Feasibility & Development of an Arabic/English Computer-Aided Detailed Estimating System

by

Habib Abdul-Sater Musallam Fayadh

A Thesis Presented to the

FACULTY OF THE COLLEGE OF GRADUATE STUDIES

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

DHAHRAN, SAUDI ARABIA

In Partial Fulfillment of the
Requirements for the Degree of

MASTER OF SCIENCE

In

CONSTRUCTION ENGINEERING AND MANAGEMENT

May, 1990

INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

UMI

A Bell & Howell Information Company
300 North Zeeb Road, Ann Arbor MI 48106-1346 USA
313/761-4700 800/521-0600

NOTE TO USERS

The original document received by UMI
contained pages with
indistinct print. Pages were filmed as received.

This reproduction is the best copy available.

UMI

FEASIBILITY & DEVELOPMENT OF AN ARABIC / ENGLISH COMPUTER-AIDED DETAILED ESTIMATING SYSTEM

LIBRARY
KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
DHAHRAN - 31261, SAUDI ARABIA

BY

HABIB ABDUL-SATER MUSALLAM FAYADH

A Thesis Presented to the

FACULTY OF THE COLLEGE OF GRADUATE STUDIES

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

DHAHRAN, SAUDI ARABIA

In Partial Fulfillment of the
Requirements for the Degree of

MASTER OF SCIENCE
In

CONSTRUCTION ENGINEERING AND MANAGEMENT

May, 1990

UMI Number: 1381129

UMI Microform 1381129
Copyright 1996, by UMI Company. All rights reserved.

This microform edition is protected against unauthorized copying under Title 17, United States Code.

UMI
300 North Zeeb Road
Ann Arbor, MI 48103

FEASIBILITY & DEVELOPMENT OF AN ARABIC / ENGLISH COMPUTER-AIDED DETAILED ESTIMATING SYSTEM

by

HABIB ABDUL-SATER MUSALLAM FAYADH

A Thesis Presented to the

FACULTY OF COLLEGE OF GRADUATE STUDIES

In Partial Fulfillment of the Requirements

for the degree

MASTER OF SCIENCE

IN

CONSTRUCTION ENGINEERING AND MANAGEMENT

KING FAHD UNIVERSITY

OF PETROLEUM AND MINERALS

Dhahran, Saudi Arabia

May, 1990

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
DHAHRAN 31261, SAUDI ARABIA

COLLEGE OF GRADUATE STUDIES

This thesis is written by **HABIB ABDULSATER MUSALLAM FAYADH** under the direction of his Thesis Advisor and approved by his Thesis Committee, has been presented to and accepted by the Dean of the College Graduate Studies, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN CONSTRUCTION ENGINEERING AND MANAGEMENT.**

Spec.
A
1
.F3933
c.3

1004035 / 1069304

Thesis Committee

Dr. Kamal Al-Subhi
Thesis Advisor

Dr. Sadi Assaf
Member

Dr. Abdullah Abdulgader
Member

Dr. Mustapha Ziad
Member

Department Chairman

Dr. Sadi Assaf

Dean, College of Graduate Studies

Dr. Ala Alrabeh

Date: 19-5-90

This thesis is dedicated to my beloved parents and family for their continuous support.

ACKNOWLEDGEMENT

Acknowledgement is due to King Fahd University of Petroleum and Minerals for support of this research.

I wish to express may appreciation to Dr. Kamal Al-Subhi who served as my Thesis Committee Chairman. I also wish to thank the other members of my Thesis Committee, Dr. Sadi Assaf, Dr. Abdullah Abdul-Gader,and Dr. Mustapha Ziad for their comments and suggestions.

Sincere thanks are due to Mr. Luqman Nagy who edited this work. Finally, thanks to all those who helped me in completing this research.

TABLE OF CONTENT

page

page

LIST OF TABLES

LIST OF FIGURES

Figure | Page

خلاصـــة الرسالـــة

اسم الطالب الكامـل : حبيب عبد الساتر مسّلم فياض

عنـوان الدراســـه : تقدير تكلفة المشاريع بأستخدام الحاسب الآلي

التخـــصـــص : إدارة المشاريع

تاريخ الشهـــادة : ٢٠ / ٥ /١٩٩٠م

تناقش هذه الرساله أهم المشاكل و الصعوبات التى تواجه مقاولى البناء عند تقدير تكلفة المشاريع و قد قام الباحث باجراء مسح استبيانى شمل ٢٤ مقاول بناء من الدرجة الأولى يعملون بالمنطقه الشرقيه من المملكه العربيه السعوديه

و قد اشتمل الأستبيان على عدة اجزاء ، حيث يبحث الجزء الأول الخطوات المتبعه في اعداد تكلفة المشاريع. أما الجزء الثاني فيتناول أهم المشاكل التى تواجه المهندسين عند إعداد التكلفة و أهم المعلومات التي يجب توفرها لاعداد التكلفه. و يحتوى الجزء الثالث و الأخير عدة اسئله تتعلق باستخدام الكمبيوتر في اعداد تكلفة المشاريع.

لقد تبين من نتائج الأستبيان قلة استخدام الحاسب الآلي في اعداد تكلفة المشاريع، رغم ما يقدمه الحاسب الآلى من مميزات في إعداد هذه العمليه بشكل خاص.

و قد قام الباحث بتطوير برنامج للحاسب الآلي يساعد التغلب على الكثير من المشاكل المتعلقه بعملية اعداد تكلفه المشاريع. و يعمل هذا البرنامج باللغتين العربيه و الأنجليزيه. و من أهم مميزات هذا البرنامج هو التغلب على الأخطاء الحسابيه و توفير الكثير من الوقت.

و في نهاية البحث قدّمت بعض الاقتراحات بشأن المواضيع التى يمكن التعمق فى دراستها مستقبلاً.

درجة الماجستير في العلوم

جامعـة الملـك فهـد للبتـرول و المعـــادن

الظهـران ، المملكـة العربيـة السعوديـــة

التاريخ : ٢٥/ ١٠ /١٤١٠هـ

THESIS ABSTRACT

NAME OF STUDENT : HABIB ABDUL-SATER MUSLLAM FAYADH

TITLE OF STUDY : FEASIBILITY & DEVELOPMENT OF AN ARABIC / ENGLISH COMPUTER-AIDED DETAILED ESTIMATING SYSTEM

MAJOR FIELD : CONSTRUCTION ENGINEERING & MANAGEMENT

DATE OF DEGREE : MAY, 1990

The process of cost estimating is a key factor contributing to the success or failure of the construction firm. This thesis discusses the main problems facing the local building contractors in the area of cost estimating. To identify the major problems, a sample survey of twenty-four building contractors classified as Type A by the Ministry of Commerce in the Eastern Province of Saudi Arabia was undertaken. The survey includes several parts such as the process of detailed estimating, the information needed in developing the estimate, and the major problems frequently facing the estimators in this process.The results of this survey are presented here.

It has been revealed by this survey, that many contractors, utilize manual estimating methods that require an excessive amount of time and effort to prepare a project bidding cost. Certainly, manual estimating systems or methods do not provide the flexibility for revision and reviewing the project bid.

In an attempt to solve some estimating problems, a microcomputer estimating system that can be used through the English and Arabic languages was developed. The development of this system is presented and discussed here. The system will assist in reducing the estimating time, effort, the calculation, and omission errors. The most important feature of this system is that all of its functions are accessible through a menu system, giving the estimator complete control over the estimation process.

MASTER OF SCIENCE DEGREE

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
DHAHRAN, SAUDI ARABIA

MAY, 1990

CHAPTER I

INTRODUCTION

1.1 General

Based on the amount of information available on a given project, construction cost estimates, frequently defined as the process of forecast of predefined future events, can be categorized into three general different groupings:

1) Preliminary or feasibility estimate,
2) Gross budget estimate, and
3) Detailed estimate.

These kinds of cost estimates must be made for a construction project - from its conception as a project through its completion. The feasibility estimate is used by the owner to measure the benefits and costs of the project at an early stage. Gross estimate is used to support the feasibility estimate. The purpose of the gross estimate is to evaluate possible design modifications to keep the project within the owner's budget; to evaluate contractor bids; and as an aid in budgeting cash-flow needs through the project [Adrian, 1982]. However, a contractor's detailed estimates play the most significant role in the construction process.

Although all construction cost estimates have a common goal, estimating methods employed are governed by the purpose of the estimate, and the stage of design or construction at which the estimate is produced.

Obviously, one can expect the degree of accuracy to vary with the amount of effort, and time taken to prepare an estimate. The quality of the estimate depends on how much information is available about the project to be estimated.

Because of the uncertainties of future events, combined with judgement and experience needed by the estimator, construction estimation will never be totally scientific . Instead the preparation of accurate construction estimates, is partly a science and partly an art, [Adrian, 1982].

The successful preparation of a construction estimate includes: the determination of work to be performed, the determination of the productivity of the resources to be used for the work, and the determination of the cost of each of these resources. The ultimate functions of construction estimates, are to identify resource requirements, costs, and durations. So it is important that the contractor is specific in his estimates to ensure that the client is fully aware of his financial obligations.

Estimating ability is one of three factors contributing to the financial success of a construction company; the other two are its success in obtaining work, and its ability to perform the work in an efficient manner. Neil [1981] has concluded that the inability to determine a bid price that adequately covers the construction and overhead costs as well as a suitable profit, was one of the major causes of contractor failure in the construction industry.

1.2 Statement of the Problem

In an atmosphere of intense competition, the real challenge is not the preparation of an estimate, it is to arrive at a competitive bid free of mistakes. According to the Task Committee on Cost Control of the Construction Division

of the ASCE, estimating mistakes generally fall into three categories: judgment errors, omissions, and mathematical or procedural errors. Combining with the fact that construction firms are frequently asked to provide time and cost estimates for projects whose scope is only very loosely defined. Johannes [1987], identified two major problems involved in estimating project costs. One problem is the high level of risk and uncertainty in the estimate. The risk and uncertainty are basically attributable to three factors: (1) requirements are subject to change; (2) innovation may be required during the project; and (3) risks are inherent in the project's life cycle since errors are inevitable. The second major problem in estimating costs is the lack of standardization and a quantitative historical cost data-base. Adrian [1982], concluded that without referance standards and well arranged historical data, it is nearly impossible to estimate the cost of a new project accurately. Each of these problems and factors tend to increase the project's costs. It is possible to take the advantages afforded by the available microcomputer technology to reduce estimating mistakes and to create good data-base files that contain all data needed in the bid preparation.

Unfortunately, it is believed that the Saudi construction market is not faraway from the estimating problems. Moreover, many Saudi contractors strongly believe that it is quite often that the lowest bidder, and consequently the one who awarded the contract, is the one makes the biggest mistakes in calculating his quantities and prices, [Personal Interviews]. In addition, due to the slump in government oil revenus, Saudi Arabia has been paying increasing attention to the construction costs and emphasizing the need for economy in design, accuracy in cost forecasting and effective cost control during the construction. [MEED, 6:6:1987,pp.40]

1.3 Objectives of the Study

Estimating construction costs, like other phases of business has undergone extensive changes in the past years because of the increased complexity and size of construction projects; changes in the economy; and changes in the estimating tools available to the estimator. The biggest change in the last years in the art of estimating has been the introduction of computers. It is the purpose of this work to investigate, develop, and implement a prototype Arabic Detailed Estimating Software. Within this overall purpose are the following specific goals:

1. to interview construction estimators, to know methods of estimating in Saudi Arabia, and to assess the need for Arabic cost estimating software,
2. to develop a conceptual framework for the Arabic estimating system,
3. to establish the technical feasibility of an Arabic Estimating System,
4. to develop the approach for the computer implementation of such a software. This includes developing some computer procedures for applying some of the function of the proposed software, and
5. to develop a simplified cost data base for using the software.

1.4 Scope

This research will be limited to the building construction contractors working in the Eastern Province of Saudi Arabia. In an attempt to include the contractors who obtain most of their work through competitive bidding, this research will be restricted to building contractors, classified as the first class by the Ministry of Commerce.

1.5 Organization

This Study is organized into six chapters. A comprehensive literature review related to the detailed construction cost estimating process and the applications of microcomputers in this process is presented in Chapter Two. This chapter includes also, an overview of the software development strategy. Chapter Three details the formulation of the sampling survey questionnaire, the research methodology used in the study, and the statistical sampling procedures. Chapter Four discusses and presents data analysis methods, and the survey results. This chapter shows the information needed in developing the cost estimate, the problem facing the local contractors in developing the detailed cost estimate, and the steps followed to develop such an estimate. Chapter Five details the steps undertaken in developing the system. This chapter contains the conceptual framework of the system and the approach for computer implementation of the system. The recommendations and conclusions of this study are presented in Chapter Six.

CHAPTER II

LITERATURE REVIEW

Construction cost estimating has been receiving broad attention in construction engineering literature. There has been a clear understanding that cost estimating is the most important task a contractor performs to improve profits and reduce risk. To keep pace with development in the modern day construction industry, many researches, and studies have been conducted. The main purpose of these efforts was to overcome the problems associated with construction cost estimating while optimizing the estimating preparation effort.

This chapter reviews prior investigations, studies, and researches of construction cost estimating and the development of computerized construction estimating softwares.

Available written materials on the subject of computerized cost estimating are found in several types of publications including: estimating textbooks, construction management books, and technical and professional papers.

2.1 Detailed Cost Estimating

Detailed cost estimating is the process whereby the contractor arrives at a timely expenditure of resources necessary to complete a construction project in accordance with the plans and specifications provided by the owner. This estimate must be very accurate and competitive to insure both getting the job and making a profit.

In preparing his estimate, the contractor must consider both the direct and indirect costs of construction. Direct costs are generally those costs that are incurred only for a particular project, such as labor, materials, equipment, and consumeables. Indirect costs, on the other hand, are generally those that are incurred as a normal cost of doing business but not wholly attributable to a particular project, such as office overhead, interest on money borrowed, and salaried supervision. Indirect costs are highly dependent on the project time, schedule, and the cash flow produced by progress payments.

The resources (skills, calender time, and man-hours) required to prepare a detailed cost estimate depend on a number of factors. One factor is the estimating experience. Another is the level of technology or state of the art involved in the job or task being estimated. Availability of orderly and complete historical cost data of previous similar construction projects is another factor. The information provided by the owner [plans and specifications] are the most important factor.

Many tools are currently available to the construction cost estimator, and many others are being developed. Among these are cost estimating handbooks that give up-to-date costs for most construction materials and operations, electromechanical devices to simplify quantity takeoffs from drawings, computers to assist in calculations, and sophisticated scheduling techniques. However, no tool is as important to the construction cost estimator as experience. The lessons learned from past successes and failures are the most important assets.

2.1.1 Sources of Information

Skitmore [1988] concluded that the accuracy of the construction estimate is

positively correlated with the amount of project information available. The information needed to perform a detailed estimate is supplied by the owner (specifications and plans), and the contractor's historical records.

The nature and extent of the construction to be done, the materials to be provided, and the quality of the workmanship required are described by the drawings and specifications. Complementing each other very closely, the drawings and specifications present a complete description of the work, and they serve as a basis for preparing the contractor's detailed estimate. The drawings portray pictorially the extent and arrangement of the components of the structure. The specifications describe verbally the materials and workmanship required .

Keeping orderly and complete files of all previous construction projects is very important for estimating future work. These files may include accurate records of bid documents, estimated and actual costs, materials prices, wages for different trades, wastage percentages, productivity rates of labor an equipment, and subcontractors information.

In effect, the accumulation and use of past project data becomes an essential part of construction cost estimating. Needless to say, historic cost information must be adjusted for differences in wage rates, location, and other conditions affecting construction cost.

2.1.2 Work Package Breakdown

The first step in developing a cost estimate of any type of work output is the development of a work package breakdown structure. The work package serves as a framework for collecting, accumulating, organizing, and computing the

direct and indirect costs of a work activity or work output. There is considerable advantage in using the work packages and its accompanying task descriptions as the basis for scheduling, reporting, tracking, and organizing as well as for initial costing.

A package is developed by subdividing a process into its major activities. These activities are logical pieces of the total project that are easy to identify with a start and a completion. Each package (activity) may vary in size, but it must be a measurable and controlable unit of work. It also must be identifiable in a chart of account in order to permit capture of both budget and actual performance information. A typical work package breakdown structure is shown in Figure 2.1, [Neil,1982].

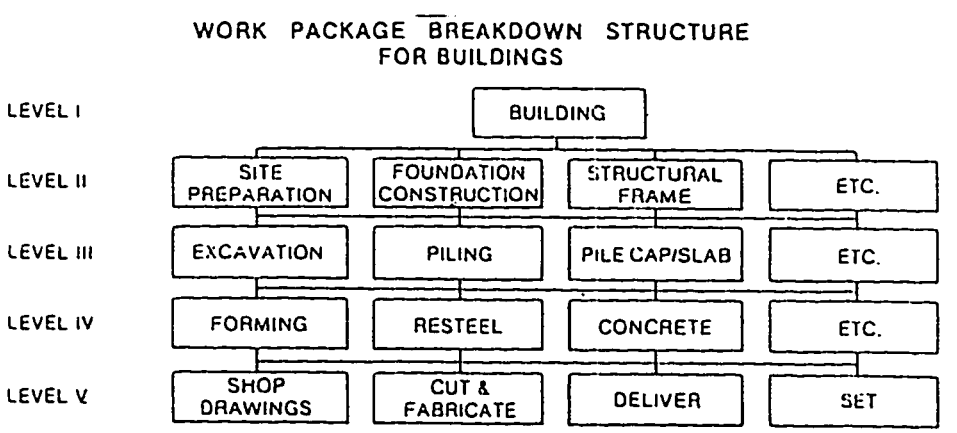


Figure 2.1: Work Pakage Breakdown [Neil 1982]

2.1.3 Cost Coding System

Cost coding is the basic framework upon which the cost budgeting and controlling systems are built. It provides a common language of identification and means of communication to be used by all those concerned with a project.

In coding design, each construction material has a code which is a series of numbers and letters. That code usually contains several items of information such as department, manufacture, and specific item identification.

According to Neil [1981], a well-designed code system must satisfy several requirements:

1. it must facilitate consolidation of information at levels of detail from very broad to very detail;
2. must be compatible with other company accounting systems;
3. must be suitable for computerized processing;
4. must be usable by typical operating personnel; and
5. must support both current and historical needs.

Figure 2.2 is a sample coding format. This sample utilizes 15 digits/letters, each represented by an "X" and these are grouped to provide identification of four categories of information : accounting classification, structure/system identification ,work package identification and resource information,[Neil, 1982].

EXAMPLE CHART OF ACCOUNTS FORMAT

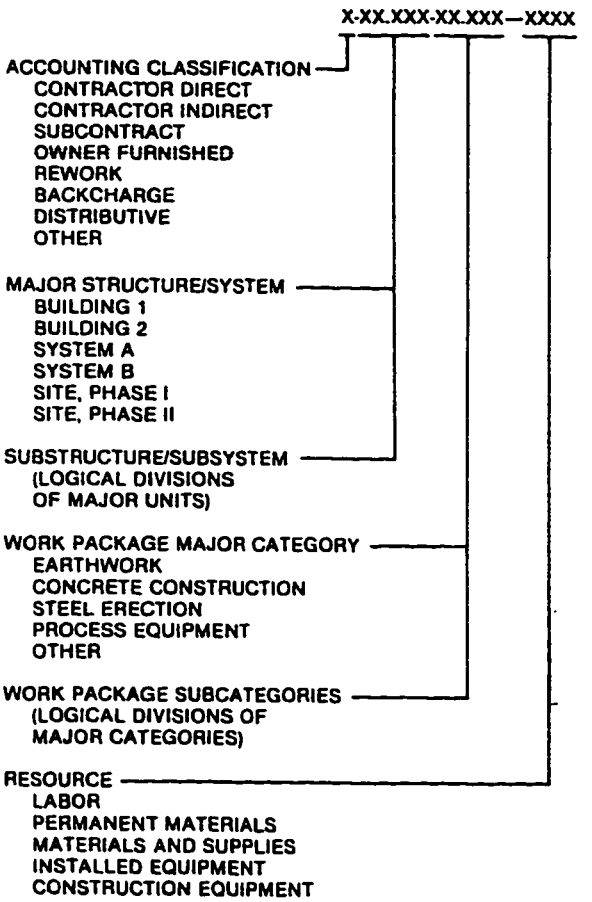


Figure 2.2: Coding System, [Neil, 1982]

2.1.4 Process of Detailed Estimating

The major steps of the detailed estimation are illustrated in Figure 2.3, with the following steps, [Aderian, 1982].

Step 1: Quantity Takeoff. As shown in Figure 2.3, the first step in preparing the detailed cost estimate is the quantity takeoff, whereby the material items are identified, separated by division and section (as found in the two-dimensional drawings representing the project), then priced.

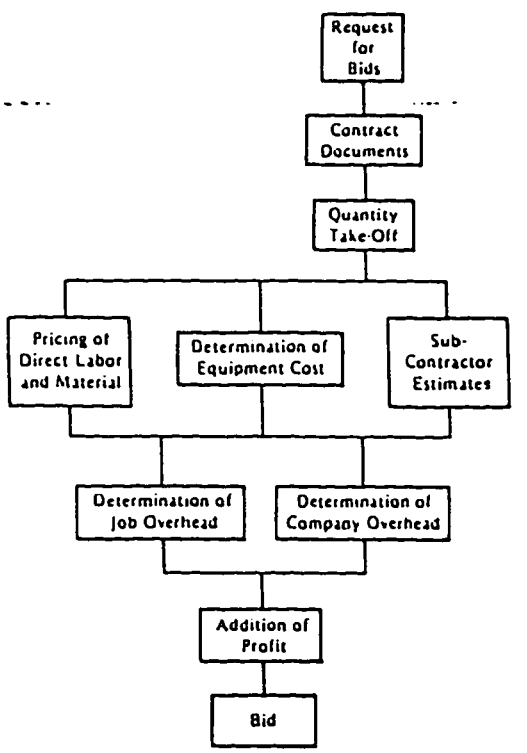


Figure 2.3: The Estimation Process, [Adrian, 1982]

Non-material items such as finishing concrete must also be identified and priced. Quantities identified on the quantity takeoff should be increased for waste caused by trimming, overlapping, and shrinking.

Step 2: Labor Rates. When the quantity takeoff is completed, the next step is to determine the number of man-hours and trades necessary to perform the work. This is accomplished primarily from knowledge gained from having performed similar work in the past. Often these data are structured according to defined work packages.

Step 3: Equipment Rates. Equipment costs assigned to a project's direct costs should represent an amount necessary to own and operate the pieces of equipment plus an amount for eventual replacement. Equipment is sometimes used for several projects during a period, making cost accounting per project very difficult. In this case, the equipment is costed at the prevailing rental rates.

Step 4: Material pricing. Estimating the basic materials required to do a job usually involves an accurate computation of the material quantities, determining the price of the material at that quantity (including a scrap or waste allowance), and calculating the total material costs. Accurate drawing takeoff methods or prespecified bills of material are required to estimate material costs effectively. Historical data and an industrial materials utilization analysis are required to predict scrap and waste accurately.

2.2 Microcomputers in Cost Estimating

Today's microcomputer technology has made it possible for construction firms to enter the computer age at all levels of technical and managerial activities. Microcomputers have became very powerful and able to perform a wide range of manipulating, storing and retrieving timely information for the purposes of planning, scheduling, estimating and controlling of various construction projects. With such dramatic advancement, the cost of these wonderful tools has reached the point where even a lay individual can purchase one.

A microcomputer consists of a number of individual components, which may not be housed in the same physical unit. Typically these components, as shown in Figure 2.4, consist of the following:

1. a microprocessor or central processing unit, which handles all calculations and decision making;

2. an internal memory to store instructions and data for use by the microprocessor;

3. input devices by which the user may supply data to the microprocessor

4. output devices by which the microprocessor communicates to the user the results of the processing;

5. mass nonvolatile and on-line storage for greater program and data handling capacity as well as for storing programs and data when the system is not operating; and

6. software to operate the system and application software programs to perform the user-desired applications.

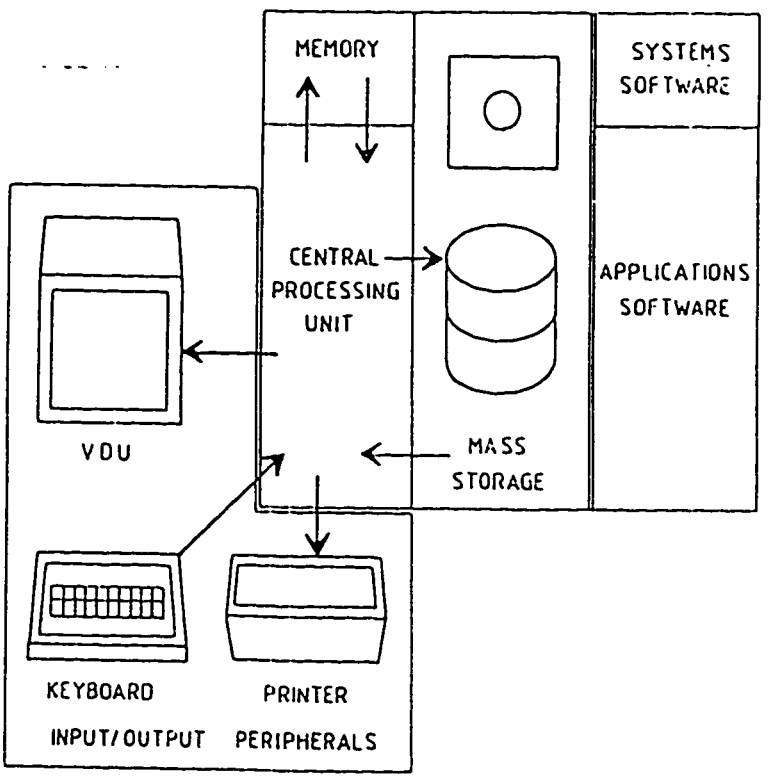


Figure 2.4, Components of a Microcomputer, [McCaffer, 1984]

This part is intended to explore some of the ways microcomputers can be used to help producing accurate estimates in an efficient and rapid manner.

An examination of the steps involved in the process of estimating leads to the conclusion that its automation is likely to expedite it and to improve its accuracy and consistency. Estimating methodical nature and its reliance upon the manipulation of large volumes of data make it attractive for computerization.

Regarding the speed, the manual process of determining the project estimate and bid price initially required approximately 12 hours to complete. The use of a microcomputer requires 3.7 hours to do the same estimatea reduction of almost 70 percent, [Rhyne, Kaminsky 1987]. Of course, computers don't make mistakes or omissions as human beings do.

Adrian [1982], suggested that computers can be used to serve four tasks in preparing construction cost estimate : (1) performing quantity takeoff; (2) storing and retrieving all the data necessary to cost each item; (3) calculating the total direct cost of the project by summing the product of each item's unit cost by the quantity of the item, the estimated job overhead, and the desired profit to obtain a total cost estimate; and (4) summarizing and checking the final results and preparing the form required for bid submission.

2.2.1 Approaches to Computerized Estimating:

2.2.1.1 Computer's Programs

Using one of the programming languages, such as BASIC, the estimater can prepare an exceedingly simple software programs that can solve some of the recurring everyday quotations used by estimaters for developing cost estimating. This approach requires a good knowledge of the language to be used in designing the program. There are several books that assume no prior computer knowledge that enable the practitioner to design and develop his own program. Alternatively, the estimater can eliminate the need to understand programming language, by purchasing and using software as designed and developed by others.

Many classes of computer applications can more effectively be purchased from the market. Obvious examples of these programs are spreadsheet programs, word processing, Data-Base, and other widespread general packages. These programs may be useful after a minimum amount of training and many times can be self-thought using existing manuals.

2.2.1.2 Electronic Spreadsheets

The electronic spreadsheet is the premier example of user friendly software developed for practically all brands of microcomputers, which enables non-programmers to easily,quickly and productively use the microcomputers. Electronic spreadsheets are marketed under trade mark names such as, VisiCalc, Lotus 1-2-3, and Multiplan. Cash-flow analysis, project cost estimating, bid analysis and equipment replacement analysis are examples of tasks that are easily adapted to the spreadsheet's tabular computational format. The electronic

spreadsheet is perhaps the most useful generic tool available to cost estimater.

An electronic spreadsheet is simply a matrix (sheet) of cells identified by columns and rows. Three types of information can be placed in a cell: numbers, labels (titles), and formulas or functions. The formulas tie the different elements of the matrix as identified by their coordinate. Once the formulas or functions are set in the spreadsheet, the program calculates the results as soon as the numbers are entered in the matrix. [Rounds,1984]

Project cost estimating is specially well-suited to spreadsheets because the user can format the estimate calculations to fit the estimating procedures of his own firm. "What-if" analysis that are so important in estimating computations are easily performed with spreadsheets. For example, the effects of alternate crew compositions and different labor productivity rates can be determined in a matter of seconds. Last minute quotations from material suppliers and subcontractors, for example, can easily be incorporated into or deleted from a spreadsheet prepared bid. In summary, spreadsheets can be used for a wide variety of functions that fall into virtually every step of the cost estimating process. [Task Committee of the Construction Division, 1985]

2.2.1.3 Integrated Software Packages

Integrated software packages combine the features of word processing, electronic spreadsheets, data-base programs and often communications and other microcomputer functions. An electronic spreadsheet program is usually the main component of the package. With a suitable microcomputer system, these softwares are versatile, flexible, and time-saving tools that can be used to assist performing virtually most cost estimating functions. However, some computer

skills and programming knowledge are required or must be learned to establish application templates of these tools. [Stewart, 1987]

2.2.1.4 Vertical Market Systems

Vertical market systems are specifically designed to perform the cost estimating function. These systems are more user friendly and require fewer computer skills; one other feature is the use of digitizers to automate the quantity-takeoff process. The vertical market systems are very powerful in creating large and complex cost estimates. Usually the vertical market systems are more expensive ; sometimes they require the purchase of hardware and software as a package, or use special peripheral devices.

Since the introduction of microcomputers, many estimating tools, systems, and softwares have been developed. However, as pointed out by Stewart and Stewart (1986), There is no comprehensive, universal cost estimating software package that can be used in all cost estimating situations, but there are a variety of packages, each having unique features that enable them to be used for different situations.

2.3 Software

2.3.1 Overview

Software generally, can be defined as a set of interrelated and interacting programs. A program is a set of instructions and statements which when decoded by a program, will cause the computer to do the assigned work. Software is the nonphysical or intangible portions of the computer system which provides the interface between the user and the electronic hardware. Computer software is not limited to computer programs. Programs need to be documented as to their structure, components, and use. According to Adrian [1982], this is considered a part of software development. However, Fox [1982], excluded these byproducts from his software's definition.

Fox [1982], and Dologite [1987], categorized all softwares into three overall types:

(1) Applications software. The programs that make the hardware performs a meaningful user tasks, like word processing, payroll, and data storage. Most applications software is bought already programmed, ready for immediate use. Examples of the available applications software are Spreadsheets, Data Processing Systems, Accounting Systems, and Database Management Systems.

(2) Systems Software. The programs that run at use time the applications software. Systems software manage the resources of the computer, i.e.disks, main memory, and CPU. These are used to run the applications software efficiently and control the environment of the applications. Users of application softwares have little direct interface with system software. Systems software consist of operating systems and utility

programs. Most operating systems come on a disk and must first be loaded into computer memory to work. They usually are simply called DOS (Disk Operating Systems). Utility programs are available for mainframe as well as microcomputers as a collection of small, separate programs that mainly help to track files, and to perform disk housekeeping. With this simple microcomputer system, users can use utility commands to format and copy disks as well as to view a directory of disk files.

(3) Support Software. The programs help the programmer to create and control their own software. Compilers and assemblers are the most well known of this category. FORTRAN, COBOL, and BASIC translators are support software, in that they support the effort to create new object programs.

The software or programming of the machine has undergone considerable changes. Brandon and Moore [1983], identified the following software development:

1. the number of computer languages has increased, each of which has been developed for a specific application,

2. some languages have become more like spoken English and therefore easier to use,

3. the operating system of the machine has become more sophisticated and less onerous to implement (sometimes to the point of not being evident to the user),

4. Software development has now reached the point where the machine

can undertake a certain amount of self-programming once a basic structure has been provided by the operator,

5. manuals related to the machine operation machine have become simpler and in many cases include a self-teaching text.

2.3.2 Characteristics of Software

Urzua [1986], lists some of the characteristics that civil engineering microcomputer software should have. Among them the program must:

- accomplish its intended functions,
- be efficient,
- be easily maintained and/or modified,
- be simple to learn and use,and
- have usable documentation.

In the development of a new estimating computer software for governmental uses, Bristol, and Costea [1986], considered the following features:

- ability to store, maintain, update and retrieve historical costs,
- ability to decrease labor spent on manual analysis and manipulation,
- ability to allow easy comparison of unit costs from various bid tabulation,
- ability to allow cost estimaters to analyze contractors for tenders,
- ability to increase uniformity of output data for use on standard bid tabulation forms, and
- flexibility.

One important characteristic of a well-designed software is that it to be interactive. Brandon [1983], has defined the interactive input as a method of operation in which the user is in direct communication with the computer and in which his decisions are influenced by the results. This means that the user could

enter data and get feedback from the computer almost instantly.

Bacher, and Lawrence [1983], classified two ways (modes) to enter data into the computer: batch and interactively. Working in batch mode, the estimater would normally load all of the needed data and then run the program at one time. Interactive input means that the data are entered into the computer as responses to the computer questions; the estimator then receives instant results or feedback.

The advantages of the interactive system are that it can be easier to use and it provides faster results and identifies and corrects mistakes. It also prevents mistakes which can result when another person enters the data, as is the case in most batch systems. In an interactive mode, the estimater creates and controls what is entered and used to create the estimate.

The flexibility of an estimating system software relates to the ease in which the user can access the cost data-base, change costs, store the estimate file, and prepare reports, [Ponder, Thomas and Juan 1986].

2.4 Software Development Strategy

The advent of micro-processor revolution has encouraged the growth of powerful large size softwares for microcomputers during the last few years. Once a decision is made to develop a software of any type, careful planning and programming are required to assure that the software will be well accepted and will meet organizational needs.

The computing industry formalizes the steps to create a new computer system into what it calls the System Development Life Cycle. Dologite [1987], divided the system development life cycle into five steps shown in Figure 2.5

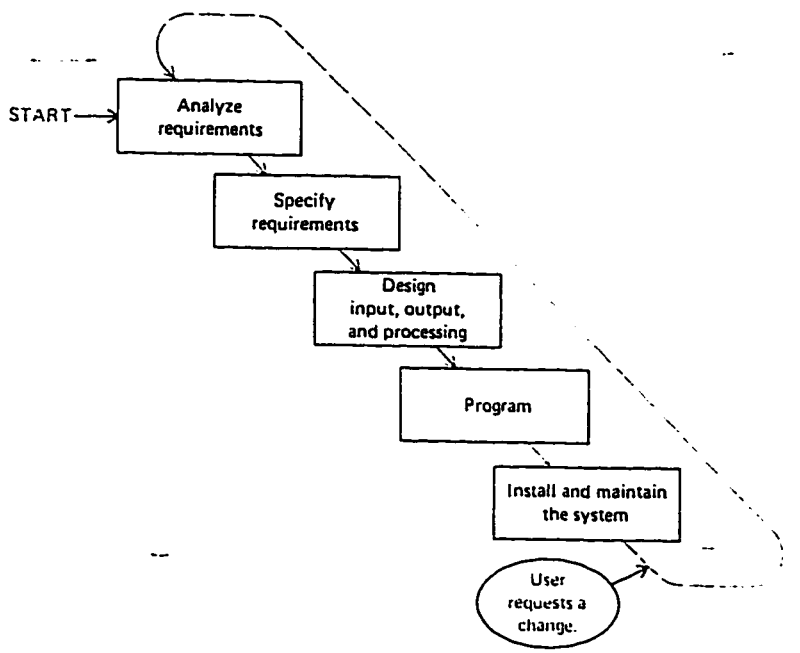


Figure 2.5: System Development Life-Cycle

Figure 2.6, gives a brief description of each step. These steps represent a formal set of guidelines and procedures for taking a system problem from beginning to end.

STEP	DESCRIPTION
Analysis	A user identifies new system requirements. A system analyst investigates the need for a new system and prepares a feasibility report.
Specification	A system analyst creates formal specifications for the new system using a diagramming or other technique.
Design	A system analyst or designer prepares formal design documents, including: Output report and screen layouts (output definition). Database record content. Input screen and form layouts (input definition). Program organization or hierarchy chart. Program logic specifications (processing definition). Hardware specifications, if needed.
Program	Computer programmers code, and test system programs.
Installation and maintenance	A system analyst coordinates system installation, including user training. Users operate the system. System analysts and programmers work with users throughout the life of the system to maintain and upgrade it.

Figure 2.6: Description of System Development Process

Proceeding through the system development life-cycle represents a systematic approach to the initiation and follow-up of a new system project. Even a request to modify an old system follows the same systematic approach to completion, as indicated in figure 2.6.

Using a somewhat different approach, Fox [1983] provided an early analysis of a software development system. In this system, the software's life-cycle consists of three phases: development phase; use phase; and continued development. In the development phase of the life-cycle, six steps are required to complete the software, (Figure 2.7) .

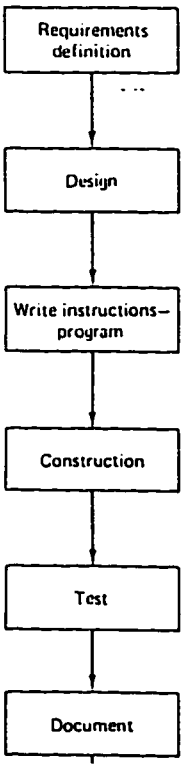


Figure 2.7: System Development Life-Cycle

Simpron [1985], suggested a more comprehensive development system consisting of 12 steps. This system is intended to create a user-friendly software, as shown in Figure 2.8. However, the number of steps is not as important as the concept of the separation of tasks and the level of detailed required [Lindman 1984].

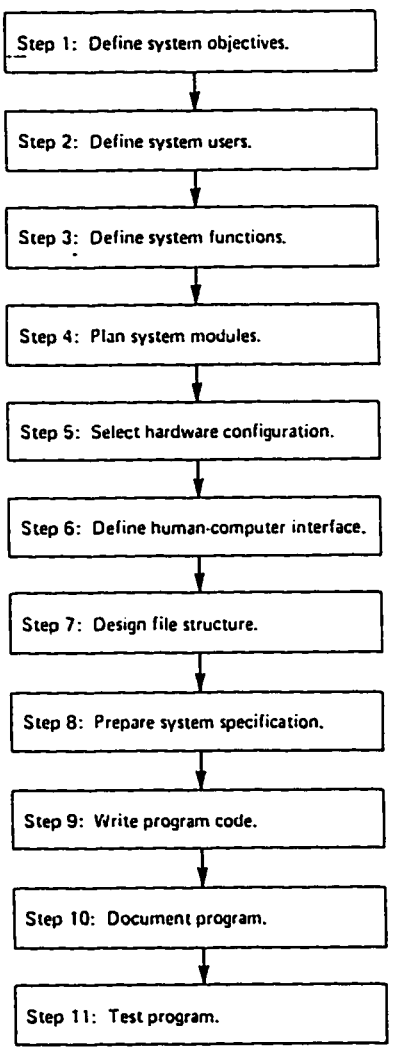


Figure 2.8: System Development Life-Cycle

2.5 Construction Cost Estimating in Saudi Arabia

Several factors have contributed to the creation of a unique construction industry in Saudi Arabia. Al-Jarallah and Mohan [1986], list some special features of the construction business in Saudi Arabia. Some of these are as follow :

- There has been a shortage of local contractors and consultants. Most contractors and consultants are foreign based.

- All unskilled and semiskilled labor is imported from far Eastern and Middle East countries.

- The working time is 10 hrs. a day, 6 days a week. Annual holidays total from 6 to 10 days. This leaves a working period of a bout 305 days a year.

- There are no organized labor unions and no strikes.

- Inflation is minimal. In the last 4 years it has been zero and, on some goods, even minus.

- As much as 40 to 50 percent of materials is imported, and therefore the proportion of material cost is relatively high. Poor material planning and estimates have been the causes of delay on some projects.

- The harsh climate reduces labor productivity and machine life.

- In Saudi Arabia, most of the public works contracted by the Saudi Government use fixed-price contracts and awarded on a competitive base.

- There is no standard form of contract in Saudi Arabia, but there are certain requirements dictated by the Government Tender Law.

2.5.1 Construction Current Situation

The fact that Saudi Arabia has completed most of the major infrastructure projects together with the slump on oil revenues, have resulted in a drastic decline in government spending on construction projects. The Planning Ministry predicts an average annual decline in construction activity of 2.8 % during the Fourth Plan (1985-1990). The impact of this situation are:

1. fewer building projects,

2. the construction market is becoming increasingly tough and competitive;

3. the cost of tender documents has risen considerably.

4. public clients are increasingly turning their attention away from quantity and speed to quality and cost control; and

5. clients are stricter than ever in monitoring the quality of the finished work, increasingly enforcing time penalties, and controlling of contractor's claims.

Moreover, retendes, higher bonding costs, delay in payments, delays in contract awarding and the shrinking volume of advance payments, are other practices that have made life tougher for all contractors.

Since 1982, increasing competitive bidding has forced a drop in tender prices of up to 50 %. Moreover, this fierce competition has helped to drive prices down, in some cases to the point where some companies have been forced to make a loss just to stay in business, [MEED, May 1986] . However, the recession has encouraged the contractors to evolve and adapt to the changing conditions. The weaker companies closed, while those stronger companies adopt some of the following strategies:

1. many contractors have made the transition into the flourishing operation and maintenance sector;

2. foreign and Saudi contractors have cut their overheads;

3. contractors are bidding on 5 to 15% profit margin other than the 50% or so commonly available in the past,

4. most of the contractors have reduced their skilled workforce;

5. some contractors are bidding at unrealistically low prices; and

6. the management and engineering aspects of the project become particularly important.

2.5.2 Estimating Practices

Despite the importance of cost estimate, little have been done with regard to construction cost estimate in Saudi Arabia. Two senior theses have been found dealing partially with cost estimate in the country.

Depending on the project type, three types of estimate are usually done to estimate the construction cost in Saudi Arabia: factor estimate, unit-cost estimate and detailed estimate . Factor estimate is prepared by the contractors of the industrial projects whereas the other two types are performed by the building contractors.

2.6 Arabization

Several techniques for arabizing personal computers have been proposed over the past years. Previous efforts in the direction of developing programming languages have resulted into two commercially available languages: AlKHAWARIZMI, and BASIC. The two languages use Basic language and can be viewed as two translations of it.

Several researches has revealed that to date, there is no an Arabic structured programming language that can effectively support the development of large applications. Instead, a good knowledge of the English language is still a requirement for developing a good practical computer program.

However, several attempts have been made to allow the use of programs that directly access the screen by arabizing the operating systems, both on hardware-base and software-base. Hardware-base arabizing techniques means that certain chips/boards in the computer and its printers have to be replaced by special Arabic-specific components. Software-base on the other hand, doesn't require any hardware replacement. Moreover, leading computer suppliers are stepping up efforts to introduce new Arabic software and hardware products. Attempts are being made to launch an Arabized version of **dBASE IV** and to produce Arabized version of Lotus 1-2-3 spreadsheet, [O'Sullivan, 1989]

A commercially available Arabization software package is NAFITHA ,sold at a cost of SR 350. NAFITHA is a program running under MS-DOS that effectively arabize the operating system. NAFITHA has been conceived as a transparent set of Arabic tools to provide users with the best environment for running popular off-the-shelf software programs without modifications. NAFITHA's additional utilities allow the user maximum control over keyboard layout, ASCII code

definition, screen character definition tables, and a flexible and configureable means of overcoming the peculiarities. NAFITHA has been developed with an open architecture that gives users flexibility in customizing the Arabic environment that best suits their needs as it is totally transparent with the use of any of the programming languages for the IBM PC .

AMEER board is another bilingual (Arabic/Latin) solution for IBM PC and the 100% compatibles, marketed at a cost of SR 900. AMEER is a pure hardware solution which achieves total software transparency with the operating system and applications. Data may be entered in either language (Arabic/Latin) within normal operation and without any modification to the software. AMEER is simply a printed circuit board plugged into one of the expansion slots of the PC. Few wires are required to be connected to the IBM monochrome adapter to provide the additional character shapes for Arabic operation.

CHAPTER III

FIELD SURVEY

3.1 Introduction

Lacking sources of information describing in full detail the process of construction cost estimating in Saudi Arabia. It is the purpose of this survey to gather the information required in developing the proposed software. Within this overall purpose are the following specific objectives:

- to identify the estimating methods followed to estimate the construction costs;
- to identify the information needed by the estimater to perform the estimate;
- to recognize the problems facing the estimators in preparing the cost estimate; and
- to assess the need for Arabic cost estimating software.

It is important to emphasize that the study focuses on the types of estimates done by building contractors classified as Grade A by the Ministry of Commerce. The survey doesn't deal with other types of estimates done by the owner, designer or other types of contractors.

3.2 Survey Design and Methodology

Due to the nature of the estimating process, it is believed that the required data and information, are best collected through direct interviews and discussion with the key estimators, rather than mailed questionnaires.

A personal interviews in which the interviewer obtains information from

respondents in face-to-face meatings, has several advantages: (1) it has a high degree of flexibility; (2) it provides a guard against confusing questionnaire items, and probes for more complete answers; and (3) it typically attains higher response rate than mail survey. However, personal interview studies are time consuming, administratively difficult, and costly. The time requirements are understandable in light of the need to travel between respondents, set up appointments, and schedule a return visit to do the interviews.[Aaker,1983]

3.2.1 Preparing the Interview Questionnaire

Preparing the questionnaire involved three stages: (1) a comprehensive review of the available relevant literature, supplied the basic information for preparing the first version of the questionnaire; (2) to ensure an interview that will be clear and short, several meetings with some experienced estimators were made guided by the first version of the questionnaire; (3) following a careful analysis review, and revision , the final draft of the questionnaire was designed

The questionnaire (see the appendix) was divided into three parts. The first part, Part A, contains questions about the firm. In the second part, Part B, the respondents were asked about the steps followed to develop the cost estimate; then they were asked about the information needed in these steps, (Sixteen information items were presented to the respondents, for which they were asked to rate them according to their importance, and adding any information that was not listed). After that, they were asked to rate some problems that may face the estimator in developing the estimate.Finally, the respondents were asked to assess the accuracy of their past estimates.

The third and the last part, Part C, contains questions about the

computerized estimating, and in case the contractor uses computers, in developing the cost estimates.

3.3 Statistical Sampling

3.3.1 Background

The ultimate objective of sampling is to select a set of elements from a population in such a way that the statistics (description of those elements) accurately portray the population from which the elements were selected. Probability sampling enhances the likelihood of accomplishing this objective.

A basic principle of probability sampling is that: a sample will be representative of the population from which it is selected if all members of the population have an equal chance of being selected in the sample. Random selection is the key to this process. It is typically to use tables of random numbers or computer programs that provide a random selection of sampling units. [Ott, 1984]

Sample size is determined or affected by many factors including the purpose of the study, the nature of the population, the amount of sampling variation to be tolerated in the estimate, the variability of the characteristics to be estimated or measured, method of estimation, and the degree of confidence with the results of the study.

The proper sample size needed for some desired precision can be approximated by using the formulas for estimating the confidence intervals of population means and proportions. In estimating an interval for a population mean from a large random sample, the theoretical formula for a confidence

interval is $\overline{X} \pm z\sigma_{\bar{x}}$. [Ott, 1984 and Rosander, 1977]

where:

$\overline{X}$: the mean of the distribution of the sample means,

z : (1.96 or 2 for 95% level), measured on each side of the mean μ,

$\sigma_{\bar{x}}$: the standard deviation of the distribution of the sample means (called "the standard error of the mean") ,

$\pm z\sigma_{\bar{x}}$: represents a certain distance plus or minus from the mean along the normal distribution's value scale (X axis). for convenience, this distance is called d ,

and then:

$$d = z\sigma_{\bar{x}}$$

and

$$\sigma_{\bar{x}} = \frac{d}{z}$$

if the sampling is from an infinite population, or from one in which it is fairly sure that the sample size will be small ($n \leq 0.05N$) in relation to the population, the formula for the mean's standard error is [McAllister 1975]:

$$\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}}$$

and using the relationship with d:

$$\frac{d}{z} = \frac{\sigma}{\sqrt{n}}$$

solving for n ,

$$n = \frac{z^2\sigma^2}{d^2} \qquad \text{(Eq.3.1)}$$

In sampling from a finite distribution when it is not fairly certain that n ,the sample size, will be small in relation to N ,the population size, the finite multiplier must be included as part of the formula (Eq3.1). For this case :

$$\sigma_{\bar{x}} = \sqrt{\left(\frac{N-n}{N-1}\right)} \times \frac{\sigma}{\sqrt{n}}$$

and substituting d/z for $\sigma_{\bar{x}}$ we get :

$$\frac{d}{z} = \sqrt{\left(\frac{N-n}{N-1}\right)}\left(\frac{\sigma}{\sqrt{n}}\right)$$

solving for n,

$$n = \frac{\sigma^2}{[(N-1)/N](d^2/z^2) + (\sigma^2/N)} \qquad \text{(Eq. 3.2)}$$

In most practical cases the factor[(N-1) /N] is of negligible importance in affecting the result and is therefore omitted in computing n . [McAllister 1975]

When it is possible that a fairly large portion will be sampled from a finite population (N), Equation 3.2 should be used. Observing that using Equation 3.1 is not only simpler but in asking for a larger sample than for Equation 3.2 is

more conservative. Since the relationship always holds, the first formula should be used to estimate the needed sample size unless time or cost are especially important. [McAllister, 1975 and Rosander, 1977]

When the determination of sample size is based on proportions, the formula for infinite population is :

$$n = \frac{p(1-p)z^2}{d^2} \qquad \text{(Eq. 3.3)}$$

and for finite population is :

$$n = p(1-p)\frac{z^2}{d^2 + [p(1-p)/N]z^2} \qquad \text{(Eq. 3.4)}$$

where :

n : sample size,

N : population size,

z : normal deviate from 5 percent tail area split 2.5 percent in each tail of the normal curve, (1.96 or 2 for 95% level),

p : the proportion of the characteristic under investigation. the value of p is assumed or estimated; if it is unknown, p can be maximized as well as the sample size when the value of p is close to 0.5 (i.e. p=.5)

d : is the expected error in the estimate with (1-) level of confidence

3.3.2 Estimating Sample Size

The sample size to be used in this research is computed in the following manner:

(1) the population of this study is limited to building contractors workng in the Eastern Province of Saudi Arabia, and classified as Type A by the Ministry of Commerce.

(2) according to the Chamber of Commerce & Industry of the Eastern Province, there are in 1989 72 Grade A building contractors working in the Province. So the total population is 72, (i.e. N = 72).

(3) the level of confidence is 95%, i.e. z = 2, and the precision interval of d, is ±0.01.

(4) the sample size is computed by using Equation 3.4 as follow:

$$n = p(1-p) \times \frac{z^2}{d^2 + [p(1-p)z^2/N]}$$

where:

p = 0.5

z = 2

d = 0.01

N = 72

$$n_0 = \frac{0.5 \times 0.5(2)^2}{(.01)^2 + [0.5 \times 0.5 \times (2)^2/72]} = 71$$

$$n_1 = \frac{n_0}{1 + \left(\frac{(n_0 - 1)}{N}\right)} = 36$$

$n_2 = 24$

$n_3 = 18$

$n_4 = 15$

$n_5 = 13$

$n_6 = 11$

The difference between n_3 , n_4 , n_5 **and** n_6 is assumed constant and insignificant, therefore, the sample size is set to 24 contractors.

(5) to achieve random selection of the sample from the total population, tables of random numbers are used. In this process the total population was labeled from 1 to 72 on the list obtained from the Chamber of Commerce & Industry, then referring to the table of random digits, a starting point was chosen, and then the contractors to be visited were identified.

3.3.3 Scoring

It is no doubt that not all of the estimation information items have the same value to the estimator. There are some information items, such as tendering documents, material prices, equipment cost, and labor rates, that are much more important than , for example, the overall economic situation ,or government regulations. Thus, to measure the importance of several information items that may be needed in construction cost estimating, a rating scale was used. This scale provides respondents with a set of categories that represent the range of possible judgements. This is called itemized rating scale, and is distinguished by the fact that the rater must select from a limited number of categories to indicate the importance of the statement under consideration by checking the appropriate position on the scale, (28). The scale as shown in Figure 3.1, is divided into five

blocks, each shows in words the degree of importance.

Figure 3.1

		Scale	Level of Importance				
#	Information Item	Words	very low	Low	Medium	High	very high
		Score	0	1	2	3	4

Each response is scored by assigning values from 0 (very low response) to 4 (very high responses) to each item. Thus, if a respondent believed that an item is very important, that response received a score of 4. A response of very low importance received a score of 0 and so on.

The same argument is used to measure the level of importance of possible problems that may face the estimator.

Each information item and each problem of questions M and N of part "B" of the questionnaire, has an importance index or severity index to help in ranking each statement according to their importance as follows:

$$\textbf{Importance.Index,(IM.IND.)} = \frac{\sum_{i=1}^{5} W_i \times f_{x_i}}{N} \times \frac{100}{4}$$

where:

W_i = the weight given to the ith response, i = 1, 2, 3, 4, 5

f_{x_i} = Responses frequency;

f_{x_1} = the frequency of "very high " responses

f_{x_2} = the frequency of "high " responses

f_{x_3} = the frequency of "medium" responses

f_{x_4} = the frequency of "low" responses

f_{x_5} = the frequency of "very low " responses

N = number of responses, (24 responses).

Illustration:

Consider item information number 1 of question M in part "B" of the questionnaire, the (IM. IND.) is calculated as follows:

Level of Importance	Weight (W_i)	Response Frequency f_{x_i}	($W_i \times f_{x_i}$)
Very high	4	19	76.0
High	3	1	3.0
Medium	2	1	2.0
Low	1	3	3.0
Very low	0	0	0.0
Sum	10	24	84

$$(\mathbf{IM.IND.}) = \frac{84}{24} \times \frac{100}{4} = 87.500$$

CHAPTER IV

DATA ANALYSIS & RESULTS

This chapter describes the statistical techniques and methods used in analyzing the survey data, and discusses the statistical results. The major findings of this survey are also presented.

Data analysis is the process whereby the raw data are transformed into the information called for in the research design. Research and fieldwork are undertaken solely for the purpose of obtaining data which, when tabulated and analyzed, will yield this needed information. Therefore, data analysis plays an important role in turning the raw data into defensible, actionable sets of conclusions, recommendations and decisions. It is actually a set of statistical methods and techniques that can be used to obtain information and insights from the raw data, including are: 1) tabulation; 2) statistical summarization; 3) ranking; and 4) sample correlation.

4.1 Tabulation

Usually the first step in data analysis is the tabulation work. It consists of sorting the data into categories and classes and counting the number of responses associated with each. These results are then summarized in order to present the findings in a more compact and more easily understood format.

The result is the frequency distribution. The frequency distribution, in addition to communicating the results of the study, can be used for other purposes: (1) to determine the degree of item response; (2) to locate errors; (3) to calculate summary statistics; and (4) to locate the distribution on the scale of measurement and the spread of scores within the distribution. The frequency distribution for questions M and N of the questionnaire are shown in appendix B. The frequency distribution of the other questions are shown in the following tables.

Table 4.1: % of Work Obtained Through Competitive Bidding

Range	Percent of Respondents
Under 25%	33.3%
25% - 50%	16.7%
50% - 75%	8.3%
75% - 100%	41.7

Table 4.2: % of Work Subcontracted on Average Job

Range	Percent of Respondents
Under 25%	58.3%
25% - 50%	16.7%
50% - 75%	0.0%
75% - 100%	25.0%

Table 4.3: Average Job Size, (Millions of SR)

Range	Percent of Respondents
Under 1	0.0%
1 - 5	14.7%
5 - 10	45.8%
Over 10	39.5%

Table 4.4: Language Used in Developing the Estimate

Language	Percent of Respondents
English only	83.3%
Arabic only	0.0%
Arabic & English	16.7%

Table 4.5: Language Used in Communication

Language	Percent of Respondents
English only	25.0%
Arabic only	0.0%
Arabic & English	75.0%

Table 4.6 Utilization of Microcomputers

Using Comp.	Percent of Respondents
Yes	16.7%
No	83.3%

The above tables reveal the following:

- almost all contractors use the English language in developing the cost estimate; this is because many employees do not speak Arabic. In addition, all drawings and specification are prepared using the English language.
- the majority of contractors surveyed (41.7%), obtain most of their work through competitive bidding.
- 75.0% of contractors use Arabic and English to communicate the estimate with the owner.
- most contractors do not use microcomputers in developing the cost estimate.

4.2 Statistical Summarization

In presenting survey findings, several statistical measures are frequently employed in an attempt to typify the data. These are called summary statistics and are usually intended to measure the central tendency and to measure the dispersion, such as standard deviation and coefficient of the mean. These techniques are used to analyze questions M and N in part "B" of the questionnaire.

4.2.1 Measurement of Central Tendency

A measure of central tendency is a single value on the measurement scale that in some way represents the location of a set of scores. There are several popular measures of central tendency, each of which represents a distribution in a different fashion, the one used in this survey is the mean. The arithmetic mean is a very precisely defined measure of central tendency. The arithmetic mean, usually refered to simply as the mean, is found by dividing the sums of the values of the observations by the number of item observed. The formula is:

$$\bar{X} = \sum_{i=1}^{n} \frac{X_i}{n} \qquad \text{(Eq. 4.1)}$$

where: $\bar{X}$ = arithmetic mean

X_i = the value of the ith response

n = number of responses

The weighted mean can be obtained using the following formula:

$$\bar{X} = \sum_{i=1}^{5} \frac{W_i \times f_{x_i}}{N} \qquad \text{(Eq. 4.2)}$$

where:

$\bar{X}$ = the weighted mean

W_i = the weight given to the ith item, i = 1, 2, 3, 4, 5

f_{x_i} = the response frequency in each class on the measurement scale

N = number of responses

Illustration

The weighted mean for information item number 1 in question part "B" of the questionnaire is calculated as follows:

Level of Importance	Weight (W_i)	Response Frequency f_{x_i}	($W_i \times f_{x_i}$)
Very high	4	19	76.0
High	3	1	3.0
Medium	2	1	2.0
Low	1	3	3.0
Very low	0	0	0.0
Sum	10	24	84

$$\bar{X} = \frac{84}{24} = 3.50$$

4.2.2 Measures of Variability

Measures of variability give an idea of the spread of a set of data scores over the scale. There are several measures of variability, each of which describes the spread of scores in a different way. Each measure of variability provides a single value (usually a distance on the measurement scale) to describe the spread of a set of scores. Any measure of variability increases in numerical value when the spread of scores (reflected by the measure) increases,(18, 29). The measures used to analyze the data of this work are; standard deviation, Coefficient of variation (C.V.), and the standard error of mean.

4.2.2.1 Standard Deviation

Standard deviation is defined to be the positive square root of the variance. The variance is defined as the average of the squared deviations of the observation values from the mean of the distribution. Since the variance is a rather difficult measure to interpret, the standard deviation is the most frequently encountered measure of variability . The properties of standard deviation make it an extremely valuable tool in sampling, correlation, and other analytical areas (35). The appropriate general formula for calculating the standard deviation ;

$$S = \sqrt{\frac{\sum(X_i - X)^2 \times f_{X_i}}{n-1}} \qquad \text{(Eq.4.3)}$$

Illustration

The standard deviation for information item number 1 in question part "B" of the questionnaire is calculated as follows:

Level of Importance	Weight	Response Frequency	$(W_i - \overline{X})$	$(X_i - \overline{X})^2 \times f_{x_i}$
Very high	4	19	0.50	4.75
High	3	1	3.0	-0.5
Medium	2	1	-1.5	2.25
Low	1	3	-2.5	18.75
Very low	0	0	-3.5	0.0
Sum	10	24		26

$$S = \sqrt{\frac{26}{23}} = 1.06$$

4.2.2.2 Coefficient of Variation (C.V.)

The coefficient of variation expresses the standard deviation as a percentage of the mean. C.V. is useful in comparing the relative variability of different kindes characteristics, that is free of the unit of measurement (29). The formula is ;

$$C.V. = \frac{S}{\overline{X}} \times 100 \qquad \text{(Eq. 4.4)}$$

where:

C.V. = coefficient of variation

S = standard deviation of the sample

$\overline{X}$ = wighted mean of the sample.

4.2.2.3 The Standard Error of Mean

The standard deviation of the sampling distribution of means is called the standard error of mean and is defined as (18)

$$\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}}$$

where σ ,is the standard deviation of the population and n is the sample size. However, in most practical situations involving sampling, σ is not known, thus $\sigma_{\bar{x}}$ must be estimated from the sample. The formula for the standard error of mean is changed from

$$\frac{\sigma_{\bar{x}}}{n}$$

to

$$\hat{\sigma}_{\bar{x}} = \frac{S}{\sqrt{n}} \qquad \text{(Eq. 4.6)}$$

where S, is the standard deviation of the sample. A correction factor may be applied to the estimated standard error of mean to compensate for the size of the sample, n , in relation to the size of the population, N , (18). Equation 4.6 then becomes:

$$\hat{\sigma}_{\bar{x}} = \frac{S}{\sqrt{n}}\sqrt{\frac{N-n}{N-1}} \qquad \text{(Eq. 4.7)}$$

4.2.3 Interval Estimation

There are two possible ways to estimate the unknown population parameters from the sample statistics: (1) as a point estimation, and (2) as an interval estimation. For example, the sample mean, $\overline{X}$, is used to estimate the unknown population mean, μ. It is useful to estimate the population mean, (μ) as an interval estimate around $\overline{X}$. Using probability sampling, it is probable that a certain interval will enclose the true value of the population mean. This interval is termed the confidence interval, and the probability of a sample mean laying within the confidence interval is termed the confidence coefficient. The formula is simply this (18),

$$\overline{X} - z\hat{\sigma}_{\overline{x}} \leq \mu \leq \overline{X} + z\hat{\sigma}_{\overline{x}} \qquad \text{(Eq. 4.8)}$$

as shown in Figure 4.1

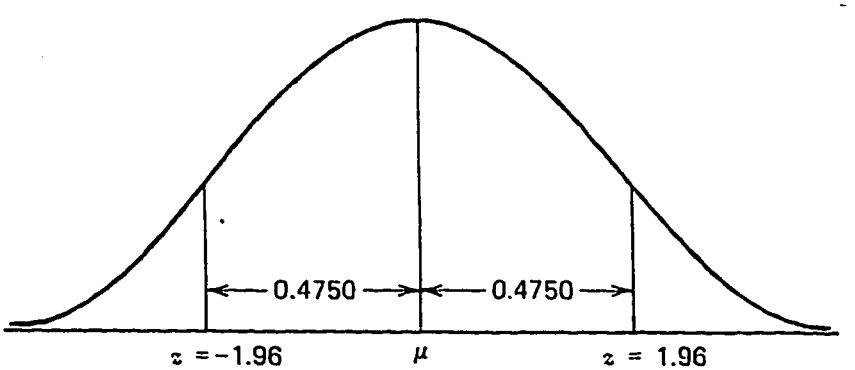


Figure 4.1: A 95% Confidence Interval of the Population Mean

Table 4.7 Mean, S.E, C.I., and C.V. for Question M in Part "B"

#	Mean	Standard Deviation	S.T.D Error of Mean	95% Confidence Interval	C.V. (%)
1	3.50	1.06	0.18	3.50 +0.36	30.28
2	3.46	0.72	0.12	3.46 +0.24	20.81
3	2.83	1.37	0.23	2.83 +0.46	48.81
4	2.37	1.09	0.18	2.37 +0.36	45.99
5	2.37	1.01	0.17	2.37 +0.34	42.62
6	3.50	0.59	0.10	3.50 +0.20	16.86
7	2.79	0.59	0.10	2.79 +0.20	21.15
8	2.92	0.88	0.15	2.92 +0.30	30.14
9	2.29	1.27	0.21	2.29 +0.42	55.46
10	1.87	1.47	0.25	1.87 +0.50	78.61
11	2.37	1.17	0.19	2.37 +0.38	38.31
12	3.08	1.18	0.19	3.08 +0.38	38.31
13	2.92	0.77	0.13	2.94 +0.26	26.37
14	2.21	1.25	0.12	2.21 +0.42	56.56
15	2.58	1.06	0.18	2.58 +0.36	41.09
16	3.04	1.04	0.17	3.04 +0.34	34.21

Table 4.8 Mean, S.E, C.I., and C.V. for Question N in Part "B"

#	Mean	Standard Deviation	S.T.D Error of Mean	95% Confidence Interval	C.V. (%)
1	2.04	0.81	0.14	2.04 +0.28	39.71
2	1.58	1.32	0.22	1.58 +0.44	83.54
3	2.42	1.59	0.27	2.42 +0.54	67.70
4	2.75	0.40	0.07	2.75 +0.14	14.54
5	2.75	0.51	0.08	2.75 +0.16	18.54
6	2.58	1.41	0.24	2.58 +0.48	54.65
7	2.33	0.87	0.14	2.33 +0.28	37.34
8	2.29	0.81	0.14	2.29 +0.28	35.37
9	1.79	0.78	0.13	1.79 +0.26	43.57
10	1.17	0.95	0.16	1.17 +0.32	55.55
11	2.92	0.93	0.15	2.92 +0.30	31.85
12	2.04	0.86	0.14	2.04 +0.28	42.17
13	2.08	1.06	0.18	2.08 +0.36	50.96
14	2.71	1.04	0.17	2.71 +0.34	38.38
15	2.79	1.02	0.17	2.79 +0.34	36.56
16	1.75	1.19	0.20	1.75 +0.40	68.00
17	2.50	1.14	0.19	2.50 +0.38	45.60
18	2.04	1.23	0.21	2.04 +0.42	60.29
19	1.83	1.01	0.17	1.83 +0.34	55.19
20	1.54	0.88	0.15	1.54 +0.30	57.14

As shown in table 4.7, the variation of the responses regarding the information needed in developing the estimate is relatively low, as indicated by the C.V. This mean that the estimators agree about the information needed to develop the estimate. Another reason for this low variation can be attributed to the nature of the study; i.e. the sample survey was limited to type A building contractors in the Eastern Province. Thus the respondents belong to this sector in doing the same work (building), under the same prevealing situations. Referring to table 4.6, one can note that the overall economic situation inflation, rate,and the historical profit in similar jobs, have the highest variation 78.61%, 55.46%, and 56.56% respectively. This reflects the existing conditions. Since some projects require some imported material, where the inflation rates are high, whereas some don't. In these days of tough competition,in addition to the slump in the local economy, it is difficult to apply the historical profit to these day's projects, this may interprets these variations.

Regarding the problems facing the estimators, it may be noted the high variation of the responses, because the problems differ from one project to another depending upon their particular situation. For example, calculation errors have a C.V. of 83.54% which is very high compared to the others; this is because these errors will not cause trouble if the estimate is reviewed several times, especially by another estimators. Content of arbitration clauses, problem No.16, has a variation of 68.00%, and this is simply because the contract agreement is highly differs according to the owner and/or type of contract.

4.3 Ranking

Questions M and N in part "B" of the questionnaire are ranked by the importance index discussed in chapter 3. Six rank tables are presented as follows:

Table 4.9: Mean Rank of Information Items Needed to Prepare the Cost Estimate, for the Total Surveyed Sample, Question M.

Rank	#	Information Item	Importance Index
1	1	Tendering Documents	87.500
2	6	Material Prices	87.500
3	2	Project Scope & Definition	86.458
4	12	Labor productivity	77.083
5	16	Risk involved	76.042
6	8	Labor Rates	72.917
6	13	Government regulations	72.917
8	3	Owner requirements	70.833
9	7	Equipment Costs	69.792
10	15	Overall economic situation	64.583
11	4	Project Location	59.375
11	5	Historical Data of Similar Work	59.375
11	11	Required equip. availability	59.375
14	9	Inflation rate	57.292
15	14	Historical profit information	55.208
16	10	Skilled labor availability	46.875

Table 4.10: Mean Rank of Problems Facing Cost Estimators in Preparing the Cost Estimate, for the Total Surveyed Sample, Question N.

Rank	#	Problem	Importance Index
1	11	Tough competition	72.917
2	15	Contract period	69.792
3	4	Incomplete drawings & specifications	68.75
3	5	Incomplete the project scope definition	68.75
5	14	Unforeseeable change in material prices	67.708
6	6	Changes of Owner requirements	64.583
7	17	Current work load	62.500
8	3	Judgment errors	60.417
9	7	Inadequate time	58.333
10	8	Lacking historical data of similar jobs	57.292
11	13	Lacking experience in similar job	52.083
12	12	Unfamiliarity with government regulations	51.042
12	1	Work item omission	51.042
12	18	Inconfidence in your workforce	51.042
15	19	Difficulty of the project	45.833
16	9	Lacking productivity informations in S.A.	44.792
17	16	Content of arbitration clauses	43.750
18	10	Lacking of cost data indexes in S.A	42.708
19	2	Calculation errors	39.583
20	20	Portion of work to be subcontracted	38.542

Table 4.11: Mean Rank of Information Items Needed to Prepare the Cost Estimate, for the Contractors Using Computers, Question M.

Rank	#	Information Item	Importance Index
1	2	Project Scope & Definition	87.500
1	6	Material Prices	87.500
3	7	Equipment Costs	81.250
3	1	Tendering Documents	81.250
5	16	Risk involved	75.000
6	13	Government regulations	68.750
6	5	Historical Data of Similar Work	68.750
6	8	Labor Rates	68.750
9	12	Labor productivity	62.500
9	15	Overall economic situation	62.500
11	11	Required equip. availability	56.250
12	10	Skilled labor availability	50.000
12	14	Historical profit information	50.000
14	4	Project Location	43.750
15	3	Owner requirements	37.500
15	9	Inflation rate	37.500

Table 4.12: Mean Rank of Problems Facing Cost Estimators in Preparing the Cost Estimate, for the Contractors Using Computers, Question M.

Rank	#	Problem	Importance Index
1	6	Changes of Owner requirements	75.000
2	11	Tough competition	68.750
3	4	Incomplete drawings & specifications	62.500
3	5	Incomplete the project scope definition	62.55
5	1	Work item omission	50.000
5	7	Inadequate time	50.000
5	8	Lacking historical data of similar jobs	50.000
5	12	Unfamiliarity with government regulations	50.000
5	15	Contract period	50.000
5	17	Current work load	50.000
11	13	Lacking experience in similar job	43.750
11	14	Unforeseeable change in material prices	43.750
13	9	Lacking productivity informations in S.A.	37.500
13	10	Lacking of cost data indexes in S.A	37.500
13	18	Inconfidence in your workforce	37.500
13	19	Difficulty of the project	37.500
17	3	Judgment errors	31.250
18	16	Content of arbitration clauses	25.000
18	20	Portion of work to be subcontracted	25.000
20	2	Calculation errors	18.750

Table 4.13: Mean Rank of Information Items Needed to Prepare the Cost Estimate, for the Contractors Not Using Computers, Question M.

Rank	#	Information Item	Importance Index
1	1	Tendering Documents	88.750
2	6	Material Prices	87.500
3	2	Project Scope & Definition	86.250
4	12	Labor productivity	80.000
5	3	Owner requirements	76.250
6	13	Government regulations	73.750
7	8	Labor Rates	72.500
8	16	Risk involved	70.000
9	7	Equipment Costs	68.750
10	15	Overall economic situation	65.000
11	10	Skilled labor availability	62.500
12	5	Historical Data of Similar Work	61.250
12	4	Project Location	61.250
12	11	Required equip. availability	61.250
15	9	Inflation rate	60.000
16	14	Historical profit information	57.000

Table 4.14: Mean Rank of Problems Facing Cost Estimators in Preparing the Cost Estimate, for the Contractors Not Using Computers, Question M.

Rank	#	Problem	Importance Index
1	11	Tough competition	73.500
1	15	Contract period	73.750
3	4	Incomplete drawings & specifications	70.000
3	14	Unforeseeable change in material prices	70.000
5	5	Incomplete the project scope definition	68.75
6	17	Current work load	63.750
7	6	Changes of Owner requirements	62.500
7	3	Judgment errors	62.500
9	7	Inadequate time	60.000
10	8	Lacking historical data of similar jobs	58.750
11	13	Lacking experience in similar job	55.000
12	18	Inconfidence in your workforce	53.750
13	12	Unfamiliarity with government regulations	51.250
14	9	Lacking productivity informations in S.A.	46.250
14	16	Content of arbitration clauses	47.500
14	1	Work item omission	46.250
17	10	Lacking of cost data indexes in S.A	45.000
17	19	Difficulty of the project	45.000
19	20	Portion of work to be subcontracted	40.000
20	2	Calculation errors	37.500

4.4 Correlation

A correlation coefficient indicates both the direction and the strength of the relation or association between two variables. One of the methods used to measure the association, is the Spearman rank-order correlation coefficient, r_s. The sign of the correlation coefficient (+ or -) indicates the type of relation. The strength of the relationship between the ranks is indicated by the numerical value of the coefficient when the relation is "perfect" the numerical value is 1.00, whereas if r_s is - 1.00 a perfect negative relation exists. An r_s of 0.00 reflects the absence of any linear relation. Thus, if a correlation between two variables exists, that relation would be revealed with the sign and value of r_s (18) . The formula of r_s is:

$$r_s = 1-6 \times \sum \frac{d_i^2}{N(N^2-1)} \qquad \text{(eq. 4.9)}$$

where:

r_s = rank correlation coefficient

d_i = the difference between the two rankings

N = number of cases.

The r_s for the contractors using computers in preparing the cost estimate and those who are not using computers for question N and M for part "B" of the questionnaire are calculated as follows:

$$r_{(12)_M} = 1-\frac{6 \times 239}{17(17^2-1)} = 0.65$$

where $r_{(12)_M}$,is the agreement between the contractors using computer and the contractors who are not using computer for question M of part "B"

$$r_{(12)_N} = 1 - \frac{6 \times 453}{20(20^2-1)} = 0.98$$

where $r_{(12)_N}$,is the agreement between the contractors using computer and the contractors who are not using computers for question N of part "B"

Tables 4.15, and 4.16 show the calculation of the correlation coefficient.

The correlation results show a high percentage of relationships between using computers in estimating and the problems frequently facing the estimators. This is expected, since the benefits of computers especially in cost estimating are obvious. This is indicated by $r_s = 0.98$ as in table 4.15, however, the difference in population size may affect this result.

Regarding the information needed in preparing the estimate, where $r_s = 0.65$ show to some extent, that this part doesn't reflect the existing situation, since the information required in cost estimating would not vary whether computers are used or not.

The correlation results, should be considered with care, since the number of contractors using computers in developing the cost estimate is very low (4 contractors), compared with the number of contractors (20 contractors), using manual methods in preparing the cost estimate.

Table 4.15: Computation of Spearman Correlation Coefficient for Information Item, Question M part "B"

Item #	Rank1	Rank2	d^2
1	3	1	4
2	1	3	4
3	15	5	100
4	14	12	4
5	6	12	36
6	1	2	1
7	3	9	36
8	6	7	1
9	15	15	0
10	12	11	1
11	11	12	1
12	9	4	25
13	6	6	0
14	12	16	16
15	9	10	1
16	5	8	9
Sum			235

Note:

Rank1 = Rank by the Computer users

Rank2 = Rank by non-Computer Users

Table 4.16: Computation of Spearman Correlation Coefficient for Problems of Estimating, Question N part "B"

Item #	Rank1	Rank2	d^2
1	5	14	81
2	20	20	0
3	17	7	100
4	3	3	0
5	3	5	4
6	1	7	36
7	5	9	16
8	5	10	25
9	13	14	1
10	13	16	9
11	2	1	1
12	5	13	64
13	11	11	0
14	11	3	64
15	5	1	16
16	19	14	25
17	5	6	1
18	13	12	1
19	13	16	9
20	18	19	1
Sum			453

Note:
Rank1 = Rank by the Computer users
Rank2 = Rank by non-Computer Users

4.5 Major Findings

This part presents the findings of this study in the following sections

4.5.1 Information Needed in Developing the Estimate

The information needed to develop the cost estimate for a given project, as revealed by this survey are as follows:

1. Tendering Documents
2. Material Prices
3. Project Scope & Definition
4. Labor productivity
5. Risk involved
6. Labor Rates
6. Government regulations
8. Owner requirements
9. Equipment Costs
10. Overall economic situation
11. Project Location
11. Historical Data of Similar Work
11. Required equipment availability
14. Inflation rate
15. Historical profit information
16. Skilled labor availability.

4.5.2 Problems Facing the Estimators in Developing The Estimate

This survey indicates that the following problems are frequently facing the construction cost estimators in developing a project cost estimate:

1. Tough competition
2. Short contract period
3. Incomplete drawings & specifications
3. Incomplete project scope definition
5. Unforeseeable change in material prices
6. Changes of Owner requirements
7. Heavy current work load
8. Judgement errors
9. Inadequate time, (short bidding Period)
10. Lacking historical data of similar jobs
11. Lacking experience in similar jobs
12. Unfamiliarity with government regulations
12. Work item omission
12. Inconfidence in the workforce
15. Difficulty of the project
16. Lacking productivity informations in Saudi Arabia
17. Hard content of arbitration clauses
18. Lacking of cost data indexes in Saudi Arabia
19. Calculation errors
20. Difficulties in identifying the portion of work to be subcontracted.

4.5.3 Process of Detailed Estimating

The process followed to develop the construction cost of a project, as revealed by this survey, can be described as shown in figure 4.1, as follows:

Step 1: As shown in the figure, the first step in construction cost estimating, is to get the tendering documents from the owner after passing the prequalification. Among others, these documents consist of drawings (blueprints) and specifications. The drawings and specifications are prepared by a design office with the coordination of the owner. Project drawings, which may consist of plot plans, foundation plans, floor plans, elevation plans, and windows and door schedules, show what is to be built, whereas the specifications describe the quality of the finished work.

Project documents, are usually divided into: electrical work, civil work, and mechanical work. Each of which is estimated separately.

Step 2: In the second step, a detailed analysis of the tendering documents and other available information is done. In case, the project documents are incomplete,the estimator may visit the site to get more information about the site, and meet with the owner to set the final scope and definition of the project.

Step 3: Quantity take-off and resource allocation. In this step, the blueprints are read to determine the quantity of material required to complete the specified project, and to determine the required workforce and equipment. In some projects, the tendering documents contain the bills of quantities; in this case, the

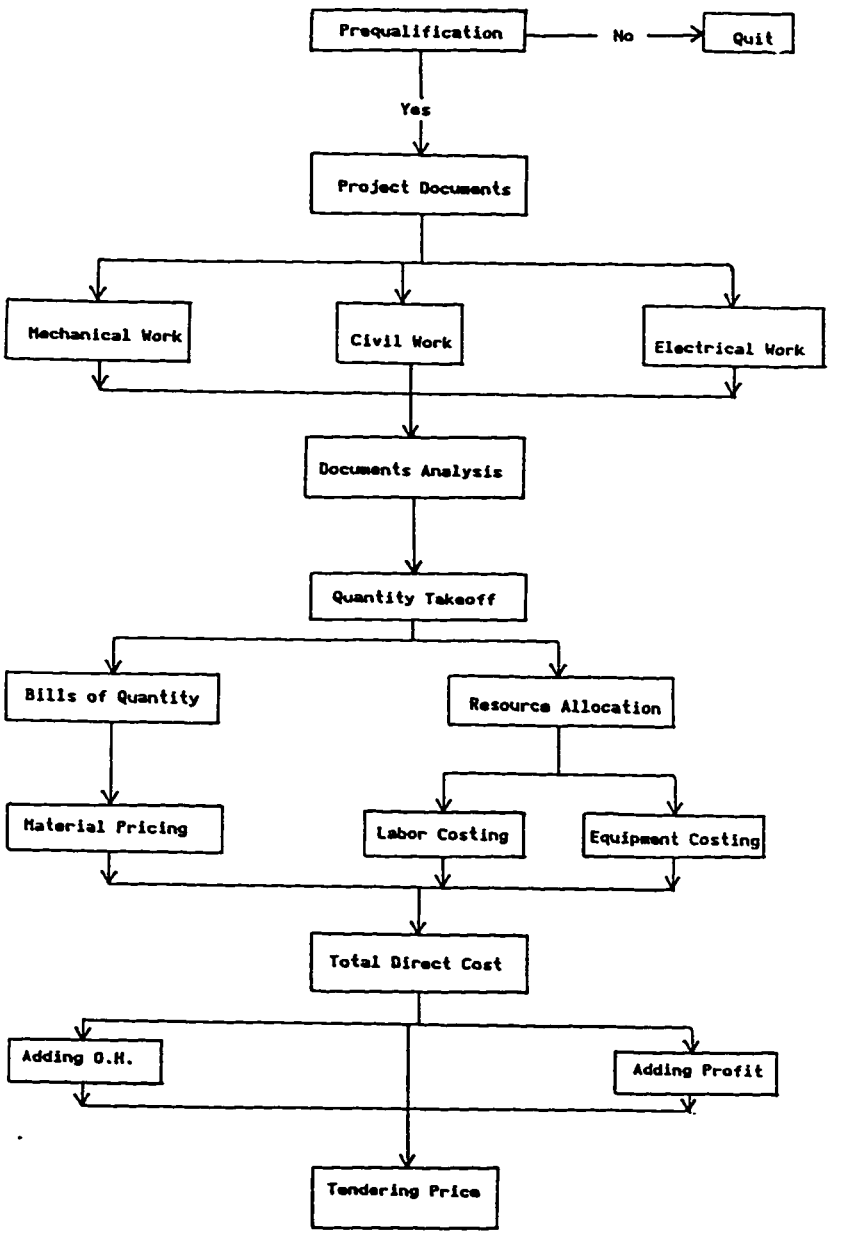


Figure 4.1: Process of Detailed Estimating

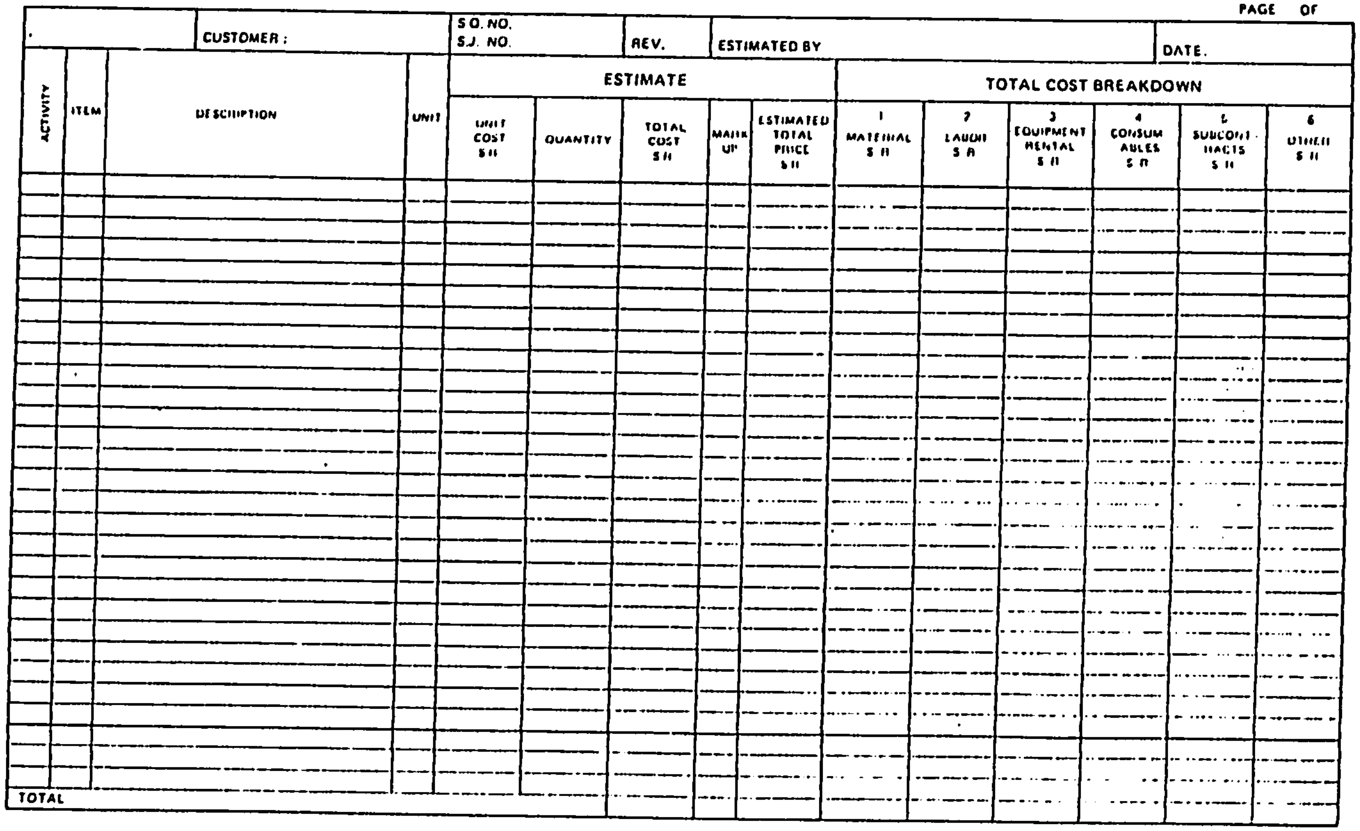
estimator checks those bills, since they are merely an estimated quantities prepaired by the design office.

The work to be subcontracted is identified and roughly estimated. In most cases, this subcontracted work is negotiated with the subcontractors and a final expected costs and prices are calculated.

Step 4: Using specifications, the estimator determines the quality of the required materials and begins the pricing process. Through the purchasing department, the estimator contacts with the material supplyers, to get an updated material prices.

To get the material cost, the estimator just multiplies the quantity of material by the unit cost of each material, and adds the 5% percent of this prices to account for wastages and damages. The estimator may refer to historical data costs of similar work in this step, especially for costing labor and equipment. Labor costs are expressed as the cost per output unit. Equipment costs are usually expressed as the cost per hour. Then the estimator multiplys the calculated labor and equipment units with the historical unit costs. As, revealed by this study, all contractors are keeping good records of historical data for each equipment and labor categories.

Step 5: In the final step, the total direct cost of material,labor and equipment is summarized in a predesigned estimating format. An estimating form used by a local contractor is shown in Figure 4.2. The estimating form indicates the division of work, the cost of required material, the cost of labor and equipment, and the total cost for this work division or element. It is in this stage that the overhead and profit is added to the direct cost. It is a common practice, as founded in this survey, that a certain percent of the direct total cost is assigned



PAGE OF

	CUSTOMER :			S.O. NO. S.J. NO.		REV.	ESTIMATED BY						DATE.	
ACTIVITY	ITEM	DESCRIPTION	UNIT	ESTIMATE					TOTAL COST BREAKDOWN					
				UNIT COST S R	QUANTITY	TOTAL COST S R	MARK UP	ESTIMATED TOTAL PRICE S R	1 MATERIAL S R	2 LABOR S R	3 EQUIPMENT RENTAL S R	4 CONSUMABLES S R	5 SUBCONTRACTS S R	6 OTHER S R
TOTAL														

Figure 4.2: An Estimating Form

PAGE OF

ITEM NO	CALCULATIONS AND COMMENTS	ITEM NO	CALCULATIONS AND COMMENTS

Figure 4.2: An Estimating Form, (continued)

to the job overhead, office overhead (usually termed overhead), and the profit. 5% to 10% of the total direct cost is usually added to the estimate as an overhead costs, and 10% to 20% is added to the estimate as a profit for that project.

Having all of these together, the tendering price is ready to be submitted to the owner.

4.6.4 Computerized Estimating

The study revealed that, 16.7% of the contractors surveyed are using computers in cost estimating. There are more than one reason for this low computer utilization. As concluded from the estimators interviewed, the following are the main reasons:

1. Many contractors believe, that microcomputer technology is so sophisticated that it needs a lot of time and effort to be learned and used it in construction applications. It was noted that, most of the estimators interviewed graduated 10 to 15 years ago when microcomputers did not simply exist.

2. The belief that cost estimating process can only be approached from an intuitive view point, so the use of computers is either meaningless or unnecessarily time and money expensive.

3. Inability to define precisely the problems to be addressed. This indicated by many estimators saying;

   "Computers can't help; since the material prices are not stable; they are varying from one project to another, according to the quantity purchased from the suppliers."

It is a common practice that contractors will receive a discount rate that may

reach 30% of the unit material cost for large quantities and cash paying.

4. General lack of interest due mainly to insufficient information about the benefits and services which microcomputers could provide for construction activities purposes.

However, about 21% of the contractors interviewed, are seriously planning to introduce the microcomputer into their construction activities, such as scheduling and estimating.

The steps followed in computerized estimating could be summarizing as follows:

1. performing quantity take-offs, and preparing bills of quantities,

2. inputting bills of quantities into the computers,

3. computer then checks whether costs and prices information in the Data Base are acceptable or needs adjustment,

4. when all of the items have been entered and costed or priced, profit and overheads are entered into the computers,

5. then, the computer will perform all calculation needed,

6. the estimate output will be displayed on the screen for review, and

7. if OK, the final bid format is printed.

4.5.5 Needs for Computerized Estimating

A concern of this survey is to assess the need fore a computer-aided estimating system. One of the most astonishing findings of this research is that there is no need for computerized estimating system, either Arabic or English. In fact, many contractors believe that their current manual techniques or methods are the best possible, and do not plan to change them. The main reason for this is due mainly to insufficient information regarding the benefits of computers in this process.

Generally speaking, this survey revealed that computers are not needed at all in the estimating process; the main reasons for this were discussed in the previous section.

And so, the only way, one can assess the true needs for microcomputers is by performing a practical demonstration of a computerized estimating system with the estimators to convince them what the computers technology can afford them.

CHAPTER V

SYSTEM DEVELOPMENT

In developing any system, whether manual or automated, the following requirements should be considered, [Byers, 1984] :

* a complete and accurate understanding of the problems to be solved including a general understanding of the potential benefits of the intended system,
* a clear understanding of the environment in which the new system will operate,
* an effective communication between the developer and the end users,
* a clear breakdown of the work required to complete the development process,
* identification of the available development tools, with a clear understanding of any technological constraints, and
* a relatively accurate estimate of time and costs required to complete the new system.

With the above in mind, the Arabic Computer-Aided Estimating System, ARAB-EST was developed as three non-separated phases connected in a linear arrangement, namely (1) the planning phase; (2) the design phase; and (3) implementation phase, as shown in Figure 5.1. This chapter describes the details involved in the development of the system. For convenience of discussion, the system is referred to as ARAB-EST .

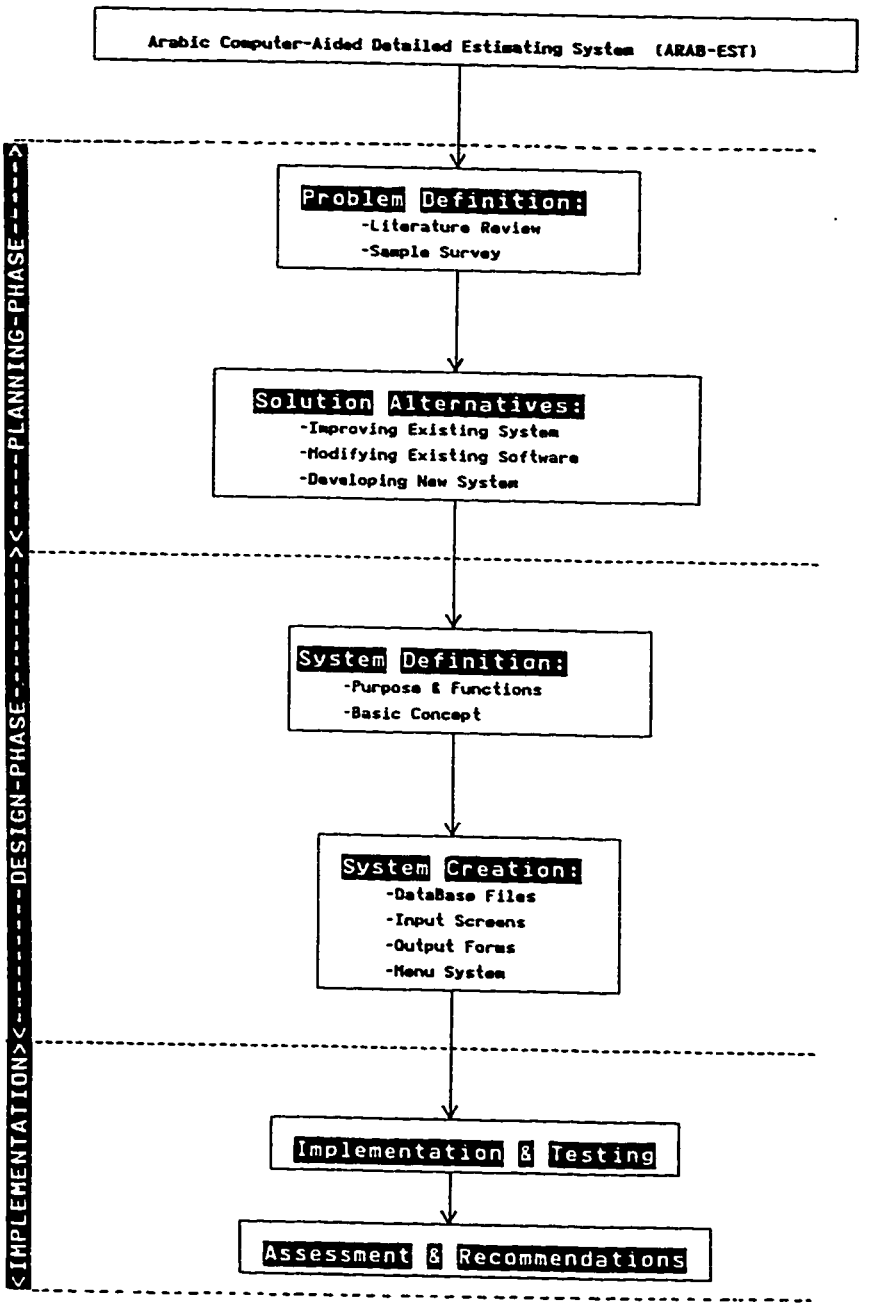


Figure 5.1: ARAB-EST Development Process

5.1 Planning Phase

The first phase in the ARAB-EST development was the planning phase. The planning task involved; problem definition, and formulation of alternative solutions.

As defined in literature, the planning task involves choosing a set of actions on a rational base, arranged chronologically, that will lead to achieving some given goals. During planning, the planners must consider the decisions to be made and the procedures to be executed in the remaining phases. These are major points to be considered for each phase, and failure to consider these points could adversely affect the life and performance of the system, [Neely,1984].

The planning phase was extremely important in (1) identifying major problem areas in the estimating process; (2) proposing alternative solutions; and (3) defining a system that meets the user needs.

5.1.1 Problem Definition

As in any system development, even manual, the first step is that of problem definition. The major objectives of problem definition are to scope the problem to be solved and to clearly define the problem to the extent necessary to provide a basis for formulating and evaluating solution alternatives. Problem definition include several activities, [Byers 1984, and Lindeman 1984] :

1. collection of data and other information on the current system,
2. analysis of performance of the current system,
3. developing physical and logical model of the current system, and
4. formulating alternative solutions.

In this work it was possible to obtain information necessary to model (describe) the current estimating process, through two different approaches: (1) literature

review (Chapter 2), and (2) sample survey of the local construction contractors (Chapters 3&4).

The complete detailed cost estimating process could be prepaired through a sequential process summarized in Figures 2.3 and 4.1, (physical) and Figure 5.2 (logical). While the estimating process, as can be seen from the figures, is basically sequential, it must be recognized that iteration is often necessary. For example, if errors are discovered or a new quotation from material suppliers have been received, during estimate development, it will be necessary to partially repeat the early activities in the development sequence. In analyzing the estimate,'What-If' analysis for example, the estimating process must be repeated.

It is important to realize that, the problems frequently encountered in prepairing cost estimate can't be always solved by computerization. Examples, among others, are incomplete project drawings and specifications, judgement errors, tough competition, and changes of owner requirements. However, computers can expedite and improve the accuracy of the estimating process. Moreover, estimating methodical nature and its reliance upon the manipulation of large volumes of data make it very suitable for computerization.

Based on the literature review and the sample survey, it was possible to identify the following deficiencies and limitations, related to the current manual estimating process, and can be solved by computers:

1. frequent calculation errors and high possibility of work item omission,
2. long time is required to retrieve and manipulate data costs,
3. difficulties in reporting the estimate reports in a usable forms (especially arabic reports),
4. ability to perform sensitivity analysis or "what-if" investigation is very time consuming, and
5. difficulties in considering last-minute quotaions.

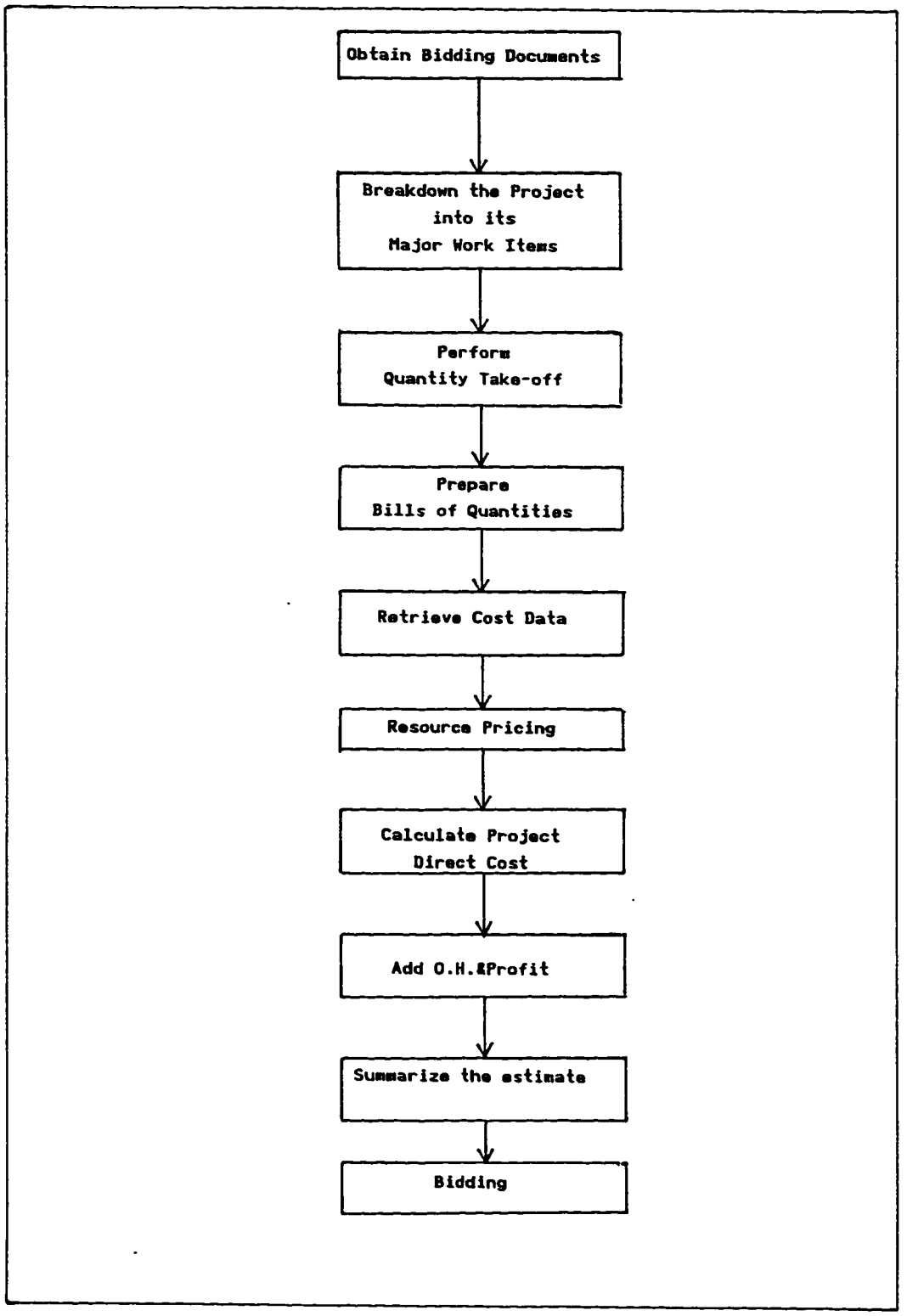


Figure 5.2: Logical Description of the Estimating Process

5.1.2 Formulation of Alternative Solutions

The purpose of this activity is to develop and analyze solution alternatives to a sufficient depth to facilitate a decision as to which alternative, if any, should be adapted. Further, the expected benefits to be derived from the selected system after it is placed in operation are to be determined. [Neely and Byers, 1984]

The following list of improvements were required for the current cost estimating system/process:

1. ability to store, maintain, and retrieve data costs and other informations,
2. ability to decrease man-hours spent on manual data calculations, analysis, and manipulation,
3. excluding quantity take-off, ability to reduce paper work to minimum,
4. ability to increase uniformity of output data for use on bid tabulation forms, both in Arabic and English languages,
5. ability to perform rapid "what-if" analysis, and
6. ability to allow cost estimator to consider last-minute quotations.

After examining the requirements of the local contractors in regard to improving the current estimating system, and searching various methods of improving the system, three major alternatives were determined to provide a wide range of options available to improve the current system:

1. **Improving the existing system:** implementation of any of the following recommendations may result in improvements to the current manual system:

- develop and use estimating standardized forms (both Arabic and English
- maintain a well organized historical data costs in a single location accessable to the estimating department (23),
- improving communication between the estimators and the project owner

and/or the consultant during the estimating process,

- keep historical records for all possible competitors and develop a bidding strategy based on the available information, and
- maintain good communication with the subcontractors and material suppliers and record the market trends.

The above recommendations, however, require a lot of time and effort to attain them, so this alternative was ignored.

2. Modifying an existing cost estimating software: all of the cost estimating software packages available in the local market are English. Moreover, these systems may not work effectively with the available arabization computer system. This approach was also ignored, since arabizing an existing software requires learning the computer language used in development, and then determining if the existing Arabic softwares can work with this development language. This approach is the same as developing a new software.

3. Developing a new computerized system: This approach was adapted, i.e. developing a new system from scratch. This system was believed to satisfy the requirements of the local contractores as revealed from the sample survey and the literature review.

The remainder of this chapter will describe in detail the steps followed to develop the ARAB-EST .

5.2 Design Phase

Having defined the problem and selected the best alternative solution, through the planning phase, the next phase in the development process is the design phase. There are two main activities in this phase, namely system definition and system creation.

5.2.1 System Definition

5.2.1.1 System Purpose & Functions

The main purpose of ARAB-EST is to store, maintain, update, and retrieve cost data and other information that may be needed in estimating a work item's cost, such as workforce rates, equipment rates, material costs, and subcontractors information. ARAB-EST then uses these information and data to calculate the construction cost of this work item. Finally, the system will print the output of calculations in a suitable forms that could be used in bidding the job, scheduling, and resource planning. To support these general purposes, the system provides the following specific functions:

- allow the user to store, update, retrieve, and access cost databases independent of their uses,
- allow the user to retrieve the required data in the estimating process automatically,
- performs the required calculations to produce cost estimate,
- allow the user to import/export data from external databases,
- print the estimating output in a usable form through English or Arabic

languages, and

- allow the user to analyze, and investigate the estimate, "what-if" analysis fore example.

ARAB-EST is intended to be used by cost estimators with little or no computer knowledge, therefore, all functions are accessed through a menu system, with immediate feedback.

The following criteria were considered in developing ARAAB-EST :

- a system that meets the user's needs in a cost-effective and reliable manner,
- a system that is understandable and easy to use,
- a system with very simple input instructions with minimal input data and meaningful tabulated outputs,
- a system that is flexible with regard to meeting continual system improvements and future system user demand, and
- a system with minimum development costs (both in time and money).

5.2.1.2 ARAB-EST Basic Concept

The basic conceptual framework of ARAB-EST is shown in Figure 5.3. The system consists of a DataBase Management System (DBMS), an Estimating Routine, and an Arabic BIOS (Basic Input/Output System) Software. The DBMS contains cost data of a firm's resources, i.e. labor, equipment, material, and other information such as subcontractors and material supplyers. DBMS can be accessed independently of its uses. The Estimating Routine contains the programs that retrieve the required data and information from DBMS as needed, to calculate, analyze, and control the estimate's input/output, through a menu driven interface system. Arabic BIOS Software is used to enable the user to arabize the input/output process.

ARAB-EST will take as input: (1) material's bills of quantity; (2) quantities of labor and equipment needed to execute a given project; and (3) information of subcontractors, if any. It will produce as output: (1) detailed estimating reports showing each work item, its total direct cost (costs of material, equipment, and labor), total indirect costs (profit and over head), and total cost (bidding cost); and (2) and summary reports classified by equipment, material, and labor.

DataBase Management System. The key to ARAB-EST development is the usage of a Database Management System, (often abbreviated DBMS). Weigal and Fenske [1984], have defined a database as a collection of interrelated data, stored together without unnecessary redundancy, and intended to serve multiple applications. Data are stored so that they are independent of the programs which use them. A common and controlled approach is used in adding new data, modifying , and retrieving existing data within the database. Data Management System (DBMS) is the interface between the user and the database.

In estimating construction costs, one deals with enormous sets of independent but interrelated data items. DBMS allows the user to store and organize these data items in a systematic and consistent manner. Using a DBMS to store and describe cost data offers the following advantages, [Mitcell, 1987]:

- ability to store and manipulate data independent of its use,
- ability to represent (complex) relationships existing among the data,
- control of data redundancy,
- possibility of maintaining data consistency and integrity, and
- provision of more sophisticated and flexible file manipulation and reprt generation facilities.

With the available DBMS technology, it is very easy to develop databases specifically tied to the needs of a particular user, and expand those databases as the user needs change.

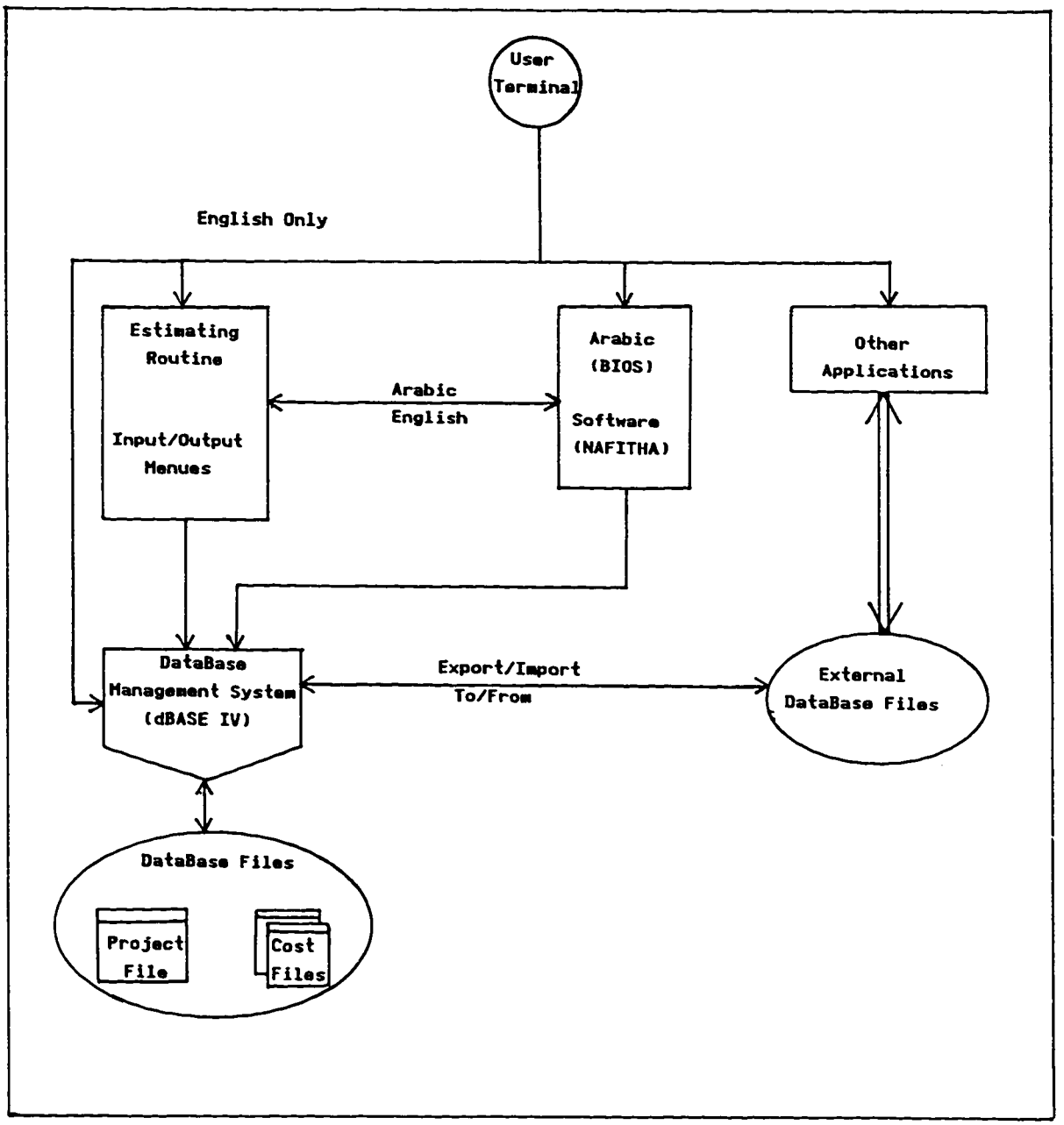


Figure 5.3: ARAB-EST Conceptual Framework

The DBMS used in ARAB-EST provides data entry, modification, and reports which manipulates six databases files via dBASE IV software. Among others, dBASE IV was selected for the following reasons:

- provides transparent data management,
- is inexpensive and easy to use ,
- is large diverse user base,
- is easy to expand and modify,
- permits formatted data entry/ display screens,
- is available for other data management applications,
- has a networking capability,
- is both programmable and interactive, and
- has a powerful built-in programming language.

The following section gives an overview of dBASE IV.

dBASE IV

dBASE IV is a database management system, a tool for managing data in database files electronically. Electronic data processing means that vast amounts of information and data can be stored, related, manipulated, and retrieved with speed and efficiency, giving the user control to use only tha data that meet certain criteria. As a DBMS, dBASE IV can bring unprecedented efficiency to a wide variety of tasks, such as managing customer files, inventories, research data and statistics.

dBASE IV could be used in two different but complementary ways: command oriented through the dot prompt (the dBASE IV equivalent of the DOS prompt), or task oriented through the Control Center, a visually oriented user interface. The Control Center acts as a high-level parent menu, permitting

the user to access to lower-level features and work surfaces for various dBASE IV tasks through the menu bar at the top of the work surface. [Towsend 1989]

User accessing dBASE IV from the Control Center can manage files (create, modify, open, append, edit, browse, close), create views, define forms, create or generate reports, run programs, and even use the Application Generator to create a new programs. In addition, dBASE IV supports an extensive high-level programming language, permitting users to develop application programs, through the program editor, in approximately one-tenth the time it would take to develop the same program in many other high-level languages, such as BASIC or C. [Simpson 1988, Townsend 1989, and Carlton 1989]

A database file is simply an organized collection of information or data, such as a list of names and addresses, sales transactions, or stock prices. In database terminology, each data base file consists of records (or rows) of information. Each record is divided into separate fields (or columns) of information. A field is the smallest part of the record that can be used to describe it. Moreover, the field in a database file define its structure. In the equipment database file, for example, each piece of equipment information (record) is divided into five fields or columns of information: equipment number, equipment description or name, unit of output measurement, and cost per unit. This is illustrated in Figure 5.4 .

Record

Equipment Number	Equipment Name	Unit of Measurement	Cost/Hour
001	Dump Truck	Hr	18.61
002	Cargo Truck	Hr	13.82
003	Pick-up	Hr	10.35

Field

Figure 5.4: Record and Fields

Six basic types of data can be entered into a field. These data types are: character to contain text, numeric and float to contain numbers, date to contain date, logical to contain either a true (T) or false (F) values and no other information, and memo to contain long text. [Simpson 1988]

In designing a database file, each field must has a name that describes it, a specific data type which it contains, a specified maximum width that indicates its capacity to store the information, if numeric data type, the number of decimal placess must be specified, and a label index (either yes or no) indicates whether the field should be indexed for later utilization.

The Estimating Routine. ARAB-EST's estimating routine is merely a set of commands that instruct the computer to control and execute the estimating process, through a menu driven interface system. the estimating routine performs the following functions:

- it retrieves data costs from the database files when they are needed,
- it performs the arithmetic calculations and displays the result on the estimating item screen as a feedback,
- it organizes and print the estimating results in a predefined output form, and
- it stores the estimated cost of each work item in the project database

The estimating routine is written in dBASE IV programming language. dBASE IV built-in programming language is the program's most advanced powerful feature. In fact, dBASE IV built-in programming language, coupled with its extensive database management capabilities, make dBASE IV very suitable tool for ARAB-EST development.

Arabic BIOS Software. The Arabic software used in ARAB-EST is NAFITHA; its main function is toenable the user to arabize the input/output activities. One of the main advantages of NAFITH, is its ability to allow the user to input data

and information, and consequently get outputs in both Arabic and English languages, without the need to add any connections or special parts to the computer. NAFITHA's User Guide & Technical Reference contains more information.

5.2.2 The ARAB-EST's Structured Design

There are several distinctly differrent flow chart designs that may support the documentation of an application program, included are; 1) system flow chart; and 2) structure chart. [Myers 1988]

According to Townsend (1989), These charts are a graphical tools for shoeing the partitionning of the system int module, thereby showing the hierarchy and organization of these modules. The modules appear as rectangles in the charts, and the lines between the rectangles show the data flow. In most dBASE IV programming, one needs only pursue a level of detail that permits defining the function of each program and procedure.

The ARAB-EST has four main moduls, each of these is defined with its functional role (single objective) :

- SETUP BATCH PROCESS; Sets up and activate the procedure file (CEST.PRG);
- ESTIMATING; Appends and edits the work items to be estimated (EST-SCR);
- PRINTING; Prints the estimating report (COST-REPA); and
- DATABASES; Edits and updates the cost database files.

Under each of these is a collection of dBASE IV codes, each with a single function relevent to the modular function. The system chart of Arab-Est is

shown in Figure 5.5, whereas Figure 5.6 shows the EST.PRG structure chart.

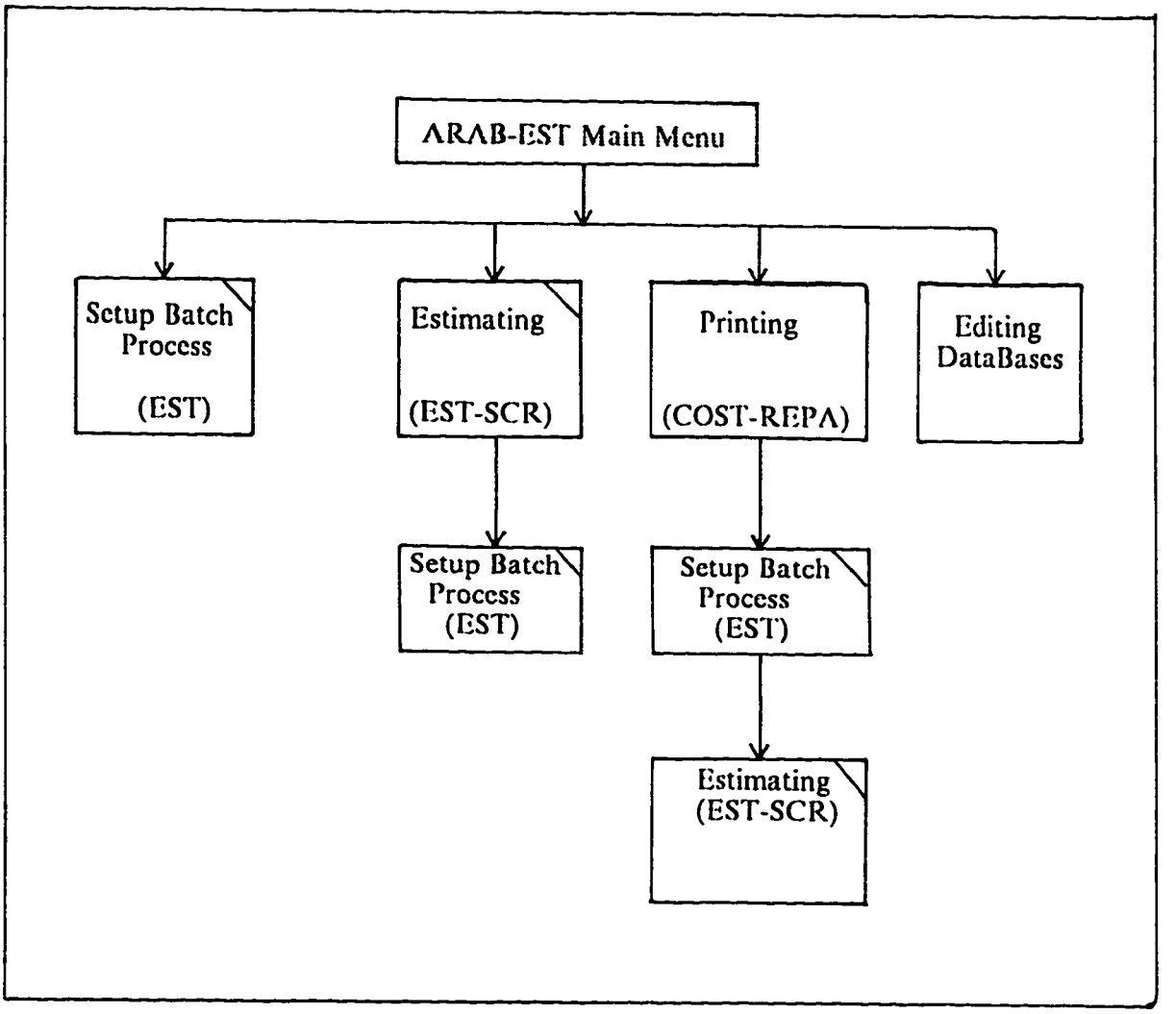


Figure 5.5: The System Flow Chart

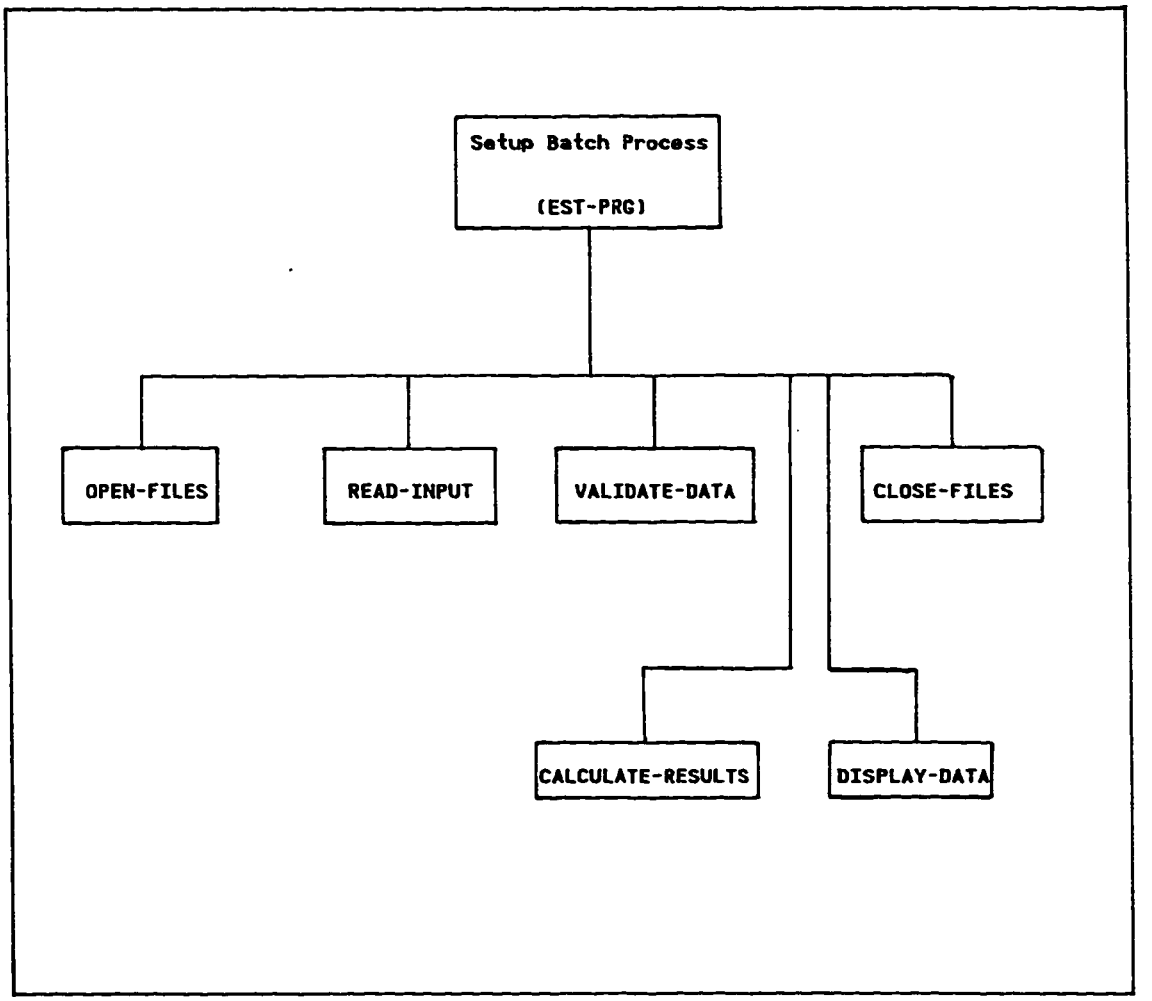


Figure 5.6: CEST.PRG Structure Chart

5.2.3 System Creation

As mentioned previously, ARAB-EST consists merely of a set of database files and a collection of dBASE IV commands stored in a program or procedure file (Estimating Routine). The Arabic BIOS software is used only to arabize the input/output processes. As such, the creation of ARAB-EST will be treated as a unit, integrating the program commands, database files, and the Arabic software.

The ARAB-EST creation process includes the following tasks:

. creating the database files,

. writing the Estimating Routine commands file,

. creating the input screens,

. creating the reports forms (outputs), and

. creating the menu system.

This process can be thought as a linear several separated tasks, using both dBASE IV's Control Center and the programming Language, together with NAFITHA.

5.2.3.1 ARAB-EST DataBase Files

ARAB-EST uses five independent, yet linked database files and a linker file. It needs a file for recording all of the work items of a project, three data cost files to store costs of labor, equipment, and material, a file that contains subcontractors information, and finally, a linker file that, through the Estimating Routine, retrieves cost data and uses them to cost each project's work item.

The databases were created using dBASE IV Control Center,(selecting <create> from the data panel of the Control Center). then at the file design

screen, for each file, the name, type, and size (width) of each field have been defined. The sections that follow discuss these files in detail.

Work Item DataBase File. The work item file, ITEM .DBF, holds the details of all project's work items. The project's work items can be identified by decomposing a given project down into its smallest component parts. The estimator can use the Construction Specifications Institute (CSI), the work-breakdown-structure (WBS), the work-element-structure (WES) formats, or his own format based on his experience, judgement, and type of the project.

While the work item file is based on CSI's 16 construction divisions, any other system can be used by the file. As this, the file contains the work item number (ItemNo), its name (ItemDesc), the subdivision number and name (Sub-Div), division number and name (Div), the item's profit rate (Profit), and the item's over-head (OH). The file structure is shown in Figure 5.7 .

Note that the ItemNo field is indexed (marked Y in the Index column). This will allow the system to retrieve the work item's information during the estimating process, or to locate a particular record in a database file.

Cost DataBase Files. There are three main resources used to construct a given project: labor, equipment, and material. Costs and prices of these resources are not constant, hence, cost records of labor rates, equipment costs, and material prices must be maintained and updated continually. These records are then retrieved when a future construction project is being estimated.

ARAB-EST contains such cost data and information in three separated database files: labor file (Lab .DBF), material file (Mat .DBF), and equipment files (Eq .DBF).

Labor DataBase File. Contains information related to the various labor classes; included are labor class number (L1No), labor class description or name (L1Desc), and cost per hour (L1C), as shown in Figure 5.7 . Note again that L1No field is indexed.

Equipment DataBase File. Contains equipment number(E1No), equipment name (E1Desc), and equipment cost per hour (E1C). E1No field is indexed also. The structure of Eq1 file is shown in Figure 5.7 .

Material DataBase File. Contains material number (M1No), material name (M1Desc), unit of measurement (M1U), and unit cost (M1C) as shown in Figure 5.7 .

Subcontractors DataBase File. In many construction projects, it is common that several project parts are subcontracted to one or more subcontractors who have special experience, equipment, and labor in these parts of the project. Subcontractors file contains subcontractor reference number (SNo) ,subcontractor name (SName), telephone number (Tel), specialty (Spec), and average cost (SCost),if any. The structure of SUB database file is shown in Figure 5.7 .

Work Item Estimating DataBase File. The work item estimating file, CEST .DBF, is the key to the ARAB-EST. This file, through the Estimating Routine, is used to retrieve cost data and other information from the databases, perform all arithmetic calculations required in estimating a project work item, and produce all estimating reports. The work item estimating file does not, however, contain all the information for these calculation and reports, instead it retrieves them from the databases. It can be viewed as a linker file that manages and links the other ARAB-EST's database files.

As an estimating file, it contains no information records about work items, material, labor, or equipment. This information and data are maintained in separate files and are referenced by a unique identifier in the estimate file. The basic structure of this file is shown in Figure 5.7.

```
Structure for database: C:                \ESTIMATE\LAB1.DBF
Number of data records:        5
Date of last update    : 01/01/80
Field  Field Name  Type        Width    Dec     Index
    1  LNO         Character       2              Y
    2  L1DESC      Character      25              N
    3  U_MEASURE   Character       4              N
    4  L1C         Numeric         5      2       N
    5  NO_OFPERS   Numeric         3              N
** Total **                       40

Structure for database: C:                \ESTIMATE\EQ1.DBF
Number of data records:        0
Date of last update    : 01/01/80
Field-- Field Name  Type        Width    Dec     Index
    1  ENO         Character       4              Y
    2  E1DESC      Character      25              N
    3  U_MEASURE   Character       4              N
    4  E1C         Numeric         6      2       N
    5  NO_PEICES   Numeric         3              N
** Total **                       43

Structure for database: C:                \ESTIMATE\MAT.DBF
Number of data records:        3
Date of last update    : 01/01/80
Field  Field Name  Type        Width    Dec     Index
    1  MNO         Character       4              Y
    2  NDESC       Character      25              N
    3  MU          Character       5              N
    4  MC          Numeric         8      2       N
** Total **                       43
```

Figure 5.7: Structure of the DataBase Files

Structure for database: C: \ESTIMATE\SUB.DBF
Number of data records: 0
Date of last update : 01/01/80

Field	Field Name	Type	Width	Dec	Index
1	SNO	Character	4		Y
2	SNAME	Character	25		N
3	TEL	Character	8		N
4	SPEC	Character	15		N
5	SCOST	Numeric	8	2	N
** Total **			61		

Structure for database: C: \ESTIMATE\ITEM.DBF
Number of data records: 1
Date of last update : 01/01/80

Field	Field Name	Type	Width	Dec	Index
1	ITEMNO	Character	5		Y
2	ITEMDESC	Character	25		N
3	SUB_DIV	Character	20		N
4	DIV	Character	20		N
5	PROFIT	Numeric	4	2	N
6	OH	Numeric	4	2	N
** Total **			79		

Structure for database: C: \ESTIMATE\CEST.DBF
Number of data records: 0
Date of last update : 01/01/80

Field	Field Name	Type	Width	Dec	Index
1	PROJECT	Character	25		N
2	ITEMNO	Character	5		Y
3	MNO	Character	4		Y
4	MQ	Numeric	6		N
5	M1Q	Numeric	6		N
6	M2Q	Numeric	6		N
7	LNO	Character	2		Y
8	LC	Numeric	5	2	N
9	LH	Numeric	5		N
10	L1H	Numeric	5		N
11	L2H	Numeric	5		N
12	ENO	Character	4		Y
13	EC	Numeric	6	2	N
14	EH	Numeric	5		N
15	E1H	Numeric	5		N
16	E2H	Numeric	5		N
17	IP	Numeric	4	2	N
18	IOH	Numeric	4	2	N
19	SNO	Character	4		Y
20	SUBC	Logical	1		N
** Total **			113		

Figure 5.7: Structure of the DataBase Files (Continued)

Illustration

Referring to the structure of EQ1 database file (Fig. 5.8), each field is specified by: field name, data type it contains, field width, decimal placess, and index. For example, E1DESC field will contain character information that describes a piece of equipment (or name), so the data type is character with a maximum width of 25 characters, as shown in the Width column in the file structure. There is no decimal placess for character dat type, consequently no decimal places is assigned in the Dec column. Moreover this field is not indexed (marked N in the Index column). In this file, E1C field contains information related to the equipment hourly cost, so this field is a numeric data type with a width of 6 and 2 decimal placess (indicated by placing 2 in the Dec column).

The information stored in this file will be required by the estimating routine in performing the estimate, so this file is linked to the CEST .DBF through the ENO field which contains the equipment code or reference number. To indicate this, the ENO field is indexed by placing Y in the Index column. Note that ENO field is also exists in the CEST file and is marked Y in the index column to relate CEST and EQ1 database files via the estimating routine. After creating this file, the information are stored in a tabular form as follows:

ENO	E1DESC	U-MEASURE	E1C	NO-PIECES
001	Dump Truck	Hr	18.61	5
002	Cargo Truck	Hr	13.82	5
003	Pick-up	Hr	10.35	3
..	..	..	..	..

However the user may not use this tabulated form to manage the file (editing, adding, changing or updating the data), instead,the equipment screen (Fig. 5.14) will be used for these purposes.

5.2.3.2 Estimating Routine

The estimating routine (Est) is coded using dBASE IV programming language and created using the MODIFY COMMAND editor. several dBASE commands and functions were used to develop the estimating routine, which comprises the following subroutines or programs:

OpenFile: This subroutine opens all the system's database files and activate the index that links the database files through a common fields: a field that exists in all databases. This short dBASE subroutine is very handy, since all data-entry screens operate on one database at a time. This subroutine, opens all database files and sets the order to the index tag for each data file.

OpenFile is stored as a procedure in the file EST.PRG along with other subroutines, that are used by the system, and is activated/called automatically.

V-Item: This subroutine ia a User-Defined Function (UDF) which is stored in the EST.PRG file and processes the following functions:

- as the user enters an item code or number, the program will seek the Item.DBF, which is already opened by the OpenFile, very quickly for the number or code that matches the one entered by the user.
- if the search fails to find a matching number or code in the Item file ,it returns .F., and a message will be displayed on the estimating screen.
- if the search did indeed find a matching number in the Item file, the program will display the item description, profit rate, and the over head in the screen.

V-Lab: This subroutine checks and validates labor numbers or codes as they are entered in the estimating screen and displays the labor class and the cost per hour for each class. The Rlabor subroutine uses the same basic logic and the same programming techniques as the Ritem subroutine. The main difference is

that the Rlabor checks, validates labor codes or number rather than item codes or numbers as they entered or changed on the screen, and it displays related information from Labor, rather than from the Item, database file.

V-Eq: This subroutine is exactly the same as the Rlabor one, except it processes the Equipment database file.

V-Mat: This subroutine is exactly the same as Rlabor one, and processes the Material database file.

V-Sub: It is exactly the same as the Rlabor subroutine and it processes the Subcontractor database file.

The flow chart of the CostEst routine is shown in Figure 5.8.

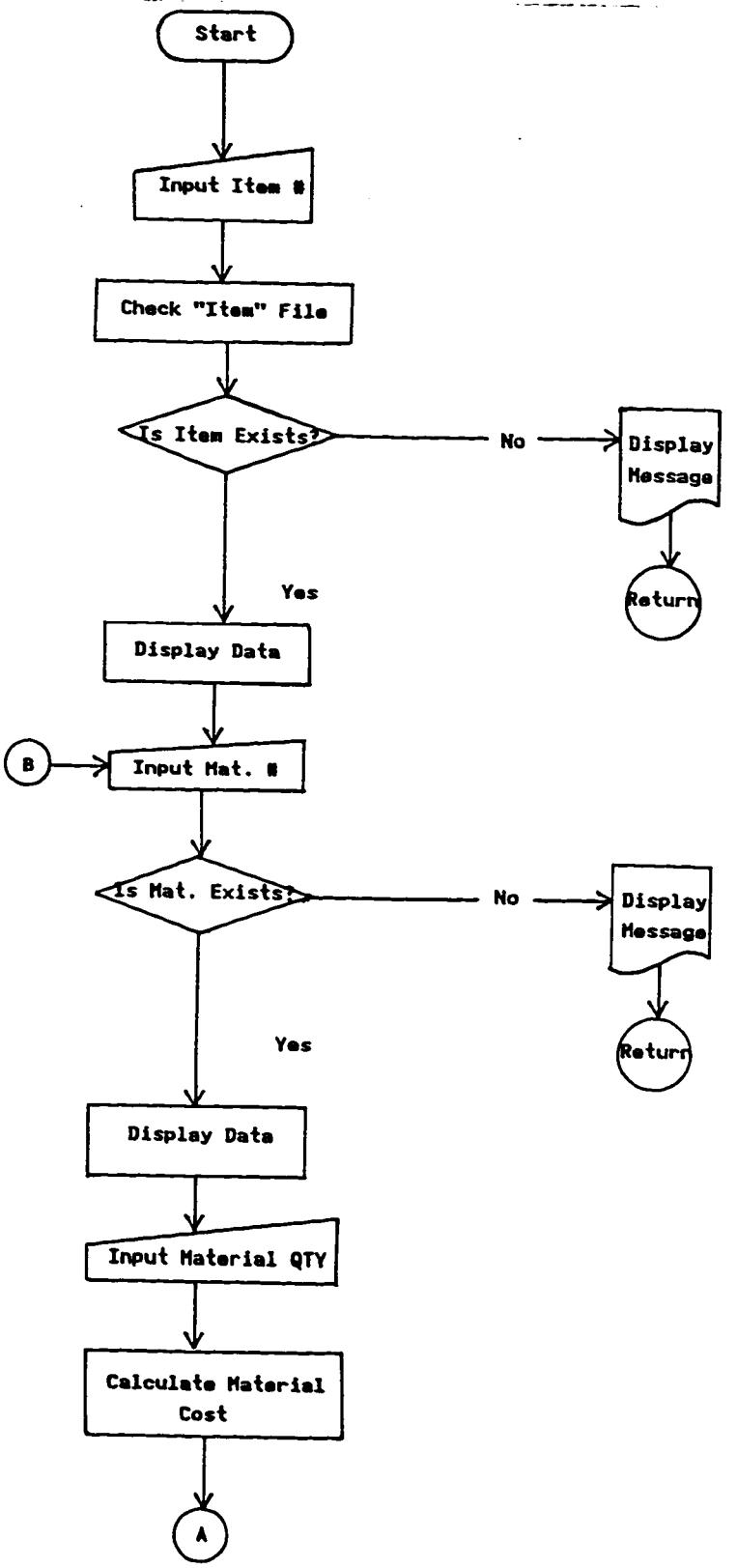


Figure 5.8: CostEst Flow Chart

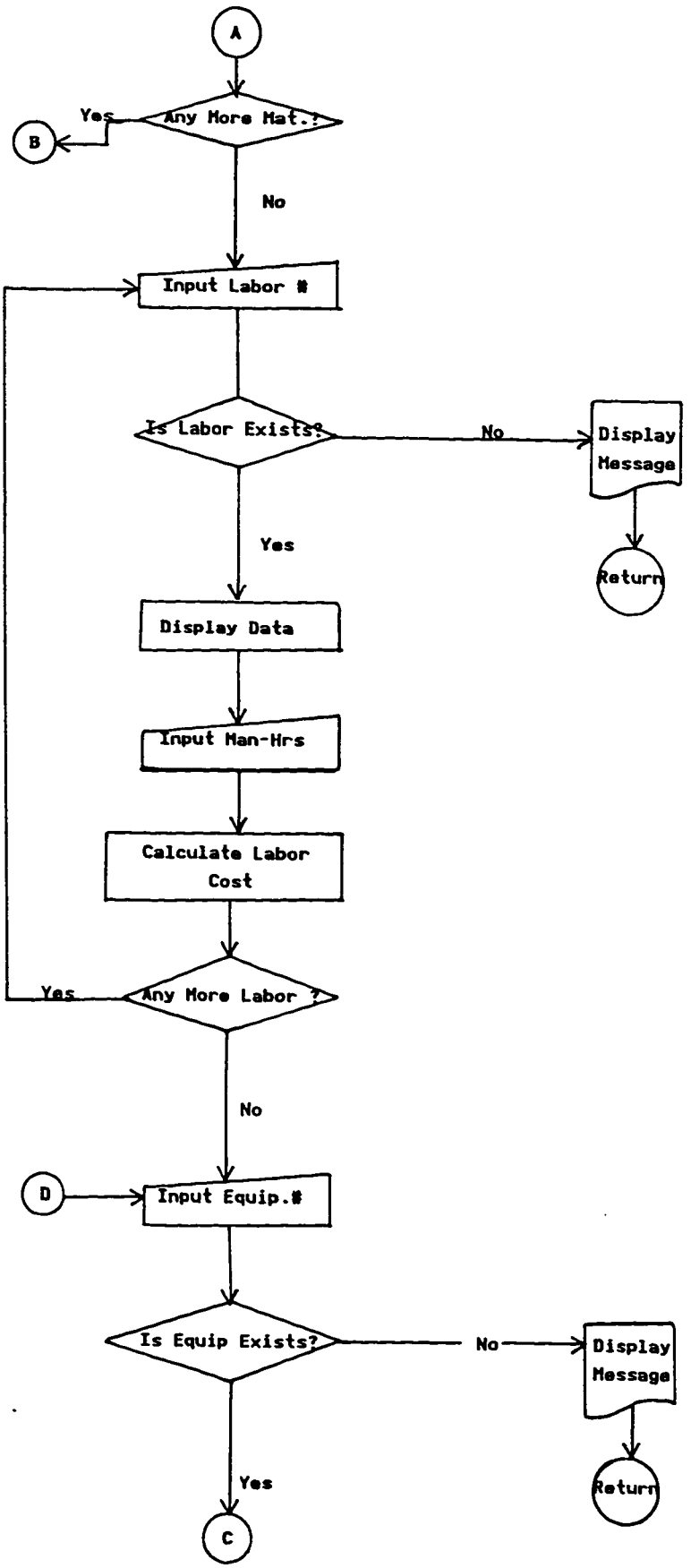


Figure 5.8: CostEst Flow Chart (Continued)

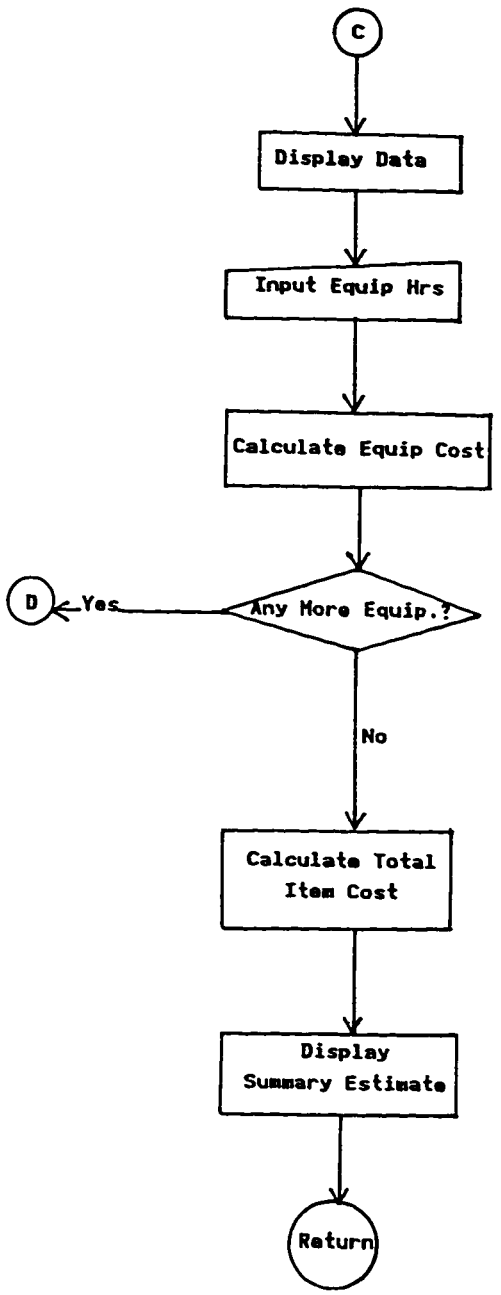


Figure 5.8: CostEst Flow Chart (Continued)

5.2.3.3 Estimating Screen

The estimating screen could be viewed as an estimating work sheet,on which all estimating's steps are done. The screen, shown in Figure 5.9, will make the estimating process very convenient. The estimator needs only to enter the reference numbers or codes of each item being estimated and the labor, material, and equipment needed to construct it. The data associated with each will be displayed on the screen; the user then enters the quantities of resources required to build this particular work item.

When the user enters an item's code, the screen will display the item name, and its profit and overhead rates. The user, next, enters the material reference number or code, material name, unit of measurement,and the unit price or cost are displayed on the screen. If the user enters the quantity of material required to perform this work item, the estimating routine will calculate the total cost and displays the result on the screen within seconds.

This step is repeated several times for estimating the costs of other material, if any, labor, and equipment. Finally, a summary of the estimate will be displayed, showing total item direct cost, its profit and overhead, and the total cost (bidding) price of the work item being estimated. Next, the screen will be ready for estimating another work item in the same way, and so on until all of the project work items are estimated.

```
10:01:30 a
{ ITEM COST ESTIMATE }  تقدير تكلفة بند العمل

اسم المشروع  {Projet Name}  :  بناء مدرسة ثانوية رقم

رقم البند  {Item #}  :  1  }}:  قواعد الأعمدة}}

                {Material Costs}  تكلفة المواد

الرقم   الأسم          الوحدة   السعر     الكمية   السعر الكلي
Ref #   Description    Unit      UnitCost  QTY      Cost (SR)
1       خرسانة جاهزة   م مكعب    250.00    600      150,000.00
3       شدات خرسانية   م مربع    105.00    50       5,250.00
2       حديد تسليح     طن        1350.00   35       47,250.00
==========
اجمالى تكلفة المواد  {Total Material Cost}  202,500.00
ESS ANY KEY TO CONTINUE..
```

Figure 5.9: The Estimating Screen

```
                {Labor Costs}  تكلفة العمال

الرقم   المهنة          تكلفة الساعة   عدد الساعات   التكلفة الكلية
Ref.#   Description     Cost/ Hr       Man-Hours     Cost (SR)
4       عامل حديد       12.00          75            900
5       نجار            12.00          100           1200
3       رئيس عمال       18.00          100           1800
==========
اجمالى تكلفة العمال  {Total Labor Cost}  3900

                {Equipment Costs}  تكلفة المعدات

الرقم   الأسم           تكلفة الساعة   عدد الساعات   التكلفة الكلية
Ref.#   Description     Cost/ Hr       Hours         Cost (SR)
6       هزاز خرسانه     5.00           100           500
7       خلاطة خرسانه    10.00          600           6000
5       حفار            90.00          50            4500
==========
اجمالى تكلفة المعدات  {Total Equipment Costs}  11000
ESS ANY KEY TO CONTINUE...
```

Figure 5.9: The Estimating Screen (Continued)

$$$$$$$$$$$$$ {Item Cost Summary}			ملخص تكلفة البند $$$$$$$$$$$$
(ريال سعودى)	217400.00		اجمالى التكلفة المباشره : {Total Direct Costs}
(ريال سعودى)	4,348.00	2.00 %	الربح { Profit } :
(ريال سعودى)	10,870.00	5.00 %	مصروفات {OverHead}:
	==========		
(ريال سعودى)	232,618.00		اجمالى التكلفة الكلية : {Total Item Cost}

{SubContractor Cost} تكلفة مقاول الباطن

Total Cost/اجمالى التكلفة (ريال سعودى)	Name الاسم	Ref.#/الرقم

Figure 5.9: The Estimating Screen (Continued)

5.2.3.4 Estimating Report

Estimating reports are perhaps one of the most important part of the estimating process. There are several estimating report forms. Specifying one is a function of the firm environment, the subsequent use of the estimating report, and the requirement of the owner. The reporting component of the ARAB-EST was created using the dBASE IV Report Generation initiated by MODIFY REPORT command. This report, shown in Figure 5.10 contains the project name, the item name and its number, and the costs of material, equipment, and labor. The total direct cost of the item being estimated is shown at the bottom of the report. Moreover, the profit , and overhead amounts are also shown. Finally, the total cost of the item is shown. Actually, the report is another form of the Estimating Screen.

بسم الله الرحمن الرحيم

اسم الشركة:

التاريخ :٩٠/٠٥/١٥

تقدير تكلفة المشروع

اسم المشروع: بناء مدرسة ثانوية رقم ١

الرقم	الوصف	الوحدة	تكلفة الوحدة	الكمية	التكلفة الكلية
	بند رقم: ١ قواعد الأعمدة				
١	خرسانة جاهزة	م مكعب	٢٥٠,٠٠	٦٠٠	١٥٠٠٠٠,٠٠
٣	شدات خرسانية	م مربع	١٠٥,٠٠	٥٠	٥٢٥٠,٠٠
٢	حديد تسليح	طن	١٣٥٠,٠٠	٣٥	٤٧٢٥٠,٠٠
	اجمالى تكلفة مواد البناء:		(ريال سعودى)		٢٠٢٥٠٠,٠٠
٤	عامل حديد	ساعة	١٢,٠٠	٧٥	٩٠٠,٠٠
٥	نجار	ساعة	١٢,٠٠	١٠٠	١٢٠٠,٠٠
٣	رئيس عمال	ساعة	١٨,٠٠	١٠٠	١٨٠٠,٠٠
	اجمالى تكلفة العمال:		(ريال سعودى)		٣٩٠٠,٠٠
٦	هزاز خرسانة	ساعة	٥,٠٠	١٠٠	٥٠٠,٠٠
٧	خلاطة خرسانة	ساعة	١٠,٠٠	٦٠٠	٦٠٠٠,٠٠
٥	حفار	ساعة	٩٠,٠٠	٥٠	٤٥٠٠,٠٠
	اجمالى تكلفة المعدات:		(ريال سعودى)		١١٠٠٠,٠٠
	مجموع التكلفة المباشرة:		(ريال سعودى)		٢١٧٠٤٠٠,٠٠
	الربح	:	٢,٠٠%		٤٠٣٤٨,٠٠
	المتفرقات	:	٥,٠٠%		١٠٠٨٧٠,٠٠
	اجمالى تكلفة البند:		(ريال سعودى)		٢٣٢٠٦١٨,٠٠

Figure 5.10: The Estimating Report

5.2.3.5 DataBase Files Screens

Changing, updating, and adding data and information to the database files, (Item, Material, Labor, Equipment, and Subcontractors), is accomplished using the screens shown in Figures 5.11 to 5.15. These screens were created using dBASE IV Form Generation at the Control Center.

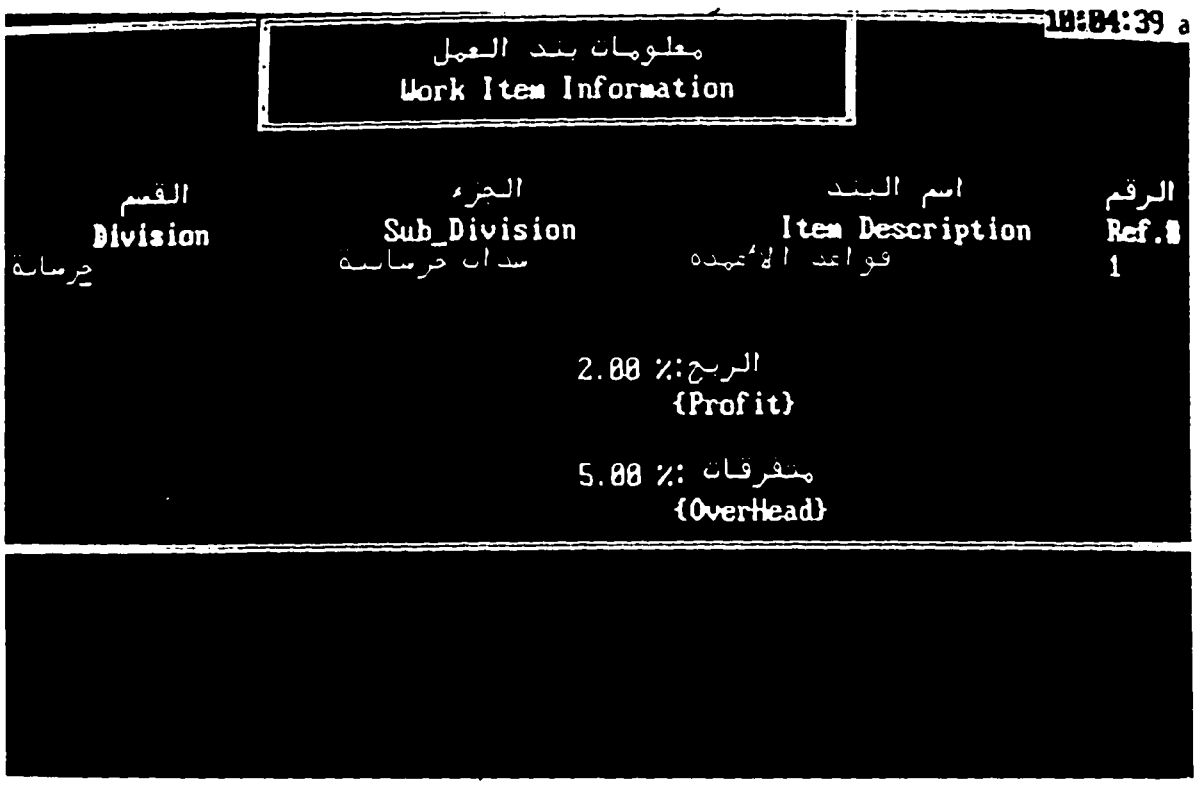


Figure 5.11: Item Screen

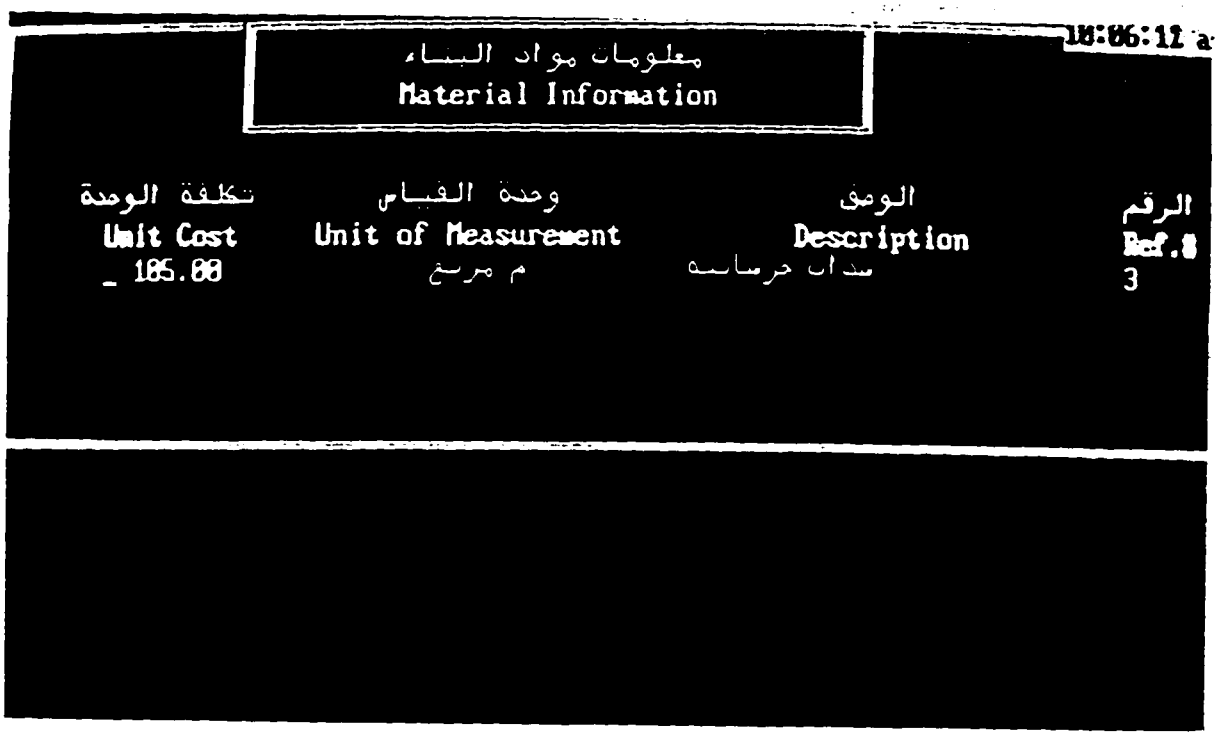


Figure 5.12: Material Screen

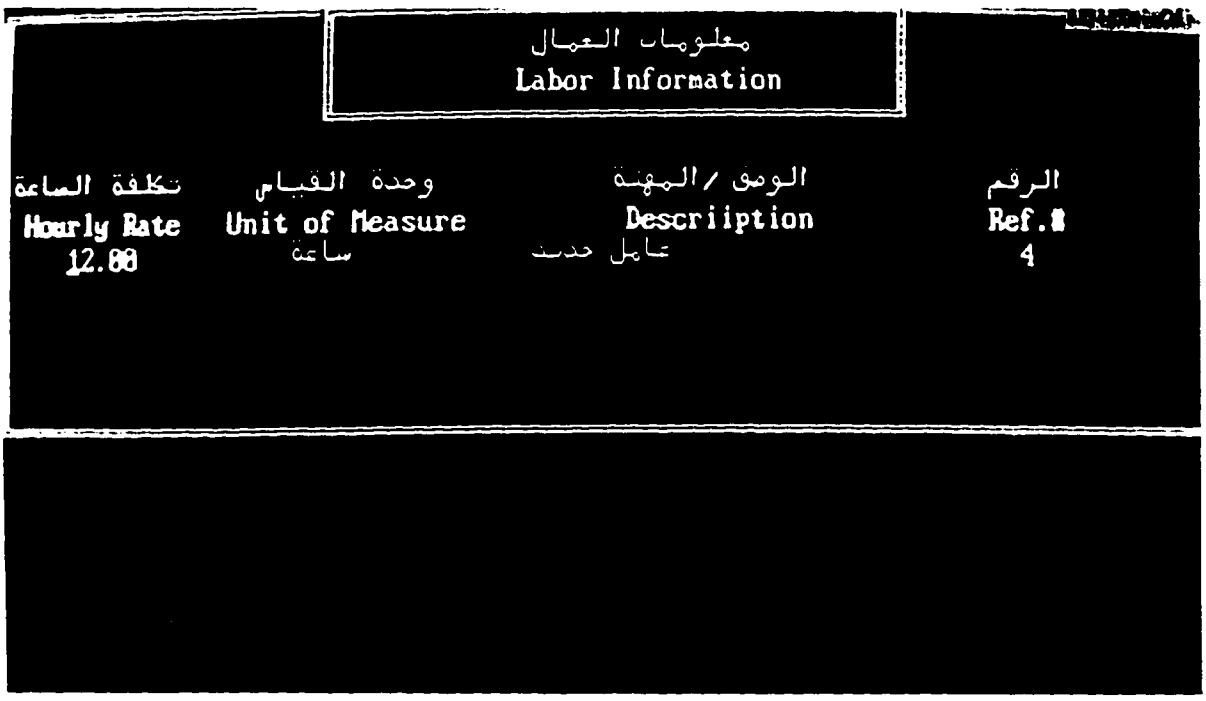


Figure 5.13: Labor Screen

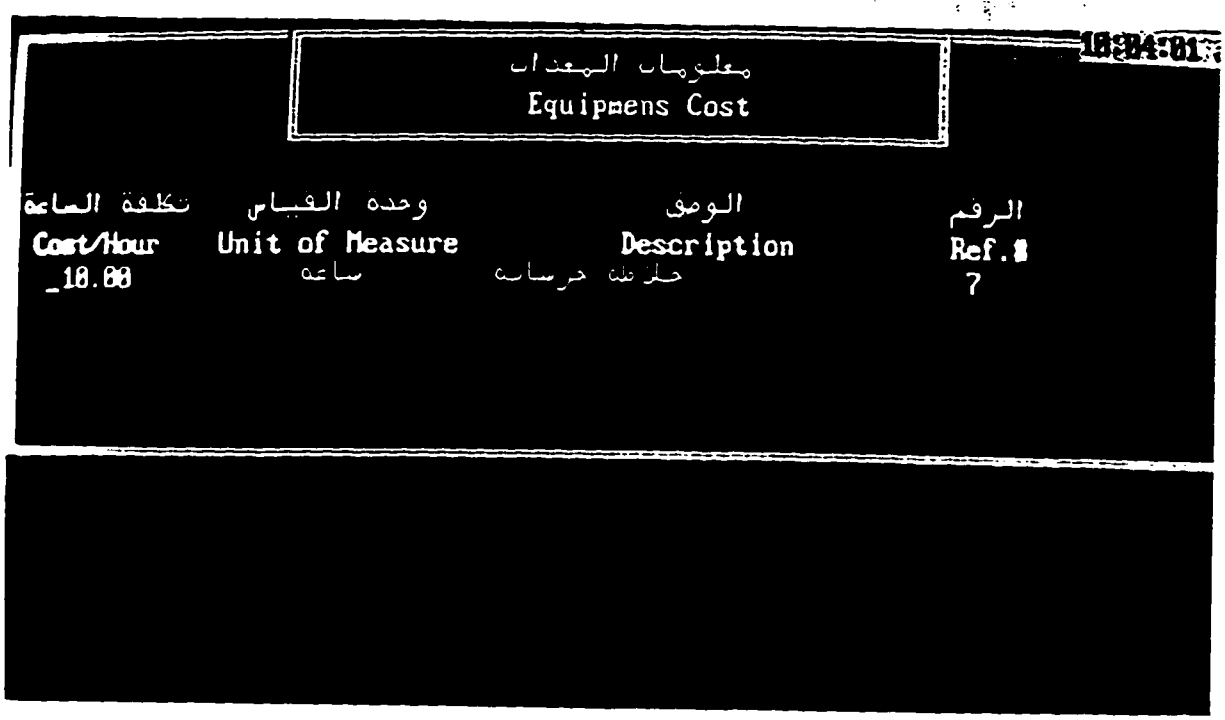


Figure 5.14: Equipment Screen

Figure 5.15: Subcontractors Screen

5.2.3.6 Menu System

The menu system is a customized menu based on actions that simplifies access to the ARAB-EST . This menu is intended to enable the user to use the ARAB-EST easely and effectively. The ARAB-EST menu is a horizontal bar menu and the submenus are vertical-column bar menus under each main menu options. The user can use the arrow keys to select the desired option from the main menu, then uses the Return key to activate the desired submenu. As shown in Figure 5.16, there are three main options, namely: Estimating; DataBase Files; and Exit. The first option allows the user to access the Estimating Screen to perform cost estimating, and then printing the estimating report, Figure 5.17. The second option, allows the user to add, change, and update each of the database files, Figure 5.16. Finally, the Exit option, exits the system. The menu system was developed using the Application Generator of the dBASE IV Control Center.

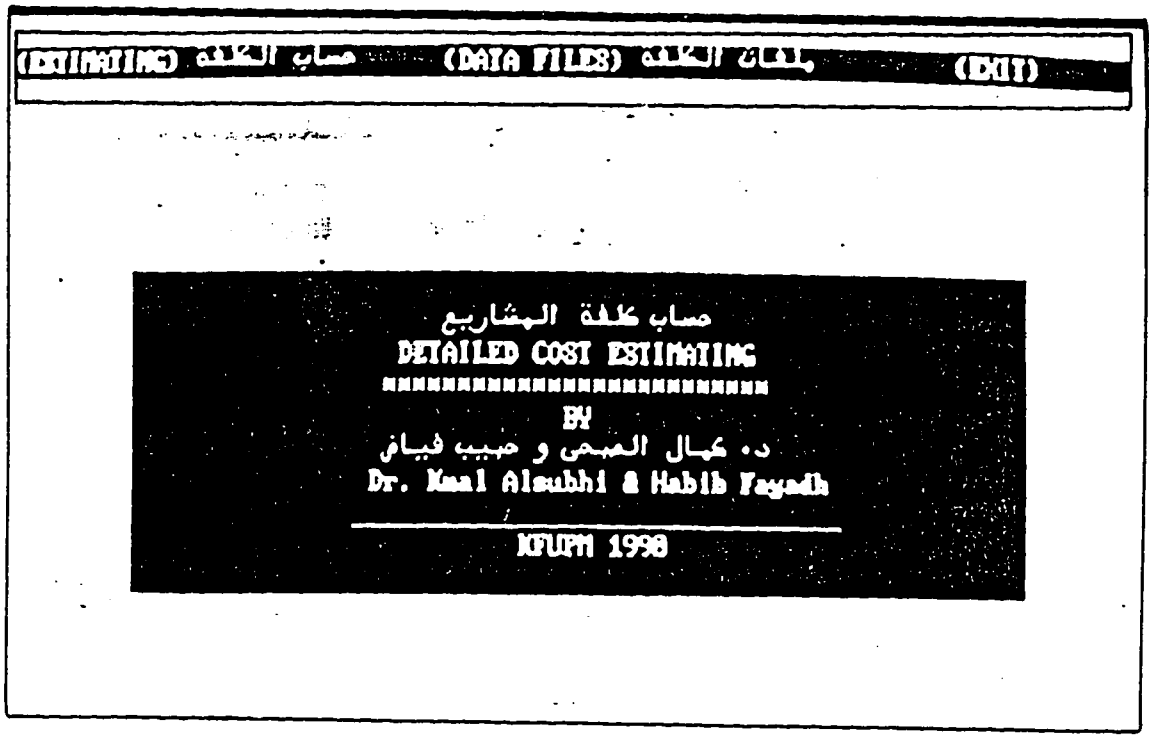


Figure 5.16: ARAB-EST Main Menu

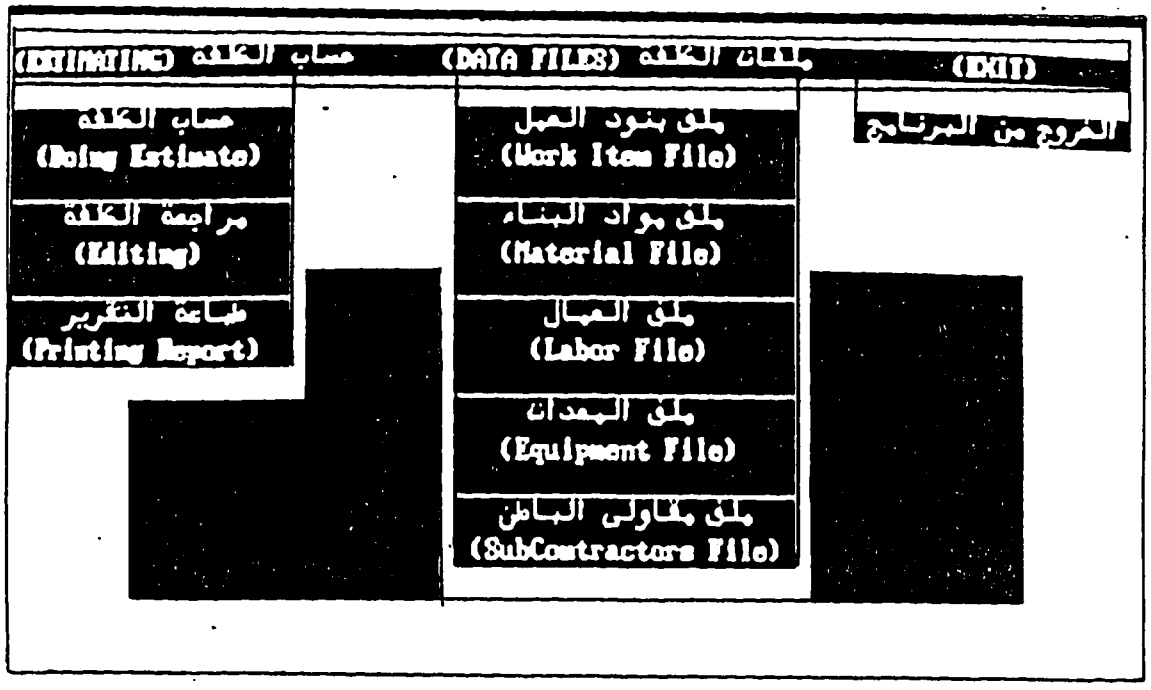


Figure 5.17: The Pull Down Menu

5.3 Testing and Implementation

The ARAB-EST was successfully tested and the expected results were obtained without major problems. An attempt was made to implement the system in an actual project in the local construction market. However, the contractors contacted, refused to install the system in their computers. They consider their computer systems as a secret part of their work and they are not allowing outsiders to access them. Consequently, a hard copies of the system's Estimating Screen, report output, and the main menu, were showed to several estimators. The results of this task, was good and they give a good impression about the system. However, this is not considered as the system implementation.

It is important to point out that implementing the system in a project is not one of the objectives of the research; consequently, it is beyond the scope of the research. The development of this system, however, was made in an attempt to solve some problems frequently facing the cost estimators working in the local construction market, as revealed by the sample survey.

Before using the system in actual estimating, the following must be done:

1. A complete set of work items of a standard project mostly done by the firm, must be entered to the system through the Item file. The user, however, can enter any work item during the estimating process.
2. Data and information of material, labor, and equipment must be also entered into the system through the screens of each file.

These tasks are done only once. Once these information and data have been entered into the system, the user can retrieve them by entering the code or reference number of the required resource. The data and the information can be changed or updated through their screens.

CHAPTER VI

CONCLUSION

6.1 Conclusion

This research was conducted to investigate the problems of the local construction building contractors in the estimating and bidding process. A personal interview questionnaire was developed and used to identify the estimating problems and to assess the general requirements of the local contractors regarding developing an Arabic Detailed Estimating System. The results of the study indicated that microcomputers are effectively applicable in the estimating and bid preparation process. An important finding during the interview stage was the apparent insufficient information about the benefits and services of microcomputers in the construction cost estimate and bid preparation process. In an attempt to solve some of the revealed estimating problems, a Computer Aided Detailed Estimating System was developed. However, the study indicated several problems that couldn't be solved through the utilization of microcomputers. These are as follow:

- tough competition,
- incomplete drawing and specifications,
- changes of owner requirements,
- judgement errors, and
- incomplete project scope and definition.

This research revealed that microcomputer technology is under utilized in solving cost estimating problems. The main reason for this is due mainly to insufficient information regarding the benefits of computers in this process. It is believed that performing a practical demonstration of any computerized estimating system with the estimators is likely to convince them to adapt such a system.

One of the findings of this research is that, the cost estimating process is prepared using the English language; however, contractors need to communicate the estimate or at least the summary estimate, in most cases through the Arabic language. Therefore, the system's menus, screens, and output were designed using both Arabic and English. The users of this system need not learn new estimating techniques or methods, since it is a copmuterization of the manual estimating process.

The users of the ARAB-EST need only to know how to operate a PC, since all of the system's functions are accessed through a menu driven system with immediate feedback.

The conceptual frame work outlined in this research could be used as a guideline in developing other Arabic Computerized applications to the construction industry. Recognizing the needs for an integrated project management system, this system could be easily integrated or combined with other construction computer systems. This particular feature is afforded by dBASE IV ,in which information contained in database files can be exported to be used by other applications, in the same way, data from other application databases could be imported to the system.

The recent developments of relatively low cost but powerful microcomputers

means that even the smallest contractors can use the advantages of this technology previously restricted to large contractors. If used properly, microcomputers can assist the estimator in developing and preparing accurate and timely construction cost estimates.

Finally, this research has proved that the available microcomputer technology can be effectively used to develop an Arabic microcomputer-based applications for solving many construction problems.

6.2 Recommendations

The following recommendations are worth consideration to help avoiding some cost estimating and bid preparation problems facing the local construction contractors:

1. A standard estimating form, work item breakdown technique, and coding system are strongly recommended. This will eliminate the omission errors frequently encountered by the estimators. CSI format may be a good system to use or start with.

2. Maintain a well organized historical data costs in a single location accessable to the estimating department .

3. Improve communication between the estimators and the project owner and/or the consultant during the estimating process,

4. Keep historical records for all possible competitors and develop a bidding strategy based on the available information, and

5. Maintain good communication with the subcontractors and material suppliers to keep pace with the market trends.

6. Using the ARAB-EST as a productivity tool.

APPENDIX-I

The Interview Questionnaire

********** Part(I) General Questions **********

The following questions about the basic characteristics of your firm. Please respond by putting a check mark next to the appropriate number.

A. Required Estimator's Experience. ----------(years).

B. Number of Permanent Employees.

{5 } Under 50 {7 } 50 - 100

{00} 100 - 150 {7 } 150 - 200 {5 } Over 200

C. Percentage of Work Obtained through Competitive Bidding.

{8 } Under 25 % {4 } 25 % To 50 %

{2 } 50 % To 75 % {10} 75 % To 100 %

D. Percentage of Work subcontracted on Average job.

{14} Under 25 % {4 } 25 % To 50 %

{0 } 50 % To 75 % {6 } 75 % To 100 %

E. Average Job Size. (millions of SR)

{0 } Under 1 {10} 1 - 5

{11} 5 - 10 {3 } Over 10

F. Language used in developing the cost estimate.

{20} English only

{0 } Arabic only

{4 } Both Arabic and English

E. Language of communication between the contractor and the owner or the consultant.

{6 } English only

{0 } Arabic only

{18} Both Arabic and English

G. Who sets up the firm's tendering prices?

{21} Top Management and/or Owner

{3 } Engineering Department, (Cost Engineer and Estimators)

{0 } Other (Please Specify)

I. How do you allocate Job overhead, project overhead, and profit?

{24} Adding a constant percent of the total direct project cost,

{0 } Allocated to each individual projects by means of an accounting application process,

{0 } Others (please Specify)

********** Part (II) Questions about Estimating **********

K. Types of Estimate Usually Done:

6 (1) Unit-Cost Estimate,in addition to |
24 (2) Detailed Estimate, <---
0 (3) Factor Estimate,
0 (4) Range Estimate,
0 (5) Others;-----------------

L. Steps Followed in Developing the Estimate;

--
--
-- --------------------
-- |See Section 4.6.3 |
-- --------------------
--
--
--
--
--
--
--
--

M. The following are some information that may be needed in setting the tendering price, and preparing the final cost estimate.

Please indicate how important is each of the following information item in preparing the cost estimate, and the bid price, of a given project, As you see them:

		Level of Importance				
#	Information Item	very low	Low	Medium	High	very high
1	Tendering Documents	0	3	1	1	19
2	Project Scope & Definition	0	0	3	7	14
3	Owner requirements	3	0	6	4	11
4	Project Location	1	3	11	4	5
5	Historical Data of Similar Work	0	6	6	9	3
6	Material Prices	0	0	1	10	13
7	Equipment Costs	0	1	4	18	1
8	Labor Rates	1	0	4	14	5
9	Inflation rate	3	3	6	8	4
10	Skilled labor availability	3	4	4	7	6
11	Required equip. availability	1	4	10	3	6
12	Labor productivity	1	3	0	9	11
13	Government regulations	0	0	8	10	6
14	Historical profit in similar jobs	1	7	8	2	6
15	Overall economic situation	0	3	11	3	7
16	Risk involved	1	0	6	7	10
17	others	0	0	0	0	0

N. The following are some problems, that may facing you in preparing the cost estimate, and setting the final tendering price of a given project; please rank each of the following problem in order of importance, as you see them:

		Level of Importance				
#	Problem	very low	Low	Medium	High	very high
1	Work item omission	1	4	12	7	0
2	Calculation errors	7	5	4	7	1
3	Judgment errors	4	5	1	5	9
4	Incomplete drawings & specifications	0	0	11	8	5
5	Incomplete the project scope definition	0	1	9	9	5
6	Changes of Owner requirements	2	6	0	8	8
7	Inadequate time	0	4	10	8	2
8	Lacking historical data of similar jobs	0	4	10	9	1
9	Lacking productivity informations in S.A.	1	6	15	1	1
10	Lacking of cost data indexes in S.A	1	10	10	1	2
11	Tough competition	0	3	2	13	6
12	Unfamiliarity with government regulations	1	4	7	7	2
13	Lacking experience in similar job	1	7	7	7	2
14	Unforeseeable change in material prices	0	4	5	9	6
15	Contract period	0	3	6	8	7
16	Content of arbitration clauses	4	6	8	4	2
17	Current work load	1	3	9	5	6
18	Confidence in your workforce	4	4	4	11	1
19	Difficulty of the project	3	4	12	4	1
20	Portion of work to be subcontracted	4	5	13	2	0
21	Others----------					

P. In General, From Your Past estimates, How do you Assess the Accuracy of Your Estimates?

{0 } (a) excellent

{5 } (b) satisfactory

{17} (c) somewhat satisfactory

{2 } (d) not satisfactory

Q. In your opinion, do you think that an Arabic estimating software is needed in the estimating process?

{0 } (a) Highly needed

{8 } (b) Somewhat needed

{16} (c) Not needed = = = > because, which of the following ?

{3 } 1. computers need expertise to operate

{ 4} 2. it take excessive time to code & enter data

{ 0} 3. outputs are not suitable for bidding

{ 0} 4. several important tasks can't be computerized

{ 0} 5. computers cost is very expensive

{ 0} 6. maintenance & service problems

{15} 7. language used in the work isn't arabic

{18} 8. computers need a lot of time & effort to learn how to operate them

{ } 9. others

********** Part (III) Questions about Computers **********

S. Do you Use Microcomputer in Developing or to Assess the estimates

{20} (1) No = = > because, which of the following ?

{3 } 1. computers need expertise to operate
{4 } 2. it take excessive time to code & enter data
{0 } 3. outputs are not suitable for bidding
{0 } 4. several important tasks can't be computerized
{0 } 5. computers cost is very expensive
{0 } 6. maintenance & service problems
{13} 7. computers need a lot of time & effort to learn how to operate them
{ } 8. others

{4 } (2) Yes:

A. Software's Name ----------

B. Software Type :
--1. Stand alone
--2. Integrated
--3. Spreadsheet
--4. Data-Base
--5. Others

C. Programs are developed by:
--1. Firm's Employees
--2. Ready to use packages.

D. Steps of Computerized Estimate:
-
-
-
-
-
-
-
-

E. Benefits of Computerized Estimation:
--1. Man-Hours Saving
--2. Accuracy & Reliability
--3. Speed & Convenience
--4. Others ----------

F. How many years has the computer been used?

G. Which of the following activities use the computer in addition to estimating?

--1. accounting
--2. project scheduling
--3. project cost control
--4. reporting
--5. resources files
--6. others

Bibliography

REFERENCES

1. Aaker, David A., and George S.Day, (1983). Marketing Research. 2nd Ed., John Wiley & Sons Inc., New York, N.Y.

2. Adrian, James J. (1982). Construction Estimating. Reston Publishing Company Inc., Reston, Virginia.

3. Al-Jarallah, Mohammed, and Satish Mohan, "Construction Management Practices in Saudi Arabia," Transportation Research Record, Issue:1056, 1986, pp.60-68.

4. Baldwin, A.N., and R. McCaffer, "The Implementation of Computer-Aided Estimating Systems in Construction Companies," Proc. Instn. Civ. Engrs, Part 1, 1984, 76, Feb., 237-248.

5. Birrell, George S., "Construction Cost Estimating," Journal of the Construction Division, ASCE, Vol. 106, No. CO4, December 1980,pp. 551-566.

6. Brandon, Peter S., and R. Geoffrey Moore, (1983). Microcomputers in Building Appraisal. Granada Publishing Ltd., London.

7. Bristol, Charles R., and Jill A. Costea, "Computerized Construction Cost Engineering in County Government," Proceedings of the Fourth Conference on Computing in Civil Engineering, Boston, Massachusetts, October 27, 1986, pp. 722-729.

8. Byers, R.H., "An Engineering Approach to Computer Application Definition," Preceedings of the 1984 International Computers in Engineering, August 12 1984, Las Vegas, Nevada.

9. Campbell, Walter J., and Saif U. Mir, "Microcomputer Applications to Unit Price Bidding," Cost Engineering, Vol. 29/No. 12, December 1987, pp. 17-22.

10. Carlton, Thomas W., and David W. solomon, (1989). dBASE IV Application Library. QUe Corporation, Carmel, IN.

11. Colin, McCarthy, "Practical Application of Software Packages for the Quantity Surveyor," Transactions of Building Cost Research Conference, Portsouth Polytechnic, 23 September 1982, pp. 352-361.

12. Collier, Keith (1987). Fundamentals of Construction Estimating and Cost Accounting with Computer Applications. Second Edition, Prentice-Hall, Inc., Englewood Cliffs, N.J, pp. 51-66.

13. Dologite, D.G., (1987). Using Computers. Prentice-Hall, Inc., Englewood Cliffs, N.J.

14. Eppes, Bill G., and Daniel E. Whiteman, (1984). Cost Accounting for the Construction Firm. John Wiley & Sons, Inc., New York, NY.

15. Erikson, Carl A., and LeRoy T. Bayer, "Estimating-State of the Art," Journal of the Construction Division, ASCE, Vol. 102, No. CO3, September 1976, pp. 455-465.

16. Fox, Joseph M., (1982). Software and its Development. Prentice-Hall, Inc., Englewood Cliffs, N.J.

17. "Future Demand for Construction Projects," MEED, 9May, 1987, pp.33.

18. Herbsman, Zohar, and J.D. Mitroni, "INES-An Interactive Estimating System," Journal of Construction Engineering and Management, Vol. 110, No. 1, March 1984, pp. 19-33.

19. Hoehne, Manfred, "Getting Contracts and Making a Profit in Saudi Arabia," Cost Engineering, Vol. 27/No. 5, May 1985, pp. 7-8.

20. Johanes, James D., "Artificial Intelligence in cost Estimating," Cost Estimator's Reference Manual, John Wiley & Sons, Inc., New York.

21. Lelong, D.B., and R.P. Chase, "Computer-Aided Software Engineering," Precedings of the 1984 International Computers in Engineering, August 12 1984, Las Vegas, Nevada.

22. Liewellyn, George, "Computer Estimating and Job Management," Concrete Construction /February 1984, pp. 163-165.

23. Lindeman, James L., and Keith C. Grandall, "Computer Estimating System- Design/Implementation," Applications of Small Computers in Construction, by Moore, W.C., Editor October 2, 1984, ASCE, pp. 29-40.

24. "Locals Consolidate Hold on Market," MEED, 6June, 1987, pp.40 .

25. McAllister, Harry E., (1975). Elements of Business & Economic Statistics. John Wiley & Sons Inc., New York, N.Y.

26. McCaffer, Ronald, and Andrew N. Baldwin, (1984). Estimating and Tendering for Civil Engineering Works. Granada Publishing, London.

27. Mitchell, W.J., 1977. Computer-Aided Architectural Design. Petrocelli / Charter, New York, N.Y.

28. Mueller, Frederick Wm, (1986). Integrated Cost and Schedule Control for Construction Projects. Van Nostrand Reishold Company, New York, N.Y.

29. Myers, Stanley E. (1988). Structured COBOL with Business Applications. Prentice-Hall International, Inc., New York, N.Y.

30. Neely, E.S., "System Planning for New Computer Programs ," Precedings of the 1984 International Computers in Engineering, August 12 1984, Las Vegas, Nevada.

31. Neil, James M.,(1982). Construction Cost Estimateing for Project Control. Prentice-Hall, Inc., Englewood Cliffs, N.J.

32. Neil, James M., "A Cost Engineering Approach to Bid Preparation," Cost Engineering, Vol. 23/No. 6, December 1981, pp. 345-350.

33. Orr, H.D., J.E. Spooner, and R.A. Stutz, "The Development and Implementation of Computer Assistance for Cost Estimating," Cost Engineering, September/October 1979,pp.177-182.

34. O'Sullivan, Edmund, "Computing in the Middle East," MEED, 17 March, 1989, pp. 8-12.

35. Ott, Lyman, (1984). An Introduction to Statistical Methods and Data Analysis. 2nd Ed., Duxbury Press, Boston, Massachusetts.

36. Ponder, Thomas C., and William E. Gallagher, "An Integrated Computer System for Cost Estimating," AACE Transactions, 1984,pp. G.8.1-G.8.4.

37. Rabehuck, Johan, "Computerized Estimating," Highway & Heavy Construction, September 1984, pp.72.

38. Rhyne, David M., and Kurt D. Kaminsky, "Automated Estimating Systems for Small Contractors," AACE Transactions, 1987, B.4.1-B.4.4.

39. Robison, Rita, "Managing by Data-Base," Civil Engineering/ASCE, October 1984, pp. 63-66.

40. Rosander, Arlyn C., (1977). Case Studies in Sampling Design. Marcel Dekker, Inc., New York, N.Y.

41. Rounds, Jerald L., "The Electronic Spreadsheet," Cost Engineering, Vol. 26/No. 6, December 1984, pp.18-20.

42. Simpson, Henry, (1985). Design of User-Friendly Programs for Small Computers. McGraw-Hill, Inc., New York, N.Y.

43. Simpson, Alan,(1988). Understanding dBASE IV. Teck Publications, Singapore.

44. Sheppard, Micheal T. "Computer-Assisted Estimating," Concrete Construction, Vol. 31, No. 3, March 1986,pp.334-335.

45. Skitmore, R. Martin, "Factors Affecting Estimating Accuracy," Cost Engineering Vol.30/No. 12, December 1988, pp. 12-17.

46. Smith, Larry A., and Tomislav Mandakovic, "Estimating: the Input into Good Project Planning," IEEE Transactions on Engineering Management, Vol. EM-32, No.4, November 1985.

47. Stewart, Podney D., and Ann L. Stewart, (1986). Microestimating for Civil Engineers. McGraw-Hill Inc., New York,N.Y.

48. Stewart, Rodney D., and Richard M.W Yskida, (1987). Cost Estimator's Reference Manual. Johon Wiley & Sons, Inc., New York, N.Y.

49. Task Committee of the Construction Division, "Application of Small Computers in Construction," Journal of Construction Engineering and Management, Vol.111, No.3, September, 1985, pp.173-189.

50. Townsend, Carl, (1989). Mastering dBASE IV Programming. Teck Publications, Singapore.

51. Townley, Tom, "The Role of the Computer in Collection, Analysis, and Application of Internal Cost Data," Cost Engineering, Vol. 26/No. 3, June, 1984, pp. 15-18.

52. Vandersteen, Martin H., "Computerized Support for Construction Projects," Cost Engineering, May/June 1979, pp. 85-87.

53. Urzua, Alfredo, "A microcomputer Program for Bearing Capacity Analysis," Proceedings of the Fourth Conference on Computing in Civil Engineering, Boston, Massachusetts, October 27, 1986, pp. 193-208.

54. Weigel, Terence A., and Fenske Thomas E., "Structural Engineering via Interactive Microcomputer," Proceedings of the Fourth Conference on Computing in Civil Engineering, Boston, Massachusetts, October 27, 1986, pp. 279-286.

VITA

Habib Abdulsater Mussallam Fayadh was born in Gazza, Palestine, on October, 1964. Upon graduation from the secondary school, he enrolled at the University of Petroleum and Minerals (UPM). In February 1988, he joined King Fahd University of Petroleum and Minerals (KFUPM) as a Master Student in the Construction Engineering and Management Program.