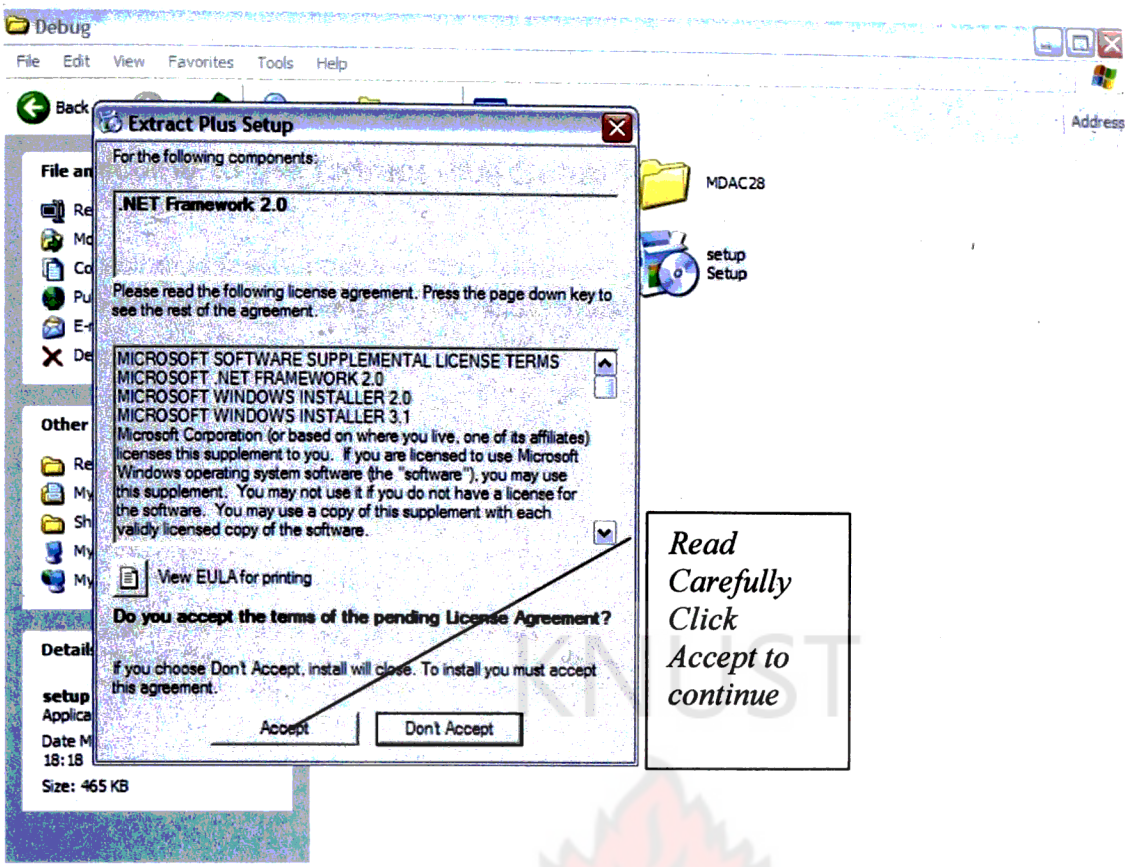


Fig B.3 The Installation of Extract plus

This window warns the end user of the End User License Agreement (EULA) and is also available for printing and reading before going further.

Step 4

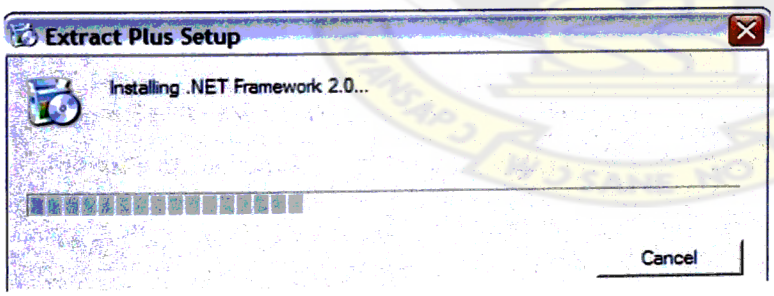


Fig B.4 The Installation of Extract plus

Once the end-user accepts the EULA then extract plus starts installing any component that is needed as well as Extract plus itself, the windows installer used in the development of extract plus was windows installer 3.0.

Step 5

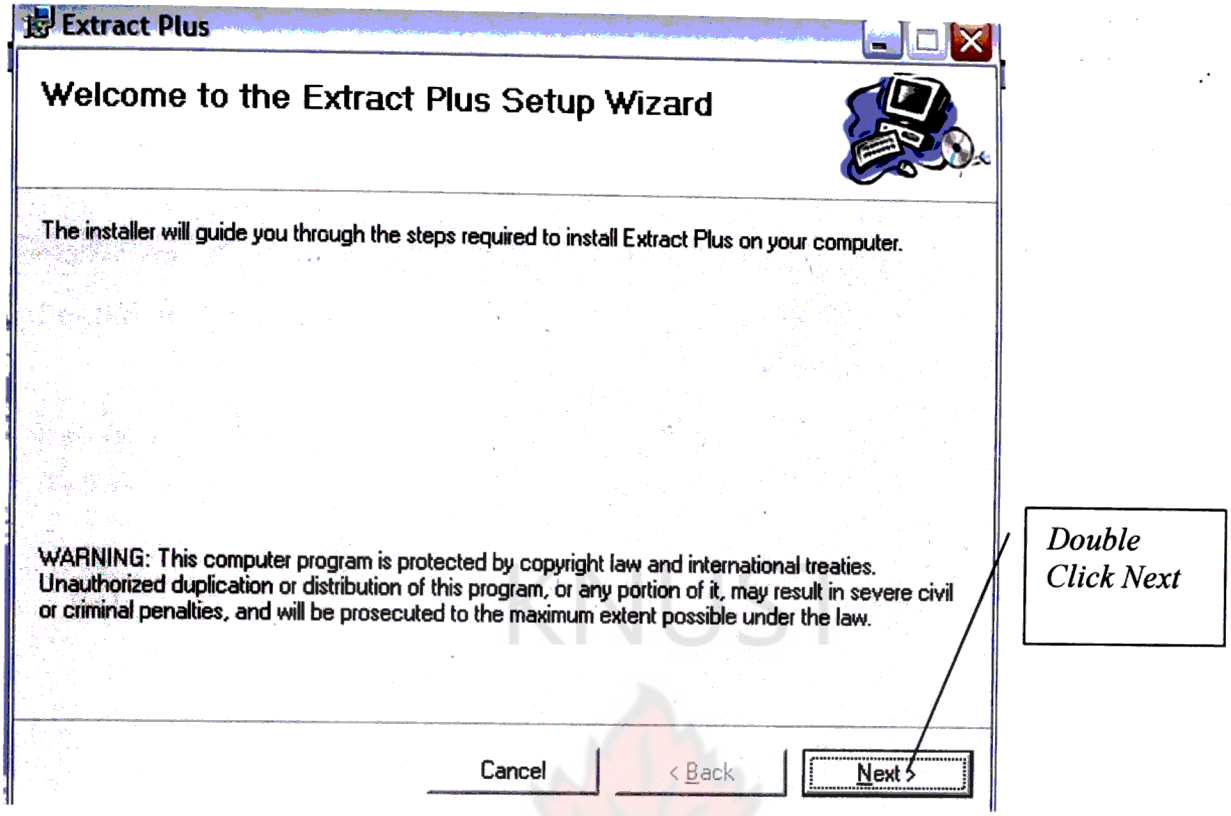


Fig B.5 The Installation of Extract plus

At this stage Extract plus's installer guides the end-user through the installation process

Step 6

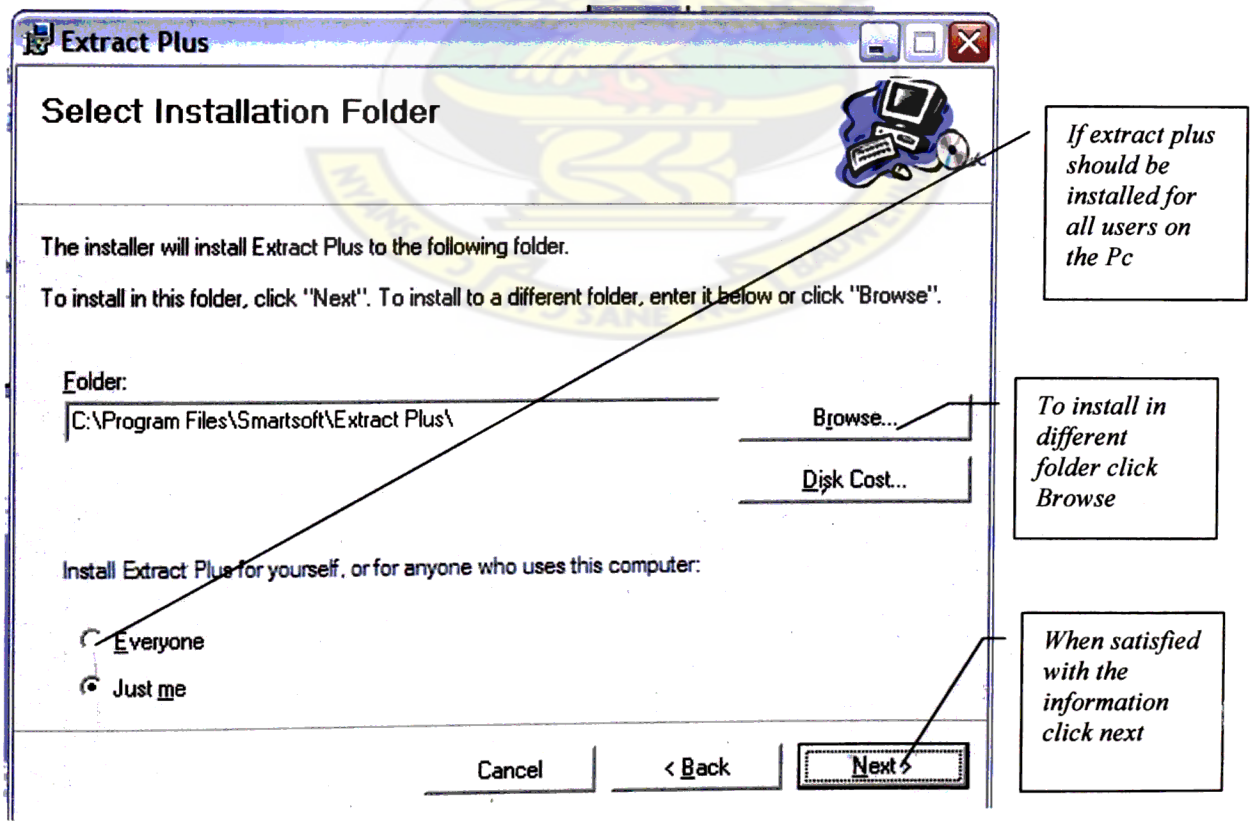


Fig B.6 The Installation of Extract plus

This window informs the end-user where to install Extract plus, the disk costs (that is the space required), whether it should be open to all users of the Pc if satisfied with the information the end user the double clicks next.

Step 7

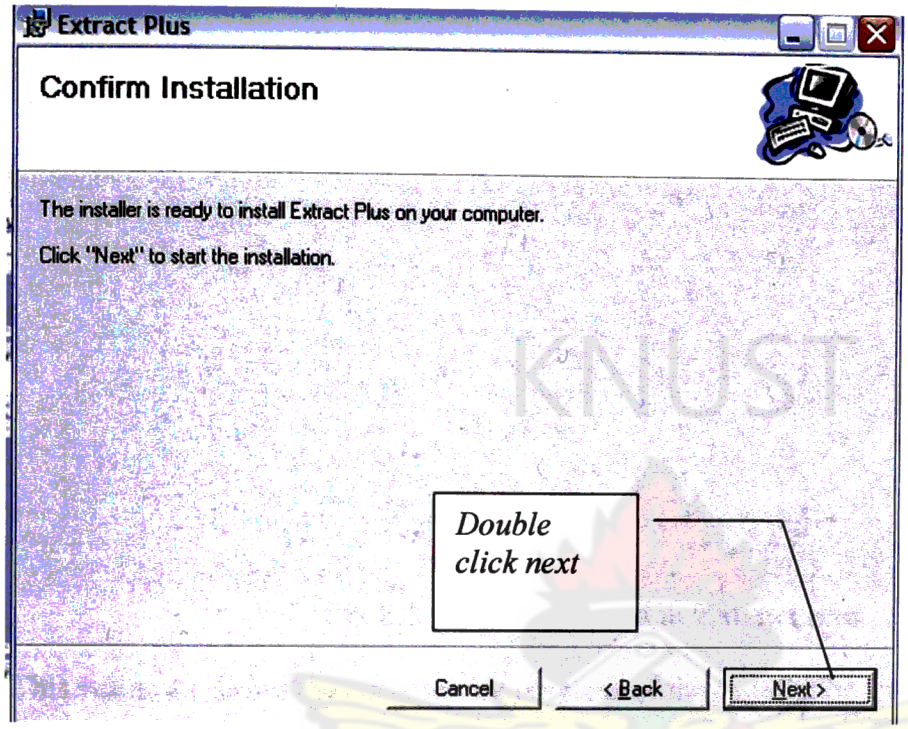


Fig B.7 The Installation of Extract plus

This window prompts the end-user to confirm the installation by double clicking next

Step 8

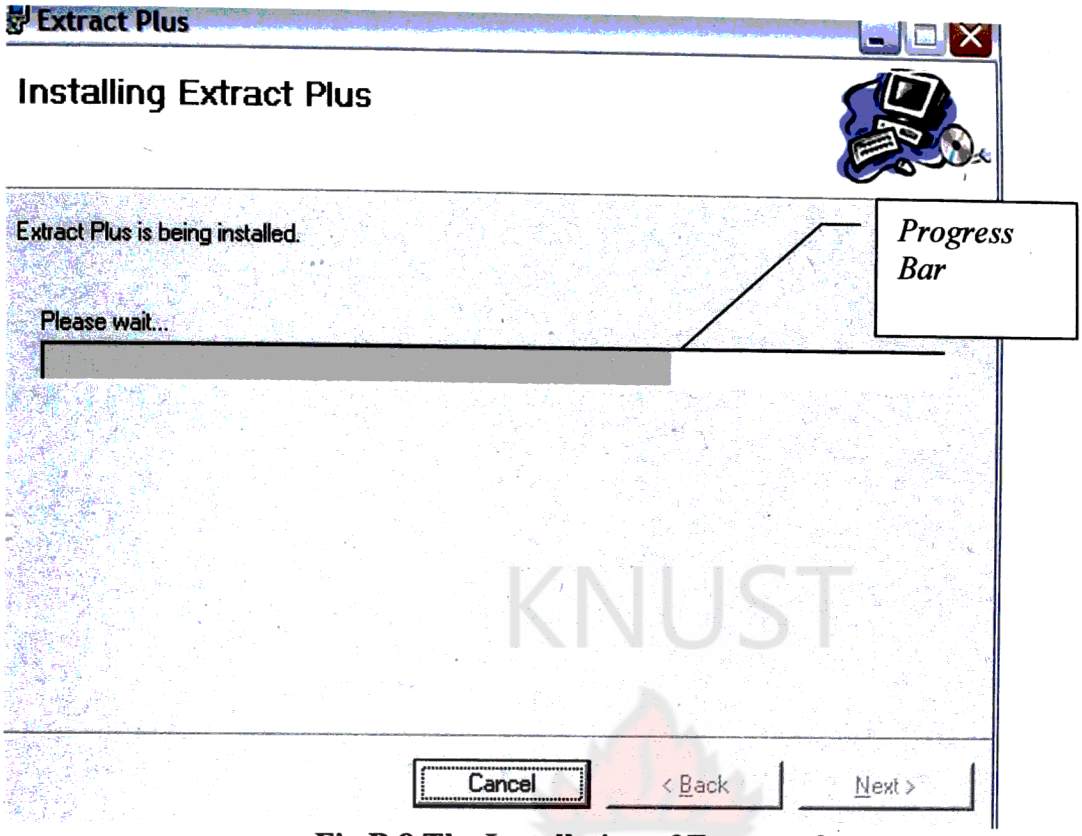


Fig B.8 The Installation of Extract plus

This windows shows the end-user the progress of the installation,

Step 9

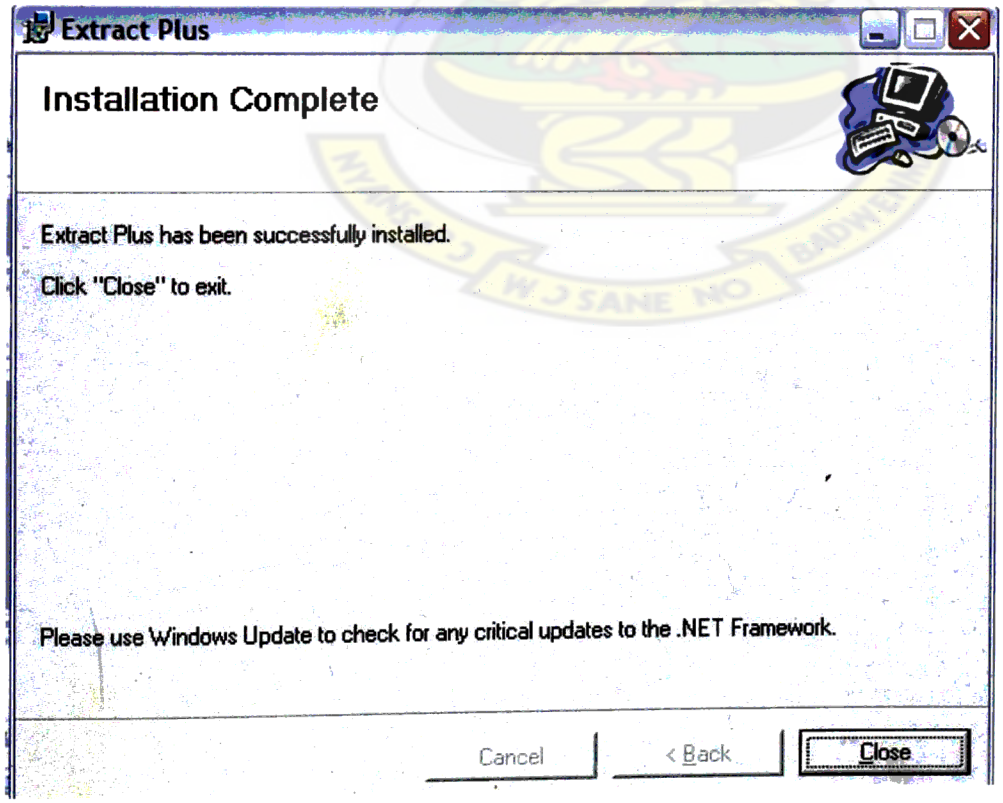


Fig B.9 The Installation of Extract plus

This window confirms to the end-user that Extract plus has successfully being installed by double clicking the close tab.

APPENDIX C

(HOW TO OPERATE THE MODEL)

How to Operate Extract Plus

This section takes the first time end-user through the basic steps in the operation of extract plus

Step 1

After successfully installing Extract plus the end-user should have a shortcut icon like the one below on the computer's desktop, by double clicking this application the end-user can start the application.

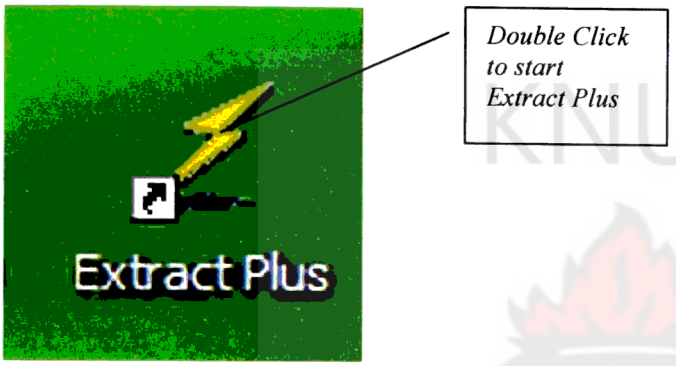


Fig C.1 The Operation of Extract plus

Step 2

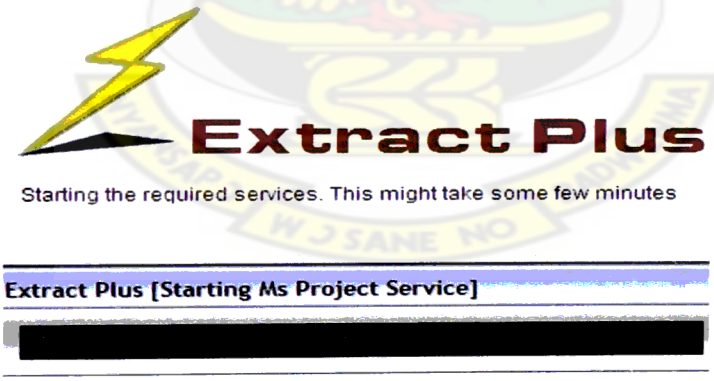


Fig C.2 The Operation of Extract plus

This window shows the end-user that the application has started loading, progress of loading is shown on the progress bar below the screen.

Step 3

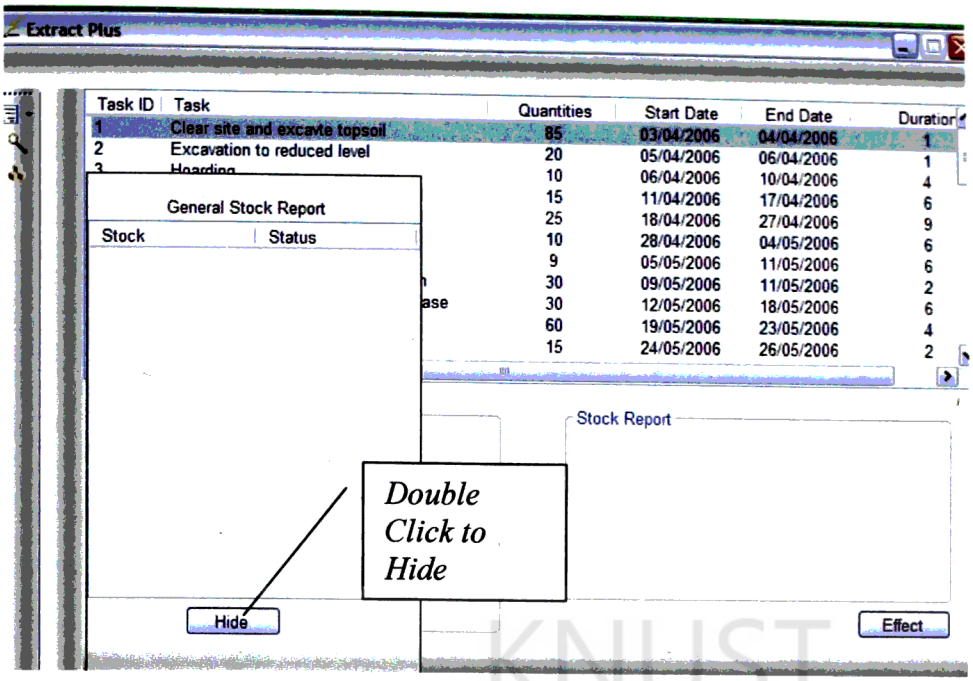


Fig C.3 The Operation of Extract plus

This window shows the end-user a blank template from which the end-user can start building on which takes us to the next step.

Step 4

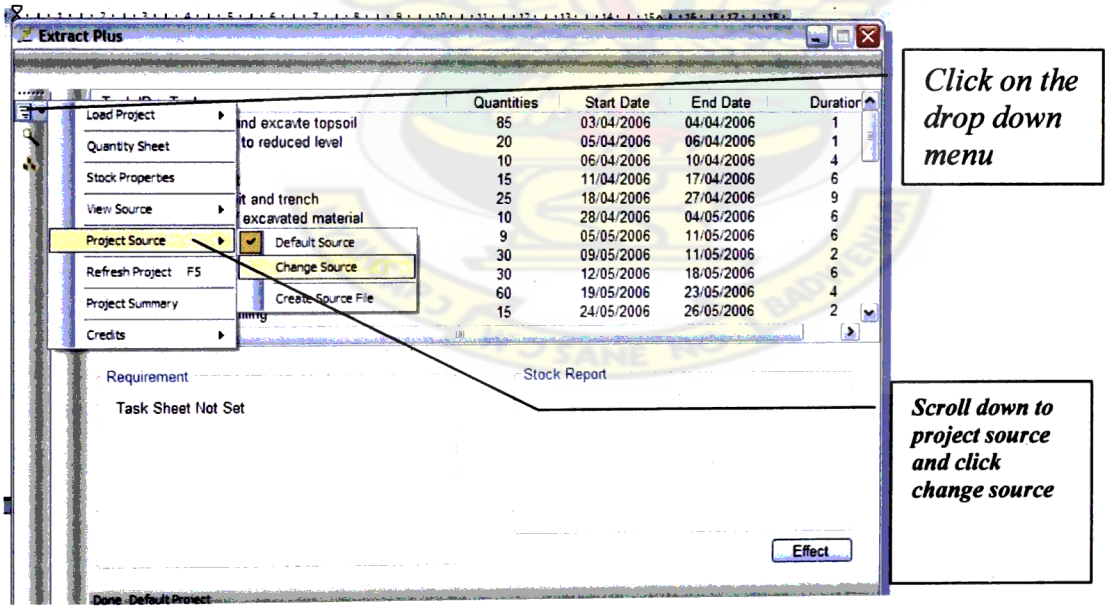


Fig C.4 The Operation of Extract plus

For Extract plus to work the source file has to be uploaded, the above window talks the end-user through the procedure. A new window appears and the end-user is asked to select the Cd/DVD drive with the installation Cd still in and Click on folder ***Eric.***

Step 5

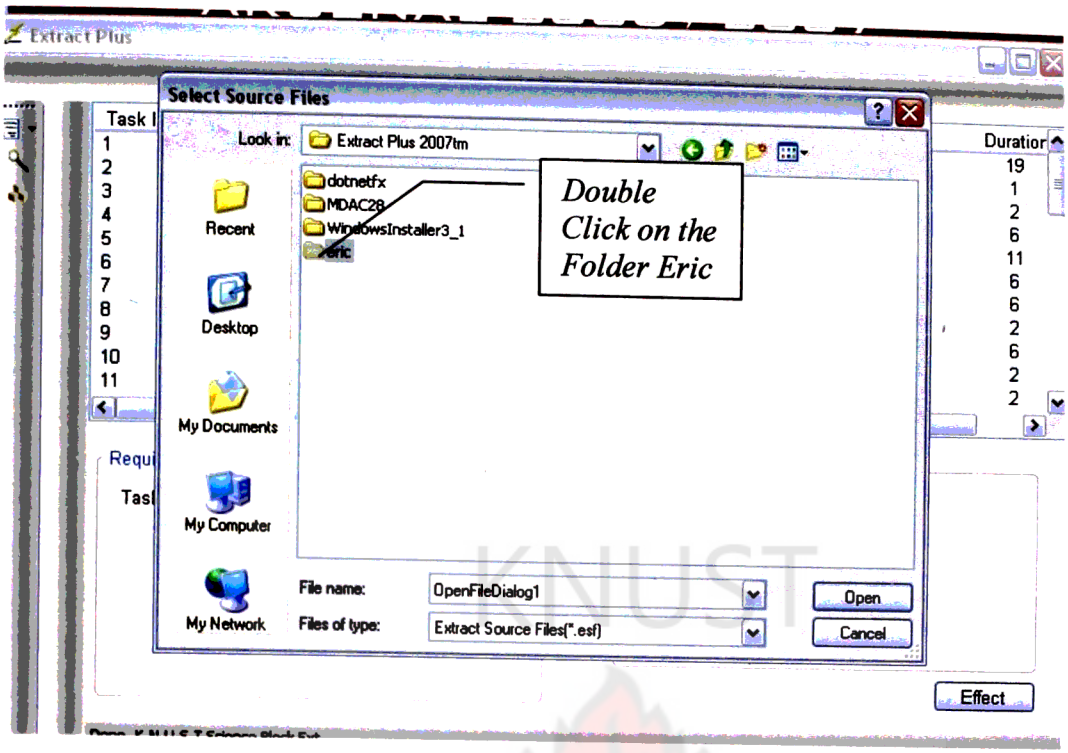


Fig C.5 The Operation of Extract plus

Step 6

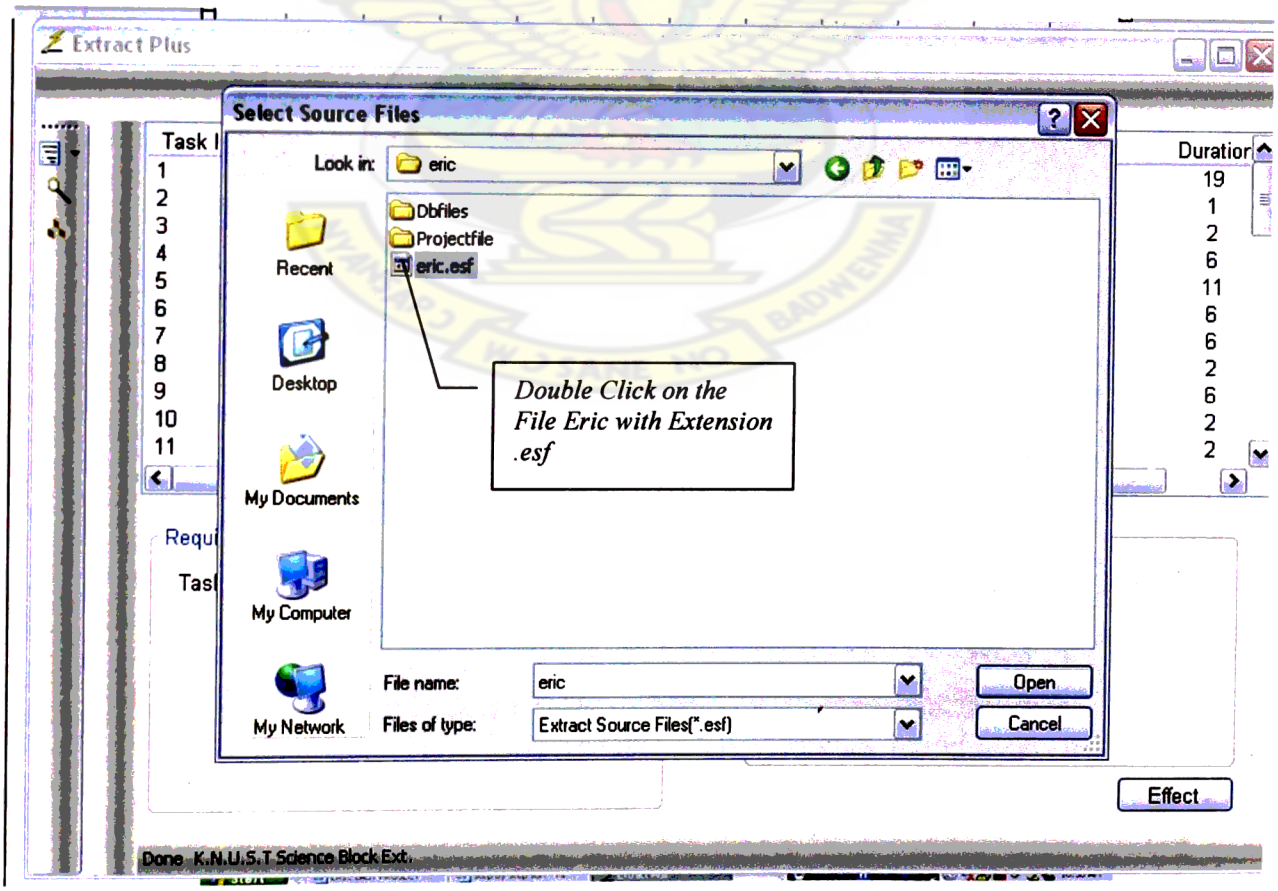


Fig C.6 The Operation of Extract plus

Step 7

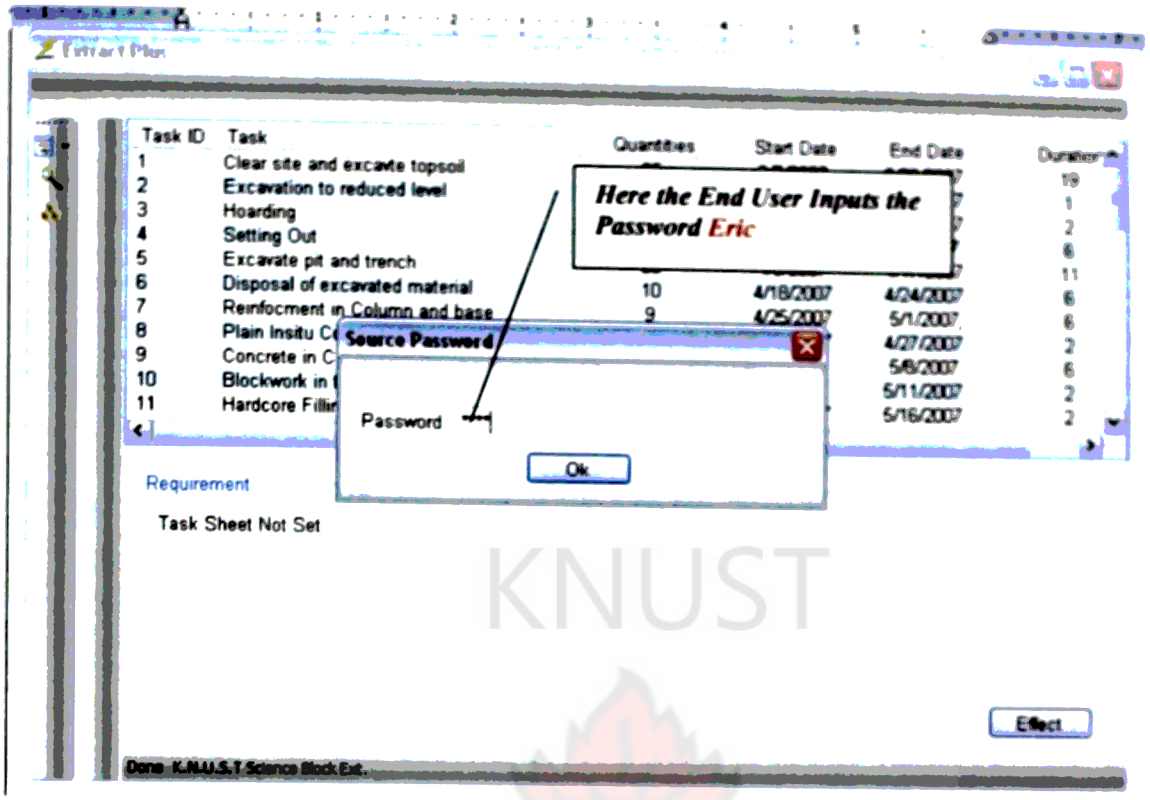


Fig C.7 The Operation of Extract plus

Step 8

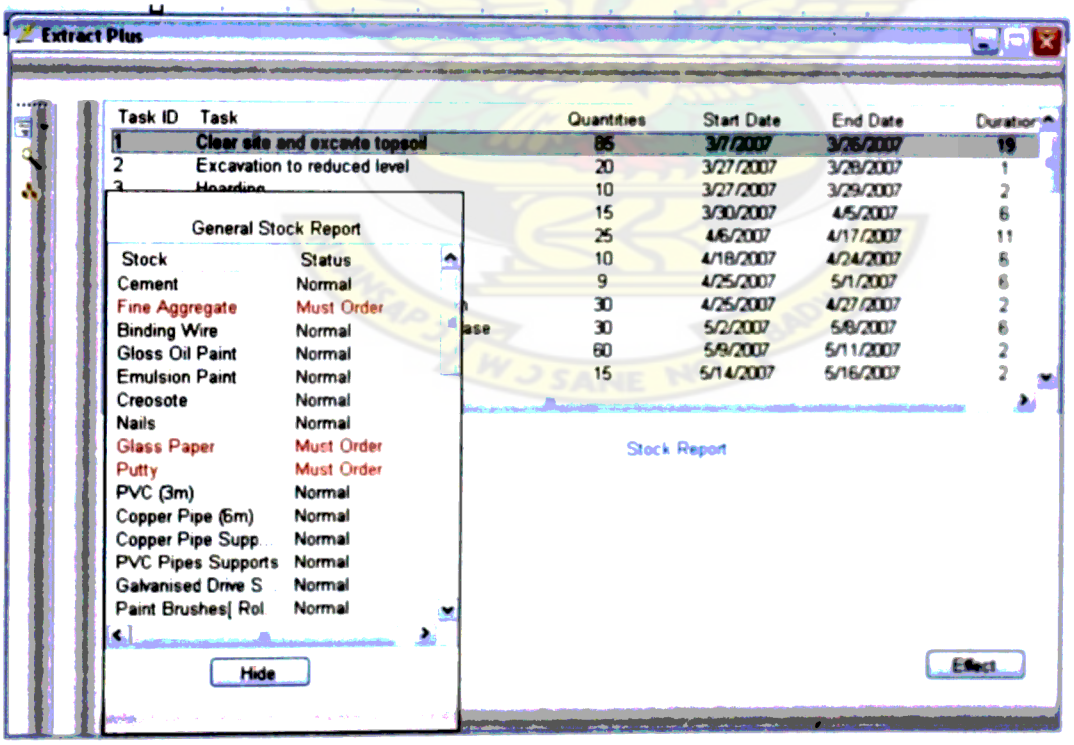


Fig C.8 The Operation of Extract plus

The window above may take a couple of minutes to load but from this stage Extract plus is ready for use.

Step 9

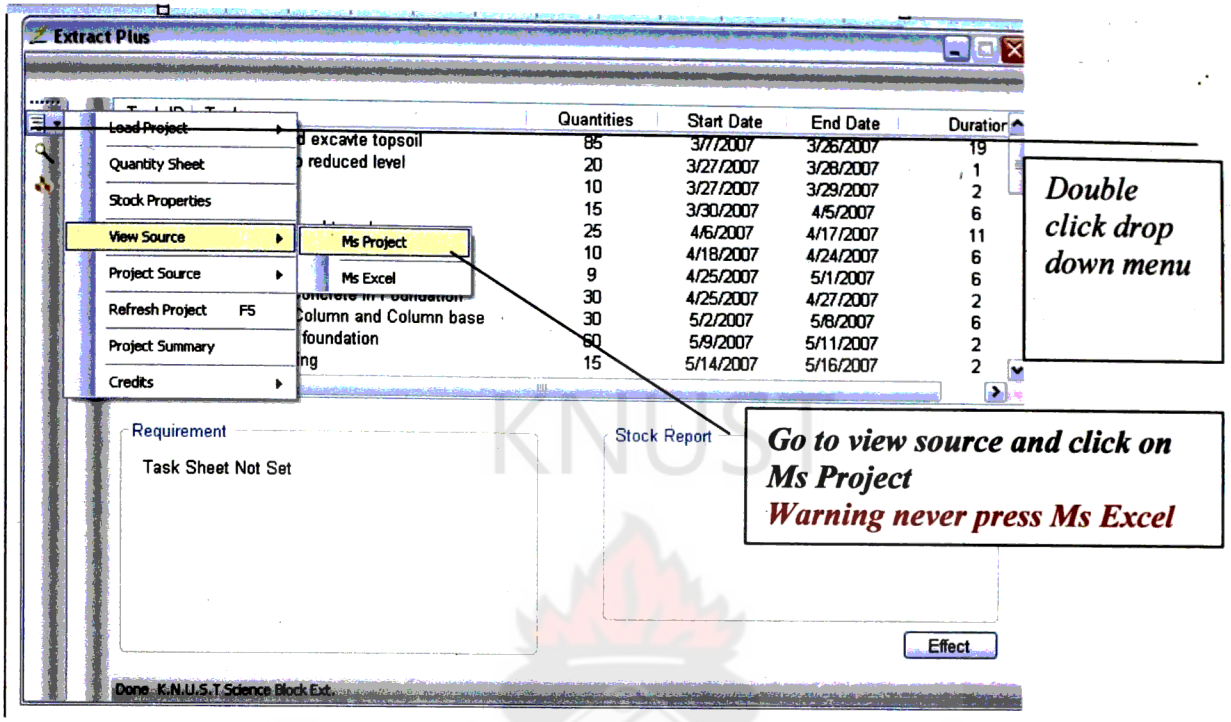


Fig C.9 The Operation of Extract plus

Step 10

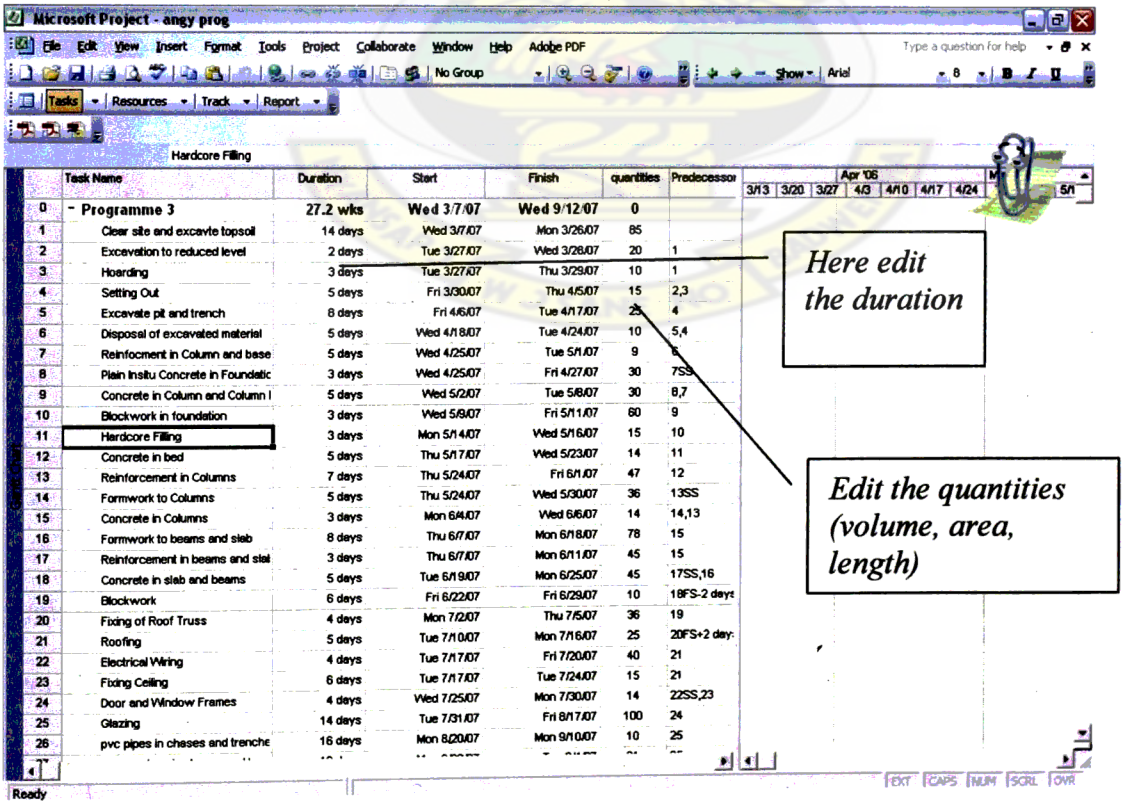


Fig C.10 The Operation of Extract plus

In this step the end user has all the privileges of planning with Ms Project with the added function of adding quantities to tasks scheduled.

Warning: please remember to save work before exiting this window or else Extract plus will not effect changes made.

Step 11

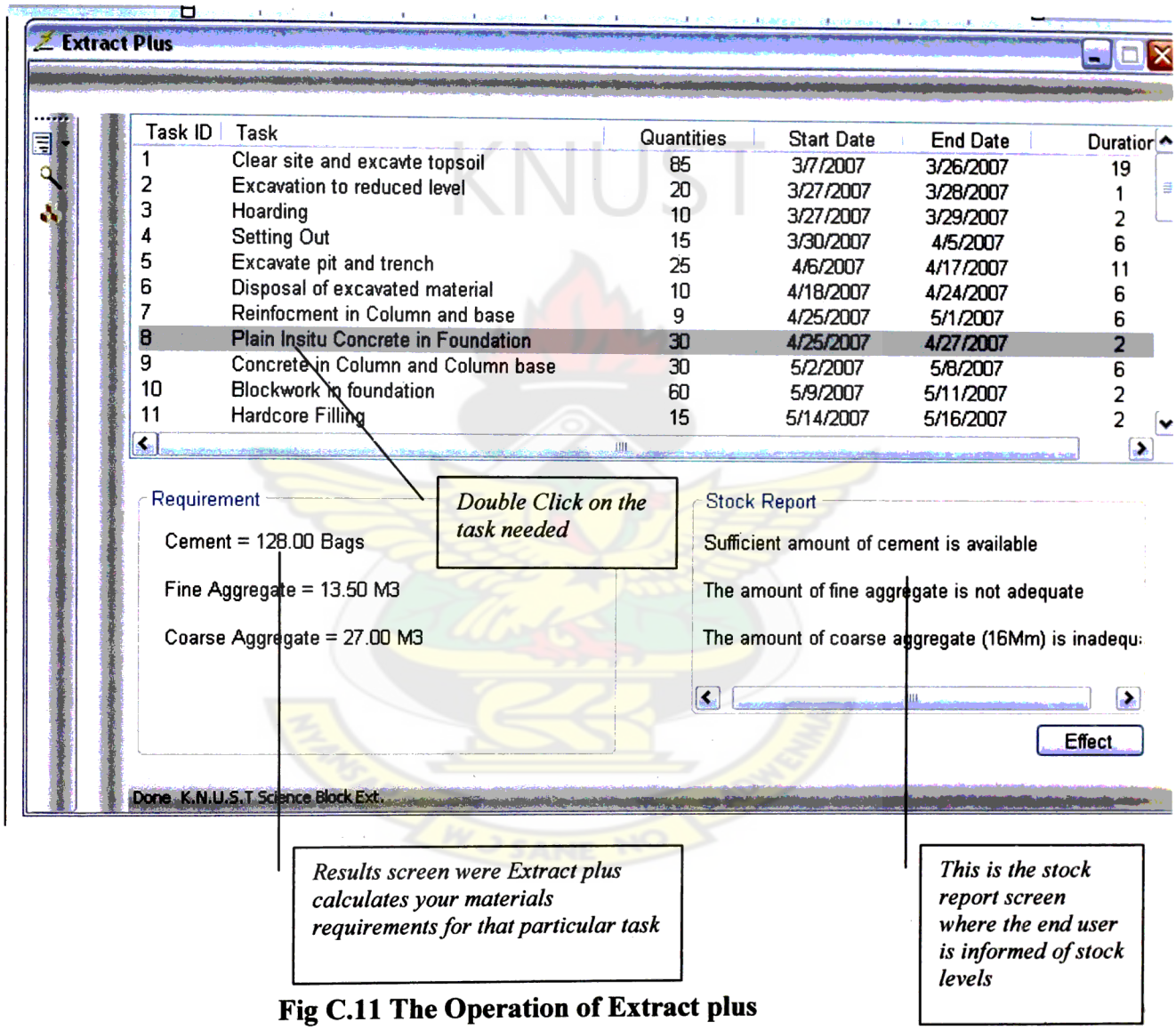


Fig C.11 The Operation of Extract plus

For step 12 the end user would need to click on the drop down menu and double click on *stock properties* to open the window below. This is the window where the end user would add all stock for the project into Extract plus's database.

Step 12

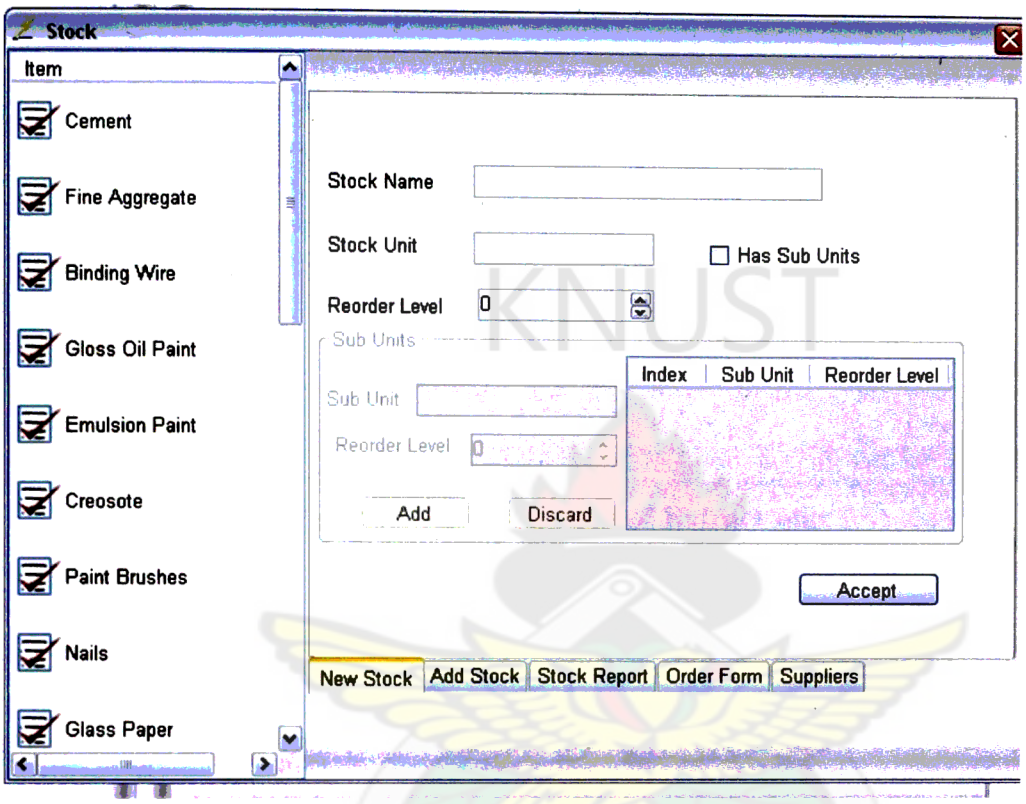


Fig C.12 The Operation of Extract plus

Step 13

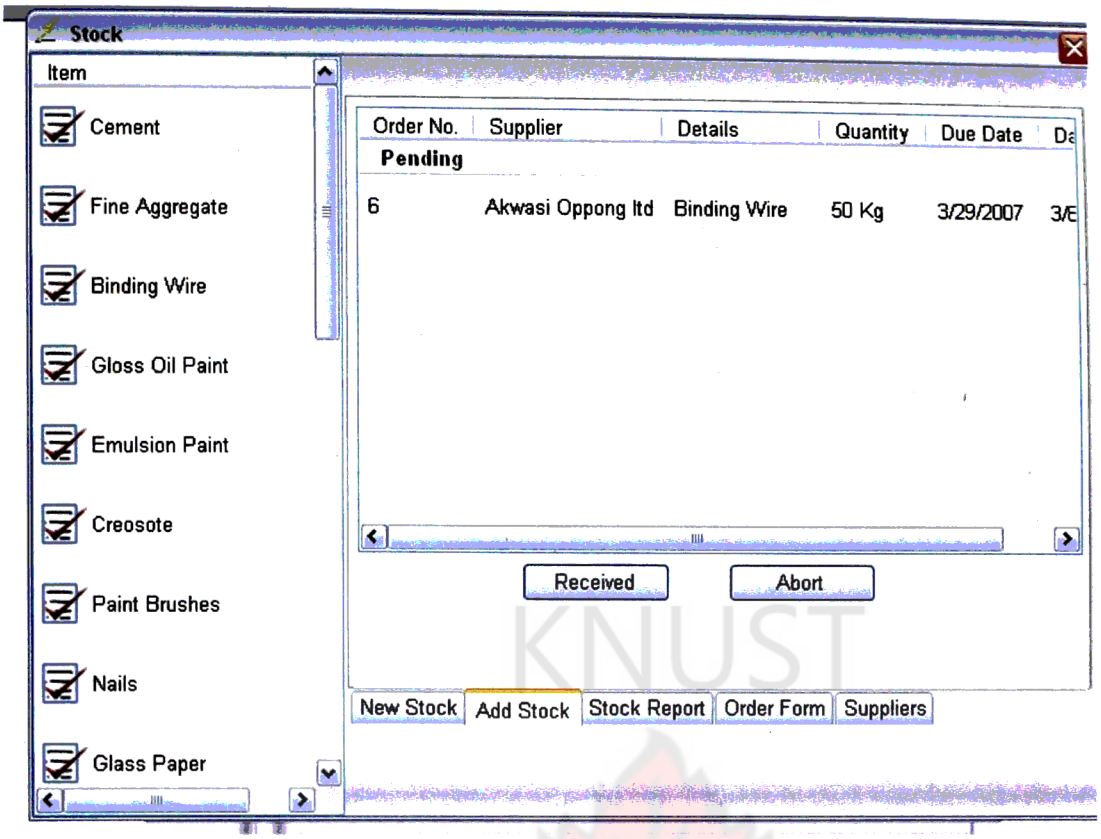


Fig C.13 The Operation of Extract plus

This window (Add Stock) shows pending orders as well as delayed orders to the end user as well as giving the end user the opportunity to receive delivered goods or aborting the order if the order is delayed.

Step14

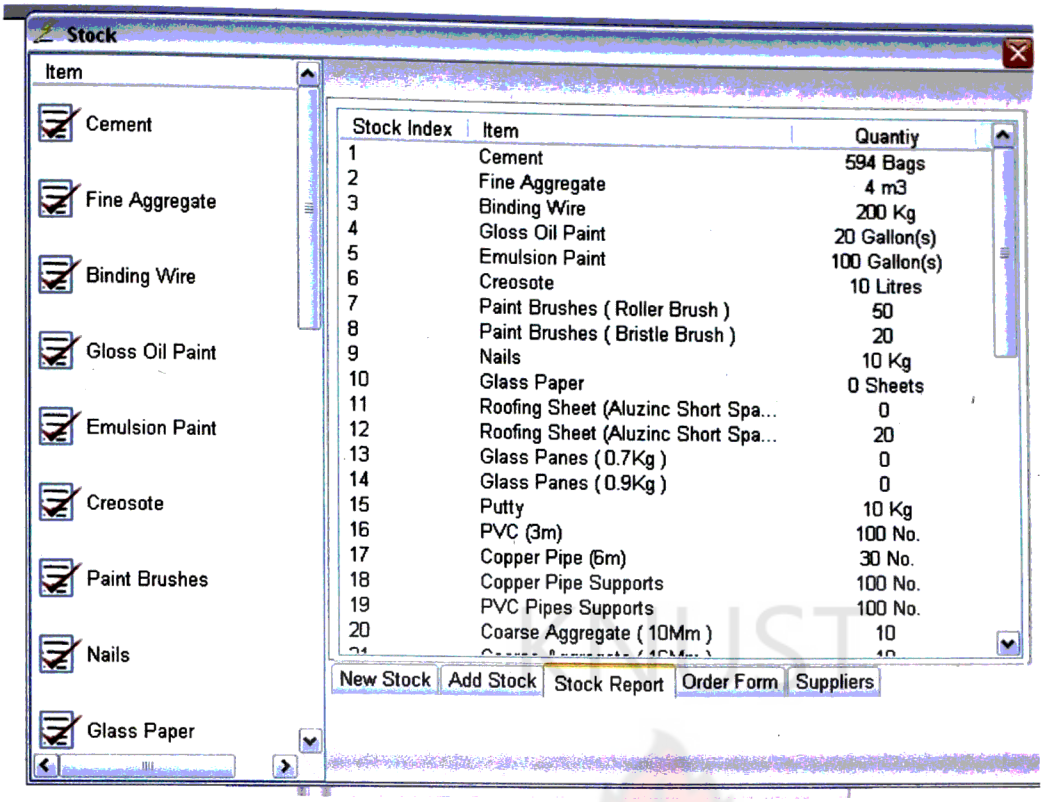


Fig C.14 The Operation of Extract plus

This window (stock report) shows the end user the stock report of Extract plus showing a list of all materials and their stock levels in the database.

Step 15

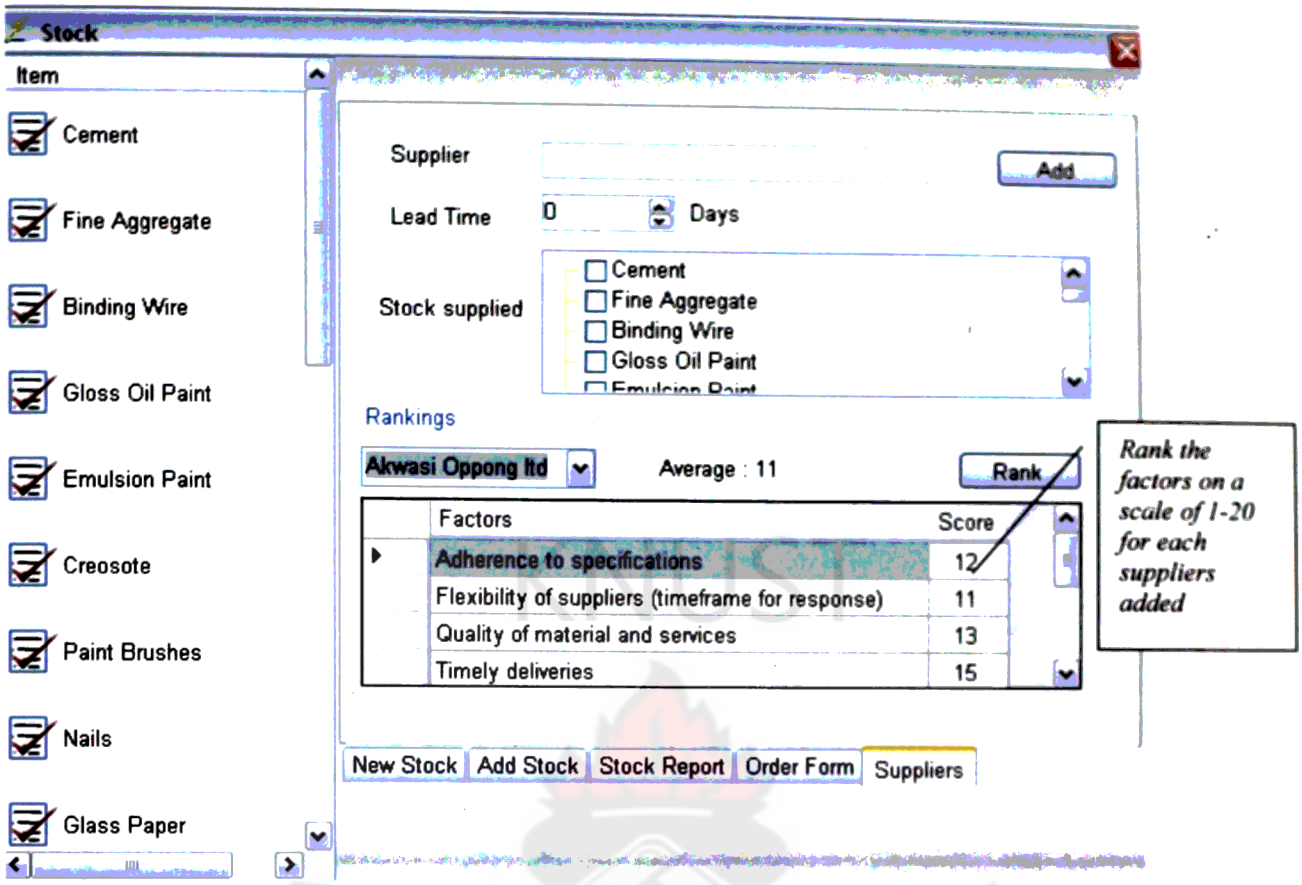


Fig C.15 The Operation of Extract plus

This step the supplier is added to the database of Extract plus, the end user inputs data like the type of materials supplied by the supplier, lead times on that material. The lower half of the window deals with ranking the supplier based on the factors listed on the LHS of the window, this would normally be based on the end users past experience with the supplier. The suppliers are ranked and the top three for every material pops up on the next window when placing an order.

Step 16

Fig C.16 The Operation of Extract plus

This window asks the end user to select a material to order, the supplier is selected from a drop down menu in the order of first, second and so on based on their rank. Once the supplier is selected based on the suppliers lead time a fixed date is set for delivery, if there is no need for lead times then a flexible calendar drops down for the selection of delivery date. The unit price and the quantity to be ordered are also placed. Another interesting feature is that all orders placed for a particular material are kept in Extract plus database for future checks and references, when every information is satisfactory, then the order button is clicked, followed by the print button for a print out (shown below), to be dispatched.

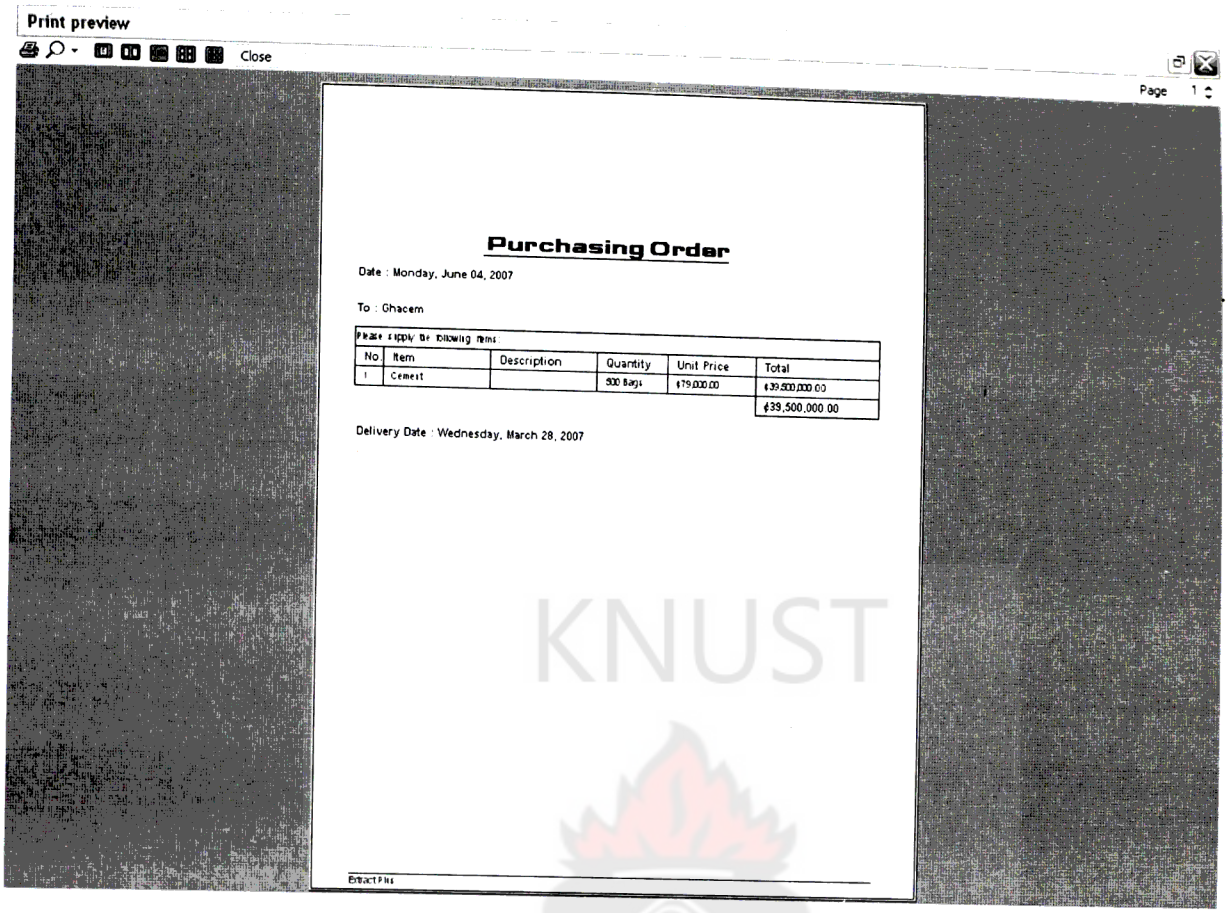


Fig C.17 The Print Out Sheet of Extract plus

APPENDIX D

(A SAMPLE OF THE SYNTAX/CODING FOR THE MODEL)

```
E:\Dotnet_trials\2005.trials\Extract ... Plus\Extract Plus\Exl_sheet.Designer.vb 3
132 Me.gp_input_cells.SuspendLayout()
133 Me.tab_stands.SuspendLayout()
134 Me.gp_vals.SuspendLayout()
135 CType(Me.num_val5, System.ComponentModel.ISupportInitialize).BeginInit()
136 CType(Me.num_val4, System.ComponentModel.ISupportInitialize).BeginInit()
137 CType(Me.num_val3, System.ComponentModel.ISupportInitialize).BeginInit()
138 CType(Me.num_val2, System.ComponentModel.ISupportInitialize).BeginInit()
139 CType(Me.num_val1, System.ComponentModel.ISupportInitialize).BeginInit()
140 Me.tab_summary.SuspendLayout()
141 Me.pn_sheet_set.SuspendLayout()
142 Me.ContextMenuStrip2.SuspendLayout()
143 Me.ContextMenuStrip1.SuspendLayout()
144 Me.SuspendLayout()
145 '
146 'tree_sheet
147 '
148 Me.tree_sheet.Dock = System.Windows.Forms.DockStyle.Left
149 Me.tree_sheet.ImageKey = "Cross.jpg"
150 Me.tree_sheet.ImageList = Me.ImageList1
151 Me.tree_sheet.Location = New System.Drawing.Point(0, 0)
152 Me.tree_sheet.Name = "tree_sheet"
153 Me.tree_sheet.SelectedImageKey = "Cross.jpg"
154 Me.tree_sheet.Size = New System.Drawing.Size(183, 528)
155 Me.tree_sheet.TabIndex = 0
156 '
157 'ImageList1
158 '
159 Me.ImageList1.ImageStream = CType(resources.GetObject("ImageList1.ImageStream
"), System.Windows.Forms.ImageListStreamer)
160 Me.ImageList1.TransparentColor = System.Drawing.Color.Transparent
161 Me.ImageList1.Images.SetKeyName(0, "Cross.jpg")
162 Me.ImageList1.Images.SetKeyName(1, "Play_triangle1.bmp")
163 '
164 'cmd_sheet_set
165 '
166 Me.cmd_sheet_set.BackColor = System.Drawing.Color.AliceBlue
167 Me.cmd_sheet_set.Location = New System.Drawing.Point(188, 456)
168 Me.cmd_sheet_set.Name = "cmd_sheet_set"
169 Me.cmd_sheet_set.Size = New System.Drawing.Size(124, 30)
170 Me.cmd_sheet_set.TabIndex = 1
171 Me.cmd_sheet_set.Text = "Quantity Sheet"
172 Me.cmd_sheet_set.UseVisualStyleBackColor = False
173 '
174 'cmd_new_sheet
175 '
176 Me.cmd_new_sheet.BackColor = System.Drawing.Color.Transparent
177 Me.cmd_new_sheet.Location = New System.Drawing.Point(312, 456)
178 Me.cmd_new_sheet.Name = "cmd_new_sheet"
179 Me.cmd_new_sheet.Size = New System.Drawing.Size(124, 30)
180 Me.cmd_new_sheet.TabIndex = 2
181 Me.cmd_new_sheet.Text = " Sheet Settings"
182 Me.cmd_new_sheet.UseVisualStyleBackColor = False
183 '
184 'pb_new_sheet
185 '
186 Me.pb_new_sheet.BackColor = System.Drawing.Color.Transparent
187 Me.pb_new_sheet.BackgroundImageLayout = System.Windows.Forms.ImageLayout.
Stretch
188 Me.pb_new_sheet.Controls.Add(Me.ck_no_stand)
189 Me.pb_new_sheet.Controls.Add(Me.comb_sheet_name)
190 Me.pb_new_sheet.Controls.Add(Me.cmd_addnew_sheet)
191 Me.pb_new_sheet.Controls.Add(Me.gp_standard)
192 Me.pb_new_sheet.Controls.Add(Me.gp_input)
193 Me.pb_new_sheet.Controls.Add(Me.TabControl1)
194 Me.pb_new_sheet.Controls.Add(Me.cmd_new_standard)
195 Me.pb_new_sheet.Controls.Add(Me.cmd_cancel
```

APPENDIX E

(CLASSIFICATIION OF CONTRACTORS FOR BUILDING WORKS BY THE MIN. OF WATER RESOURCES, WORKS AND HOUSING)

INITIAL REGISTRATION FEE

CLASS	INITIAL FEE (¢)	RENEWAL FEE(¢)
D1/K1	10,000,000.00 Each	5,000,000.00 Each
D2/K2	3,000,000.00 Each	1,000,000.00 Each
D3/K3	500,000.00 Each	200,000.00 Each
D4/K4	200,000.00 Each	100,000.00 Each

Operational Financial Ceiling

The Contractors are classified into the classes below.

OPERATIONAL FINANCIAL CEILING (CEDIS EQUIVALENT OF)		
FINANCIAL CLASS	CATEGORY "D" GENERAL BUILDING	CATEGORY "K" CIVIL WORKS
1	Over US$500,000.00	Over US$500,000.00
2	US$ (200,000.00 – 500,000.00)	US$ (200,000.00 – 500,000.00)
3	US$ (75,000.00 – 200,000.00)	US$ (75,000.00 – 200,000.00)
4	Up to US$75,000.00	Up to US$75,000.00

MINIMUM PERSONNEL REQUIREMENT FOR CLASSIFICATION

Table "A"

"D1" – GENERAL BUILDING WORKS

ITEM	DESCRIPTION	NO. REQUIRED	QUALIFICATION
1	Works Manager	2	10 years building construction with Building Technology, Architecture/Engineering, Surveying Diploma and/or City & Guilds Final in Carpentry or Masonry or equivalent, or 7 years building construction experience and Building Technology/Architecture/Surveying Degree or equivalent.
2	Quantity Surveyor	1	BSc. Building Technology with 5 years experience or AGIS or Diploma with 6 years experience.
3	Site Agent	2	Building Technology, Architecture, Engineering, Surveying Degree and/or City & Guilds Final in Carpentry or Masonry or equivalent.
4	Accounts Officer	1	ACA Part 1 or 15 years approved experience.
5	Works Superintendent	3	!0 years experience in building construction with Intermediate or Final City & Guilds in Carpentry or Masonry or O.T.D. in building.
6	Carpentry Foreman	8	8 years experience in Carpentry
7	Mason Foreman	8	8 years experience in Masonry
8	Steel Bender Foreman	8	8 years experience in Steel Bending
9	Surveyor	2	10 years practical experience
10	Painter Foreman	8	8 years experience in Painting
11	Purchasing Officer	1	8 years experience in Purchasing

MINIMUM PERSONNEL REQUIREMENT FOR CLASSIFICATION

Table "A" (continued)

"D2" – GENERAL BUILDING WORKS

ITEM	DESCRIPTION	NO. REQUIRED	QUALIFICATION
1	Works Superintendent	2	10 years building construction with Building Technology, Architecture/Engineering, Surveying Diploma and/or City & Guilds Final in Carpentry or Masonry
2	General Works Foreman	3	7 years building construction experience, Intermediate City & Guilds Final in Carpentry or Masonry.
3	Carpentry Foreman	2	5 years experience in Carpentry
4	Mason Foreman	2	5 years experience in Masonry
5	Steel Bender Foreman	2	5 years experience in Steel Bending
6	Surveyor	2	5 years practical experience
7	Painter Foreman	1	5 years experience in Painting
8	Purchasing Officer	1	5 years experience in Purchasing

MINIMUM PERSONNEL REQUIREMENT FOR CLASSIFICATION

Table "A" (continued)

"D3" – GENERAL BUILDING WORKS

ITEM	DESCRIPTION	NO. REQUIRED	QUALIFICATION
1	Works Superintendent	8	7 years building construction experience with City & Guilds Intermediate in Carpentry or Masonry (minimum qualification).
2	General Foreman	2	7 years building construction experience with Intermediate City & Guilds in Carpentry or Masonry.
3	Carpentry Foreman	2	5 years experience in Carpentry
4	Painting Foreman	1	5 years experience in Painting
5	Mason Foreman	2	5 years experience in Masonry
6	Steel Bender Foreman	1	5 years experience in Steel Bending
7	Surveyor	1	3 years practical experience
8	Purchasing Officer	1	3 years experience in Purchasing
9	Book-Keeper	1	5 years minimum experience.

MINIMUM PERSONNEL REQUIREMENT FOR CLASSIFICATION

Table "A" (continued)

"D4" – GENERAL BUILDING WORKS

ITEM	DESCRIPTION	NO. REQUIRED	QUALIFICATION
1	General Foreman	1	5 years building construction experience with Intermediate City & Guilds in Masonry.
2	Mason Foreman	1	3 years experience in Masonry
3	Carpentry Foreman	1	3 years minimum experience
4	Painting Foreman	1	3 years minimum experience
5	Book-Keeper	1	5 years minimum experience.