Computer aided estimating for civil engineering contractors.

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COMPUTER AIDED ESTIMATING FOR CIVIL ENGINEERING CONTRACTORS

by

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A Doctoral Thesis submitted in partial fulfilment of the requirements for the Award of Doctor of Philosophy of the Loughborough University of Technology.

July 1982

SUMMARY

At the start of the research the impact of computers upon the world of estimating for civil engineering works had been minimal and barely touched the six thousand middle sized companies within the construction industry. The challenge of the research was to:

- determine the requirements of a computer aided estimating system for civil engineering estimators;
- to design a system to meet those requirements;
- to produce and field test the system;
- to explore the use of estimator's data within other functions within the contractor's organization.

A study and critical appraisal of previous research and the six types of existing estimating systems was made to determine why computers have failed to make an impact upon this area of the construction industry. The estimating and tendering process was examined by interviewing eight estimators from three different civil engineering companies a minimum of four times over a period of one year. Eleven existing methods of task analysis were examined, were found satisfactory for the analysis of the estimator's tasks for the purpose of the research. A hybrid method of analysis was developed which was used to analyse the estimator's tasks for the purpose of producing a Specification for a computer aided estimating system.

The system was produced by an iterative method of design, development, testing and re-design until an acceptable solution was reached.

The system was tested by:

- installing a minicomputer within the estimating department of a civil engineering contractor's organization and inviting six estimators to test and comment on the system;
- demonstrating the system to individuals and groups of practising estimators from forty construction companies where comments on all asspects were noted.

As a result of the research a computer aided estimating system that was acceptable to civil engineering estimators was produced. To date eight such systems have been installed within contractor's offices and this fact gives some indication of the success in meeting this main objective. The other outcome of this work is:

- the determination of the implementation and user support requirements for the introduction of computer aided estimating systems into contractor's organizations;
- the production of user support facilities for the system including a comprehensive user manual and training programmes for the system.

In addition the work has created a platform for the construction of a completed linked suite of construction management programmes unavailable before because of the paucity of existing computer aided estimating systems.

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ACKNOWLEDGEMENTS

I should like to thank all those who helped with the work undertaken in this thesis especially:

- my supervisor, Dr. R. McCaffer, for his encouragement, guidance and willingness to assist throughout my research;
- Moira Biggins and Christine Siddons, without whose programming skills the project would not have been possible;
- the other members of the Computer Aided Estimating Research and Development Group, for their encouragement;
- Elinor Tivey for the typing of the thesis;
- the estimators from co-operating companies for their time and patience in attending meetings and demonstrations.

1.0 INTRODUCTION

1.1 BACKGROUND

Computers have the ability to store large volumes of data that may be processed quickly and accurately. However, by 1979 at the start of the research work, the use of computers had made little impact upon estimating for civil engineering projects. The number of commercially available packages designed specifically for estimating was small and each of these had few, if any, users.(1) The use of computer aided estimating methods was limited to larger construction companies who had developed their own systems. While estimators gave several good reasons for the limited use of computers in estimating, computer facilities existed that could overcome these problems and so it was suggested that the real reason that computers had not been widely used for estimating was that none of the systems available reflected both the manner in which the estimator worked and were commercially viable. Therefore the challenge of this research was to determine the requirements of a computer aided system for civil engineering estimates, to design a system to meet these requirements that would be acceptable to practising estimators and viable to the construction company, to produce and field test such a system and to explore the use of estimators data by other functions within the contractor's organization.

1.2 THE CASE FOR USING COMPUTERS IN ESTIMATING

The case for using computers within the estimating process exists on the grounds that man and the computer have complementary information processing techniques. Computers have the ability to store and process large volumes of data accurately at great speeds.

Estimators are capable of resolving ambiguity, recognising novelty and working creatively. When combined, the potential exists for performing estimating in a more efficient manner. Procedures which consistently provide accurate cost estimates require extensive data manipulations.[2] Computers can perform these manipulations but still allow the estimator control of the data used. An essential to commercial success in construction is more accurate estimating.[3] Computers can eliminate calculation and transcription errors. The corporate memory a computer based system can provide can be larger and more up to date than manual records. Computers can give estimators access to these comprehensive data files and take the drudgery out of estimating.[4]

1.3 EXTENT OF COMPUTER USE IN ESTIMATING

There are more than 50 000 companies within the United Kingdom construction industry and over 6000 of these employ more than 25 people.[5] All of these companies have to estimate the cost of construction work in order to obtain contracts and remain in business. The estimating function within the contractors organization is of fundamental importance to the company's existence. Only a small proportion of these have adopted computer aided estimating methods within their estimating departments. Surveys of network planning packages [6][7], found forty-six different programs or systems. These have sold many times. In comparison, the number of commercially available packages designed specifically for estimating is small. Hamlyn-Harris [8] in 1979 undertook a survey with the Design Office Consortium and found only seven separate systems. The maximum number of users for each system was below ten. It was evident that the impact of computers on the estimating world has been minimal and has barely touched the middle sized companies that make up the bulk of companies within the industry.

1.4 ESTIMATORS' REASONS FOR NOT USING COMPUTERS

The reasons put forward by estimators for such limited use of computers are:

- the complexity of the estimating and tendering process and the information exchange involved cannot be accommodated by a computer system;

- every civil engineering project is unique. Little data used within one estimate is directly applicable to another even if the project is of a very similar nature;

- no system can allow for the flexibility of approach used by the estimator when pricing construction work and reflect the full effect of the estimator's judgement;

- the time and cost involved in setting up and maintaining an estimating system makes it unprofitable to use computers for the estimating function;

- fears for the security of confidential company data when stored on computer files;

- problems with the introduction of errors into the estimating calculations which remain undetected over several estimates;

- loss of estimators jobs or the requirement of extensive retraining.

The above problems have meant that most construction companies have ignored the possible use of computers within the estimating process even though research and experience has identified areas within the process where computers may be used.

Roberts [9] in a feasibility study on a method of computerised estimating for motorways found the system proposed to be both feasible and practical. Bramwell [10] developed a suite of programs to assist with the pricing of drainage and ancillary classes of work. Bainbridge [11] produced a batch run estimating program which was tested by Gibb [12] and found to be satisfactory within the limitations of the amount of data that could be satifactorily handled.

Typical claims of construction companies that have developed their own computer aiding systems are:

- a significant reduction in the man hours required to price an estimate [3] ;
- better estimates and an increased throughput in bills of quantities prices [13] ;
- a cost effectiveness proved by comparison of the estimator's production with and without the system [14] .

Even with such evidence of the uses of computer aided estimating systems, estimators question their profitability and are reluctant to invest in the hardware and software necessary to produce systems for their company.

1.5 THE RESEARCH UNDERTAKEN

This research centred upon identifying the requirements of estimators then designing and producing a system to meet those requirements. Included within the research was the testing of the system to determine its acceptability in a commercial environment and evaluate the profitability of using such a system within a construction company.

Estimating is the first function within the contractors organization to assemble data on a construction project. The flow of this data to other functions such as planning cost flow and measurement is limited by the format of the data and how it is filed under existing manual practices. The adopting of computer aided estimating systems leads inevitably to a structured storage of data together with a formalized access to the information stored. Consequently there is no apparent reason why the estimator's data may not be used as a basis for calculations undertaken by other functions within the contractors organization. The research was therefore extended to include an explanation of the part estimators data could play within these functions and how the data may be accessed by the personnel concerned.

1.6 AIMS

Against this background, the main objective of this research was taken as the design and testing of a Computer Aided Estimating System for Civil Engineering Contractors. This main objective was divided into the following key aims.

i) A study and critical appraisal of previous research and existing systems to determine why computers have failed to make an impact upon this area of the construction industry.

ii) A study of the Estimating and Tendering process with a view to determining system requirements.

iii) The design and production of a Computer Aided Estimating System.

iv) The field testing of the system.

v) Determination of the profitability of Computer Aided Estimating Systems.

vi) The exploration of the extension of computer usage that is possible once computer aided estimating is established within the company and the estimator's data may be utilized by other functions within the organization.

To satisfy the key aims the following secondary but none the less important aims requiring fundamental work were also adopted:

a) A review of the techniques of task analysis in order to select the most effective tool in the study of the estimating and tendering process and determination of the system requirements.

b) A comparison of system requirements with existing systems to determine why existing systems had not been more successful.

c) A study of the procedures, operations and different languages available for the design of the dialogue between the estimator and the computer system.

d) The establishment of training and user support needs for computer aided estimating systems.

1.7 THE WORK UNDERTAKEN

To satisfy these aims the following work was undertaken:

i) Previous research was assessed and literature reviewed together with a study of existing commercially available computer aided estimating systems. These systems were analysed and classified with respect to the range of facilities offered to the user.

ii) The estimating and tendering process was studied together with the task of the estimator within the contractors organization by reviewing current literature and interviewing estimators from co-operating companies. Six estimators from three co-operating companies were interviewed regularly over a period of eighteen months.

iii) To fully assess the tasks of the estimator some method of task analysis was required. Eleven different methods of task analysis in common use were reviewed. No satisfactory existing method was found which would produce an observed pattern of behaviour from which a full description of the operations carried out by the estimator could be prepared. Consequently a hybrid method was developed which assembled data by informal interview and then made a structured analysis of the operations carried out by the estimator. This enabled an assessment of the constraints to the estimator's performance to be made and a study of the communication pattern surrounding the estimator. The method isolated the calculations involved in the estimating and tendering process, assessed what information could be readily stored in computer files for use by the estimator and outlined the reports needed by different company personnel.

iv) From the study of the previous research, the estimating and tendering process and the analysis of the estimator's tasks, the requirements of a computer aided estimating system were identified.

v) Different types of commercially available estimating systems were reviewed and six analysed and classified with respect to the facilities they offered the user. Where the systems failed to meet the requirements of the estimator, the shortcomings were catalogued.

vi) To meet the requirements of the civil engineering estimator a computer aided estimating system was designed and produced. The system was not produced for a specific hardware configuration. Initial development utilized the university's mainframe computer. The acquisition of two micro-computers enabled the work to be continued on smaller machines. The intention was to provide the system on a range of hardware to suit contracting companies of all sizes.

The production of the software for the system required the drawing up of a detailed specification consisting of a structured dialogue which showed the requirements of the system and the language and format of the dialogue that the estimator would use when operating the system. This required a study of existing software languages and dialogue structures.

The methodology behind the design and production of the system involved an iterative process of design, development, assessment and re-design until an acceptable solution was reached.

To enable testing and demonstrations of the system to be undertaken, the system was developed in two stages. The drawing up of a detailed specification and the production of a working system to a first stage took twelve months. Following the testing of the system the specification was redrawn with the additional facilities suggested from feedback obtained in the field trials and demonstrations.

vii) The system was tested in the following manner. First in-house checks were performed to ensure that the arithmetic calculations were correct and that all foreseeable errors of user input were detected. Secondly the software was implemented on to a mini-computer and placed inside the estimating department of a civil engineering contractor for a six month period. Six estimators within the organization were invited to test and comment on the system. One of the estimators performed a programmed series of tests culminating in the pricing of a complete Bill of Quantities and the submission of a tender to a client. The users reactions were monitored by informal discussions, semi-structured interviews and a system users diary kept throughout the trial period. Thirdly, the system was demonstrated to individuals and groups of practising estimators from forty construction companies whose comments on all aspects were recorded.

viii) A study was made of the different types of computer user and their needs and requirements. The different types of user support for interactive computer systems were reviewed.

ix) The types of user of a computer aided estimating system were identified together with their needs throughout the stages of their development with the system.

The forms of user support necessary for the successful implementation of a computer aided estimating system were also identified. A comprehensive user reference manual was produced.

x) The commercial viability of Computer Aided Estimating Systems was assessed by studying the increased profitability resulting from the adoption of the system. Profitability was estimated by considering:

- saving in man hours per estimate produced;
- improved communications within the organization;
- the production of better information with which to make management decisions.

xi) Tests on the time taken to input the change data using the commands available on the system were used to synthesise the overall time taken to produce a typical estimate for a contract. This time was compared with that required for typical manual calculations using data provided from estimators within the cooperating companies.

xii) A study of possible extentions to the system was made. Data relating to the build-up of the bill items for the contract were analysed to determine where it may be of use to other functions within the company such as financial and project planning. Methods of accessing contract data held on computer files were examined. Prototype systems developed by Allsop(15) and Bowman(16) to cover the areas of cashflow calculations and tender planning were tested to ascertain the viability of such extensions.

The link between the planning and estimating functions at the pre-tender stage was examined to establish the use of estimator's data by planning engineers.

1.8 MAIN FINDINGS

From the research the following conclusions were made.

i) Previous research into the use of computers for estimating purposes had concluded that computerized estimating for civil engineering contractors was both feasible and practical. Systems developed by the larger companies had been adopted by themselves but not made commercially available. Of the six existing commercially available computer aided estimating systems reviewed, none gave the estimator the full range of facilities required for the production of direct cost estimates for construction work. The main reasons for these shortcomings were:

- inflexibility of approach to the pricing of bill items;
- the ability to modify data from a library of information was limited;
- the estimator was unable to easily retrieve and re-work bill item calculations;
- the systems were not easy and convenient to use;
- none of the systems combined the two fundamental approaches to construction estimating, unit rate estimating and operational estimating with a supportive data library.

ii) The eleven techniques for task analysis reviewed were all established techniques accepted by scientists for the analysis of different forms of human tasks. The techniques ranged from a general overview of the task performers job to a detailed analysis of the skills required. However, none were suitable for the analysis of the task of the civil engineering estimator for the purpose of producing a specification for a computer aided estimating system.

No technique isolated the operations performed by the estimator into the three areas which represented the areas where a computer can assist the estimator with his tasks; calculation, data storage and reporting.

A method for analysing the tasks of the construction estimator was produced which was based upon an informal interview followed by a structured analysis of the operations involved in the tasks to ascertain the contribution that may be made by the computer. The advantage of this approach was that it enabled a study of the estimators task to be broadly examined to ensure all aspects of his work were considered. Then, by dividing the operations within each task into specific categories directly related to the use of the computer, the full impact of the computer upon the tasks could be assessed.

iii) The tasks of the estimator within the estimating and tendering process were found to be influenced by the following major factors;

- the format of the clients documentation;
- the nature of civil engineering work;
- the individualistic approach of the estimator;
- the detail of information to be acquired;
- the liability to a change in approach to both the construction method for the project and the method of pricing;
- the communication pattern of information passed between those participants within the process;
- the constraint of time;
- the risk of errors.

The varying emphasis of each of these factors with respect to the specific contract under consideration determined the method of approach to pricing the work within the project and the timing and order of the estimate preparation.

iv) The general requirement of a computer aided estimating system are:

- the system must be available for use by the estimators at any time both within and outside the normal working day;
- simultaneous input and output to the system must be available on several terminals;
- the estimators within the company should be capable of working intermittantly or in parallel on a number of tenders;
- it must be possible for work on individual tenders to be suspended and recommenced without difficulty;
- all data processing should be undertaken within the company;
- the system must be interactive;
- a hard copy of the estimator's work including both input, output and the calculations performed should be available if required;
- the estimating procedure within the system must follow the same logic pattern as the existing manual systems.within companies;
- the system must be capable of assisting at all stages of the tender process:
  - the build-up of the direct cost estimate;
  - the production of information for tender adjudication;
  - the addition of mark-up factors to produce a tender total;
- information relating to completed tenders should be stored on the system for future reference.

The program parameters for the system are to:

- calculate bill item prices from input data by a number of different methods;
- apply calculated item rates against all relevant bill items;
- provide an extension and summation of bill item prices to produce direct cost totals;
- provide a variety of reports and bill listings for the estimator and other company personnel within the estimating and tendering process;
- store data on different resources and their requirements for different construction methods;
- store lists of all-in rates and materials and subcontractor prices for the contract under consideration;
- store the full build-up of each bill item within the contract with the facility to retrieve, check and rework the item if required;
- assist the estimator in his communication with other parties both inside and outside the contractors organization;
- maintain the estimators skill and extend his knowledge of the construction processes;
- limit potential errors within the estimating process.

All the above requirements are fundamental to a computer aided estimating system. If they are not met by the system the estimator cannot be expected to accept the system for every-day use.

v) User support requirements for computer aided estimating systems are dependant on the type of user of the system and the stage of their development with the system. Computer aided estimating systems are used by all three types of computer use;

- the estimator's clerk , (for data input),
- the estimator , (a "specialist" user),
- the senior manager , (for decision making),

User support requirements change with time as the user acquires skill and knowledge in the use of the computer. User development is continuous but four basic stages may be recognised;

- the pre-implementation phase ,(before the system is installed),
- the implementation phase, (when the system is installed),
- the operational phase, (when the system is installed and fully working),
- the evolutionary phase, (as the user develops his understanding and use of the system).

User support requirements for the Interest System need to meet the different needs of the system users at all stages of their development.

vi) The following forms of user support are necessary for the successful adoption of the INTEREST System into a contractors organization;

- instruction manuals;
- within system aids;
- formal training instruction;
- provision of a local expert;
- specialist computer personnel.

Instruction manuals are necessary to provide a detailed description of the system with appropriate examples to which any use may refer. A separate less formal guide should be provided for each of the different type of user which may be easily amended to include information related to their familiarisation with the system.

The best form of user support is that which is incorporated within the system as it makes for ease of reference. Within the INTEREST system user support was provided by using annotated commands within the menu of options available to the user at each point in the program. These menus were capable of being suppressed by the user when familiar with the operation of the system to increase the speed of operation of the system. On selecting an incorrect command, the options available to the user are automatically displayed by the system to enable the user to make a correct decision.

Because of the importance of the estimating function to the contractor's organization a comprehensive training programme is required for the users when the system is implemented into the company.

The training requirements of each type of user were analysed and a detailed training program produced for the system.

The introduction of a computer system into a company inevitably leads to the role of "computer expert" being assumed by a member of the organization. This position should be formally recognised by the company and developed to provide a point of reference for all Interest users within the company.

Access to specialist computer knowledge is necessary for future development of the system that will inevitably follow the growth of the system within the company and the development of the individual user.

vii) It is difficult to directly justify the financial outlay of computer aided estimating systems on the increased speed of pricing items within the bill of quantities. Estimators demand interactive computer systems that allow them flexibility of approach to the pricing of bill items and the facility to readily amend item build ups. The speed of operation of the system is limited by the input of data required from the user and the format of reports which must be selected. Tests carried out using the system showed that in the production of the direct cost estimate the time savings obtained over traditional manual methods were not substantial. However, the facilities that exist within a computer to:

- produce reports of labour, plant, material and subconstractor costs and reports of total labour, plant and material quantities for use by the adjudication panel;
- allow automatic updating of resource prices throughout all the appropriate bill items;

- produce reports of materials and subcontractor quotations that are still outstanding for the estimate under preparation;
- provide a regularisation within the company of the estimator's build-ups of item prices;
- help identify the cost important items within the Bill of Quantites;
- assist in the reduction of errors within the estimate due to omission of item prices;
- obtain a direct cost total for the work prepared on the estimate to date at any time within the estimating period;
- improve the reconciliation of the quantities of labour, plant and materials resources required for the contract;
- improve records of the estimator's build-ups;
- allow the inclusion of additions, surcharges, site overheads, head office overheads and profit margins;
- allow the addition of mark-up factors to be undertaken on a "what-if" basis and the process to be repeated several times to determine the most appropriate mark-up strategy;
- store knowledge on different construction methods that is quickly accessible and remains within the company when an estimator changes employer;
- reduce and eventually abolish the need for comptometer operators;
- provide a storage system for completed tenders that may be quickly and easily accessed to study past calculations and the resources required for different methods of construction;
- provide a structured storage system for contract data that may be readily accessed by other personnel within the company who are involved with other management functions;

- produce better records and the possibility of a link with site control so enabling the estimators cost data to become the site managers 'control' data and perhaps the link of feedback from the site to the estimators data;

make the capital outlay required to purchase, implement and run a computer aided estimating system a profitable proposition.

viii) The benefit of computer aided estimating to communications between different functions within the company and the increase in the available information for senior management decision making purposes can provide increased profitability. This benefit cannot be directly quantified except in the instances where information from the estimating system may be directly used for other functions such as planning or cost control. In these cases there is a direct saving in man hours that would otherwise be necessary to produce the same information. The INTEREST system produces improved reporting facilities on data relating to each construction contract. Although this should assist senior management in decision making (particularly if linked to "what-if" type computer models) this cannot be quantified.

ix) Computer aided estimating systems may be used as a basis for holding contract data that can be accessed and utilised by other functions within the contractor's organization. Access may be permitted to the contract data file containing details of the build-up of each item within the bill of quantities. This data is useful to planning, cost control and financial functions and access may be obtained in three main ways:

- manual access only ;
- the right to access computer files,

- the right to access computer files and transpose data for use in the relevant function.

  The advantage of this access is that, at the pre-tender stage, the user has the ability to check the estimator's requirements for the project.

  After the contract has been secured the data held within the estimator's files becomes contractual with implications for all other functions within the organization. A sample survey amongst 12 construction companies indicated that in 84% ov the companies the planning and estimating vunctions were not fully integrated. The two functions were pursued in parallel with informal interaction limiting divergence. All companies consulted indicated the importance of a close co-operation between the planning and estimating functions and welcomed links to the estimator's data that may be accessed by others.

x) Facilities were available within computer technology for the production of a computer aided estimating system that met the requirements of estimators within the civil engineering industry.

A system was produced that:

- was fully interactive;
- gave full flexibility to the estimator;
- could incorporate a range of facilities from which the estimator could select the approach required;
- enabled bill items to be retrieved from the contract file and re-worked as required;
- provided a basis of pricing a bill item that could be easily amended by the estimator to incorporate his exact requirements;
- combined unit rate and operational estimating with a supportive data library.

The system was tested and found acceptable by estimators within construction companies. An analysis of the use of the system found it to be commercially viable.

1.9 GUIDE TO THE THESIS

Fig 1 gives a schematic guide to the thesis and shows the development of the computer aided estimating system. (See page 25).

Chapter 2 describes the estimating and tendering process. The parties that are involved in a contract to undertake a civil engineering project are identified. The methods of selecting a contractor are described together with the ways in which estimates for construction work are prepared. An analysis is made of the stages involved in the preparation of an estimate for a contract based on the Bill of Quantities from the receipt of the contract documents to the submission of the Form of Tender. This provides a background to the most common method of letting work for civil engineering projects in the United Kingdom and identifies the main tasks in the process of preparing an estimate and tender for construction work.

Chapter 3 identifies the calculations involved within the estimating and tendering process and includes typical examples. These calculations form the basis of the estimator's work and should be included within any computer aided estimating system.

Chapter 4 describes the method of analysis of the estimator's tasks within the estimating and tendering procedure. The major operations within each task are analysed with respect to the assistance a computer based system could give to the estimator. The major factors influencing the estimating and tendering procedure are identified and from this analysis the detailed requirements of a computer aided estimating system are produced.

Chapter 5 gives the reasons why estimators are reluctant to use computers for estimating purposes and analyses existing commercially available computer aided estimating systems to asses how they meet the requirements identified in Chapter 4.

Chapter 6 describes the design of a system to meet the requirements of a computer aided estimating system identified in Chapter 5. The basic principles of man computer communication are considered including the hardware and software interface. The development of the structured dialogue of procedures and operations to support the system function is together with all aspects of the software interface.

Chapter 7 gives details of the INTERESTSystem after the first stage of development and in the form implemented on a minicomputer and tested in the estimating department of a civil engineering contractor.

Chapter 8 describes the testing of the Interest System and the feedback obtained from demonstrations to other estimators and senior construction personnel.

Chapter 9 gives the detailed specification for the second stage of development of the Interest System describing the revisions that resulted from the feedback obtained from the trials and demonstrations.

Chapter 10 reviews the user support requirements for the Interest computer aided estimating system. The different types of user support are considered together with the types of users of computer aided estimating systems, their needs and the different phases of user support that are experienced during the adoption of a computer system.

Chapter 11 studies the profitability of the Interest System and compares estimates produced manually with those priced using the Interest System. Methods of accessing estimator's data by other personnel within the company are outlined together with exploratory studies of how the data held in the file of contract details may be utilized in other functions such as project and financial planning within the company.

Chapter 12 contains the conclusions of the research.

The appendices contain the following information:

i) Describes methods of budget estimating.

ii) A survey to investigate.the relationship between estimating and tender planning to discover whether these functions were undertaken by different staff within the construction company and whether files of estimators build-ups would be beneficial to subsequent job control activities.

iii) A checklist of preliminary and site on-cost requirements.

iv) Descriptions of existing methods of task analysis that were considered for use in the study of the estimator's tasks within the estimating and tendering procedure.

v) Examples of dialogue styles.

vi) A list of companies who have had demonstrations of the system, commented on the facilities and suggested additions and amendments.

vii) Details of the testing of the INTEREST system within a contractor's organization including an analysis of the priced bill of quantities, the comments from the informal interviews and system diary and the structured interview and the replies of the user.

viii) A detailed user manual for the INTEREST system including full details of the facilities available with examples of the data that may be stored, calculations performed and reports obtained.

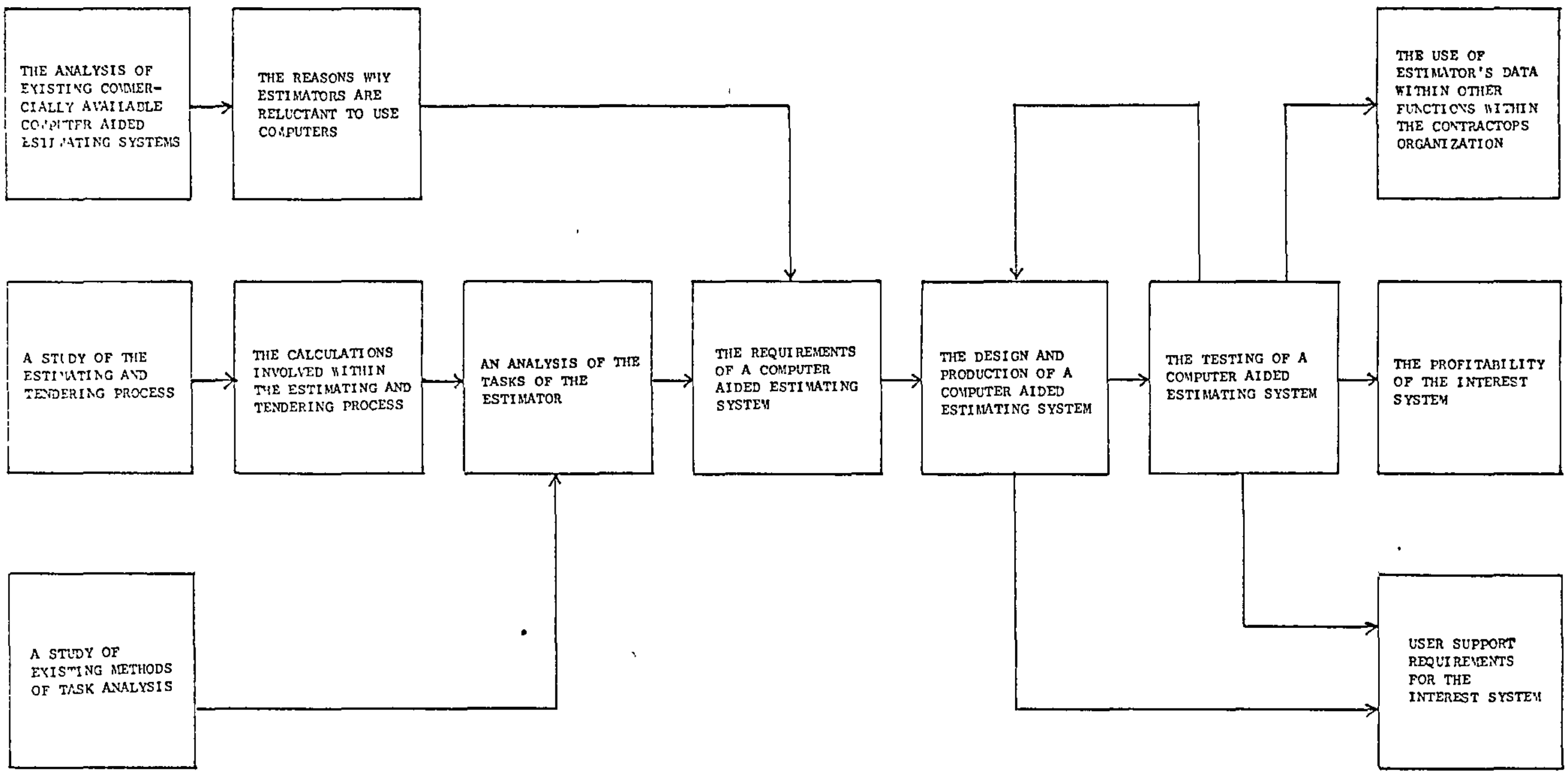


Figure 1 - A SCHEMATIC GUIDE TO THE THESIS

2.0 THE ESTIMATING AND TENDERING PROCESS

Civil Engineering projects are characterized by their size, capital cost and the range and number of resources required to bring about their completion. This chapter reviews:

- the parties involved in a contract to construct civil engineering works and the relationship between each party;
- the methods of selecting a contractor;
- the way in which estimates for construction projects are made;
- the estimating and tendering process from the receipt of the contract documents to the submission of a Form of Tender.

Current literature relating to the estimating and tendering process was studied and estimators from co-operating companies were consulted. Six estimators from three companies were interviewed regularly over an eighteen month period to ensure all aspects of the process were incorporated in the review.

The process of estimating and tendering for construction work consists of two separate but related tasks, estimating and tendering.[17] Estimating consists of calculating the probable cost to the contractor of efficiently carrying out the work if awarded the contract. This calculation is based upon the physical conditions on site and the contractual obligations defined in the contract documents. Tendering consists of establishing the final price and terms for the contract. This involves an assessment of the likely margin of error in the estimate, together with the risk and possible financial effects of undertaking the project.

The engineering estimator is required to calculate the detailed cost estimate of the project under consideration. This relies upon the identification of the individual resources required to undertake the work.

On completion of the direct cost estimate, additions are made to cover the cost of head office overheads and profit and risk and this produces a total tender sum for the project.

The majority of construction projects in the United Kingdom are based upon the Bill of Quantities document. This requires the estimator to determine rates for each item and then extend each item rate and total the item sums to produce a total tender sum for the contract.

The following stages in the estimating and tendering process were identified:

i) The receipt of the contract documents and the decision to tender for the work.
ii) The project study and the selection of an appropriate method of construction.
iii) The selection of sub-contractors and negotiation of rates.
iv) Obtaining materials quotations.
v) Establishing rates for labour and plant.
vi) Calculation of Direct Cost rates.
vii) Calculation of site overheads.
viii) Tendering adjustments.
ix) Pricing and extension of the bill of quantities.

An outline to the process is given in Fig 2, page 28.

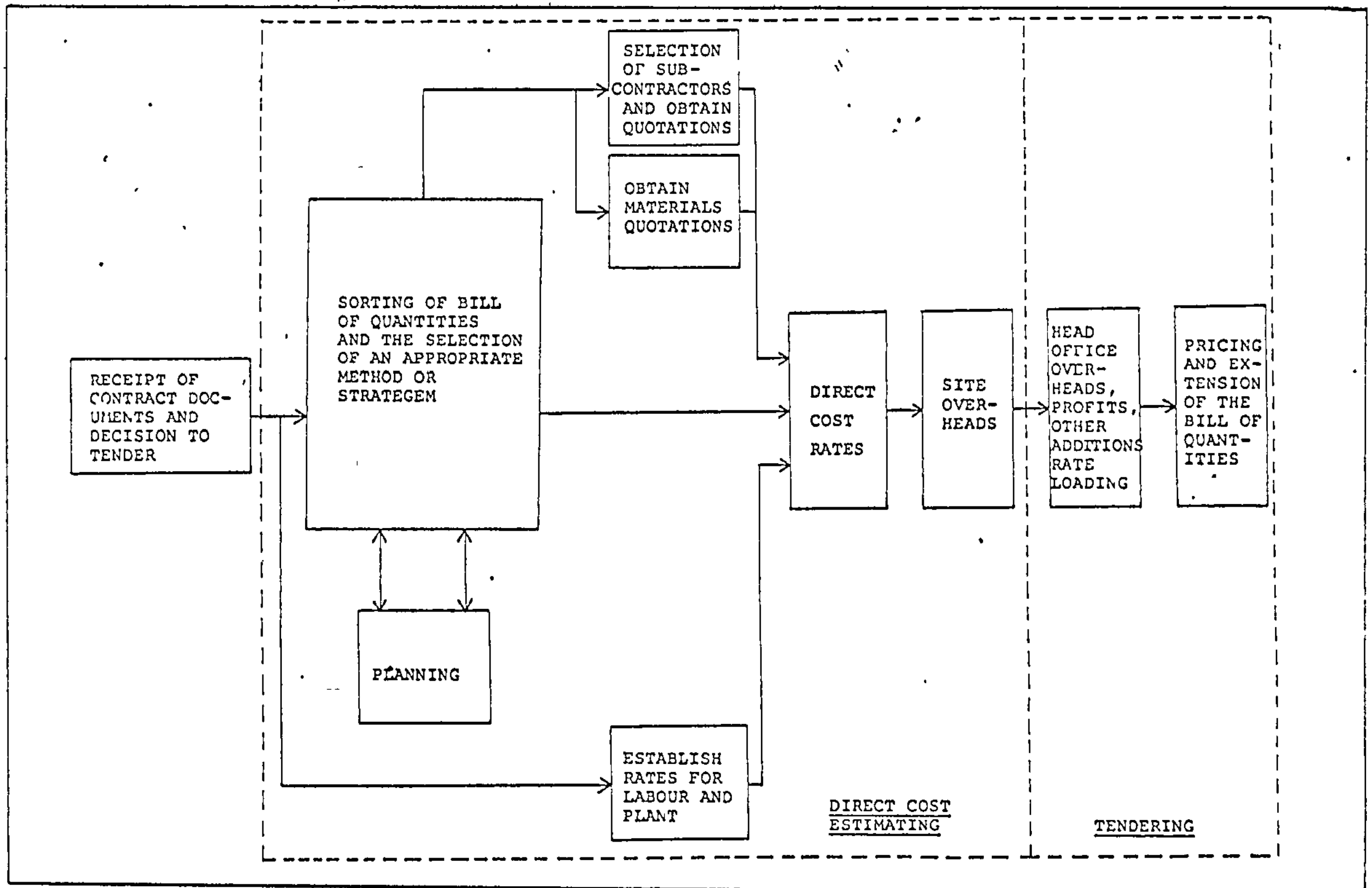


Figure 2 - THE ESTIMATING AND TENDERING PROCESS

The estimating and tendering process is more than a series of structured procedures to process contract documents. The process affects several different functions within the contractors organization and is characterized by the complex communication pattern and random order of data accumulation and transfer. Estimating and tendering involves a specific management philosophy. This means that within each construction company the estimator, while carrying out the calculations involved in the process, places special emphasis on certain aspects that have been identified by senior management as particularly relevant. Within each estimate analyses and reports giving particular items of information are required to be produced as part of company procedure.

2.1 THE PARTIES INVOLVED IN A CIVIL ENGINEERING CONTRACT

There are normally three parties involved in a civil engineering project:

- the Promoter;
- the Engineer;
- the Contractor. (18)

2.1.1 THE PROMOTER

The Promoter may be a government department, local authority, nationalized industry, incorporated company group of individuals or private person. The Promoter identifies the need for a project and obtains the necessary finance. Before the project may be commenced it is necessary for the Promoter to obtain the necessary legal authority to commence the work. In the case of ~~the~~ large projects this may involve an Act of Parliament. (19)

2.1.2 THE ENGINEER

At an early stage in the project the Promoter will require advice as to the feasibility and relative merit of alternative engineering solutions relating to the suggested project. Where a salaried engineer is not under his employment the Promoter must find suitable firm of consultant engineers who are willing to advise. The range of work involved in civil engineering projects often necessitates the engineer himself seeking specialist advice from other sources. Should the Promoter decide after initial consultations to go ahead with the project the Engineer is appointed by the Promoter to design and supervise the works and act as the employer's agent. [20]

2.1.3 THE CONTRACTOR

The Contractor may be any person, firm or company undertaking to perform specific works or services involved within the civil engineering works. Civil Engineering Contractors may be classified as general or specialist contractors. General contractors undertake responsibility for the execution of the whole project. Specialist contractors normally perform their work by subcontract to the general contractor although alternatively may enter into a direct contract with the Promoter.

2.2 METHODS OF SELECTING A CONTRACTOR

Acting as the Promoter's agent the Engineer will be responsible for the preparation of the contract documents and the selection of a contractor.

The formation of a contract under English Law involves "an offer from one party which is accepted by the other, and each party must contribute something into the bargain". [21]

Civil engineering work is executed after a contract between the Promoter and Contractor. Contracts may be classified as follows: (22)

- Measurement Contracts;

  (including (i) Bills of Quantities Contracts

  (ii) Schedule of Rates Contracts)

- Lump Sum Contracts;

- Cost Reimbursement Contracts,

  (including (i) cost plus percentage fee contracts

  (ii) cost plus fixed fee contracts

  (iii) cost plus fluctuating fee contracts

  (iv) target price contracts)

- "All-in" Contracts. (These cover both design and construction and may be on a measurement, lump sum or cost reimbursement basis).

The different types of contract essentially centre around the basis of payment. In Measurement and Lump Sum Contracts, payment is determined by the rates and prices tendered by the contractor prior to the commencement of work. In Cost Reimbursement Contracts the contractor is paid the actual cost of completing the works plus a fee to cover overheads and profit.

The majority of construction contracts are Measurement Contracts based on the following contract documents:

- Form of Contract,
- General Conditions of Contract,
- Specification,

- Contract Drawings;
- Form of Tender;
- Bill of Quantities.

The Form of Contract is the legal undertaking between the Promoter and the Contractor for the execution of the work in accordance with the other contract documents.

The General Conditions of Contract define the terms under which the work is to be carried out. The relationship between the Promoter and Engineer and Contractor is stated together with the duties of each party, the powers of the Engineer and the terms of payment. It is generally the practice to use Standard Conditions of Contract with adjustments to suit the special conditions of the project concerned. It is the duty of the Engineer to advise the Promoter on the standard form best suited to his requirements. For civil engineering contracts the most widely used form is the I.C.E. Conditions of Contract.[(23)] The advantage of standard forms of contract is that the contractor is fully conversant with the contract clauses and therefore need not make as much provision for risk in his tender.

The Specification for the works describes in detail the work required under the contract and the type and quality of the materials to be used in the construction. Also stated are the standards of workmanship and the finish to be obtained. In certain situations the specification may also specify the order work is to be carried out and the methods that are to be employed. Specifications are normally prepared with close reference to British Standards.

The Contract Drawings are required to enable the Contractor to ascertain the exact location of the works and what is required within the contract.

The drawings should also indicate the nature of the existing topography and in particular the proximity to other structures and old works.

The Form of Tender is the Contractor's written offer to carry out the work in accordance with the other contract documents. This offer states the total tender sum, the time for completion and any other particulars of the offer.

The Bills of Quantities for the work are prepared by measurement from the Contract Drawings. They itemise the various supplies activities and services for which the Promoter requires prices to be submitted. For each item within the bill the Promoter indicates the quantity which he considers will be required within the works. The Contractor is required to insert against each item his appropriate price and the unit rate on which this is based. By totalling the prices for the individual items the total tender price for the contract may be calculated. The drawing up of the Bills of Quantities from the Contract Drawings is undertaken using an appropriate method of measurement. The Civil Engineering Standard Method of Measurement (CESMM) [(24)] states the principles and techniques of measurement to be employed for civil engineering contracts. Work is "itemized" in sufficient detail for it to be possible to distinguish between the different classes of work, and between work of the same nature carried out in different locations or in any other circumstances that may give rise to different considerations of cost. The CESMM is described in detail with examples by Barnes. [(25)]

The importance of the Bill of Quantities is not only limited to that of establishing a total tender price for the contract. The rates included in the document are the basis of payment as construction proceeds and work is completed. The Contractor is then paid regularly on the measured amount of work completed to date.

In most construction contracts the Contractor is selected on the basis of a competitive tender. (26) The tender list may be open or selective.

In the open tender method the Promoter advertises in appropriate press outlets inviting interested Contractors to apply for the relevant contract documents. The Contractor may then submit a tender for the works. The open tender method has the advantage of:

- allowing all interested Contractors to tender,
- allowing the tender list to be made up without bias;
- ensuring good competition,
- preventing Contractors forming 'pricing rings'.

The disadvantages are:

- the tender lists become long and the procedure costly,
- public accountability may be questioned if the lowest offer is not accepted,
- it is difficult for the Promoter to ignore the lowest price even if he considers the tender to be from an inefficient Contractor;
- a Contractor submitting too low a price may resort to claims or bad workmanship to prevent a loss;
- the better Contractors are disuaded from tendering.

The disadvantages were clearly recognised by the Banwell Committee (27) who criticised the undue use of the open tendering method.

In selective tendering a short list of Contractors is drawn up by the Engineer and the Companies are invited to submit tenders. The recommended number of Contractors on the list being between five and eight.[28] The list is drawn up from a file of suitable Companies. The advantages of selective tendering are:

- the cost of tendering is kept to a minimum;
- the competing Contractors may include a reasonable allowance for profit and remain confident of obtaining work;
- as only competent Companies are involved, the lowest tender received can be confidently accepted.

The disadvantages of the method are:

- unless the list is frequently revised, allegations of favouritism may take place;
- tender prices are higher than for open tenders;
- there is a greater chance of collusion between contracting companies.

2.3 ESTIMATING METHODS

There are several ways of estimating the cost of the construction of a project. These may be classified as simple or advanced estimating techniques and are described in detail by Bathurst and Butler [29], Dell 'Isola and Kirk [30] and Niel [31]. The method adopted depends on the level of detailed information available, the needs of the recipient of the information and the time available to prepare the estimate.

The methods can be summarized under the following headings:

- Unit Method;
- Space Method;
- Element Method;
- Approximate Quantity Method;
- Detailed Cost Estimating Method.

The Unit Method, Space Method and Element Methods are estimating techniques used by the quantity surveyor for budget estimating. These methods enable the Engineer to prepare estimates for the Promoter at the feasibility stage of the project design. The Approximate Quantity Method is used by both the Engineer and the civil engineering contractor to obtain an approximate cost for the project. For the Engineer, the method is another budget estimating technique. The Contractor's estimator uses the technique to prepare an approximate cost of the project on receipt of the contract documents. Details of budget estimating methods are given in Appendix 1.

When at the stage of submitting a tender for a project, the Contractor's estimator is concerned only with detailed cost estimating. The estimate that is required is not only a forecast of the total cost for the project. Moyles [32] listed the additional purposes of the Contractor's cost estimate as:

- to assist in the valuation of variations;
- to aid the planning of construction operations;
- to forecast Plant, Labour and Material requirements;
- to enable the comparison of estimated and actual costs;
- to help in the selection of subcontractors and suppliers;
- as a basis for cash flow forecasting;
- to establish contractual obligations.

The level of information required to assist in all these purposes demands a detailed analysis of the work to be completed.

Detailed cost estimating requires an analysis of the resources required to undertake a construction project. In addition to the quantity of each resource required, the cost of each resource for the project must be ascertained. For labour resources this entails an assessment of present labour rates adjusted to reflect the location and working conditions of the site. Materials, plant and subcontractor resources are costed after obtaining the appropriate written quotation. The analysis of the construction work may be carried out by consideration of the project programme and the operations involved or by a detailed analysis of the lists of measured items given in the Bill of Quantities. The total construction cost being calculated by totalling the cost of the operations on bill items respectively.

Detailed cost estimates may be prepared by either considering the resources required to complete an operation or by pricing the items within the Bill of Quantities based upon an output or usage rate required for each resource used for the work detailed within the bill item. The two approaches are known as Operational and Unit Rate Estimating [33]. Examples of the calculations involved are given in Chapter 3.

2.4 THE ESTIMATING AND TENDERING PROCESS

The estimating and tendering process within a Contractor's organization starts with the receipt of the contract documents and ends with the submission of the Form of Tender. The process is shown in Figure 2, page 28 . Each stage of the process is now described in detail.

2.4.1 THE RECEIPT OF THE CONTRACT DOCUMENTS AND THE DECISION TO TENDER FOR THE WORK

On receipt of the tender documents and an invitation to tender for a project, the Contractor must decide whether or not to submit a tender. This will be dependant on the following factors:

i) The client and his professional advisors;

ii) The project type, size, location and timing;

iii) The contract conditions;

iv) The extent and quality of the documentation provided;

v) The staff available to prepare an estimate;

vi) The potential profitability considering the risks involved;

vii) The finance that will have to be obtained to undertake the work.

Harrison (34) emphasises that the decision to submit a tender should result from the implementation of a company tendering policy. This should be formed as a result of trading and marketing policies that provide the following information·

i) Turnover target. (This should be divided to show in which markets and in what proportions the total turnover can be obtained);

ii) Overheads budget;

iii) Gross and net profit targets;

iv) Anticipated volume of enquiries required to achieve the turnover.

Tendering policy and turnover requirements can be represented by a tendering programme of the form indicated by Davies (35). An example of this is given in Chapter 3 on page 70.

A Contractor is at liberty to decline an invitation to tender and return the contract documents unpriced. Some Contractors are reticent of doing this for fear of offending clients. This results in submitting insufficiently prepared tenders that may obtain work at unprofitable prices or in the submission of offers at prices so high as to lack credibility. Alternatively the Contractor may submit a cover price. Each stage of the estimating and tendering process increases the company's investment. Tomlin [36] recommends a thorough check of the contract documents to ensure that the technical complexity of the job is within the company's capabilities and staff resources. A late decision to abort a tender or the submission of a qualified tender that results in disqualification may prove a very expensive exercise.

The decision to submit a tender is solely a senior management one based on the suitability of the project. This must be judged by how the project, as perceived from an initial study of the contract, meets the company requirements. No operations are performed on the contract documents apart from a careful study of the work involved and the standard required. Company requirements are assessed from the financial director's regular analysis of the company's financial position.

2.4.2 THE PROJECT STUDY AND THE SELECTION OF AN APPROPRIATE METHOD OF CONSTRUCTION

The estimator must gain a full appreciation of the work involved within the project. This is obtained by:

- a study of the contract drawings,
- an analysis of the Bill of Quantities and other contract documents,
- a site visit,
- the preparation of the method of construction for the works.

In civil engineering contracts a copy of the contract drawings are sent to each company tendering for the work. Any aspects of the project that are unclear from the drawings and details provided are clarified by consultation with the Engineer.

The estimator analyses the Bill of Quantities and totals all bill items containing similar classes of work. This operation is more than a tedious clerical task to calculate the principal quantities of work within each trade classification. The estimator must produce a detailed list of all the materials required for the contract and assess which items of work are to be subcontracted. This calls upon both the estimator's technical and commercial knowledge. Harrison (37) states the minimum requirements of an estimator's understanding to be:

- understanding of specifications including the materials and processes to which they refer sufficiently to recognise unusual or unreasonable requirements;
- understanding Bills of Quantities and Standard Methods of Measurement on which they are based;
- understanding of Conditions of Contract sufficiently to recognise when expert advice is desirable,
- knowledge of methods, equipment, normal outputs, etc. for normal types of work and how to obtain such information for other work types;
- sufficient knowledge of temporary works design, planning methods, etc. to enable the estimator to make efficient use of specialist assistance.

It is normal practice for the estimator and planner to visit the site for construction of the works. From this visit a report is prepared which gives details of:

- the description of the site,
- the positions of existing services,
- a description of ground conditions;
- an assessment of the availability of labour,
- any problems relating to the security of the site,
- details of access to the site,
- topographical details of the site;
- a description of the facilities available for the disposal of the spoil;
- details of the demolition of any works and temporary works to the adjoining building.

Method statements are prepared giving details of how the works will be constructed. These are more than a logic statement as to how work shall proceed. Also included is information on labour, plant and material requirements. Alternative methods of construction are considered together with different sequences of work, differing rates of construction and alternative site layouts.

Once a method has been chosen the consequences must be fully investigated. The combination of equipment and manpower most suitable for the work must be assessed and costed. A number of alternative plans based upon different methods will be assessed and compared in terms of the total cost. In this manner the optimum cost of carrying out the work will be found. This may involve the rejection of an earlier method even though this causes changes in calculations already undertaken as the rest of the estimating process continues.

This link between the planning and estimating functions may be extended throughout the whole estimating process. Barnes [33] explained that the influence of planning on the estimating process occurred in two main ways;

i) the two functions may be fully integrated. The contract programme being used as the basis for calculating the full cost and revenue characteristics of the contract. These figures are then transposed into the rates entered into the Bill of Quantities;

ii) the two functions are not fully integrated and the planned use of the plant and labour resources is costed in total to be checked against the labour and plant cost totals as calculated by the estimators. The two functions are pursued in parallel with informal interaction limiting their divergence.

In a small survey undertaken as part of the research it was found that the 84% of companies indicated that situation (ii) is the most common approach. All of these companies stated the importance of a closer integration between the planning and estimating functions. (See Appendix II).

The amount of detailed information incorporated into the tender plan depends on the time available and the degree of competitive pricing considered necessary to obtain the contract. A secondary purpose of the tender plan is to provide a basis for the subsequent contract plan [38]. Not all companies produce a pretender plan for each individual project, some relying upon information from similar projects [39].

The draft project programme is usually prepared in bar chart form based upon the major items of work. This enables the estimator to check for gaps in the assessment of the work involved in the contract and co-ordinate periods for which equipment is on site. Pilcher [(40)] recommends Network Analysis for pretender planning because of the ability to highlight fallacies in the logic of construction at an early stage.

2.4.3 THE SELECTION OF SUB-CONTRACTORS

The estimators review of the Bill of Quantities (as described in 2.4.2) involves consideration of the work within the contract that may be sub-contracted. The lengthy procedure of obtaining and comparing sub-contractor quotations necessitates an early decision as to which types of work are to be sub-contracted. The final decision will be dependant upon:

- the size of the contract,
- the specialization of the work involved,
- company taxation reasons;
- the risk factor of the work.

and although the estimator may obtain sub-contractor quotations, their inclusion is decided by senior management. Sub-contractor quotations may be obtained by the estimator or by a separate department set up to carry out this task.

The bill items relating to work that is to be sub-contracted must be considered separately as they represent a different commitment by the Contractor. The absence of direct financial risk should not be allowed to obscure the indirect risk of heavy losses caused by delay and disruption to the main works if sub-contract work is allowed to proceed without adequate control.

Pearson [41] states that effective control of sub-contractors begins with their selection. The company should keep a list of approved sub-contractors for the different classes of work. The estimator in addition to having access to this information needs to make checks with personnel both inside and outside his own organization. It is essential to know whether a sub-contractor has been used before by the company and whether the service supplied was satisfactory in every aspect.

Information to be communicated to the sub-contractor:

The contract made with a sub-contractor should include in addition to the customary contract conditions, written confirmation of the following details in order that his work is clearly defined and the constraints imposed are fully understood by both parties.

i) the sub-contract programme should be stated in a reasonably detailed form, giving a realistic work sequence and timed programme;

ii) the contract stage the service is required and the sub-contractor's commitments on either side of this date determined in order that unavoidable changes in schedule can be made as smoothly as possible;

iii) the sub-contractor's responsibilities with respect to making good other work;

iv) the position regarding the supply of equipment, access ways, storage facilities, etc;

v) where the responsibility lies for the provision of water, power and any other services;

vi) specific instructions from the client regarding materials to be used or work practices adopted;

vii) facilities for inspections by the main contractor's representatives before the start of the contract;

viii) responsibility for informing the appropriate body when work has to be inspected at various stages;

ix) control information to be provided regularly by the sub-contractor while present on site;

x) site safety and industrial relation requirements.

This information is obtained by the estimator from the contract documents and contract programme. Appropriate sections of the conditions of contract and specification may be copied direct from the contract documents and forwarded to the sub-contractor with copies of the drawings. A detailed abstraction from the contract programme may be necessary to ensure the sub-contractor is fully aware of the periods he is required on site, the production level needed and the interaction with other sub-contractors. The use of standard letters and sub-contractor enquiry forms speeds the issue of information and ensures that no basic contractual details are omitted.

Where sub-contractor quotations are obtained by a separate department within the company the estimator is required to consult regularly with the personnel involved to ensure that documentation for the sub-contract is forwarded to all listed sub-contractors and quotations are received in time to be included within the estimate. If the estimator is required personally to carry out this task then the communication required, although direct, is with people outside the company organization.

On receipt of sub-contractor quotations the estimator is required to check that all the items have been priced correctly in accordance with the unit of measurement required.

The selection of the sub-contract price to be included in the estimate is not necessarily a question of finding the cheapest. Consideration must be given to all the factors known about the sub-contractor and any qualifications that may have accompanied the quotation. Where contractual problems exist they must be checked and agreed with the legal department.

Having selected a sub-contractor the estimator does not simply enter the appropriate rate against the relevant items in the Bill of Quantities. An assessment has to be made of the attendance necessary for the sub-contractor and any particular site on costs.

Attendance falls into two categories:

i) General Attendance;

ii) Special Attendance.

General Attendance consists of·

- use of temporary works (eg standing scaffolding);
- accommodation facilities, messrooms, sanitary and other welfare facilities ,
- office accommodation and storage space for plant and materials,
- lighting, water power and other services;
- materials unloading and distribution;
- clearing away of rubbish.

Specialist contractors require extra attendance that varies with their particular trade. The Southampton Group of the IOB Estimating Section [42] give details of typical requirements for different classes of work.

For example, demolition requires:

- giving notice and paying charges incurred in disconnecting public services;
- provision of protection to workers and the public, (fans, screens, tarpaulins etc);
- the making good of existing structures where called for in the bill descriptions.

To calculate attendance requirements the estimator must fully understand the contract programme and the integration of the sub-contractors into the main works and have negotiated with sub-contractors to fully determine their requirements on site. This may take the duration of the tender period and is carried on in parallel with the building up of the main section of the estimate.

2.4.4 OBTAINING MATERIALS QUOTATIONS

Due to the effects of inflation and the variance of delivery costs, the estimator is required to obtain a quoted price for every material to be used on the project. This requires the abstraction from the contract documents (as described in 2.4.2) of a detailed list of all the materials and the total quantities required. Suitable suppliers are then contacted to obtain a quotation. Responsibility for sending out enquiries within the contractors organization may lie with the buyer or the estimator. If satisfactory quotations for the many materials required for a construction project are to be obtained within the limited time available, a good communications link between the estimating and buying functions is essential.

Taylor [43] recommends that an enquiry section should be formed within or under the control of the Purchasing Department. This should be located near to the Estimating Department to facilitate rapid communication.

Enquiries to suppliers should state·

- the specification of the material;
- the quantity of the material,
- the likely delivery programme including both the period for which supplies would be needed and the daily or weekly requirements;
- the address of the site,
- means of access,
- traffic restrictions and conditions affecting delivery;
- period for which the quotation is required to remain either open for acceptance or firm;
- the date by which the quotation is to be submitted,
- the person within the contractor's organization to whom any reference concerning the enquiry should be made.

Mudd [44] outlines a procedure for the estimator and provides guidance for the purchase of particular materials items. As with the selection of sub-contractors, the use of standard letters and forms assists the speed of operations and reduces problems to the supplier by ensuring that all relevant information is included.

The information to be included within the enquiry shows that the estimator has to abstract details relevant to each material from the contract documents and determine when they are required on the project from the contract programme. In many instances a copy of the original documents is satisfactory. The tender submission date determines the latest date for the quotation to be received.

As with the obtaining of sub-contractor quotations, the ultimate responsibility rests with the estimator to obtain the information. Where the actual task is carried out by a special department within the organization, the estimator must communicate regularly with the personnel to ensure the correct information has been issued and quotations duly received.

On receipt of a quotation that appears favourable, the following details must be checked before the quotation is accepted as satisfactory and the price included within an item build up [(45)].

i) the quotation covers the actual material stated on the drawing;

ii) the material meets the standard stated in the specification;

iii) the quantity and unit rate is appropriate to the total quantity required in the works at the unit of measurement of the unit rate to be priced in the bill of quantities;

iv) the delivery period and delivery programme meets the time required for incorporation in the works;

v) the discount rate (where applicable) is not less than the normal market rate;

vi) the trading conditions and terms of payment are acceptable;

vii) the time limit which may be applied to the acceptance of the suppliers offer;

viii) whether the material is offered on a fixed price basis or at prices ruling at the date of delivery.

The estimator is required when checking quotations to ensure that materials meet the requirements of the contract documents and can be delivered to the site at the times required by the contract programme. In addition the contractual obligations to be entered into for the supply of the material must be satisfactory.

The determination of the materials price for inclusion in the direct cost estimate may be considered to be one of the most accurate aspects of estimating. The process of obtaining materials prices as has been described can be seen to consist solely of contacting suppliers who have the material available and negotiating a suitable rate under satisfactory contractual conditions. Moyles [32] comments that the estimator has in addition to undertake the more difficult task of determining material wastage, damage, theft and delivery discrepancies. For some materials this may reach particularly high proportions and this aspect must be assessed by the estimator and effected in the price included in the estimate.

2.4.5 ESTABLISHING RATES FOR LABOUR AND PLANT

Following the sorting of the Bill of Quantities items and selection of appropriate methods of work the estimator will have determined the labour and plant resources that will be required to undertake the construction of the project. Before the pricing of the bill items is commenced it is necessary to calculate the labour and plant rates for the resources to be used.

The information necessary to perform these calculations is obtained through:

- construction industry standard agreements;
- study of the contract programme,
- an examination of the site location and the market for labour and plant.

From this information the estimator must determine the true hourly cost of labour to the company. This "all-in" rate is usually determined for three basic categories of workers - labourers, craftsmen and plant operators.

Construction plant for a contract may be:

i) hired from a plant hire firm,

or ii) obtained from the company plant division.

In either case the estimator must calculate the true cost to the company of the plant item. Information has to be received from plant personnel within the company and different plant hire companies externally on the availability and price of plant items. Transportation, erection and dismantling costs and procedures. An example of the calculations of plant rates for hired and company plant is included in Chapter 3. It should be noted that the rate offered by the plant hire firm is normally only valid for the date of the enquiry. The rate will fluctuate during the contract period due to the effects of inflation and the state of trade at the time the machine is required. Depending on the conditions of contract the estimator may have to consider additions to cover likely fluctuations in plant rate.

2.4.6 DIRECT COST RATES

Direct Cost Rates are calculated by the estimator for each bill item or groups of bill items. The calculations involve the selection of resources required to execute the work and the determination of appropriate cost and production rates. This is shown diagrammatically in Fig.3 page 52 .

The all-in rates for labour and plant are calculated at the start of the estimate. Materials and sub-contractor quotations are obtained during the tender period and incorporated as and when they are received.

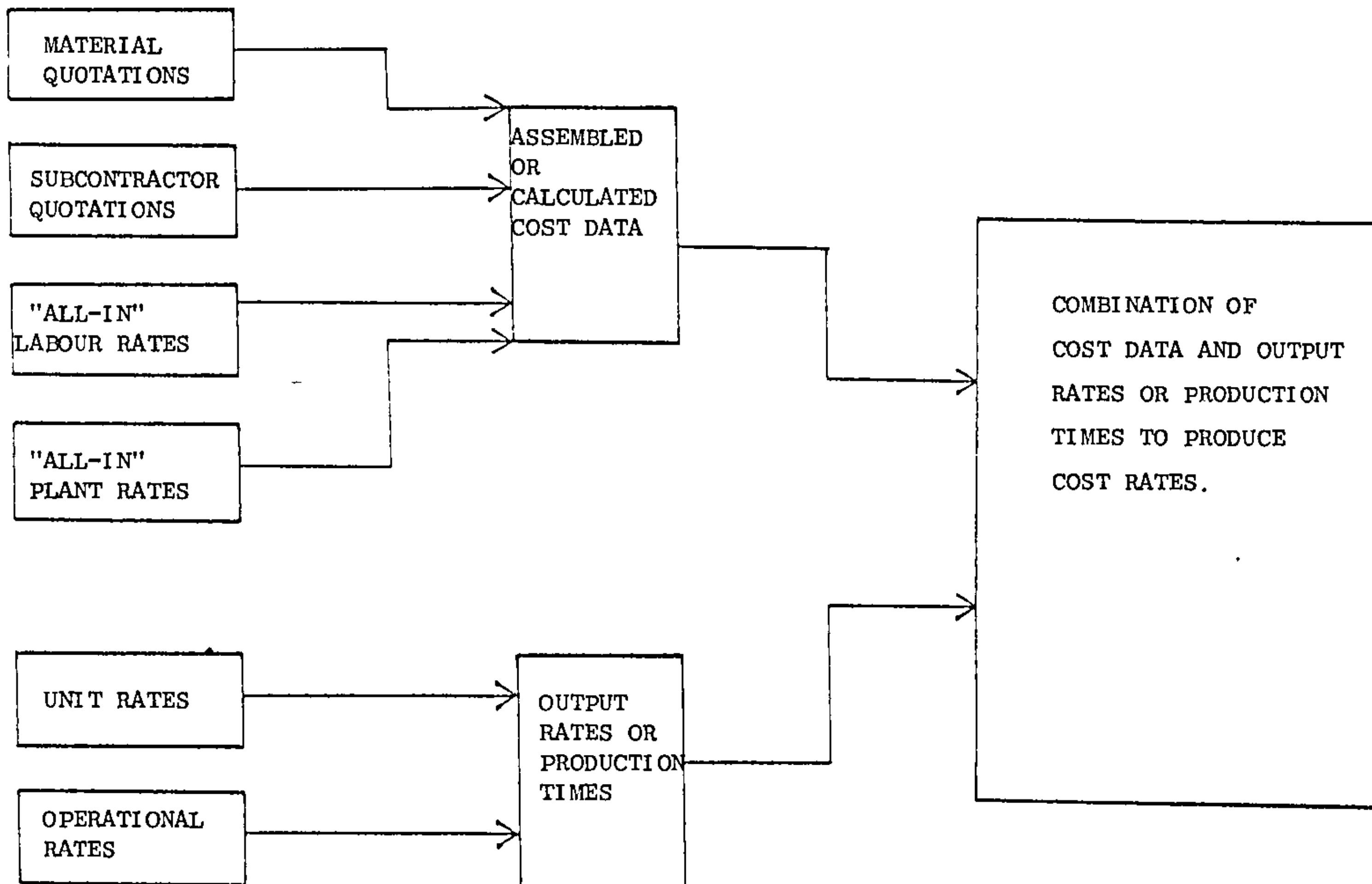


Figure 3 - THE CALCULATION OF THE DIRECT COST RATE

The output rates or production times used in calculating the direct cost may be obtained from Unit rates or Operational rates. Unit rates are based upon output or usage rate that may be:

i) abstracted from previously recorded company manuals;

ii) taken from the estimator's "personal" manuals;

or iii) "known" to the estimators by their experience.

All such output or usage rates are subject to modification by the estimator following the appraisal of the particular conditions of work under consideration. Such appraisal is frequently subjective.

An example of unit rate estimating is included in Chapter 3.

The alternative to using such rates is to estimate the duration of the activities or operations involved and to base the calculations on the estimated costs of the labour and plant required for the duration of the work. (As opposed to assuming any particular output rate). These durations are either derived from the planning exercise where logic sequences may determine a duration, by building up from several assumed output rates or again by experienced judgement. Calculations based on the duration of construction activities or operations are known as Operational Estimating.

An example of Operation Estimating is given in Chapter 3.

Both operational and unit rate type estimating are used by civil engineering contractors estimators although neither method is adopted to the exclusion of the other. Operational estimating is particularly prevalent in civil engineering contracts because such contracts have a large 'plant' element and plant is susceptible to idle time that accrues costs that are not readily catered for in the unit rate approach.

Some contractors not only estimate the major plant dominated sections (e.g. earthworks) in this manner but also try to include as much of the remaining items of work in their operational estimating approach.

If a truly Operational Estimating approach was adopted then the estimating process would comprise planning, calculating the costs of the resources for each operation or activity and transferring this data to the bill of quantities. This approach is popular particularly with companies who have adopted network based planning techniques for most of the contracts. However the major impediment to adopting this approach is the bill of quantities. Operational formated bills for building work proposed and tested by Forbes and Skoyles [46][47] in an attempt to make estimating 'more realistic' have failed to make the impact they had hoped and are not in common use.

By including method related charges the CESMM [24] encourages the concepts of operational estimating. However the CESMM does not produce operational formated bills and to date only accounts for about 20% - 25% of all civil engineering bills of quantities.

The detailed build-up for each bill item is calculated and recorded by the estimator on work sheets. A typical example is given on page 55 . The format of the estimators work sheets may vary from company to company but essentially they are the same. The basic information on the item priced (reference, description, quantity and unit) is recorded together with the cost and production rates. This information is extended to produce a total rate for the item that is split into the main cost code categories, labour, plant, materials, etc.

ESTIMATE SHEET

Item	Man hrs unit	Total Man hrs		Trade Rate	Description	Quant	Unit	Lab	PM	TM	Plant	X4	Labour		Perm Materials		Temp Materials		Plant		
1					Excavat^n & c/a	2.25	m^3					11.29									
	1	0.38		1.50	JCB & driver @ 6 m^3/hr	0.375	hrs	3.50			10.00		1.31						3.75		
	1	0.37			Tipper	0.375	hrs	3.50			4.50		1.31						1.67		
2	1.57	4.77		2.15	Supplying & laying 21" concrete pipe	30	lin m	3.42	48.75			23.78	10.20		146.25						
3	3.25	6.66		2.15	Mass concrete bed & haunch	2.05	m^3	6.99	26.00			57.31	14.33		53.30						
4	2.25	9.34		2.15	F1 formwork to concrete	4.15	m^2	4.84		6.00		43.00	20.09				24.90				
5	1.47	4.13		2.15	Supply & compact imported fill	2.81	m^3	3.16	5.10				8.88		14.33						
					plate vibrator 4 m^3/hr	0.70	hrs				2.00	30.02							1.40		
6	0.125			2.15	75 mm lean-mix base	9.0	m^2	0.27					2.42								
						0.68	m^3		21.60			4.02			14.69				0.90		
			27.86											58.60		228.57		24.90		7.74	319

Figure 4 - A TYPICAL EXAMPLE OF AN ESTIMATORS WORK SHEET

As and when the estimator considers each item and information becomes available, the build-up is completed and the direct cost estimate total increases. Bill items are considered by the class of work to which they refer, the estimator concentrating on each class of work in turn. It is important for the estimator to compare and adjust similar rates to obtain a correct balance between bill items. This may involve the item build-up being adjusted several times before finally being accepted by the estimator.

When accepted, the rate for a bill item is transferred to a photostat copy of the bill of quantities. It is normal for the estimator to subdivide the bill page into several columns to record the breakdown of the item rate. This enables the total of each cost category to be calculated for each page and hence the complete contract. An example is given on page 57 .

A bill of quantities may contain several thousand items. If bill items are ranked longest to smallest and plotted against the cumulative value of the bill then it may be seen that a large proportion of the total value of the contract is contained within relatively few bill items. This curve is known as the 'Pareto Curve' (32) and although it varies from contract to contract it can be seen that some 80% of the contract value is contained within some 20% of the bill items. It is illustrated in Figure 6, page 58 .

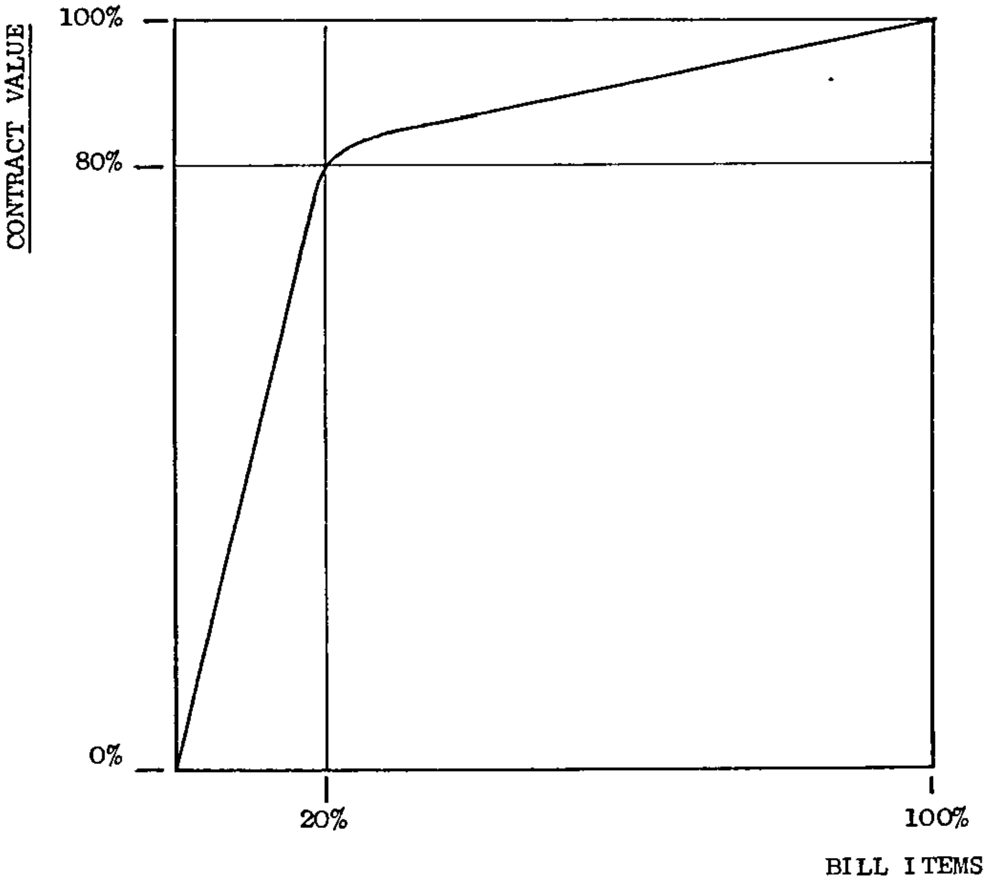
This is important to the estimator in both the attention given to the bill item and the method of pricing. The format of the bill of quantities requires the estimator to price every bill item. Many of the bill items are insignificant to the total value of the bill and are therefore priced as quickly as possible using Unit rate estimating methods.

PART 3 - OUSTON LAND REALIGNMENT

Item Nr	Code Nr	Item Description	Unit	Quantity	Rate	Amount £	p
		LABOUR PLANT MAT S/C					
		PIPEWORK - PIPES					
1	I313.1	150 mm Diameter standard concrete pipe in trench, maximum depth 1.4 m. 2.02 3.61 3.71	m	27 ✓	9.34	252.	18
2	I313.2	150 mm Diameter porous concrete pipe in trench, maximum depth 1.4 m. 2.02 1.75 2 78	m	382 ✓	6.05	2311	10
3	I612.1	75 mm Diameter PVC class D water main in 0.75 m deep trench, along verge in Ouston Lane. 1.00 0 65 1.93	m	425 ✓	3.58	1521.	50
4	I612.2	75 mm Diameter PVC Class D water main digging out old $1\frac{1}{2}$" diameter water main in 0.75 m deep trench, on western side of Tadcaster Bypass. 1.00 0.65 3.28	m	50 ✓	4.93	246.	50
		PIPEWORK - FITTINGS AND VALVES					
5	J321	150 mm Diameter concrete oblique angle junction 3.65 4.82 7.48	Nr	13 ✓	15.95	207	35
6	J631	75 mm to 4" Diameter taper to connect Ouston Lane Water main to existing 4" diameter water main. 4.28 3.61 4.65	Nr	2 ✓	12.54	25	08
		PIPEWORK - MANHOLES AND PIPEWORK ANCILLARIES					
7	K252	Precast concrete catchpit with 1200 x 600 mm clear opening medium duty multiple triangular cover. 108.71 120.21 111.2	Nr	5 ✓	340.12	1700	60
8	K360	Precast concrete trapped gully 450 x 750 mm deep, with 450 x 500 mm clear opening grade D heavy duty double triangular gulley grate and frame. 34.71 42.82 15.87	Nr	13 ✓	92.4	1201	20
					Page Total	7465.	51

3/3

Figure 5 - THE DIVISION OF THE TOTAL ITEM RATE



80% OF CONTRACT VALUE REPRESENTED BY
20% OF THE BILL ITEMS.

Figure 6 - THE 'PARETO CURVE'

Alternatively they may be priced without calculation. This is frequently described as gash or spot rate estimating. The estimator is not concerned with the actual resources required to complete the item on their individual outputs. All that is required is to enter a sum of money against the various cost code categories to cover the cost of completing the work.

The 'cost important' items by definition require more detailed attention. In civil engineering work these tend to be the items that are priced by an Operational rate method although Unit rate estimating is used in major items of a repetitive nature.

The estimator has complete freedom of approach in how he decides to price a particular bill item although he may be called upon to justify this to the adjudication panel.

2.4.7 SITE OVERHEADS

When the direct cost for the project has been completed it is possible to assess the site overheads or on costs.

These may be summarized under the following headings:[48][49][50]

i) Site management and supervision;

ii) Plant,

iii) Transport;

iv) Scaffolding,

v) Miscellaneous labour;

vi) Accommodation,

vii) Temporary works and services;

viii) General items,

ix) Commissioning and handover;

x) Sundries requirements.

For the calculation of the sum of money necessary to cover these costs the estimator refers to detailed check lists of requirements. Examples of these check lists are given in Appendix III. Reference is also made to the contract programme and the direct cost estimate totals. The direct cost estimate totals indicate the level of overhead support required for the project and the contract programme identifies the timing and duration of overhead requirements.

The check lists show the estimator what allowances should be made in each category. It is the estimators responsibility to check that the latest rates for services, transport, site accommodation are included. This involves communication with the company personnel department, plant department and external statutory authorities to ensure all the requirements for the particular location are covered.

The calculation of site overheads is the last process in calculating the direct cost of the project. The estimator is then required to present to senior management reports relating to the project. These reports contain:

- a brief description of the project;
- a description of the method of construction;
- notes of any unusual risks which are inherent in the project and which are not adequately covered by the conditions of contract or bills of quantities;
- any unresolved or contractual problems ;
- an assessment of the state of the design process and the possible financial consequences thereof;
- notes of any major assumptions made in the preparation of the estimate;

- assessment of the profitability of the project,

and - any pertinent information concerning market and industrial conditions.

The costs of the work included in the estimate are reported to senior management in cost reports that give details of·

- main contractor's labour;
- main contractor's plant allocated to rates;
- main contractor's materials;
- main contractor's own sub-contractors;
- sums for nominated sub-contractors;
- sums for nominated suppliers;
- provisional sums and dayworks,
- contingencies;
- amounts included for attendance on domestic and nominated sub-contractors;

and - amounts included for materials and sub-contract cash discounts.

The estimator must also assemble the total hours for each category of labour and the total hours or weeks for each major item plant and total quantities for materials. These resource totals are compared with the planners calculated resource totals and any differences reconciled.

2.4.8 TENDERING ADJUSTMENTS

The direct cost estimate for the project is assessed by representatives of the senior management and representatives of the estimating team.

It is the responsibility of this "adjudication panel" to satisfy themselves that the estimate is adequate and represents the likely cost to the company of completing the work if awarded the contract. The estimator responsible for the preparation of the estimate is questioned as to his assumptions and decisions. Frequently lump sum additions or subtractions are made to the estimate to adjust the total sum.

Additions are made to the estimate to include allowances for head office overheads, profit and risk.

Additional administrative costs can be easily assessed and forecast from previous records of head office rates, heating charges, etc. In order to provide accurately for overhead costs it is necessary to know the relationship between costs and turnover. A monthly comparison of the level of turnover with overhead costs should indicate the required contribution from future contracts. The cost of financing the project can be obtained from analysis of the cash flow for the project. An example is given in Chapter 3.7.

The amount of profit required by a construction company for a particular project varies with:

- volume of work in hand;
- orders anticipated;
- market conditions;
- risk factor.

To assess these factors the tender adjudication panel require an analysis of the following information:

- the preliminary items within the bill;
- work to be undertaken directly by the contractor,
- the contractors specialist service requirements,
- the total materials value and proportion of bulk materials;
- the work to be sub-contracted;
- the sub-contractors nominated by the Engineer;
- the supplies nominated by the Engineer;
- provisional sums and prime cost items;
- dayworks;
- contingency allowances.

It is usual to add different profit margins for company work and sub-contracted work.

The addition of monies to cover these factors changes the estimate into a tender. Two alternative structures of the tender price are given by Bainbridge [11] and shown in Figures 7 and 8 page 64

Rate loading is carried out when the total tender sum has been determined. This is the process whereby the rates for some bill items are raised while for others they are lowered, so keeping the total tender sum the same. The object of this 'loading' of bill items is·

- to make extra money on bill items,
- to improve cash flow for the project;
- to make extra money through inflation indices.

Figure 7

SCHEMATIC DIAGRAM OF THE STRUCTURE OF TENDER PRICE

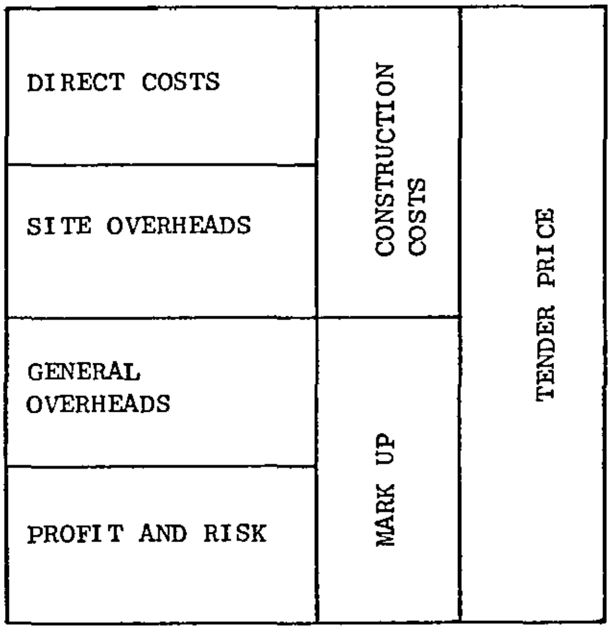
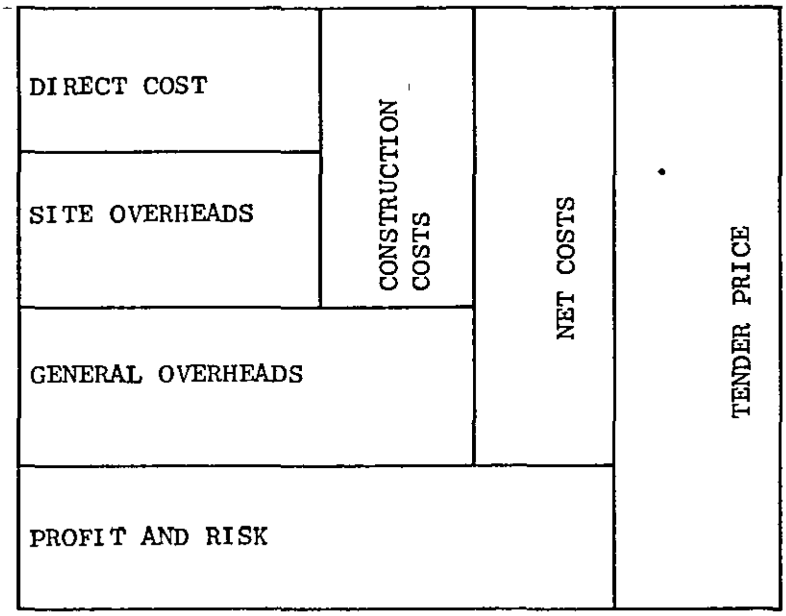


Figure 8

SCHEMATIC DIAGRAM OF THE ALTERNATIVE STRUCTURE OF TENDER PRICE



There may be items within the bill where the estimator considers that the quantity has been underestimated. The chance exists of making additional money by artificially raising the rate of the item so as to capitalize on any increase in the actual amount of work completed on the project.

By raising the rates of bill items relating to work completed early within the project the estimator increases the positive cash flow for the project and reduces the capital "locked up" in the project. In situations of high interest rates and low inflation this proves financially attractive.

During periods of high inflation and low interest rates it may be attractive to load the bill items relating to work to be completed in the latter stages of the project. This enables additional monies to be accrued following the calculations using the appropriate inflation indices.

2.4.9 PRICING AND EXTENSION OF THE BILL OF QUANTITIES

The tender figure for the contract must be entered into the contract documents. Where only the submission of a Form of Tender is required only global sums are entered. In submitting a tender with a priced Bill of Quantities the direct cost rates calculated need to be amended to take account of adjustments to the estimate, the mark up allowances and any rate loading.

Additions may be in the form of percentage additions or lump sum adjustments. Percentage additions may be made to either particular cost code categories (ie 10% on labour, 20% on plant etc) or to individual items within the bill.

Lump sum adjustments are frequently made by using the preliminary section of the bill to include the balance of the mark up. The process of apportioning money throughout sections of the bill or particular classes of work is rarely performed because of the clerical effort required.

The transfer of the rates into the Bill of Quantities must be carried out manually by the estimator. The bill is then passed to the comptometer operators for extension, (the multiplication of each item rate by the quantity) totalling and checking. The final stage is the returning of the completed Bill of Quantities to the promoter or his representative together with the Form of Tender formally offering to undertake the works.

3.0 THE CALCULATIONS INVOLVED IN THE ESTIMATING AND TENDERING PROCESS

This chapter contains examples of the principle calculations performed during the estimating and tendering process. These include:

- the turnover and tendering programme,
- the "all-in" labour rate,
- the "all-in" mechanical plant rate,
- an example of Unit rate estimating,
- an example of Operational estimating;
- the calculation of site overheads;
- an example of the cash flow analysis for a construction project;
- adjustments to the tender to allow for inflation and rate loading.

The calculations are analysed with respect to·

- the input required;
- the source of the input;
- the results produced,
- how the results are incorporated into the tender.

A complete computer aided estimating system should have the facilities to support all these calculations whether fully integrated into the main part of the system or provided as sub-programs.

3.1 THE TURNOVER AND TENDERING PROGRAMME

Davies (35) states the importance of tendering within a defined tendering policy. This can be established when, having defined trading and marketing policies, the following information is prepared:

- a turnover target divided into each market showing the proportions in which the total turnover is to be obtained,
- an overheads budget;
- gross and net profit targets;
- the anticipated volume of enquiries required to achieve the turnover.

The tendering policy can be represented by a tendering programme, showing the values and latest dates to achieve the volume of enquiries and turnover target. Examples of a turnover programme and tendering programme produced by Davies (35) are included as Figs 9 and 10, pages 69 and 70 . For simplicity, the turnover programme is geared to only three market sectors and the tendering programme shows one sector only.

3.2 ALL-IN LABOUR RATE

The estimator must determine the basic hourly rate and all the numerous expenses resulting directly from the employment of labour to calculate the true hourly cost of labour to the company. The "all-in" rate is usually calculated for three basic categories of workers - labourers, craftsmen and plant operators.

The main items to be considered are:

- the basic or current wage rate inclusive of the cost of Guaranteed Minimum Bonus Payments and Joint Board Supplement Rules;
- payments required by the Working Rule Agreement (plus rates, tool money, dirt money etc);
- allowances to cover guaranteed time;

TURNOVER PROGRAMME for Financial Year ending 31 1 1975   TOTAL TARGET £9 500 000   TOLERANCE 10% (UPWARDS ONLY)

MARKET SECTION TARGETS – TOLERANCES (EACH SECTION) 12½% UP OR DOWN

MARKET A £1 000 000

MARKET B £3 000 000

MARKET C £4 500 000

ALL IN £000's

	Financial Year 1973							Financial Year 1974													Financial Year 1975						
	Aug	Sep	Oct	Nov	Dec	Jan	Half Years Totals	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Totals for F Y 1974	Feb	Mar	Apr	May	Jun	Jul	Half Year's Totals
WORKS IN PROGRESS																											
MARKET A	20	15	5	-			40												-		-			-	-	-	
MARKET B	295	270	290	215	140	160	1370	135	145	180	180	140	140	130	150	135	120	95	100	1650	90	70	40	50	20	5	275
MARKET C	270	295	275	260	180	130	1410	105	115	100	100	90	90	105	110	110	100	35	80	1140	45	15	5				65
TOTALS	585	580	570	475	320	290	2820	240	260	280	280	230	230	235	260	245	220	130	180	2790	135	85	45	50	20	5	340
CONTRACTS TO BE GAINED																											
MARKET A	-	10	25	35	40	50	160	45	65	80	105	105	120	130	120	105	70	20	35	1000	60	70	45	50	50	30	305
MARKET B	10	20	20	45	25	40	160	70	85	105	110	130	140	140	140	125	120	85	100	1350	100	110	125	125	120	95	675
MARKET C			5	25	30	40	100	80	120	185	210	270	305	345	370	400	430	285	360	3360	340	340	360	385	320	320	2065
TOTALS	10	30	50	105	95	130	420	195	270	370	425	505	565	615	630	630	620	390	495	5710	500	520	530	560	490	445	3045
COMBINED TURNOVER																											
MARKET A	20	25	30	35	40	50	200	45	65	80	105	105	120	130	120	105	70	20	35	1000	60	70	45	50	50	30	305
MARKET B	305	290	310	260	165	200	1530	205	230	285	290	270	280	270	290	260	240	180	200	3000	190	180	165	175	140	100	950
MARKET C	270	295	280	285	210	170	1510	185	235	285	310	360	395	450	480	510	530	320	440	4500	385	355	365	385	320	320	2130
TOTALS	595	610	620	580	415	420	3240	435	530	650	705	735	795	850	890	875	840	520	675	8500	635	605	575	610	510	450	3335

Figure 9 – TURNOVER PROGRAMME

TENDERING PROGRAMME for Financial Year ending 31 1 1977

MARKET SECTION A

Turnover Target	£1,000,000	
Less Work In Progress	______	
To be obtained		£1,000 000 = 48 Turnover Months

MARKET SECTION RECORDS DATA

Average Value of Contracts	£250 000 (adjusted for inflation)
Average Duration	12 months
Average Monthly Turnover	£21,000 (approximately)
Average Tender Success Rate	1 in 5
No. of Enquiries Required	Minimum 25 (in 18 months period)
Successful Tender Target	5 (in 18 months period)

	1973						1974												1975						
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	
ENQUIRY PROGRAMME * (5 in Apr/Jul 73)	5*	1	2	3	2	2	2	2	2	2	2	3	2		.	.	.	.	.			.	.	.	TOTAL 25
TENDER SUCCESS PROGRAMME * (1 in July 73)	1*		1		1		1					1	1												TOTAL 5
PROJECTED STARTS	1			1		1			1				2												TOTAL 6
TURNOVER MONTHS IN FINANCIAL YEAR	6			9		11			10				12												TOTAL 48

Figure 10 - TENDERING PROGRAMME

- sick pay schemes,
- employers liability insurance;
- training levy;
- National Insurance/Social Security,
- Pensions;
- holidays with pay schemes;
- allowances to cover redundancy;
- wage related benefits.

The following annotated example shows the inclusion of all these factors. The approach follows that of Benedict [51] with reference to Walkinshaw [52].

It is required to calculate:

- site working hours,
- weeks worked in a year,
- actual hours worked in the year,
- non productive overtime,
- the costs of employing labour;
- the annual cost of labour.

The input for the calculations is obtained through:

- construction industry standard agreements and statutory employment conditions,[53]
- the contract programme;
- an examination of the site location and current market for labour.

This information is used to produce factors and allowances that may be added to the standard hourly rate.

The all-in rate will vary for each contract and also with different estimators allowances.

SITE WORKING HOURS

Assume the site works a Summer and Winter period.

SUMMER PERIOD - 30 weeks

Hours worked   Monday to Friday   8.00am to 5.30pm

Therefore from WRA Rule VI

Monday to Thursday	8 hours normal	1 hour overtime
Friday	7 hours normal	2 hours overtime

This gives a working week of 39 hours plus 6 hours overtime.

Non productive overtime = 6.0 x 0.5 = 3 hours

Total paid hours per week = 48 hours

WINTER PERIOD - 22 weeks

Hours worked   Monday to Friday   8.00am to 4.30pm

This gives a working week of 39 hours plus 1 hour overtime.

Non productive overtime = 0.5 hours

Total paid hours per week = 40.5 hours

TIME UNWORKED DURING THE YEAR

HOLIDAYS	Rule VIA of WRA
WINTER	7 working days + Christmas, Boxing day, New Year.
	Total = 2 calendar weeks.
SUMMER	Two calendar weeks.
EASTER	4 working days following Easter Monday.
ADDITIONAL	4 Bank holidays during the Summer period.
	Total holidays = 5 weeks 4 days.

SICK LEAVE

Assume off work 1 week Summer - 2 weeks Winter

First three days not paid.

Thereafter paid at £4.49 per working day.

Reduction with respect to earnings related supplement DHSS?

INCLEMENT WEATHER

Assume 60 hours inclement weather per year.

WEEKS WORKED IN A YEAR

Total weeks worked in the year	=	52 weeks
Holidays	=	5 weeks 4 days
Sick leave	=	3 weeks
Weeks worked in the year	=	43 weeks 2 days.

ACTUAL HOURS WORKED PER YEAR

Summer period	30 weeks x 45 hours	=	1980
Winter period	22 weeks x 40 hours	=	320
			2300

Hours unworked due to holidays

Summer period	2 weeks annual holiday	
	1 week easter week	
	4 days bank holiday	
	Total 3 weeks 4 days ie	180.5 hours
Winter period	2 weeks Christmas period	85 hours
	Total hours unworked due to holidays	265.5 hours

Hours unworked due to inclement weather 60.0

Hours unworked due to sick leave	
1 week summer	47.5
2 weeks winter	85.0
TOTAL HOURS LOST THROUGH SICKNESS	132.5
Loss of hours through giving men notice	7

TOTAL HOURS UNWORKED IN THE YEAR 465

TOTAL HOURS WORKED IN THE YEAR 1835

CALCULATION OF NON PRODUCTIVE OVERTIME

Non productive overtime in summer = 30 x 3 hours = 90

Non productive overtime in winter = 22 x 0.5 " = 11

Less holidays and sick leave

ie winter period 2 weeks sick deduct 12 hours

2 weeks holiday

summer period 1 week sick

3 weeks 4 days holiday deduct 2.4 hours

TOTAL DEDUCTIONS 14.4 hours

NON PRODUCTIVE OVERTIME = 86.6 hours

COSTS OF EMPLOYING LABOUR

Basic rates of pay: (Working Rule Agreement Rule 1)

Labourers	162.5 p/hour
Tradesmen	190 p/hour

Note operatives paid at Labourer rate with appropriate plus rate.

Overtime paid at 1½ or 2 times hourly rate (WRA Rule VII)

Bonus - assume 30% including guaranteed minimum.

Tool money varies per tradesman - say - 85 per week

Plus rates assumed at 2%

Holiday stamps and Death benefit £8.45 per week

Sick pay £4.49 per day (after first three days).

National Insurance = 13.7% of payroll

C.I.T.B. levy = £10.00 Labourers

£45.00 Tradesmen

Severance pay - assume 2%

Insurance (employers and public liability) - assume 2%

Small tool allowance - say 2½%

Supervision - say 6½%

Allowances may also be necessary in certain conditions for additional plus rates. The Working Rule Agreement should be studied for special conditions (Rule VC), Night work (Rule XIV), Shiftwork (Rule VIII), Tide work (Rule IXA), Periodic travel (Rule XI), Height money (Rule XIIIA(c)) etc.

Examples of the calculation of the Total Annual Cost of Labour and "All-In" Labour rate are given in Figures 11 and 12, pages 76 and 77 .

CALCULATION OF ANNUAL COSTS OF LABOUR

	LABOURER	CRAFTSMAN
Basic Rate x No. of hours worked		
162.5 x 1835 or 190 x 1835	£2981.87	£3486.5
Inclement weather		
Basic rate x 60 hours		
162.5 x 60 or 190 x 60	£ 97.5	£ 114.0
BASIC TOTAL	£3079.37	£3600.5
Bonus - 30% (including guaranteed minimum)	£ 923.81	£1080.15
Non productive overtime		
Basic rate x 86.6	£ 140.72	£ 164.54
Public holidays - basic rate x 8 hours x 8 days	£ 104.00	£ 121.60
Sick pay £4.50 x 9	£ 40.5	£ 40.5
Tool money 85p x 43.2		£ 36.72
Plus rate of 2% on basic total	£ 61.59	£ 72.01
PAID TOTAL	£4349.99	£5116.02
National Insurance 13.7% paid total	£ 595.95	£ 700.89
C.I.T.B. levy	£ 10.00	£ 45.00
Annual holidays and death benefit 47 weeks x £9-10	£ 427.7	£ 397.15
Small tool allowance 2½%	£ 108.75	£ 127.90
Supervision allowance 6½%	£ 282.75	£ 332.54
	£5744.59	£6719.50
Allowance for severance pay 1½%	£ 86.17	£ 100.79
Insurance 2%	£ 114.89	£ 134.39
TOTAL ANNUAL COST	£5976.20	£6985.23

Figure 11 - CALCULATION OF THE ANNUAL COST OF LABOUR

CALCULATION OF THE 'ALL IN' RATE

Total Annual Cost for Labourers	=	£5976.20
Total worked hours	=	1835
Therefore 'all in' rate	=	£5976.20/1835
	=	£3.25/hr
Total Annual Cost for Craftsmen	=	£6985.23
Total worked hours	=	1835
Therefore 'all in' rate	=	£6985.23/1835
	=	£3.81/hr

Figure 12 - CALCULATION OF THE "ALL-IN" LABOUR RATE

3.3 "ALL-IN" MECHANICAL PLANT RATE

Construction plant for a project may be hired from a plant firm or obtained from the company plant division. The estimator must incorporate into the rate used in his build up the true cost of the plant.

For hired plant, the cost of all additional running costs not covered by the hirers quotation must be included. These running costs include:

- emoluments of the operator,
- fuel,
- oil;
- grease,
- other consumables.

Most hired plant is provided with an operator. The estimator may have to allow for additional monies to bring the operators rate up to these covered by any site agreement. Where no operator is provided the full all-in operator rate must be added. Fuel costs are normally calculated on the basis of an estimated number of litres per hour for the plant. The estimator consults his own records or those from standard manuals such as Spence-Geddes [54]. Oil and grease may be allowed for as an allowance per hour of plant time or a percentage addition to the fuel cost. Other consumables are allowed for by a percentage addition.

Where plant is hired the basis of the rate is the hourly rate as negotiated with the company. To this the estimator adds allowances to cover those aspects not included in the hire contract. The information required by the estimator is obtained from his own records or standard manuals.

Where the plant item is owned by the contractor the rate used by the estimator must cover both the ownership and operating costs. The following example based on Harris and McCaffer [55] shows how this may be built up.

Calculation of the hourly rate for a crane given the following information:

Initial cost	£58 050
Resale value	£ 4 050
Average working hours per year	2000
Years of life of the machine	10
Insurance premiums per year	£ 220
Licences and tax per year	£ 150
Fuel at 20 litres per hour	£0.18 per litre
Oil and grease	10% of fuel cost
Repairs and maintenance	15% of initial cost per year
Required rate of return on capital	15%

Overheads are not included for simplicity.

Item	£ per annum
Depreciation - straight line $= \frac{£54\ 000}{10}$	5 400
Interest on finance, expressed in terms of an annual mortgage type payment $\frac{58050 \times 0.199 \times 10 - 58050}{10}$	5 747
Insurance and tax	370
Ownership cost	£11 517

Item		£ per annum
Fuel (litres)	- 20 x 0.18 x 2000	7 200
Oil and grease		720
Repairs	15% x 58 050	8 707
Operating cost		16 627
Total cost		28 144

Marginal hire charge $= \frac{28\ 144}{2\ 000} =$ £14.08 per hour

The above calculation allows for the generation of sufficient income to replace the asset, cover operating costs and provide a return on the initial capital invested. If the company plant division is run as more than a service department and is expected to contribute to head office overheads and profit then an additional allowance must be added.

The hourly rate as calculated is that which the company plant department would produce for the estimator. An average number of hours per annum is used in the calculations. The estimator should assess if the hours the plant is used in the contract will vary from the average and make an allowance for extra fuel, oil and grease. Similar additions should be made for particularly tough working conditions, sand/clay/rock etc.

Whether using hire or internal plant the estimator works from a basic rate supplied and makes allowances according to the expected circumstances of the project. As with the "all-in" labour rate, this rate is then used throughout the build-up of the direct cost estimate.

3.4 AN EXAMPLE OF UNIT RATE ESTIMATING

In unit rate estimating the calculation of a labour, plant or material rate is based upon a predetermined output or usage rate and the quantity of work stated against the bill item. An example is given below:

ITEM	DESCRIPTION OF WORK	UNIT	QTY	RATE	AMOUNT
A	Supply and Fix High Yield Rebar to B.S 4447 - 20mm dia.	TNNE	6.35		

The estimator decides to employ the following resources:

20mm Diameter High Yield Rebar - Cut, Bent and Delivered.

Steel fixer

22 R B Crane (for off-loading the steel)

The output or usage rates are taken from company or personal data and amended to reflect the specific contract conditions.

20mm Diameter High Yield Rebar	1.10	TNNE/TNNE
Steel fixer	18.50	HR/TNNE
22 R B Crane	0.20	HR/TNNE

A quotation is received for the supply of the steel and the all-in rate calculated for the steel fixer and 22 R B Crane.

These prices are as follows:

20mm Diameter High Yield Rebar	247.00	£/TNNE
Steel fixer	5.75	£/HR
22 R B Crane	15.46	£/HR

The rate for each resource is then calculated.

Resource rate = usage rate x cost.

The Total rate for each cost code (Labour, Plant, Materials) calculated. The rates added to give the total item rate and the bill item amount calculated by multiplying by the quantity,

ie.

Rate for 20mm Dia. High Yield Rebar = 1.10 x 247 = 271.70 £/TNNE

Rate for Steel fixer = 18.5 x 5.75 = 106.37 £/TNNE

Rate for 22 R B Crane = 0.2 x 15.46 = 3.09 £/TNNE

TOTAL ITEM RATE = 381.16

TOTAL ITEM COST = 2420.38

The calculation as explained above is carried out on the estimator's work sheets and then the rates transferred to the bill of quantities.

3.5 AN EXAMPLE OF OPERATIONAL ESTIMATING

Operational Estimating is the calculation of a rate for labour and plant groups based upon the total quantity of work involved and the total period that resources will be required on site. This is illustrated in the example below:

An estimator is pricing the plant required to place concrete on a particular contract. From the bill he knows that the total amount of concrete is 8000 m3. He decides that concrete may be poured at an average rate of around 210 m3/week giving a total number of weeks for concreting at 38. The maximum pour to the base slab is some 160 m^3. Concrete will be delivered by 'Ready Mix'.

He decides that the plant he will need for the placing of the concrete will be:

- 2 No. 22 R B cranes;
- 4 No. Concrete Skips,
- 6 No. Dumpers,
- 6 No. Vibrators.

The plant will be hired from the company plant yard at a weekly rate, held on site for the full 38 weeks, and used solely for the purpose of placing concrete. The total cost for the operation is therefore:

Item	No.		Weekly rate		No. weeks		Cost £
22 R B crane	2	x	220.0	x	38	=	16720.00
Concrete Skip	4	x	10.0	x	38	=	1520.00
Dumper	6	x	25.0	x	38	=	5700.00
Vibrators	6	x	10.0	x	38	=	2280.00
			TOTAL COST			=	£26220.00
			COST PER M3			=	£3.28

This rate can then be applied to each bill item involving the placing of concrete on a pro rata basis related to the quantity involved. For example, if the estimator now wished to price this bill item:

ITEM	DESCRIPTION OF WORK	UNIT	QTY	RATE	TOTAL
F722.1	Place concrete to bases	M3	56.0	3.28	183.68

The calculations for Operational Estimating involve estimates of the total quantity of work, resource prices and time. Resource prices are obtained from all-in rates based on a weekly period or calculated from an hourly rate assuming an average working week for the period on site.

The period on site is calculated from an assumed output rate and checked against the contract programme. The total quantity of work is obtained by abstraction from the Bill of Quantities in Stage 1 of the estimating and tendering process.

The rate calculated is applied to all the bill items that constitute the total quantity of work. The estimator may price a bill item by a combination of Unit Rate and Operational estimating. Consider the following bill item:

ITEM	DESCRIPTION OF WORK	UNIT	QTY	£ RATE	£ AMOUNT
B	Mix and place concrete class 27.5/20 to bases	M3	56.0	50.27	2815.12

The placing of the concrete to the bases may be calculated on an Operational estimating basis (say as in the previous example giving a rate of 3.28 £/M3). The provision of concrete would be calculated on a unit rate basis. Suppose the concrete is to be supplied by 'Ready Mix' at £42.75/M3. The estimator allows 10% wastage so the rate for material = 42.75 x 1.1 = 47.02 £/M3. This gives a total rate for the item of £50.27/M3 and a total item amount of £2815.12.

3.6 CALCULATION OF SITE OVERHEADS

The calculation of the sum of money required to cover site overheads is based upon detailed check lists containing references to all the items of materials, plant and services necessary to operate a construction project. Details of these check lists are contained in Appendix III.

A typical set of calculations with respect to site management and supervision requirements is shown in Table 1, page 85.

TABLE 1 - SITE OVERHEADS - SITE MANAGEMENT REQUIREMENTS

A - SUPERVISION (TECHNICAL)

	No	WEEKS from	WEEKS To	WEEKS No	Cost each per week	£
Project Manager	1	1	38	38	400	15 200
Agent	1	1	38	38	350	13 300
Sub Agent	2	1	38	38	350	26 600
Senior Engineer	1	1	38	38	350	13 300
Section Engineer	2	1	38	38	300	22 800
Setting out Engineer	2	1	38	38	250	19 000
Junior Engineer	2	5	38	33	250	16 500
Senior Measurement Engineer	1	1	38	38	350	13 300
Measurement Engineer	1	5	38	33	300	9 900
Junior Measurement Engineer	1	5	38	33	250	8 250
Quantity Surveyor						
Assistant Quantity Surveyor	2	5	38	33	300	19 800
Production Controller						
Senior Laboratory Engineer						
Laboratory Engineer						
Laboratory Technicians						
Works Manager						
General Foreman	1	1	38	33	400	13 200
Section Foreman	2	1	38	33	350	22 100
Foreman - Carpenter	1	5	38	33	350	11 550
Foreman - Scaffolder	1	5	38	33	350	11 550
Foreman - Steelfixer	1	5	38	33	350	11 550
Foreman - Bricklayer	1	5	38	33	350	11 550
			Carried to Summary A		£260450	

Reference is made by the estimator to the site plan contract programme and the direct cost estimate to ascertain:

- the nature of the site (dispersed or compact);
- the number of operatives to be controlled;
- the number of sub-contractors to be co-ordinated.

A formal organization structure should be prepared for the contract and a bar chart of staff requirements prepared to ensure continuity of supervision over the duration of the contract.[56] All technical staff, foreman and clerical staff necessary for the running of the site should be included.

3.7 AN EXAMPLE OF THE CASH FLOW ANALYSIS FOR A CONSTRUCTION PROJECT

The cost of financing a construction project must be included in the mark-up additions for head office overheads. This is calculated from the cash flow analysis for the project. The importance of the management of cash flow is emphasised by Smith.[57] Within the construction industry Spellmans [58] and Tapner [59] have shown how construction companies fail principally because of cash flow problems. An example of the cash flow analysis for a typical construction project is given below:

To calculate the cash flow the following data is needed:

- a graph of contract value against time;
- the project costs broken down into labour, plant, materials and sub-contractor categories;
- the measurement and certification interval;
- the payment delay between certification and the contractor receiving the cash;

- the retention conditions and repayment arrangements;
- the terms of paying the resource costs and the delay between incurring a cost liability and making payments.

VALUE v TIME

A graph of contract value against time is prepared from a study of the contract programme drawn up in a bar chart form. The total tender sum is sub-divided to cover each of the activities on the bar chart by consideration of the work involved and the monies in the relevant items in the bill of quantities. The value for each activity is then apportioned throughout the time period. From this the value in each month of the contract and the cumulative value per month may be calculated, (see Figures 13 and 14, pages 88 and 89).

	MONTH NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
EXCAVATE	2	2																		
CONCRETE FOUNDAtNS		1	4																	
G F SLAB			1	2																
COLS G TO F1					4															
FLOOR 1						2	4													
COLS 1 TO F2								4												
FLOOR 2									3	4										
COLS F2 → ROOF											4									
ROOF STRUCTURE												2	2							
CLADDING											7	2	1	1						
SERVICES													4	1	1					
FINISHES.															1	1				
VALUE IN £ (0000's) /MONTH	2	3	5	2	4	2	4	4	3	4	11	4	7	2	2	1				
CUMULATIVE VALUE (0000's)	2	5	10	12	16	18	22	26	29	33	44	48	55	57	59	60				

Figure 13 - BAR CHART PROGRAMME FOR ONE PROJECT WITH CONTRACT VALUES

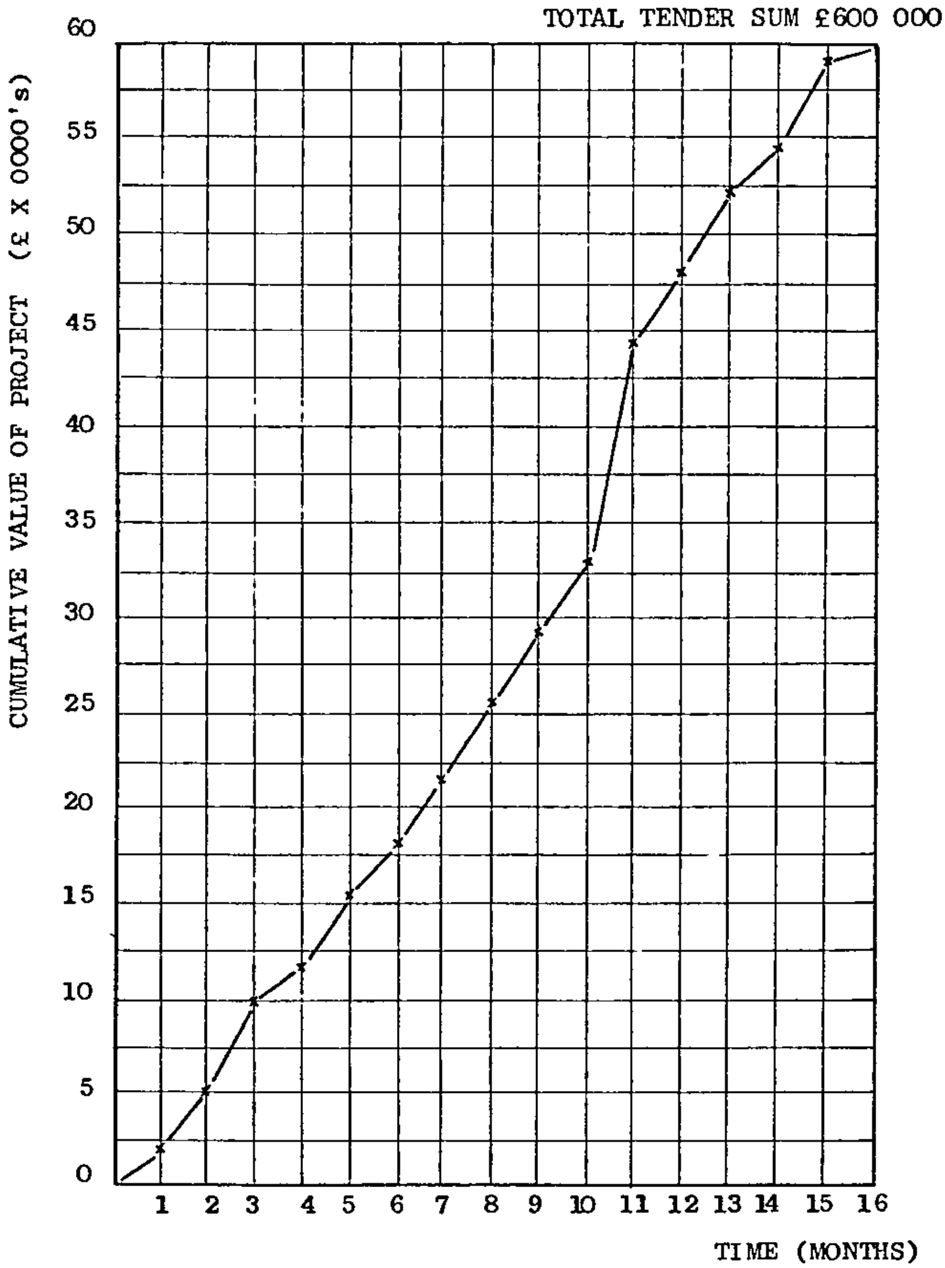


Figure 14 - CUMULATIVE VALUE v TIME CURVE FOR THE PROJECT

PROJECT COSTS AND COST v TIME

It is required to calculate a similar curve for cost against time. This is calculated from consideration of the percentage addition made to the contract costs to cover profits and overheads. Assume each bill item carries the same percentage addition. Then, the cumulative cost against time is a simple proportion of the cumulative value for each month. For example if the contribution margin is 15%

Value = cost + 15% = 1.15 x cost

Therefore Cost = value/1.15 = 0.87 x value.

From the direct cost summary for the contract it is possible to calculate the percentage of cost in each resource category, labour, plant, materials etc. For this project assume:

Labour	20%	104 400
Plant	40%	208 800
Materials	20%	104 400
Subcontractors	20%	104 400
	100%	522 000

THE MEASUREMENT AND CERTIFICATE INTERVAL AND THE PAYMENT DELAY BETWEEN CERTIFICATION AND THE CONTRACTOR RECEIVING CASH

Assume the following conditions with respect to the contractual conditions covering the measurement of the works and the consequent payment by certificate.

Retention 10% of value

No maximum retention figure set

Retention monies paid as follows:-

50% retention paid one month after completion.

50% retention paid six months after completion (at the end of the maintenance period).

First certificate submitted at the end of month - 1 certificate then submitted on a monthly basis. One month delay between submission and payment.

THE PAYMENT BY THE CONTRACTOR OF RESOURCE COSTS

Assume the following delays between the incorporation of resources in the project and the subsequent payment for them:

Labour	Nil
Plant	Two months
Materials	Two months
Subcontractors	Two months

THE CALCULATION OF CAPITAL LOCK-UP

Having assembled the above data it is possible to calculate the capital lock-up for the project. This is shown in Table 2 , page 92 In this table the time period of one month is used. (A more accurate calculation could be obtained by using a time interval of one week). The explanation of Table 2 is as follows:

Row 1 is the cumulative value for the project derived as previously discussed;

Row 2 is the cumulative value less retention;

Row 3 is the value less retention (Row 2) shifted by an amount equal to the payment delay between valuation and the contractor receiving his money;

Row 4 is the cumulative retention payments inserted at the time they would be received.

The cumulative costs for the total project are shown in Row 5. The proportion of costs due to labour is calculated and inserted in Row 6. This is repeated for materials in Row 8, for Plant in Row 10 and for subcontractors in Row 12.

Rows 7, 9, 11 and 13 shift the cost liabilities shown in Rows 6, 8, 10 and 12 by an amount equal to the average delay in incurring the cost liability and making the payment.

Row 14 is the cumulative cash out and is the sum of Rows 7, 9, 11 and 13.

Row 15 is the cumulative cash flow from Row 3 plus Row 4 less Row 14.

MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	22
CUMULATIVE VALUE 1	2·0	5·0	10·0	12·0	16·0	18 0,	22 0	26 0	29 0	33·0	44·0	48·0	55·0	57 0	59·0	60 0			
CUMULATIVE VALUE-RETENTION 2	1·8	4·5	9 0	10·8	14·4	16·2	19·8	23·4	26·1	29·7	39·6	43·2	49 5	51·3	53 1	54 0			
CUMULATIVE PAYMENT RECV'D FROM CERT. 3		1·8	4·5	9·0	10·8	14·4	16 2	19·8	23·4	26·1	29·7	39·6	43·2	49·5	51·3	53·1	54 0		54·0
CUMULATIVE RETENTION PAYMENT 4																	3·0		3 0
CUMULATIVE COSTS 5	1·74	4·35	8 7	10 44	13 92	15·66	19·14	22 62	25·23	28·71	38·28	41·76	47·85	49 59	51·33	52·2			
CUMULATIVE LABOUR COSTS 6	0 348	0 87	1 74	2·088	2·784	3 132	3·828	4·524	5·046	5 742	7·656	8 352	9 57	9 918	10 266	10 44			
CUMULATIVE LABOUR PAYMENT 7	0·348	0 87	1·74	2·088	2·784	3·132	3·828	4 524	5·046	5·742	7 656	8·352	9·57	9·918	10·266	10·44			
CUMULATIVE MATERIALS COSTS 8	0·348	0 87	1·74	2·088	2·784	3 132	3·828	4·524	5·046	5·742	7·656	8·352	9 57	9·918	10·266	10·44			
CUMULATIVE MATERIALS PAYMENTS 9		0 348	0·87	1·74	2 088	2·784	3·132	3·828	4·524	5·046	5·742	7·656	8 352	9·57	9 918	10 266	10 44		
CUMULATIVE PLANT COSTS 10	0 696	1·74	3·48	4·176	5 568	6 264	7 656	9·048	10 08	11 484	15·312	16 704	19·14	19·836	20·532	20 88			
CUMULATIVE PLANT PAYMENTS 11		0·696	1·74	3·48	4·176	5·568	6264	7·656	9·048	10·08	11 484	15·312	16704	19·14	19 836	20 532	20 88		
CUMULATIVE S/C COSTS 12	0·348	0 87	1·74	2·088	2·784	3·132	3 828	4·524	5·046	5·742	7·656	8 352	9·57	9 918	10 266	10 44			
CUMULATIVE S/C PAYMENTS 13		0 348	0·87	1·74	2·088	2·784	3·132	3·828	4·524	5·046	5·742	7·656	8 352	9 57	9·918	10 266	10 44		
CUMULATIVE CASH OUT 14	0 348	2 262	5·22	9·048	11·136	14 268	16·356	19·836	23·142	25·914	30 624	38 976	42·978	48 198	49·488	51·504	52 20		
CUMULATIVE CASH FLOW 15	− 0·348	− 0 462	− 0·72	− 0 048	− 0·336	+ 0·132	− 0·156	− 0·036	+ 0·258	+ 0·186	− 0·924	+ 0·624	+ 0·222	+ 1·302	+ 1·812	+ 1·596	+ 4·8		

TABLE 2 - CASH FLOW CALCULATIONS FOR THE PROJECT

The discrepency between costs and revenue received must be met by the contractor either from capital supplied from the company's cash reserve or borrowed. If the cash is borrowed, interest will be charged to the company, if cash from the cash reserve is used the project should be changed for the interest earning capability. The interest payable may be obtained by calculating the shaded area between the two curves in Figure 15, page 94

Area between the curves	=	
Assume interest rate	=	19% per annum
Interest payable	=	$\frac{4.2 \times 50000\ £\ \text{months}}{12\ \text{months}} \times 19\%$
	=	£3325

An allowance in the overheads to cover this amount may then be made. Further details of construction cash flow forecasting methods may be found in Kerr (60), McCaffer and Pike (61), McKay (62) and Cook and Japson (63).

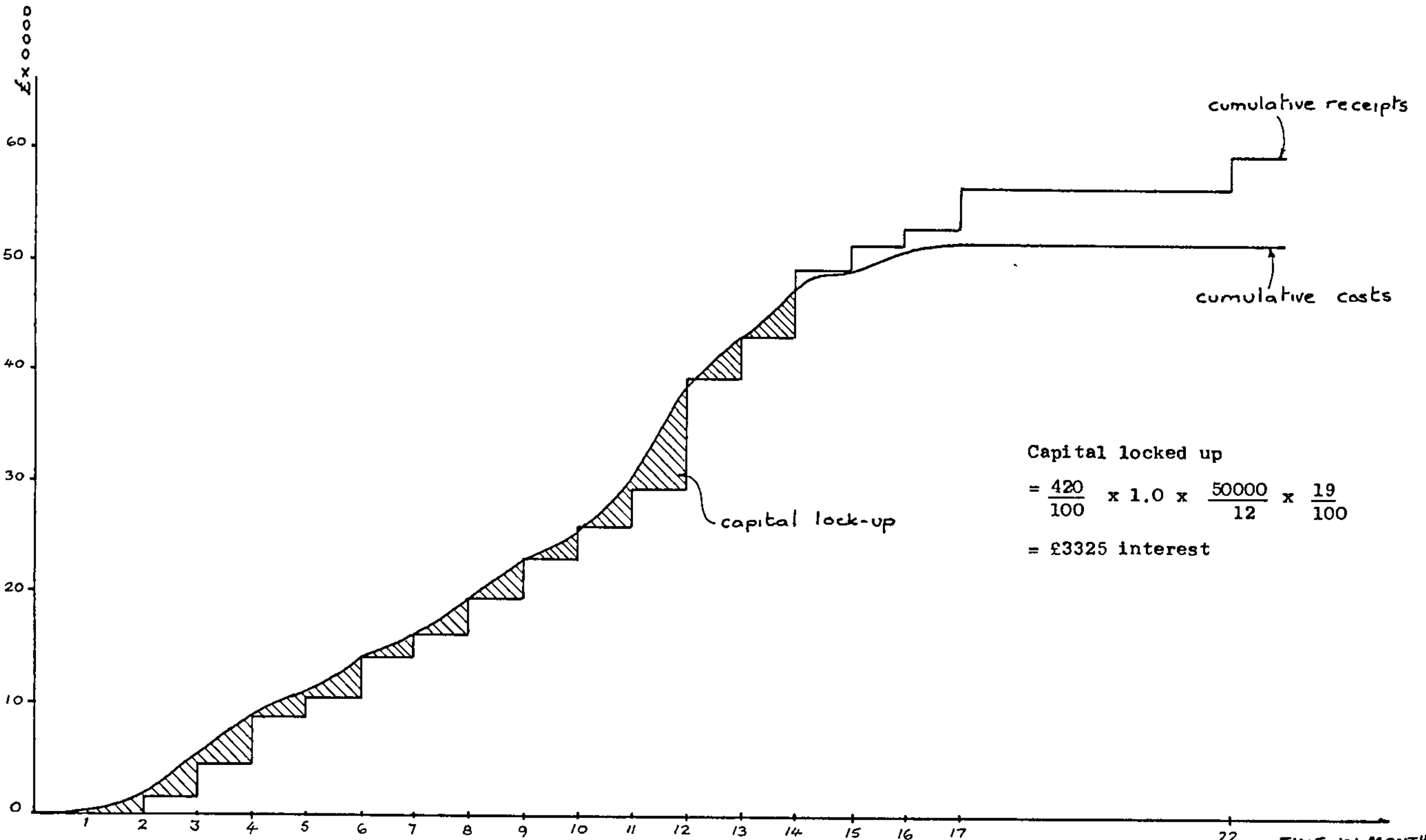


Figure 15 - THE CAPITAL LOCK-UP FOR THE CONTRACT (PAYMENT ON CERTIFICATE ONE MONTH INTERVALS

3.8 CERTIFICATES AND PAYMENT

The contractual position with respect to payment for work completed on construction projects is normally based on the General Conditions of Contract for use with works of Civil Engineering Construction [23].

The procedure may be described as follows:

i) The Contractor submits to the Engineer after the end of each month a statement showing the estimated contract value of the permanent work executed up to the end of the month;

ii) The Contractor is then paid on certificate, by the Engineer, the amount due to him on account of the value of permanent work executed up to the end of the month less the value of permanent work executed up to the end of the previous month;

iii) To this amount is added - an amount as the engineer may consider proper on account of materials for permanent work delivered; an amount to cover the provision of Construction Plant and Temporary Works; any payment made to the Contractor is subject to retention; one half of the retention monies becomes due to the Contractor upon completion of the works; the remainder is paid after expiration of the Period of Maintenance.

Included within the Bill of Quantities will be preliminary items and the Contractor will seek payment for these at various stages throughout the construction of the work.

Preliminary items are of four kinds [64]:

- cost related;
- time related;
- single payment;
- a combination of two or more of the above.

Preliminary items which are cost related are dependant on the expenditure programme for the project. Preliminary items which are time related depend for their value on the contract period. Single payment preliminary items are dependant on the execution of items of work at a particular point within the contract programme.

Payment for preliminary items can be made on the basis of the type of item (see above) or by considering the total value of the items as if they were all cost related or all time related [65].

Under special contractual conditions groups of items or an agreed sum are considered critical costs and paid to the Contractor at the beginning of the contract as a 'mobilisation' payment.

The Contractor must give careful consideration to the payment of monies for work completed as this may radically effect the company's cash flow and consequently the capital lock up and overhead requirements. This is best indicated by considering the cash flow example already used. The example assumed the payment of monies following a valuation at the end of every month. If a valuation was only carried out at the end of every two months the capital lock up is increased to £8122. See Table 3, page 97 and Figure 16, page 98

MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	22
CUMULATIVE VALUE		5 0		12·0		18 0		26·0		33 0		48·0		57·0		60·0			
CUMULATIVE VALUE-RETENTION		4·5		10 8		16·2		23 4		29·7		43·2		51·3		54·0			
CUMULATIVE PAYMENT RECV'D FROM CERT.			4 5	4·5	10·8	10·8	16·2	16·2	23·4	23·4	29·7	29 7	43·2	43·2	51·3	51·3	54·0		
CUMULATIVE RETENTION PAYMENT																	3·0		
CUMULATIVE CASH OUT	0·348	2 262	5 22	9·048	11 136	14·268	16 356	19·836	23·142	25 914	30 624	38 976	42·978	48 198	49 488	51·504	52·20		
CUMULATIVE CASH FLOW	−0·348	−2·262	−0·72	−4·548	−0·336	−3·468	−0·156	−3 636	+0·258	−2·514	−0 924	−9·276	−0 378	−4 998	+1·812	−0·204	+4·80		

TABLE 3 - REVISED CASH FLOW CALCULATIONS FOR THE PROJECT

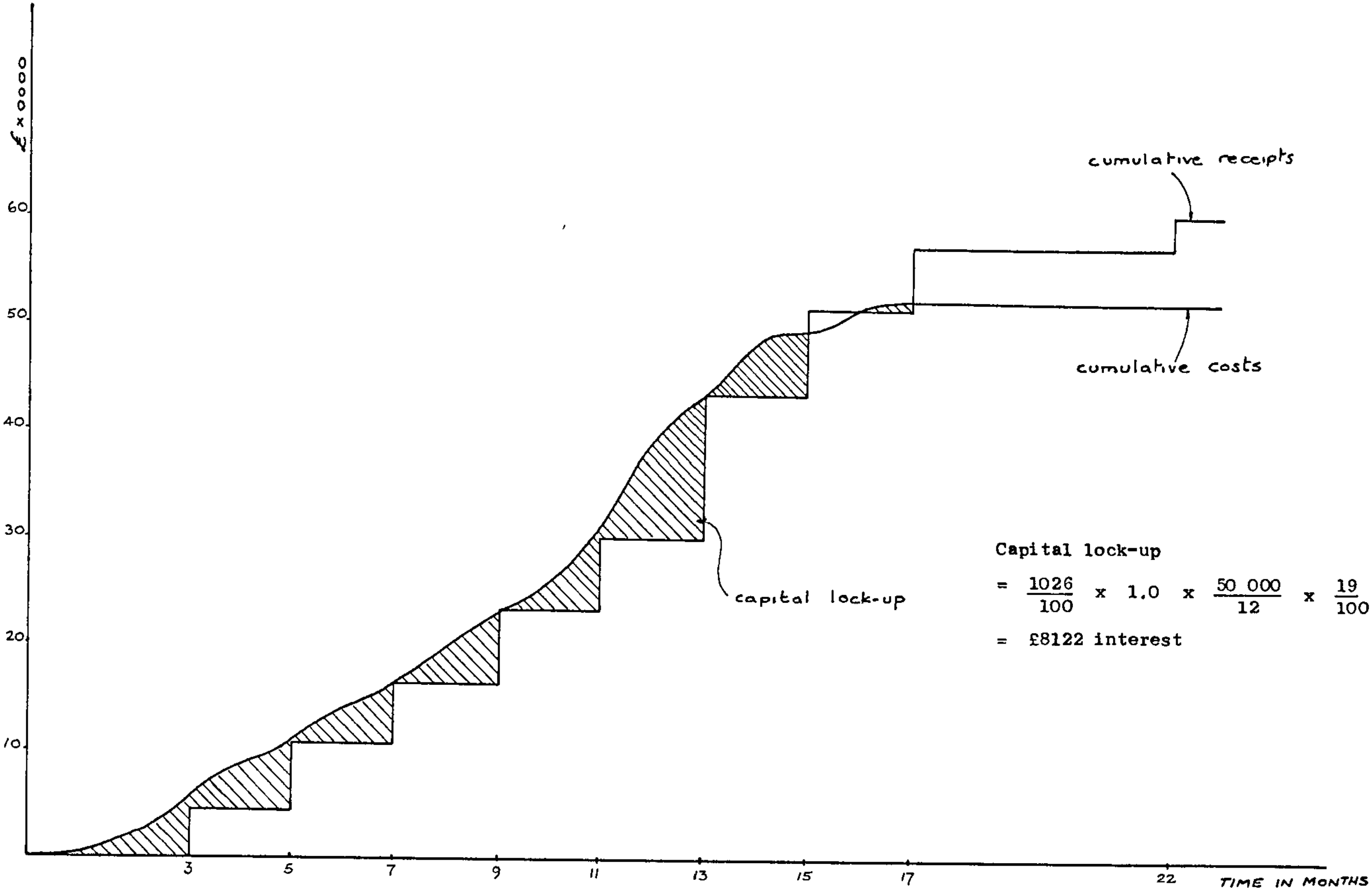


Figure 16 - THE CAPITAL LOCK UP FOR THE CONTRACT (PAYMENT ON CERTIFICATE TWO MONTH INTERVALS)

Payment for preliminary items may result in the underpayment of some items and the overpayment of others. Where a time related method is used and the contract runs behind program, overpayment will occur. Where the cost related method is used, there is a danger of inadvertantly exceeding the total of the preliminaries when the total value of the Contractor's work is increased by variations.

Under the CESMM [24], tenders have the option to define a group of bill items and insert charges against them to cover those expected costs which are not proportional to the quantities of permanent works.

To distinguish these items they are called Method Related Charges.

They are themselves divided into charges for recurrent or time related costs elements, (such as maintaining site facilities or operating major plant) and charges for elements which are neither recurrent nor directly related to quantities (such as setting up site, bringing plant to site and temporary works). The idea behind this is to effect a fair representation of the Contractor's costs so as to avoid claims and a climate of contention which result from variations in bill item quantities. If there is a variation reducing the work volume it is seldom necessary for the Contractor to claim for the cost of under-utilization of resources or under-recovery of indirect costs. Such costs are covered by the Method Related Charges and payment against them is not reduced. If there is a variation increasing the work volume or causing a delay producing an increase in the costs covered by Method Related Charges, adjustment of the charges can be made within the terms of the contract obviating the necessity for a claim.

The procedure for Method Related Charges has to allow for the situation which develops if the Contractor changes his mind about arrangements which were assumed when pricing his tender. In the event for example of a Contractor who has entered charges for a batching plant deciding to use ready-mixed concrete, interim payments against the Method Related Charges should be certified in proportion to the quantity of concrete placed. It would be unreasonable, in the contractual sense, to do otherwise. If there were variations affecting the volume of concrete placed it would similarly be unreasonable to do anything other than value the varied quantity at a rate carrying an appropriate proportion of the charges for the batching plant.

3.9 ADJUSTMENTS TO THE TENDER TO ALLOW FOR INFLATION AND 'RATE LOADING'

In 1971, the Steering Group on Price Adjustment Formulae published a report (66) recommending a formula based on the use of monthly indices as a means of adjusting contract values for changes in the cost of the labour, plant and materials required in the construction of civil engineering projects. The formula was based on monthly price indices reflecting changing costs in the following elements of construction work within civil engineering contracts.

i) Labour;

ii) Plant,

iii) Aggregate;

iv) Cement;

v) Bricks;

vi) Cast Iron;

vii) Coated Roadstone;

viii) Fuel,

ix) Imported Softwood,

x) Reinforcement;

xi) Structural Steelwork.

The Department of the Environment became responsible for collating and publishing monthly figures for indices in the above categories. The fifth edition of the I.C.E. Conditions of Contract [23] published in June 1973 adopted this method of indices as a replacement to the clause relating to the variation of price (labour and materials) within the Fourth Edition of the I.C.E. Conditions of Contract [67]. The use of the formula has been accepted by the civil engineering industry [68].

The application of the civil engineering price adjustment formulae to contracts changed the approach of Contractors who had previously concentrated on reducing their capital lock up by attempting to gain payment for all works at the earliest possible opportunity. If the rate of inflation was higher than the cost of capital then by improving their contract cash flow Contractors were depriving their companies of adequate compensation as calculated by the Baxter formula for increased costs [62].

The following factors identified by Kerr [60] and Pike [62] need to be considered if the Contractor is to fully appreciate the contract cash flow:

- gross profit margin;
- cash out delay;
- cash in delay;
- retention monies;
- contract durations;

- over or under measurement;
- the shape of the cost curve;
- the delay in payment for variations;
- borrowing costs;
- investment return,
- contract value breakdown as indicated in the contract documents.

Having considered the above factors the Contractor may minimise his capital lock up by increasing specific item rates within the bill of quantities while keeping the total tender sum the same by reducing others. This action is known as 'rate-loading'. Rate loading may be performed on individual bill items or complete classes of work. The cash flow for the project will be affected but not the competitiveness of the tender. An example calculation is shown below.

Consider the following Bill of Quantities:

ITEM	DESCRIPTION OF WORK	UNIT	QTY	RATE	AMOUNT
A	Class F3 'Formwork'	m^2	8	16.23	129.84
B	High Tensile Rebar 20 mm dia.	TNNE	28.39	273.27	7758.13
C	Excavate Unsuitable Material	m^3	40	6.77	270.80
D	Insitu Concrete Class E	m^2	20	80.86	1617.20
E	Two coats tar sprayed or brushed on waterproofing	m^2	303	1.75	530.25
	TOTAL TENDER SUM				10306.22

It is decided to increase the rate for the bill item D by 20 percent and adjust the other bill items accordingly to keep the total tender sum the same.

Bill item D is increased by 20%

ie. item rate (D) = 97.03

item amount (D) = 1940.64

Increase in total tender sum = 1940.64 - 1617.20

= 323.44

$$\text{Difference} = \frac{\text{CHANGE IN ITEM D}}{\text{total tender sum - original item amount (D)}}$$

$$= \frac{323.44}{8689.02}$$

$$= 0.0372$$

1 - Difference = 0.9627

This then becomes the multiplier for all bill items except item D, ie.

Item A	=	129.84	x	0.9627	=	124.99
Item B	=	7758.13	x	0.9627	=	7468.75
Item C	=	270.80	x	0.9627	=	260.70
Item E	=	530.25	x	0.9627	=	510.23

The item rates become:

Item A	15.62
Item B	263.08
Item C	6.52
Item E	1.68

and the re-adjusted bill becomes:

ITEM	DESCRIPTION OF WORK	UNIT	QTY	RATE	AMOUNT
A	Class F3 'Formwork'	m^2	8	15.62	124.96
B	High Tensile Rebar 20 mm dia.	TNNE	28.39̇	263.15	7470.78
C	Excavate Unsuitable Material	m^3	40	6.52	260.80
D	Insitu Concrete Class E	m^3	20	97.03	1940.04
E	Two coats tar sprayed or brushed on waterproofing	m^2	303	1.68	509.04
	TOTAL TENDER SUM				10306.14

In this example a minor adjustment has been made to item B to bring the bill total back to £10306.

4. AN ANALYSIS OF THE ESTIMATOR'S TASKS AND THE REQUIREMENTS OF A COMPUTER AIDED ESTIMATING SYSTEM

The development of a computer aided estimating system based solely on a specification resulting from a study of the estimating and tendering process and the calculations involved would be unsatisfactory. Estimating is a management process and not simply a series of calculations carried out in isolation to produce a final totalled sum on a sheet of paper.

No computer system can be designed without consideration for the people who are to use it. A computer aided estimating system must reflect the needs of the estimator. Simple systems based on providing calculating routines (see Chapter 5) are viable but limited because they seek only to provide the user with a sophisticated calculator. No system that aims to provide full assistance to the estimator in all aspects of the estimating process can be produced without an analysis of the tasks of the estimator.

This chapter describes the principles of task analysis, reviews eleven different methods of analysing tasks and describes in detail the technique produced by the writer to analyse the tasks of the civil engineering estimator. The technique adopted enabled the function of the estimator to be fully understood and a full list of the requirements for a computer aided estimating system to be identified.

4.1 TASK ANALYSIS

It is important to distinguish between a job, a task and an operation.

A job is considered to be a person orientated term which has title and contractual implication [69]. This provides a framework within which the tasks of a person are assigned.

A task may be defined as an element or operation of work by means of which a specific result is achieved [70]. Any task may be further split into a number of constituent operations. Each operation may be further subdivided. This is shown diagrammatically in Fig. 17 page 107.

It is normal to collect data from the observed behaviour of the task performer and analyse this data to produce a full task description. This may be undertaken in one of four main methods of field observation. In each one of these the observer interacts differently with the subjects under study. The roles are catergorized as:

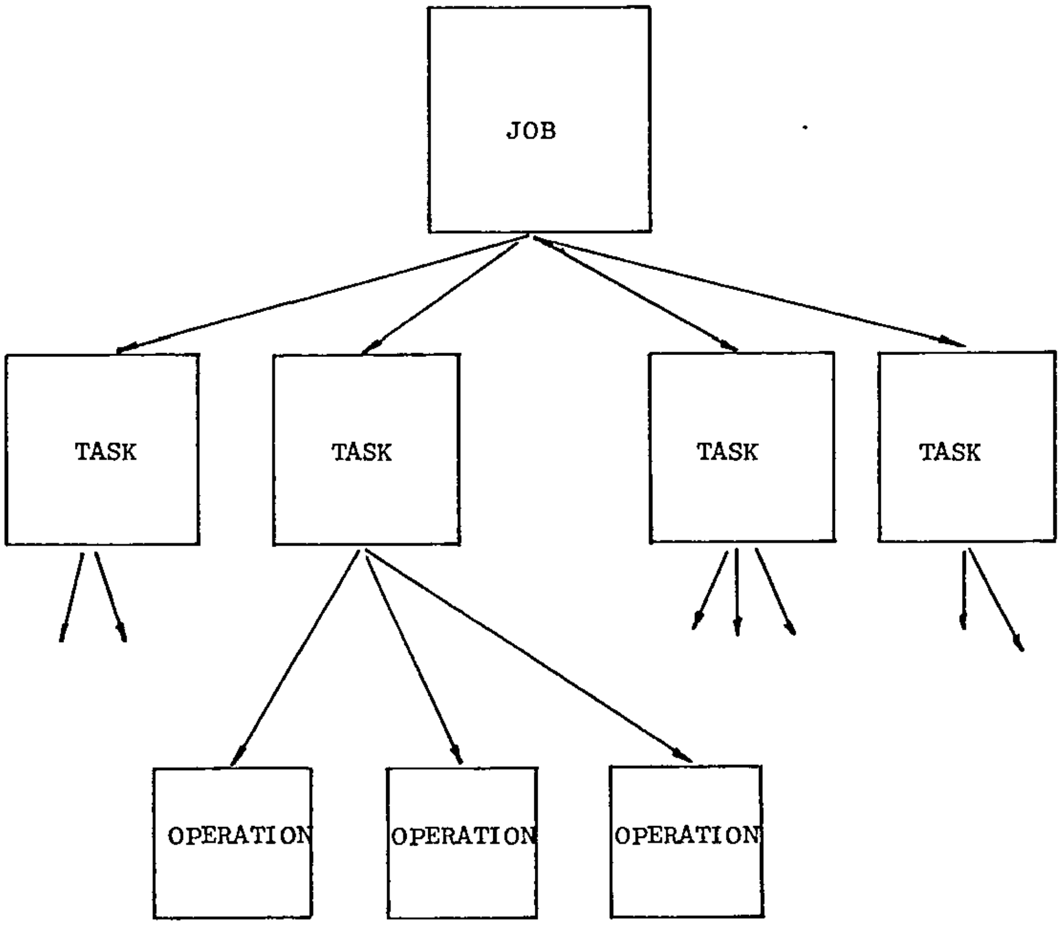
- Complete Observer;
- Complete Participant;
- Observer as Participant;
- Participant as Observer. (71)

The Complete Observer places himself on the periphery of a social setting to gather information. No attempt is made to interact with the subjects of the study.

The Complete Participant attempts to become an integrated member of the group under study while concealing any scientific intent.

The Observer as Participant is only concerned with formal and brief relationships with the subjects under study. Using events such as interviews and questionaires immediate responses are obtained. No enduring relationship is formed.

The Participant as Observer is included within the group he is studying making his presence known and attempting to establish relationships with the subjects of his study.



<u>EXAMPLE</u>:

JOB	:-	ESTIMATOR
TASK	:-	OBTAIN MATERIALS QUOTATION
OPERATIONS:-		ASSEMBLE DETAILS OF MATERIALS, SEND OUT ENQUIRIES TO POSSIBLE SUPPLIERS, REVIEW QUOTATIONS etc.

Figure 17 - THE SUBDIVISION OF THE ESTIMATORS JOB INTO TASKS AND OPERATIONS

Of these four research roles Becker (72) described participant observation as the most suitable for exploring a new field for the purpose of identification, definition and description of problems, concepts and indices. Observation alone is inappropriate for obtaining the attitudes and opinions of people. The interview is the most appropriate method for this purpose (73).

Consequently, for the purposes of specifying the role of man and machine in a computer aided estimating system the author decided to analyse information attained from interviews with estimators and then make a structured analysis of the data to classify the operations performed.

4.2 TECHNIQUES OF TASK ANALYSIS

Task analysis techniques have been developed for a number of purposes. The most common are:

- work station design;
- specifying man - machine systems;
- job design;
- job training;
- environmental evaluation;
- product design.

There is no established single metholodgy or theoretical framework for assessing, describing or evaluating tasks (74). Task analysis was used in this research to produce a man - machine system specification, ie. to establish the role that technology and the computer in particular could play in assisting the estimator. This was not simply a question of specifying the parts of the estimator's tasks that a machine may perform and detailing the remainder to be performed by the estimator.

The problem was to determine how the various operations within the tasks may be best allocated to produce an optimum system for estimating for civil engineering works. Annet and Duncan [75] emphasized that for a single task many different levels of description exist, varying from relatively gross statements of procedure to a micro-analysis at the physiological level of muscle action. The major problem when confronted with the performance of an experienced man in a working situation is what to describe and at which level of detail. In this research it was considered unnecessary to analyse in minute detail every aspect of the estimator's task but rather to establish the principal operations within the task and their inter-relationships.

Eason and Harker [74] surveyed members of the Ergonomics Society to establish the types of task analysis techniques used by practising ergonomists. The following techniques were found:

- Simulation;
- Literature Search;
- Hierarchical Task Analysis;
- Critical Incident Technique;
- Activity Analysis;
- Ranking.

Other techniques found by the author include:

- Diaries;
- Functional Job Analysis;
- Skills Analysis;
- Open Systems Approach;
- Signal Flow Graph Analysis.

These different types of task analysis are reviewed in Appendix IV. The method used in the research is described in the next section.

4.3 THE ANALYSIS OF THE ESTIMATOR'S TASKS

No method of task analysis reviewed was directly applicable to this research. Consequently a hybrid method was used by the writer. Following the collection of data by informal interview:

- a formal analysis was made of the operations carried out by the estimator;
- an assessment was made of the constraints to the estimator's performance;
- an assessment was made of the communication pattern surrounding the estimator.

This enabled a study of the estimator's tasks to be broadly examined to ensure all aspects of the job were considered. Then by dividing the operations within each task into specific categories directly related to the use of the computer, the full impact of the computer upon the tasks could be assessed.

4.3.1 AN ANALYSIS OF THE OPERATIONS PERFORMED BY THE ESTIMATOR

The hierarchical task analysis method outlined by Annet & Duncan [75] and detailed in [69] and [76] was used to break the tasks of the estimator into a series of operations. Each operation was then assessed to determine how the computer may assist the estimator in his work. Consideration was given to the three functions of the computer; filing system, calculator, and report generator to identify the role the computer should play.

It should be noted that the emphasis was purposely centred on the standard, most frequent aspects of the estimators tasks rather than the rarer phenomenon or versions of the tasks. This was because the purpose of the analysis was to specify a computer aided estimating system and not a computerized estimating system. No attempt was made to restructure the estimator's tasks, only to assist his performance with computing facilities where they were considered applicable.

From the study of the estimating and tendering process the principle tasks of the estimator were identified as:

- the review of the contract documents;
- an assessment of the proposed site for the works;
- the calculation of the site overhead costs;
- the calculation of the direct cost of the bill items;
- the addition of mark-up allowances to produce the final tender rates.

Each of these tasks was broken down into a series of operations. This is shown diagrammatically in Figs. 18 to 28 inclusive on pages 112 to 122 inclusive.

Consideration of the method of analysis shows that it is possible to split any operation into a series of sub-operations until a minute level of activity is obtained. The criteria decided upon to determine the level of operation reached were:

- the computer could supply no assistance;
- the data concerned could be calculated easily by the estimator and input directly;
- no great saving was evident if the system was developed to assist this operation.

1

REVIEW
CONTRACT
DOCUMENTS

2

ASSESSMENT
OF THE
PROPOSED
SITE

3

CALCULATION
OF SITE
OVERHEAD
COSTS

4

CALCULATION
OF THE DIRECT
COST OF THE
BILL ITEMS

5

ADDITION OF
MARK-UP
ALLOWANCES

Figure 18 - THE PRINCIPLE TASKS OF THE ESTIMATOR

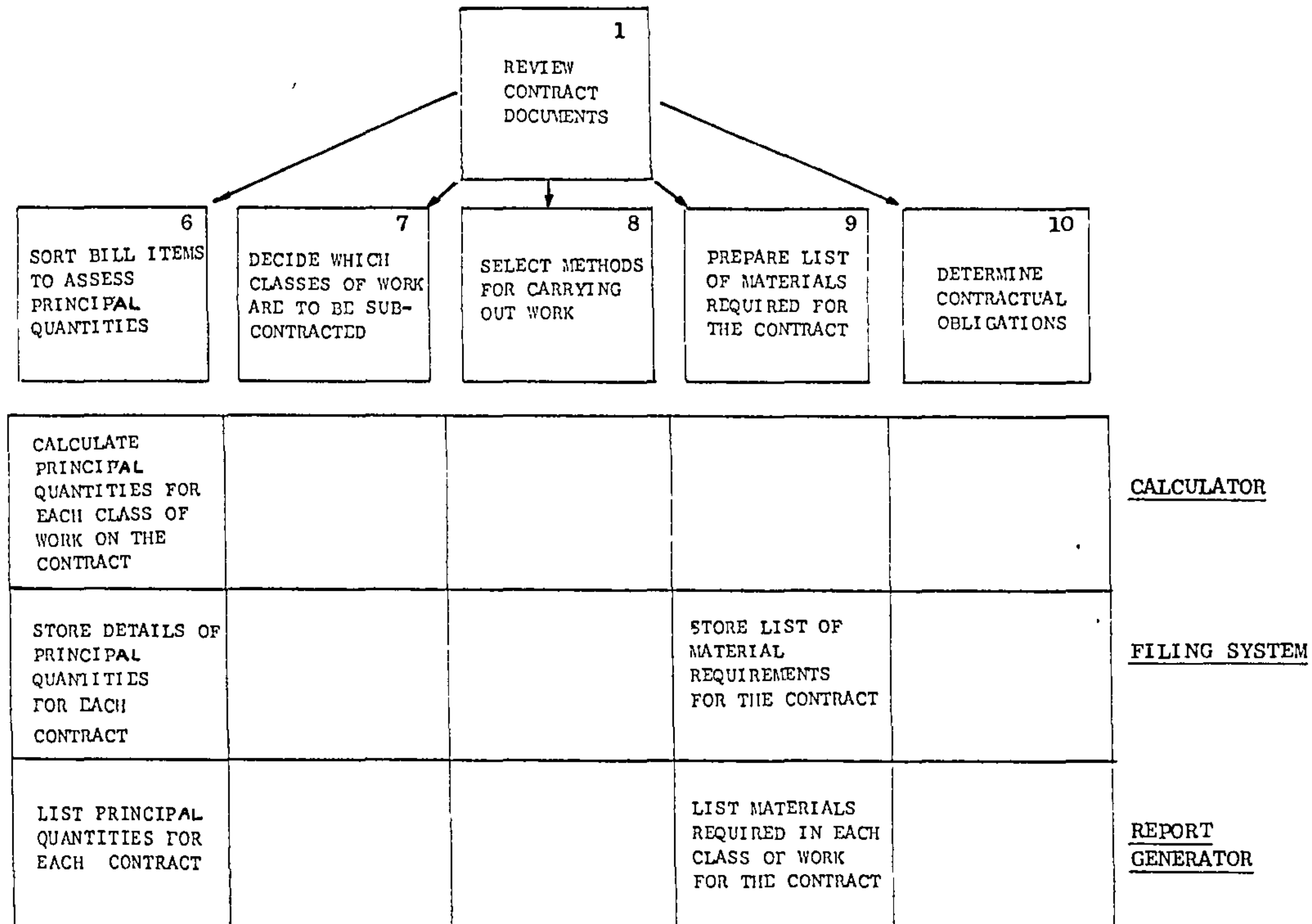


Figure 19 - THE REVIEW OF CONTRACT DOCUMENTS

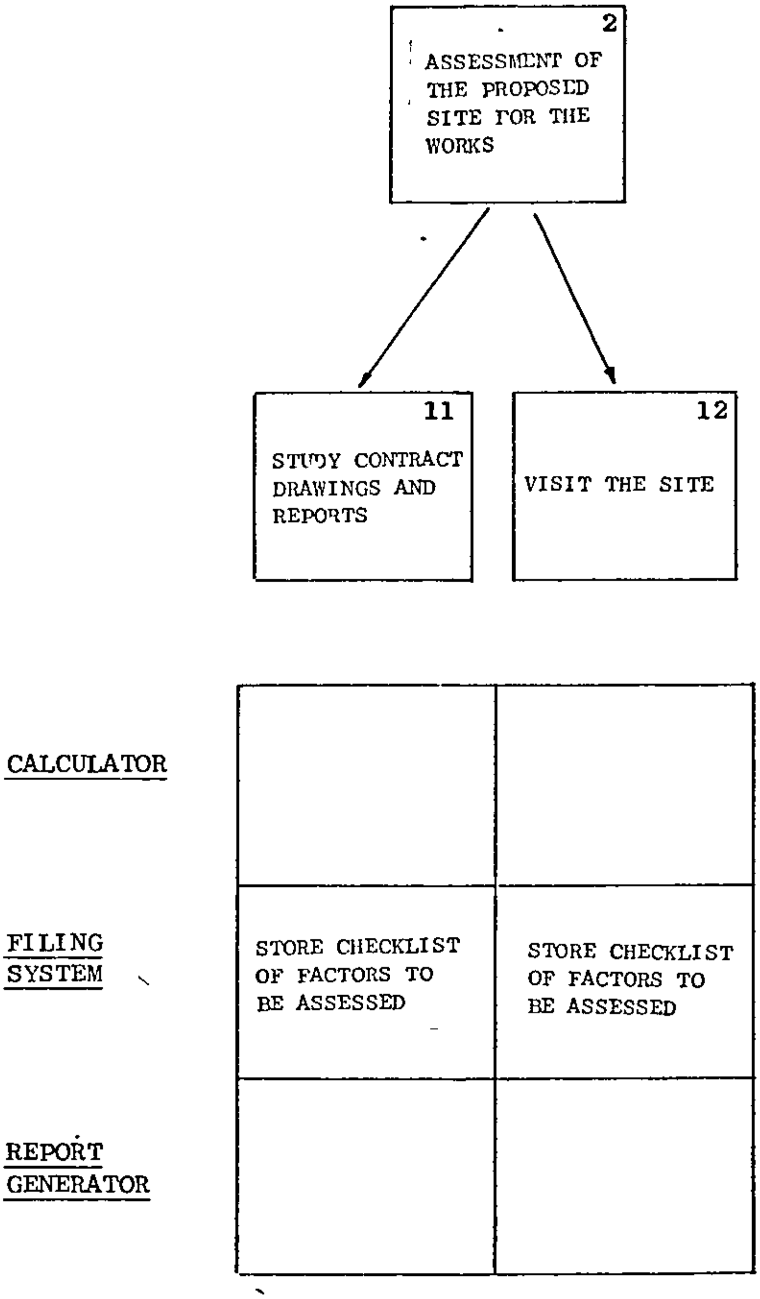
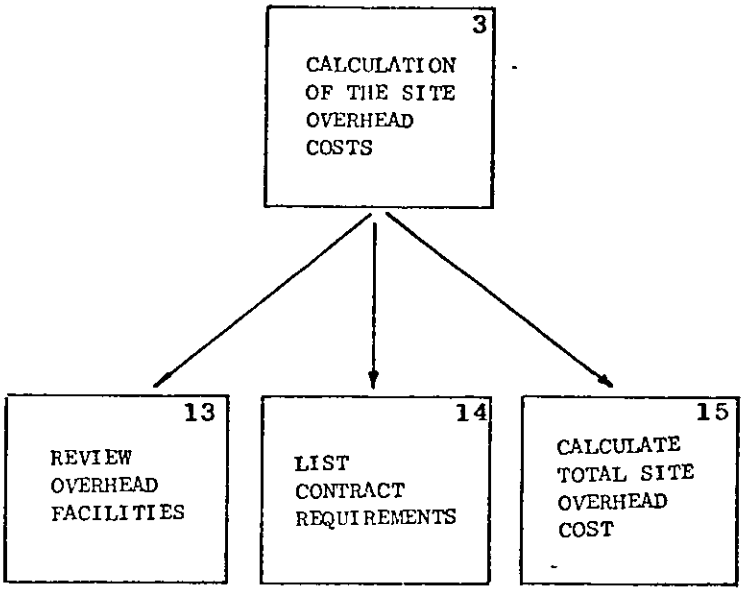
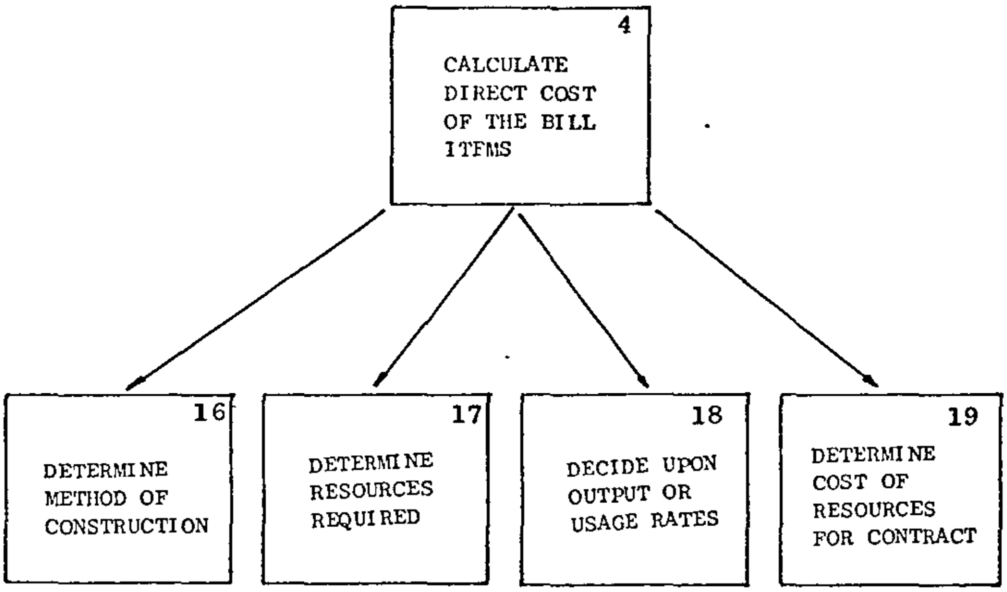


Figure 20 - THE ASSESSMENT OF THE PROPOSED SITE FOR THE WORKS



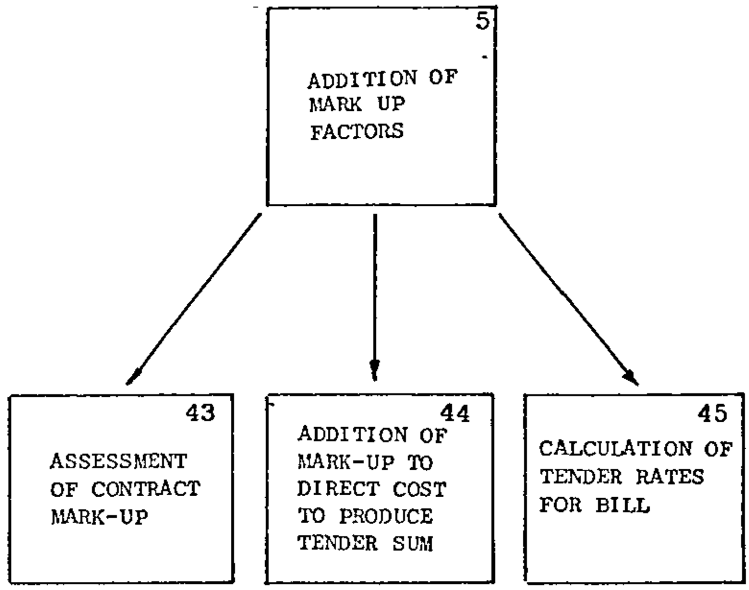
CALCULATOR			CALCULATE TOTAL OVERHEAD COST
FILING SYSTEM	STORE DETAILS OF OVERHEAD FACILITIES	STORE CONTRACT REQUIREMENTS	STORE TOTAL OVERHEAD COST FOR THE CONTRACT
REPORT GENERATOR	LIST DETAILS OF OVERHEAD FACILITIES	LIST DETAILS OF CONTRACT REQUIREMENTS	LIST TOTAL OVERHEAD COST BREAKDOWN

Figure 21 - THE CALCULATION OF THE SITE OVERHEAD COSTS



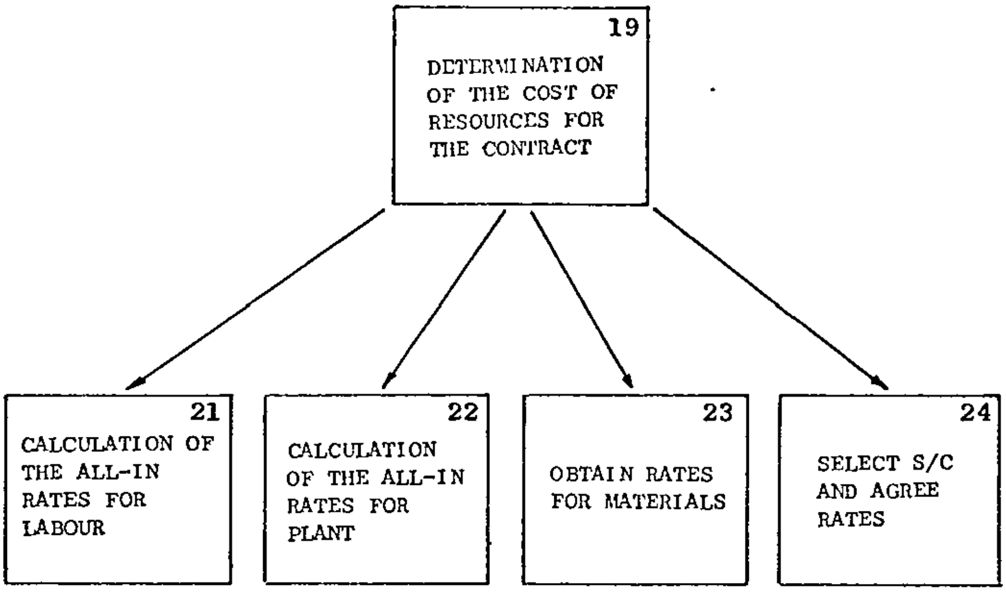
CALCULATOR				CALCULATION OF THE TOTAL COST OF THE RESOURCES TO BE USED
FILING SYSTEM	STORE DETAILS OF DIFFERENT METHODS OF CONSTRUCTION	STORE DETAILS OF RESOURCES FOR CONSTRUCTION WORK	STORE OUTPUT/ USAGE RATES FOR RESOURCES	STORE COSTS OF RESOURCES FOR EACH CONTRACT
REPORT GENERATOR	LIST DIFFERENT METHOD OF CONSTRUCTION	LIST DETAILS OF RESOURCES	LIST OUTPUTS/ USAGE RATES FOR RESOURCES	LIST COSTS OF RESOURCES FOR EACH CONTRACT

Figure 22 - THE CALCULATION OF THE DIRECT COST OF BILL ITEMS



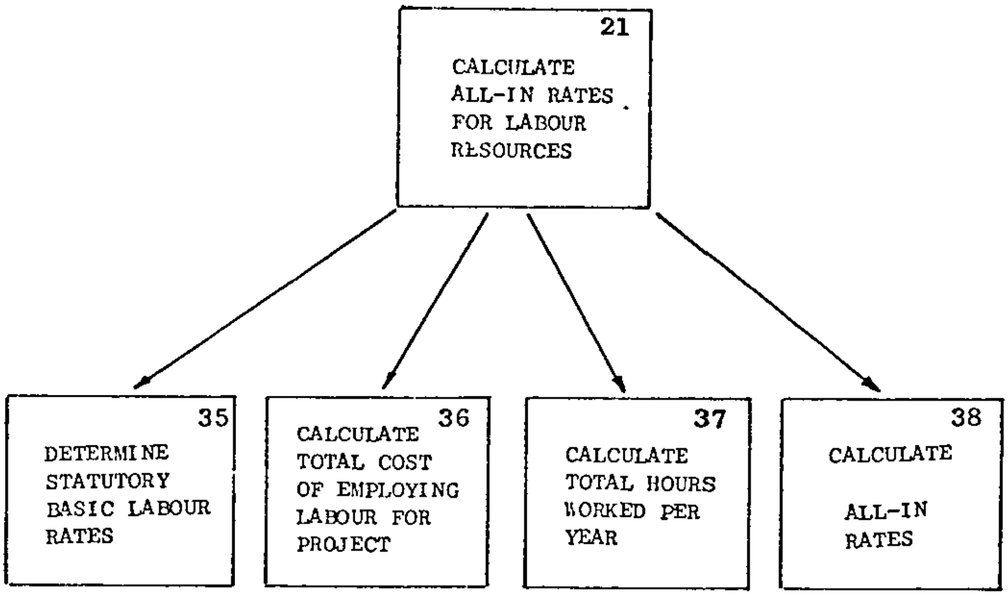
CALCULATOR		CALCULATION OF TOTAL TENDER SUM	ADJUST ITEM RATES TO REFLECT MARK-UP
FILING SYSTEM		STORE LIST OF MARK-UP FACTORS	STORE CONTRACT TENDER RATES
REPORT GENERATOR		LIST MARK-UP FACTORS	PRINT BILL LISTING WITH TENDER RATES

Figure 23 - THE ADDITION OF MARK-UP FACTORS



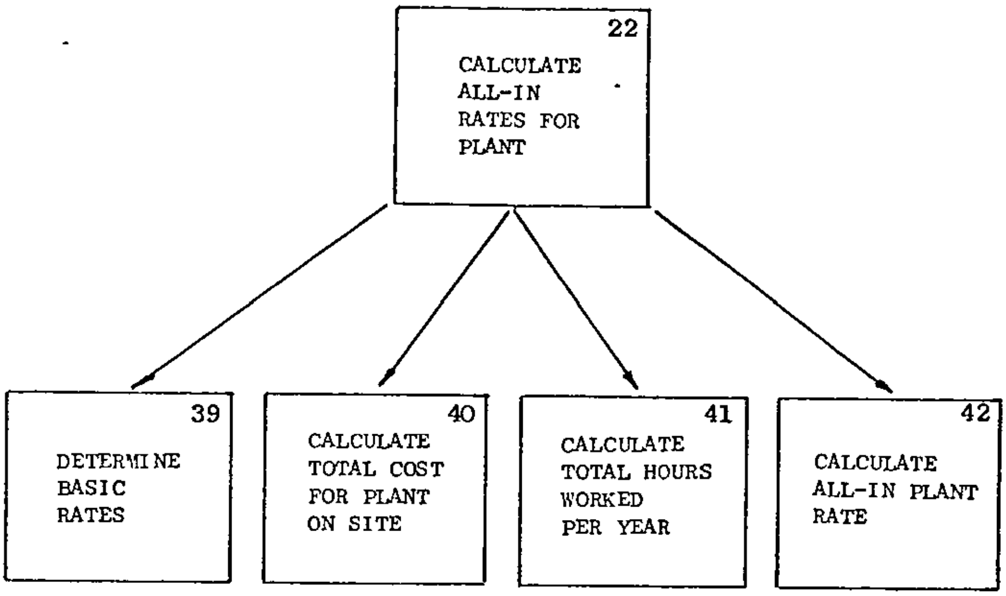
CALCULATOR	CALCULATE TOTAL RATE OF EMPLOYING LABOUR ON THE CONTRACT	CALCULATE TOTAL RATE OF EMPLOY-ING PLANT ITEMS ON THE CONTRACT		
FILING SYSTEM	STORE DETAILS OF LABOUR COSTS AND AVAILABILITY	STORE DETAILS OF PLANT COSTS AND AVAILABILITY	STORE STANDARD ENQUIRY INFORMATION AND SPECIFICATIONS LISTS OF MATERIALS SUPPLIERS	STORE DETAILS OF SUITABLE SUB-CONTRACTORS AND LISTS OF SUB-CONTRACTORS FOR EACH CONTRACT
REPORT GENERATOR	LIST DETAILS OF LABOUR COSTS	LIST DETAILS OF PLANT COSTS AND AVAILABILITY	LIST INFORMATION AND SUPPLIERS	LIST SUB-CONTRACTORS AND RATES

Figure 24 - THE DETERMINATION OF THE COST OF RESOURCES FOR THE CONTRACT



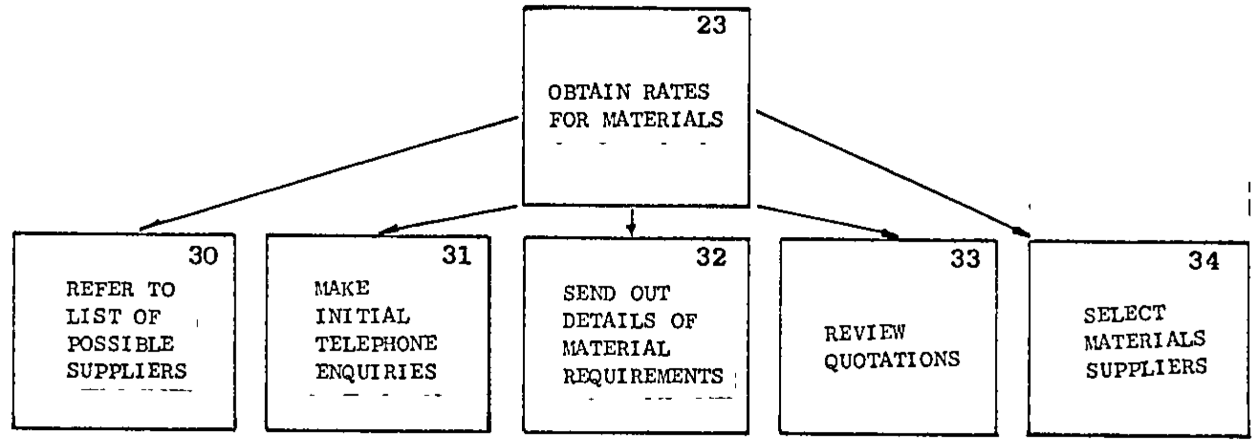
<u>CALCULATOR</u>		CALCULATE TOTAL COST OF EMPLOYING MAN ON PROJECT	CALCULATE TOTAL HOURS WORKED IN A YEAR ON THE PROJECT	CALCULATE RATE
<u>FILING SYSTEM</u>	STORE BASIC LABOUR RATES	STORE DETAILS OF COST OF LABOUR FOR THE CONTRACT	STORE DETAILS OF CONTRACT HOURS	STORE ALL-IN RATE FOR USE IN CONTRACT ESTIMATE
<u>REPORT GENERATOR</u>		LIST DETAILS OF COST OF LABOUR FOR THE CONTRACT	LIST DETAILS OF HOURS TO BE WORKED ON CONTRACT	DISPLAY BUILD-UP OF RATE

Figure 25 - THE CALCULATION OF ALL-IN RATES FOR LABOUR RESOURCES



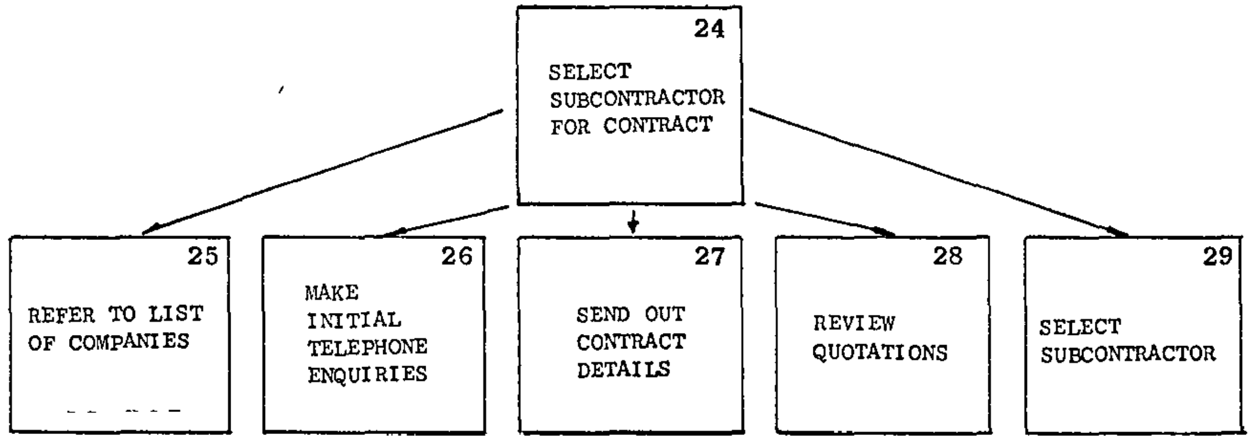
CALCULATOR		CALCULATE TOTAL COST OF THE PLANT ITEM ON SITE	CALCULATE TOTAL HOURS PLANT USED ON PROJECT IN THE YEAR	CALCULATE ALL-IN PLANT RATE
FILING SYSTEM	STORE BASIC COMPANY AND HIRE PLANT RATES	STORE DETAILS OF COST OF PLANT FOR THE CONTRACT	STORE DETAILS OF CONTRACT HOURS	STORE ALL-IN RATES FOR USE IN CONTRACT ESTIMATE
REPORT GENERATOR		LIST DETAILS OF PLANT COSTS FOR THE CONTRACT	LIST DETAILS OF PLANT HOURS TO BE WORKED ON THE CONTRACT	DISPLAY BUILD-UP OF RATE

Figure 26 - THE CALCULATION OF ALL-IN RATES FOR PLANT



					CALCULATOR
STORE LISTS OF SUITABLE SUPPLIERS		STORE STANDARD CONTRACTS AND SPECIFICATIONS	STORE DETAILS OF SUPPLIERS AND PRICES		FILING SYSTEM
LIST COMPANIES TO APPROACH FOR QUOTATIONS		GENERATE CONTRACT AND SPECIFICATION TO SUIT PROJECT	LIST MATERIALS SUPPLIERS AND PRICES		REPORT GENERATOR

Figure 27 - OBTAINING RATES FOR MATERIALS



					CALCULATOR
STORE LIST OF SUITABLE SUBCONTRACTORS		STORE STANDARD CONTRACTS AND SPECIFICATIONS	STORE DETAILS OF SUBCONTRACTORS AND PRICES		FILING SYSTEM
SELECT COMPANIES TO APPROACH FOR QUOTATIONS		GENERATE CONTRACT AND SPECIFICATION WITH AMENDMENTS TO SUIT PROJECT	LIST SUB-CONTRACTORS AND PRICES		REPORT GENERATOR

Figure 28 - THE SELECTION OF SUBCONTRACTORS FOR THE CONTRACT

Each of the operations shown in Figs 18 to 28 was analysed to assess the role a computer might play in assisting the estimator with the task. The results are summarised below.

i) THE REVIEW OF THE CONTRACT DOCUMENTS

When the estimator reviews the contract documents he is concerned with:

- determining contractual obligations;
- deciding which classes of work are to be subcontracted;
- selecting methods for carrying out the work;
- preparing a list of materials requirements for the contract;
- sorting the Bill of Quantities items into groups to establish the principle quantities for the contract.

No computer assistance is possible for the first three operations listed above. The computer could however be used to store a list of materials required for the contract and programmed to supply reports of the materials concerned. The sorting of the Bill of Quantities items into groups and the calculation of the principle quantities involves the input of all the bill items and their quantities at the start of the estimate. Each bill item would have to be coded and a set of priority rules included for the sorting and collation of the items. Data on the items could easily be stored and the items listed in a number of different reports. Although technically possible this form of system tends towards "computerized estimating". It was decided not to follow this approach, but to allow the estimator to input data on each bill item as he proceeded with their pricing.

The system would then reflect the estimator's current approach and work pattern.

ii) AN ASSESSMENT OF THE PROPOSED SITE FOR THE WORKS

The assessment of the proposed site for the works involves:

- a full study of the contract drawings and specialist reports;
- visiting the site.

Neither of these two operations can be usefully supported by the computer. The only facility within the computer that could be utilised is the storing of detailed check lists of factors that need to be assessed when looking at the site. This information can just as easily be supported by a check list prepared manually as with information provided by a computer.

iii) THE CALCULATION OF THE SITE OVERHEAD COSTS

The calculation of the site overheads for a project involves a decision as to the facilities and services required for the project and an assessment of the costs involved. (See Chapter 3). Most construction companies calculate site overheads by reference to a detailed check list of requirements in which the estimator enters the number of units of each resource required and the relevant cost. This is then totalled and the sum incorporated into the total tender sum.

While it would be possible to store on the computer files details of site overheads in the form of a check list that my be assessed by the estimator as a basis for calculating the overheads total, no significant saving could be seen over a manual method and it was decided not to provide computer facilities to support this task.

The calculation of the total site overhead cost is a simple summation exercise that may be quickly performed manually, and similarly no great advantage was seen using the computer for this purpose.

iv) CALCULATION OF THE DIRECT COST OF THE BILL ITEMS

With respect to the calculation of the direct cost of the items within the Bill of Quantities a study of the Figures on pages 118 to 122 indicates that in this task the use of the computer can have a considerable impact. To fully assist the estimator in this task a computer aided estimating system should:

- store details of the different methods of construction, the resources required and typical output rates for the resources;
- store details of the resources and their costs for the contract under consideration;
- perform the calculations adopted by the estimator to arrive at the total rate for completing the work within the bill item;
- perform the summation of bill item costs at the levels of summation required to produce a direct cost total for the project.

In producing a prototype computer aided estimating system it was this task of the estimator that the author decided demanded the closest attention. Any computer system is only successfully integrated into the company organization if acceptable to the personnel who are required to operate the system as the basis of their normal work.

The requirement of the estimator to calculate the total rates for work within the bill items represents the principle task involved within the job. The operations within this task may be supported by all the facilities available from a computer system. Hence, it was decided that the prototype estimating system should concentrate on reflecting these operations.

v) THE ADDITION OF MARK UP ALLOWANCES TO PRODUCE THE FINAL TENDER RATES

Although not responsible for decisions concerning the mark-up required for the contract, the estimator is required to adjust the rates in the bill to reflect the decisions made at the tender adjudication meeting. This process is more quickly performed by the computer and represents a real time saving over manual methods. In addition it is possible to make adjustments throughout all the bill items and not just global additions. It was apparent from the task analysis that facilities should be included to perform the operations within this task.

4.3.2 THE CONSTRAINTS TO THE ESTIMATOR'S PERFORMANCE

The analysis of the estimators task required an assessment of the constraints to the estimator's performance in order that any system produced should allow for the constraints imposed and wherever possible help to alleviate them. The main constraints on the estimator were identified as:

- Time;
- The limitations of the contract documents;
- Risk of errors.

TIME

Every tender must be submitted by a certain time on a certain date. No tender will be considered after this time. In order that the adjudication panel may make the necessary additions and adjustments before tender submission the estimator is set a definite date by which each estimate must be complete. The time factor involved limits the detail of the estimate that may be prepared. Although the estimator may have access to substantial information relating to the project the time scale may preclude the level of detail to which his estimate may be made. The actual time allowed by the promotor or his representatives varies with the value of the contract, type of contract, and market conditions. Even for the largest and most complicated of projects the time given to the estimator is only a matter of weeks and days.

THE LIMITATIONS OF THE CONTRACT DOCUMENTS

The contract documents produce limitations as to the conditions of contract, the standard of work that must be produced, the resources used and the level of detail of the information that is available. In some cases the construction procedure may even be predetermined by the client although the option may exist to submit alternative proposals. The tender system is designed to ensure that all estimates are prepared on an equitable basis.(77) All contractors are supplied with the same information. The level of information supplied should be sufficient to enable an accurate estimate of the work involved to be obtained. The documents are not prepared as a final complete statement of the work involved but rather as an assessment to form a basis for selection of a contractor and the future payments and negotiations.

Changes in the details of the contract documents are common even within the tender period as the client's representatives amend the actual content of the work.

RISK OF ERRORS

Inherent in the estimator's work is the risk of errors which may result in an incorrect analysis of the contract and a direct cost total which does not reflect the true requirements of the contract. This may have resulted in the contractor not being awarded the contract because the tender sum was too high or obtaining the work at uneconomical rates. This fear is always prominent in the estimator's mind and has been cited as one of the reasons estimators are wary of using computers (1).

Slattery (78) states the common errors made by estimators. These are listed in Table 4 page 129. The adoption of increased technology should aim at reducing the errors within the estimating process. Table 4 was analysed with respect to whether a computer aided estimating system would reduce these errors. The results are shown in Table 5 page 130.

The use of computers within the estimating process introduces additional risks of errors being included within the estimate. These are:

- omissions of bill items;
- incorrect prices being included;
- corruption of data;
- errors in calculations not readily apparent;
- monies being allocated to incorrect bill items;
- incorrect resources being included in bill items.

Table 4 - COMMON ERRORS MADE BY ESTIMATORS. Slattery (78)

Errors in calculation from dimensional data.
Transposition of figures.
Misplacing the decimal point.
Errors in copying from one paper to another.
Errors in scheduling the length of the job.
Errors in wage rates (omitting fringe benefits etc).
Making insufficient allowances for waste.
Errors in estimating material prices on an unstable market.
Errors in figuring transportation rates.
Omission of plant and equipment charges.
No allowances for contingencies.
Errors in bill extensions.
Page omissions in the total.
Omission of the main office overhead.
Missing materials entirely at the take-off stage.
Overlooking addenda issued.
Using incorrect units of measurements.
Revising item totals but not extensions.
Omitting the profit margin.

Table 5 - ERROR REDUCTION IN COMPUTER AIDED ESTIMATING

COMMON ESTIMATING ERRORS	Will computers correct this? YES	NO	POSSIBLY
Errors in calculation from dimensional data.		✗	
Transposition of figures.			✓
Misplacing the decimal point.	✓		
Errors in copying from one paper to another.	✓		
Errors in scheduling the length of the job.			✓
Errors in wage rates(omitting fringe benefits etc).	✓		
Making insufficient allowances for waste.	✓		
Errors in estimating material prices on an unstable market.			✓
Errors in figuring transportation rates.		✗	
Omission of plant and equipment charges.			✓
No allowance for contingencies - bad weather, labour troubles, winter conditions etc.		✗	
Errors in making extensions for quantity/price.	✓		
Totalling each page, then losing a page in the summary.	✓		
Omission of the main office overhead.			✓
Missing materials entirely on take-off.			✓
Overlooking addenda issued.		✗	
Using incorrect units of measurements.			✓
Revising item totals but not extensions.	✓		
Omitting the profit.	✓		

Any system produced should reduce the risk of these errors to a minimum.

COMMUNICATION AND INFORMATION EXCHANGE

The estimator in completing his tasks experiences information exchange both internally within the contractor's organization and externally with outside contacts. This is shown diagrammatically in Fig. 29 page 132, and can be summarized into the functions below.

PLANNING : Discussion of construction methods and tender programme.
Reconciliation of the resources used on the contract.
Information for production planning.

PURCHASING : Details for the acquisition of materials prices.
Records of suppliers past performance.

LEGAL : Queries arising from the examination of contract documents.
Problems with contracts for sub-contractors and materials suppliers.

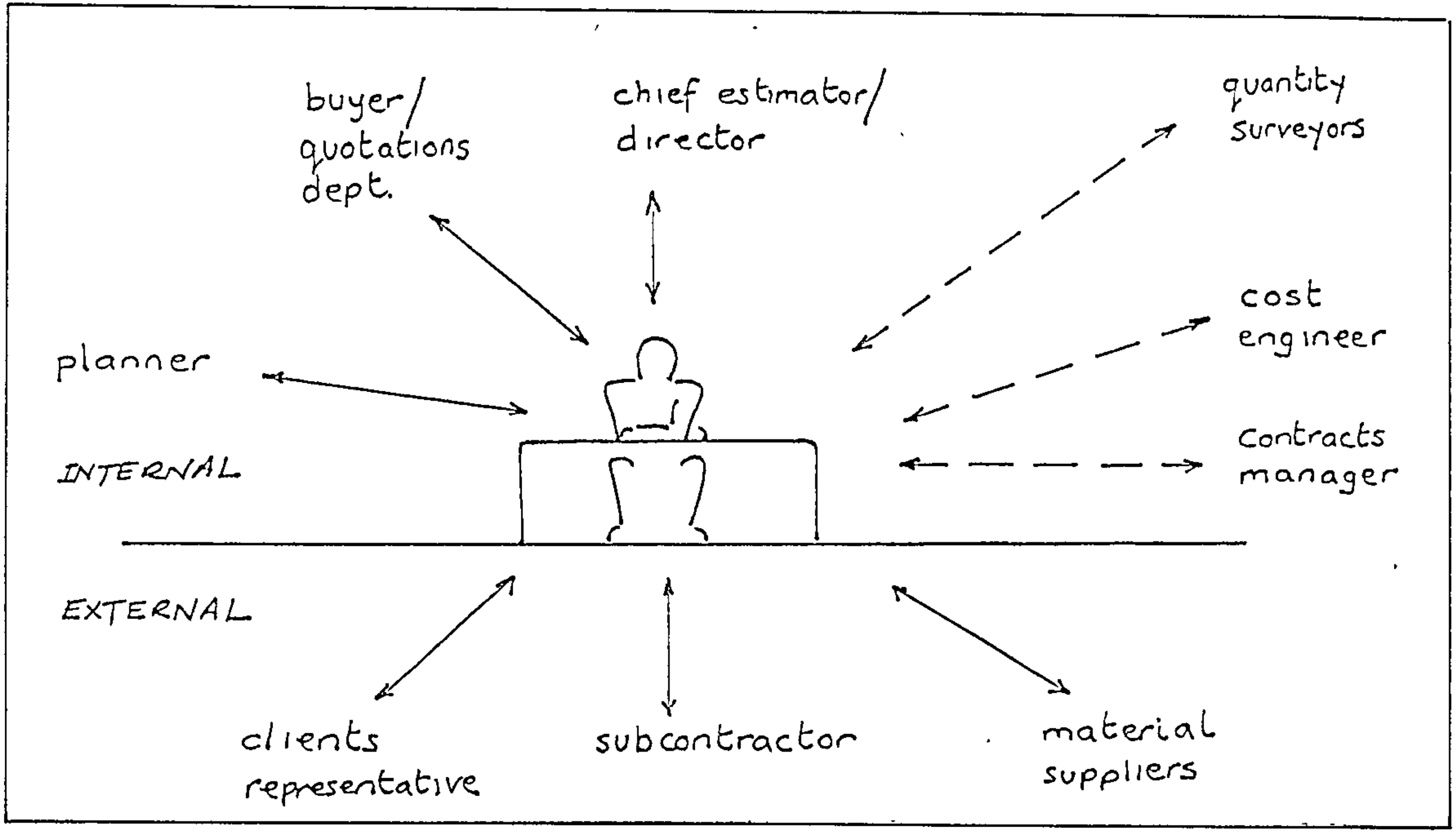


Figure 29 - ESTIMATOR COMMUNICATION

4.4 THE REQUIREMENTS OF A COMPUTER AIDED ESTIMATING SYSTEM

From this analysis of the estimator's tasks it was possible to produce a detailed list of requirements of a computer aided estimating system for estimators. These requirements are listed below under the headings of:

- General Requirements of the System;
- Program Parameters for the System.

GENERAL REQUIREMENTS OF THE SYSTEM

1. The system must be available for use by the estimators at any time both within and outside the normal working day.
2. Simultaneous input and output to the system must be available on several terminals.
3. The estimators within the company should be capable of working intermittently or in parallel on a number of tenders.
4. It must be possible for work on individual tenders to be suspended and recommenced without difficulty.
5. All data processing should be undertaken within the company.
6. The system must be interactive.
7. A hard copy of the estimator's work including both input, output and the calculations performed should be available if required.
8. The estimating procedure within the system must follow the same logic pattern as existing manual systems within companies.
9. The system must be capable of assisting at all stages of the tender process:
   - the build up of the direct cost estimate;
   - the production of information for tender adjudication;

- the addition of mark-up factors to produce a tender total.

10. Information relating to completed tenders should be stored on the system for future reference.

PROGRAM PARAMETERS FOR THE SYSTEM

1. Calculate each bill item cost from the input data on resources via a unit or operational rate process or the entry of a rate to cover each of the cost code categories.
2. Apply calculated item rates against all relevant bill items.
3. Calculate the extension of each item to produce an item price and provide a summation of bill items at several levels to produce a total direct cost for the contract.
4. Produce reports showing the division of the total rate for each bill item into labour, plant, materials and sub-contractor costs.
5. Produce listings of all the resources used in the contract including the total quantity and total direct cost.
6. Provide listings of information required for job functions related to the estimating process.
7. Store data on resource (materials, labour, plant) prices in a reference library.
8. Store data on methods of construction in a reference library.
9. Hold data on gang make-ups and production standards for use in pricing commonly recurring bill items. This data to include different methods of construction.
10. Store a list of materials prices for the contract.

11. Store a list of sub-contractor rates for the contract.
12. Store a list of all-in labour and plant rates for the contract.
13. Store the full build-up of each bill item within the contract with the facility to retrieve, check and re-work the item if required.
14. Ability to handle input of data and data changes in any order and at any time.

The requirements 1 to 14 may be considered as primary requirements necessary to assist with the main function of the estimator's task. In addition to these there are secondary requirements which are necessary to support other aspects. These are:

15. Assist the estimator in his communication with other parties both inside and outside the contractor's organization.
16. Maintain the estimator's skill and extend his knowledge of the construction processes.
17. Limit potential errors within the estimating process.

It was the basic challenge of the research to design and produce a computer aided estimating system to meet these requirements.

5. THE REASONS WHY ESTIMATORS ARE RELUCTANT TO USE COMPUTERS AND AN ANALYSIS OF EXISTING COMPUTER AIDED ESTIMATING SYSTEMS

In 1979 a survey was undertaken by Hamlyn-Harris [8] to review commercially available computer aided estimating packages. Only 7 were found that were suitable for civil engineering estimators. Each package had few if any users. The use of computers for estimating was limited to larger construction companies who had developed their own systems. The impact of computers upon the estimating world was found to be minimal and had barely touched the middle sized and smaller companies that make up the bulk of the companies within the industry.

Discussions with estimators indicated that they were reluctant to use computers for estimating for the following reasons:

- complexity of the estimating process and the data availability;
- computers and estimators judgements;
- computers and errors;
- computers and security;
- computers and tender deadlines;
- the time and cost involved in setting up and maintaining an estimating system.

This section describes these reasons in detail.

Six types of computer aided estimating systems are reviewed with regard to how they fit the needs of the estimator and meet the requirements of a computer aided estimating system as identified in Chapter 4.

No system was found that truly reflected the manner in which the estimator works and gave a fully flexible approach to estimating. The main shortcomings of the existing systems were:

- inflexibility of approach to the pricing of bill items;
- the ability to modify data from a library of information was limited;
- the estimator was unable to easily retrieve and re-work bill item calculations;
- the systems were not easy and convenient to use;
- none of the systems combined the two fundamental approaches to construction estimating, unit rate estimating and operational estimating with a supportive data library.

5.1 THE REASONS WHY ESTIMATORS ARE RELUCTANT TO USE COMPUTERS

Estimators gave the following reasons for their reluctance to use computers in the estimating and tendering process.

i) COMPLEXITY OF THE ESTIMATING PROCESS AND THE DATA AVAILABILITY

It has been shown in Chapter 2 that the estimating and tendering process is a complex procedure. During the preparation of the cost estimate and the tender the estimating department has exchanges of information with planning departments, purchasing departments and company directors internally within the organization and sub-contractors, material suppliers and clients externally.

Estimators refer to their historical records, company manuals and other supporting data. Every civil engineering project is unique. Little data used within one estimate may be directly used within another even if the project is of a very similar nature.

Estimators foresee difficulties in integrating computer systems into this fairly complex set of procedures. Problems are anticipated in allowing for information that does not appear on time, handling data that arrives in random order and amending details within the estimate when proposed methods of executing the work are changed.

ii) COMPUTERS AND ESTIMATOR'S JUDGEMENT

Estimating is a process that involves a mixture of calculation and judgement. Estimators are concerned about their opportunity to exercise this judgement fearing that the introduction of computers will reduce the estimator to the input of contract items that are automatically priced by systems incorporating banks of data. In addition, many fear that using a computer in estimating will prevent the build-up of a 'feel' for the job (79).

iii) COMPUTERS AND ERRORS

The very nature of the estimator's task means that errors made in the preparation of tenders may prove very expensive to the company in the long-term if they are awarded the project. Slattery (78) lists common estimating errors. These can be summarized into categories of:

- Transposition errors;
- Errors in calculations;
- Omission errors.

While the introduction of computers should reduce calculation errors the fear is that others may be incorporated. The danger is that the estimator receives results of calculations performed input data without knowing precisely what was done, how the answer is arrived at and even if it is correct. Although by the standard of calculations employed in other engineering functions (eg. finite element analysis) the calculations in estimating are simple, the fear is that because of the number of items within a bill of quantities and the complexity of the estimating process, errors will be made. Moreover, if these errors are incorporated in basic data held on files then they may recur many times before becoming apparent.

iv) COMPUTERS AND SECURITY

The estimating process has a particularly acute security problem in that the calculations being undertaken relate to tenders not yet submitted and estimators are very aware of the value of this information to competitors. Senior management fear the introduction of computers may lead to security risks and crimes relating to the computer where information on tenders is passed to other companies.

Research by Becker (80) argues that environment, not personality is the most useful factor in predicting crimes linked to the use of computers. By limiting the computer to "aiding" the estimator and becoming only an extension of the office equipment, the risk of security problems from within an organization will be reduced. By adopting mini and micro computers within an estimator's office whose sole use is for estimating, the estimator's information is capable of tight control with respect to security problems from outside the organization.

v) ESTIMATORS AND RE-TRAINING

Estimators will require some re-training if they are to adopt computers to producing project estimates. Their fear of this is basically a fear of the unknown. The level of education in computers is very low amongst management in the construction industry and this has led to concern that estimators require to be retrained as programmers. While the estimator must acquire some keyboard skills, all that is needed in addition is the ability of computers to handle stored data on file to create other files etc., and an awareness of the main components of a computer system.

vi) COMPUTERS AND TENDER DEADLINES

All tenders must be submitted within the time subscribed by the client or his representative. There can be no allowances for delay. Machine breakdowns may cause all data to become suddenly inaccessible. Software problems produce incorrect or dubious results. The introduction of any computer aided estimating system must be accompanied by back-up systems or procedures such that any failure of technology, particularly in the latter stages of tender preparation leave the estimator with sufficient information to complete the tender. Similar arguments were put forward when computer systems were first introduced to process payroll. While the consequences of failing to produce payroll on time are serious it should be remembered that the process is simpler and less involved than estimating. Even allowing for no hardware or software problems some estimators are concerned that the use of computers will produce no substantial time savings in the production of the direct cost estimate. In a recession period when an increasing number of tenders must be processed to obtain the same work load nothing must be introduced to reduce time availability that is already critical.

vii) THE TIME AND COST INVOLVED IN SETTING UP AND MAINTAINING AN ESTIMATING SYSTEM

Estimators are concerned about the time and cost of setting up and maintaining a computer aided estimating system. (81) The cost may be listed as follows:

- obtaining computer facilities;
- purchasing or developing the applications software;
- training costs;
- operating costs;
- the cost of setting up and maintaining the library data files.

Estimating falls within the category of "Management Information" (82). This means that the production of software becomes intertwined with management philosophy and it becomes difficult to achieve a concensus of opinion about what the program is expected to do and the way in which it must be done. The fear is not only the direct cost of implementing a system but the indirect cost and disruption caused to the estimating department. Any switch to computer aided estimating must be carried out in parallel with manual systems over a number of months. This would disrupt the department and user experienced estimators who would normally be involved with the preparation of tenders.

The reasons detailed above represent real fears of the estimator when considering the possible use of computers in the estimating and tendering process. Some of the reasons are based on a calculated assessment of the problems involved.

Others are fears based upon a lack of knowledge of the way in which computer systems could be capable of operating with respect to the estimating and tendering function.

The writer believed that there was no real reason why existing computer facilities could not be utilized to produce a computer aided estimating system that was both acceptable to civil engineering estimators and commercially viable. Different existing computer aided estimating systems were first studied to assess how they met the requirements of civil engineering estimators.

5.2 AN ANALYSIS OF COMPUTER AIDED ESTIMATING SYSTEMS

The writer analysed the commercially available computer aided estimating systems together with company in house systems of which information was available. The analysis revealed different approaches to the problem of using computers for estimating purposes. Six main types of system were found.

- System I - A Basic Estimating and Tendering System.
- System II - A Standard Price Book System.
- System III- A Standard Price Book System with Additional Calculation Routines.
- System IV - A System Based upon the 'Work Group' Approach.
- System V - Systems Based on Large Data Libraries.
- System VI - Cost Models that may be Used for Tendering.

Each type of system was considered in detail. Close attention was given to the input required, the results achieved and the reports obtained.

The facilities provided by each system were compared with those requirements identified in Chapter 4 as fundamental to a computer aided estimating system. These were the facilities to:

- calculate bill item prices from input data by a number of different methods;
- apply calculated item rates against all relevant bill items;
- provide an extension and summation of bill item prices to produce direct cost totals;
- provide a variety of reports and bill listings for the estimator and other company personnel within the estimating and tendering process;
- store data on different resources and their requirements for different construction methods;
- store lists of all-in rates and materials and subcontractor prices for the contract under consideration;
- store the full build-up of each bill item within the contract with the facility to retrieve, check and rework the item if required;
- assist the estimator in his communication with other parties both inside and outside the contractors organization;
- maintain the estimators skill and extend his knowledge of the construction processes;
- limit potential errors within the estimating process.

SYSTEM I - BASIC ESTIMATING AND TENDERING SYSTEM

The most basic form of estimating and tendering system is concerned solely with the extension of bill item rates to produce unit net costs. Additions as required may then be made to cover on-costs, profits etc, and these are included to produce a grand total for the item. The estimator may at any time change the cost code rates within an item and produce new totals. Project summary reports may be called for to show the totals within each bill section and their proportionate contribution to the total tender sum. The system may be extended to include a start and completion week for each activity which enables a simple bar chart and value curve to be calculated for the project.

The system is run on a micro computer with 'floppy disc' storage. It is command driven with cursor control. The V.D.U. screen is formatted to include all the information relating to one bill item. This is amended by the estimator, written in to the contract file and the next item input. Examples of the information available from a typical system [83] are given on pages 145 and 146.

This type of system is really providing calculating routines with a limited number of reporting facilities. Because no detailed build-ups of bill items are considered or stored it is impossible to obtain a reconciliation of resource totals for the project. No assistance is given to the estimator in the abstracting and analysis of bill items. Bill items may only be priced by one method, the addition of cost rates to each cost category.

ITEM REF.	QUANT	UNITS	LABOUR RATE	PLANT RATE	MAT. RATE	S/C RATE	ON-COSTS % A	ON-COSTS % B	ON-COSTS % C	START WEEK	END WEEK
1A	406	M3	2.10	10.20	16 60	-	10 00	-	-	2	5
1B	102	M3	8.30	17.50	10.00	-	12.00	-	-	2	10
1C	51	M3	-	-	-	21.06	-	-	-	6	14
1D	47	M3	16.10	21.20							

Figure 30 - PRINT OUT FROM A BASIC ESTIMATING AND TENDERING SYSTEM I

ITEM REF	LABOUR SUM	PLANT SUM	MAT. SUM	S/C SUM	QUANT	UNITS	NET RATE	NET TOTAL	TOTAL ON-COST	TENDER PRICE	TENDER RATE
1A	852·6 (7·3)	4141·2 (35·3)	6739·6 (57·4)	–	406	M3	28·9	11733·4	10 0%	12906·7	31·79
1B	846·6 (23·2)	1785·0 (48·9)	1020·0 (27·9)	–	102	M3	35·8	3651·6	12·0%	4089·8	40·09
1C	–	–	–	1074·1 (100·0)	51	M3	21·06	1074·06	–	1074·1	21·06
1D	756·7 (24·2)	996·4			47	M3					

Figure 31 - PRINT OUT FROM A BASIC ESTIMATING AND TENDERING SYSTEM II

No data library of resource costs or performance data is maintained, each estimate relying on the complete new input of data. The system has no facilities for assisting with materials prices or subcontractor quotations.

From the aspect of the estimator's task the system fails to achieve the primary aim of pricing bill items from basic input data on resources. The data entered consists of calculated rates for each bill item which enables only the summation of the total construction cost. No facilities are provided for the inclusion of changes in the estimate resulting from input of data from materials suppliers. The system can be seen to contribute little to the estimator's task providing more of an aid to tendering than the calculation of the direct cost estimate. The system provides no assistance for the maintenance of the estimator's knowledge. No information is stored and made accessible to the estimator when pricing items or other contracts.

SYSTEM II - STANDARD PRICE BOOK SYSTEM

This type of system is based upon standard price books using published wage rates, materials and plant costs and standard labour and plant outputs. A separate price book is set up to cover different classes of costruction work. Item descriptions are included followed by a detailed rate analysis that shows:

- material, plant and labour costs;
- the net cost total;
- the bill item rate;
- wastage and unloading allowance for materials
- plant and labour outputs;
- overhead and profit percentages.

This information is regularly updated as necessitated by market price changes. Different price books may be compiled for different forms of construction to give cost comparisons. Users of the system may set up price books where their own costs, outputs and overheads are entered.

The estimator is given the ability to change the rates, costs and percentage additions included for each item. The system can therefore be used to:

- price tenders direct from the standard price book;
- price the smaller bill items within the tender from the standard price book with longer items repriced and printed using quo·tations received from each tender;
- price tenders using private price books with updating where required.

Output for the system usually consists of a print out giving component rates and their extensions. These are then totalled to produce the total tender sum.

Typical print outs from a price book system [84] are shown in Tables 6 and 7, pages 150 and 151.

This type of system provides more detailed information of the build-up within the bill rates and the component production and cost rates involved. The basic calculations of the estimator's task are performed utilising both data input by the user and data held on a library of information. No help is given to the estimator in the analysis of the bill. Only a unit rate approach to the pricing of bill items is undertaken, the user having no flexibility of approach nor the ability to compare different methods of pricing.

The reports produced by the system are limited in both the quantity and level of information supplied to the estimator and for other functions within the company. No facilities exist for the fast update of resource prices throughout all relevant bill items. Maintenance of the estimator's knowledge is provided by the data library that may be updated at regular intervals.

TABLE 6 - TYPICAL PRICE BOOK PRINT OUT I

STANDARD PRICE BOOK NO. 19:40

PLUMBING AND ENGINEERING INSTALLATIONS

WORK SECTION NO. 19

Copper service or waste pipes to BS 2871 Table X

Conex compression straight couplings (Type A - 301)

At 4 metre centres in running lengths

Conex clips or brackets at 1.5 metre centres

(1) Saddle clips (59)

(2) Single spacing clips (60)

(3) Two piece spacing clips (57)

Fixing to timber surfaces

Conex catalogue reference is CJ8 issue 5

Date of price list is May 1980

Percentage increase on this list is 27%

Is labour gang rate advanced plumber

If so please insert consolidated labour rate in pounds per hour

Plumbers rate per hour is 5.54

Gang rate per hour is 5.54

Please insert your required overheads & profit as....percent (note: if o/hds are included in labour rates - include only profit here) 15%

(1) Fixing to timber surfaces with conex saddle clips and brass screws

15 mm pipe

Cost of pipe per metre = .7

Straight coupling each (301) = .622

Pipe clip or bracket each (59) = .038

Screws & sundries per metre = .02

Waste allowance = 5%

Labour constant in hours per metre = .075

Material cost per metre = .945

Labour cost per metre = .415

Net cost per metre = 1.36

O3hds & profit per metre = .204

Bill rate per metre = 1.564

TABLE 7 - TYPICAL PRICE BOOK PRINT OUT II

STANDARD PRICE BOOK NO. 26:11

DRAINAGE WORK SECTION NO. 26

DRAIN TRENCHES

Excavation - by tracked excavator - (5/8 Cu yd: 0.48 cu m)

In firm soil or ordinary clay

Is labour gang rate labourer only

If so please insert consolidated labour rate in pounds per hour

Labourers rate per hour is 3.31

Gang rate per hour is 3.31

Please insert your required overheads & profit as....percent (note: if o/hds are included in labour rates - include only profit here) 15%

Hourly hire charge including drive & fuel 2 11.5

Net working hours as a proportion of hours hired 2 .75

Number of supporting labourers = 1

Total gang rate per hour = 3.309

(Note: delivery and return separately priced)

Excavations commencing at ground (or reduced) level

Excavate trench for drain pipe not exceeding 200 mm nominal size and not exceeding 2 m deep

Machine output in cubic metres per hour = 6

Trench width taken as (in metres) = .6

Earth work support allowance per square metre of side (in pounds) = .4

Grade & compact bottoms in hours per square metre (labourer) = .25

Earth backfill & compact in hours per cubic metre (labourer) = 1

CACE NO. 26:11

AVERAGE DEPTHS - RATES PER LINEAR METRE

.25M	.5m	.75m	1m
Materials .2	Materials .4	Materials .6	Materials .8
Plant .38	Plant .76	Plant 1.14	Plant 1.58
Labour 1.07	Labour 1.65	Labour 2.23	Labour 2.8
Net cost 1.65	Net cost 2.81	Net cost 3.97	Net cost 5.1
O/hds & P .24	O/hds & P .42	O/hds & P .59	O/hds & P .77
Bill rate 1.89	Bill rate 3.23	Bill rate 4.56	Bill rate 5.9

SYSTEM III - STANDARD PRICE BOOK SYSTEM WITH ADDITIONAL CALCULATION ROUTINES

An improved version of the price book system is that which incorporates additional calculation routines [85]. These routines recognise that output rates need to be adjusted to reflect the circumstances of the project to which they are being applied, and as an alternative to the estimator entering a corrected output rate for the item a routine is made available to assist the calculation. For example, a bill item of mixing and placing concrete may include the following variables;

- Proportions of cement : fine aggregate : coarse aggregate,
- 28 day cube strength;
- type of cement;
- required additives,
- site mixed or "Ready Mixed",
- number of men engaged in mixing process,
- transportation of concrete;
- location for placing;
- type of location in which concrete is to be placed;
- whether concrete is recinforced.

To price such an item, the program enquires of the estimator the answers to a series of questions designed to establish the circumstances of the items being priced. This information may be applied:

- by using a stored set of arithmetic constants which are applied in the calculation;
- by using a stored procedure for deriving the values which are to be used arithmetically.

The estimator is required to enter prices for material, plant and labour, the methods to be used and the performance or capacity of the plant. This information is selected from a menu of options. A typical dialogue is shown below:

Site Mix	Yes
Ready Mix	No
Cement Type	
Portland	Yes
Sulphate Resisting	No
Rapid Hardening	No
High Aluminia	No
Aggregate	
38 mm	No
19 mm	Yes
10 mm	No
38 mm all-in	No
19 mm all-in	No
Mix Type	
1 - 12	No
1 - 8	No
1 - 3-6	No
1 - 2-4	Yes
1 - 1½-3	No etc.

The results available from a system such as this vary from details of particular rates calculated for different classes of work within the project to the production of item totals for the contract. Typical examples are given in Figs. 32 and 33 , pages 154 and 155 . The degree of sophistication of the results is normally dependant on the length of the development period for the system.

This type of system extends the facilities of system II by offering more selection to the estimator in the data to be used in the calculation process. The data however remains linked to a single method of calculation with the selection of information being from a range of alternatives.

B of Q REF	QUANT.		LAB RATE	LAB EXTN	MAT RATE	MAT EXTN	PLANT RATE	PLANT EXTN	PROFIT RATE	PROFIT EXTN	PC's PROV SUMS	CONSOLIDATED RATE	CONSOLIDATED EXTN
1/1/A	730	M3	12 00	8750·00	22·05	16096·50	2·10	1533·00	–	–	–	36·15	2589·50
1/1/B	25	M3	12·00	300·00	10·16	254·00	5·25	131·25	–	–	–	27·41	685·25
1/1/C	103	M3	12·00	1236·00	12·10	1246·3							

Figure 32 - EXAMPLE OF A PRINT OUT FROM AN ENHANCED PRICE BOOK SYSTEM

Excavation in firm clay — Estimate No 77/88
Hyd backacter tracked 0 37 cu m capacity — Machine cost/hour = 6 00
%age hand excavation = 12 50 profit % = 10 00 — Lab gang rate = 1 58

DESCRIPTION		CYCLE TIME	UNIT	RATE	LABOUR RATE	PLANT RATE	MATRL. RATE	PROFIT	
Reduce level & load									
N E	100mm deep	0 30	sq m	0 17*	0 08	0 08	0 08	0 00	0 02
	100mm deep	0 30	sq m	0 24*	0 11	0 11	0 00	0 02	
	200mm deep	0 48	sq m	0 31*	0 15	0 13	0 00	0 03	
	250mm deep	0 55	sq m	0 36*	0 18	0 15	0 00	0 ,03	
	300mm deep	0 60	sq m	0 42*	0 22	0 16	0 00	0 04	
Exc.	300mm deep	2 00	cu m.	1 39*	0 72	0 54	0 00	0 13	
Excavate basements & load									
N E	1 5m deep	2 25	cu m	1 56*	0 81	0 61	0 00	0 14	
1 5 –	3 0m deep	2 36	cu m.	1 97*	1 15	0 64	0 00	0 18	
3 0 –	4 5m dep	2 60	cu m	2 43*	1.51	0 70	0 00	0 22	
Excavate trench & load									
N E	1 5m deep	2 50	cu m.	2 19*	1 28	0 71	0 00	0 20	
3 0 –	4 5m deep	2 89	cu m	2 70*	1 67	0 78	0 00	0 25	
Excavate pier holes & load									
N E	1 5m deep	2 75	cu m	2 07*	1 14	0 74	0 00	0 19	
1 5 –	3 0m deep	2 89	cu m	2 67*	1 65	0 78	0 00	0 24	
3 0 –	4 5m deep	3.18	cu m	3 30*	2 14	0 86	0 00	0 30	
Excavate from spoil heaps & load									
		1 50	cu m.	1 21*	0 69	0 41	0 00	0 11	

Figure 33 - PRINT OUT FROM STANDARD PRICE BOOK SYSTEM WITH ADDITIONAL CALCULATION ROUTINES

The depth of the analysis is extended but not the flexibility or level of information provided within the reports. The knowledge of the estimator is maintained but no extension is offered to his skills

SYSTEM IV - SYSTEMS BASED ON THE WORK GROUP APPROACH

Systems based upon the Work Group approach attempt to reflect more closely the actual way in which estimators work. Information is stored within the system to assist the estimator price items of work by assembling the resources required (labour, plant and materials) and considering the cost and production or usage rates applicable. A library of groups of resources known as 'Work Groups' is set up. 'Work Groups' or gangs are comprised of groups of resources suitable for carrying out commonly occurring construction operations such as:

- Excavation of Foundations;
- Concreting to Column Bases;
- Formwork to Slab

etc.

The relationship between bill items, work groups and resources is shown in Figure 34 below.

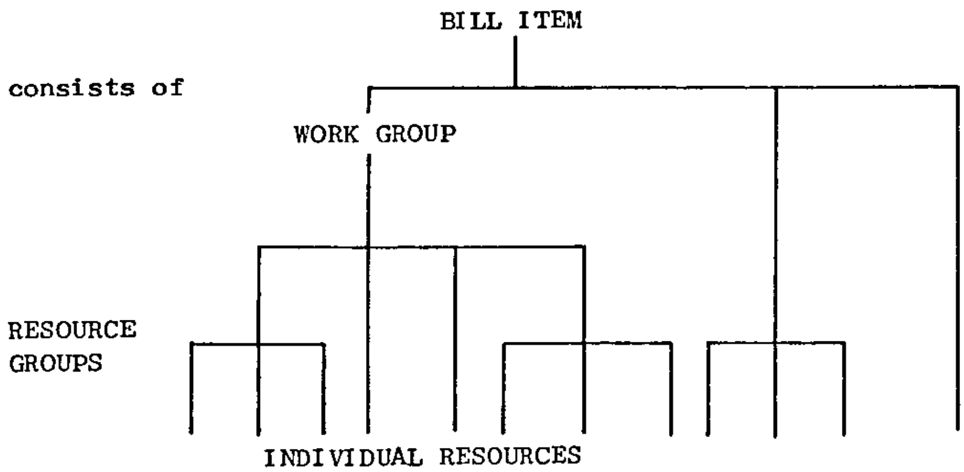


Figure 34 - THE RELATIONSHIP BETWEEN BILL ITEMS, WORK GROUPS AND RESOURCES

This method of system construction reflects the way the estimator progresses from bill item lists to abstraction of quantities, method selection, pricing of unit resources and the calculation of the final bill rate. Materials are dealt with separately but are abstracted in the same manner and may be regarded as single or groups of resources. Once the estimator has established the relationships between bill items and resources the system can be used to:

- enter and record data as the estimate proceeds;
- store and retrieve files of data,
- provide simple calculation routines,
- display and/or print output required.

The advantages of this approach are:

- it closely resembles the way in which the estimator works manually,
- it allows the estimator to price bill items at the level of detail he requires,
- it enables comprehensive reports to be obtained.

The system allows calculations from input data by:

- reference to a Work Group held on the library;
- by combining resources or resource groups to produce a work group unique to the project;
- by the direct entry of unit rates applied to the individual cost code categories.

The production and cost data may be handled at various levels. Because the input data may be more comprehensive, in addition to priced lists of bill items and the production of the total construction cost, improved facilities exist for producing reports both for the estimator and other related functions. The estimators knowledge is maintained by the library system and his skill at pricing items enhanced by the range of combinations of data that may be examined.

The main disadvantage of the system is that it is centred upon a unit rate approach to estimating with no provision for operational estimating calculations. Depending on the individual system it may or may not be possible to price bill items by entering a single sum of money or rates for specific cost codes.

SYSTEMS BASED ON LARGE DATA LIBRARIES

Systems based on large data libraries utilize the computing power and storage capacity of large mainframe computers. The basis of the system is a master library consisting of lists of commonly recurring construction items found in bills of quantities. Related to this list is another consisting of construction resources (labour, plant and materials) which are costed. In their simplest form [86] this information is organised in a sparse matrix format, the two axes representing the construction items and available resources (see Fig. 35, page 159). The cross reference being the quantity of resource required to produce an item.

Pricing a tender involves setting up a separate tender file consisting of each bill item, quantity and library reference.

On processing the bill the data relating to resource requirements is accessed and transferred to the tender file. If no construction item exists on the library, one may be entered on to the project file. Alternatively a single sum may be entered against a bill item. Prices for resources may be taken from the resource price file or overwritten for the particular project.

Figure 35 - SIMPLE ORGANIZATION OF LIBRARY DATA

Library Organization

Resources

1 1 000 Maximum

Construction Items 1 ... 2 250 Maximum

	CT	ST	SA	LAB	BKS	....
Conc 20m Pa	x	x	x	x		Sparse Matrix giving resource requirements for building items
	x	x	x	x		

Price Data Base | x x x x x x x x x x x x x x |

A more complex form of data library system enables prices for construction projects to be produced at several levels (87). Cost data is stored on different types of projects. This is based on a particular geographical location and a time datum. The system produces eight levels of cost estimate which increase in detail. Each increase in level reflects increased knowledge of the project's details. The first four levels are derived through a historical data base of previously built structures and consequently may be termed preliminary estimates.

The latter four levels are detail estimates derived from a detailed data base of labour plant and materials costs for various activities. (See Figures 36 and 37, pages 161 and 162).
By employing factors which allow for differing construction costs and time periods, all building analyses are adjusted to the datum. It is also necessary to make allowance for differing work effectiveness of the operatives in different geographical areas.

Systems incorporating large data libraries were originally run on a batch process, the user being required to code forms for data preparation. There has been a move in recent years towards making the process more interactive with entry by keyboard of the bill item data, data amendment details, and requests for printouts.

This type of estimating system depends on a large comprehensive library of construction cost information that requires the user to relate each bill item to a library item. This library with its extensive resource information is costly to set up and maintain. The system does not operate in the same manner as an estimator either in the range and level of pricing methods or the flexibility of approach. Such systems may be considered computerized estimating rather than computer aided estimating for they do not assist the estimator with the process calculation by the selection of basic data. The systems replace the estimator in this role reducing their skill level and changing the nature of their task.

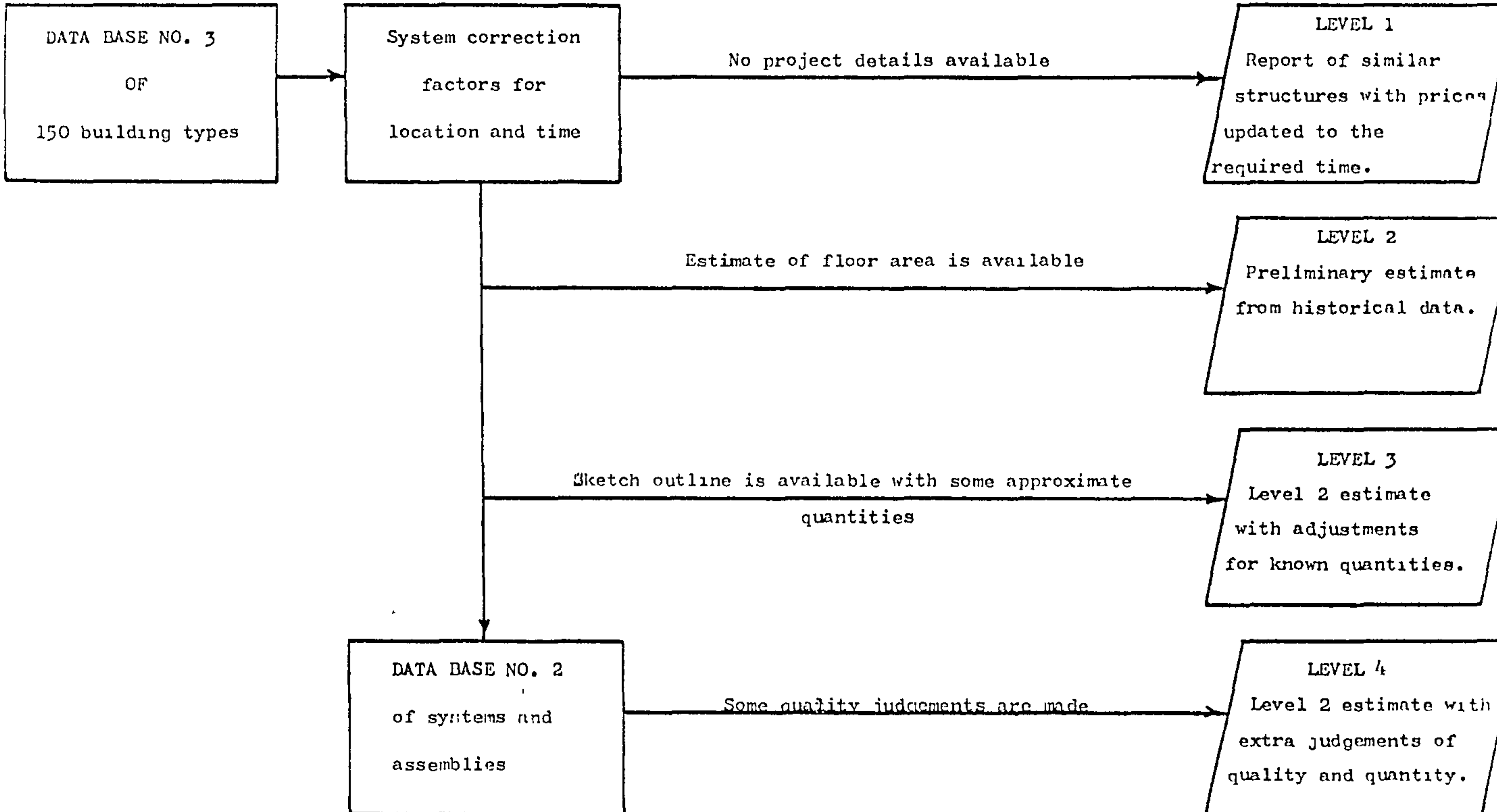


Figure 36 - THE ORR SYSTEM STRUCTURED LEVEL OF ESTIMATING SHEET I

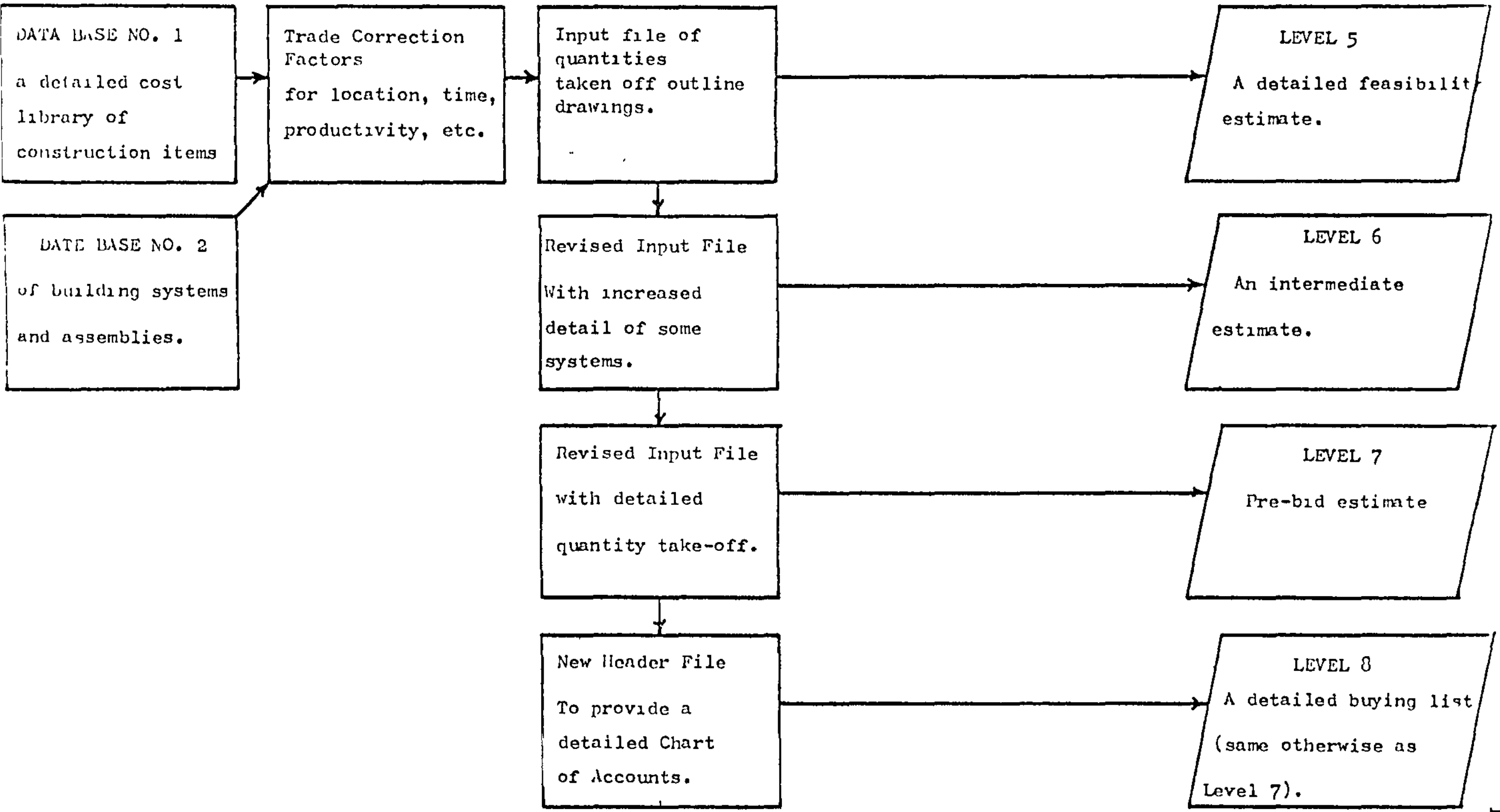


Figure 37 - THE ORR SYSTEM STRUCTURED LEVEL OF ESTIMATING SHEET 2

SYSTEM VI - COST MODELS THAT MAY BE USED FOR TENDERING

This type of estimating system is an extension of network planning and cost modelling. It concentrates specifically on operational estimating and is best suited to companies who estimate by the costing of detailed contract programmes to produce a total tender sum which is then divided into suitable bill item rates.

A typical system developed by Barnes [88] requires the estimator to define the project by a series of operations. These operations may be in general form or in detail. The resources required and their limitations (number, production rate, time on site etc.) which affect the cost and timing of the overall project are specified. The estimator must complete the logic diagram for each operation. This may take the form of a network including for each activity its number, description, timing and the list of preceding activities plus allowable overlaps. Alternatively the estimator may input a predetermined schedule of activities with their timings.

For each activity the estimator must assess and input the likely use of constraining resources. Each activity's cost is divided into separate cost code categories. The system will then calculate a schedule to minimize the total cost within the requirements of the constraining resources. Resource reconciliations and percentage utilization reports are produced. The user can obtain reports of cash flow forecasts for the project.

The main advantage of this type of system is that it takes into account resources and time in addition to costs. Calculations from resource data are based on the operational form of estimating, no use is made of a library of data information.

This necessitates the input of all data for each contract. No other method of calculation from basic data is possible. Reports are centred around resource requirements for the contract period. No listings comparable to the bill of quantities are produced. All bill item rates used in the tender must be abstracted from the system reports.

5.3 THE CLASSIFICATION OF THE COMPUTER AIDED ESTIMATING SYSTEMS

The computer aided estimating systems available to estimators vary considerably in the level of computing power provided and the range of facilities offered. The hardware required to operate the system varies from the smaller micro-computer to the largest mainframe. The computer systems may be classified in two ways, either batch systems or interactive systems and either with a supporting data library or no supporting data library. Figure 38 below represents this classification.

	BATCH	INTERACTIVE
DATA BASE	A	C
NO DATA BASE	B	D

Figure 38 - The Classification of Computer Systems for Estimating

Types A and B, the batch systems, tend to belong to the "first generation". Type A tends to be based on unit rate estimating methods and is more prevalent in building work than civil engineering. The need for estimators to complete proformas, have cards punched, wait for processing and then receive a considerable volume of data made such systems unattractive. The need to have large computers to handle the large volumes of data made group A systems expensive and out of reach by all but a few large contractors. Later developments of these early systems have found early type A systems being transferred to type C. Halfway transfers to remote job entry systems have also been undertaken. There is a clear trend away from type A to type C. The reason being that batch systems gave estimators little control over the calculations. Type B systems fall into two categories. B1 which are really like type A but without a supporting data library. That is they do unit rate estimating calculations but the estimator needs to put in all data. B2 systems are network based systems and are best suited to OPERATIONAL ESTIMATING. These are used in civil engineering contracts because of the close link provided to planning and because of the suitability of operational estimating to civil engineering work. Type D systems are network systems that allow the input to be put in via a terminal in an interactive way.

Figure 39 below represents a classification system of computer system for estimating with the six types of systems considered plotted.

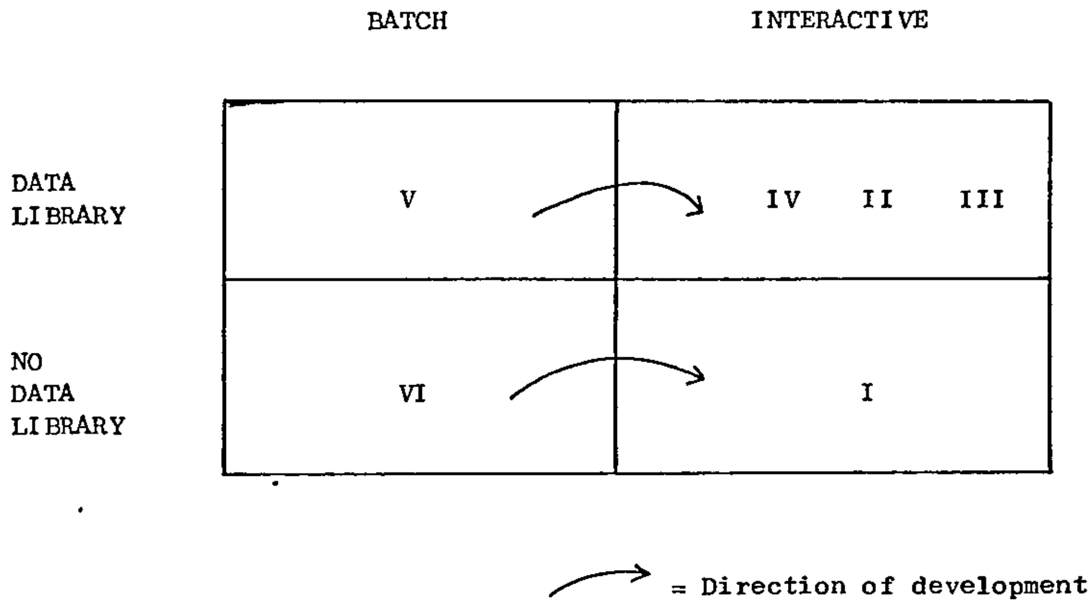


Figure 39 - THE CLASSIFICATION AND DEVELOPMENT TREND OF COMPUTER SYSTEMS FOR ESTIMATING

The tendency in the development of computer aided estimating systems is towards interactive systems that:

- incorporate some form of data library ;
- provide a range of facilities that the estimator may use to price bill items;
- provide the estimator with supportive subroutines to assist with calculations carried out within the estimating and tendering process;
- provide comprehensive reporting facilities.

No systems were found that met the fundamental requirements of a computer aided estimating system. No system provided the full flexibility of approach required by estimators in the pricing of bill items including Unit Rate and Operational Estimating.

6. THE DESIGN AND PRODUCTION OF A COMPUTER AIDED ESTIMATING SYSTEM

In this research the challenge was to design and produce a computer aided estimating system to meet the requirements of civil engineering estimators who have to price construction contracts based upon Bills of Quantities. Having identified these requirements (see Chapter 4), the design of such a system is not simply a matter of producing algorithm to carry out the calculations required within the estimating and tendering process. The success of computer systems is dependant on their acceptance to the user. This requires that any system is produced with consideration of all aspects of man-computer interaction.

This section reviews aspects of man computer interaction that needed to be considered for the production of a satisfactory computer aided estimating system. These aspects included:

- human performance;
- computer system performance;
- the hardware interface;
- the software interface;
- environment;
- the specific application of the system;
- special problems related to the system.

Of all these factors the closest attention was given to the design of the software interface. This aspect of man computer interaction was given the closest consideration because it was the factor over which greatest control was possible in the design and production of the system and the most important aspect in deciding the acceptability of the system to the civil engineering estimator. The constituent parts of the software interface are shown in Figure 42, page 178.

An analysis of the factors of man computer interaction led to the following decisions representing the basic design parameters for the production of a computer aided estimating system.

(i) No computer or peripheral equipment was selected as the sole basis of the system. The software had to be capable of being implemented on computers ranging from the largest mainframe machine to the mini/micro computer.

(ii) The function of the system would be to provide computer facilities to assist the estimator in the estimating and tendering process. These facilities would have to meet the requirements of a computer aided estimating system as detailed in Chapter 4.

(iii) The system would have to reflect the different requirements of all three types of computer user; clerk, specialist and manager.

(iv) The interaction mode for the system would be that of data entry, calculation, selection and output reporting control.

(v) The dialogue language for the software would be based upon a constrained language system. The straightforward approach of menu selection combined with an instruction and response type dialogue would enable the functions required by the estimator to be selected and performed in any order.

(vi) The development of the dialogue procedures and operations would require continual exposure to practising estimators to ensure the completed system would be acceptable to industry.

(vii) The time base of the estimating system should reflect the normal response time of an estimators task and overall take no longer than the time at present required manually to complete the task.

(viii) The dialogue structure should incorporate the principles of good message design and be adapted as requested by individual construction companies.

The background to this work was that the use of computers in estimating by civil engineering contractors had to date been restricted to all but a few large companies with well developed computer service departments.

The prima facie case for using computers in estimating is very strong and the reasons for the lack of use were identified as:

(i) capital cost of installing such systems;

(ii) the limited choice of software commercially available for estimating;

(iii) a mismatch between the facilities offered by most of the commercially available software and the estimators needs;

(iv) estimators fears of computer technology.

The reasons that points (ii) and (iii) existed are:

(a) in general the construction industry personnel, such as estimators, do not specify their computer system requirements with a clarity that can be acted upon by software houses. (This is particularly true if the software houses have no construction background);

(b) the estimating process is more diffuse than other applications, such as network planning for example, and so clearer specifications are required; and

(c) the estimators were not themselves pressing for a change and were generally resistant.

The diffuse nature of the estimating process is due mainly to three factors:

(1) the variable nature of the work being estimated;

(2) the various forms of the contract documents prepared by the clients' or promotoers' representatives; and

(3) the estimators who retain highly individualistic approaches.

Estimating software designed for one company is likely to be generally unacceptable because it is too individualistic and reflects the foibles of the particular company's processes. Therefore in work relating to estimating a methodology was required that would take account of the estimators lack of clarity of specification and the wide range of processes known as estimating without producing systems unacceptable to intended users.

The methodology evolved was an iterative process of interviewing, developing and demonstrating. The interviews allowed the technique of task analysis to be employed to define the estimators tasks.

The iterative process is represented in Figure 40 below:

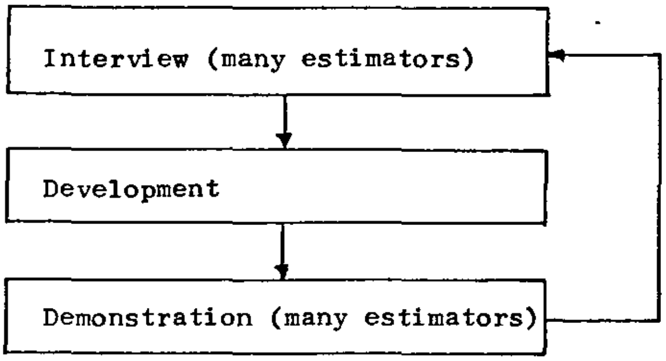


Figure 40 - The Iterative Process of System Development

The process was continued until an acceptable solution was reached.

This interative approach allowed the estimators from co-operating companies to develop their own appreciation and understanding and so improve their ability to specify their requirements. By involving many estimators in this process the risk of satisfying the foibles of only a few were reduced.

The role of the writer in this process included the following functions:

- discussions with construction industry estimators and managers to determine their requirements;
- preparation of the specification of the system including the facilities available to the estimator, the dialogue design and the contents and format of the reports;
- advising the programming staff on the solutions to production problems;
- testing the system to ensure that its requirements were met in the most appropriate manner;

- demonstration of the system to construction industry estimators and managers and analysing their comments for possible inclusion in the system;
- the supervision of the field testing of the system within a civil engineering contractors organisation;
- the production of user support facilities including user reference manuals and training programmes.

6.1 THE PRINCIPLES OF MAN COMPUTER INTERACTION

Eason (89) considered the allocation of functions between man and computer. These are summarized in Figure 41 below.

TASK ALLOCATION

COMPUTER GOOD / MAN POOR	COMPUTER POOR / MAN GOOD
Speed of processing	Pattern recognition
Accuracy of processing	Goal formation
Large scale memory	Resolving ambiguity
Rapid translation	Recognising novelty
	Creativity
(PRE-PROGRAMMED)	(SELF-PROGRAMMED)

Figure 41 : Task Allocation between Man and Computer

An analysis of Figure 41 shows that man and the computer have complementary information processing characteristics. Close man-computer interaction offers a potential for task performance that neither can match alone. "Successful man computer communication is dependant on the development of systems where man can control and direct the performance of the system to accommodate the novel features of the task", Eason (89).

Table 8 page 174 indicates the main factors in man-computer interaction. All these factors play a part in the successful use of a computer system and their relative importance was considered with respect to the design and production of a computer aided estimating system.

1. Human Performance

   Basic characteristics and limitations eg. size, speed, skills, errors, flexibility etc.

   Special aspects eg. selection / training / user support; eg. modelling the user / decision-making / problem-solving

Special aspects	eg. selection	eg. modelling the user	
	training	decision-making	
	user support	problem-solving	

2. Computer System Performance

   Basic characteristics and limitations eg. capacity, speed, reliability.

   Special aspects for MCI eg. language facilities
   system response time
   security

3. Hardware Interface

   Displays, Controls, Terminals and Consoles.
   Applied ergonomics for good workstation design.
   Human needs and new devices.

4. Software Interface

   The non-hardware communication media.
   Languages and linguistic systems (MCI aspects).
   Information organisation eg. message structure and verbosity, display format and layout (including eg. microfilm output, questionnaire and other input forms).
   Human needs and new approaches.

5. Environment

   Physical : workstation space and layout, lighting, noise, etc.

   Psychological : influence (eg. via motivation, strain, etc) of the working group, of the job structure (eg. shift working), of the system structure (eg. open/closed, rigid/flexible, etc), of the social climate and of the organisation design.
   Applied ergonomics and social science for good environment design.

6. Specific Applications

Specialist users	Computer assisted learning
Business users	Computer aided design
Naive users	Man-computer telecommunications
Public systems	Computer conferencing

7. Special Problems

   Evaluation - especially criteria and methods
   - especially social implications versus cash costs
   - importance of real world studies (not in lab. only).

   Privacy of personal information.
   Ergonomics of programming and the job of the programmer.
   Documentation and related job aids.
   Influence of MCI upon job design and organisation design.
   Influence of MCI upon society.

TABLE 8 - MAJOR FACTORS IN MAN-COMPUTER INTERACTION (From Shackel(90))

6.2 HUMAN PERFORMANCE

The system was designed assuming that the users would have no prior knowledge of computers or computing. They would possess no special skills on aspects of human performance over and above that already recognised in their professional background and the carrying out of their existing jobs as estimators in the construction industry. Where during the production of the system special aspects or requirements became apparent (eg. in training and user support) provision was made to fulfill these needs. (See Chapter 10).

6.3 COMPUTER SYSTEM PERFORMANCE

The basic characteristics of performance of a computer system are capacity, speed and reliability. Initial development of the system took place on the University's Prime 400 Mainframe computer. As a result of monies from government funding organisations the following equipment was purchased:

- A Genesys Design Centre
  (with Computer Automation Li40 mini computer)
- A Cromemco Z2H micro computer.

It was then possible to test the viability of the system when based on a small dedicated machine. The advantage of a mini/micro computer was that the machine became available to install in a contractors office for a test period. This enabled the full impact of a computer estimating system within a contractors organisation to be studied.

Miller [91] states three ways in which estimators may obtain computing facilities:

- via the company mainframe;
- via a computer bureau mainframe;
- by the purchase of a suitable mini/micro computer.

By installing the system on machines at both ends of the scale of modern computing power, it became possible to examine the requirements of computers and estimating for civil engineering contractors of varying size within the construction industry.

Emphasis was placed on the production of a system capable of running on micro computer systems. This was because:

(i) Having produced a system on a micro computer it would be relatively easy to implement the system on a larger more powerful machine.

(ii) Computer capacity and speed is relative to the cost of the machine purchased. By concentrating attention on the micro computer a system would be produced that was within the purchasing range of the smaller sized civil engineering company.

6.4 THE HARDWARE INTERFACE

Computer hardware consists of the displays, controls, terminals, consoles and other peripheral equipment of fixed physical form. Human factors specialists have tended to concentrate on the problems of man computer interaction presented by the hardware interface. Extensive research has been undertaken on the types of input keyboards prefered, (eg. (92) and (93)).

Close attention has been paid to the problems of displaying information on visual display screens. General guidance for designers and purchasers of V.D.U's and terminals can be found in the V.D.T. manual by Cakir, Hart and Stewart [94]. While not all hardware interface problems have been resolved, sound principles and guidelines have been determined.

As with the computer selection performance, no particular hardware configuration was selected for use with the computer aided estimating system to be produced. It was assumed that any hardware upon which the system would be implemented would be designed from sound ergonomic principles and if called upon to select and recommend a suitable hardware configuration for the running of the system then appropriate checks to produce a satisfactory man-computer interaction would be made at that stage.

6.5 THE SOFTWARE INTERFACE

Computer software consists of the programs or algorithms that carry out the operation of the system hardware and perform the applications required by the user. The design and production of a computer aided estimating system consisted of producing applications software for this specific purpose.

The software interface is the name given to the link between the user and the program. Stewart [95] states that the two principle requirements of the software interface are:

- that it should fit the function it serves in the overall systems design;
- that the structure of the dialogue enables the function to be fulfilled.

The components of the software interface are shown diagrammatically in Figure 42, page 178.

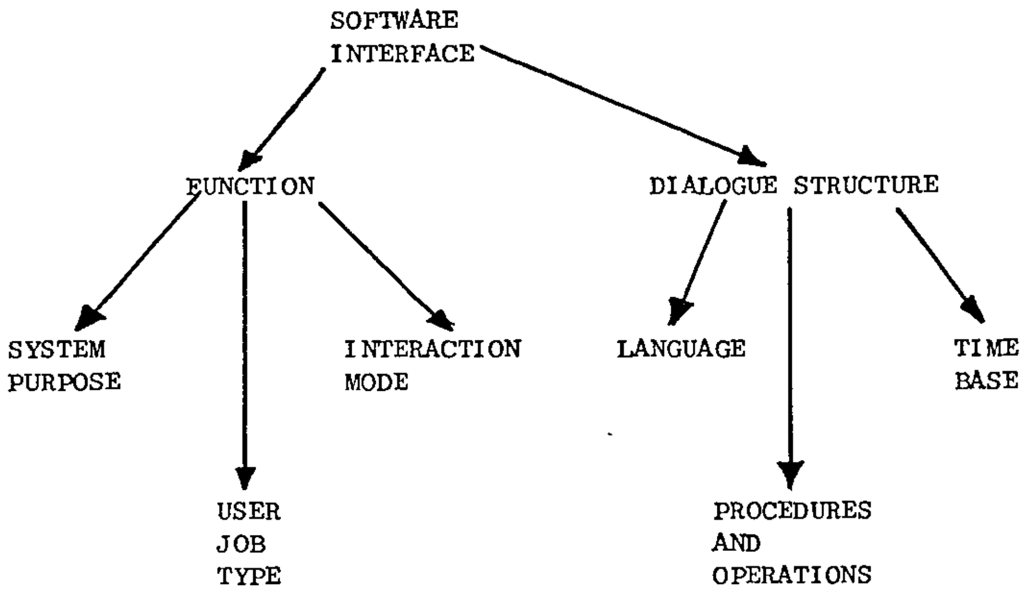


Figure 42 - The Components of the Software Interface

This aspect of man computer interaction was considered in great detail during the design of the system because it was the factor over which the author had most control and also the most important aspect in deciding the acceptability of the system to the civil engineering estimator.

Each aspect of the software interface was considered individually.

6.5.1 FUNCTION

The function of the software depends on the nature and purpose of the system and the type of job the user is performing. This requires an analysis of the specific tasks that are performed by the users of the system. The analysis of the estimating process, the calculations undertaken and the analysis of the estimators tasks enabled the function of the system to be clearly defined.

The purpose of the system was to produce computing facilities to assist the estimator in the estimating and tendering process. The system was designed to meet the requirements of a computer aided estimating system as listed in Chapter 4. An examination of the estimating and tendering process shows that the following personnel could be directly involved with a computer aided estimating system within a contractors organisation.

COMPTOMETER OPERATOR OR TYPIST	-	Input of the Bill of Quantities.
ESTIMATOR	-	Preliminary coding of bill items. Pricing of Bill of Quantities. Obtaining reports.
CHIEF ESTIMATOR AND DIRECTORS	-	Obtaining reports. Making mark-up additions.

Each of these type of users represents a different type of computer user. The users are classified with respect to the basic types of computer user identified by Eason et al [96] in Chapter 6, where the specialist nature of this particular computer application is described.

To work efficiently systems must effectively provide a different type of interface for each user. The estimating system was designed and produced taking into full account the different user job types. This was accomplished by ensuring that the relevant parts of the software interface that affected the different users were designed to meet their individual requirements.

Irrespective of the type of user of the system the software interface must incorporate an interaction mode related to the function of the system. This may range from the user being permitted only to enter data through to the user programming the system to obtain his exact needs. The system was designed so that the interaction mode was that of data entry, calculation selection and output reporting control. No attempt was made to produce software that would involve any direct programming by the user to obtain results outside the clearly defined options of the system.

6.5.2 DIALOGUE STRUCTURE

Shackel [97] describes the dialogue structure as a set of procedures through commands and responses for the exchange of information between the computer and the human user. This uses an agreed language and the medium of an interactive device such as a VDU or keyboard/printer terminal. The users understanding of the system is directly related to the dialogue and good dialogue design is critical to the success or failure of the total system [98].

No comprehensive theory of dialogue design has yet emerged. Hebditch [99] states the attributes of good dialogue as:

Easy to learn	Efficient
Easy to use	Relevant
Easy to extend or modify	Consistant
Error avoiding	Adaptive
Error detecting	Helpful
Unobstrusive	Can be personalized
Economical	User modifiable

Gaines and Facey [100] state some principles of dialogue design. They exphasize that the user must always feel in control of the system. To make control possible the user needs to know·

- where he has been;
- where he is;
- where he can go from here.

The system should be simple and easy to control. Each input by the user should be met with an immediate unambiguous response. This should be sufficient to identify the type of activity taking place within the system. The user should be capable of free movement around the system. A 'reset' command should be available to abort from a current activity and return to a local initial state.

It is essential that the user is involved with the development of the dialogue. Damodran [101] emphasizes this and summarizes the function of user involvement as:

- contributing to effective systems analysis and design;
- promoting user understanding and commitment to the system;
- providing an 'early warning system' of potential indirect effects;
- identifying areas of organizational change.

The dialogue structure should enable the function of the software to be fulfilled and should suit the purpose of the system, the user job type and the interaction mode. The components of dialogue structure are:

- language;
- time base;
- procedures and operations.

Dialogue language is the underlying structure that forms the basis for dialogue. A computer system should wherever possible be consistant with the existing usage of the language by the proposed user. Consequently the selection of terms and names is an important aspect of dialogue design. Language within computer systems that is terse, coded or abbreviated often leads to problems for users who are accustomed to a task vocabulary which is powerful and rich in expression.

Fitter [102] has classified and described the main groups of programming languages and related them to dialogue styles. Hebditch [99] lists eight main categories of dialogue style.

These have been combined to give the diagram below:

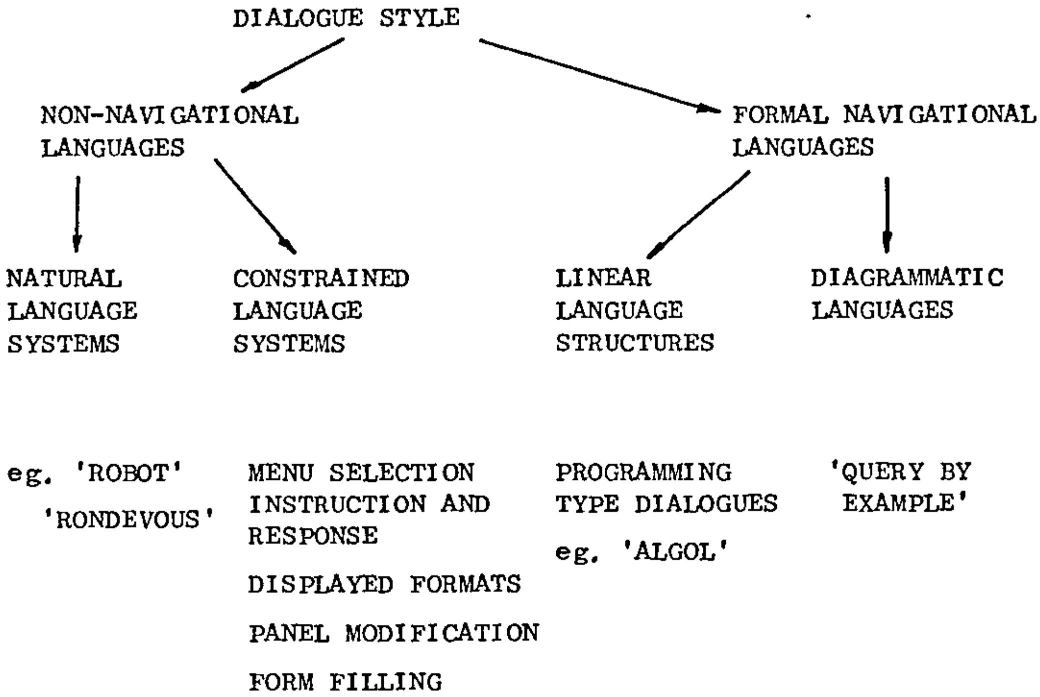


Figure 43 - Types of Dialogue Language (after Fitter (102))

Examples of the different types of dialogue language are given in Appendix V.

For the design of a computer aided estimating system it was decided to adopt a constrained language system. The range of user types and the general level of familiarity with computer systems that exists within civil engineering organizations demanded a simple method of selection of the various facilities available to the user. The straightforward approach of menu selection combined with an instruction and response type dialogue enabled the functions required by the estimator to be selected and performed in any order. This closely reflects the estimators method of working already identified in Chapters 2 and 4 . In particular, the menu selection method is well suited to the incorporation of the information received by the estimator. This as detailed in Chapter 2 is characterized by the randomness of production and the size, sequence and rate at which details are received. In pricing bill items the estimator is faced with a number of different approaches to the problem of how to price particular bill items. The menu selection method closely reflects this manner of working.

By constant exposure of the system to practising estimators during the development stage the nature of the questions included within the dialogue was keptrelevant to the estimators normal use of language.

6.5.3 PROCEDURES AND OPERATIONS

The dialogue language must be organised into procedures and operations to enable the user to interact with the system. It is important that the system should not inhibit human flexibility. The procedures and operations required for "naive" users are different from those of experienced users.

The system should be flexible enough to handle various levels of user. Procedures are necessary for the input and output of data and for general interaction between the user and the system.

The development of procedures and operations to undertake functions involves the design of messages within the software. This requires consideration of:

- display formats;
- display coding;
- error handling.

6.5.4 DISPLAY FORMATS

Principles for the design of good display formats are documented in Hartley [103] and Cakir, Hart and Stewart [94]. The display of information to the user should not include undue coding or abbreviation. Any jargon used should be that of the user and not that of the computer programmer. No unclear item formatting should be included in the display.

The factors that contribute to good formatting are:

- logical sequencing;
- spaciousness;
- relevance;
- consistency;
- grouping;
- simplicity.

The sequence or order of information that is to be entered or displayed should be logical to the system, the users task and the information source.

Spacing and blanks are important to aid in the recognition and identification of items of information and to emphasise and maintain the structure of the display. Clutter reduces legibility. If a large amount of information must be provided it is more satisfactory to provide a series of displays as opposed to a single display. The format should be as simple as possible with only information directly relevant to the user displayed. Information that may be useful on only some occasions should be incorporated in a second display.

Screen formats should be consistent for the specific task for which they are designed. With consistent formats unfamiliar or new format can be more readily and accurately interpreted. Consistency should be obtained:

- between different displays engaged in the same task;
- with other modes of handling the same task;
- with the input requirements of subsequent stages in handling the data.

Grouping similar items together within a display improves their readability and can also highlight relationships between different items of data.

Formats should be as simple as possible. Highly detailed, complex displays must be structured and organised to provide the information required in as straightforward a manner as possible.

The display formats for the system evolved with the discussion prompted by the estimators who saw demonstrations of the system. The trial period within the contractors organisation also provided valuable feedback on this subject.

6.5.5 DISPLAY CODING

Coding the man-computer language becomes inevitable in order to:

- speed up the flow of information;
- make use of limited storage space;
- enable comprehensive display formats.

The most common form of coding is alphanumeric coding where language is coded or abbreviated so that the words used are shortened. Other forms of coding include:

- colour coding;
- brightness coding;
- spatial coding (formatting);
- shape and size coding;
- flashing.

A comprehensive description of display coding is given by Stewart [95].

Within the system display coding was kept to a minimum. Because the system was being produced for a range of V.D.U. hardware only alphanumeric coding was adopted. The principles discussed in Ashton [104] were adhered to where possible. Coding within the displays incorporated classification coding adopted for the storage of resource data on the company library. This is discussed in Chapter 7 . Descriptions introduced by the user were displayed in full or truncated as opposed to abbreviated.

6.5.6 ERROR HANDLING

The detection of errors in the data input of the user constitutes an important part of the software interface. Error handling techniques are necessary to avoid, detect, report and correct errors. Hebditch [99] provides guidelines for these purposes.

The structure of the INTEREST system with a menu selection of commands and instruction and response interaction mode guides the user and reduces the probability of incorrect data. The amount of coding required was reduced to a minimum as this tends to be a common cause of introducing errors. Wherever possible the relevance of input data was limited to the first two characters of a command, the remaining characters becoming redundant. Within the INTEREST system defaults and 'reasonableness' checks were incorporated to avoid and detect errors. Error coding messages were avoided to minimize the need to refer to user manuals. Error checks were installed to check each stage of input. Unless the data provided by the user is meaningful the incorporation and subsequent use is not permitted. The system defaults to repeat the enquiry for data giving a statement of why the previous entry is incorrect. This avoids making the user re-key valid data during error correction.

Wherever the user incorporates resource data from the library, a statement of the resource selected is given and the user asked to confirm his choice. In this manner there is a reduced chance of the estimator allowing incorrect data into the estimate.

Examples of display formats, display coding and error handling techniques are included in the annotated user reference manual contained in Appendix VIII and in Chapter 7

It was important that the dialogue structure incorporated the principles of good message design. Where necessary this may have to be amended to suit individual construction companies.

6.5.7 TIME BASE

The software dialogue consists of language which is organised into procedures and operations. The time base is the timing underlying this organisation. This may be divided into:

- the system response time;
- the system transaction time.

The system response time is the time taken for the system to respond to a query or instruction from the user. Various sources suggest different critical response times although little evidence is available as to what constitutes an acceptable delay. Instantaneous or zero response delays may appear ideal as there is no likelihood of a decrease in the throughput of information or any interference with keying efficiency that can be found with slow response times. However extremely fast response times are only obtained by high financial investment in hardware. The user may find that he is being 'paced' by the system. Fast response on one system leads to the expectation of a fast response in every system, with inevitable disappointments and frustrations. Human beings normally work at a mean response time of two seconds. Most computer users will tolerate a few seconds delay and longer delays are acceptable if they can be predicted by the user. A variation in system response time is acceptable for different facilities and at different stages within the system operation. Delays of greater than one minute disrupt decision making and the problem solving ability of the user with corresponding frustrations and dissatisfaction with the system.

System response time is dependant on the efficiency of the hardware used to run the system, processor utilisation and the structure of the software. This may vary considerably from one computer system to another.

System transaction time is the time the user spends at the terminal from switching on to walking away having completed the task. This is a function of the design of the system and the hardware and system reliability. Where multi-user systems are in operation the transaction time will be dependant on how many other users are at present using the system.

From the receipt of the contract documents to the submission of the tender the estimator is involved in many system transactions. These will vary considerably in time depending on the information available and the task to be performed. What is important to the estimator is the total time taken to prepare the direct cost estimate for the project. Estimators are required to work to a tender submission date. There are clear advantages for the adjudication panel in the contract estimate being held on the computer. However unless the system enables the estimator to prepare his initial cost estimate within the same time as could be achieved manually the system cannot be considered viable. This aspect is discussed further in Chapter 11

For the design of a computer aided estimating system it was important that the time base should reflect the normal response time of an estimator's task and overall take no longer than the time at present required manually to complete the task.

The two main reasons that make it difficult to achieve consistency in following the sequence of operation of the users task are:

- system design programming problems;
- difficulty for the designer to assume the users position.

Green, Sime and Fitter [105] discuss the problems facing the programmer. The difficulty of the designer in assuming the users position can only be overcome by the user constantly reassessing the specification and monitoring the production of the system.

The development of the system depended upon constant interaction with practising estimators to ensure that the procedures and operations incorporated within the system reflected the users requirements. This relied upon the iterative process of development, demonstration, consultation and reassessment. The tendency of each company (and even each estimator) to adopt slightly different approaches to estimating meant the system developed reflected the concensus of opinion as to the facilities required.

6.6 ENVIRONMENT

The importance of the hardware interface extends beyond input and output devices of the system to include work station and environmental issues. The problems of adequate working areas at suitable heights and at the correct visual, thermal and acoustic environments are fundamental to a user who may occupy the work station for several hours at a time as a regular part of their job.

A detailed workstation checklist incorporating all relevant factors is given in Table 9, page 193. The relative importance of all the factors shown in Table 9 depends on the specific combination of the user's task and the hardware system being used.

The development of the computer aided estimating system was not undertaken for a particular office location. As with the hardware interface, the installation of the system into any office location would need to be carefully considered from all environmental aspects to ensure they produced a satisfactory man-computer interaction.

TABLE 9 - A DETAILED VDU/WORKSTATION CHECKLIST - after Stewart (106)

VDU/work station checklist

User and task factors : who will use the work station and what tasks will they perform?

Range and limits of users' characteristics? e.g.
- age
- sex
- body size
- experience
- training

Tasks to be performed? e.g.
- activities
- functions

Man-machine factors : will the work station suit the size, shape and other characteristics of the actual or potential users?

Can the users reach and operate the controls? e.g.
- alphanumeric keyboard
- special function keys
- power and other VDU controls
- other computer equipment
- other office equipment

Can the user see and read the displays? e.g.
- VDU screen
- VDU control and indicator lights
- other equipment displays
- source or other necessary documents
- look-up lists, operating details
- other office lists or directories

Can the user work in a comfortable position and get in and out easily? e.g.
- posture
- leg and knee room
- table and desk height
- seat height
- stretching or bending

Workspace factors : will the work station suit the tasks the user needs to perform and the job aids required?

Work surfaces? e.g.
- size, number
- accessibility

Storage? e.g.
- for printout and manuals
- other work documents
- job aids (such as calculators, pencils, etc)
- personal belongings
- 'buffer' for batching

VDU work station checklist (contd)

Seating? (if any) e.g.		adjustable swivel or fixed arms stable
Interaction with other equipment? e.g.		telephone calculator, etc.
Sharing the VDU? e.g.		queues access privacy security audience effects
Clutter? e.g.		bins for rubbish trailing wires
Maintenance access? e.g.		regular non-routine

Environment factors : is the physical environment conducive to effective use of the VDU and will the VDU create an environmental problem for users or others?

Acoustic environment?	e.g.	noise caused by VDU noise caused by ancillary equipment noise environment for user
Thermal environment?	e.g.	VDU sensitive to heat VDU generating heat
Visual environment?	e.g.	adequate light for source documents adequate ambient illumination reflections from screen or other surfaces glare from screen or other surfaces
Safety environment?	e.g.	electrical hazards vibrations/knocks chemical hazards

The checklist may be used to compare or evaluate proposed work stations. The answers or responses to the various checks and questions can be simply yes/no or more complex ratings. The relative importance of these and any other factors will depend on the specific combination of user, task and system.

6.7 SPECIFIC APPLICATION

When designing and producing a computer system it is important to identify clearly the range of applications for which the system will be used and the range and type of users who will be called upon to use the system.

The system to be produced was clearly designed for a specific purpose, that of aiding the civil engineering estimator in the estimating and tendering process for civil engineering works.

Chapter 10 states the types of users that would be using a computer aided estimating system.

Eason et al [96] in a study of different types of computer user identified three separate classes:

- the clerk;
- the specialist;
- the manager.

Each type of user had different basic needs which are summarized below.

THE CLERK

The clerical user is concerned primarily with the input of data relating to the processing of documents (e.g. orders, invoices, etc). Additional tasks may involve the checking of data for accuracy and the updating of existing data. The job of the clerk has minimal discretionary content and is fundamentally dependant on the computer system. Consequently the level of job satisfaction and performance is mainly dependant on the organisation of the function within the company.

THE SPECIALIST

The specialist user is usually a professional person (engineer, designer etc) who is required to use a computer in order to obtain a solution to a complex technical problem. Depending on the applications software available this may involve using a commercially available package, i.e. fitting the task to the facilities available, or developing new software to perform the task. The specialist user will have sufficient time to learn about the computer system in some detail. This may even involve learning to program the computer.

THE MANAGER

The manager uses a computer to provide him with the information required for decision making. As a computer user he is characterized by the random, intermittent use made of the computer. Unlike the clerk, the manager can reject the information service if it is found unsatisfactory either in content or performance. The type of the manager's decisions may vary considerably from occasion to occasion. His job content is constantly changing and a high work load allows little time for tasks peripheral to the decision making. All these factors make the development of computer systems for managers extremely difficult. A survey of managers as computer users [107] showed that increasing flexibility and computer power failed to provide a more satisfactory service for managers. Where system operation presents problems the manager may stop using the system directly and interpose a "human interface".

It can be seen that the types of user of a computer aided estimating system fall into each of these three categories. The titles may be restated as:

- the estimators clerk;
- the estimator;
- the contractors senior management.

THE ESTIMATOR'S CLERK

The estimator's clerk may be a junior estimator or a person employed specifically for data preparation. Their task would be to input the details of the bill of quantities on to the computer to create the file of bill items for the contract. This would relieve the estimator of the task of data input providing more time for other important tasks at the start of the estimating process.

THE ESTIMATOR, THE CHIEF ESTIMATOR

The system was specifically designed to meet the tasks of the civil engineering estimator in the estimating and tendering process described in detail in Chapter 2 .

An additional form of specialist user is that of the chief estimator or alternatively the estimator with overall responsibility for the system. This will entail the setting up and maintenance of the company library, the creation of contract specific files and all system security.

THE CONTRACTOR'S SENIOR MANAGEMENT

The contractor's senior management are present at the adjudication meeting for each tender. The manager or director requires the ability to access the system to obtain details of the direct cost estimate.

This may be in the form of the build-up of each individual bill item or by producing specific reports from which he may assess the mark up for the contract.

It was necessary to design and produce the system taking into full account these different types of computer user and their development with the system. This was accomplished by ensuring that the relevant parts of the software interface that affected the different users were designed to suit their individual requirements. The type of user also affects the type of user support that needs to be provided. This is considered in detail in Chapter 10.

6.8 SPECIAL PROBLEMS

The introduction of a computer system may require the consideration of special problems that need to be overcome to produce satisfactory man-computer interaction. These may be specific to the organization in which the system is to be used or the particular function to which the system is related. The problems may encompass broader issues such as the influence upon society in general or raise questions with respect to individual privacy.

The design and production of a computer aided estimating system had no particularly unique problems. Consideration of aspects such as:

- overcoming users fears and prejudices;
- producing an acceptable system;
- producing a system that would increase profitability;

are present whatever the purpose for which a system is designed.

7. THE INTEREST - C.E. COMPUTER AIDED ESTIMATING SYSTEM FOR CIVIL ENGINEERING CONTRACTORS

This chapter describes the prototype computer aided estimating system that was produced. This was called 'INTEREST-C.E.' standing for Interactive Estimating for Civil Engineers. The system was produced to meet the requirements of a computer aided estimating system as identified in chapter 4.4 . Particular attention was paid to producing a system that assisted the estimator in his task but did not "computerize" the process to the extent of radically changing the estimator's approach to his work and how the principle tasks were performed within the estimating and tendering process.

Included in this section is an outline of the system and a detailed description of the procedures and operations adopted to meet each of the main requirements of the system as detailed in chapter 4.

7.1 AN OUTLINE OF THE SYSTEM

The basis of the system is the ability to build up details of the direct cost of each item within the Bill of Quantities for the contract under consideration and store this data on file. When the direct costs for the contract have been completed, additions may be made to the item rates to allow for profits and overheads. Adjustments to individual prices may also be performed. This is shown diagrammatically in figure 44 below:

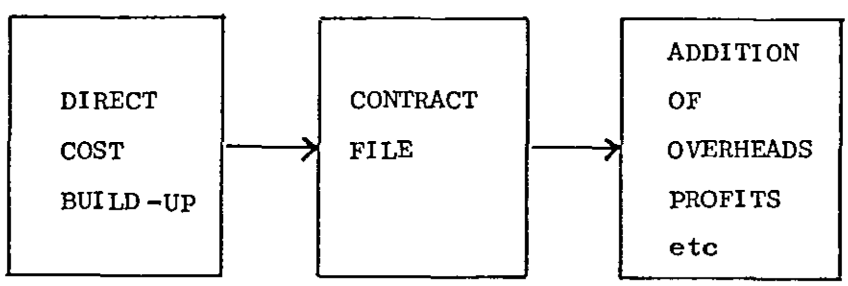


Figure 44 - The Basis of the INTEREST system

A complete flow chart for the system is given in figure 45, page 201.

To prepare a direct cost estimate, data must be obtained on the resources required to perform the work, their respective outputs or usage and their costs. Some of this data may be taken from the company data library. Other information which is contract specific will have to be introduced by the estimator while preparing the estimate. Included in this category will be most of the material prices which have to be obtained for each estimate.

Data held on the company library is available to all estimators for incorporation into any contract currently under consideration. These data have to be set up by each different company using the system and will include standard build ups, resource listings and performance data. The system comprises two separate programs. The first allows the chief estimator or person in control of the system to set up contract files for the project under consideration and maintain the company data library of information. The second program enables the estimator to input details on each item within the Bill of Quantities, prepare a direct cost estimate for the project and then make the necessary mark-ups determined by the adjudication panel to produce the total tender sum for the contract.

The system is command driven. That is to say to help him prepare his estimate the estimator can call upon a command from a 'menu' displayed before him. There is no set order for the program to run.

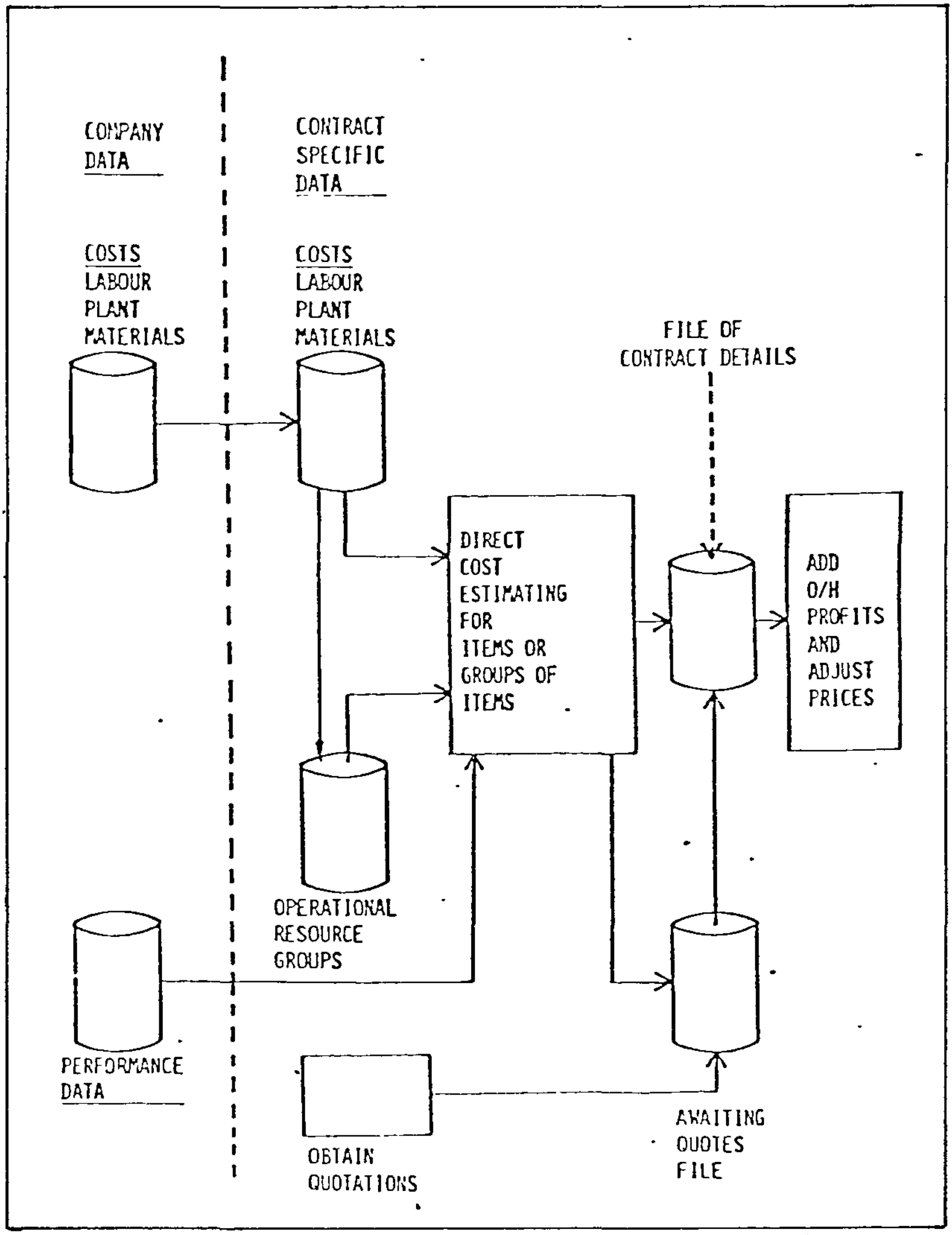


Figure 45 - The Flow Chart of the INTEREST system

No start or finish point. The estimator can for as long as he wishes change or adjust his estimate build-up. Flexibility has been considered at all times to enable several alternatives to be taken and any adjustments made.

The system of commands are grouped together in a main and sub-menus. The main menu of commands is shown below:

INPUT ITEM
RETRIEVE ITEM
EDIT DATABASE RESOURCES
BUILD OPERATIONAL RATE
ADD MARKUPS
SORT AND EVALUATE
PRINT REPORTS
COPY ON
STOP

Each command enables the estimator to undertake a particular task. The approach to this task is determined by the selection of a command from the sub-menu displayed. A full listing of the commands and their inter-relationship is given in figure 46, page 203. An outline description of each of the commands and their function within the system is given below:

Command INPUT allows the input of data by the use of the following commands·

BILL SECTION and PAGE NUMBER allow the appropriate section and page number of the bill to be used. The estimator can work through the bill in the order the items are presented or move from section to section, page to page at will.

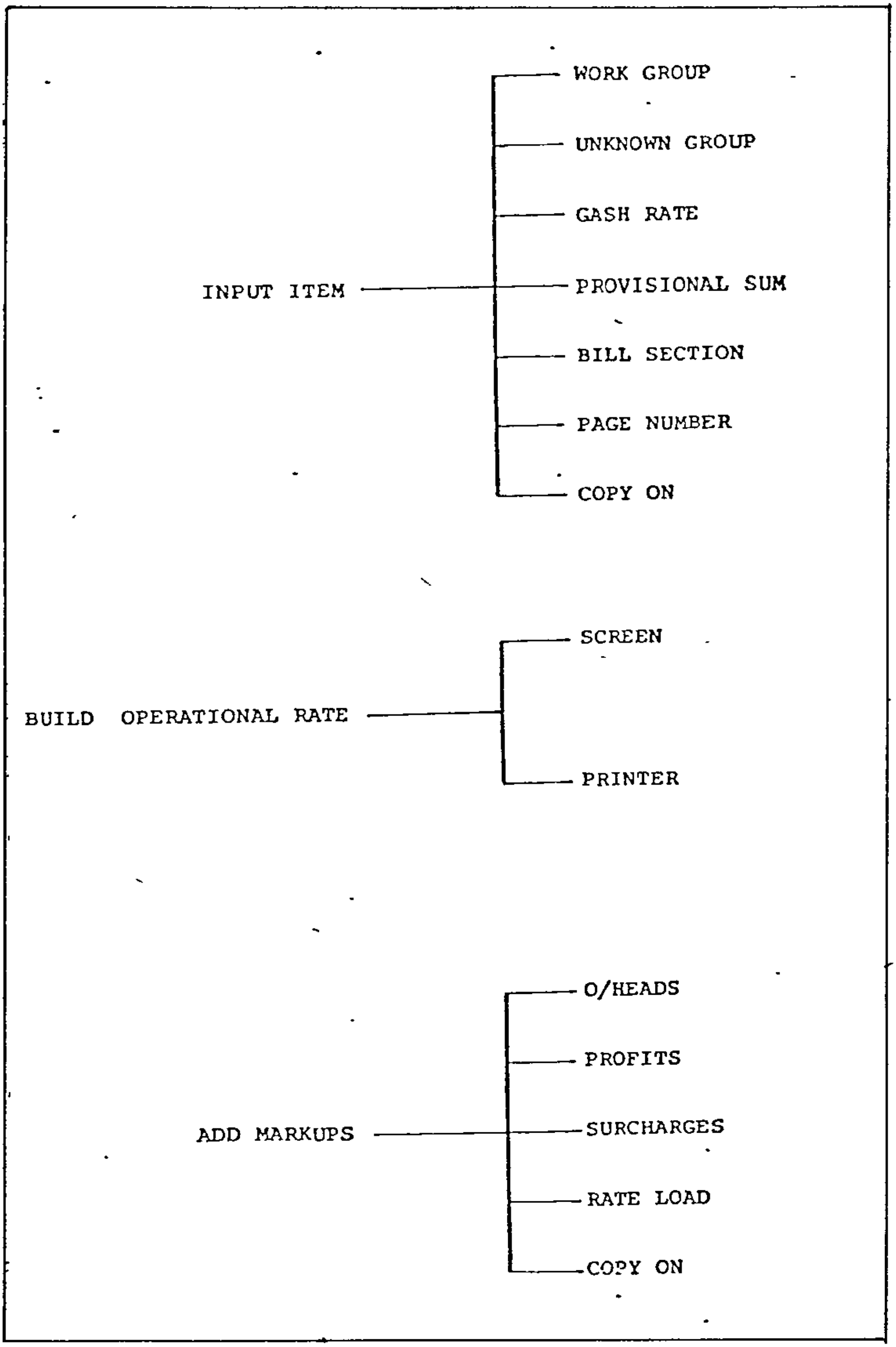


Figure 46 - Listing of Commands

- PRINT REPORTS
  - BILL LIST
  - SUMMARY LIST
  - PAGE LIST
  - SECTION LIST
  - RECONCILIATION
  - PLANT SHARING
  - DATABASE RESOURCE SHARING
  - QUOTES LIST
  - COPY ON
- RETRIEVE ITEM
- EDIT DATABASE RESOURCES
- SORT AND EVALUATE
- COPY ON
- STOP

Figure 46 - Listing of Commands (continued)

Commands WORK GROUP, UNKNOWN GROUP and CASH RATE allow the estimator to prepare a cost estimate of an item or group of items. WORK GROUP uses data held on a computer file. These data comprise resource groups or build-ups for commonly recurring items of work. The other two commands rely on filed data relating to individual resources or upon resource information and rates input by the estimator.

The PROVISIONAL SUM command is designed for the entry of Provisional Sum items by allowing the entry of a single sum of money to cover the bill item.

The command RETRIEVE ITEM enables the user to retrieve at any time any item that has previously been priced and fitted onto the contract file. The build-up of the item can then be re-worked if required and the item returned to the contract file.

The command EDIT DATABASE RESOURCES allows the description, cost code, cost and units of resources on the contract database to be inspected and amended to suit the contract as required.

The command BUILD OPERATIONAL RATE allows the user to calculate an overall price rate for groups of resources based on a total amount of work and a total time on site. The options SCREEN and PRINTER determine whether the output giving the breakdown of the group is presented to the user via the Visual Display Unit or the printer.

The command ADD MARKUPS is used to add monies to the direct cost of the contract by the following commands:

OVERHEADS and PROFITS allow the addition of overheads and profits on a percentage and lump sum basis. This money is then apportioned throughout the bill items.

SURCHARGE allows the adjudication panel to surcharge or reduce monies under any of the cost code headings on a percentage basis.

RATE LOAD allows specific bill items to be chosen and their value increased whilst all the other items on the bill are reduced pro rata.

The user may enter bill items in any order. The command SORT and EVALUATE must be used before any listing or reports are generated from the contract file.

The command PRINT REPORTS gives the user the ability to obtain various reports of information from the contract file.

BILL LIST, SUMMARY LIST, PAGE LIST, SECTION LIST are lists of the items on the contract file with different forms of presentation.

QUOTES LIST is a report from the file containing information on the materials for which quotations have been requested.

PLANT SHARING and DATABASE RESOURCE SHARING give printouts of the resources used in Operational Estimating with details of how the resources have been allocated to the various Operational Groups.

The command COPY ON allows the user to obtain a printout of all the input and information displayed via the V.D.U.

The command STOP closes all the files and calls a halt to the program.

7.2 A DETAILED DESCRIPTION OF THE PROCEDURES AND OPERATIONS ADOPTED WITHIN THE SYSTEM TO MEET THE MAIN REQUIREMENTS

7.2.1 THE CALCULATION OF BILL ITEM PRICES

The calculation processes adopted by the estimator require that different types of operations may be performed on input data to produce priced items within the Bill of Quantities. Facilities were produced to undertake:

- Unit-rate estimating;
- Operational estimating;
- a combination of Unit rate and Operational estimating;
- apply rates to individual cost code categories within the bill items;
- enter a single sum of money to cover a bill item.

Within the Interest system, Unit rate estimating may be carried out by reference to Work Groups held on the data library or by a combination of resources to produce groups unique to the contract under consideration. Performance and cost data may be entered by the user or obtained from information held on the library files. The operations of Unit rate estimating are performed by the WORK GROUP and UNKNOWN GROUP commands.

WORK GROUP COMMAND

This command is used to form the basis of pricing a standard bill item.

After having entered the bill item number, quantity and the reference code for the work group, the bill item is priced using the resources stored within the relevant work group held in the library.

A full breakdown of the item is displayed on the V.D.U. for the estimator to check. The total item cost and unit rate is shown together with resource costs and usage rates. If the estimator answers YES to the question 'Do you want a reconciliation?' the total amount of each resource required to complete the item is given.

The estimator then has full flexibility to amend anything within the build-up before the item is passed to the contract file. This is done by a number of options:

FILE	-	to put item into the contract file.
RATIO	-	to change a usage rate by a percentage.
MODIFY	-	to add or delete resources or modify usage rates.
OPERATIONAL	-	to add or delete operational rates.
LUMP	-	to apply the calculated rate to other items.
CHANGE	-	to change the quantity.

The example below shows the pricing of a bill item relating to brickwork. In practive the estimator should not need to make all these changes but they have been included below to show the full facilities available. Everything underlined has been entered by the estimator. All other information is displayed automatically by the computer. The estimator has to price the bill item.

A - BRICK FACEWORK 105MM THICKNESS AS DRAWING NO. 3050.31/RB/6645 226m^2

- He decides to use work group U221.0 from the database library to price the item.

```
Command?
WO
WORK GROUP option
Section  1  Page   1
Item letter?
A
Library CESMM code?
U221.Ø
FACING HALF-BRICK       VERTICAL WALLS
Quantity (in M2  )?
126

Section  1  Page   1  Item A
Library CESMM code U221.Ø
FACING HALF-BRICK       VERTICAL WALLS                          126.ØØ M2
Data base resources
--------------------
Res.  Cat.  Description             Usage rate          Cost              Total
----  ----  -----------             ----------          ----              -----
 558  DIR.  FACING BRICKS           Ø.Ø58 TH  /M2      52.35Ø $/TH       $382.57
 56Ø  DIR.  MORTAR                  Ø.Ø22 M3  /M2      22.85Ø $/M3        $63.34
 562  LAB.  BRICKLAYER              2.4ØØ HR  /M2       3.65Ø $/HR      $11Ø3.76
 563  LAB.  BRICKLAYER'S LABOURE    1.92Ø HR  /M2       2.75Ø $/HR       $665.28
 561  AUX.  SCAFFOLDING UP TO TH    1.ØØØ M2  /M2       2.4ØØ $/M2       $3Ø2.4Ø
                                                                    -------------
Item rate     19.98 $/M2                               Item cost      $2517.35
Do you want a reconciliation of data base resources?
Y
Res.  Cat.  Description                                              Amount
----  ----  -----------                                              ------
 558  DIR.  FACING BRICKS                                              7.31 TH
 56Ø  DIR.  MORTAR                                                     2.77 M3
 562  LAB.  BRICKLAYER                                               3Ø2.4Ø HR
 563  LAB.  BRICKLAYER'S LABOURER                                    241.92 HR
 561  AUX.  SCAFFOLDING UP TO THREE METRES                           126.ØØ M2
Options are:-
      FILE   - to put item into the contract file
      RATIO  - to change a usage rate by a percentage
      MODIFY - to add or delete resources or modify usage rates
      OPERATIONAL - to add or delete operational rates
      LUMP   - to apply the calculated rate to other items
      CHANGE - to change the quantity
```

The estimator decides that the usage rate for the bricklayer must be increased by 25 per cent so he uses the RATIO option.

```
Option?
RA
RATIO option
Resource number?
562
Percentage increase/decrease in usage rate?
25
Resource number?
END
Section  1  Page   1  Item A
Library CESMM code U221.0
FACING HALF-BRICK       VERTICAL WALLS                          126.00 M2
Data base resources
-------------------
Res.  Cat.  Description             Usage rate        Cost              Total
----  ----  -----------             ----------        ----              -----
 558  DIR.  FACING BRICKS           0.058 TH  /M2     52.350 $/TH      $382.57
 560  DIR.  MORTAR                  0.022 M3  /M2     22.850 $/M3       $63.34
 562  LAB.  BRICKLAYER              3.000 HR  /M2      3.650 $/HR     $1379.70
 563  LAB.  BRICKLAYER'S LABOURE    1.920 HR  /M2      2.750 $/HR      $665.28
 561  AUX.  SCAFFOLDING UP TO TH    1.000 M2  /M2      2.400 $/M2      $302.40
                                                                   ------------
                                                  Item cost         $2793.29
Item rate     22.17 $/M2
Do you want a reconciliation of data base resources?
Y
Res.  Cat.  Description                                              Amount
----  ----  -----------                                              ------
 558  DIR.  FACING BRICKS                                            7.31 TH
 560  DIR.  MORTAR                                                   2.77 M3
 562  LAB.  BRICKLAYER                                             378.00 HR
 563  LAB.  BRICKLAYER'S LABOURER                                  241.92 HR
 561  AUX.  SCAFFOLDING UP TO THREE METRES                         126.00 M2
Options are:-
      FILE   - to put item into the contract file
      RATIO  - to change a usage rate by a percentage
      MODIFY - to add or delete resources or modify usage rates
      OPERATIONAL - to add or delete operational rates
      LUMP   - to apply the calculated rate to other items
      CHANGE - to change the quantity
```

The estimator decides to delete the resource number 561, SCAFFOLDING UP TO THREE METRES and price for the provision of this resource in the preliminaries section of the bill. The modify option is used to delete the resource from the build-up.

```
Options are:-
      MODIFY RESOURCE
      ADD RESOURCE
       DELETE RESOURCE
      DISPLAY ITEM
 Option?
DE
Resource number?
561
```

It is required to increase the price of the mortar in this item to £33.25/m^3 from £22.850/m^3.

```
Options are:-
      MODIFY RESOURCE
      ADD RESOURCE
       DELETE RESOURCE
      DISPLAY ITEM
 Option?
MO
Resource number?
560
Resource  560    MORTAR
Usage rate   0.022 M3  /M2
Cost  22.850 $/M3
Do you wish to change the usage rate?
NO
Do you wish to change the cost?
Y
New cost (in $/M3  )?
33.25
```

and add the provision of a dumper to assist with the work.

```
Options are:-
      MODIFY RESOURCE
      ADD RESOURCE
       DELETE RESOURCE
      DISPLAY ITEM
 Option?
ADD
Resource number?
19
PLT. DUMPER     1.20M3                               1.940 $/HR
Confirm?
Y
Usage rate (in HR  /M2  )?
0.1
```

```
Options are:-
     MODIFY RESOURCE
     ADD RESOURCE
      DELETE RESOURCE
     DISPLAY ITEM
 Option?
DI
Section  1  Page   1  Item A
Library CESMM code U221.0
FACING HALF-BRICK        VERTICAL WALLS                          126.00 M2
Data base resources
-------------------
Res.  Cat.  Description              Usage rate          Cost              Total
----  ----  -----------              ----------          ----              -----
 550  DIR.  FACING BRICKS            0.058 TH   /M2     52.350 $/TH       $382.57
 560  DIR.  MORTAR                   0.022 M3   /M2     33.250 $/M3        $92.17
 562  LAB.  BRICKLAYER               3.000 HR   /M2      3.650 $/HR      $1379.70
 563  LAB.  BRICKLAYER'S LABOURE     1.920 HR   /M2      2.750 $/HR       $665.28
  19  PLT.  DUMPER      1.20M3       0.100 HR   /M2      1.940 $/HR        $24.44
                                                                     -------------
Item rate    20.19 $/M2                               Item cost       $2544.17
Do you want a reconciliation of data base resources?
NO
Options are:-
     FILE   - to put item into the contract file
     RATIO  - to change a usage rate by a percentage
     MODIFY - to add or delete resources or modify usage rates
     OPERATIONAL - to add or delete operational rates
     LUMP   - to apply the calculated rate to other items
     CHANGE - to change the quantity
Option?
```

The estimator is now happy with the build-up for the item but realizes he has entered an incorrect quantity. The option CHANGE is used to correct this:

```
CH
New quantity?
226
Section  1  Page   1  Item A
Library CESMM code U221.0
FACING HALF-BRICK        VERTICAL WALLS                          226.00 M2
Data base resources
-------------------
Res.  Cat.  Description              Usage rate          Cost              Total
----  ----  -----------              ----------          ----              -----
 558  DIR.  FACING BRICKS            0.058 TH   /M2     52.350 $/TH       $686.20
 560  DIR.  MORTAR                   0.022 M3   /M2     33.250 $/M3       $165.32
 562  LAB.  BRICKLAYER               3.000 HR   /M2      3.650 $/HR      $2474.70
 563  LAB.  BRICKLAYER'S LABOURE     1.920 HR   /M2      2.750 $/HR      $1193.28
  19  PLT.  DUMPER      1.20M3       0.100 HR   /M2      1.940 $/HR        $43.84
                                                                     -------------
Item rate    20.19 $/M2                               Item cost       $4563.34
Do you want a reconciliation of data base resources?
NO
Options are:-
     FILE   - to put item into the contract file
     RATIO  - to change a usage rate by a percentage
     MODIFY - to add or delete resources or modify usage rates
     OPERATIONAL - to add or delete operational rates
     LUMP   - to apply the calculated rate to other items
     CHANGE - to change the quantity
Option?
```

It is decided to file the item build-up onto the contract file and price another item. However, it is required to price two other items at the same rate so the option LUMP is used to apply this build-up to the relevant items in addition to bill item 1/A.

```
LU
Item filed
LUMP option
Are you entering all items in the same bill section?
NO
Bill section?
2
Page number?
2
Item letter?
A
Quantity (in M2  )?
126
Item filed
Bill section?
3
Page number?
21
Item letter?
A
Quantity (in M2  )?
78
Item filed
Bill section?
END
 2 extra item(s) entered using rate    28.19 $/M2
```

(Note: Using the option FILE would have priced only item 1/A using these resources and rates).

Contained within the list of options is that of:

OPERATIONAL - to add or delete operational rates.

Section 7.2.1 describes how operational rates can be built up using data from the company plant file or the contract database. These rates can be applied to work groups from the database files.

UNKNOWN GROUP COMMAND

It would be impossible to set up a library of work groups to cover every activity and bill item encountered on civil engineering contracts.

The command UNKNOWN GROUP enables the estimator to build up his own work group to price an item. Held within the database are listings of resources and their costs. The user can build up his item cost using these resources or add in resources previously unknown to the system to produce a unique grouping for the particular contract.

The bill item code and a description of the work must be entered together with the units and the quantity. Also required is a CESMM classification to assist with sorting of the items by trade.

The estimator must decide whether he wishes to build up the unknown group using Unit rates from the database or operational rates that he has compiled separately. An example of the Unit rate calculation is shown on the following page.

Unit Rates

The estimator enters the option UN and then is faced with a list of options:

MODIFY RESOURCE

ADD RESOURCE

DELETE RESOURCE

DISPLAY ITEM

First he will want to add resources together so he uses the option ADD. He will be asked to enter a resource number. If this resource is already in the library a description will be printed out to check that it is the resource of which the estimator was thinking. Assuming it was the correct resource, he is then required to enter a usage rate and the resource is added into the build up. If the resource of the number was not on the file a message will be given:

'Resource is not in file.

Do you wish to enter a resource with this number'

Answering YES requires some additional information to be entered:

A description of the resource

The cost code

Units of the resource

Cost per hour.

This resource is then added to the resource listing for the duration of the contract. If at any time it is wished to delete or modify any of the resources built up this can be performed by use of the option DELETE and MODIFY.

When the estimator wishes to see the overall build up he can call upon the option DISPLAY which will give him a full breakdown of the item, the resources included and the total cost.

The item can then be dealt with as per the normal options:

FILE

RATIO

MODIFY etc.

An example of using the UNKNOWN GROUP command is now given.

```
        Commands are:-
                    WORK GROUP
                    UNKNOWN GROUP
                    CASH RATE
                    PROVISIONAL SUM
                    BILL SECTION
                    PAGE NUMBER
        (or press RETURN to return to main menu)
Command?
UN
UNKNOWN GROUP option
Section  1  Page   1
Item letter?
B
CESMM classification?
E999.0
Description?
EXCAVATION OF UNSUITABLE MATERIAL
Units?
M3
Quantity?
50
Options are:-
      UNIT RATES
      OPERATIONAL RATES
Option?
UN
Options are:-
      MODIFY RESOURCE
      ADD RESOURCE
       DELETE RESOURCE
      DISPLAY ITEM
 Option?
ADD
Resource number?
136
Resource is not on file.
Do you wish to enter a resource with this number?
Y
Description?
JCB 3C EXCAVATOR
Cost code?
PLT
Units?
HR
Is this Item Requiring Quotes?
N
Cost (in $/HR  )?
4.5
PLT.  JCB 3C EXCAVATOR                                  4.500 $/HR
Usage rate (in HR  /M3  )?
0.25
```

```
Options are:-
      MODIFY RESOURCE
      ADD RESOURCE
       DELETE RESOURCE
      DISPLAY ITEM
 Option?
ADD
Resource number?
28

PLT.  LORRY TIPPER 6.5 TONNE                                  3.540 $/HR
Usage rate (in HR  /M3  )?
0.25
Options are:-
      MODIFY RESOURCE
      ADD RESOURCE
       DELETE RESOURCE
      DISPLAY ITEM
 Option?
ADD
Resource number?
1
LAB.  LABOURER                                                2.750 $/HR
Confirm?
Y
Usage rate (in HR  /M3  )?
0.25


Options are:-
      MODIFY RESOURCE
      ADD RESOURCE
       DELETE RESOURCE
      DISPLAY ITEM
 Option?
DI
Section  1  Page   1  Item 8
CESMM classification E999.0
EXCAVATION OF UNSUITABLE MATERIAL                            50.00 M3
Data base resources
-------------------
Res.  Cat.  Description            Usage rate        Cost            Total
----  ----  -----------            ----------        ----            -----
 136  PLT.  JCB 3C EXCAVATOR      0.250 HR  /M3     4.500 $/HR       $56.25
  28  PLT.  LORRY TIPPER 6.5 TON  0.250 HR  /M3     3.540 $/HR       $44.25
   1  LAB.  LABOURER              0.250 HR  /M3     2.750 $/HR       $34.37
                                                                 -------------
Item rate     2.70 $/M3                             Item cost       $134.87
Do you want a reconciliation of data base resources?
YES
Res.  Cat.  Description                                         Amount
----  ----  -----------                                         ------
 136  PLT.  JCB 3C EXCAVATOR                                   12.50 HR
  28  PLT.  LORRY TIPPER 6.5 TONNE                             12.50 HR
   1  LAB.  LABOURER                                           12.50 HR
Options are:-
      FILE   - to put item into the contract file
      RATIO  - to change a usage rate by a percentage
      MODIFY - to add or delete resources or modify usage rates
      OPERATIONAL - to add or delete operational rates
      LUMP   - to apply the calculated rate to other items
      CHANGE - to change the quantity
Option?
FI
Item filed
```

Operational estimating may be carried out using weekly or hourly priced resources. Each calculation is performed using the total quantity of the work involved in the respective operation. Operational calculations are contract specific, the rate calculated being used only for the particular project. Operational estimating is carried out by using the BUILD OPERATIONAL RATE command.

BUILD OPERATIONAL RATE COMMAND

The command BUILD OPERATIONAL RATE is used by the estimator when it is required to price certain items on an operational basis.

In the example following an operational group is built up to produce a plant rate for placing concrete (CONCPLA). This contains the same resources as the example shown in Section 3.2., and is produced by adding together plant items from the company plant file.

In addition to using resources from the company plant file, it is possible to build up operational groups from the hourly priced resources on the contract database. A group is built up to cover the labour for placing concrete (CONCLAY) using this source of data.

```
Calculation of Operational Group Rate
Input Operation RATE Code
PLACON
Enter Description
PLANT FOR PLACING CONCRETE
Enter Units
M3
Enter Total Quantity for the Operation
8000

            Build up of the Resources for the Operation
Enter Average Number of HOURS/WEEK
56
           DATA OPTIONS
 CP - Enter Data from Company Plant File
 DB - Enter Data from Contract Data Base
 ST - Stop
Enter Option
CP
Enter Resource Code(Type END when Finished)
990
  990  22RB CRANE                                      $220.00
```

```
Is that OK ?
Y
How many of this Resource type are Required ?
2
Enter Total Number of Weeks on Contract(0.2 Weeks = 1 Day)
76
Enter Total Allocation as a Percentage
100
Enter Resource Code(Type END when Finished)
991
  991  CONCRETE SKIP                                        $20.00
Is that OK ?
Y
How many of this Resource type are Required ?
4
Enter Total Number of Weeks on Contract(0.2 Weeks = 1 Day)
152
Enter Total Allocation as a Percentage
100
Enter Resource Code(Type END when Finished)
992
  992  DUMPER                                               $25.00
Is that OK ?
Y
How many of this Resource type are Required ?
6
Enter Total Number of Weeks on Contract(0.2 Weeks = 1 Day)
228
Enter Total Allocation as a Percentage
100
Enter Resource Code(Type END when Finished)
993
  993  VIBRATOR                                             $10.00
Is that OK ?
Y
How many of this Resource type are Required ?
6
Enter Total Number of Weeks on Contract(0.2 Weeks = 1 Day)
228
Enter Total Allocation as a Percentage
10
Figure is not a real value
 Please enter again
100
Enter Resource Code(Type END when Finished)
END
          DATA OPTIONS
 CP - Enter Data from Company Plant File
 DB - Enter Data from Contract Data Base
 ST - Stop
Enter Option
ST
PLACON   - PLANT FOR PLACING CONCRETE                          Units M3
---------------------------------------------------------------------------
                                                       Average      Resource
  Res Cat  Description      Unit  $/Week No Week Alloc. Output Rate    Cost
  --- ---  -----------      ----  ------ ------- ------ -----------  --------
P 990 PLT. 22RB CRANE          2  220.00   76.00 100.00 0.53  HR/M3  $16,720.00
P 991 PLT. CONCRETE SKIP       4   20.00  152.00 100.00 1.06  HR/M3   $3,040.00
P 992 PLT. DUMPER              6   25.00  228.00 100.00 1.60  HR/M3   $5,700.00
P 993 PLT. VIBRATOR            6   10.00  228.00 100.00 1.60  HR/M3   $2,280.00
                                                                   -----------
                                          Total Cost for Operation  $27,740.00
                                                                   -----------
Total Quantity used in Calculation       8000.00 M3
Rate for the Operation                      3.47  $/M3
Options are :-
               FILE   - File Resource Build up and Rate
               DELETE - Remove Operational Rate from File
               MODIFY - Add, Delete, or Modify Resources
               CHANGE - Change the Quantity used
FI
```

```
Input Operation RATE Code
CONCLA
Enter Description
LABOUR FOR PLACING CONCRETE
Enter Units
M3
Enter Total Quantity for the Operation
8000

          Build up of the Resources for the Operation
Enter Average Number of HOURS/WEEK
56
          DATA OPTIONS
 CP - Enter Data from Company Plant File
 DB - Enter Data from Contract Data Base
 ST - Stop
Enter Option
DB
Enter Resource Code(Type END when Finished)
1
   1  LABOURER                                                  $2.75 (Per Hour)
Is that OK ?
Y
How many of this Resource type are Required ?
5
Enter Total Number of Weeks on Contract(0.2 Weeks = 1 Day)
190
Enter Total Allocation as a Percentage
50
Enter Resource Code(Type END when Finished)
160
Do you wish to input a New Resource with Reference   160
Y
Enter Description
CONCRETE FINISHER
Enter Cost Code(1-5)
1
Input Cost(Per Hour)
3.5
Input Units
HR
 160  CONCRETE FINISHER                                         $3.50 (Per Hour)
```

```
Is that OK ?
Y
How many of this Resource type are Required ?
1
Enter Total Number of Weeks on Contract(Ø.2 Weeks = 1 Day)
36
Enter Total Allocation as a Percentage
1ØØ
Enter Resource Code(Type END when Finished)
END
          DATA OPTIONS
 CP - Enter Data from Company Plant File
 DB - Enter Data from Contract Data Base
 ST - Stop
Enter Option
ST
CONCLA    - LABOUR FOR PLACING CONCRETE                         Units M3
-------------------------------------------------------------------------------
                                                      Average       Resource
  Res Cat  Description     Unit  $/Week No Week Alloc. Output Rate    Cost
  --- ---  -----------     ----  ------ ------- ------ -----------  --------
    1 LAB. LABOURER           5  154.ØØ 19Ø.ØØ  5Ø.ØØ  Ø.66  HR/M3   $14,63Ø.ØØ
  16Ø LAB. CONCRETE FINISHER 1   196.ØØ  36.ØØ 1ØØ.ØØ  Ø.25  HR/M3    $7,Ø56.ØØ
                                                                   -----------
                                           Total Cost for Operation $21,686.ØØ
                                                                   -----------

Total Quantity used in Calculation       8ØØØ.ØØ M3
Rate for the Operation                     2.71  $/M3
Options are :-
             FILE   - File Resource Build up and Rate
             DELETE - Remove Operational Rate from File
             MODIFY - Add, Delete, or Modify Resources
             CHANGE - Change the Quantity used
FI
File Updated
```

Once operational rates have been calculated they may be used to price bill items using UNKNOWN command.

In the following example the estimator wishes to price the bill item:

F722.1 PLACE CONCRETE TO BASES 80m^3

by the UNKNOWN GROUP option. This is carried out using Operational Rates and the item priced by adding the operational rate codes PLACON and CONCLA together. When it is wishes to display the item build up this is carried out by using the option DISPLAY ITEM.

It is then possible to obtain a reconciliation of the resources used and, if required, use all the usual options:

FILE

RATIO

MODIFY

OPERATIONAL

LUMP

CHANGE

to make amendments.

```
        Commands are:-
                    WORK GROUP
                    UNKNOWN GROUP
                    GASH RATE
                    PROVISIONAL SUM
                    BILL SECTION
                    PAGE NUMBER
        (or press RETURN to return to main menu)
Command?
UN
UNKNOWN GROUP option
Bill section?
1
Page number?
1
Item letter?
F
CESMM classification?
F722.1
Description?
PLACE CONCRETE TO BASES
Units?
M3
Quantity?
80
```

```
Options are:-
      UNIT RATES
      OPERATIONAL RATES
Option?
OP
Options are:-
      ADD OPERATIONAL RATE
      DELETE OPERATIONAL RATE
      DISPLAY ITEM
Option?
ADD


Operational rate code?
PLACON
PLANT FOR PLACING CONCRETE                              3.47 $/M3
Amount allocated so far       0.00 M3
Confirm?
Y
Options are:-
      ADD OPERATIONAL RATE
      DELETE OPERATIONAL RATE
      DISPLAY ITEM
Option?
ADD
Operational rate code?
CONCLA
LABOUR FOR PLACING CONCRETE                  /          2.71 $/M3
Amount allocated so far       0.00 M3
Confirm?
Y
Options are:-
      ADD OPERATIONAL RATE
      DELETE OPERATIONAL RATE
      DISPLAY ITEM
Option?
DI


Section  1  Page   1  Item F
CESMM classification F722.1
PLACE CONCRETE TO BASES                                     80.00 M3
Operational rates
-----------------
Code      Description                              Cost          Total
----      -----------                              ----          -----
PLACON    PLANT FOR PLACING CONCRETE               3.47 $/M3     $277.40
CONCLA    LABOUR FOR PLACING CONCRETE              2.71 $/M3     $216.86
                                                             -------------
Item rate      6.18 $/M3                           Item cost     $494.26
Do you want a reconciliation of operational rates?
NO
Options are:-
      FILE    - to put item into the contract file
      RATIO  - to change a usage rate by a percentage
      MODIFY - to add or delete resources or modify usage rates
      OPERATIONAL - to add or delete operational rates
      LUMP    - to apply the calculated rate to other items
      CHANGE - to change the quantity
Option?
```

```
MO
     MODIFY RESOURCE
     ADD RESOURCE
      DELETE RESOURCE
     DISPLAY ITEM
 Option?
ADD
Resource number?
1
LAB.  LABOURER                                               2.750 $/HR
Confirm?
Y
Usage rate (in HR  /M3  )?
0.25
Options are:-
     MODIFY RESOURCE
     ADD RESOURCE
      DELETE RESOURCE
     DISPLAY ITEM
 Option?
DI
Section  1  Page   1  Item F
CESMM classification F722.1
PLACE CONCRETE TO BASES                                        80.00 M3
Data base resources
-------------------
Res.  Cat.  Description            Usage rate       Cost            Total
----  ----  -----------            ----------       ----            -----
   1  LAB.  LABOURER               0.250 HR  /M3    2.750 $/HR      $55.00
Operational rates
-----------------
Code       Description                              Cost            Total
----       -----------                              ----            -----
PLACON     PLANT FOR PLACING CONCRETE               3.47 $/M3       $277.40
CONCLA     LABOUR FOR PLACING CONCRETE              2.71 $/M3       $216.86
                                                                 -------------
Item rate      6.87 $/M3                            Item cost       $549.26
Do you want a reconciliation of data base resources?
NO
Do you want a reconciliation of operational rates?
N
Options are:-
      FILE    - to put item into the contract file
      RATIO   - to change a usage rate by a percentage
      MODIFY  - to add or delete resources or modify usage rates
      OPERATIONAL - to add or delete operational rates
      LUMP    - to apply the calculated rate to other items
      CHANGE  - to change the quantity
Option?
FI
```

In the example above the estimator has decided that for this particular bill item extra labour is required for the placing of the concrete to the bases. He uses the MODIFY OPTION to add the resource from the contract database file. This illustrates an important feature of the INTEREST system. Operational rates and unit rates can be added together.

Whenever the user wishes to make global percentage additions/ subtractions, the program prints out the current status of these to ensure that there is no chance of the amendments being made twice. While for example it would be potentially lucrative for a profit margin of 8% to be added twice, this would not be very beneficial if the tender was consequently too high and the company did not win the contract.

When the estimator wishes to price a bill item by a particular work group from the library or include an additional resource within an item build up a description of the resource and details of the cost are displayed and the user is asked whether this is in fact the resource that was required. In this manner it is a conscious decision by the estimator whether or not to accept a resource. This avoids gross errors where totally incorrect resources are included in build ups for work items.

Contained within the list of options displayed within the WORK GROUP command is the option:

OPERATIONAL - to add or delete operational rates.

In the following example, it is required to price a bill item:

MIX AND PLACE CONCRETE CLASS 30/20 -
56.00M3

This is carried out in the following manner. The provision of concrete is costed using a work group (classification F153.0) from the database file. To this is added the two operational rates calculated for the operational groups LAYCONC and CONCPLA.

```
WO
WORK GROUP option
Section  1  Page   1
Item letter?
E
Library CESMM code?
F153.0
DESIGN STRUT. CONC. 30 MPA  20 MM. AGGR. OPC
Quantity (in M3  )?
56
Section  1  Page   1  Item E
Library CESMM code F153.0
DESIGN STRUT. CONC. 30 MPA  20 MM. AGGR. OPC                          56.00 M3
Data base resources
-------------------
Res.  Cat.  Description            Usage rate          Cost                Total
----  ----  -----------            ----------          ----                -----
 500  PLT.  20/14 MIXER            0.160 HR   /M3      1.880 $/HR          $16.84
 501  PLT.  2M3 READY-CRETE TRUC   0.140 HR   /M3      2.400 $/HR          $18.82
 503  DIR.  OPC                    0.400 TN   /M3     23.320 $/TN         $522.37
 505  DIR.  SAND                   0.350 M3   /M3      3.900 $/M3          $76.44
 508  DIR.  20 MM AGGR.            1.000 TN   /M3      3.900 $/TN         $218.40
 511  PLT.  DIESEL                 1.050 GA   /M3      0.850 $/GA          $49.98
 512  PLT.  SILO (50 TONNE)        0.160 HR   /M3      0.500 $/HR           $4.48
 513  LAB.  MIXER DRIVER           0.160 HR   /M3      2.890 $/HR          $25.89
 514  LAB.  SHOVEL OPERATER        0.160 HR   /M3      2.890 $/HR          $25.89
                                                                        -------------
Item rate    17.13 $/M3                                Item cost          $959.12
Do you want a reconciliation of data base resources?
NO
Options are:-
      FILE    - to put item into the contract file
      RATIO   - to change a usage rate by a percentage
      MODIFY  - to add or delete resources or modify usage rates
      OPERATIONAL - to add or delete operational rates
      LUMP    - to apply the calculated rate to other items
      CHANGE  - to change the quantity
Option?
OP
Options are:-
      ADD OPERATIONAL RATE
      DELETE OPERATIONAL RATE
      DISPLAY ITEM
Option?

ADD
Operational rate code?
PLACON
PLANT FOR PLACING CONCRETE                                 3.47 $/M3
Amount allocated so far      80.00 M3
Confirm?
Y
Options are:-
      ADD OPERATIONAL RATE
      DELETE OPERATIONAL RATE
      DISPLAY ITEM
Option?
ADD
Operational rate code?
CONCLA
LABOUR FOR PLACING CONCRETE                                2.71 $/M3
Amount allocated so far      80.00 M3
Confirm?
Y
Options are:-
      ADD OPERATIONAL RATE
      DELETE OPERATIONAL RATE
      DISPLAY ITEM
Option?
DI
```

```
Section  1  Page   1  Item E
Library CESMM code F153.0
DESIGN STRUT. CONC. 30 MPA  20 MM. AGGR. OPC                        56.00 M3
Data base resources
-------------------
Res.  Cat.  Description              Usage rate          Cost              Total
----  ----  -----------              ----------          ----              -----
 500  PLT.  20/14 MIXER              0.160 HR  /M3       1.880 $/HR        $16.84
 501  PLT.  2M3 READY-CRETE TRUC     0.140 HR  /M3       2.400 $/HR        $18.82
 503  DIR.  OPC                      0.400 TN  /M3      23.320 $/TN       $522.37
 505  DIR.  SAND                     0.350 M3  /M3       3.900 $/M3        $76.44
 508  DIR.  20 MM AGGR.              1.000 TN  /M3       3.900 $/TN       $218.40
 511  PLT.  DIESEL                   1.050 GA  /M3       0.850 $/GA        $49.98
 512  PLT.  SILO (50 TONNE)          0.160 HR  /M3       0.500 $/HR         $4.48
 513  LAB.  MIXER DRIVER             0.160 HR  /M3       2.890 $/HR        $25.89
 514  LAB.  SHOVEL OPERATER          0.160 HR  /M3       2.890 $/HR        $25.89
Operational rates
-----------------
Code      Description                                    Cost              Total
----      -----------                                    ----              -----
PLACON    PLANT FOR PLACING CONCRETE                     3.47 $/M3        $194.18
CONCLA    LABOUR FOR PLACING CONCRETE                    2.71 $/M3        $151.80
                                                                      -------------
Item rate    23.31 $/M3                                  Item cost       $1305.10
Do you want a reconciliation of data base resources?
NO
Do you want a reconciliation of operational rates?
NO
Options are:-
      FILE   - to put item into the contract file
      RATIO  - to change a usage rate by a percentage
      MODIFY - to add or delete resources or modify usage rates
      OPERATIONAL - to add or delete operational rates
      LUMP   - to apply the calculated rate to other items
      CHANGE - to change the quantity
Option?
FI
```

There will always be some items in the bill for which the estimator will not want to make a complete build-up but will only want to enter a suitable rate under the various cost codes. If this is the case then the GASH RATE command should be used.

GASH RATE COMMAND

An item number, description, the quantity and units must be entered and a rate entered for each cost code as required.

The full options available are:

ADD RATE

CHANGE RATE

DELETE RATE

DISPLAY ITEM

From the above it will be seen that it is always possible to amend any rate entered. The option DISPLAY ITEM produces a full listing of cost codes, the rates entered and the overall item rate and cost.

The options:

FILE

MODIFY

LUMP etc.

can then be utilised as required.

The example given below shows how the GASH RATE command is used to price a bill item 'BREAK OUT EXISTING REINFORCED CONCRETE'. The estimator decides to enter a rate for labour and plant to cover this item.

```
                    WORK GROUP
                    UNKNOWN GROUP
                    GASH RATE
                    PROVISIONAL SUM
                    BILL SECTION
                    PAGE NUMBER
      (or press RETURN to return to main menu)
Command?
GA
GASH RATE option
Section 1  Page  1
Item letter?
C
CESMM classification?
E998.0
Description?
```

```
BREAK OUT EXISTING CONCRETE
Units?
M3
Quantity?
25
Options are:-
      ADD RATE
       CHANGE RATE
       DELETE RATE
      DISPLAY ITEM
 Option?
ADD
Cost code?
LAB
Rate (in $/M3  )?
21.25
Options are:-
      ADD RATE
       CHANGE RATE
       DELETE RATE
      DISPLAY ITEM
 Option?
ADD
Cost code?
PLT
Rate (in $/M3  )?
45.5
Options are:-
      ADD RATE
       CHANGE RATE
       DELETE RATE
      DISPLAY ITEM
 Option?
DI
Section  1  Page  1  Item C
CESMM classification E998.0
BREAK OUT EXISTING CONCRETE                                          25.00 M3
      Category                     Rate in $/M3
      --------                     ------------
        LAB.                              21.25
        PLT.                              45.50
                                      ----------
                        Item rate         66.75 $/M3
                        Item cost       $1668.75
Options are:-
      FILE   - to put item on contract file
      MODIFY - to alter a rate
      LUMP   - to apply the calculated rate to other items
      CHANGE - to change the quantity
Option?
MO
Options are:-
      ADD RATE
       CHANGE RATE
       DELETE RATE
      DISPLAY ITEM
 Option?
CH
Cost code?
PLT
Rate is      45.50 $/M3
New rate?
35.5
Options are:-
      ADD RATE
       CHANGE RATE
       DELETE RATE
      DISPLAY ITEM
 Option?
DI
Section  1  Page  1  Item C
CESMM classification E998.0
BREAK OUT EXISTING CONCRETE                                          25.00 M3
      Category                     Rate in $/M3
      --------                     ------------
        LAB.                              21.25
        PLT.                              35.50
                                      ----------
                        Item rate         56.75 $/M3
                        Item cost       $1418.75
```

PROVISIONAL SUM COMMAND

For Provisional Sum Items it is required to enter a single sum of money against an item as specified in the Bill of Quantities. This is undertaken with the Provisional Sum Command. This command allows a sum of money to be allocated to a bill item. This is then stored under the Provisional Sum cost code. No surcharge or mark-up factors are applied to this category so that in the final bill listing this sum remains as originally stated by the client's quantity surveyor.

An example of using this command is shown below.

```
      Commands are:-
                    WORK GROUP
                    UNKNOWN GROUP
                    GASH RATE
                    PROVISIONAL SUM
                    BILL SECTION
                    PAGE NUMBER
      (or press RETURN to return to main menu)
 Command?
 PR
 PROVISIONAL SUM option
 Section  1  Page   1
 Item letter?
 Y
 CESMM classification?
 X123.0
 Description?
 INSTALL PUMPS
 Sum?
 2500
 Section  1  Page  1  Item Y
 CESMM classification X123.0
 INSTALL PUMPS
 Sum:  $2500.00    Cost code: PROV
 Options are:-
      FILE   - to put the item on the contract file
      CHANGE - to change the sum of money
 Option?
 FI
```

7.2.2 APPLICATION OF CALCULATED ITEM RATES AGAINST ALL RELEVANT BILL ITEMS

The build-up of a particular bill item may be used to automatically price other items within the Bill of Quantities that the estimator has decided to price at the same rate and using the same resources.

This procedure is performed by using the LUMP option. The estimator is required to enter details of the bill items which he wishes to price at the same rate, (item reference, quantity, units etc) and the item is then priced automatically.

7.2.3 THE EXTENSION AND SUMMATION OF BILL ITEMS TO PRODUCE DIRECT COST TOTALS

By using the command SORT AND EVALUATE, the computer calculates the extension of each bill item (the quantity x rate) and produces the total cost for the contract by the summation of all bill item costs. The cost totals are produced at various levels of collection and information is printed out giving:

- the breakdown of the item total rate into the rate for each cost code category;
- the item total rate;
- the bill item amount;
- the page total;
- the section total;
- the total cost of all the bill items.

Examples of these totals are given in the next section of this chapter.

7.2.4 REPORTS AND BILL LISTINGS

The estimator may at any time obtain one of several reports using the bill items priced to date, the resources used and the price quotations received or still outstanding. The type of reports available are listed in the menu below.

BILL LIST

SUMMARY LIST

RECONCILIATION

PLANT SHARING

DATA BASE RESOURCE SHARING

QUOTES LIST

Examples of these reports are given in figures 47 to 51, pages 233 to 237 . Some of these reports (eg. BILL LIST) are a direct copy of the reports produced in the existing manual process of estimating and tendering. Others (such as RECONCILIATION) are produced readily by the computer but are unobtainable within the manual process without prodigious clerical effort.

The command RECONCILIATION enables the estimator to obtain a listing of the total of each resource used on the project estimate. For each resource the number, description and total quantity is given along with the total direct cost and total resource contribution (ie direct cost + mark up).

Reports such as QUOTES LIST enable the estimator to pass information to other functions within the company organization. In this case the buyer may be provided with a listing of resources for which the estimator still requires quotations that have to be included within the estimate calculations.

Bill Of Quantities Listing

PAGE 1 Contracts - PRINT OUT FOR MANUAL DATE 5/10/80

BILL PAGE 1
BILL SECTION 1

		LAB.rate	PLT.rate	DIR.rate	AUX.rate	S/C.rate	TOT.rate	Quantity	Sum	
A	FACING HALF-BRICK VERTICAL WALLS									
		20.34	.38	10.18	0.00	0.00	30.90	226.00 M2	6983.40	
B	EXCAVATION OF UNSUITABLE MATERIAL									
		1.21	3.39	0.00	0.00	0.00	4.60	50.00 M3	230.00	
C	BREAK OUT EXISTING CONCRETE.									
		37.50	59.84	0.00	0.00	0.00	97.34	25.00 M3	2433.50	
E	DESIGN STRUT. CONC. 30 MPA. 20 MM. AGGR. OPC									
		5.58	6.73	0.00	1.32	0.00	13.63	56.00 M3	763.28	**Awaiting Quotes**
F	PLACE CONCRETE TO BASES									
		6.08	5.52	0.00	0.00	0.00	11.61	80.00 M3	928.80	
Z	INSTALL PUMPS								2500.00	
									************	
									13,838.98	

Figure 47 - AN EXAMPLE OF A BILL LIST PRINT OUT WITH THE FULL BREAKDOWN OF EACH COST CODE RATE, TOTAL RATE, QUANTITY AND SUM

Bill Of Quantities Listing

PAGE 1 Contract: - PRINT OUT FOR MANUAL DATE 5/10/80

BILL PAGE 1
BILL SECTION 1

		TOT.rate	Quantity	Sum	
A	FACING HALF-BRICK VERTICAL WALLS	30.90	226.00 M2	6983.40	
B	EXCAVATION OF UNSUITABLE MATERIAL	4.60	50.00 M3	230.00	
C	BREAK OUT EXISTING CONCRETE	97.34	25.00 M3	2433.50	
E	DESIGN STRUT. CONC. 30 MPA 20 MM. AGGR. OPC	13.63	56.00 M3	763.28	**Awaiting Quote**
F	PLACE CONCRETE TO BASES	11.61	80.00 M3	928.80	
I	INSTALL PUMPS			2500.00	
				***********	
				£13,838.98	

Figure 48 - AN EXAMPLE OF THE BILL LIST PRINT OUT GIVING THE DESCRIPTION, TOTAL RATE, QUANTITY AND SUM

Bill Of Quantities Listing

Contract1 - PRINT OUT FOR MANUAL DATE 5/10/80

TENDER PRICE SUMMARY

LABOUR COSTS

DIRECT COST	5812.49		
OVERHEAD @ 12.0 %	697.50		
	***********		
DIRECT COST PLUS OVERHEAD		6509.99	
PROFIT @ 8.0 %		520.80	
PROPORTION OF LUMP SUM		2886.95	
		**********	
TOTAL TENDER PRICE FOR LABOUR			£9,917.74

PLANT COSTS

DIRECT COST	1611.78		
OVERHEAD @ 20.0 %	322.36		
	***********		
DIRECT COST PLUS OVERHEAD		1934.13	
PROFIT @ 8.0 %		154.73	
PROPORTION OF LUMP SUM		800.54	
		**********	
TOTAL TENDER PRICE FOR PLANT			£2,889.40

Figure 49 - THE TENDER PRICE SUMMARY OF THE BILL PRINT OUT

Resource Reconciliation

PAGE 1 Contract 1 - PRINT OUT FOR MANUAL DATE 5/10/89

SUMMARY OF RESOURCES USED IN UNIT RATE ESTIMATING

Resource Number	Description	Resource Total Quantity	Resource Direct Cost	Resource Contribution
1	LABOUR	32.50 HR	£98.31	£157.73
19	DUMPER 1.20M3	43.00 HR	£83.42	£153.17
28	LORRY TIPPER (DERV EXC) 6.5 TONNE	12.50 HR	£44.25	£74.79
136	JCB 3C EXCAVATOR	12.50 HR	£56.25	£94.81
500	21/14 MIXER	21.12 HR	£39.71	£66.93
501	2M3 READY-CRETE) TRUCK (1 MILE HAUL)	18.48 HR	£44.35	£74.76
503	OPC	52.80 TN	********Awaiting Quote********	
505	SAND	46.20 TN	********Awaiting Quote********	
508	20 MM AGGR.	132.00 TN	********Awaiting Quote********	
511	DIESEL	138.60 LA	£117.81	£174.65
512	SILO (50 TONNE)	21.12 HR	£10.56	£17.80
513	MIXER DRIVER	21.12 HR	£32.64	£52.37
514	SHOVEL OPERATER	21.12 HR	£25.44	£40.81
558	FACING BRICKS	24.94 TH	£2,219.66	£3,584.42
560	MORTAR	9.46 M3	£30[illegible].09	£492.67
562	BRICKLAYER	1032.00 HR	£2,906.11	£5,078.69
563	BRICKLAYER'S LABOURER	825.60 HR	£1,752.75	£3,063.09

Figure 50 - RESOURCE RECONCILIATION FOR UNIT RATE ESTIMATING

QUOTES LIST

The estimator can obtain a list from the QUOTES FILE of both the materials for which quotations have been received and those for which prices are still out-standing. This enables him to have a constant up-to-date record of the latest price situation. Examples are given below.

RESOURCES AWAITING QUOTES

CONTRACT:- PRINT OUT FOR MANUAL

Res.	Cat.	Description	U.U.M.
43	AUX.	DERV	KG
44	AUX.	PETROL	KG
47	DIR.	CEMENT BS12	T
48	DIR.	20MM AGGREGATE	T
49	DIR.	40MM AGGREGATE	T
50	DIR.	SAND	T
61	DIR.	HY BARS BS4449 10MM DIAM	T
62	DIR.	HY BARS BS4449 12MM DIAM	T
63	DIR.	HY BARS BS4449 16MM DIAM	T
64	DIR.	HY BARS BS4449 20MM DIAM	T
65	DIR.	HY BARS BS4449 25MM DIAM	T
68	DIR.	HY FABRIC BS4483 REF A393 6.16KG/M2	M2

QUOTE PRICES

CONTRACT:- PRINT OUT FOR MANUAL

Res.	Cat.	Description	Rate	Supplier
503	DIR.	OPC	40.00 £/TN	BLUE CIRCLE
505	DIR.	SAND	10.00 £/TN	THORPE QUARRIES
508	DIR.	20MM AGGREGATE	8.00 £/TN	THORPE QUARRIES
538	DIR.	HIGH YIELD STEEL FABRIC 2 KG/M2	240.00 £/TNNE	RUM RIVER
540	DIR.	HIGH YIELD STEEL FABRIC 4 KG/M2	240.00 £/TNNE	RUM RIVER

Figure 51 - LIST OF RESOURCES AWAITING AND IN RECEIPT OF QUOTES

7.2.5 STORAGE OF DATA ON DIFFERENT METHODS OF CONSTRUCTION AND THE RESOURCES REQUIRED

One method of pricing bill items is by data held on computer file as a WORK GROUP. These data comprises resource groups or build-ups for commonly recurring items of work. This data includes different methods of performing the same item of work giving the estimator access to information on alternative methods of construction.

Two main files are used to store this data.
The WORK GROUP file consists of information on each of the work groups (or gangs) built into the library,

i.e. reference number
description
number of resources within the work group
resource numbers
relevant output rates

The resource numbers of the WORK GROUP file are indexed to the resource numbers of the RESOURCE file which contains the resource cost. This is shown diagrammatically in figure 52, page 239.
The way files are structured enables more than one work group to access the same resource and at the same time gives access to the resources for combination as the estimator may require. For instance, a typical work group related to the trade of brickwork may be:

RESOURCE	USAGE RATE	COST RATE
Facing bricks	0.058 TH/M2	52.350 £/TH
Mortar	0.022 M3/M2	22.850 £/M3
Scaffolding	1.000 M2/M2	2.400 £/M2
Bricklayer	1.920 HR/M2	2.560 £/HR
Bricklayer's Labourer	1.920 HR/M2	1.930 £/HR

This would be filed under the heading 'Facing Half Brick - Vertical Walls' and given an appropriate reference code.

REF. CODE	DESCRIPTION	UNITS	NO. RES	OUTPUT RATE	RES NO.	OUTPUT RATE	RES NO.	OUTPUT RATE	RES NO.	OUTPUT RATE	RES NO.	OUTPUT RATE	RES NO.
U221.0	FACING HALF BRICK VERTICAL WALLS	M2	5	0.058	178	0.022	190	1.00	180	1.920	181	1.920	143

WORK GROUP FILE

RESOURCE FILE

RES NO.	DESCRIPTION	UNITS	COST
177			
178	FACING BRICKS	TH	52.35
179			
180	SCAFFOLDING	M2	2.40
181	BRICKLAYER	HR	2.56
182			

Figure 52 - THE STRUCTURE OF THE WORK GROUP AND RESOURCE FILES

Each company using the system would be required to set up and maintain its own company data library. This involves two important decisions.

The first decision relates to who is to prepare the information to be stored within the data library. The company may already have a standard manual of estimators' data. This can be directly transposed onto computer files. Where this does not exist data will have to be assembled. The person chosen to perform this task must be someone with a broad base of estimating experience who has a sound knowledge of the type and range of work with which the company is involved. A senior member of management should be responsible for the collation and vetting of data whether the task is carried out by a single person or a group of people within the estimating department.

The second decision concerns the type of coding system to be used for the work groups on the library. The INTEREST system was developed around the coding structure in the Civil Engineering Standard Method of Measurement (CESMM) (24). An example of this is given in figure 53 page 241. This does not restrict the use of the system to CESMM Bills of Quantities only provides a coding system under which library information may be stored. The CESMM coding structure was chosen for the development of the system because although not universally used for the production of Bills of Quantities the structured format suited data storage and was familiar to most estimators.

Where a company requires to use an alternate method of coding or develop its own, some amendments to the program are necessary.

24

CLASS F: IN SITU CONCRETE

Excludes In situ concrete for:
capping of boreholes (included in class B)
diaphragm walls (included in class C)
drainage and pipework (included in classes K and L)
piles (included in classes P and Q)
roads, pavings and kerbs (included in class R)
rail track foundations (included in class S)
tunnel and shaft linings (included in class T)
foundations for fences and gates (included in class X)

FIRST DIVISION	SECOND DIVISION	THIRD DIVISION
Provision of concrete 1 Designed mix for ordinary structural concrete m^3 2 Prescribed mix for ordinary structural concrete taken from Table 50 of CP 110 Part 1 m^3 3 Prescribed mix for ordinary structural concrete not taken from Table 50 of CP 110 Part 1 m^3	*Grades of concrete* 1 7 or 10 2 15 3 20 4 25 5 30 6 40 7 50 8 60	*Cement to BS 12 or BS 146* 1 10 mm aggregate 2 14 mm aggregate 3 20 mm aggregate 4 40 mm aggregate *Cement to BS 4027 (sulphate resisting)* 5 10 mm aggregate 6 14 mm aggregate 7 20 mm aggregate 8 40 mm aggregate
Provision of concrete 4 Designed mix for special structural concrete m^3		*Cement to BS 12 or BS 146* 1 10 mm aggregate 2 14 mm aggregate 3 20 mm aggregate 4 40 mm aggregate *Other cements* 5 10 mm aggregate 6 14 mm aggregate 7 20 mm aggregate 8 40 mm aggregate
Provision of concrete 5 Prescribed mix for special structural concrete m^3		
Placing of concrete 6 Mass m^3 7 Reinforced m^3 8 Prestressed m^3	1 Blinding 2 Bases, footings and ground slabs 3 Suspended slabs 4 Walls	1 Thickness not exceeding 150 mm 2 150–300 mm 3 300–500 mm 4 exceeding 500 mm
	5 Columns and piers 6 Beams 7 Casing to metal sections	1 Cross sectional area not exceeding 0 03 m^2 2 0 03–0 1 m^2 3 0 1–0 25 m^2 4 0 25–1 m^2 5 exceeding 1 m^2 6 Special beam sections
	8 Other concrete forms	

Figure 53 - AN EXAMPLE OF A TRADE CLASSIFICATION FROM CESMM

7.2.6 LISTS OF ALL-IN RATES AND MATERIALS AND SUBCONTRACTOR PRICES FOR THE CONTRACT UNDER CONSIDERATION

Each contract for which an estimate is being prepared has a separate file of resource prices unique to the particular contract. The estimator must be able to:

- use prices from a company data library;
- set the price as zero and "awaiting quotations";
- include a price but mark the resource as "awaiting quotations";
- set a price for the resource for the contract;
- introduce a new resource and price to the system;
- hold price information on plant resources on a weekly rate basis;
- readily amend resource prices to individual bill items and throughout all bill items which include the resource.

Within the INTEREST system resources may be priced in two ways.

(1) Resources whose prices are known are marked on the resource file as '<u>not</u> requiring quotes'. When such resources are used in the bill item, their prices, which may be modified by the user, are put on the contract file. Typical examples of resources handled in this way would be labour rates for the contract and revised hourly plant hire rates.

(2) Resources whose prices are not known (mainly materials) are marked in the resource file as 'requiring quotes' and initially have a zero price. When a quote becomes available for such a resource, it is entered onto the resource file.

When a bill item is being built up using such a resource, the price is displayed if it is not zero or replaced with **AQ** if it is zero. If a report is requested of the bill items processed to date the system determines whether or not a quotation has been received for the resource in question. In the case where the price of a resource has not yet been determined the fact that the price is missing is highlighted. In the bill listing, this is done by printing under each bill item the identifying numbers of resources with zero prices. In reconciliations, zero priced resources are marked *AQ*.

This method of working enables the price of a resource 'requiring quotes' to be changed so that if a better quotation is obtained when a price has already been entered into the resource file, the new quote can be entered into the bill easily.

A diagram of how the system handles resource prices is given in figure 54, page 244 .

7.2.7 FACILITY TO RETRIEVE, CHECK AND REWORK BILL ITEM BUILD UPS

The INTEREST system does not store the rate for a bill item but the complete build up; the resources required, their outputs or usage rates and their costs. This enables:

(i) A reconciliation of all resources included within the estimate to be made;

(ii) The ability to retrieve, check and rework bill item build-ups.

This latter facility is achieved within the running of the system by using the command RETRIEVE. Details of the pricing of the bill item are obtained from the contract file. The estimator then has the facility to rework the item; adding, changing or deleting details or repricing the item completely by another method.

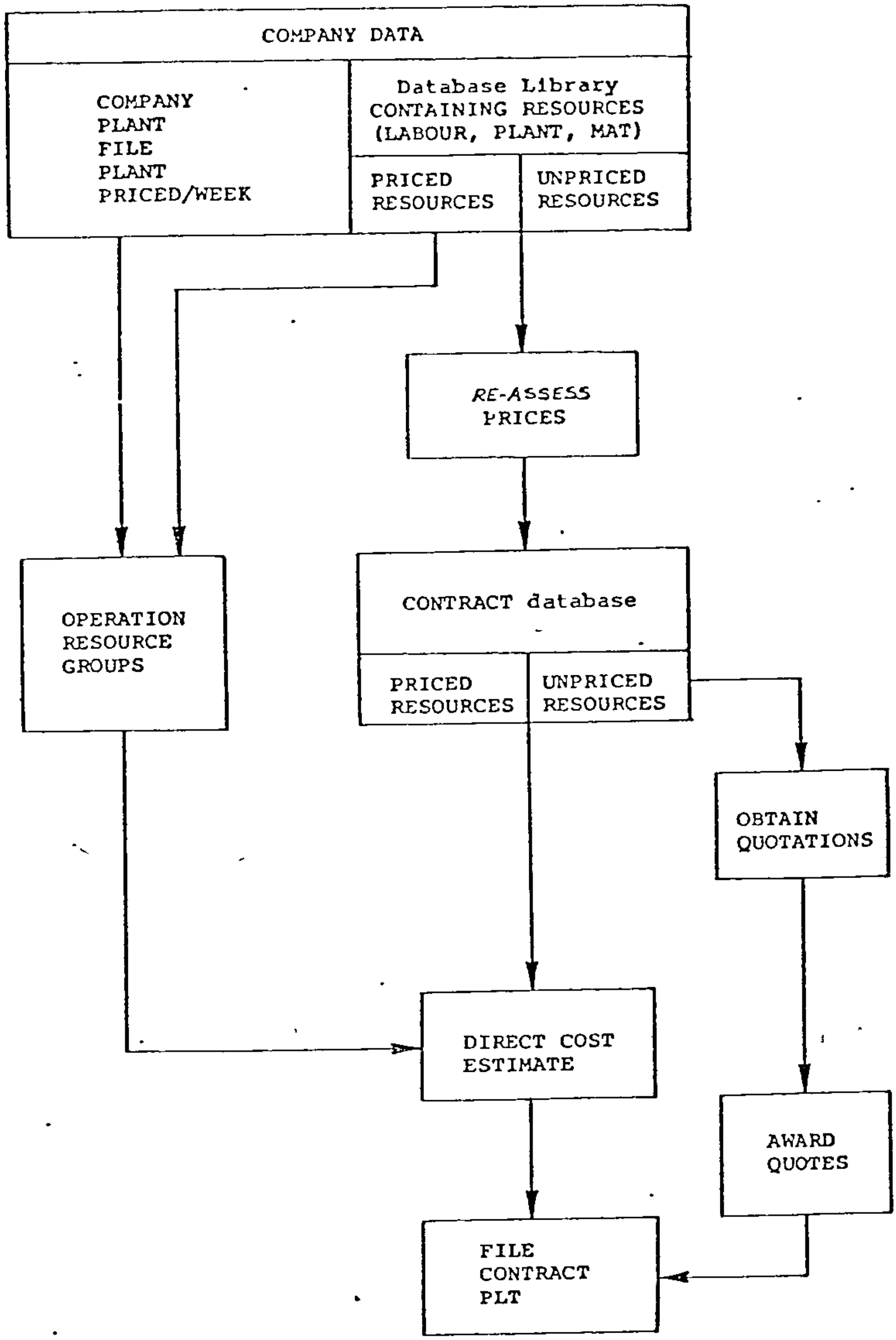


Figure 54 - How System Two Handles Resource Prices

7.2.8 ASSIST THE ESTIMATOR IN THE COMMUNICATION WITH OTHER PARTIES WITHIN THE ESTIMATING PROCESS

An examination of the estimating and tendering process in Chapter 2 and the tasks of the estimator in Chapter 4 showed the complex information exchange related to the estimating function. A computer aided estimating system should assist in the communication of data between the relevant parties. This may be achieved in two main ways.

The system may produce reports containing information that may be passed to other functions within the company either to assist them directly with their tasks or to provide details of the estimator's calculations. An example of the former is the printout containing resources which are awaiting quotations. An example of the latter is the reconciliation report which could be passed to the planning team involved with the contract in order that they may compare the estimator's totals with their own.

In addition the estimating system may provide data for the estimator that may indirectly improve communications between company personnel by enabling the estimator to check aspects of the tender that otherwise may have been overlooked. The report giving details on the quotations received for certain resources displays information on the suppliers name. The allocation of resources used in Operational estimating provides a check as to the allocation of key items of plant.

The subject of improved communication is dealt with in more detail in Chapter 11

7.2.9 MAINTAIN THE ESTIMATOR'S SKILL AND EXTEND HIS KNOWLEDGE OF CONSTRUCTION PROCESSES

It is important that the introduction of a computer aided estimating system into a construction company should not result in a gradual decrease in an estimator's skills leading to the company being dependant on the computer library for the method of undertaking work and the calculation processes within the system to perform the production of the estimate. Estimators also fear the introduction of 'computerized' estimating will lead to a reduction in their job content and a change of their function within the estimating and tendering process to a more clerical role.

By producing a computer aided estimating system that augments the tasks of the estimator within the estimating and tendering process, no reduction in the estimator's skills should result. The intention has been to replace the mechanical computational aspects of the estimator's tasks by the computer and provide extra facilities from which the estimator's knowledge and understanding of the estimate may grow.

The production of an estimate using the INTEREST system is not undertaken by any formalized method. The estimator is free to chose how and when the pricing of bill items and the preparation of reports is undertaken. The facility always exists to change the method of approach to the problems involved within the estimate and produce alternative solutions.

By operating in this manner the skills of the estimator is maintained. To operate the system an understanding of how computer systems function is required together with some basic keyboard skills.

These two aspects provide an enhancement to the estimator's skills.

There is no reason why the estimator's knowledge of the construction processes should be reduced. Any additional information obtained by the estimator is easily incorporated into either the estimate being prepared or the main data library. The main data library will be maintained by an estimator in overall control of the system. By giving all the estimators' within the company access to the company data this should improve their knowledge of different construction processes.

7.2.10 THE LIMITING OF POTENTIAL ERRORS WITHIN THE ESTIMATING PROCESS

Estimators fear the introduction of errors into their calculations which pass un-noticed within the calculation of the total tender sum. This can result in the company not being awarded a tender it would otherwise have gained or being awarded a contract at a price which does not reflect their true cost in carrying out the construction work.

Table 5, page 130 shows common estimating errors and indicates whether or not the use of computers will enable these errors to be eradicated.

It is important that the use of computers within the estimating and tendering process does not introduce new errors. In the production of the INTEREST system great attention was made to the detection and correction of errors within the system. However familiar a user is with a system he will still make errors; errors in the keying-in of information, errors in transcribing data dn judgement errors. The INTEREST system was written to incorporate error checks wherever it is possible.

While the system cannot tell if the user has made transcription or judgement errors, (the wrong quantity, an incorrect resource etc), the printer facility ensures that the user always has to hand a copy of what has been included in the item build up. From this, a check is always possible on details held within the contract files. If the estimator is unhappy about an item the RETRIEVE ITEM command enables the calculations to be amended. The system has been made as difficult as possible to 'crash' and bring to a halt as a result of incorrect responses from the user. A check is made on each input of information and if this is of the wrong format then the data will not be accepted and a message will be given to re-enter. Some typical examples of this are given below.

```
Please enter command
WWWW
This is not a valid command - please re-enter
WO
WORK GROUP option.  Bill section 5 page  5
Enter item letter
A
Enter reference code
E335.Ø
EXC. MAT. RE-USE FOUND. DEPTH 2.Ø-5. M
Enter quantity in M3
RRRR
RRRR   is not a valid number; please re-enter
345
```

The user must state the Bill Section and Page Number before using the system to enter bill items. If this has not been done then the program requests these details. At various points within operating the commands a statement of the Bill Section and Page Number is made to provide a constant check to the user. Furthermore, once a bill item has been entered into the contract file, another with the same coding cannot be included.

All these features help to ensure that the correct items go into the correct sections and are not duplicated.

```
Please enter command
WORK
Warning - Bill Section is not defined
Please enter bill section
5
Warning - page number is not defined
Please enter page number
5
WORK GROUP option.  Bill section 5 page  5
Enter item letter
A
Enter reference code
K99
K99  is not a valid reference code; please re-enter
K999.Ø
Work group K999.Ø is not on file
```

8. THE TESTING OF THE INTEREST SYSTEM

This chapter describes the testing of the INTEREST system. Testing of the system was necessary to check that the system performed all calculating, filing and reporting facilities satisfactorily and to ensure that the system was acceptable to the civil engineering estimator. The following tests were performed:

- arithmetic checks of the calculation operations within the system;
- error detection checks within the system dialogue;
- system checks for the pricing of complete Bills of Quantities;
- demonstrations to individuals and groups of practising estimators to ensure feedback from construction industry personnel;
- field trials of the system within the estimating department of a civil engineering company.

The acceptability of the system was assessed on how closely the system reflected the estimator's tasks and whether in using the system:

i) the calculating, filing and reporting facilities offered by the system fully supported the operations carried out by the estimator;

ii) using the system decreased or at best did not increase the constraints on the estimator's performance;

iii) the communication and information pattern within the company was not altered.

The different tests carried out upon the INTEREST system enabled the system to be confirmed as acceptable to civil engineering estimators.

A list of additional facilities and enhancements considered necessary was produced for inclusion in the next version of the system. (See Chapter 9). The question of the profitability of computer aided estimating systems was highlighted and this was seen to require separate analysis. (See Chapter 11). Aspects of user training and support were analysed and the basis of the user support requirements for the INTEREST system formulated. These are discussed in detail in Chapter 10.

8.1 CALCULATION CHECKS ON THE OPERATIONS WITHIN THE SYSTEM

One of the biggest fears of estimators is the inclusion within a computer aided estimating system of errors which go un-noticed and are included within several tenders before being detected. (See Chapter 5). The highly sensitive nature of estimators' calculations and the production of the total tender sum submitted to the client required that the INTEREST system should not only perform calculations correctly but be seen to perform the calculations correctly.

The inclusion of every new command within the system was accompanied by checks to ensure the arithmetic validity. The system was tested by the pricing of a specimen bill of quantities covering all the functions contained in the system to ensure that arithmetically the performance was correct.

Wherever possible within the print out of reports cross checks were incorporated to enable the user to check that calculations had been performed correctly. An example is shown in figure 55, page 252.

PAGE 5 Contracts - PRINT OUT FOR MANUAL

Bill Of Quantities Listing

DATE 5/10/80

DIRECT COST SUMMARY

PAGE	SECTION	LABOUR	PLANT	DIR.MAT.	AUX.MAT.	SUB.CON.	TOTAL
1	1	3568.80	1517.72	1326.96	49.98	0.00	6463.46
13	1	33.44	54.48	0.00	67.83	0.00	155.75
2	2	1365.15	24.44	739.81	0.00	0.00	2129.41
21	3	845.10	15.13	457.98	0.00	0.00	1318.2[illegible]
SUM TOTALS		5812.49	1611.78	2524.75	117.81	0.00	10066.82

Figure 55 - CROSS CHECKING WITHIN THE INTEREST RESULTS

Here the direct cost summary is totalled for each page within the bill and the monies split within the cost code categories to provide a cross check. At the end of the tender report section a statement of bill totals is made and a check instigated between subtotals. Using techniques such as these, the validity of the totals produced was indicated.

8.2 ERROR DETECTION CHECKS WITHIN THE SYSTEM DIALOGUE

A fundamental principle of the design of the software was the checking of the validity of all input. However familiar a user is with a system he will still make errors; errors in keying in information, errors in transcribing information and judgement errors. The system was written to incorporate error checks wherever possible. While it is impossible for the system to detect transcription or judgement errors (the wrong quantity, an incorrect resource etc), the printer facility ensures the user always has to hand a hard copy of what has been included in the build up.

A check is included on each input of information by the user and if of the wrong format then the data will not be accepted and a message will be given to re-enter. Some typical examples have already been shown in Chapter 7.

Extensive tests were made by the input of incorrect data to ensure that in all commands within the system invalid data was not accepted.

The command QUIT was incorporated to enable the user to abort from a particular command and return to suitable point for recommencement of the estimate.

The system was tested for the use of this command at all appropriate points to ensure that the function was performed and the user returned to a suitable point within the system without the inclusion of incorrect data onto the contract file.

8.3 SYSTEM CHECKS FOR PRICING COMPLETE BILLS OF QUANTITIES

Computer programs are normally developed using a limited amount of data. Even though the system performs satisfactorily under trials, problems may occur when processing the quantity of data normally associated with the task of the program. These problems usually take the form of:

- system 'crashes' due to exceeding file limits;
- display format field widths being exceeded;
- a reduction in system response time and consequently transaction time.

To test the software it was mounted on a 'Design Centre' mini computer. A complete bill of quantities of some 2000 bill items was entered onto the computer and the items priced using the facilities available. The system was timed to assess the sort time on bill items and the retrieval time for a priced bill item from the contract file. Timings were also carried out on the time required to print out bill items in report forms. The results are shown in figure 56, page 255.

Retrieval time was constant no matter how many bill items had been entered onto the contract file.

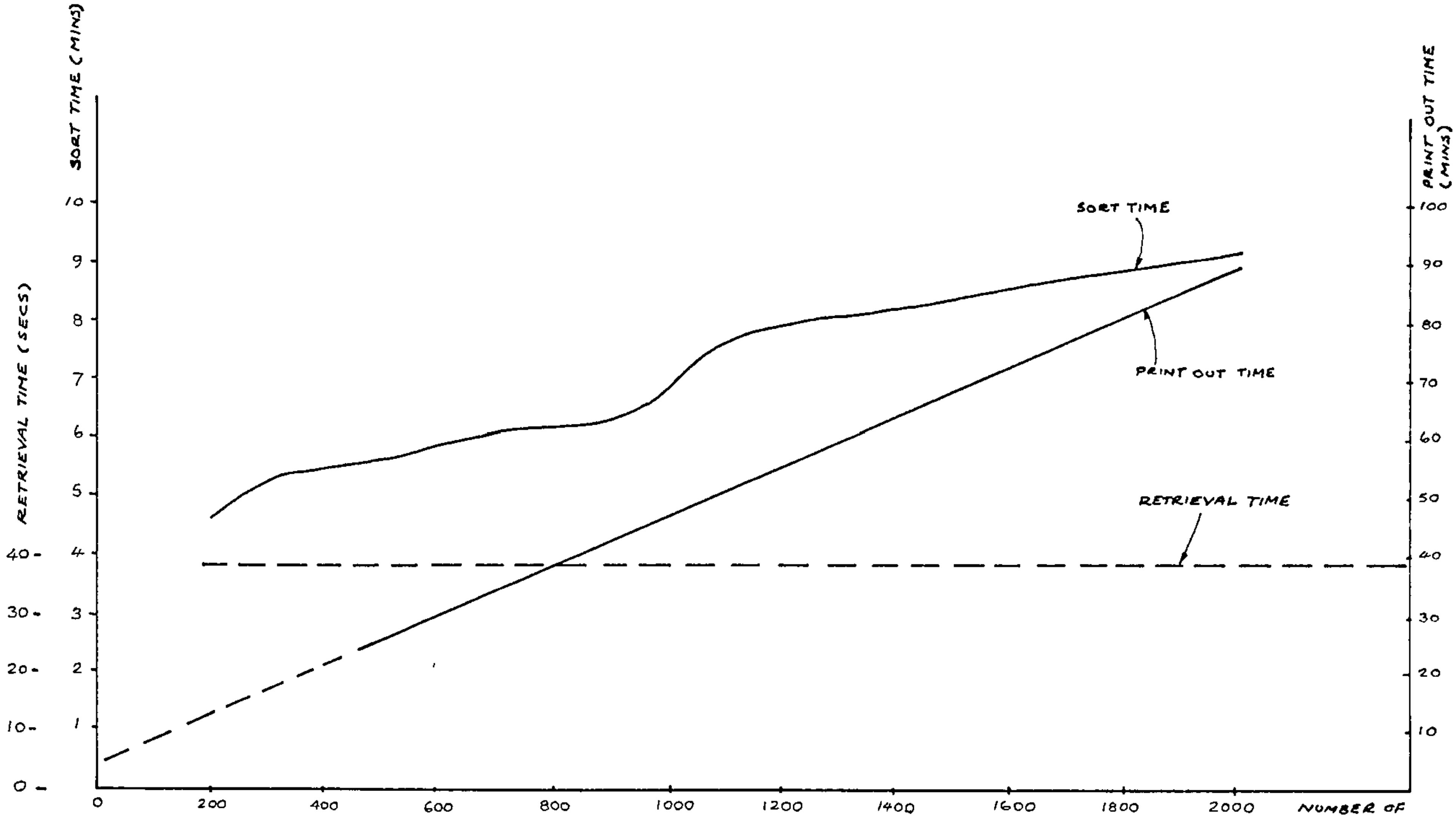


Figure 56 - TIMINGS TAKEN ON THE RETRIEVAL, SORTING AND PRINT OUT OF THE SYSTEM

The time being a function of the total number of bill items that the file had been initialised to accept.

Print out time varied directly with the number of bill items. The time is dependant on the speed of the printer with a four minutes residual time dependant on the computer system.

The time taken to sort and calculate the priced bill item totals in the contract file gradually increased to nine and a quarter minutes for some two thousand bill items. Although a significant time in computing terms this is negligible compared with the time needed to perform this task manually.

At no time did the system 'crash' due to inadequate file sizes. Display format field widths were not exceeded except where incorrect data was entered. There was no unexpected large increase in system response time when performing the main operations within the system.

8.4 DEMONSTRATIONS TO INDIVIDUALS AND GROUPS OF PRACTISING ESTIMATORS

As already described in Chapter 6, the development of the INTEREST system was an iterative process that relied upon the demonstration of the system to practising estimators. The feedback obtained from construction industry personnel ensured that the procedures and operations within the system met those required by the practising estimator. In addition, the display formats and message designs could be checked to ensure that all the information presented to the user was meaningful and necessary.

A list of companies who have reviewed the system is included in Appendix VI.

8.5 FIELD TRIALS OF THE SYSTEM WITHIN THE ESTIMATING DEPARTMENT OF A CIVIL ENGINEERING COMPANY

8.5.1 Introduction

The INTEREST system was put on loan to a medium-sized civil engineering contracting company to enable full field trials to be undertaken within a commercial environment.

The program was implemented on a Computer Automation Li 40 minicomputer supplied with 10 megabytes hard disk storage capacity. A visual display unit and input keyboard was provided to input data and monitor the system. A printer was supplied to enable the user to obtain a hard copy of bill listings and reports. No special facilities were required to effect the system installation. The hardware was set up in the chief estimator's office and powered from the normal office power supply. Reference was made to a checklist of human factors and ergonomic considerations [106] and every effort was made to provide a satisfactory working environment for the users.

8.5.2 USER SUPPORT AND TRAINING

The members of the estimating department who had been selected by the company to use the system had never received formal training in computing and never previously seen or operated the INTEREST system.

A modular training programme was developed by the writer and used to introduce the estimators to the system.

The contents included:

- an introductory talk on computers and the problems of linking computers and estimating;
- a demonstration of the system;
- the method of operation of the computer hardware;
- a series of simple exercises of increasing difficulty to teach the users the facilities available within the system.

The training period lasted two days and by the end of this time the users were competent in the operation of the system and capable of selecting the correct option and performing the necessary procedures to price bill items in a manner they considered appropriate.

A comprehensive user reference manual was provided containing examples of all the facilities within the system. The users were encouraged to record all their reactions to the system in a diary which was kept permanently with the system. The initial procedure in the event of hardware or software problems was telephone contact with the writer to determine the exact nature and possible cause of the problem.

Regular visits were made to the company throughout the period of the trial when problems and reactions to the system were discussed and recorded.

This enabled the author to monitor the trial and introduce measures considered necessary to ensure the user support requirements were met.

8.5.3 THE SETTING UP OF THE COMPANY DATA LIBRARY

The first task for the company was to input data on resources and build up work groups of company data that could be used as a basis for pricing bill items.

Data on resources commonly used on civil engineering contracts was assembled and input under the following categories; Labour, Plant and Materials. Prices were included where applicable or the cost set at zero and the resource marked as awaiting quotes. Space was left within the data files for including additional resources required for individual contracts.

It was never intended that within the trial period the company should set up a complete library with work groups under every trade classification found in the CESMM. Attention was focused on the commonly occurring items within the following classes of work: In situ-concrete; Concrete Ancillaries; Pipework; Brickwork; Blockwork and Masonry. Reference was made to existing estimator's notes to abstract suitable information that may be included in the library.

8.5.4 THE PRICING OF A BILL OF QUANTITIES

After the users had familiarised themselves with the system and commenced the set up of the data library, attempts were made to price specimen bill items using the system.

Attention was focused initially upon concrete work, this being the most common class of civil engineering construction work and incorporating both 'unit rate' and 'operational estimating' methods. Attention then turned to other classes of work. Bill items from completed contracts were used so that the results obtained using the system could be checked against manual calculations.

The system was then used to price sections and classes of work for incorporation within estimates being prepared within the estimating department. This enabled further examination to be made of the facilities that were available without fully committing the pricing of a complete estimate to the computer system.

A suitable contract was then selected to be priced using the system. Selection of the project was undertaken with great care. The project had to be large enough to fully reflect a typical civil engineering estimate prepared by the company but not too large so as to present problems to a user who had only limited experience of the system. (Whatever method was used to price the contract a tender still had to be submitted on the appropriate date). However, too small a project would not realistically test the system's facilities. The project also needed to be representative of the type of contract regularly priced by the company, and of work familiar to the estimator involved in the trial. This would then remove any difficulties resulting from the individuality of the contract.

An estimate for a small by-pass contract comprising of some 150 bill items was selected and the direct cost estimate and tender mark-up calculated using the facilities available within the system. The tender was submitted on time and the company's bid placed third.

8.5.5 THE RESULTS OF THE FIELD TRIALS

Results from the field trials within the contractors organization were obtained by informal and structured interviews with the users and by reference to the diary that was kept with the system. Also analysed were details from the priced bill of quantities that made up the tender priced on the system. Details of these are given in Appendix VII.

The field trials confirmed that the system provided the main calculating, reporting and filing facilities to enable the estimator to perform the operations within his task. The system reflected the manner in which the estimator worked and provided the necessary flexibility of approach to the build up of the direct cost. The tests highlighted facilities and aspects that would have to be extended. Some of these were general points, others were needs particular to the company concerned. All of these were given careful consideration and included where appropriate in the next developed stage of the system. (See Chapter 9).

With respect to the constraints laid upon the estimator's performance the system proved too slow. This was principally due to the type of hardware used in the test. There were also areas of the dialogue structure that slowed up the use of the system and attempts were made in the following version of the program to overcome this problem. It was found that whilst no major errors were introduced by the program the estimator's performance was marred by the requirement of having to check and reset the page number of the bill item. This operation is not performed when the estimator is manually preparing an estimate and so tended to be omitted when using the computer system.

This required tedious deletions and re-entry of data when the error was noticed. Time was wasted in the changing from one mode of pricing to another to deal with different bill items. It was decided that whilst the estimator tended to be orientated around the bill item the system was orientated around the method of pricing.

As a result it was decided that the next version of the system would involve the entry of all the data on the bill item at the start of the estimate. This would make the system 'item orientated' and once entered and checked would remove the errors in page number setting experienced by the estimator.

Concern around this question of time raised queries as to the profitability of computer aided estimating systems. It was decided to investigate this aspect as a separate study. This is described in Chapter 11.

The length of time of the field trials and the level of contact maintained with the company made it impossible to fully assess the impact of a computer aided estimating system upon the contractor's organization. However, the following points were evident:

- the introduction of a 'dedicated' system performing one particular function and housed within the users office made a minimal impact on the organization;
- the use of the system produced a 'local expert' who was regarded by other members of the organization as an authority on both the system and computers in general. While this may be seen to enhance his role within the organization it was not necessarily condusive to his testing of the system;

- there was no evidence of the system failing to produce the information required by the estimator his his direct use or the use of other people within the organization. The lack of comments passed by the users in this area of performance suggested that no change was made upon the flow of information within the organization.

Extensive research remains to be undertaken in the area of the impact of computer aided estimating upon the contractor's organization. The following main areas, (as defined by Whistler [108]), need all to be assessed:

- the impact upon the organizational structure;
- the impact upon decision-making;
- the impact upon authority and control;
- the impact upon job content.

These factors will vary with the type of organization and the type of computing facilities (mainframe or dedicated mini) used to run the system.

The provision of user support and training was important to meet the users initial and continuing requirements for the system. Although the system was considered very 'user friendly' the changing needs of the user throughout the trial period necessitated constant reference to the user documentation and the training programme. This was emphasised by the fact that the intermittant use of the system necessitated a certain amount of re-learning at the start of each new session.

The user and training requirements for the INTEREST system are described in detail in Chapter 10

9.0 THE SPECIFICATION OF INTEREST C.E.3.

The specification of INTEREST C.E.3 was prepared following the detailed testing and review of the prototype system described in Chapter 7. Enhancements and amendments to the system were made in the following areas:

- system parameters and operational procedures;
- reporting facilities;
- display formats.

Each of these areas are now discussed in detail with examples where appropriate. A detailed description of INTEREST C.E.3 is contained in the copy of the user reference manual in Appendix VIII.

9.1 SYSTEM PARAMETERS AND OPERATIONAL PROCEDURES

9.1.1 DATA ENTRY PROGRAM

INTEREST was developed as a computer "aided" estimating system. The C.E.2 version relied upon the estimator to input bill item details as referenced in the Bill of Quantities. This operation was incorporated within the method of pricing of the bill item that had been adopted by the estimator. The advantages of this method was that:

- the estimator had direct personal control over the items entered onto the contract file;
- a simple computer program was required;
- the entry of bill items was incorporated into the main program;
- the estimator could proceed immediately with the pricing of the bill from receipt of the contract documents.

There were however disadvantages of the estimator entering the bill item details. It was found that:

- the time taken to perform this operation slowed the estimators rate of pricing;
- automatic pricing of the complete Bill of Quantities from the Work Group Library could not be performed immediately to obtain an initial estimate for the contract;
- a list could not be obtained of bill items still awaiting to be priced.

In C.E.3 it was decided to incorporate a bill entry program to enable a clerk or junior estimator to enter the basic parameters of each bill item. In addition to solving the disadvantages stated above, this improved the relationship of the system to the estimator's normal working pattern. The trial within the construction company showed that a common error made by the estimator was that of failing to set the Bill Section and Page Reference correctly. This resulted in items being entered onto the contract file with the wrong reference and considerable time being needed to make the necessary corrections. By changing the system from one orientated around the method of pricing to one orientated around the items on the contract file this problem should not occur. By entering all the bill items at the start of the estimate and coding similar items in the same manner the facility to price these automatically at the same rates became possible.

The procedure of working with the additional program is shown in figure 57 below:

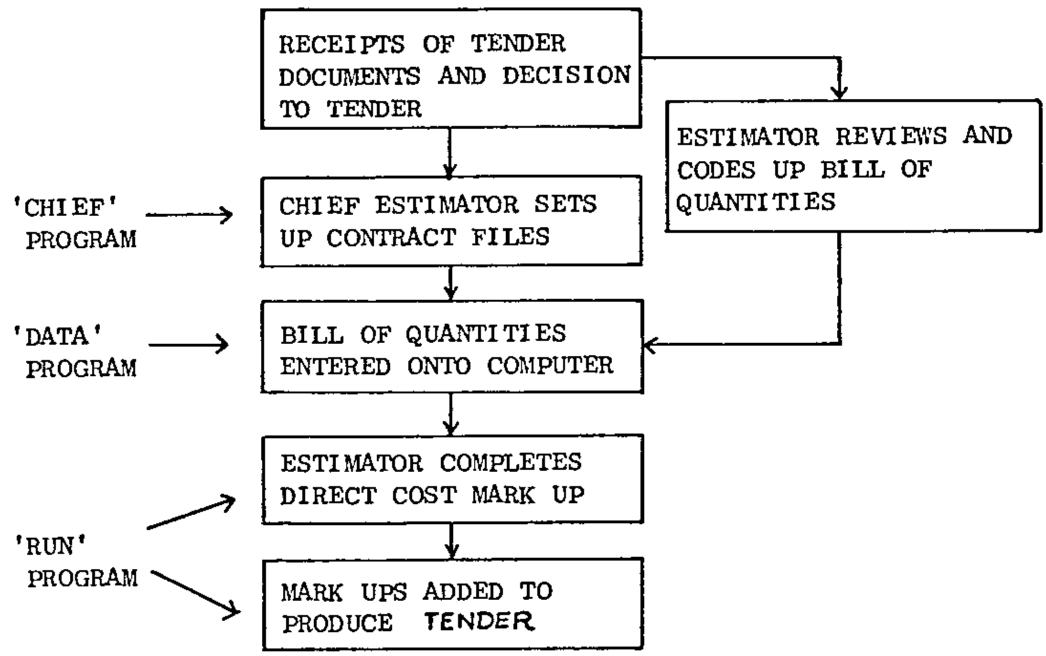


Figure 57 - THE PROCEDURE OF WORKING WITH INTEREST C.E.3

The 'Chief' program allows the chief estimator to set up the contract files, enter the appropriate passwords and set up or amend data on the company library.

The 'Data' program enables the user to input details of the bill items.

The 'Run' program allows the build up of the direct cost estimate and the addition of appropriate mark up factors to produce the total tender sum.

9.1.2 BILL ITEM DESCRIPTIONS

The majority of the ninety-two estimators who reviewed the system stated that some form of description should be included for each bill item. This would not take the form of the exact detailed description found in the bill, but rather 'key' words that would enable the estimator to identify the item without reference to the bill.

The facilities included in C.E.3 enabled the estimator to:

- include descriptions for all bill items;
- include descriptions for some bill items;
- amend descriptions at any stage;
- omit descriptions completely.

Where the bill item is priced by using a work group from the library the description of the work group is included automatically.

The obvious advantage of descriptions being included is that the item is recognised by the estimator without having to refer to the bill. The disadvantage is the increase in storage space required and the time taken to enter the descriptions.

9.1.3 THE STORAGE OF ADDITIONAL INFORMATION ON EACH CONTRACT BEING PRICED BY THE COMPANY

Within the C.E.2 system the contract title is stored for each estimate priced by the system. Many companies expressed a desire for more information to be stored on each contract.
In particular, the following information was required to be stored on the computer:

- tender submission dates;
- client reference;

- consulting engineer reference;
- approximate contract value.

C.E.3 stores this information and enables the company to obtain a listing of current estimates being prepared by the company. This is important for assessing the likely future workload and the corresponding of overheads.

9.1.4 EXTENSION OF THE WORK GROUP CODING SYSTEM TO HANDLE NON CESMM CODING

Within INTEREST C.E.2 the Work Groups within the company data library were coded under the CESMM. Trials within the contractors organization showed that while ideal for bill of quantities that had been prepared under the CESMM, problems arose when attempting to price Bills of Quantities prepared by alternative methods of measurement. The 'fit' between the bill items and the coded work groups not being close enough to facilitate easy use of the system.

Certain construction companies whose work was of the type predominantly measured by alternative methods of measurement stated the preference to be able to build up a library of Work Groups referenced under a coding system based upon the D.O.T. method of measurement. Other companies stated the preference to establish their own library system. Consequently it was decided to make provision for a Work Group Coding System of up to eight alphanumeric characters for the C.E.3 system. This would enable a company using the system to build up the library on whatever basis that is selected.

9.1.5 STRUCTURED NUMBERING SYSTEM FOR RESOURCES

Each of the resources used within the estimate build-up must be coded with some form of reference system. Within the prototype system the resources were referenced by a number ranging from 1 to 999. No distinction was made as to the order of the resources within the resource file. The user was free to select any number and attribute any resource to that reference on the resource file. This proved unsatisfactory because of the length of time required to find individual resources within the resource listings. For the INTEREST C.E.3 version it was decided to use a reference coding system based upon up to 6 characters, the first two of which are alphabetical. This is shown in Table 10 on page 271.

The system was extended to enable data to be stored on weekly priced labour and plant. It is also possible to store groups of resources for each cost code category and mixed gangs containing materials plant and labour resources. The levels of resources shown in Table 10 were considered appropriate for normal company requirements. Where a particular company may wish to change the structure of the resource file this may be easily accommodated.

TABLE 10 - A STRUCTURED NUMBERING SYSTEM FOR RESOURCES

L1-L1000	LABOUR	(HOURLY)
LW1-LW1000	LABOUR	(WEEKLY)
LG1-LG1000	LABOUR GROUPS	(HOURLY)
LWG1-LWG1000	LABOUR GROUPS	(WEEKLY)
P1-P1000	PLANT	(HOURLY)
PW1-PW1000	PLANT	(WEEKLY)
PG1-PG1000	PLANT GROUPS	(HOURLY)
PWG1-PWG1000	PLANT GROUPS	(WEEKLY)
M1-M12000	MATERIALS	
AW1-AW1000	AUXIALLARY PLANT	(WEEKLY)
MG1-MG2000	MATERIALS GROUPS	
AWG1-AWG1000	AUXILLARY PLANT GANGS	(WEEKLY)
S1-S1000	SUBCONTRACTORS	
OP1-OP1000	OPERATIONAL GROUPS	
XG1-XG1000	MIXED GANGS	
XWG1-XWG3000	MIXED GANGS	(WEEKLY)

In this manner resources in listings are more easily located when required by the user for inclusion in an estimate. Within each division of the resource file the space may be further subdivided as shown for Plant resources in Table 11, page 273. Full details of setting up the resource files are given in the User Reference Manual in Appendix VIII.

9.1.6 ENHANCEMENTS TO THE OPERATIONAL ESTIMATING FACILITY

The facility to calculate rates on an 'Operational' basis proved an important facility in the C.E.2 program. It was decided in C.E.3 to enhance the facility by:

(i) Calculating the total number of weeks resources were required on site from an average output figure entered by the user. (The reverse of the calculation included in the prototype).

(ii) Allowing the inclusion of the same resource more than once within the operational group. This may be for a different time period and/or a different allocation.

(iii) Entering the number of weeks each individual resource is required on site and not the total number of resource weeks.

(iv) Permitting the use of resources that are "awaiting quotes" within the build up of an operational group.

(v) Extending the number of resources permissible within an operational group build up to ten.

(vi) Incorporating labour resources based upon a weekly rate and allowing the estimator to change the rate used within the group build up.

(vii) Indicating within the operational group display the breakdown of the rate into labour and plant proportions.

TABLE 11 - EXAMPLE OF SECTIONS WITHIN THE PLANT RESOURCE COST FILE

PLANT RESOURCE CODES	PLANT ITEMS
P1 to P49	Compressors
P50 to P99	Compressor tools
P100 to P149	Conc. Mixers
P150 to P199	Conc. Batching Plant
P200 to P249	Conc. Pumps
P250 to P299	Mobile Cranes
P300 to P349	Dumpers
P350 to P399	Excavators
P400 to P449	Forklifts
P450 to P499	Generators
P500 to P549	Hoists
P550 to P599	Hoist Ancillaries
P600 to P649	Lorries - tippers
P650 to P699	Lorries - ordinary
P700 to P749	Water pumps
P750 to P799	Rollers
P800 to P1999	

(viii) Applying the cost of the operational group not only on a rate basis but also by apportioning the total cost on a percentage basis.

These extended facilities were incorporated to increase the flexibility of the operational estimating facility and to provide alternative links with the unit rate form of estimating.

9.1.7 THE COMBINATION OF TWO WORK GROUPS

INTEREST C.E.3 allows the combination of two separate Work Groups from the company library in order to price a single Bill of Quantities item. This is required when the item within the bill has been measured in a non-standard form and includes work that is normally priced separately. In this instance two Work Groups may be combined on a percentage basis to enable the item to be priced directly from the library. The facility also enables certain other types of bill items to be priced via the library of information with a minimum of data storage. For example, when pricing French Drains it is important that the exact depth is used in calculations to allow for the cost of the imported granular backfill material. To store data on every type of drain allowing for different pipes and depths of trench would be tedious to produce and very costly in terms of storage capacity. However it is possible to store details on a standard depth of trench and also on a 1.0m additional depth as separate work groups. The appropriate item may then be priced by taking 100% of the work group relating to the standard depth and the required percentage of the additional depth work group to gain the exact quantities required: eg. to price an item relating to a French Drain of depth 2.2m deep. Price as 100% of Work Group of drain standard depth 1.5m (including pipe) plus 70% of Work Group of trench 1.0m deep containing granular backfill.

9.1.8 THE INCLUSION OF OUTPUT RATES FOR ITEMS OF PLANT

Within the INTEREST C.E.2 system all resource requirements are calculated and displayed in terms of Usage Rates, (ie. the resource requirement per unit quantity, HR/M3 etc). This with respect to plant resources was providing information to the estimator in an un-natural form. Plant production being normally expressed in terms of output rates, (work quantity per time unit) as opposed to usage rates (the time taken to perform a fixed quantity of work).

Provision was made in the C.E.3 system to express plant production in terms of output even though this required the checking of the resource category before inclusion in any calculations and the amendments to display formats.

9.1.9 AN EXTENSION OF THE COST CODE FACILITIES

The original cost codes used by the system to allocate monies from resources to various categories within the estimate were:

LAB - Labour

PLT - Plant

DIR - Direct Materials

AUX - Auxiliary Materials

S/c - Subcontractors.

An additional category was kept for Provisional Sum Items as these are not affected by any on-costs made by the estimator to the direct cost total.

The inclusion of facilities to accommodate Prime Cost Suppliers and Prime Cost Subcontractors provided additional sums of money that needed to be categorized together with the Provisional Sums.

It was also found that estimators needed to highlight particular information within the estimate (eg. Fuel Costs). To enable this to be done an additional cost category was provided to which resources may be allocated. This gave a full cost code category listing of:

- Labour;
- Plant;
- Direct Materials;
- Auxiliary Plant;
- Subcontractors;
- Prime Cost and Preliminaries;
- Additional.

9.1.10 THE INCORPORATION OF 'WASTAGE FACTORS', 'WEIGHTING FACTORS' AND 'NUMBER OF USES' FOR FORMWORK

The cost of a bill item within the C.E.2 system was based upon the usage rate required for each resource. This usage rate incorporated all the parameters that the estimator considered before finalising the requirement for the work at hand. (Wastage, weighing, number of uses of materials etc). From the display above it is impossible to determine what these factors are and it was found in the trials that the estimator when reviewing priced bill items had to make constant reference to manual calculations to check what allowance had been made for these factors. This proved unsatisfactory and extended the time spent on each bill item. Within the C.E.3 system these factors are considered separately. The revised item build up display presents this information to the user.

The build up of a bill item priced with the C.E.2 system, figure 59, page 285, should be compared with that of a similar item priced with the C.E.3 system, figure 58, page 284.

9.1.11 ABILITY TO PRICE RESOURCES ON A WEEKLY BASIS

Unit Rate estimating concentrates on resources priced on an hourly basis. Operational Estimating calculates the total cost of resources over a period and relates this cost to the total quantity of work to be performed. It was found that estimators also made calculations using a weekly cost for the provision of labour and plant. Within the data library of C.E.3 therefore it was decided to allow prices to be held on a weekly basis for inclusion in the build up of item prices and operational calculations.

9.1.12 AN EXTENSION OF THE LUMP FACILITY

The lump facility was provided in the prototype system to enable bill items similar to the one having just been considered to be priced at the same rate with the same build up of resources. This operation was carried out after the filing of the completed bill item by asking the user to enter details on the bill items that it was wished to price at the same rate.

The entry of all the bill of quantity items onto the contract file at the start of the estimate enables the LUMP FACILITY to be extended. It is now possible to check all the bill items that have been coded with the same code as the one being considered and automatically price them throughout the bill. This greatly speeds up the pricing of bill items.

9.1.13 AN EXTENSION OF THE METHODS OF PRICING

The INTEREST C.E.2 system provided the following ways of pricing bill items:

- Unit Rate (Work Group from the Library);
- Unit Rate (Unknown Group build-up by the user);

- Operational Rate;
- Cash Rate;
- Provisional Sum.

Detailed discussions with estimators showed that these facilities needed to be extended to cover all the eventualities found within a bill of quantities.

The ability to price a bill item by entering a single sum of money allocated to a particular cost code category was required. Some bill items are not formally priced but marked as "Included In" the actual money needed being contained within item rates elsewhere in the bill.

Detailed provisions were also included to cover Prime Cost Suppliers and Subcontractors. These include the ability to enter a single sum (not affected by additional mark up factors) followed by a percentage allowance for profit and an allowance for attendance. In this manner the full cost to the contractor is covered but the financial commitment as detailed in the Bill of Quantities kept separate.

Within INTEREST C.E.2 a resource could only be used once within a particular build-up. Should it be necessary to use two separate items of the same resource then a new resource had to be created under a separate resource code before it may be included. With the C.E.3 system it was decided to enable a resource to be entered more than once under the same reference code even though more complex checking was required whenever it became necessary to make modifications to the resources within the build-up.

9.1.14 FACILITY TO HANDLE SUBCONTRACTOR QUOTATIONS

The INTEREST C.E.2 system allowed for the inclusion of subcontractor rates within the estimate by using the Gash Rate command to accept the rates and make any necessary allowance for attendance. The importance of subcontractors to the civil engineering contract necessitated the provision of a separate facility within the system for the entry of subcontractor quotations.

It was decided to include in the main menu of commands a command to process subcontractor quotations. Each different subcontractor is recognised by an individual code with the prefix S. On receiving a quotation the user allocates a subcontract code to the subcontractor and enters details of the name and discount applicable. Facilities are then provided for entering the quotations received and allocating them against the relevant bill items. Facilities were necessary for changing all aspects of subcontractor details. Several subcontractor rates may be applicable to each bill item.

9.1.15 AN EXTENSION TO MARK-UP FACILITIES

The mark-up facilities required by estimators include an allowance for overheads, profit, surcharging of cost code categories and rate loading. Within the C.E.2 system addition of this money was possible by the addition of a single sum of money apportioned throughout all the bill items or by the adding of percentage on costs of the direct cost figure for each cost code category.

Within the C.E.3 system it was decided to upgrade the mark-up facilities by allowing:

- the addition of a lump sum of money via the introduction of an additional bill item;

- the ability to introduce a notional on-cost to the bill items at the start of the estimate that may be amended to a later stage;
- the ability to change the on-cost for individual bill items not just a cost code category;
- the facility to apportion a lump sum or make a percentage addition to a particular section of the bill or an individual trade classification.

This extension to the previous mark-up facilities enables money to be added into different parts of the Bill of Quantities in a number of different ways. This reflects the requirements of estimators who may make adjustments on both a global and specific basis to bill items grouped not only by their type but also their position in the bill.

9.2 REPORTING FACILITIES

Discussions with practising estimators and with the users during the trial period indicated that the reporting facilities available within the INTEREST system would have to be extended. Changes were required to the content, format and availability of the reports. These were designed to give:

- either direct cost rates or tender rates;
- the total rate or the total rate divided into cost code categories;
- output directed towards the screen or the printer;
- selective reporting.

The estimator is primarily concerned with the build-up of the direct cost rate and it is this detailed information that he requires to be listed.

Following the tender adjudication, mark-up factors are decided and added to the estimate. This produces the tender rates and it should be possible to list these separately. For some internal company purposes it may be necessary to compare these two figures and a report is necessary in which both are displayed to enable a detailed comparison to be made.

Formal reports submitted to the client, senior management or other parties within the estimating and tendering process require only the total rates for the bill items to be shown. For the estimator's personal use it is often required to split the total rate into the rate for each cost code category. The system must be capable of presenting both these types of detail at the request of the user.

The INTEREST system has been designed to be operated with a printer to enable the user to obtain hard copy reports whenever required. However, it should not be necessary to have to do this when it is only required to review listings and reports. The reporting facilities of the C.E.2 system were available only on the printer. Trials showed that the C.E.3 version should enable selective reports to be displayed on the V.D.U. Where this was possible within the limited format space of the V.D.U. screen reporting information was presented in this way.

The reports of system C.E.2 consisted of complete listings of all the bill items or resources within the contract. For an average construction contract of say 1500 bill items the time taken to display or print all this information to obtain one specific piece of information would be prohibitive. Therefore selective reporting facilities were specified for the C.E.3 system to enable the user to obtain:

- the build-up for an individual bill item;
- details of each page of the bill;
- information on each section of the bill;
- a complete bill listing.

This range of reports covers the requirements of all the personnel linked with estimating and tendering process.

Apart from formal reports related to the bill of quantity items additional reports were identified as being required by the user to provide assistance in the running of the estimate. Examples of these are listings of the Operational Groups and Unknown Groups built up by the estimator in the course of the direct cost estimate. A full list of the reports available from the system is contained in Section 6 of the User Reference Manual.

9.3 DISPLAY FORMATS

INTEREST C.E.3 incorporated revised display formats throughout the program. These were designed to enable a greater amount of information to be displayed more succinctly to the user.

The following principle changes were made to the display formats:

- unit rate estimating build-up;
- operational rate estimating group build-up;
- reporting formats.

A typical unit rate estimating build-up for INTEREST C.E.3 is shown in figure 58, page 284 . This should be compared with the similar build up from the C.E.2 system shown in figure 59, page 285 . The resources are now given an alphabetical prefix to distinguish between different types.

The resource description, although the same number of characters is presented on two lines. This allows more information to be displayed. Instead of a single usage rate that includes the resource requirement and a wastage factor, the allowance for wastage is now shown as a separate figure. The unit rate for each resource is displayed, not the extended total resource sum. The total item rate is calculated and how this rate is determined from the rate for each resource category shown.

Figure 60, page 286 shows the revised display for an operational group of resources. This should be compared with figure 61 on page 285. The details of the resources forming the total cost of the operation are given in both instances. In addition to the Total Quantity used in the calculation and the Total Rate for the operation the C.E.3 version gives information on:

- the total number of weeks in the operation;
- the average hours per week;
- the average output per week;
- the Plant rate for the operation;
- the Labour rate for the operation.

The number and type of reports available from the C.E.3 system enable more varied and detailed information to be obtained by the estimator. The format of these reports was designed to present this information to the user in a clear concise manner. Examples of the reports are given in Section 6 of the User Reference Manual.

Interest CE 3 Bill Item

Contract Identifier

MAN1 NARBOROUGH BRIDGES.

Date

12/06/82

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Quantity 310 M3
100 % of Work Group F237.0
DESIGN STRUCT. CONC. 20 MPA 20 MM AGGR. SRC

Code	Description		Cost/Hour	Usage	Weight Factor	Cost/M3
L513	MIXER DRIVER	-	£3.41	.160	100.0%	£0.55
L514	SHOVEL OPERATER	-	£4.10	.160	100.0%	£0.66

Code	Description		Cost/Hour	Output	Weight Factor	Cost/M3
P500	21/14 MIXER	-	£1.88	.160	100.0%	£11.75
P501	2M3 READY-CRETE TRUCK (1 MILE HAUL)	-	£2.40	.140	100.0%	£17.14
P512	SILO (50 TONNE)	-	£0.50	.160	100.0%	£3.13

Code	Description		Net. Cost/Unit	Usage	Wastages Per Unit	Cost/M3
M504	SULPHATE RESISTANT CEMENT	-	£0.00/TN	.320	0.0%	£0.00*
M505	SAND	-	£0.00/M3	.350	0.0%	£0.00*
M508	20 MM AGGR.	-	£0.00/TN	1.100	0.0%	£0.00*

Code	Description		Cost/M3
OP1	PLANT FOR PLACING CONCRETE	-	£8.95

TOTAL LABOUR	COST/M3	£1.20
TOTAL PLANT	COST/M3	£40.97
TOTAL NET COST/M3		£42.17

Figure 58 - THE BUILD-UP OF A BILL ITEM IN THE C.E.3 SYSTEM

Section 1 Page 1 Item E
Library CESMM code F153.0
DESIGN STRUT. CONC. 30 MPA 20 MM. AGGR. OPC 56.00 M3
Data base resources

Res.	Cat.	Description	Usage rate	Cost	Total
500	PLT.	20/14 MIXER	0.160 HR /M3	1.880 $/HR	$16.84
501	PLT.	2M3 READY-CRETE TRUC	0.140 HR /M3	2.400 $/HR	$18.82
503	DIR.	OPC	0.400 TN /M3	23.320 $/TN	$522.37
505	DIR.	SAND	0.350 M3 /M3	3.900 $/M3	$76.44
508	DIR.	20 MM AGGR.	1.000 TN /M3	3.900 $/TN	$218.40
511	PLT.	DIESEL	1.050 GA /M3	0.850 $/GA	$49.98
512	PLT.	SILO (50 TONNE)	0.160 HR /M3	0.500 $/HR	$4.48
513	LAB.	MIXER DRIVER	0.160 HR /M3	2.890 $/HR	$25.89
514	LAB.	SHOVEL OPERATER	0.160 HR /M3	2.890 $/HR	$25.89

Item rate 17.13 $/M3 Item cost $959.12

Figure 59 - THE BUILD-UP OF A BILL ITEM IN THE C.E.2 SYSTEM

PLACON - PLANT FOR PLACING CONCRETE Units M3

	Res	Cat	Description	Unit	$/Week	No Week	Alloc.	Average Output Rate		Resource Cost
P	990	PLT.	22RB CRANE	2	220.00	76.00	100.00	0.53	HR/M3	$16,720.00
P	991	PLT.	CONCRETE SKIP	4	20.00	152.00	100.00	1.06	HR/M3	$3,040.00
P	992	PLT.	DUMPER	6	25.00	228.00	100.00	1.60	HR/M3	$5,700.00
P	993	PLT.	VIBRATOR	6	10.00	228.00	100.00	1.60	HR/M3	$2,280.00

Total Cost for Operation $27,740.00

Total Quantity used in Calculation 8000.00 M3
Rate for the Operation 3.47 $/M3

Figure 61 - THE OPERATIONAL GROUP DISPLAY INTEREST C.E.2 SYSTEM

Interest CE 3 Operational Group

Contract Identifier		Date
MAN1	NARBOROUGH BRIDGES	12/06/82

OP1 - PLANT FOR PLACING CONCRETE

Code	Description	Nr.	£/Week	No Week	Alloc.	Cost
P17	CONC SKIP 0.80M3	4	£12.32	38.0	100%	£1,872.64
P19	DUMPER 1.20M3	6	£108.64	38.0	100%	£24,769.92
P147	22 RB TRACKED CRANE	3	£346.08	38.0	100%	£39,453.12
P516	VIBRATOR (PETROL)	6	£8.40	38.0	100%	£1,915.20
			Total Cost for the Operation			£68,010.89

Total Quantity used in Calculation	7600.0 M3
Total Number of Weeks in Operation	38.0 Weeks
Average Hours Per Week	56.0
Average Output per Week	200.00 M3/Week
Plant rate for the operation	£8.95/M3
Total Rate fo the Operation	£8.95/M3

Figure 60 - THE OPERATIONAL GROUP DISPLAY - INTEREST C.E.3 SYSTEM

Many other smaller changes in the dialogue display were incorporated to improve the standard of the message design. Included within these is a 'clear screen' facility that removes redundant information from the screen and re-displays key information (such as menus and item build-ups).

10. USER SUPPORT REQUIREMENTS FOR THE INTEREST SYSTEM

When computers were first introduced into organizations the attention of human and social scientists concentrated on the organizational consequences[109][110]. Increasingly however, attention became focused upon the human user within the computer system as it became evident that the achievement of system objectives was dependant on the commitment of users to the system. A survey of some twenty-six companies [96] emphasized their point and examined the factors that determined the successful implementation of computer systems.

Computer systems are comprised of components with which people are generally unfamiliar. This lack of understanding leads to doubts fears and resistance to their introduction. In extreme cases it may even lead to a total rejection. Psychological research has shown that the process of introducing change is a crucial determinant of human reaction to change. Coch and French [111] showed that smooth implementation of new methods was possible if those to be affected by changes participated in the planning of the change.

The estimating function is critical to the survival of the construction company. The function reflects the management philosophy of the individual organization and involves a complex communication pattern both internally and externally. In providing a computer system to be operated by people within organizations there will exist a gap between what the user knows and what it is necessary to know to use the system to its full potential. In the event of this deficiency there is a requirement for assistance. Equipping the user with this assistance is the essential function of 'user support'[112].

The introduction of the INTEREST computer aided estimating system was seen to require comprehensive user support to ensure both the successful implementation of the system and the continued use of the system to its maximum effectiveness within the construction company.

Several different types of user support exist. They may be broadly classified as documentory support or human support methods and comprise of:

- instruction manuals;
- system centred aids;
- circulars;
- formal training instruction;
- computer advisory personnel;
- dedicated programmers;
- local experts;
- organizational representatives(113).

No one method of user support is satisfactory in meeting the needs of all the users of the system at the various stages of their development with the system. The best form of user support to provide for a system depends upon:

- the type of user;
- the user's individual needs;
- the stage of the user's development with the system(114).

An analysis was made of the needs of the different types of users of the INTEREST program throughout the stages of their development with the system.

The forms of user support chosen by the writer for the INTEREST system were:

- a comprehensive instruction manual;
- within system aids;
- formal training instruction;
- provision of a local expert;
- access to computer advisory personnel.

An instruction manual covering all of the system's functions with detailed examples is necessary as a reference to which the user may turn for assistance if no other is available. The disadvantage of such a large document is obviated by within system aids provided to give as much help to the user as possible via the VDU screen. Formal training instruction is necessary to provide an introduction to the system. No computer system can be introduced into a company without some instruction. Because of the lack of knowledge of computers and their capabilities held by most estimators the instruction needs to contain some basic background to computing. As a "local expert" will inevitably become a figure in the organization it is sensible to develop the role. Assistance in solving problems within a computer system is more readily obtained from a person than a manual. As the user develops with the system, it is inevitable that their needs will grow. This will eventually require some amendments to how the system operates and computer advisory personnel will be needed to ascertain the work involved.

By using these forms of assistance to the user, support facilities will exist that cover all of the different types of user of the system and meet their individual needs. Whatever their stage of development with the system their requirements for information and assistance will be met.

This chapter gives details of the background to different methods of user support and the choice and production of the support systems for the INTEREST program. A comprehensive user instruction manual was produced and a training programme for users developed. A copy of the instruction manual is included in Appendix VIII.

10.1 TYPES OF USER SUPPORT

To use any system, the user must be aware of how the system can be adjusted to meet his requirements. Where the user is unaware of what is required to exploit the system a 'knowledge gap' exists. User support is then required to give the user assistance in determining how best to approach his problem. There are several types of user support 'mechanisms' categorised under the main headings of documentary or human support. These are shown in figure 62 below.

DOCUMENTARY	HUMAN
INSTRUCTION MANUALS	FORMAL TRAINING INSTRUCTORS
SYSTEM CENTRED AIDS	COMPUTER ADVISORY PERSONNEL
CIRCULARS	DEDICATED PROGRAMMERS
	LOCAL EXPERTS
	ORGANIZATIONAL REPRESENTATIVES

Figure 62 - Types of User Support (after Damodran)[113]

DOCUMENTARY SUPPORT

Instruction manuals for a system are provided by the supplier and are normally written by people who are expert in the use of the system. In order to cover every aspect of the facilities they are inevitably bulky documents which are difficult to access to obtain the specific piece of information that is required.

The present trend is for user aids to be incorporated within the program to assist the user, particularly when learning how to use the system. These may range from "HELP" facilities which consist purely of documentation stored on computer files and displayed within the dialogue of the software to extensive teaching facilities linked to the main applications program to provide a comprehensive computer aided learning package.

Circulars are normally distributed by the suppliers of the system to give notice of the latest revisions to the software and new procedures that may be carried out. Arriving intermittently following the system installation and implementation they are often mislaid or ignored by users.

HUMAN SUPPORT

The installation of a new system is usually accompanied by a formal training programme where instructors demonstrate and teach the new facilities available to appropriate company personnel. The support provided is dependant on the financial committment to the training programme and the amount of information that may be assimilated within a short specified period. This is usually only so far as that deemed necessary to enable the user to use the system successfully.

Where systems are developed 'in house', computer advisory personnel and dedicated programmers are available to support the user. This tends to be only systems centred support, often the programmer has no real understanding of the subject area on which it is required to develop facilities. The programmer, however well intentioned, may develop solutions to problems that although elegent in computing terms do not meet the detailed requirements of the user.

User support is often supplied by contact with other users and organizational representatives. These may provide some support as the users needs evolve although this support may well be influenced by alterior motives eg. further sales of hardware or software.

A better form of user support mechanism for promoting the evolution of the user and the system is that of a "local expert" [115]. Local experts are generally computer users who by their interest in the system acquire additional information and develop more of a knowledge of the system than the other users around them. The development of a "local expert" is generally fostered by a lack of alternative sources of computing expertise. Where this occurs informally the "local expert" usually experiences an increase in work load and a disruption of his normal work pattern. Depending on the type of user this intrusion may range from a welcome source of prestige and status to an undesired intrusion.

10.2 USER SUPPORT REQUIREMENTS

In order to select the most appropriate form of user support for a system it is necessary to consider the requirements for support that will arise.

This demands consideration of:

- the type of user of the system;
- user support needs;
- the stages of user development.

Each of these aspects is now considered.

10.2.1 THE TYPE OF USER

Research undertaken by the Department of Human Sciences and Technology (HUSAT) at Loughborough University of Technology identified three basic types of computer user:

- the clerk;
- the specialist;
- the manager.

Chapter 6.7 described each of these types of user and how a computer aided estimating system would have users that fall into each of these three categories. The titles were restated as:

- the estimator's clerk;
- the estimator;
- the contractor's senior management.

10.2.2 USER SUPPORT NEEDS

Each type of computer user will have different needs. Eason et al [96] charaterized the sources of need for user support as:

- System centred needs;
- Task centred needs;
- User centred needs.

System-centred needs arise from the necessity for users to learn to execute the required operating procedures in locating programs, entering and retrieving data, processing data and specifying the required format for output.

Task-centred needs are those concerned with obtaining assistance in identifying and specifying those system facilities most appropriate and conducive to successful task performance.

User-centred needs arise from personal factors of a psycho-social nature such as the need for belonging, security status and for learning and self development. Such human needs exist independantly of the computer system but are frequently affected by the indirect consequences of computer installation.

The need for user support may arise from any or all three of the above sources. This may occur individually or as a combination of needs and careful consideration is required to determine at any stage the true source of user need.

10.2.3 THE STAGES OF USER DEVELOPMENT

Eason et al (96) recognised that the requirements for user support changed with time. As the user required skills and knowledge in the use of the computer system his requirements changed from that needed to carry out initial basic functions to a desire to utilize the computers full potential and reflect more advanced ideas.

User development is continuous, but four basic phases may be recognised:

- Pre-implementation phase;
- Implementation phase;

- Operational phase;
- Evolutionary phase.

PRE-IMPLEMENTATION PHASE

The pre-implementation phase begins at the stage the company first seriously considers the use of a new system. The success of the proposed system will be dependant on the primary users of the system. It is the people that spend the majority of their time inputing data, performing calculations and preparing reports that determine the standard of information supplied to others within the company. There is an obvious need for their consultation and involvement with the implement decision. They will be concerned with the facilities and operations required by the system and its potential to assist them in their work. Lack of understanding can often promote disinterest and aversion to a new system. It is important therefore at this early stage that the people involved receive re-assurance as to their degree of system control and the implications with respect to their job security and satisfaction of the new system.

IMPLEMENTATION PHASE

When the system is installed, the user is pre-occupied with learning the required operating procedures and re-adjusting his normal task performance to accept the new system. All this time, the earlier fears of the user are either dispelled or confirmed according to the quality of the system design and the support provided to aid the new skills to be learnt. There is a natural tendency for people to resist change and hence the level of support provided at this stage is crucial. It is important that the system not only fits the task of the user but can be quickly and effectively learned.

OPERATIONAL PHASE

The operational stage may be considered as that which is reached when the system has been installed and is functioning within the organization to the extent of meeting all the primary objectives. The presumption often made is that user support is now minimal. Eason et al [96] suggest that at this stage other support requirements become evident.

Non-routine events (breakdowns, errors etc) produce system centred needs that may not have been catered for in previous training. Changes in the user's task requirements may produce circumstances outside the normal running of the system. The user may find the routine function of the system fails to meet all his needs of extension of knowledge. Greater understanding of the system may lead to considerations of refinements or extensions to the facilities available.

EVOLUTIONARY PHASE

The evolutionary phase is an extension of the Operational phase. Depending on the particular system and the organization will be the degree and direction in which the system may involve. This will result in inevitable system modifications and consequentially need for further advice and technical skill. The evolutionary phase renews the cycle of user development. Hence user support may be seen as an ongoing requirement not solely an action necessary at the initial stages of the introduction of a system.

The phases of user support do not necessarily parallel the phases of system development. The factor of staff turnover inevitably means that new personnel will be required to use the system. Due to time and financial constraints this is usually necessary without any formal training programme which may have been provided initially for other users within the company during the initial implementation of the system.

User support requirements are seen to be a complex combination of three main parameters. This is summarized in figure 63, page 299

10.3 USER SUPPORT REQUIREMENTS FOR A COMPUTER AIDED ESTIMATING SYSTEM

An analysis of figure 63, page 299 with respect to the user support requirements for a computer aided estimating system shows that the full range of user support requirements need to be met. The INTEREST system will be used by all three types of computer user, with a range of user needs and with different stages of development.

As INTEREST is an interactive system specifically designed to meet the estimator's task and is normally used on a dedicated machine, the system centred and task centred needs are likely to be complementary once the initial requirements to learn the basic operating skills of the hardware have been fulfilled.

At the pre-implementation stage, the main user needs will be the user-centred needs of the estimating department. Whereas the senior management will be concerned with the advantages of the system, the estimators will inevitably be concerned with their status and job security following the introduction of the computer system.

At the implementation stage, the needs of all three types of users will be centred on the system and identifying the system facilities most appropriate to completing the task they wish to perform.

When the system is fully operational, the system centred needs of the estimators clerk and the estimator will be minimal except in the case of instances outside the normal running procedure, (ie breakdowns) which will demand user requirements that relate to the system.

USER TYPE	USER DEVELOPMENT				
	USER NEEDS	PRE-IMPLEMENTATION	IMPLEMENTATION	OPERATIONAL	EVOLUTIONARY
	SYSTEM-CENTRED				
ESTIMATOR'S CLERK	TASK-CENTRED				
	USER-CENTRED				
	SYSTEM-CENTRED				
THE ESTIMATOR	TASK-CENTRED				
	USER-CENTRED				
	SYSTEM-CENTRED				
CONTRACTOR'S SENIOR MANAGEMENT	TASK-CENTRED				
	USER-CENTRED				

Figure 63 - A MODEL OF USER NEEDS AND POSSIBLE SOURCES FOR USER SUPPORT FOR INTEREST (112)

Similarly, the task-centred needs will reduce significantly except for the unusual task that demands careful consideration of how to go about pricing the work using the system. With respect to the senior management however, the system centred and task centred needs will remain important because the infrequent use made by them of the system. This will inevitably entail some relearning everytime the system is used.

As the system is continued to be used some form of evolution will occur. This may take the form of changes in print outs and displays, additional commands, or links to other functions within the company that are related to estimating. Within the estimating department, user needs will become increasingly user centred as the estimators wish to extend their level of performance.

The alternative forms of user support were reviewed with respect to the INTEREST system. On the basis of the above analysis, the testing of the system in the contractor's office and the work by the writer supplemented by Hall [II2], it was decided to use the following forms of user support:

- instruction manual;
- within system aids;
- formal training instruction;
- "local expert";
- computer advisory personnel.

10.3.1 INSTRUCTION MANUAL

A comprehensive reference manual is required for the system to formally state the facilities that are available and the manner in which the system should be used to meet the task requirements of the estimator's clerk, the estimator and senior management.

For all the disadvantages of this form of support[116] it is necessary to provide a reference source that may be held within the company to provide a fall-back point with which to deal with problems.

A less formal user guide could also be provided for each of the different types of user of the system. This would be of the loose leaf form so that the contents may be easily amended to include information predominantly related to the stage of development of the individual user.

A copy of the reference manual produced for the INTEREST system is included in Appendix VIII.

10.3.2 WITHIN SYSTEM AIDS

The system should include as a minimum requirement the facility of fully descriptive lists of commands and options to ensure that at each point within the system the user is fully aware of the courses of action that may be taken. These lists should be capable of being removed from the computer dialogue when the user is familiar with the system but may be displayed whenever required to help re-learn the system. Ideally the information supplied within the command lists should be capable of extension if required by the user into a comprehensive "Help" facility.

The Within System Aids incorporated in the INTEREST system are evident in the print out included in the user reference manual in Appendix VIII.

10.3.3 FORMAL TRAINING INSTRUCTION

The introduction of any new system, whether manual or machine based, into an organization requires a review of the skills of the people who will be directly and indirectly affected.

Where there is a difference in the level of skill required by the user and that at present available, some form of training should be provided to meet the discrepency. In extreme cases, the introduction of additional personnel into the organization may be required.

Formal training instruction is required by all three types of user of the INTEREST system at the implementation stage. A training programme was produced for the system. This required an assessment of:

- the population of INTEREST users;
- the training requirements of each type of user;
- the selection of appropriate training methods.

THE POPULATION OF INTEREST SYSTEM USERS

The INTEREST system was specifically designed to meet the requirements of the civil engineering estimators in producing tenders for construction contracts. Within this user population are people of different ages and backgrounds who have a varying knowledge and experience in the use of computers. The system was designed to be operated without any specialist knowledge of computing so that the population of users need not include any computing professionals. Each category of users have different training requirements and a different training programme should ideally be produced for each category.

Training programmes by necessity assume a heterogeneous trainee population. This is clearly not the case in practice, some people will be better than average at some tasks and inferior at others.

An ideal training programme should be capable of accommodating the individual differences of the trainee. Individual differences in performance and learning reflect underlying differences in motor and mental ability which determine the rate of acquisition of a task during training. The training programme should therefore be adapted to the ability of each individual wherever possible.

The age of the trainee plays an important part in the development of training programmes. Older people have particular limitations due to declining physical abilities and mental capacity. This has been well documented by Talland (117), Birren (118) and Murrell (119). Older people find it more difficult to obliterate or ignore irrelevant features in the task and this lack of discrimination increases the information content that must be handled. The older person tends to be less risky in decision-making and considerable anxiety is often present with respect to re-training for a new job. These aspects must all be considered when preparing training programmes for middle-aged or older people. Training recommendations for older people are given by Newsham (120).

With respect to the training programme for the INTEREST system it was decided that because a large proportion of a company's estimating staff would come into the middle-aged or older category an emphasis would be made on:

- learning in parts with cumulative stages;
- ensuring consolidation of learning before passing onto the next part of the task;
- increasing the length of the learning period.

THE TRAINING REQUIREMENTS FOR EACH TYPE OF INTEREST USER

THE ESTIMATOR'S CLERK

The estimator's clerk, whether a junior estimator or a person employed for data preparation is required to input the details of the bill of quantities for the contract after the bill items in the document have been coded by the estimator. This operation requires the fast input of data. The training programme developed assumes the clerk to already be proficient in typing skills. Where this is not the case this training should first be undertaken.

Instruction is required as to the purpose of each of the commands within the Data Input program and how the information input by the user may be checked. A full understanding of the computer system is not required, although knowledge of the fundamentals of the system would enhance the users job satisfaction. Likewise, it is important that the user should understand the role played in the use of estimating system and the importance of his individual task. The 'clerk' type user may in some companies be required to obtain and input data on resource prices. Where this is the case additional training is required with appropriate modules abstracted from the estimator training programme.

The training needs of the estimator's clerk may therefore be summarized as:

- an introduction to the basic elements of a mini/micro computer system;
- an understanding of the role the user will play in the operation of the INTEREST system;
- the ability to enter data from a marked up Bill of Quantities for a given contract;

- the ability to examine that data for errors of input and make any necessary corrections.

The user may be considered proficient in this task when the data input program may be operated with only the normal level of errors commensurate with a typist's proficiency.

THE ESTIMATOR AND THE CHIEF ESTIMATOR

The INTEREST computer aided estimating system has been specifically designed to fit the tasks of the civil engineering estimator in the calculation of the direct cost for a construction contract. This has been based on a formal analysis of the estimator's task. (See Chapter 4.1). The problems of the estimator in using the system as a replacement for the manual operation are principally ones of execution, learning how the system may be utilized to perform his task. The training needs of the estimator may therefore be identified as:

- an introduction to the data input keyboard and its operation;
- the conceptual understanding of the system and how it operates;
- an understanding of each of the commands within the system, how to locate them and how to use them to perform the operations required.

The enquiring nature of the estimator and his demands for detailed knowledge requires that an understanding is taught of the basic components of a mini/micro computer system.

The INTEREST system has been produced as a general computer aided estimating package. It has not been tailored to any particular company or individual but is the product of a concensus of opinions.

Consequently there will be a need to train the estimator to fully understand any terminology and operations not normally used.

The estimator may be considered proficient in the operation of the system when he can:

- operate the hardware without assistance in its normal mode of operation;
- locate the contract for which he is required to produce an estimate;
- adjust all the prices of the resources for the contract;
- understand the structure of the system to enable any command to be located;
- understand the facilities offered by each command and perform a specified task with each command;
- produce an estimate unaided by using the commands available to reflect his requirements for the estimate build up.

One senior estimator within the company will be required to manage the INTEREST system. This will entail not only setting up files for each contract on the computer but the preparation and maintenance of the company library of data. This entails no formal training in computing, these functions being handled by a separate program within the system. However, extra training will be required in the utilization of these commands and a better understanding of the concepts and structure of the system will be necessary.

When proficient the chief estimator must be capable of:

- setting up files for a new contract;

- deleting information on an old contract;
- making copies and storing information on existing contracts;
- inputing new data into the company library;
- modifying or deleting information from the company library.

THE CONTRACTOR'S SENIOR MANAGEMENT

The construction manager or director requires the system to produce detailed information on which to base commercial decisions. Training is therefore required to enable him to:

- operate the hardware without assistance;
- locate the contract for which he is required to produce an estimate;
- obtain the build-up for any item within the bill;
- select any command necessary from the list of mark-up facilities to enable on-costs to be calculated and apportioned throughout the bill;
- obtain any report required from the reporting facilities present.

He should be proficient enough to carry out the above tasks unaided and finalize a tender satisfactorily, producing a total tender sum and a list of bill items with the required rates.

THE SELECTION OF APPROPRIATE TRAINING METHODS

The selection of an appropriate training method for each category of user of the system involved the consideration of the different forms of learning structure and a decision on training tactics. Gilbert ( ) and Mechner ( ) identify three basic learning structures:

- "chain" structures;
- "multiple discrimination" structures;
- "concept" structures.

To identify the learning approach to meet the needs of the INTEREST system users it was necessary to classify their requirements under one of the above headings.

'CHAIN' STRUCTURES

'Chain' structures consist of a rigid sequence of signals or events that must be carried out in a pre-determined order. Training for this type of chain operation involves establishing an overlap between successive links. This may be accomplished by progressive learning, role learning, or regressive learning. Whatever the approach employed, the trainee cannot be expected to perform at top proficiency immediately. Satisfactory performance is only reached after the necessary practice and repetition. 'Chains' involving motor skills are retained fairly easily while verbal 'chains' are easily forgotten.

In the INTEREST system a typical 'chain' structure would be switching on the computer and locating the estimate for the contract.

MULTIPLE-DISCRIMINATION LEARNING

A multiple discrimination involves distinguishing one category of phenomena from another. Before multiple discriminations can be learnt each of the signals making up the set to be discriminated must be learnt. The teaching or learning of multiple discriminations involves identifying distinctive conditions. All conditions should be presented together at the same moment in time to face necessary discrimination to be made by the trainee.

This should be started with the easiest and gradually moved to more subtle instances.

Correct discriminations must be confirmed to the trainee. Practice is less important than in chain learning for it does not appear to strengthen discriminations once they have been acquired. Whether the discriminations are easy or difficult to learn they appear very easily forgotten.

An example of multiple discriminations within the INTEREST system is the Main and Sub-menu of commands. Here the user must be capable of discriminating between the various commands within the menu, recognising their capabilities and how and when they are to be used within the operation of the system.

CONCEPT LEARNING

A concept may be defined as a generalization about a whole class of phenomena that differ from each other in outward appearance. In order to classify different types of phenomena it is necessary to identify abstract stimuli, (ie properties such as colour, shape, number, position, size etc). The aim of the teacher should be to ensure that the student is capable of identifying the class of phenomena that is to be generalized and the limits of variability that will be tolerated. The tactics for teaching must involve generalization within the class and discrimination between classes. Davies [(123)] demonstrated that repetition, rehearsal or practice contribute little to either the acquisition of a concept or its retention. If a concept has not been acquired as the result of a teaching procedure repetition of the same procedure is unlikely to obtain a satisfactory result.

A fundamental concept of the INTEREST system is the hierarchical structure of commands within the system. This concept has to be understood before the user can move freely throughout the system from one command to another to effect the build-up of the direct cost estimate. Any training system employed should emphasize this concept and provide alternative means of demonstrating its importance.

A training scheme was developed by the writer for the INTEREST system incorporating:

- lectures and demonstrations (with appropriate audio-visual aids);
- informal group discussions;
- guided tuition of the operation of the system;
- structured exercises undertaken by each trainee.

The scheme was devised as a series of modules each with a defined objective. Progression from one module to another was not permitted unless it was considered that the objective of the existing module had been met and the student was judged to have reached the required level of proficiency in the task involved. The following modules were included in the training programme:

Module 1 - Talk on computers and estimating;

Module 2 - Demonstration of the system;

Module 3 - The components of a microcomputer system;

Module 4 - The input keyboard;

Module 5 - Running the INTEREST programs;

Module 6 - Pricing bill items and printing reports;

Module 7 - How the system handles resource prices;

Module 8 - The system control program;

Module 9 - Pricing a simple Bill of Quantities.

10.3.4 "LOCAL EXPERT"

The introduction of any computer system leads to the evolution of a "local expert"[115]. It seems logical that rather than let this disrupt the normal work pattern of the expert that the position is formally recognised within the company. This will provide a direct channel between the company and the suppliers of the system to enable specific problems to be solved and provide a point of reference for all users within the company who have specific problems.

The INTEREST system requires one estimator to act as the controller of the system, setting up contract files, deleting contract data and maintaining the library of company data. This responsible role should be formally recognised and the estimators knowledge of the system developed so that he becomes the "local expert" for the system within the company.

10.3.5 COMPUTER ADVISORY PERSONNEL

After the implementation of the INTEREST system the user will still have the need of access to computer advisory personnel. As the users understanding of the system grows, his needs will evolve. Eventually he will have requirements for amending displays and printouts or extending the system to incorporate other aspects of his tasks which may readily be performed within the system. It is important that a continuing liaison is maintained between the user and computer advisory personnel, whether they may be within the company or the suppliers of the system, in order that the system may be extended wherever possible and used to its full capacity.

11.0 AN ASSESSMENT OF THE PROFITABILITY OF THE INTEREST SYSTEM

The primary objectives of a company are survival, growth and profit[124]. The level of profit which is required is not necessarily the maximum possible but a figure determined as satisfactory with budget expectations[125]. A company pursues secondary objectives which contribute to the overall profitability of the organization. These include innovation of methods and procedures to increase efficiency and hence profitability. The task of the manager is to make economic decisions to increase profitability. This may be by one of two methods:

- cost reduction expenditures;
- income expansion methods[126].

Some management decisions may produce both these events. The majority aim to bring about one or other of them. Most suggestions to increase profitability centre around a reduction of future costs for a continued level of gross income. When income expansion measures are considered, any adopted scheme must first result in a total income that exceeds the total cost committment and secondly produce a net profit that is sufficiently attractive.

The development of the INTEREST computer aided estimating system produced a system capable of assisting the civil engineering estimator in the performance of his tasks. The adoption of the system by a construction company will depend on an increase in profitability to offset the capital outlay and increased overhead committment. (Maintenance, consumables, etc.)

The estimating department within a contractor's organization is a semi-fixed overhead necessary to obtain construction work.

The chief estimator may aim to increase profitability by several methods:

(i) Reduce the number of man hours to produce each tender, maintain the same number of tenders submitted and reduce the cost of the estimating department by reducing the number of estimators.

(ii) Increase the number of tenders priced by the estimating department while maintaining the same level of staff. This reduction in the unit-cost of each tender, if accompanied by the same success rate, increases company turnover.

(iii) Improve the standard of the estimates and tenders produced in an attempt to:

- win more tenders for the same number of tender submissions;
- provide better information for tender adjudication leading to better management decisions.

(iv) Provide an estimating service that supplies information in a form suitable for better monitoring and control of the construction projects that are awarded, so increasing company profitability.

This section describes the research undertaken to assess the profitability of the INTEREST system. Studies were made to:

- calculate the cost reduction resulting from any saving in the estimator hours required to produce a single tender;
- assess the increased number of tenders submitted when adopting the system and maintaining the same number of estimators within the company;

- determine the contribution made by the INTEREST system to more accurate estimating and better management decisions at the tender adjudication;
- define the areas where the INTEREST system may provide project information in a form suitable for other functions within the company at both the pre and post tender stage.

An attempt was made during the trial period within the contractor's organization to assess whether there was a saving in the man hours needed to produce an estimate using the system, or if there was a marked increase in the number of tenders processed by the same staff. This was followed by tests on the INTEREST system by the writer to synthesise the production of estimates and evaluate possible savings in estimator time.

It became apparent that due to:

- the unique nature of each estimate;
- the different methods of pricing bill items;
- the changes made to the estimate during the tender period;
- the variable flow of information within the tender period;
- the learning curve for the system;

it was possible to assess whether or not in the production of any particular individual tenders there were savings in man hours. This remains an area for further long-term field trials. While it was possible to estimate the time taken to input data and produce a direct cost estimate for a project it was impossible to calculate the estimator's time spent in considering alternative solutions and estimating labour and plant output and usage rates.

With manual methods the object of the estimating department is to produce the best possible estimate within the time available. The adoption of a computer aided estimating system does not change this objective. The profitability of a computer aided estimating system therefore can only be assessed from the aspect of savings in man hours by considering the standard of the number of tenders produced by a department over a period of time as compared with consideration of whether the same number of estimates of the same standard could have been produced manually. No construction company had used the INTEREST system for a long enough period to overcome the learning problems and make this type of assessment. Therefore a study was made by the writer as to how the adoption of a computer aided system may improve communication between company staff and whether the standard of management information produced when using the system is improved.

The comparison of these improvements against the capital cost of the system is a subjective one that individual companies must make when deciding on the probable profitability of a computer aided estimating system such as INTEREST. In the opinion of the writer the facilities that exist with computer aided estimating systems to:

- produce reports of labour, plant, material and sub-contractor costs and reports of total labour, plant and material quantities for use by the adjudication panel;
- allow automatic updating of resource prices throughout all the appropriate bill items;

- produce reports of materials and subcontractor quotations that are still outstanding for the estimate under preparation;
- provide a regularisation within the company of the estimator's build-ups of item prices;
- help identify the cost important items within the Bill of Quantities;
- assist in the reduction of errors within the estimate due to omission of item prices;
- obtain a direct cost total for the work prepared on the estimate to date at any time within the estimating period;
- improve the reconciliation of the quantities of labour, plant and materials resources required for the contract;
- improve records of the estimator's build-ups;
- allow the inclusion of additions, surcharges, site overheads, head office overheads and profit margins;
- allow the addition of mark-up factors to be undertaken on a "what-if" basis and the process to be repeated several times to determine the most appropriate mark-up strategy;
- store knowledge on different construction methods that is quickly accessible and remains within the company when an estimator changes employer;
- reduce and eventually abolish the need for comptometer operators;
- provide a storage system for completed tenders that may be quickly and easily accessed to study past calculations and the resources required for different methods of construction;

- provide a structured storage system for contract data that may be readily accessed by other personnel within the company who are involved with other management functions;
- produce better records and the possibility of a link with site control so enabling the estimators cost data to become the site managers 'control' data and perhaps the link of feedback from site to the estimators data;

make the capital outlay required to purchase, implement and run a computer aided estimating system a profitable proposition.

11.1 PROFITABILITY AS ASSESSED FROM THE FIELD TRIALS

In the field trials undertaken it was impossible to prove whether the estimator, when pricing the contract using the INTEREST system, would save time over existing manual practices. This was due to the following factors;

- the hardware used for the trial;
- the learning curve;
- the uniqueness of each estimate.

The hardware used for the trial, a Genesys Design Centre, was unsuitable for the INTEREST software in the respect that it had been designed primarily for large computational tasks which were processor dependant. This computer utilized data checking and optimising routines which slowed the input and output of data from the hard disc. The INTEREST software is dependant on fast access to library files and consequently when implemented on the Design Centre the overall performance was too slow for an interactive system.

Even after an appropriate training programme there is a learning curve related to the ability of the estimator to satisfactorily handle the production of estimates for contracts. The estimator's allocated to test the INTEREST system found that an increase in workload within the department prevented them from spending continuous time on the system and consequently their learning and performance with the system suffered. On several occasions it was necessary to re-learn techniques already mastered and performance never reached the level that would be achieved if the system was in everyday use.

The uniqueness of every contract estimate meant that it was impossible to directly compare the time taken to manually produce an estimate with the time taken using the INTEREST system. The different approaches of estimators to pricing the same contract made it impossible for one person to carry out the task manually while another produced an estimate using the computer. Therefore a direct comparison between manual and computer based estimating could not be made.

In such circumstances only the throughput of a significant number of estimates using the system would enable comparison with existing manual methods to be made. The time constraint of the trial made this type of assessment impossible.

11.2 TESTS TO SYNTHESIZE THE PRODUCTION OF ESTIMATES

To study the time taken to produce estimates with the INTEREST system as compared with manual performance, tests were undertaken on the time taken to input and change data using the commands available within the system to synthesize the overall time taken to produce a typical estimate for a contract.

When using the INTEREST system the following operations are necessary to produce first a detailed estimate and then a fully priced tender for a contract:

(i) The setting up of the contract files and input of background data to the project.

(ii) A study of the Bill of Quantities with the coding bill items to reference them where appropriate to Work Groups that are held on the company library.

(iii) The input of details on the Bill of Quantities items onto the computer files with appropriate referencing to work groups on the company library.

(iv) The review by the estimator of the resources required for the contract with the necessary amendments to the resource file.

(v) The pricing of the bill items.

(vi) The input of subcontractor and materials prices.

(vii) The production of reports for the tender adjudication meeting.

(viii) The adjustment of the estimate to produce a final tender sum.

(ix) The submission of a priced Bill of Quantities.

Each of these operations is now described in detail.

The setting up of the contract files and the input of background data on the contract is a on-off operation necessary to allocate computer file space and set up the necessary passwords.

A study of the Bill of Quantities is always necessary on the receipt of the contract documents. Using the INTEREST system the estimator must code appropriate bill items to Work Groups on the Library using the reference system employed. Also the estimator should identify which of the items within the bill will be priced using subcontractor quotations and label the items accordingly.

The input of details of the Bill of Quantities items onto the computer files is an additional operation to the existing estimating and tendering process.

The following details need to be input for each bill item:

- item reference;
- description (if desired);
- units;
- quantity;
- Work Group reference;
- whether a subcontract item.

The prices for resources used on a contract are usually unique to that particular project. Each estimate has its own file of resource data. The estimator must review the details of the resources, change the all-in rates for labour and plant to his new calculations and mark appropriate materials resources as awaiting quotations.

Each bill item for the contract must be inspected by the estimator and amended to produce a satisfactory build-up of resources for the work involved. This will be a lengthy operation as is the existing manual process. The exact time needed to undertake this task is dependant on:

- the type of contract;
- the number of bill items;
- the number of classes of work;
- the form and content of the contract documents;
- the method of pricing of the items;
- the number of subcontractor quotations;
- the number of changes necessary during the period of the estimate;
- the performance of the hardware;
- the number of amendments made by the client to the contract details.

As the direct cost estimate is being prepared there will be the requirement to include subcontractor and materials prices as and when they are received. This will involve the updating of the resources price file on a regular basis in order that the latest prices are always included in any calculations.

The production of reports for the tender adjudication meeting includes the calculation of the direct cost for the contract and the collation of information on specific classes of work aid resources used. This task must at present be performed by comptometer operators and can only be performed once. Using the computer these totals may be produced quickly and whenever they are required.

Following the tender adjudication meeting there will be a need to add a mark-up allowance to the direct cost estimate to produce a total tender sum. This additional money needs to be added in a number of ways ranging from the straight addition of a single sum of money to the apportionment of a sum of money throughout all the bill items.

When submitting a tender for a contract the client may accept a tender sum presented on computer print out. Where this is not the case the rates must be transfered from the computer print out to the Bill of Quantities document and checked.

11.3 THE TIMING OF THE PRODUCTION OF A TYPICAL ESTIMATE

Using the INTEREST software implemented upon a single user CROMEMCO 22H microcomputer an estimate was priced by the author for a typical contract of some 440 bill items. The system represented a typical configuration that a user may purchase as a dedicated machine for use solely for estimating. The hardware consisted of:

- a Cromemco 22H microcomputer with 64K C.P.U. and a 10 M Byte Hard Disk unit;
- a Tally 1806 printer;
- Volker Craig 404 V.D.U.

The contract chosen was based upon a Bill of Quantities for a motorway overbridge with side-roads. The bill items were repeated over several sections. This allowed a comparison of the pricing of similar items to be made and provide a check as to the arithmetic calculations of amendments made to particular classes of work. Bill item descriptions were included on some items but not others to give an indication of the effect this extra data had on the time required to enter the bill.

The following timings were taken with respect to the operations described in Chapter 11.2.

11.3.1 THE SETTING UP OF THE CONTRACT FILES

This procedure took a total of 15 minutes, to input data on the contract, check and amend the details and set up the file space on the computer files.

11.3.2 THE CODING OF THE BILL ITEMS

The time taken to code bill items to a library depends upon the following factors:

- the type of contract;
- the item referencing system in the Bill of Quantities;
- the referencing system of the library;
- the number of Work Groups held on the library and the range of types of work;
- how often similar bill items are repeated in different sections of the bill;
- the experience of the estimator.

Where the estimator is pricing a bill drawn up under the CESMM, if the library of company data has been set up using the same basis of trade classification and subdivision then coding would be a straightforward exercise. Attempting the same operation where a Bill of Quantities had been drawn up by an unusual method of measurement and relating these items to a complex company coding system would take considerably longer.

To code up 30 bill items took the writer ten minutes using a non standard bill with a coding system based upon the CESMM. In practice, where an estimator wished to include bill item descriptions, key words in the bill description would have to be marked to show the data input person what to include. This exercise would take some 5 seconds per bill item.

11.3.3 THE INPUT OF DETAILS OF THE BILL OF QUANTITIES ITEMS

The time taken to input the data into the system is dependant on:

- the keyboard skills of the operator;
- the type of bill item;
- how the estimator wishes to price the item;
- whether or not item descriptions are included;
- whether a work group reference was included.

Typical average timings taken are included in Table 12, page 325. From this it may be seen that the average time taken to input a bill item was some 28 seconds if the item description was included and some 12 seconds where this was omitted. Where bill items were referenced to Work Groups on the library, although no description was necessary, the average time was again some 28 seconds.

The writer, although familiar with the input keyboard possessed no typing skills and therefore in practice the input of bill item details would be faster when performed by trained data preparation personnel.

Assuming a 10% increase in speed on items not including a description and 25% on those with a description typical times for the input of a 500 item bill would be some 2¾ hours and 1½ hours respectively. (This makes no allowance for relaxation time). If thirty percent of the bill items are to be priced by Work Groups the time increases to 3¾ hours and 2 hours respectively.

Method of Pricing	Descriptions	Average Time (Seconds)
ITEM SUM	YES	24.0
	NO	8.25
SPOT RATE	YES	27.5
	NO	17.14
S/c	YES	33
	NO	12
BUILD UP OF RESOURCES	YES	30
	NO	14
WORK GROUPS	NO	28

TABLE 12 - TYPICAL TIMINGS FOR THE INPUT OF BILL ITEM DETAILS

NOTE: Where items were to be priced using Work Groups from the data library, no descriptions were input, the Work Group descriptions being utilized.

11.3.4 <u>THE REVIEW OF THE CONTRACT RESOURCE FILE</u>

To inspect and amend details on ten resources took just under three minutes. To review some 500 resources would take $2\frac{1}{2}$ hours.

11.3.5 <u>THE PRICING OF THE BILL ITEMS</u>

In order to prepare the direct cost estimate the estimator must price all the items within the Bill of Quantities. This may be undertaken in a number of ways. Respective timings for these methods are given below.

If all the items within the bill have been linked to Work Groups within the library then the bill may be priced automatically. To inspect and file an item priced by a work group took 57 seconds. To inspect an item, make two changes to the build-up and then file took 112 seconds. If it was required to make two replacements to existing item build-ups the operation took a total of 180 seconds.

To price a bill item by a single sum of money allocated to one cost code took an average 26-25 seconds. Where this was extended to allocate monies to three cost code categories the time increased to 30.5 seconds.

Where the spot rate facility was used to price items by allocating a rate to various cost codes the time required was an average 47 seconds.

Using the subcontractor quotations facility it was possible to enter fifty-six subcontractor rates in 745 seconds, an average of 13 seconds per item.

To build up a bill item price from first principles using four resources took two minutes 38 seconds.

Using the operational estimating facility it was possible to build up an operational group of four resources in two minutes eleven seconds. To price a bill item by the use of two operational groups took an average of two minutes.

Within the INTEREST system there exists the facility to price bill items automatically at the same rate as other bill items using the "lump" facility. To price items via this facility took an average 23 seconds per item.

To calculate the total direct cost of the project took 21 minutes. To print out details of the 440 bill items on an average speed printer (180 characters per second) took just under 50 minutes.

11.3.6 ANALYSIS OF THE RESULTS

From the results obtained in the test bill, the following facts were evident:

(i) If bill items were priced by using a Work Group from the data library the direct cost estimate for the contract could be automatically produced.

(ii) Where it was necessary to inspect all the bill items priced from the data library and amend the resource details this proved a lengthy procedure.

(iii) Pricing bill items by the entry of subcontractor quotations was the fastest method of pricing items by the introduction of data.

(iv) Inputing bill items with descriptions takes approximately 1.8 times as long to perform than without descriptions.

(v) Where 30% of the bill items input had to be linked to Work Groups on the company library the time to input the bill items increased by approximately one third.

(vi) The relative times taken to price bill items using the various facilities of the system range from thirteen seconds per item to 180 seconds per item. (This is shown diagrammatically in figure 64, page 329.

11.3.7 USING THE RESULTS TO PREDICT THE TIME REQUIRED TO PRICE A BILL OF QUANTITIES

From the results of the test it is possible to predict the time taken to price an estimate using the INTEREST system depending on the various approaches of the estimator to the pricing of the individual bill items.

Assume the estimator wishes to price a 325 item Bill of Quantities and that the bill items are priced in the manner shown in Table 13, page 330.

The necessary time to price the bill using the computer may be calculated as follows:

To set up the contract files - ¼ hour.

To review the bill, allocate 100 work groups, and mark 60 items to be priced by subcontractors would take 1 hour.

To mark the bill item descriptions that were required to be input into the computer would take 1½ hours.

To input the Bill of Quantities onto the computer would take 2½ hours plus say ½ hour to check the items input and make minor corrections.

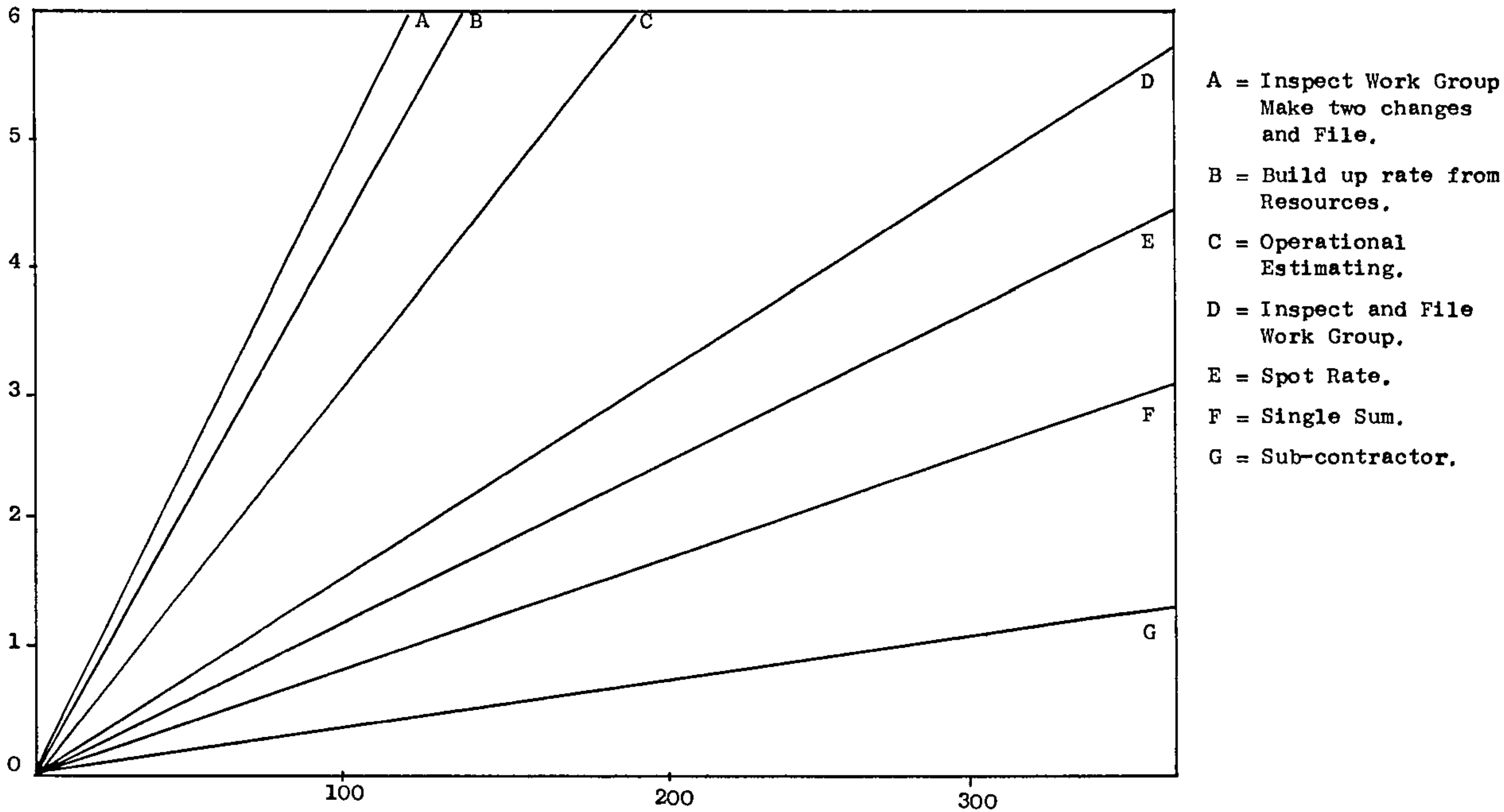

Figure 64 - THE RELATIVE TIMES TAKEN TO PRICE BILL ITEMS

NUMBER OF BILL ITEMS	% OF TOTAL	METHOD OF PRICING
50	15.38	Directly from Work Groups on the company library
50	15.38	From Work Groups with added or amended resources
50	15.38	From build-ups of resources
50	15.38	By operational estimating using a total of ten groups
60	18.46	By subcontractor prices
30	9.41	Spot rate
10	3.08	By an item sum
25	7.69	Provisional sum and prime cost items

Table 13 - THE METHODS USED TO PRICE THE BILL ITEMS

To review 500 resources on the resource file for the contract, input the revised all-in labour and plant rates and mark the materials as awaiting quotations, $2\frac{1}{2}$ hours.

To price the bill items in the manner indicated in Table 1 would take a total of 7.3 hours interpolating the timings from figure 64 page

To review the prices on 500 resources and input say 400 prices and supplier details, 2 hours.

To calculate the direct cost total and print out the bill listing, 52 minutes.

The total time taken to produce the direct cost estimate using the system is therefore:

$$0.25 + 1.0 + 1.5 + 2.5 + 0.5 + 2\tfrac{1}{2} + 7.3 + 2 + 1.0$$
$$= \underline{18.55 \text{ man hours}}$$

It should be noted that the above timings do not include any allowance for the time taken for the estimator to actually estimate work within the project. Whereas some of the estimating will be performed while operating the system, other time will inevitably be spent performing tasks such as determining appropriate outputs and obtaining subcontractor and material quotations. The estimator is continually evaluating the direct cost estimate and adjusting his previous calculations. The time taken to produce the direct cost estimate will inevitably extend to fill the time available within tender period. Consequently no direct comparison is possible between manual methods of estimating and the time taken to produce an estimate using the computer. The time predicted by the calculations within this chapter must be considered as a segment of the total time within the tender period.

The assessment of the profitability of a computer aided estimating system then becomes a subjective assessment of whether the cost of producing a computer based estimate is substantiated by the additional facilities provided by the system.

While the time taken to produce a direct cost estimate may be no shorter than by manual means the use of a computer for calculation and reporting provides the following facilities:

(i) The ability to produce reports of labour, plant, material and subcontractor costs and reports of total labour, plant and material quantities that may be presented to the tender adjudication panel.

(ii) The input of resource prices as and when they become available within tender period. The computer will then automatically include the latest price wherever the resource has been used within a bill item build-up.

(iii) The 'Awaiting Quotations' facility enables the estimator to obtain listings of the materials and subcontractor quotations that are still outstanding at any point in time. The listing may then be passed to the appropriate personnel within the company to secure a fixed price. This facility becomes more important the nearer the tender submission date approaches.

(iv) By using the company library to initially price bill items the estimator may discover the cost important items within the estimate and focus his attention for more detailed calculations appropriately.

(v) The calculations of the total direct cost for the project, (or a section or trade within the project) may be obtained at any stage. The calculating power of the computer means the estimator does not have to wait until the end of the time period allowed for the direct cost estimate to produce a direct cost sum. The role of the comptometer operator is reduced and may be abolished.

(vi) Using the computer to perform the calculations required at all stages removes the risk of human error.

(vii) Facilities within the system enable details to be obtained of bill items that have not been priced or include resources that are still awaiting quotations. This reduces errors due to the omission of item prices.

(viii) The storing of the build-up of each bill item upon the contract file enables a total requirement for each resource within the project to be quickly obtained. These totals may then be compared with the planning engineers calculations. Manually such calculations require prodigious clerical efforts.

(ix) The ability to store data on past tenders and then quickly access the information gives the estimator ready access to past calculations and the resources required for different methods of construction.

For the senior management within the construction company a computer based estimating system provides:

(i) Improved records of estimators build-ups for bill items that may be readily accessed and reviewed.

(ii) The ability to allow for the inclusion of additions, surcharges, site overheads, head office overheads and profit margins in a simple and quick manner that enables sums of money to be directed to the exact part of the Bill of Quantities required.

(iii) The addition of mark-up factors on a "what-if" basis so that the process may be repeated several times to determine the most appropriate mark-up strategy.

(iv) The regularisation within the company of both the estimating process and the estimator's build-up of item prices.

(v) The ability to store knowledge on different construction methods and resource requirements in a readily accessible form that remains within the company and does not disappear when estimators change their employer.

The structured storage of the estimators data provides information that may be accessed by personnel involved with other management functions within the company. This may occur at the pre-tender stage and is described in detail in the following section of this chapter.

11.4 IMPROVED COMMUNCATIONS BETWEEN COMPANY STAFF

A system may be considered profitable if communications between company staff can be improved by its adoption. In the case of a computer aided estimating system this may be the communication between staff employed on functions within the estimating process (eg planning, purchasing) or staff employed on functions relating to the construction stage of the project where information assembled by the estimator may be utilized, (eg post tender planning, cost control, valuations etc).

An examination of the estimating and tendering process (Chapter 2) and the tasks of the estimator (Chapter 4) showed the complex information exchange related to the estimating function. The estimator is required to:

- identify legal problems relating to the contract documents and subcontractor agreements;
- provide information on materials requirements to the purchasing department to enable quotations to be prepared;
- collate, assess and include materials prices and sub-contractor quotations within the estimate;
- discuss with planning engineers construction methods and the tender programme;
- agree with planning engineers a reconciliation of resources used on the contract.

By using a computer aided estimating system, the estimator's data may be made accessible to other functions within the organization. The following example relates to pre-tender planning and shows how the transfer of information may take place.

11.4.1 THE USE OF THE ESTIMATORS DATA BY THE CONTRACT PLANNING TEAM

The link between planning and estimating was described in Chapter 2 and examined in a survey performed by the writer as part of the research programme. It was found that the two functions of planning and estimating may be fully integrated, the contract programme being used as a basis for calculating the full cost and revenue characteristics of the contract. More commonly the two functions are not integrated and the planned use of plant and labour resources is costed in total by the planners and checked against the labour and plant totals as calculated by the estimator.

The majority of construction companies use bar-charts for planning at the pretender stage. Simple logic networks are also recommended[127].

Consider the following example where the estimator has been using a computer aided estimating system such as INTEREST to prepare the estimate, and the planning engineer for the contract is using a computer based planning package which hitherto operated on a stand alone basis.

The INTEREST system enables the total resource requirements for the contract to be quickly calculated from the estimator's build-ups for the items within the Bill of Quantities. These totals may then be checked against the planner's calculations. The facilities provided by the INTEREST system enable the estimator's data to be made available to the planner. The data the estimator records in his contract file includes all his build-ups, assumed outputs and costs. The data available to the estimator in his Performance Data file contains gang build-ups for common items of work. The data contained in the Operational Resource Groups File contains the estimator's build-ups for say the "Concrete Production and Placing Gang" or the "Excavation Gang", with the associated durations. It is evident that the data contained in these three files is very useful if not essential to the planner in preparing his production plans.

There are three possible ways of giving the planner access to his data:

- manual access only;
- the right to inspect files;
- the right to inspect files and software to transpose data for use in his planning.

These three possibilities are now considered.

MANUAL ACCESS ONLY

The planner may be given manual access to the estimator's data. This requires the estimator to provide a printout listing of the contract file, resource file and the performance data file. The planner is then in possession of all the estimator's data while he prepares his input for his planning package. This is the cheapest solution in terms of acquiring new equipment of software. However, the method is unsatisfactory in respect that the planner receives large printouts which if he accesses the most up to date copies regularly will cause him to be inundated with paper.

THE RIGHT TO ACCESS FILES

The planner could be provided with the software to enable him to inspect the estimator's data files and record the items of data he required. This is shown in figure 65 below.

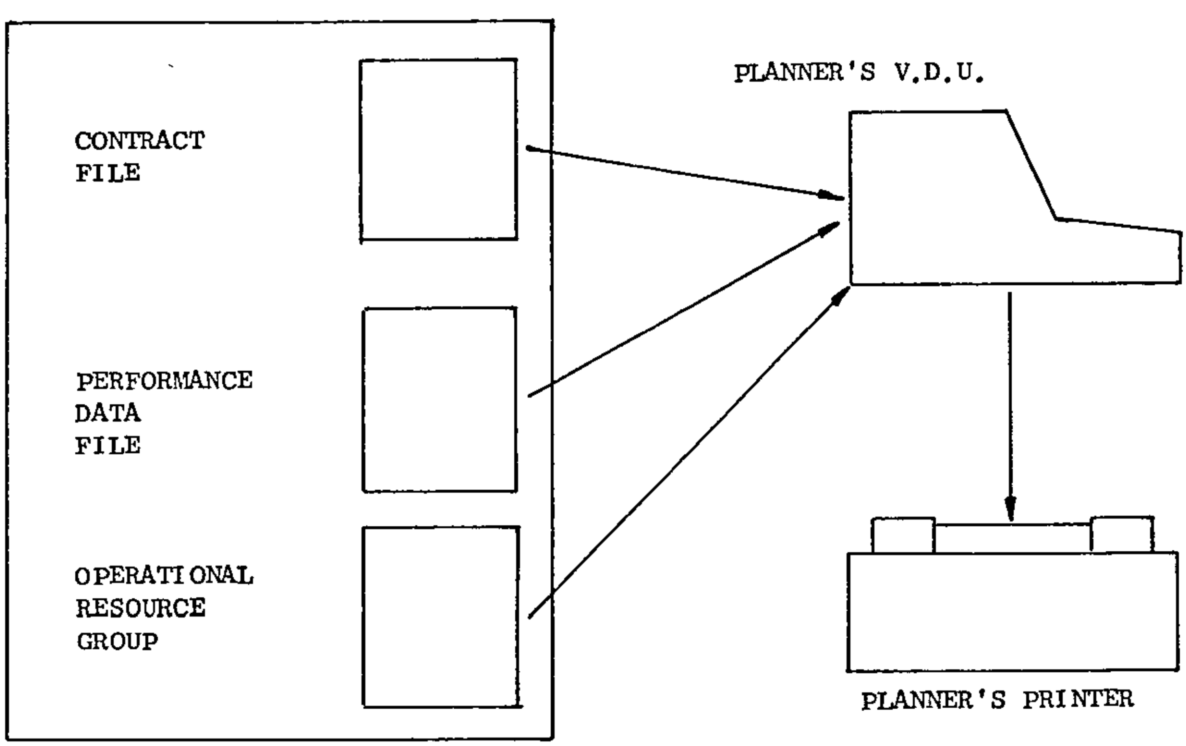

Figure 65 - THE PLANNERS RIGHT TO ACCESS THE ESTIMATORS DATA FILES

The software would allow the planner to inspect the build-up of an item but not alter the information contained.

THE RIGHT TO INSPECT FILES AND SOFTWARE TO TRANSPOSE DATA

In this method the planning engineer may access the estimator's data and enter the data into a computer file of input data for the planning package that is to be used. It is probable that the data in the estimator's files will require some transposition to make it compatible with the input requirements of the planning package. As before the planner would only have the right of inspection of the estimator's data and not the ability to change the contents of any of the files. Some amendments to the planning package used may be required to enable data transference to take place. This is shown diagrammatically in figure 66 page 339.

The link to the estimator's data and the remote job entry link to the planning package with the planner providing any translation required may be replaced by an automatic translation of the estimator's data. This is shown in figure 67, page 341, and would inevitably be more expensive in both hardware and software.

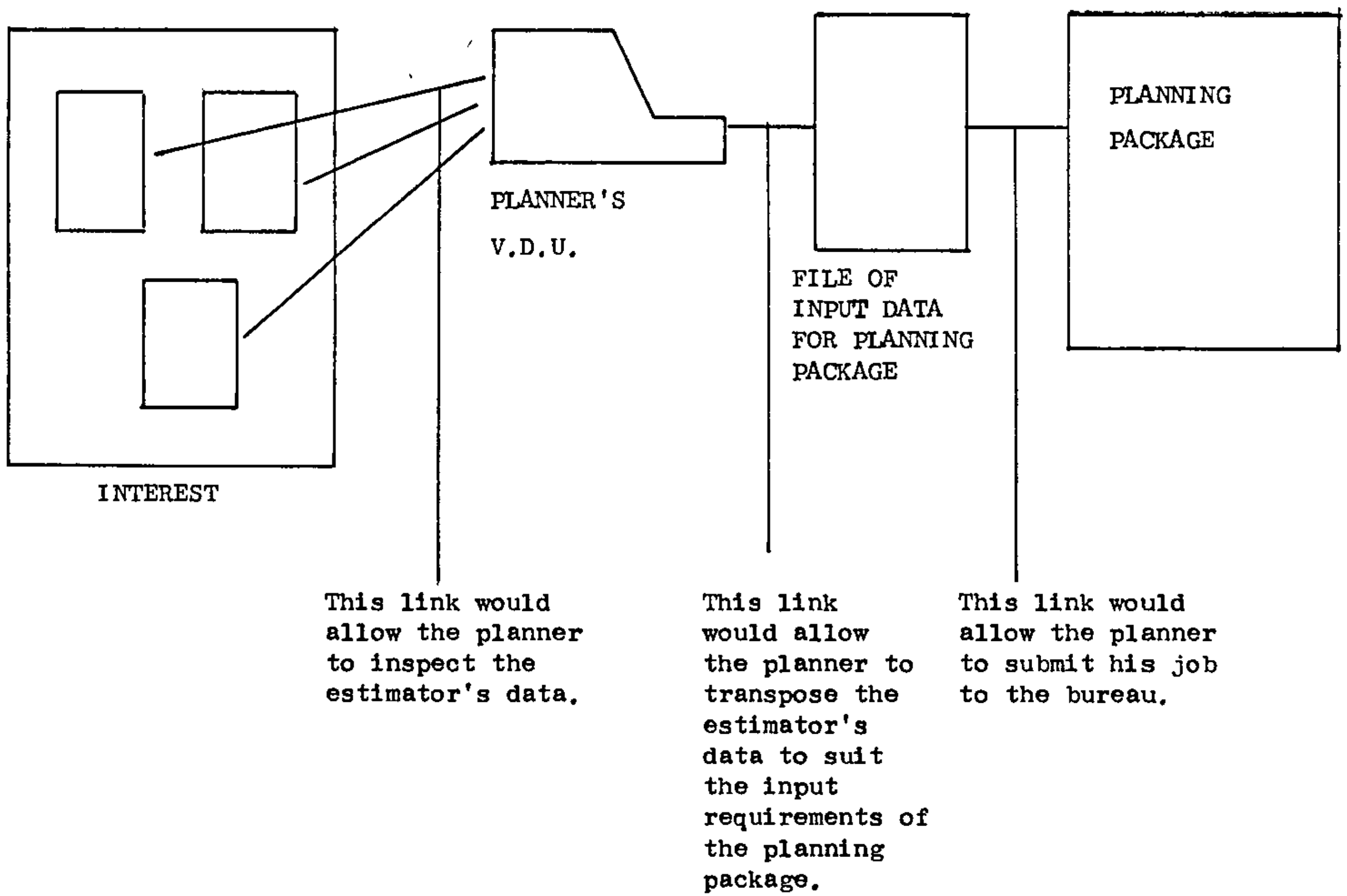

Figure 66 - THE PLANNER'S RIGHT TO INSPECT FILES AND SOFTWARE TO TRANSPOSE DATA

This example may be applied to other functions within the company such as purchasing and represents the range of possibilities for improving communications between different sections with the company. These possibilities are considered a real improvement in communications within the organization which would result in a more efficient and therefore profitable company.

On award of the contract to the contractor the estimator's data may be used as a basis for detailed project planning, cost control, valuations etc. The structured nature of the data which is held in a readily accessible form may be inspected in any of the three ways already described with respect to data at the pretender stage. Although it is inevitable that contract staff will decide to undertake certain parts of the construction in different ways and that changes in the contract details resulting from the engineers variations will render some of the estimator's data obsolete, his initial calculations are invaluable as a basis for further work. Given a complete system it would be possible for the results of the site work to be incorporated into the system to provide data for the estimator's use when pricing new contracts. This is shown diagrammatically in figure 70, page 365.

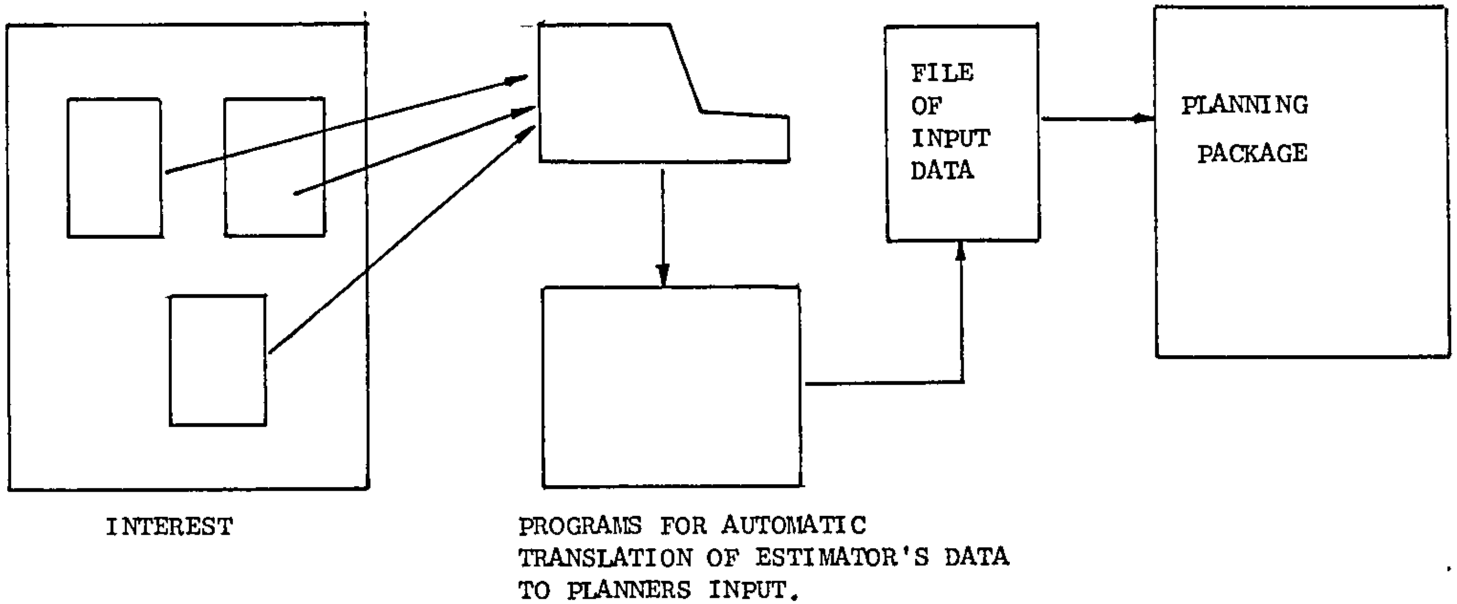

Figure 67 - THE AUTOMATIC TRANSLATION OF THE ESTIMATOR'S DATA

11.4.2 A SOFTWARE PACKAGE DIRECTLY LINKING ESTIMATING AND PLANNING

There exist a great many software packages in the form of stand alone planning packages based on network planning. (Reference may be made to (6) and (7)). The writer could find none linked to computer aided estimating systems.

Bowman (16) in conjunction with the writer produced a prototype planning system called TIANAREBA, Time Analysis and Resource Balancing, to link to the INTEREST C.E.2 system. This system was developed to provide a computer based network analysis system for planners that would utilize the estimator's data.

The planner assigns and apportions items from the Bill of Quantities to the activities of a construction programme. The network is then built up based on the logical relationships between activities and the resource constraints specified. It is then possible to obtain both time and resource analyses for the contract to determine the full resource requirements for the contract period.

The planner assigns and apportions items from the Bill of Quantities that has been priced using the INTEREST system to network activities representing the pretender construction programme. The network is then built up in the normal manner to reflect the time and logic relationships for each activity and form a basis for the time analysis. The build up of resource requirements for each activity to form the basis for the resource balancing analysis may be made by either:

- the conventional approach to network analysis of specifying the resources used by each activity; or
- extracting resources from the bill item build-ups as found in the INTEREST system.

Constraints on resources that are considered as "resource-limited" are then introduced and time and resource balancing analysis performed. Resource aggregations are produced using either:

- earliest start times;
- the 'resource-limited' scheduled times of the activities as the basis for the timescale.

The results of the network analysis are stored on file so as to provide a basis for other calculations such as cash flow.

TIANAREBA shows that the data assembled by the construction estimator may be directly utilized by other functions within the organization and represents the first step towards a fully integrated management system for civil engineering contractors.

11.5 THE PRODUCTION OF BETTER AND MORE COMPREHENSIVE INFORMATION FOR MANAGEMENT

The use of computer aided estimating systems provides senior management with contract data in a structured and accessible form that enables a better understanding of the contract and makes it easier to assess the effects of financial amendments to the contract.

Existing manual methods rely on the estimator to abstract and present information to the senior management. Using the INTEREST system it is at any time possible to inspect a bill item to review how the item has been priced and the resources required to complete the work. The reconciliation facility enables an immediate check on the total quantity of each resource that is required within the project to be obtained. The flexible reporting system enables information to be quickly supplied in a form that is readily useable. All this may be achieved independant of the estimator.

The computational facilities provided by the computer and the ease of changing the function involved make it possible for senior management to assess the contract on a "what-if" basis and make their final decision dollowing detailed assessment of all relevant parameters. An example of this is provided in the facilities within the system to add mark-ups. Percentage factors are easily added, lump sums of money distributed and rate-loading calculations quickly carried out. These calculations may be quickly carried out several times and the results compared. This would be impossible to do manually within the time available for tender adjudication.

Chapter 3.7 indicated the importance in calculating the cash flow for the project to determine the capital lock up and the subsequent additions that should be made within the tender to allow for this on-cost. This calculation is normally only performed once because of the clerical effort involved.

Cash flow analysis for the construction project involves:

- the drawing up of a project programme in bar chart form;
- the calculation of direct cost of the project as detailed in the bill of quantities;
- the apportionment of the sum to the bar chart programme;
- the determination of the cash flow parameters;
- the calculation of the cash flow curve.

The time available within the tender period to produce the cash flow calculations for the contract does not enable a fully accurate apportionment of all the bill items to the construction programme. The lengthy, tedious calculations involved mean that the process is only normally carried out once, no time is given to examining the full implication of changes in the cash flow parameters.

The production of a computer based system CAFFLARR linked to the INTEREST programme to perform this task (15) meant that it was possible to:

- apportion accurately all the bill items to the correct section of the construction program;
- perform the cash flow calculations quickly and easily;
- incorporate the cash flow parameters at a greater level of detail;
- change the cash flow parameters and assess their sensitivity to the capital lock-up within the contract and the interest payments required.

CAFLARR enables the following reports to be obtained:

- resource aggregation and resource requirements for each week of the contract;
- the breakdown of costs for each week of the contract;
- the payments, receipts and value of work for the project;
- the full cash flow for the project including the interest paid or received on monies accrued in the contract.

Figures 68 and 69 , pages 346 & 347 show typical reports from the program. Calculations such as these, while impossible to carry out manually on more than a one-off basis because of the time limitations of the estimating and tendering process are easily achieved and repeated when estimating is based on a computer system.

COST BREAKDOWN
****

WEEK	LAB.	PLANT	D. MAT	A MAT	SUB-C	COST	C/COST	O-H	PROFIT	CONT.
1	3.7	132 4	0 0	0 0	0 0	136 1	136.1	13.6	7.5	21 1
2	3 7	132.4	0 0	0.0	0 0	136 1	272 2	13 6	7 5	21 1
3	55 1	8 8	110.2	0 0	0 0	174 2	446 4	17.4	9 6	27 0
4	55 1	8 8	110 2	0 0	0 0	174 2	620.6	17.4	9 6	27.0
5	289.7	8.8	297 7	0 0	900 0	1456 3	2116 9	149 6	57 5	207 2
6	234 6	0 0	187.5	0 0	900 0	1322 1	3438.9	132 2	48 0	180 2
7	234.6	0 0	187.5	0 0	900 0	1322 1	4761 0	132 2	48 0	180 2
8	234.6	0 0	187.5	0 0	900 0	1322.1	6083 1	132 2	48 0	180 2
9	234 6	0 0	187 5	0 0	900 0	1322 1	7405 2	132 2	48 0	180 2
10	31.2	0 0	23 9	0.0	311 1	366 2	7771.4	36 6	11.6	48.2
11	31 2	0.0	23.9	0.0	311.1	366 2	8137.6	36.6	11 6	48 2
12	31 2	0 0	23 9	0 0	311.1	366 2	8503 7	36 6	11 6	48 2
13	31.2	0 0	23.9	0 0	311 1	366 2	8869 9	36 6	11 6	48 2
14	31.2	0.0	23 9	0 0	311.1	366.2	9236.1	36 6	11.6	48 2
15	31 2	0.0	23 9	0.0	311.1	366.2	9602.2	36.6	11.6	48.2
16	31 2	0 0	23 9	0 0	311 1	366.2	9968 4	36 6	11.6	48.2
17	31 2	0.0	23.9	0 0	311 1	366	210334.6	36.6	11.6	48 2
18	31.2	0.0	23.9	0 0	311.1	366.	210700 7	36.6	11.6	48.2

Figure 68 - THE COST BREAKDOWN FOR THE PROJECT AS PRODUCED BY CAFFLARR ON A WEEK BY WEEK BASIS

PAYMENTS, RECEIPTS AND VALUE OF WORK
****

WEEK	COSTS	O-HEADS	VALUE	CUM-VAL	RECEIPTS
1	3.75	0.00	157.22	157.22	0.00
2	3.75	0.00	157.22	314.44	0.00
3	55.13	0.00	201.17	515.60	0.00
4	55.13	0.00	201.17	716.77	0.00
5	289.73	0.00	1703.44	2420.21	0.00
6	234.60	0.00	1502.27	3922.49	0.00
7	234.60	0.00	1502.27	5424.76	0.00
8	234.60	0.00	1502.27	6927.03	0.00
9	234.60	13.61	1502.27	8429.30	0.00
10	273.78	13.61	414.37	8843.67	0.00
11	1173.78	17.42	414.37	9258.04	0.00
12	1237.70	17.42	414.37	9672.40	0.00
13	1127.46	149.63	414.37	10086.77	3530.24
14	1127.46	132.21	414.37	10501.13	3530.24
15	1116.67	132.21	414.37	10915.50	3530.24
16	529.78	132.21	414.37	11329.86	3530.24
17	366.17	132.21	414.37	11744.23	8360.04
18	366.17	36.62	414.37	12158.59	8360.04
19	335.00	36.62	0.00	12158.59	8360.04
20	335.00	36.62	0.00	12158.59	8360.04
21	335.00	36.62	0.00	12158.59	10141.82
22	335.00	36.62	0.00	12158.59	10141.82
23	335.00	36.62	0.00	12158.59	10141.82
24	335.00	36.62	0.00	12158.59	10141.82
25	23.89	36.62	0.00	12158.59	11854.63
26	0.00	36.62	0.00	12158.59	11854.63
27	0.00	0.00	0.00	12158.59	11854.63
28	0.00	0.00	0.00	12158.59	11854.63
29	0.00	0.00	0.00	12158.59	11854.63
30	0.00	0.00	0.00	12158.59	11854.63
31	0.00	0.00	0.00	12158.59	11854.63
32	0.00	0.00	0.00	12158.59	11854.63
33	0.00	0.00	0.00	12158.59	11854.63
34	0.00	0.00	0.00	12158.59	11854.63
35	0.00	0.00	0.00	12158.59	11854.63
36	0.00	0.00	0.00	12158.59	12158.59

Figure 69 - PAYMENTS, RECEIPTS AND VALUE OF WORK AS SHOWN BY THE CAFFLARR SYSTEM ON A WEEK BY WEEK BASIS

12. CONCLUSIONS

The main objective of this research was the design production and testing of a Computer Aided Estimating System that would be acceptable to civil engineering contractors. This main objective was divided into the following principal aims:

- a study and critical appraisal of previous research and existing systems to determine why computers have failed to make an impact upon this area of the contraction industry;
- a study of the estimating and tendering process with a view to determining system requirements;
- the design and production of a computer aided estimating system;
- the field testing of the system;
- determination of the profitability of computer aided estimating systems;
- the exploration of the extension of computer usage that is possible once computer aided estimating is established within the company and the estimator's data utilized by other functions within the organization.

The research incorporated the following secondary aims:

- a review of existing techniques for the analysis of human tasks;
- a comparison of system requirements with the facilities offered by existing computer aided estimating systems;
- a study of the procedures, operations and different languages available for the design of the dialogue between the estimator and the computer;

- the establishment of training and user support needs for computer aided estimating systems.

Previous research indicated that computers were capable of contributing to the task of the estimator within the estimating and tendering process. However, only a small proportion of the total number of construction companies had hitherto adopted computer aided estimating methods within their estimating departments. These tended to be the larger construction companies who produced their own systems. The impact of computers on the estimating world had been minimal and barely touched, the 6000 middle-sized companies with between 25 and 50 employees who make-up the bulk of the companies within the construction industry. From the work undertaken the following conclusions were drawn:

12.1 FACTORS INFLUENCING THE TASK OF THE ESTIMATOR WITHIN THE ESTIMATING AND TENDERING PROCESS

The estimating and tendering process was studied, and described in Chapter 2. Chapter 3 gives examples of the calculations involved in this process. Chapter 4 reports the detailed analysis of the estimator's task.

From the above work it was possible to isolate the factors that influence the task of the estimator within the estimating and tendering process:

(i) The format of the client's documentation;

(ii) The nature of the specific construction work within the project;

(iii) The individualistic approach of the estimator;

(iv) The detail of information that has to be acquired;

(v) The susceptibility to a change in either the construction method for the project or the method of pricing;

(vi) The communication pattern of information within the contractors organization;

(vii) The constraint of time;

(viii) The risk of errors.

The exact emphasis of each of these factors varies from company to company and with the tender under preparation. This determines the method of approach to pricing the work and the timing and order of the estimate preparation.

These factors define the principle parameters for the design of the system described in Chapter 6.

12.2 THE SHORTCOMINGS OF EXISTING COMPUTER AIDED ESTIMATING SYSTEMS

Chapter 5 contained the analysis of the following types of commercially available computer aided estimating system:

- a basic estimating and tendering system;
- a standard price book system with the additional calculation routines;
- a system based upon the 'Work Group' approach;
- systems based upon large data libraries;
- cost models that may be used for tendering.

The main shortcoming of these systems were found to be:

- inflexibility of approach to the pricing of bill items;
- limited ability to modify data from the library of information;
- inability to easily retrieve and rework bill item calculations;
- difficulty in using the system;
- none of the systems combined the two fundamental approaches to construction estimating, unit rate estimating and operational estimating with a supportive data library.

As a result the systems had very few if any users over and above their original developers. The maximum number of users of the most popular system was five.

12.3 THE ANALYSIS OF THE ESTIMATOR'S TASKS

None of the six types of commercially available computer aided estimating systems reviewed in Chapter 5 were found to provide facilities that met the full needs of the estimator. The main shortcomings of the existing systems were listed in 12.2.

In order to produce a computer aided estimating system that provided full assistance to the estimator in all aspects of the estimating and tendering process it was not enough just to study the process and the calculations involved. A full task analysis of the estimator's tasks was necessary to enable the function of the estimator to be fully understood and determine:

- the operations performed by the estimator;
- the constraints to the estimator's performance;
- the communication pattern surrounding the estimator.

This work is described in detail in Chapter 4.

Appendix IV reviews eleven different types of task analysis that were available to the writer for the analysis of human tasks. None of these methods were suitable for the analysis of the estimator's tasks for the purpose of producing a detailed specification for a computer aided estimating system. None of these methods enabled the operations within the estimator's task to be analysed with respect to the facilities available from the computer and the extent to which they may be utilized.

A hybrid method of task analysis was produced incorporating the collection of data by informal interviews with six estimators from three co-operating constructions. This was followed by the hierarchical analysis of the operations involved in the estimating and tendering process, together with the assessment of the constraints and communication patterns surrounding the estimator.

This method ensured that all aspects of the estimator's job were considered. Then by dividing the operations within each task into the specific categories directly relating to the use of the computer as:

- a filing system;
- a calculator;
- a report generator;

the full impact of the computer upon the tasks of the estimator could be assessed and a detailed list of requirements of a computer aided estimating system produced. The method enabled a detailed analysis to be performed to the level required by the user while at the same time ensuring that the main factors affecting the performance of the task were identified.

A full description of the requirements of a computer aided estimating system is given in Chapter 4.

12.4 REASONS WHY ESTIMATORS ARE RELUCTANT TO USE COMPUTERS WITHIN THE ESTIMATING AND TENDERING PROCESS

Interviews with sixty-five estimators within the civil engineering industry highlighted the following reasons, described in Chapter 5, for the lack of use of computers within the estimating and tendering process:

- the complexity of the estimating and tendering process and the information exchange involved cannot be accommodated by a computer system;
- every civil engineering project is unique. Little data used within one estimate is directly applicable to another even if the project is of a very similar nature;
- no system can allow for the flexibility of approach used by the estimator when pricing construction work and reflect the full effect of the estimator's judgement;
- the time and cost involved in setting up and maintaining an estimating system makes it unprofitable to use computers for the estimating function;
- fears for the security of confidential company data when stored on computer files;
- problems with the introduction of errors into the estimating calculations which remain undetected over several estimates;
- loss of estimator's jobs or the requirement of extensive retraining.

These reasons, combined with the shortcomings of existing computer aided estimating systems explained the lack of use of computers for the purpose of estimating for civil engineering works and helped define the requirements of the computer aided estimating system which was to be produced.

It was evident that estimators did not understand the facilities available within modern computing systems that could be used to assist them in their work. Fears of errors and security problems with computer systems prejudiced assessments of profitability. Natural fears existed with respect to loss of employment or extensive retraining requirements.

Consequently it was necessary to find a different method to specify and develop the system from the normal direct method of interviewing prospective users and asking them to state their requirements for the system.

12.5 THE REQUIREMENTS OF A COMPUTER AIDED ESTIMATING SYSTEM

For a computer aided estimating system to be accepted by civil engineering estimators for everyday use the system had to meet the following general requirements and program parameters identified as a result of:

- an analysis of the estimating and tendering process and the calculations involved (Chapters 2 and 3);
- the analysis of the tasks of the estimator (Chapter 4);
- a review of existing commercially available computer aided estimating systems (Chapter 5);
- the study of previous research and the review of existing literature (Chapters 2 and 3).

GENERAL REQUIREMENTS

(i) The system must be available for use by estimators at any time both within and outside the normal working day.

(ii) Simultaneous input and output to the system must be available on several terminals.

(iii) The estimators within the company should be capable of working intermittently or in parallel on a number of tenders.

(iv) It must be possible for work on individual tenders to be suspended and recommenced without difficulty.

(v) All data processing should be undertaken within the company.

(vi) The system must be interactive.

(vii) A hard copy of the estimators work including both input output and the calculations performed should be available if required.

(viii) The estimating procedure within the system must follow the same logic pattern as existing manual system within companies.

(ix) The system must be capable of assisting at all stages of the tender process:

- the build-up of the direct cost estimate;
- the production of information for tender adjudication;
- the addition of mark-up factors to produce a tender total.

(x) Information relating to completed tenders should be stored on the system for future reference.

PROGRAM PARAMETERS

The production of detailed cost estimates and tenders adjustment to produce tenders requires the following facilities:

- calculate bill item prices from input data by a number of different methods;
- apply calculated item rates against all relevant bill items;
- provide an extension and summation of bill item prices to produce direct cost totals;
- provide a variety of reports and bill listings for the estimator and other company personnel within the estimating and tendering process;
- store data on different resources and their requirements for different construction methods;
- store lists of all-in rates and materials and sub-contractor prices for the contract under consideration;
- store the full build-up of each bill item within the contract with the facility to retrieve, check and re-work the item if required;
- assist the estimator in his communication with other parties both inside and outside the contractors organization;
- maintain the estimators skill and extend his knowledge of the construction processes;
- limit potential errors within the estimating process.

All the above requirements are fundamental to a computer aided estimating system. If they are not met by the system the estimator cannot be expected to accept the system for everyday use.

These requirements formed the basis for the development of the INTEREST system described in Chapter 6.

12.6 THE DESIGN AND PRODUCTION OF A COMPUTER AIDED ESTIMATING SYSTEM

The requirements of a computer aided estimating system identified in Chapter 4 relate solely to the performance of the estimator within the estimating and tendering process.

To produce an acceptable computer based system it was necessary to do more than write a series of algorithmns to meet these requirements. The specification and design of the system necessitated consideration of the main aspects of man-computer interaction.

These include:

- human performance;
- computer system performance;
- the hardware interface;
- the software interface;
- environment;
- the specific application of the system;
- special problems related to the system.

Of all these aspects particular attention was given to the design of the software interface because it was the factor over which greatest control was possible in the design and production of the system and the most important aspect in deciding the acceptability of the system to the civil engineering estimator.

The methodology developed for the design and production of the INTEREST system was an iterative process of interviewing, developing and demonstrating. This method enabled the system to be produced irrespective of estimator's lack of awareness of the facilities available from modern computer technology.

The interviewing stage assembled data relevant to the estimator's tasks. The method of task analysis employed enabled the facilities required by the estimator to be determined and the part played by each of the three main functions available from the computer to be identified. The development of the system assessed the requirements of man-computer interaction to produce a successful facility within the computer system. The demonstration of this facility to practising estimators enabled comments to be assessed and refinements made as appropriate.

In addition, the method allowed estimators from co-operating companies to develop their own appreciation and understanding of computers and so improve their ability to specify their requirements. By involving many estimators in this process the risk of satisfying the foibles of only a few were reduced.

The research proved that facilities were available within computer technology for the production of a computer aided estimating system that met the requirements of estimators within the civil engineering industry. It was possible to produce a system that was:

- fully interactive;
- gave full flexibility to the estimator;
- could incorporate a range of facilities from which the estimator could select the approach required;
- enable bill items to be retrieved from the contract file and reworked as required;
- provided a basis for pricing a bill item that could be easily amended by the estimator to incorporate his exact requirements;
- combined unit rate and operational estimating with a supportive data library.

The system produced was then tested and reviewed by estimators and senior management from forty-six construction companies and comfirmed as acceptable for adoption within a contractor's organization.

12.7 THE TESTING OF THE INTEREST SYSTEM

To test the system fully and confirm its acceptability to civil engineering estimators, the following tests were performed:

- arithmetic checks of the calculation operations within the system;
- error detection checks within the system dialogue;
- system checks for the pricing of complete Bills of Quantities;
- demonstrations to individuals and groups of practising estimators to ensure feed-back from construction industry personnel;
- field trials of the system within the estimating department of a civil engineering company.

The acceptability of the system was assessed on how closely the system reflected the estimator's tasks and whether in using the system:

i) the calculating, filing and reporting facilities offered by the system fully supported the operations carried out by the estimator;

ii) using the system decreased or at best did not increase the constraints on the estimator's performance;

iii) the communication and information pattern within the company was not altered.

The different tests carried out upon the INTEREST system enabled the system to be confirmed as acceptable to civil engineering estimators and ensured that all the facilities provided performed correctly, detected appropriate user errors and satisfied the requirements of a computer aided estimating system.

From the trial period within the contractor's organization it was possible to prepare a detailed list of enhancements to the system. These were included in the specification of INTEREST C.E 3. The question of the profitability of computer aided estimating systems was highlighted and this was seen to require a separate analysis. Aspects of user training and support were analysed and the basis of the user support requirements for the INTEREST system formulated.

12.8 THE TYPES OF USERS OF COMPUTER AIDED ESTIMATING SYSTEMS AND THEIR USER SUPPORT REQUIREMENTS

When computer systems are introduced into an organization they must be operated by people. Inevitably there is a gap between what the future user knows and what it is necessary to know in order to use the system to its full potential. Providing the user with the assistance to overcome this deficiency is the function of user support.

Chapter 10 identified the user support requirements for the different types of user of the INTEREST system.

Computer aided estimating systems are used by each of the three types of computer user:

- the estimator's clerk, (for data input);
- the estimator, (a specialist user);
- the senior manager, (for decision making).

User support needs are dependant on the type of user of the system and their stage of development with the system. User support requirements change as the user acquires skill and knowledge in the use of the system. This development is continuous but four separate stages may be recognised:

- the pre-implementation phase, (before the system is installed);
- the implementation phase, (when the system is installed);
- the operational phase, (when the system is installed and fully working);
- the evolutionary phase, (as the user of the system develops his understanding and raises his level of performance with the system).

The following forms of user support are required for the successful adoption of the INTEREST system into a contractors organization.

- instruction (reference) manuals;
- within system aids;
- formal training instruction;
- provision of a local expert;
- specialist computer personnel.

These forms of support are necessary to cover the range of computer user and their various stages of development. Within any organization there will always be changes in personnel. Consequently the estimating department will always consist of those experienced in the use of the system and those who are approaching the system for the first time.

The provision of the user support requirements for the INTEREST system are described in detail in Chapter 10. A copy of the user reference manual produced for the system is included in Appendix VIII.

12.9 THE PROFITABILITY OF THE INTEREST COMPUTER AIDED ESTIMATING SYSTEM

A study was undertaken of the profitability of the INTEREST system. This was reported in Chapter 11. It was found that to assess the profitability of a computer aided estimating system the most appropriate method was to the standard of a number of tenders produced by an estimating department over a period of time. It must then be decided whether or not the same number of estimates, of the same standard, could have been produced manually.

No construction company had used the INTEREST system for a long enough period to overcome the learning problems and make this type of assessment. Computer aided estimating systems were found to provide construction managers with extensive facilities for improving the quality of the estimates produced and improving both the communication of contract data within the company and the level of project information available for management decision making purposes. These facilities are described in detail in Chapter 11.

The comparison of the value of these improvements against the capital costs of running the system is a subjective one that individual companies must make when deciding on the profitability of the INTEREST system. The evidence obtained from discussions with the sixty-five estimators and senior management who have assessed the system suggests that the facilities produced make the capital outlay required to purchase, implement and operate a computer aided estimating system a profitable proposition.

The INTEREST system produces improved reporting facilities on data relating to each construction contract for which a tender is prepared. This increase in the available information for senior management decision making purposes can provide increased profitability. This should assist the senior management in making "what-if?" type decisions. (An example of this is in the sensitivity analysis of bill item rates that may be performed by adjusting individual resource prices).

Computer aided estimating systems may be used as a basis for holding contract data that can be accessed and utilized by other functions within the contractors organization. Access may be permitted to the contract data file containing details of the build-up of each item within the Bill of Quantities. Access may be obtained in three ways:

- manual access only;
- the right to access computer files;
- the right to access computer files and transpose data for use in the relevant function.

In this manner the estimator's project data may be utilized by other functions within the contractors organization such as planning, cost control, valuations etc.

This benefit cannot be directly quantified except in instances where information obtainable from the estimating system may be utilized and produces a direct saving in man hours that would otherwise be necessary to collate the same information separately.

12.10 MAIN RESULTS

The most tangible result of this research work was the production of a computer aided estimating system for civil engineering contractors. The creation of this system was the result of:

- a study of the estimating and tendering process and the calculations involved;
- a detailed analysis of the tasks of the estimator within the estimating and tendering process, (this required the development of a new method of task analysis suited to the production of a specification for a computer system);
- a review of six types of existing computer aided estimating systems;
- an analysis of why estimators are reluctant to use computers for estimating purposes;
- the preparation of a detailed list of requirements of a computer aided estimating system;
- a study of all the main aspects of man-computer interaction;
- the development of a design methodology that incorporated interviewing estimators, developing facilities within the system and demonstrating the results to practising estimators;
- extensive testing of the system including trials within a contractor's organization;
- an assessment of the profitability of the INTEREST system.

The manifest failure of existing computer aided estimating systems was that they were not being used by companies other than those that had produced them. To date, eight INTEREST systems have been installed within contractors offices and this provides some evidence of success in meeting the main objective.

The other outcome of this work is:

- an understanding of the implementation and user support requirements for the introduction of computer aided estimating systems into contractor's organizations;
- the production of user support facilities for the INTEREST system including a comprehensive user manual and training programmes for the system.

In addition, the work has created a platform for the construction of a completed, linked suite of construction management programmes. This has not been available before because of the paucity of existing computer aided estimating systems. This is shown in figure 70 below:

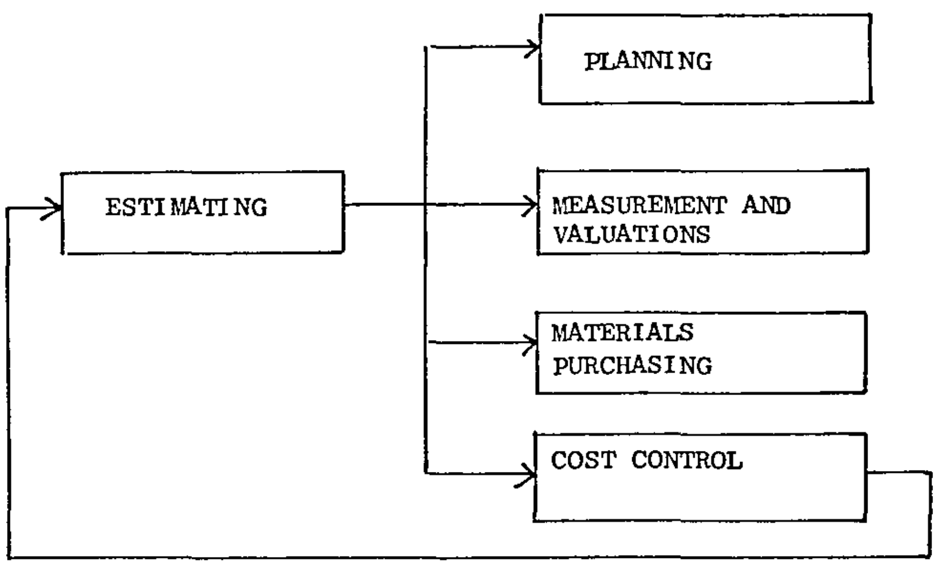

Figure 70 - A LINKED SUITE OF CONSTRUCTION MANAGEMENT PROGRAMMES

To demonstrate this viability, prototype systems linked to INTEREST have been produced for Cash Flow and Planning purposes. CAFLARR, (Cash Flow and Resource Reconciliation) allows estimator's data to be allocated to a bar chart programme. The input of parameters for payment and income produces the cash flow calculations for the project. TIANAREBA (Time Analysis and Resource Balancing) consists of a precedence network planning system that may be operated using resource data input by the planning engineer or based upon the resource requirements used by the estimator to build-up his estimate.

The supplementary benefits of this work which proved to be of fundamental importance to the success of the research and valuable to future work of a similar kind are:

- the production of a method of task analysis suitable for the assessment of human tasks for producing a specification for a computer system;
- the development of an appropriate design methodology for the production of computer systems where the potential users are ignorant of possible computer facilities to assist them in their tasks.

12.11 THE SIGNIFICANCE OF THE WORK

The significance of this work can be viewed in the following areas:

(i) The provision of a comprehensive, flexible estimating software package that has proved to be acceptable to practising civil engineering estimators where no system specifically related to civil engineering existed before the start of the research.

(ii) The opportunity for the development of software packages for other functions within the contractor's organization that are based upon the estimator's collection of project data.

(iii) The level of awareness within the construction industry as to the facilities available for the use of computers for estimating and other construction management purposes has been raised as a result of demonstrations both in-house and at seminars and conferences.

(iv) The provision of a computer based model of the complete build-up of a project tender which enables both sensitivity and optimisation analyses to be performed to show the effect of variations of resource prices and the different tender mark-up policies available to senior management.

(v) The production of a method of task analysis specifically for the analysis of human tasks for the purpose of specifying requirements for computer systems.

(vi) The determination of user support requirements for the introduction and operation of computer aided construction management systems.

(vii) The identification of a methodology for the design, production and review of computer systems for users unaware of, or prejudiced against, the facilities available from modern computer technology.

12.12 FUTURE WORK

As a result of this research, the following areas for future study were identified:

(i) The interface between estimating and tender planning to identify the details and data that are fundamental to both functions and how this data may best be accessed by both parties. This research has already commenced within the Department of Civil Engineering at Loughborough University of Technology.

(ii) The extension of facilities within the INTEREST system to provide additional optimization routines to assist estimators in their tasks.

(iii) The extension of the computer aided estimating system to provide structured files of data accessible to other functions within the contractors organization, such as cost control, valuations and materials purchasing.

(iv) A study of the long-term affects of the introduction of computer aided estimating systems into the contractor's organization.

(v) The production of a fully integrated management system for specialist contractors such as Builder/Developers. This research has already commenced within the Dept. of Civil Engineering at Loughborough University of Technology.

REFERENCES

1. McCAFFER R., "Increasing Efficiency - will the Computer help?" Paper given to the Chartered Institute of Building Conference, 1980.

2. BOYER L.T. and VOLKMAN R.C., "Remote Terminal Cost Estimating". Proceedings of the American Society of Civil Engineers (Journal of the Construction Division), Vol. 98, March 1972.

3. MILLER J.L., "Computer Aided Estimating". Estimating Information Service ISSN. No. 35, Chartered Institute of Building, Winter 1979/80.

4. BARNES N.M.L., "What can Computing do to Improve the Profitability of a Building Business?" Synopsis of a talk given to the Building Advisory Service Seminar, 22nd February, 1980.

5. NATIONAL ECONOMIC DEVELOPMENT OFFICE, "The Public Client and the Construction Industries (Wood Joint Working Party Studying Public Sector Purchasing)" HMSO. 1974.

6. DESIGN OFFICE CONSORTIUM, "Evaluation Report No. 4 - Computer Programs for Construction Management", 1979.

7. STRAFFURTH C. and WALTON H., "Programs for Network Analysis". National Computing Centre, 1979.

8. HAMLYN-HARRIS H., "A Review and Critical Appraisal of Commercially Available Computer Aided Estimating Systems for Builders and Civil Engineers", M.Sc. Project Report, L.U.T., October 1979.

9. ROBERTS A., "Feasibility Study : Computerised Estimating for Motorways". M.Sc. Project Report, L.U.T. September 1975.

10. BRAMWELL D.M., "Computer Aided Systems in Civil Engineering using Drainage as the Prime Data Base", Ph.D. Thesis, University of Aston in Birmingham, 1975.

11. BAINBRIDGE A.B., "Computer Aided Estimating", M.Sc. Project Report, L.U.T., September 1976.

12. GIBB D., "Field Testing a Computer Aided Estimating System". M.Sc. Project Report, L.U.T., April 1979.

13. HUNTER K.N., "Experience and Practice in Setting Up and Use Of a Computer Aided Estimating System". Paper given to the Building Advisory Service Seminar, 22nd. February 1980.

13. BRADBURN S.M., "The Use of Computers in Estimating" - "Estimating Information Service ISSN. No. 22", Chartered Institute of Building, Autumn 1976.

15. ALLSOP P., "Cash Flow and Resource Aggregation from Estimator's Data (Computer Program Caflarr)". M.Sc. Project Report, L.U.T. September 1980.

16. BOWMAN S., "Tianareba : Time Analysis and Resource Balancing". M.Sc. Project Report, L.U.T. September 1981.

17. C.I.O.B. "Code of Estimating and Tendering Practice". The Chartered Institute of Building, 1973.

18. THE INSTITUTION OF CIVIL ENGINEERS., "Civil Engineering Procedure". Thomas Telford 1976.

19. ACT OF PARLIAMENT, "Thames Barrier and Flood Protection Act, 1972.

20. MARKS R.J., MARKS R.J.E., GRANT A.A., and HELSON P.W., "Aspects of Civil Engineering Procedure", Pergamon, 1978.

21. UFF J., "Construction Law", Sweet and Maxwell, 1974.

22. HORGAN M.O.C. and ROVLSTON F.R., "The Elements of Engineering Contracts". E and F.N. Spon Ltd. 1977.

23. THE INSTITUTION OF CIVIL ENGINEERS., "I.C.E. Conditions of Contract (Fifth Edition)" I.C.E. June 1973.

24. THE INSTITUTION OF CIVIL ENGINEERS., "Civil Engineering Standard Method of Measurement (CESMM)". Thomas Telford Ltd., 1976.

25. BARNES N.M.L., "Measurement in Contract Control". Thomas Telford Ltd., 1976.

26. ENTERKIN H. and REYNOLDS G., "Estimating for Builders and Surveyors". Heinemann 1978.

27. BANWELL., "The Placing and Managements of Contracts for Building and Civil Engineering Work". HMSO, 1964.

28. NATIONAL JOINT CONSULTATIVE COMMITTEE FOR BUILDING., "Code of Procedure for Single Stage Selective Tendering". R.I.B.A., Publications Ltd., 1977.

29. BATHURST P.E. and BUTLER D.A., "Building Cost Control Techniques and Economics". Heinemann, 1980.

30. DELL 'ISOLA A.J. and KIRK S.J., "Life Cycle Costing for Design Professionals". McGraw Hill, 1981.

31. NIEL J.M., "Construction Cost Estimating Concepts and Their Application". Ph.D Dissertation, Texas A and M University, August 1978.

32. MOYLES, B., "An Analysis of the Contractors Estimating Process". M.Sc Thesis, L.U.T. 1973.

33. BARNES N.M.L., "The Design and Use of Experimental Bills of Quantities for Civil Engineering Contracts". Ph.D Thesis, UMIST, 1971.

34. HARRISON R.S., "Tendering Policy and Strategy". Paper given to CICC Conference, May 15th/16th 1980, Chartered Institute of Building.

35. DAVIES F.A.W., "Preparation and Settlement of Competitive Tendering for Building Works". Estimating Information Service ISSN No. 16 - April 1976, Chartered Institute of Building.

36. TOMLIN I., "Tendering - The Decision Taking". Paper given to Chartered Institute of Building Conference March 16th 1977.

37. HARRISON R.S., "Training Needs of an Estimator in Estimating in Building and Civil Engineering". Ed. R. McCaffer, Proceedings of Conferences held on Sept. 20th 1973 and March 22nd/23rd 1974 at Loughborough University of Technology.

38. GALE G.N., "Management and Productivity Techniques", in Construction Management in Principle and Practice Ed. Brech E.F.L., Longman 1971.

39. SPRINGETT D.E., "The Estimating Team - Some Aspects of its Work". Estimating Information Service ISSN No. 5, July 1972, Chartered Institute of Building.

40. PILCHER R., "Appraisal and Control of Project Costs". McGraw Hill, 1973.

41. PEARSON A.W., "Forms of Construction Management". Paper to Sixth Congress of the International Council for Building, Budapest, Hungary, Oct. 1974.

42. SOUTHAMPTON GROUP OF THE I.O.B. ESTIMATING SECTION., "Sub-contractors - Invitation to Tender and Adjudication of Quotations". Estimating Information Service ISSN No. 7, January 1973, Chartered Institute of Building.

43. TAYLOR H.F., "Materials Purchasing - The Link between Estimator and Buyer". Estimating Information Service ISSN No. 4, April 1972, Chartered Institute of Building.

44. MUDD D.R., "Suppliers - Invitation to Tender for the Supply of Materials". Estimating Information Service ISSN No. 19 Chartered Institute of Building.

45. FARROW J.J., "Tendering an Applied Science". Paper produced for and published by The Chartered Institute of Building 1976.

46. FORBES W.S. and SKOYLES E.R., "The Operational Bill". The Chartered Surveyor, Vol. 95, 1963, pp 429-439.

47. FORBES W.S. and SKOYLES E.R., "A Practical Application of Operational Bills". The Chartered Surveyor, Vol. 98, 1966, pp 489-493.

48. MASON D., "The Limitations of Estimators Data Bases". M.Sc. Project Report, L.U.T. September 1980.

49. FRENCH-KIER LTD., Unpublished Internal Document for Calculation of Site on-costs.

50. TARMAC CONSTRUCTION LTD. Unpublished Internal Document for Calculation of Site on-costs.

51. BENEDICT J., "Build-up of Unit Labour Rate for Estimating". Building Trades Journal. March 17th 1972.

52. ARTICLE. "The Inclusive Cost of Labour". Construction News, Nov. 4th 1977.

53. CIVIL ENGINEERING CONSTRUCTION CONCILIATION BOARD FOR GREAT BRITAIN., "Working Rule Agreement". Civil Engineering Construction Conciliation Board, July 1981.

54. SPENCE GEDDES, "Estimating for Building and Civil Engineering Works". Ed. G. Chrystal Smith, Newnes Butterworths, 1981.

55. HARRIS F. and McCAFFER R., "Modern Construction Management". Granada, 1977.

56. PILCHER R. "Principles of Construction Management", McGraw Hill, 1976.

57. SMITH J.E., "Cash Flow Management". Woodhead Faulkner, 1975.

58. SPELLMANS K., "Predicting the Failure of a Construction Company". Accountancy, August 1978.

59. TAPNER V., "Walking Through the Shadow of Insolvency and Surviving". Building, January 23rd, 1976.

60. KERR D., "An Investigation into the Factors which Affect Cash Flow and Net Profit Margins in Construction Projects". M.Sc. Project Report, L.U.T., 1973.

61. McCAFFER R. and PIKE J.J., "Contract Cash Flow". Construction News Magazine, April 1978.

62. McKAY I.B., "To Examine the Feasibility of a Computer Program for Cash Flow Forecasting by Contractors". M.Sc. Project Report, L.U.T., 1971.

63. COOKE B. and JEPSON W.B., "Cost and Financial Control for Construction Firms". Macmillan 1979.

64. RAMUS J.W., "Contract Practice for Quantity Surveyors". Heinemann 1981.

65. TURNER D.F., "Quantity Surveying Practice and Administration". Godwin 1979.

66. ECONOMIC DEVELOPMENT COMMITTEE FOR CIVIL ENGINEERING, "Report on Price Adjustment Formulae for Civil Engineering Contracts". NEDO, 1971.

67. THE INSTITUTION OF CIVIL ENGINEERS, "I.C.E. Conditions of Contract (Fourth Edition)". I.C.E. Jan. 1955.

68. STEPHENSON D., "Baxter Gets Engineers Vote of Confidence". Construction News. Dec. 10th 1975.

69. ANNET J., DUNCAN K.D., STAMMERS R.B., and GRAY M.J., "Task Analysis". Training Information No 6, HMSO, 1971.

70. STAMMERS R.B., and PATRICK J., "The Psychology of Training", in series Essential Psychology, Ed. Herriot P. Methven, 1975.

71. GOLD R.L., "Roles in Sociological Field Observations". Social Forces, 36, March 1958, pp 217-223.

72. BECKER H.S., "Problems in Inference and Proof in Participant Observation". American Sociological Review, 23, 1958, pp 652-660.

73. ABEYTUNGA, "The Role of the First Line Supervisor in Construction Safety - The Potential for Training". Ph.D Thesis, University of Aston, Dec. 1978.

74. HARKER S.D.P., and EASON K.D., "Task Analysis in Theory and Practice". Paper presented to the Ergonomics Society Annual Conference, Nottingham University, March 1980.

75. ANNET J. and DUNCAN K.D., "Task Analysis and Training Design". Occupational Psychology, 41, 1967, pp 211-221.

76. DUNCAN K.D., "Strategies for Analysis of the Task", in Strategies for Programmed Instruction, Ed. Hartley J, Butterworths 1972.

77. SEELEY I., "Civil Engineering Quantities". Macmillan, 1971.

78. SLATTERY F.J., "Fundamentals of Estimating for Engineering Construction". Australian Federation of Construction Contractors, 1978.

79. OLIVER P.A., "Computer Assisted Estimating for the Contractor". Unpublished notes on Computer Applications and Methods Group Informal Discussion at the Institution of Civil Engineers, 21st January 1980.

80. BECKER J., "Who are the Computer Criminals?" New Scientist, March 13th 1980.

81. HARRISON R.S., "Applications of Computers to Bills of Quantities and Estimating". Proc. of the Institution of Civil Engineers. Part 1, 1976, pp 185-186.

82. NEALE R., "A Realistic Approach to Computers and Construction Management". Scottish Local Authorities Special Housing Group Newsletter No 7100, Dec. 1980

83. STEMMOS LTD., A Computer Aided Estimating and Tendering System, London.

84. ALEX SHAW and CO. LTD., Computer Aided Estimating System, London.

85. RYAN T.M., "Computers for Estimating". Building Technology and Management, January 1981.

86. MARTIN J.L., "Computers in Businesses". Unpublished paper , Witswatersrand University, South Africa 1980.

87. ORR SYSTEMS, Cost Systems Engineers Inc. Fort Worth, Texas, U.S.A., Support in U.K. provided by Control Data Limited, East Barnet, Herts.

88. BARNES N.M.L., "Cost Modelling - An Integrated Approach to Planning and Cost Control". Engineering and Process Economics, 2, 1977, pp 45-51.

89. EASON K.D., "Dialogue Design, Implication of Task Allocation Between Man and Computer". Proc. of the Conference on Man-Computer Communication, Loughborough University of Technology, 1979.

90. SHACKEL B., "Dialogues and Language - Can Computer Ergonomics Help?" Proc. of the Conference on Man-Computer Communication, Loughborough University of Technology, 1979.

91. DAVIE S.T., "Is it Applicable for me, Value for Money and Secure?" in a Plain Builders Guide to Computing Chartered Institute of Building Occasional Paper No 14, CIOB, 1977.

92. ALDEN D.G. DANIELS R.W. and KANANCK A.F., "Keyboard Design and Operation : A Review of Major Issues". Human Factors 1972, 14 (4) pp 275-293.

93. FERGUSON D. and DUNCAN J., "Keyboard Design and Operating Posture". Ergonomics 17, 1974 pp 731-744.

94. CAKIR A., HART D.J. and STEWART T.F.M., "The V.D.T. Manual", Wiley, 1980.

95. STEWART T.F.M., "Displays and the Software Interface". Applied Ergonomics, 1976, 7.3 pp 137-146.

96. EASON K.D. et al, "MICA Survey". Report of a Survey of Man-Computer Interaction in Commercial Applications. SSRC Grant Report, HR 1844/1, 1974.

97. SHACKEL B., "Man-Computer Communication" Infotech State of the Art Report. Infotech International 1979.

98. MARTIN J., "Design of Man-Computer Dialogues", Prentice Hall, 1973.

99. HEBDITCH D., "Design of Dialogues for Interactive Commercial Applications", Man-Computer Communication, Infotech State of the Art Conference, 1978.

100. GAINES B.R. and FACEY P.V., "Some Experience in Interactive Systems Development and Application", Proc. IEEE, 63, pp 894-911.

101. DAMODRAN L., "The Role of User Support - Actual and Potential". Husat Memo 151, Department of Human Sciences, L.U.T. 1977.

102. FITTER M., "Dialogues for Users". Proc. of Infotech Conference on User Friendly Systems, 1979.

103. HARTLEY J. "Designing Instructional Text". Kogan Page, 1978.

104. ASHTON R.G., "A Note on the Ergonomic Design of Abbreviations for use with Cathode Ray Tube Displays", HUSAT Memo No. 14, Dept. of Human Sciences, L.U.T. 1971.

105. GREEN T.R.G, SIME M.E. and FITTER M.G., "The Problems the Programmer Faces". Proc. of the Conference on Man-Computer Communication, L.U.T. 1979.

106. STEWART T., "Human Factors in the use of Visual Display Units" from Grover (Ed), "Visual Display Units and their Application". IPC Science and Technology Press, 1976.

107. EASON K.D., "The Manager as a Computer User" HUSAT Memo No. 44, Dept. of Human Sciences, L.U.T. 1973.

108. WHISLER T.L. "The Impact of Computers Upon Organizations", Praeger, 1970.

109. STEWART R., "How Computers Affect Management". Macmillan, 1971.

110. MYERS C., "The Impact of Computers Upon Management". M.I.T. Press, 1967.

111. COCH L. and FRENCH J.R.P., "Overcoming Resistance to Change". Human Relations, Vol. 1, 1948, pp 512-532.

112. HALL D.M., "An Evaluation of User Support Requirements for a Computer Aided Civil Engineering Estimating System". M.Sc. Project Report, L.U.T. 1981.

113. DAMODRAN L., SIMPSON A., WILSON P., "Designing Systems for PeopleP. NCC Publications, 1981.

114. EASON K.D., DAMODRAN L., and STEWART T.F.M., "Man Computer Interaction at Work". HUSAT Memo No. 62, Dept. of Human Sciences, L.U.T. Sept. 1962.

115. DAMODRAN L., "User Involvement in System Design : Why? and How?" HUSAT Memo No. 128. Dept. of Human Sciences, L.U.T. 1976.

116. STEWART T., "Communcation with Dialogues", paper to Man-Computer Communication, Infotech State of the Art Conference, 1978.

117. TALLAND G.A., "Age and Span of Immediate Recall", in G.A. Talland Ed. Human Ageing and Behaviour, Academic Press, 1968.

118. BIRREN J.E., "Translations in Genrontology - from Lab to Life, Psychology of Speed and Response". American Psychologist 29, 1974, pp 808-815.

119. MURRELL K.F.H., "Industrial Aspects of Ageing". Ergonomics 5, 1962, pp 147-153.

120. NEWSHAM D.B., "The Challenge of Change to the Adult Trainee". Training Information Paper 3, HMSO, 1969.

121. GILBERT T.F., "Mathematics : The Technology of Education". Journal of Mathematics, 1,1 and 1,2 1962.

122. MECHNER F., "Science Education and Behavioural Technology", in R. Glaser Ed. Teaching Machines and Programmed Learning II, National Educational Assoc. Washington D.C. 1965.

123. DAVIES I.K., "The Management of Learning". McGraw Hill, 1971.

124. BARNES M.C., FOGG A.H., STEPHENS C.N., TITMAN L.G., "Company Organization Theory and Practice", Allen and Unwin, 1970.

125. THE INSTITUTION OF CIVIL ENGINEERS, "An Introduction to Engineering Economics". The Institution of Civil Engineers, 1969.

126. TAYLOR G.A., "Managerial and Engineering Economy - Economic Decision Making". D. Van Nostrand, 1980.

127. FERRY D.J. and BRANDON P.S., "Cost Planning of Buildings". Granada, 1980.

128. RICS., "Standard Form of Cost Analysis", Royal Inst. of Chartered Surveyors, 1963.

129. CURRIE R.M. and FARADAY J.E., "Work Study", Pitman, 1976.

130. INTERNATIONAL LABOUR OFFICE, "Introduction to Work Study". International Labour Organization, 1978.

131. CARNEY J., "Activity Sampling", Unpublished paper presented to a construction plant and methods short course - Construction Industry Training Board in conjunction with L.U.T. January 1974.

132. LEPLAT J. and BISSERET A., "Analysis of the Processes involved in the Treatment of Information by the Air Traffic Controller". The Controller 5, 1966, pp 13-22.

133. PULVER H E., "Construction Estimates and Costs". McGraw Hill, 1969.

134. ATTON W., "Estimating Applied to Building". Godwin, 1969.

135. BARTON J.I., "Estimating for Heating and Ventilating". Newnes, 1964.

136. WHITEHEAD G., "Guide to Estimating for Heating and Ventilating Contractors".

137. SPONS., "Architects and Builders Price Book". Ed. Davis, Beifield and Everest. E and F.N. Spon Ltd. 1979.

138. GEOFFREY SMITH and PARTNERS., (ED) "Griffiths Building Price Book 1980". Barton Publishers, 1980.

139. TAYLOR E., SEAWARD P.D., GRAY J., BEISHON R.J., "An Analysis of the Behaviour of Estimators in the Civil Engineering Industry". unpublished paper Sussex University, 1973.

140. GRANT G., "The Estimators Tasks and Skills". Building Trades Journal, Dec. 13th 1974, pp 52 and 55.

141. ASHLEY S., "Chief Estimator : Consistent Approach". Building, 16th Dec. 1977.

142. HARTLEY J., "Evaluation", in J. Hartley (Ed.) Strategies for Programmed Instruction : An Educational Technology. Butterworths, 1972.

143. DAVIES J.P., "Task Analysis and an Approach to Coaching in Sport", unpublished M.Sc Dissertation, Applied Psychology Dept. University of Aston in Birmingham.

144. FLANAGAN J.C., "The Critical Incident Technique", Psychological Bulletin, 51, 1954, pp 327-358.

145. GLICKMAN A.S. and VALANCE T.R., "Curriculum Assessment with Critical Incidents". Journal of Applied Psychology, 42, 1958, pp 329-335.

146. FURST S.J., "Constructing Evaluation Instruments", McKay.

147. FREEMAN J. and BYRNE P.S., "The Assessment of Post Graduate Training in General Practice". Soc. for Research into Higher Education, 1976.

148. BRENNAN C.W. "Wage Administration", Irwin, 1963.

149. McBEATH G., and RANDS D.N., "Salary Administration". Business Publications, 1964.

150. BELCHER D.W., "Wage and Salary Administration". Prentice Hall, 1963.

151. PATERSON T.T., "Job Evaluation". Business Books, 1972.

152. STEWART R., "Managers and their Jobs". Macmillan, 1967.

153. MARPLES D., "Studies of Managers - a Fresh Start". Journal of Management Studies, 4, 1967, pp 282-289.

154. MINTZBERG H., "Structured Observation as a Method of Study Work". Journal of Management Studies, 7, (1), 1970, pp 87-104.

155. FINES A. and WILEY W.W., "An Introduction to Functional Job Analysis". Methods for Manpower Analysis Monograph No. 4, W.E. Upjohn Institute, 1971.

156. SEYMOUR W.D., "Skills Analysis Training". Pitman, 1968.

157. SEYMOUR W.D., "Industrial Training for Manual Operations". Pitman, 1954.

158. HARKER S.D.P. and EASON K.D., "Task Analysis in Theory and Practice". HUSAT Memo 206, Dept. of Human Sciences, L.U.T. March, 1980.

159. MILLER R.B., "Task Description and Analysis" in Psychological Principles in Systems Development", Ed. R.M. Gagne, Holt, Reinhart and Winston, 1962.

160. BEISHON R.J., "Problems of Task Description in Process Control". Ergonomics, Vol. 10, Part 2, 1967.

161. HARRIS L.R., "User Orientated Data Base Query with the Robot Natural Language Query System". International Journal of Man-Machine Studies 9, 1967, pp 697-713.

162. ADDIS T.R., "Machine Understanding of Natural Language", International Journal of Man-Machine Studies 9, 1977, pp 207-222.

163. LONQUET-HIGGINS C. and ISARD S.D., "The Monkey's Paw". In Man-Computer Interaction, Inst. of Elec. Engineers, Con. Pub. No. 68, pp 83-88.

164. CUFF R.N., "Database Query Systems for the Casual User", report EE - MSS - CAS - 79, Man Machines Systems Lab. Dept. of Elec. Engineering Science, University of Essex, 1979.

165. ZLOOF M.M., "Query by Example", Proc. of AFIPS National Computing Con. Report Number 44, 1975, pp 431-438.

166. McCORMICK E.J., "Human Engineering", McGraw Hill, 1957.

COMPUTER AIDED ESTIMATING FOR CIVIL ENGINEERING CONTRACTORS

by

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APPENDICES

APPENDIX I

METHODS OF BUDGET ESTIMATING

This Appendix contains examples of methods of Budget Estimating.

(i) UNIT METHOD

The Unit Method assumes the cost of a project is related to the number of functional units that it accommodates (eg pupils/school, beds for hospital etc). The cost of similar projects are used to estimate the cost of the project under consideration,

eg. The cost of a multi-storey car park for 600 cars was £2,700,000.

Cost per car - £2,700,000/600 = £4,500.

Cost of car park to accommodate 500 cars = 500 x 4500 = £2,250,000.

This method may be extended to incorporate time where estimates are necessary for industrial production projects. (ie. An estimate for a brewery may be based on the cost per number of barrels of beer produced per year).

(ii) SPACE METHOD

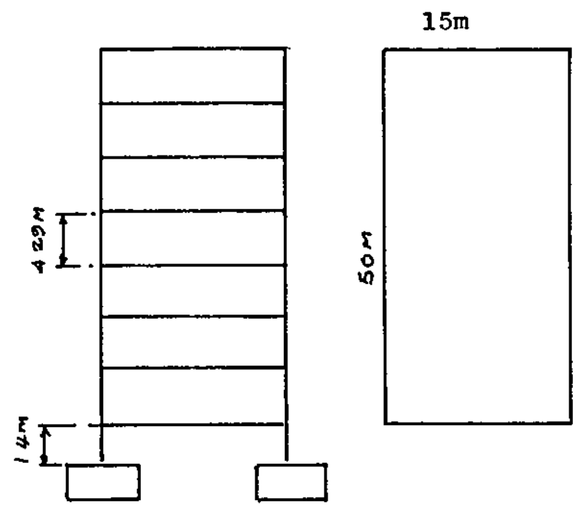
The space method estimates the cost of a building on the basis of the volume, (cost per m^3) or surface area, (cost/m^2). Knowing the basic dimensions of the structure an estimate may quickly be made of the total cost. Some form of common standard of measurement is necessary in order that the rate obtained for one design may be compared with another. (eg. pitched roof design compared with flat roof design). The traditional method of calculation was the 'cubic' method until it was proved that the cost of a building is more closely related to the floor area than its cubic capacity.

An extension of the space method is the storey enclosure method that attempts to compensate for the height and shape of a structure. The areas of the floors of the building are 'weighted' by different percentages and the figures totalled to give the number of storey enclosure units.

The example in Table 14 and Table 15, pages 385 and 386 was taken from Ferry and Brandon [127].

OFFICE A

Actual Cost	=	£2,758,000
Area	=	5024 m^2
Cube	=	24000 m^3
No. of storeys	=	7
Storey height	=	4.29 m
Foundation Depth	=	1.4 m
Wall thickness	=	0.25 m



ELEVATION PLAN

OFFICE B

Actual Cost	=	£1,995,000
Area	=	5742 m^2
Cube	=	24000 m^3
No. of storeys	=	8
Storey height	=	3.75 m
Foundation depth	=	1.4 m

Dimensions identical to office A but eight storeys included. Therefore storey height = 3.75 m

TABLE 14 : COMPARISON OF OFFICE A AND OFFICE B

CUBIC METRE METHOD	SQUARE METRE METHOD
OFFICE A ANALYSIS	OFFICE A ANALYSIS
$\frac{£1,758,000}{24,000} = £73.25/m^3$	$\frac{£1,758,000}{5024} = £349.92/m^2$
OFFICE B FORECAST	OFFICE B FORECAST
£73.25 x 24000 = £1,758,000	£349,92 x 5,742 = £2,009,000
Error - underestimate of 12%	Error - overestimate of 0.7%

STOREY ENCLOSURE METHOD

OFFICE A ANALYSIS			OFFICE B FORECAST
Lower floor	717.75 x 2	= 1435.50	As for A 16959.42
First floor	717.75 x 2.15	= 1543.16	add
Second floor	717.75 x 2.30	= 1650.83	Extra floor (7th)
Third floor	717.75 x 2.45	= 1758.49	717.75 x 3.05 2189.14
Fourth floor	717.75 x 2.60	= 1866.15	TOTAL £19,148.56
Fifth floor	717.75 x 2.75	= 1973.81	
Sixth floor	717.75 x 2.9	= 2081.48	£19149 x £103.65
Roof	750.00 x 1.0	= 750.00	= £1,984,800
Ext. walls	3900.00 x 1.0	= 3900.00	
		£16959.42	Error = 0.51%

$\frac{£1,758,000}{16950} = £103.65/SEU$

TABLE 15 : COMPARISON OF METHODS OF ESTIMATING COST OF OFFICE B

(iii) ELEMENT METHOD

Under the elemental method of estimating the structure is broken down into a number of major elements which can be measured from sketch drawings and priced separately. The elemental costs are then added to give the total estimate for the project.

eg. Element - External Wall.

Area on proposed project - 2500 m^2 .

Cost per square metre of external wall (or elemental unit rate) from records = £45 00.

Cost of wall for proposed project = 2500 x 45.00 = £112,500.

The Standard Form of Cost Analysis (128) was produced by the RICS to provide suitable elemental breakdowns of structures. This analyses structres under the following headings:

- Sub-structure
- Superstructure
- Internal Finishes
- Fittings and Furnishings
- Services
- External Works

each with a hierarchical sub-division of elements.

(iv) APPROXIMATE QUANTITIES METHOD

The Abbreviated Quantities Method involves the preliminary measurement of the work contained within the contract to establish the principle quantities.

The cost of the project is then calculated based upon recorded costs for that particular class of construction work,

eg.	Total concrete work	=	760 m^3
	Unit cost/m^3	=	£32.64
	Total cost of concrete work	=	£24,806

The total cost of the project is then calculated by summation of the cost of each of the principle quantities.

All of the above methods rely upon the keeping of historical cost data which has to be amended to allow for inflation, market conditions and individual project anomalies.

APPENDIX II

SURVEY TO INVESTIGATE THE RELATIONSHIP BETWEEN ESTIMATING AND TENDER PLANNING

This Appendix contains the results of a survey which was undertaken amongst twelve construction companies of varying sizes to discover more about the relationship between estimating and tender planning. A questionnaire was designed to find out whether:

- the functions of estimating and planning were undertaken by different staff within the company;
- closer integration between planning and estimating was desirable;
- computer based data on the estimators calculations would be more accessible than build-ups held in records produced manually.

Comments were invited on the relationship between estimating and tender planning and whether further research into the interface between the two functions was desirable.

A copy of the questionnaire is included in figure 71 page 391.

A summary of the results is shown in figure 72 page 392.

Comments made on this subject are contained on pages 393 to 396 inclusive. A list of the companies concerned is also included on page 397.

In 84 percent of the companies surveyed planning and estimating was undertaken by different staff within the company. The need for close liaison between estimators and planners was evident and a closer integration between the two functions was desirable.

Please answer YES or NO to these questions by entering a tick in the appropriate box.

	NO	YES
1. Is estimating and tender planning undertaken by different staff within your company?	☐	☐
If YES · Is a closer integration between estimating and tender planning desirable?	☐	☐
If NO : Would access to planning software integrated with the estimators' computer aided system be of value?	☐	☐
2. Computer files enable estimators' build-ups and calculations to be held in a more accessible form than manual records. Would this be beneficial to subsequent job control activities?	☐	☐
3. Do you consider it important to pursue research into the interface between estimating and tender programming?	☐	☐

Any comments on this aspect would be helpful.

Any further comments you may have on the relationship between estimating and tender planning:-

Name:
Position:
Company:

THANK YOU

Figure 71 - QUESTIONNAIRE SHEET FOR THE SURVEY

Please answer YES or NO to these questions by entering a tick in the appropriate box.

		NO	YES
1.	Is estimating and tender planning undertaken by different staff within your company?	2	10
	If YES : Is a closer integration between estimating and tender planning desirable?	0	10
	If NO : Would access to planning software integrated with the estimators' computer aided system be of value?	0	2
2.	Computer files enable estimators' build-ups and calculations to be held in a more accessible form than manual records. Would this be beneficial to subsequent job control activities?	1	11
3.	Do you consider it important to pursue research into the interface between estimating and tender programming? Any comments on this aspect would be helpful.	0	12

Any further comments you may have on the relationship between estimating and tender planning:-

Name:
Position:
Company:

THANK YOU

Figure 72 - THE RESULTS OF THE SURVEY

The need to reconcile a resourced programme with the prices within the bill was considered essential, particularly on larger projects, if tenders were to be competitive. The integration of planning and estimating was considered important so that planning engineers appreciated the cost of the resources they employed. The altitude that planners plan and estimators estimate reduced the quality of the tender. Certain operations involved in the tender production frequently involved a duplication of effort (eg calculation of bulk quantities, outputs etc.). In all but one instance the use of computer files to store estimators data was considered to enable data to be held in a more accessible form which would be beneficial to subsequent job control qctivities. All companies approached considered that further research on the planning and estimating interface was important.

COMMENTS MADE BY THE COMPANIES APPROACHED

"In the larger civil engineering tender it is essential to correlate a resourced programme with the prices in the Bill of Quantities. It is sometimes not possible to do this because of the amount of manual work entailed. If it is not done the tender is not as competitive as it would otherwise have been".

"There are a number of other important aspects to correlate, eg:-

(i) Programme feasability as indicated by the client;

(ii) Phasing of particular parts of the tender;

(iii) Key resource dates;

(iv) Cash flow (very important)".

"On projects greater than £2 million the planning and estimating was carried out by different personnel".

"The integration of estimating and planning a tender is vital so that planners truly appreciate the cost of the resources they apply to the construction methods. Perpetuation of the planners plan and the estimators estimate attitude must be limited if better quality tenders are required".

"This department has endeavoured to base all project planning on the information on which the estimate is based. Using manual procedures this has proved successful and with the implementation of computerised estimating it is in my view the next logical step to link in the planning process with a further program".

"The speed and accuracy of information obtained by computerisation of the estimating and planning functions will show a considerable saving in the use of staff resources".

"Should be a development of present estimating research and could have applications in budget estimating.

"The programme should be a resultant of the estimate and will become a more meaningful document".

"The following operations could be most usefully shared between the estimator and planner as they frequently involve duplicated effort in a manual system.

1. Bulk Quantities - available to all members of the tem (including purchasing) with all the cubes, supers, runs and numbers reduced to a common agreed unit for each trade section. This will greatly assist the planner to assess the realistic work volume.

2. Agreed outputs between the estimator and planner applied to the overall bulk quantities will greatly assist the final reconciliations of resources.

3. Integration of the estimating information to the planners programme (not necessarily in network format) will produce much more meaningfull resource histograms, and should also provide a high quality cash flow. The latter will only work if the resources are separately identified and this operation is generally considered too difficult at tender stage without a computer to handle the volume of figures.

4. In the absence of a Bill of Quantities, a Contractor's Bill, prepared in elemental form to suit the programme and construction method will permit the progress of the work to reflect the certification payments. This is already a standard feature on most overseas projects administered by American Consultants.

5. From 4 stems full cost control and forecasting systems which rely on the estimator's tender values for the comparisons which are required".

"The information used/required by Estimators and Planners can vary quite considerably depending upon the type of construction involved. Generally estimators require more small detail information and are not normally concerned about numbers of operatives, whereas planners are inclined to operations and need to labour resource their charts".

"In my opinion a programme completed before pricing begins would be most helpful to estimators and the subsequent discussions produce the best blend of each departments knowledge".

Frequently the reconciliation is done on an aggregation of a particular resource against a particular cost item.

eg	man hours	in placing all concrete
	man hours	on fix strip lean and oil
		all soffit formwork
	machine hrs/m^3	for bulk excavation

It is only when such a reconciliation is done between the planners and the estimators work that a true resource cost against a particular item can be determined.

Only when this is done does one have a valid basis to compare a sub-contract price for eg. ready-mixed concrete, site clearance or bulk excavation etc. One may need to be able to do this very early in the tendering process as a separate exercise.

	COMPANIES CONTACTED	POSITION OF PERSON CONTACTED
1.	Reed and Mallik Ltd.	Chief Engineer and Deputy Managing Director
2.	Goodhall Barnard Ltd.	Managing Director
3.	Sheldon Contracting Ltd.	Agent
4.	Shield Brothers Ltd.	Director
5.	C.P. Roberts and Co. Ltd.	Director
6.	Lehane, McKenzie and Shand.	Area Estimator
7.	Tarmac International.	Senior Planning Engineer
8.	W. Townson and Sons.	Estimating Director
9.	Lilley Construction Ltd.	Director
10.	French Kier Construction Ltd.	Estimating Manager
11.	Cementation International Ltd.	Tendering Administration Manager
12.	Leeds City Countil	Assistant Director Technical Division

APPENDIX III

A CHECKLIST OF PRELIMINARY AND SITE ON-COST REQUIREMENTS

The estimator must make allowance for the following site on-costs:

A	Supervision - Technical
B	Supervision - Clerical
C	Sundries and attendance
D	Canteen
E	First Aid, Welfare, Industrial Relations
F	Offices and Administration Area
G	Site Transport
H	Resident Engineers Transport
J	Sundry Finance Charges
K	Plant, Tools, etc
L	Plant Haulage
M	Clearance Items
N	Fixed Contract Allowance
P	Cranage, Scaffolding
R	Quantity Surveying/and Design Fees
S	Temporary Works
T	Noise and Safety.

NOTE:

This list is based upon the checklist used by Tarmac Construction Company Ltd. with amendments made as a result of discussions with the co-operating companies contacted.

A - SUPERVISION (TECHNICAL)

	No	WEEKS			Cost each per week	£
		from	To	No		
Project Manager						
Agent						
Sub Agent						
Senior Engineer						
Section Engineer						
Setting out Engineer						
Junior Engineer						
Senior Measurement Engineer						
Measurement Engineer						
Junior Measurement Engineer						
Quantity Surveyor						
Assistant Quantity Surveyor						
Production Controller						
Senior Laboratory Engineer						
Laboratory Engineer						
Laboratory Technicians						
Works Manager						
General Foreman						
Section Foreman						
Foreman - Carpenter						
Foreman - Scaffolder						
Foreman - Steelfixer						
Foreman - Bricklayer						
	Carried to Summary A					

B - SUPERVISION (CLERICAL)

	No	WEEKS			Cost each Per week	£
		From	To	No		
Office Manager						
Cashier						
Timekeeper						
Wages Clerk						
Goods Received Clerk						
Purchasing Clerk						
Storeman						
Materials Checker						
Plant Checker						
Cost Clerk						
Bonus Clerk						
Telephone Operator						
Typist						
Calculator Operator						
First Aid Orderly						
Safety Officer						
Industrial Relations Officer						
	Carried to Summary B					

C SUNDRIES	No.	Works	Cost each	£
Watchman				
Security Patrol				
Lamping etc				
Chairman				
Office orderly				
Cleaner				
Yard Gang				
	Carried to Summary C			

D CANTEEN	£
Mobile Canteen	
Purchase of Equipment	
Hire of Equipment	
Running Costs	
Canteen Staff	
Carried to Summary D	

E - FIRST AID/WELFARE/INDUSTRIAL RELATIONS	£
Fixed Charges to Site	
Weekly Charges to Site	
Carried to Summary E	

F OFFICES & ADMINISTRATION AREA

Hutting

	UNIT		RE	TOTAL	RATE	£
Headquarters						
Section Offices						
Stores						
Fitting Shop						
Canteen						
Total Erect & Dismantle						
Laboratory Erect & Dismantle						
Hire of Hutting					P/WK WKS	
Hire of Hutting					P/WK WKS	

			RE	No	WKS	RATE	
Portable Offices							
Portable Shelters							
Latrines							
Toilet Block							

Hutting Sub-Total

Equipment

	COST			CREDIT	
		RE	TOTAL		
Office Furniture					
Office Machines					
Laboratory					

Equipment Sub-Total

Sundries

		RE	No	MTHS	RATE	
Surveying Equipment						
(a) Levels						
(b) Theodolites						
(c) Other						
Stationery & Postage						
Rates						
Radio						

Sundries Sub-Total

Carried forward

Section F Cont d

Compounds etc

	QTY	L	P	M	RATE	Brought forward £
Hardstanding T C						
Hardstanding R E						
Compound Fencing						
Oil Compound						
Oil Trap						
Loading Ramp						

Compounds Sub-Total

Temporary Mains Installations

Telephone – Installation	
Charges	
Electricity – Connections, Cables etc	
Charges	
Water – Installation	
Charges	
Drainage	

Temporary Mains Sub-Total

CARRIED TO SUMMARY F'	

G SITE TRANSPORT

	No	WEEKS	RATE	£
Labour Coaches, Vans etc				
Staff Land Rovers				
Staff Pick-ups				
Fitters Land Rovers or Vans				
Fitters Welding Truck				
Bowsers, Water				
Bowsers, Fuel				
Site Lorries				
Site Dumpers				
Fordson Tractor and Trailer				
Laboratory Van or Lorries				
Staff Cars (not personal)				
Drivers				
CARRIED TO SUMMARY 'G'			£	

H R E SITE TRANSPORT

	No	WEEKS	RATE	£
Land Rovers				
Cars				
Drivers				
CARRIED TO SUMMARY 'H'			£	

J. SUNDRY FINANCE CHARGES

	£
Insurances (Contract All Risks)	
Other Insurances (Marine, Tidal, Flying etc)	
Bond	
Special Finance Charges	
CARRIED TO SUMMARY 'J' £	

K PLANT, TOOLS & EQUIPMENT ETC (not incl elsewhere)

	No	WEEKS	RATE	£
Batching Plant				
Burning Gear				
Crushing &/or Screening Plant				
Generating Plant				
Precasting Yard				
Small Mixer & Wet Hoppers				
Conveyors				
Compressors				
Compressors Tractor				
Derricks				
Barbending and Steel Stock Yard				
Traffic Lights				
Traffic Control Signs				
Diesel Tank				
Petrol Tank				
T V O Tank				
Weighbridge				
Consumables (not incl Plant consumables)				
Protective Clothing				
¢Tool Account				
CARRIED TO SUMMARY 'K'			£	

L - PLANT HAULAGE

	NO.	WAYS	RATE	£
Excavators				
Tractors and Scrapers				
Batching Plants				
Offices				
Depot Haulage				
			CARRIED TO SUMMARY L £	

M - CLEARANCE ITEMS

	£
Drying out Buildings	
Clean down Buildings	
Clear up Site	
Clean Off Roads	
Tidy Bins	
CARRIED TO SUMMARY M £	

N - FIXED PRICE CONTRACT ALLOWANCE

	£
Labour	
Plant	
Materials	
Sub-Contract	
Staff	
CARRIED TO SUMMARY N £	

P- CRANAGE

	No	WEEKS	RATE	£
Tower Crane (Incl operator)				
Derrick (Incl operator)				
Mobile Crane (Incl operator)				
Erect/Dismantle Tower Crane				
Erect/Dismantle Derrick				
Gabbards				
Kentledge				
Cranage Sub-Total				

P-SCAFFOLDING

	No	WEEKS	RATE	£
External				
Internal				
Soffits				
Towers				
Hoists				
Labour				
Scaffolding Sub-Total				

CARRIED TO SUMMARY P £

FEES ETC

	£
Q S Fees	
Design Fees	
Office Costs	
Tender Costs	
CARRIED TO SUMMARY R' £	

S. TEMPORARY WORKS

Summary Sheet

	No	UNIT	RATE	£
Pumping				
De-watering (well-points)				
Access Road				
Land (for offices tips, etc)				
Working space for Excavations				
Centering				
River Diversions				
Stream Diversions				
Coffer Dams				
Bored Piles-Empty Drive				
Cut-off Pile Heads				
Dispose of surplus from piles				
Temporary Works specialist S/C				
Construction Joints in Concrete				
Water bar (not billed)				
Site lighting				
Weather protection				
Heating of Aggregates				
Temporary fencing				
Over break				
Publicity				
Advertising Signs				
TOTAL				
DEDUCT ITEMS INCLUDED IN BILLS				
CARRIED TO SUMMARY 'T' £				

T- NOISE REGULATIONS

	No	Unit	Rate	£
Noise Barriers				
Hush Piling				
Compressor/Plant Encasement				
Restricted Hours – Standing Costs				
Noise Regulations Sub-Total				

T SAFETY

Roof Edge Rails				
Staircase Handrails				
Hoist Protection				
Safety Nets				
Temporary Covers				
Safety Lighting				
Safety Boat (River Works)				
Lifebelts				
Safety Sub-Total				

Carried to Summary 'U' £

APPENDIX IV

METHODS OF TASK ANALYSIS

This appendix describes the methods of Task Analysis which were considered for the analysis of the tasks of the estimator.

(i) Activity Analysis ;

(ii) Simulation ;

(iii) Literature Search ;

(iv) Hierarchical Task Analysis ;

(v) Critical Incident Technique ;

(vi) Job Ranking;

(vii) Diaries ;

(viii) Functional Job Analysis;

(ix) Skills Analysis;

(x) Open Systems Approach;

(xi) Signal Flow Graphs Analysis.

No method was found satisfactory for the purpose of analysing the tasks of the civil engineering estimator for the production of a specification for a computer aided estimating system.

(i) ACTIVITY ANALYSIS

Time spent doing work can be considered as being made up of a number of individual moments during each of which a particular state of activity prevails [129]. By analysing the various activities it is possible to build up a complete picture of the tasks of the individual.

A full "time study" can be used to determine the activities being carried out by the worker and their duration. Time study involves the direct observation of work while it is being performed.

Direct time study is only of use for repetitive work, ie any job which is subsequently going to be repeated under the circumstances which applied and by the method used while the study was being taken. Time study is the original technique of work measurement and is well documented in [129] and [130]. The results may be shown graphically as in figures 73 and 74, page 414.

Activity sampling is the name given to a technique requiring only a fraction of the time and effort involved in a full-time study. A number of individual moments are selected at random intervals from a representative period for the job. From direct observation a record is made of the particular activity in progress at each of these moments. The results for the sample can be used to estimate within definable limits the proportion of job time being occupied by each type of activity that has been recorded.

Descriptions and examples of activity sampling may be found in Harris and McCaffer [55] and Carney [131]. The results are often shown in a graphical fashion as in figure 75 page 415.

Activity Analysis is best suited to manual tasks. Time study techniques are inappropriate for studying the task of the estimator. While the pricing of estimates may be a repetitive job, the circumstances and approach to the problem are always different. To obtain accurate results for the pricing of a contract would be time consuming and costly because the observer would need to study the estimator over the whole of the tender period to obtain information from the full cycle of work within the estimating and tendering process. Any results obtained would be difficult to apply to the preparation of other estimates.

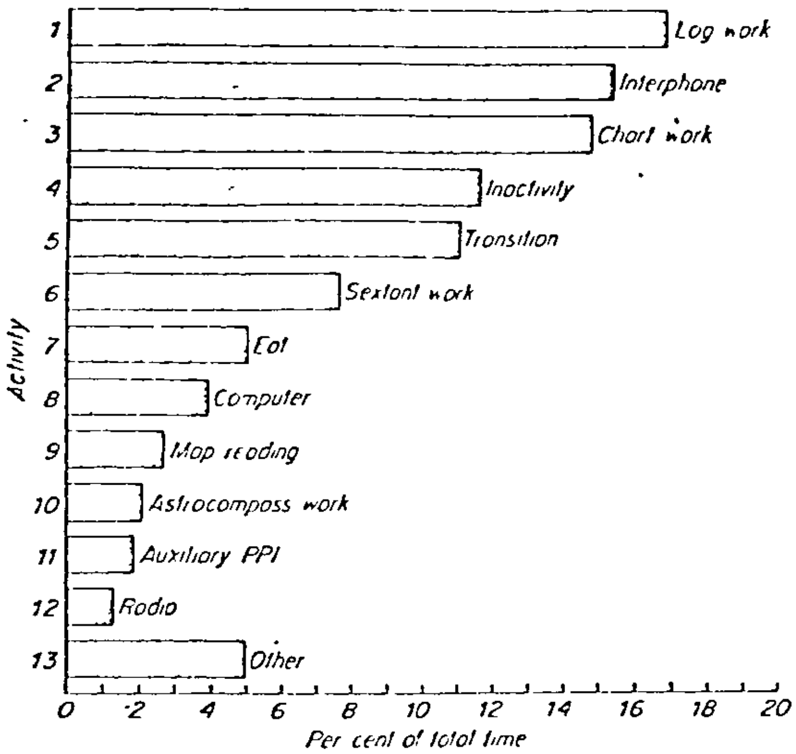


Figure 73 - GRAPHICAL RESULTS OF THE STUDY

McCormick (166)

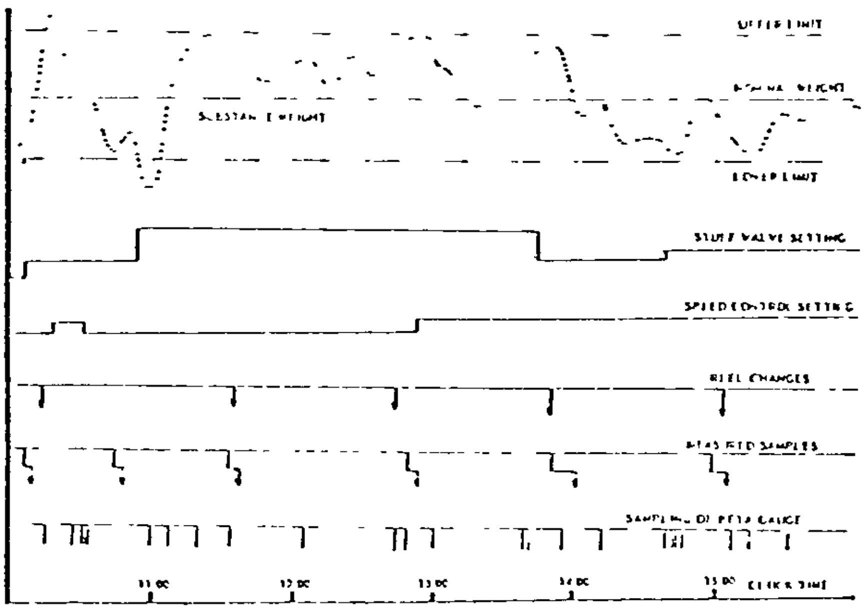


Figure 74 - GRAPHICAL RESULTS OF THE STUDY II

McCormick (166)

Activity sampling, while being a cheaper, quick analysis of the work of the estimator, only identifies the activities involved in the estimators tasks and the percentage of his total time spent on each activity.

Estimating has no fixed cycle of activities and the skill is essentially a mental one. Neither time study or activity sampling can produce an analysis of the estimators tasks at a level that is sufficient for the production of a specification for a computer aided estimating system.

ACTIVITY SAMPLING STUDY

STUDY No 542/1 SHEET 4 OF

OBSERVER CGW DATE 10 – 1 – 56

ROUND No	TIME		WORKER / ~~MACHINE~~								OBSERVATIONS						
	ON	OFF	1	2	3	4	5	6	7	8	a	b	c	d	e	f	No
25	7 40	7 48	✓										✓				1
				✓								✓					2
					✓								✓				3
						✓								✓			4
							✓									✓	5
								✓								✓	6
									✓		✓						7
										✓	✓						8
26	7 55	8 02	✓												✓		1
				✓									✓				2
					✓						✓						3
						✓					✓						4
							✓						✓				5
								✓								✓	6
									✓			✓					7
										✓	✓						8
27	8 05	8 12	✓								✓						1
				✓							✓						2
					✓								✓				3
						✓										✓	4
							✓				✓						5
								✓			✓						6
									✓		✓						7

Figure 75 - ACTIVITY SAMPLING : OBSERVATION SHEET - CURRIE (129)

(ii) SIMULATION

Simulation in the context of the task analysis of the estimator means constructing a model situation of the estimator in his normal job to analyse what the estimator is required to do in the performance of his tasks. This procedure would enable information for analysis to be generated and theories on the approaches made to solving problems to be postulated and validated.

Simulation techniques are generally used in the development of new systems where tasks do not exist or where task situations may be dangerous. (For example, the study of air traffic controllers undertaken by Leplat and Bisseret [132]).

It would have been extremely difficult to simulate an estimator working in his office environment. However, paper and pencil exercises could have been constructed to obtain information as to how estimates are prepared. In the circumstances of the research programme it was not plausible to study estimators performance because of the time and cost involved in putting estimators through a range of exercises representing a full tender preparation. Moreover, the simulation exercises may only have shown one aspect of the estimators task and not highlighted the communication links with other parties and the information exchange that is a fundamental area of the job.

(iii) LITERATURE SEARCH

With well documented jobs it is possible to perform a detailed task analysis from a review of existing literature relating to the tasks involved. For common tasks within the industrial environment previous research often provides a comprehensive breakdown of what is involved. Information available relates to predominantly manual rather than managerial tasks.

Research into the literature available relating to the tasks of the civil engineering estimator showed little directly related information. By extending the literature search to include estimating for building and other allied industries more data became available.

The "Procedure of Estimating and Tendering" (17), details the process for the building industry. This includes standard forms and checklists. No such equivalent exists for civil engineering work.

Books such as that produced by Pulver (133), Atton (134), Barton (135), and Whitehead (136), give examples of how to price different classes and trades of work within their respective commercial environments. Included within the text are examples of typical calculations and tables of allowances and factors to be applied to individual contract situations. Texts such as these concentrate upon the calculations involved in the estimating and tendering process with examples of how to approache the pricing of different types of work. This approach is followed by the series of papers published by the Chartered Institute of Building in their "Estimating Information Service". Information supplied is extended to include reference to effect of changes in contract law upon estimating and also modern technology.

Other publications for estimating purposes are solely price books (137), (138). No details are given of resource requirements and build ups but for each trade classification of construction work typical labour, plant and material rates are given. These cost rates are based upon standard costs and the estimator is required to make adjustments for inflation and the particular site location.

A review of published papers and journals shows very little research directly related to the tasks of the construction estimator.

The only academic study traced was that carried out by Taylor et al [139], which concentrated upon the behaviour of estimators in the civil engineering industry. Articles on the daily routine and tasks of the estimator such as [140], and [141] describe the variation in daily routine within the job function but failed to analyse the relationship between respective tasks, or analyse how the tasks may be assisted by new technology.

While existing literature may give outlines as to the daily routines of the construction estimator and the methods of approach to the pricing of different types of construction work little detailed information is available as to the tasks of the estimator. No information was available to enable detailed specification of a computer aided estimating system to be produced.

(iv) HIERARCHICAL TASK ANALYSIS

Hierarchical Task Analysis is the name given to an analysis technique developed at the University of Hull. The method is outlined by Annett and Duncan [75] and discussed in detail by Stammers and Patrick [70] and Hartley [142]. Tasks are broken down into operations which are the units of analysis. No level of analysis is assumed, it being possible to subdivide operations to any level required. Consideration of each operation is carried out isolating input, actions and feedback. This involves not only a description of the operation but an assessment of the psychological demands. Analysis of the task in terms of operations proceeds hierarchically from the first operation. As each operation is isolated, two questions are asked of it:

(i) what is the probability without training of inadequate performance?

(ii) what would be the costs to the system of inadequate performance?

To each estimate of probability of failure a numerical figure is given (P). An assessment of cost value (C) is also made. Further analysis of the operation is made by considering P x C. If this exceeds a predetermined value then further examination of the operation continues. When an operation is broken down into sub-operations the ordering of the subordinates, their sequence and selection for examination must be stated. An example of this approach is given in figure 76 page 420.

Hierarchical Task Analysis was designed principally for the analysis of tasks for the purpose of designing training programmes. The formalized structured approach centres upon input received by the operator, the reaction and subsequent feedback. The results of the analysis are recorded in a tabular form stating:

- a list of operations linked to a flow diagram;
- training comments with rules for sequencing suboperations;
- training solutions;
- difficulties that exist in the operation.

An example is given from Davies [143] in figure 77 page 420.

Hierarchical Task Analysis is not directly applicable to the design of a man-machine specification. The decision making rule for the further analysis of each operation is irrelevant to the task analysis of the estimator. The technique is suited mainly to manual tasks where alternative actions are clearly defined. With respect to managerial functions such as estimating, the alternatives are seldom the same nor the decision criteria applicable from one situation to another.

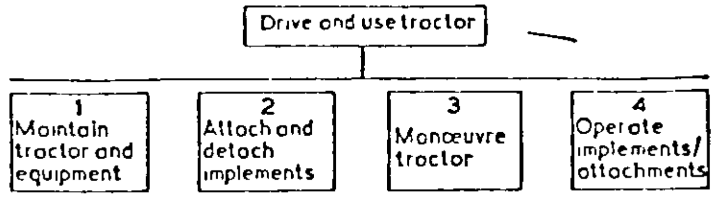
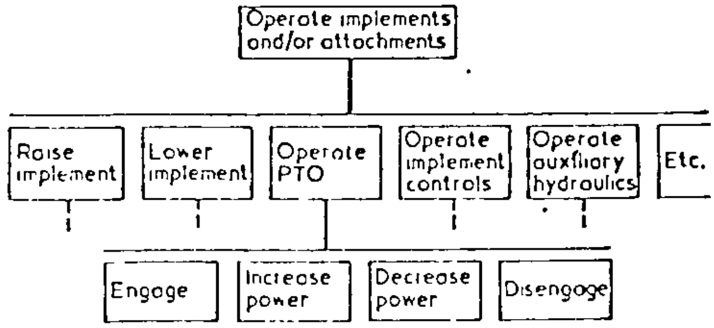


Fig 3.2 First stage of a task analysis of tractor driving



Partial further breakdown of operation 4 of tractor driving

Figure 76 - HIERARCHICAL TASK ANALYSIS, SPLITTING AN OPERATION INTO SUB-OPERATIONS - STAMMERS AND PATRICK (70)

No	Description of Operation and Training Notes	I/F	A	Redescribed
1	Fence with the sabre [R] Convention means an invariant order 1,1 to 1,3. Score a hit on the target of the opponent without getting hit oneself within the rules. Must learn the convention – poss'bly fencing films	–	x	1,1–1,3
1,1	Attack the opponent [R] Invariant order 1,1,1 to 1,1,3 although 1,1,1 (the grip) is maintained throughout the fight. The target is anywhere above the waist of the opponent including the arms. Once indicated this should be clear, may be helped by colouring the target area	–	x	1,1,1–1,1,3
1,2	Defend on opponent's attack [R] Always 1,2,1 but defence may be by either evasion (1,2,2) or by parrying (1,2,3) [I] The choice of alternative depends on the amount of pressure in the fight and upon the strengths and weaknesses of the opponent and is thus specific to each fight. Evasion should not be encouraged because it does not earn the right to attack	x	x	1,2,1–1,2,3
1,3	Reply to opponent's attack [R] Operation 1,3,1 and 1,3,2 are wholly time shared but the type of hit (1,3,2) will vary from one riposte to another. All ripostes follow a parry by the rules of fencing	–	x	1,3,1–1,3,2

Extract from a task analysis table of fencing

Figure 77 - HIERARCHICAL TASK ANALYSIS, TABULAR FORM - DAVIES (143)

(v) CRITICAL INCIDENT TECHNIQUE

The Critical Incident Technique analyses jobs with respect to those tasks considered "critical" and those considered "non-critical". The technique was first developed from studies of air crews by Flanagan[144]. It has also been applied to Naval Officers[145] and other professional persons [146] [147].

The observer judges a task to determine the degree to which it is effective or ineffective in securing the overall completion of the job. A critical task is one that makes the difference between success and failure in carrying out important aspects of the job. Non critical tasks are these which have little relation to success in securing the overall completion of the job. The observer must ensure that the sample of incidents recorded are representative. This requires:

- getting reports from a variety of different situations;
- collecting incidents until no new types of behaviour are reported in significant numbers;
- selecting only incidents from the recent past so as to avoid dramatic or outstanding experiences.

The critical incident technique was initially developed for training purposes and is best suited for this purpose. The collection of data necessary to identify all critical incidents is time consuming to obtain. While suitable for the analysis of some professional jobs it is not suited to those such as estimating which require the assembly and manipulation of data. In jobs such as these it is often difficult to assess which parts of the constituent tasks are critical and which are not. This is because there are often alternative ways of presenting information and collating data.

(vi) JOB RANKING

Job ranking is a non analytical procedure where complete jobs are compared one with another and arranged and ranked in order of their importance, difficulty or value to the company [148]. The method is used principally for the determination of wage and salary scales. Some researchers [149] regard the method as preferable to other quantitative and time span methods. A typical ranking process is that described by Belcher [150] and detailed by Paterson [151].

(i) Job descriptions are prepared and set out on cards to be used in the ranking process.

(ii) Factors are selected as a basis of ranking.

(iii) One common factor is selected for all jobs in order that direct comparisons in terms of this factor may be made.

(iv) The jobs are then marked. First this is undertaken by people in each department and then by an evaluation committee of departmental heads. (This may be performed on the basis of card sorting or paired comparison).

The disadvantages of the method are:

- it lends itself to too much disagreement;
- it is difficult to counteract bias among the rankers who cannot know much about all the departments within the company;
- grades within the ranking do not constitute equal units;
- the system is highly subjective with no checking system;
- the jobs may be ranked on the basis of incomplete information and without the benefit of well designed standards;
- it superficially ranks the job holder rather than the job;
- the rank position of different jobs is likely to be influenced by prevailing wage rates.

With regard to the preparation of system specification for estimation the system is too global in approach and of no practical use unless the job under consideration can be closely identified in a range of jobs that have comprehensive existing specifications provided. The unique nature of the estimator's job within the contractor's organization does not make this method feasible from the research undertaken.

(vii) DIARIES

An alternative method to observation of individuals performing their tasks is to provide diaries in which the subjects are asked to keep a record of their actions. The main advantage of this method is that it is simple and cheap to undertake. It is easier to record activities for a longer period than by using observation and more subjects may be studied in a specified time period. The classification of the tasks performed is made by the person who know what they are doing.

Stewart [152], used the method of self-recording diaries to discover the similarities and differences in the way in which managers spent their time. A diary was designed to record:

- WHERE the manager was working;
- WITH WHOM he was working;
- HOW HIS TIME WAS SPENT.

Examples of the diary sheet with annotations are given in figures 78 and 79 pages 425 and 426.

Critics of the technique [153], [154], claim that diary recording may be inaccurate and does not provide substantial insight into the actual content of the activities being undertaken. Other disadvantages of the method are:

- the scope of what may be studied is limited because the subject cannot devote much time to filling in the diary;
- the content is limited because it is difficult to get different subjects to record similar items of work in the same way;

Time of Starting Incident?* ___

Duration: Hrs. ___ Mins ___ (nearest 5 mins)

DID YOU DO THIS

Alone? [0] With one other person? [1] With 2 or more? [2]

WHERE?		WHO?		HOW?		WHAT?	
0	Own Office	+	INTERNAL Boss	+	Committees [d]	0	Finance
1	Other internal	−	Boss's boss	−	Discussion [e]	1	General management [h]
2	Other units [a]	0	Secretary	0	Selection interviewing	2	Marketing and Sales
3	External	1	Subordinates	1	Social [f]	3	Personnel
4	Home	2	Subordinates' subordinates	2	Telephoning	4	Production
5	Travelling	3	Colleagues [b]	3	Figure work	5	Public Relations
		4	Fellow [c] Specialists	4	Reading, external	6	Purchasing
		5	Other internal	5	Writing & Co reading [g]	7	Research and Development
		6	Other units [a]	6	Other work [h]	8	
		7	EXTERNAL Customers	7	Inspection [i]		
		8	Suppliers	8	Lectures and conferences		
		9	Other external	9	Travelling [f]		

FLEETING CONTACTS

	Personal	Telephone	Interruption?
Boss	0	0	0
Secretary	1	1	1
Subordinates	2	2	2
Other internal Other units	3	3	3
External	4	4	4

Figure 78 - EXAMPLE OF DIARY SHEET - STEWART (152)

The Diary used in the Research

FOR EPISODES LASTING 5 MINUTES OR MORE

Please start a fresh sheet whenever there is a change under any one of the headings 'Did you do this', 'Where?', 'Who?', 'How?', 'What?'. This means that, except for 'Who?', there should never be more than one tick under one of these headings.

- 'Incident' is what you have taken a fresh sheet to record, that is a change in one of the headings

a 'Other units' means other establishments, divisions, or subsidiary companies belonging to the same parent company

b. 'Colleagues' are those reporting to the same line boss as you

c 'Fellow Specialists' are those doing a similar job to you, in another department, or elsewhere in the parent company They may or may not be at the same level as you

d 'Committee' is any pre-arranged group meeting It may or may not have an agenda

e. 'Discussion' is talking, which is not classified under one of the other headings.

f. 'Social' is when work is combined with a social activity.

g 'Writing & Co reading' includes dealing with correspondence Company reading is of material produced by the company.

h 'Other work' means just thinking But please read more detailed notes

i 'Inspection' is a personal tour of work place.

j. 'Travelling' is when you are travelling for your work and *not* doing any other work listed under 'How?'.

k 'General management' is when you are dealing with two or more management functions, such as sales and production, at the same time, or in the same meeting But if there is a clear division between the discussions on two functions, please record on separate sheets

For more detailed information about headings, please see separate instructions

FOR CONTACTS OF UNDER 5 MINUTES

Please enter in Fleeting Contacts section below

There may be a number of such fleeting contacts during the main incident that you have recorded above, or before you start a fresh sheet. So you can have a number of ticks in this section.

When recording a fleeting contact no entries should be made in the main section of the diary, but a tick should be put in the adjoining column if this interrupts what you were doing.

Figure 79 - NOTES FOR DIARY SHEET - STEWART (152)

- the level of detail cannot be easily changed to allow a study in greater depth of various aspects.

The method of self recording diaries was unsuitable for analysing the task of the civil engineering estimator because the level of detail of the results obtained would have only given an insight to the estimator's task and not provided sufficient information on which to base the specification for a computer aided estimating system. The method would have interfered with the estimator's task performance over the whole of the period of tender preparation. Because of the estimator's lack of conceptual understanding of computers and their capabilities in estimating and tendering process it would have been difficult to identify where the computer could contribute to the estimator's task.

(viii) FUNCTIONAL JOB ANALYSIS

Functional Job Analysis is an extension of Hierarchical Task Analysis developed by Fine and Wiley [155] to enable all tasks and jobs to be compared on a common basis. A task statement is prepared describing each task the worker is expected to perform within the context of their job. Within this task statement, particular emphasis is put on the relationships between Data, People and Things. The following questions are asked:

- Who? (always the worker)
- Performs what action?
- To accomplish what immediate result?
- With what tools, equipment and work aids?
- Upon what instructions?

Analysis of the task statement allows the task to be classified within a behaviour pattern defined in Worker Function Scales (see figure 80 page 415) which provide a standardized language to describe workers actions. The three hierarchies Data, People and Things provide two ways of systematically comparing and measuring the task requirements of any given task in any job. These two measures are 'level' and 'orientation'. Level is the relative complexity of one task compared to another. Orientation is the relative involvement of the Worker with Data, People and Things as he performs a given task.

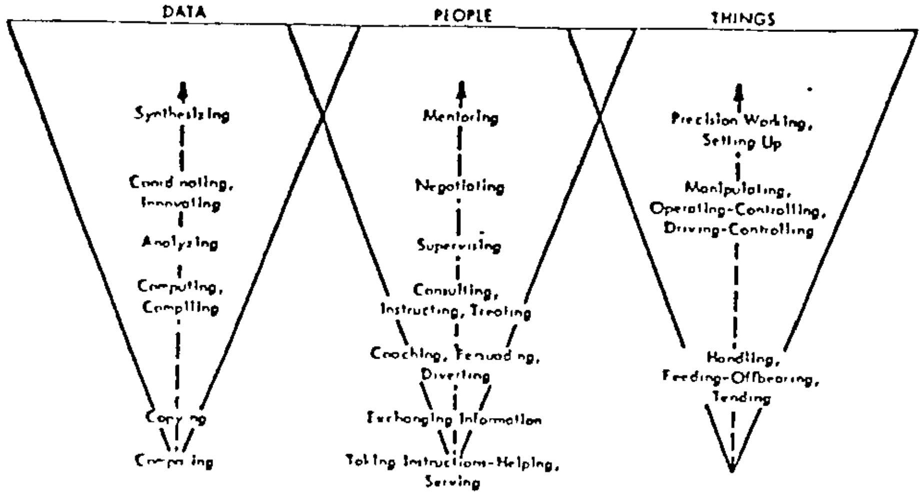
Level and orientation measures can be applied to all tasks and integrated to cover all jobs. Hence all jobs and tasks may be compared whatever their content.

Functional Job Analysis provides a good basis for:

- the assessment of the level of task complexity;
- comparing task performance requirements;
- determining instructions to be given to workers;
- assessing if a worker's performance is satisfactory;
- determining qualifications required to perform the task;
- to establish training requirements for the task.

The method provides a structure for studying the tasks of the construction estimator. However, the descriptions of the functions do not give an analysis at the detail necessary for a system specification. The orientation of the analysis showing the worker involvement with Data, People and Things while providing an indication of communication patterns does not highlight the actual information obtained and the manner in which the data transfer takes place.

Summary Chart of Worker Function Scales



Note Each successive function reading down usually or typically involves all those that follow it The functions separated by a comma are separate functions on the same level separately defined They are on the same level because empirical evidence does not make a hierarchical distinction clear

The hyphenated functions *Taking Instructions Helping Operating Controlling Driving-Controlling* and *Feeding Offbearing* are single functions

Setting Up Operating Controlling Driving-Controlling Feeding Offbearing and *Tending* are special cases involving machines and equipment of *Precision Working Manipulating* and *Handling*, respectively, and hence are indented under them

Complete Version of Data Function Scale

The arabic numbers assigned to definitions represent the successive levels of this ordinal scale The *A* and *B* definitions are variations on the same level There is no ordinal difference between *A* and *B* definitions on a given level.

Level	*Definition*
1	*Comparing*-Selects, sorts, or arranges data, people, or things, judging whether their readily observable functional, structural, or compositional characteristics are similar to or different from prescribed standards.
2	*Copying*-Transcribes, enters, and/or posts data, following a schema or plan to assemble or make things and using a variety of work aids
3A	*Computing*-Performs arithmetic operations and makes reports and/or carries out a prescribed action in relation to them
3B	*Compiling*-Gathers, collates, or classifies information about data, people, or things, following a schema or system but using discretion in application.
4	*Analyzing*-Examines and evaluates data (about things, data, or people) with reference to the criteria, standards, and/or requirements of a particular discipline, art, technique, or craft to determine interaction effects (consequences) and to consider alternatives
5A	*Innovating*-Modifies, alters, and/or adapts existing designs, procedures or methods to meet unique specifications, unusual conditions, or specific standards of effectiveness within the overall framework of operating theories, principles, and/or organizational contexts
5B	*Coordinating*-Decides time, place, and sequence of operations of a process, system, or organization, and/or the need for revision of goals, policies (boundary conditions), or procedures on the basis of analysis of data and of performance review of pertinent objectives and requirements Includes overseeing and/or executing decisions and/or reporting on events
6	*Synthesizing-Takes off in new directions* on the basis of personal intuitions, feelings, and ideas (with or without regard for tradition, experience, and existing parameters) *to conceive new approaches* to or statements of problems and the development of system, operational, or aesthetic "solutions" or "resolutions" of them, typically outside of existing theoretical, stylistic, or organizational context.

Figure 80 - WORKER FUNCTION SCALES - FINE AND WILEY (155)

(ix) SKILLS ANALYSIS

Skills analysis was developed for the analysis of industrial manual tasks. Starting from a detailed breakdown of the task provided standard work study techniques each movement made by an experienced worker is identified and analysed in detail. These movement are studied with respect to the type of movement, over what distance and identifying which senses are involved in initiating, controlling and terminating the movements.

An example of such an analysis taken from Seymour [156] is shown in Table 16 pages 431 and 432.

Human performance is not simply a matter of a series of movements accomplished in a mechanical fashion but depends on a constant information exchange between brain and limbs to initiate, control and terminate movements [157]. The skilled performance of any task thus requires a complex pattern of muscular contractions in response to an equally complicated pattern of sensory stimuli.

Skills analysis charts the sensory processes which are involved in the performance of the task.

The level of detail entered upon to complete a skills analysis for any task is obviously too detailed for the production of a system specification. The method is primarily for the producing training programmes for the manual worker and not the analysis of a professional person in an office environment.

SKILLS ANALYSIS—WRAPPER STEMMING (C.T.W.) FOR SPUN PIPE TOBACCO

Note The hand stemming of tobacco leaves has been superseded by other methods except for such specialist products as the one referred to

Item	*Left Hand*	*Right Hand*	*Vision*	*Other Senses*	*Comments*
1 Select Leaf			Eyes to pile of leaf, determine leaf for selection and point of grasp		-
		Grasp leaf with T, 1 and 2, move with leaf until nose is visible			
			Determine position on nose approximately 1" from top of leaf		
	Grasp selected point with T and 1 on either outer sides of leaf touching stem with tips of both T and 1				
2 Remove Stem	Hold leaf stationary whilst stem is being drawn out to 6" rotate hand once in clockwise direction while R.H is wrapping leaf around back of hand during the continued drawing out of the stem process When leaf has passed around "heel" of hand and R.H starts to draw leaf up back of hand, release hold of nose with T	Release hold on leaf and regrasp stem immediately below left hand T and 1, with finger nails of T and 1 R H Break stem and commence to draw stem out from Leaf to about 6" Pass hand holding stem behind left hand and continue to draw stem leaving the leaf lightly resting against the back of the left hand			During removal of stem hold leaf in left hand at right angles to body draw stem with right hand towards body until about 6" of stem has been parted from the leaf

TABLE 16 - SKILLS ANALYSIS - WRAPPER STEMMING FOR SPUN PIPE TOBACCO - after SEYMOUR (156)

Item	*Left Hand*	*Right Hand*	*Vision*	*Other Senses*	*Comments*
	and 1 and lightly hold leaf in hand with 3 and 4 by holding leaf against palm	Bring stem between T and 1 L H to cross over 1 and 2 at 1st knuckle joint of left hand	Control passage of stem between fingers of left hand		
	Grasp leaf lightly as close to stem as possible with T and 1st and 2nd, T controlling Hold by applying sufficient pressure on stem against 1st knuckles of 1 and 2 to enable end of stem to be removed cleanly			*Kinaesthetic* (L H) Sufficient control to hold leaf whilst end of stem is being removed without holding up normal movement or allowing "flags" to remain on removed stem	
		Put aside clean stem in stem bag to R H side			
3 Place leaf on band	Rotate hand once in anti-clockwise direction to unwrap leaf from hand Reposition T 1 and 2 on nose of leaf holding leaf on left hand side at nose T on front face of leaf, 1 and 2 on back	Grasp nose with T on front and 1st and 2nd at back on right hand side of leaf at nose Tear along stem by moving R H across in front of stationary left hand quickly, holding nose of leaf firmly during tearing	Control right hand grasp		
		Hold R H side of leaf lightly between 3 and 4 and palm and grasp nose of left hand side of leaf with T on top and 1 and 2 on underside of leaf		*Kinaesthetic* (L H) Tension critical to	

TABLE 16 contd

(x) OPEN SYSTEMS APPROACH

Eason and Harker (158) have developed a method of task analysis based upon an "Open Systems" approach. The task is represented in the form illustrated in figure 81 below.

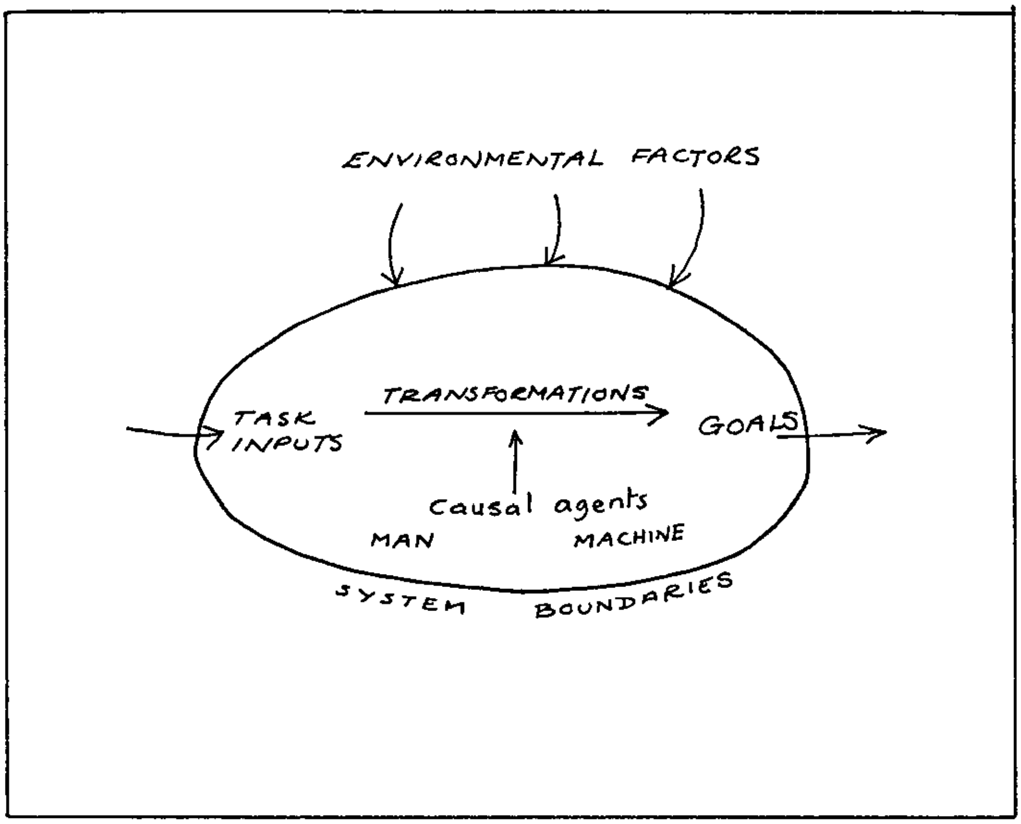


Figure 81 - EASON AND HARKER OPEN SYSTEMS APPROACH TO TASK ANALYSIS

The task is defined as the requirement to process a set of inputs and transform them into an output state which conforms to the criteria of a defined goal.

The transformation is brought about by the effect of casual agents; man and the machines he uses to assist him. System boundaries determine the limits within which the analysis will operate and define the level at which task inter-relationships are explored. (These are usually synonymous with the parameters within the job description). Tasks may be simple or complex. An example of a simple task is switching on a machine. A complex task may require a large organization, for example the production of a motor vehicle.

The Open Systems model conforms with that used by Miller (159) as a basis for task description, and concentrates not only on those aspects the task performer perceives to be his task but also the task parameters which lie outside his control. It has been designed as a multi-purpose tool for task analysis capable of being used for the analysis of all types of tasks. The method produces results that may be analysed for a number of different purposes.

A basic model for the task of the estimator is given in figure 82 page 435.

The Open System approach was not developed for use in the research because the generalized approach, although satisfactory for studying the parameters affecting the estimator in his task was not suited to the breakdown of the operations within the task to identify the aspects of the three areas where the computer may contribute to the estimator's task. While accommodating different levels of task analysis the lack of inherent structure prevents the method being readily useable to produce a detailed analysis showing the interelation of the operations that make up the tasks.

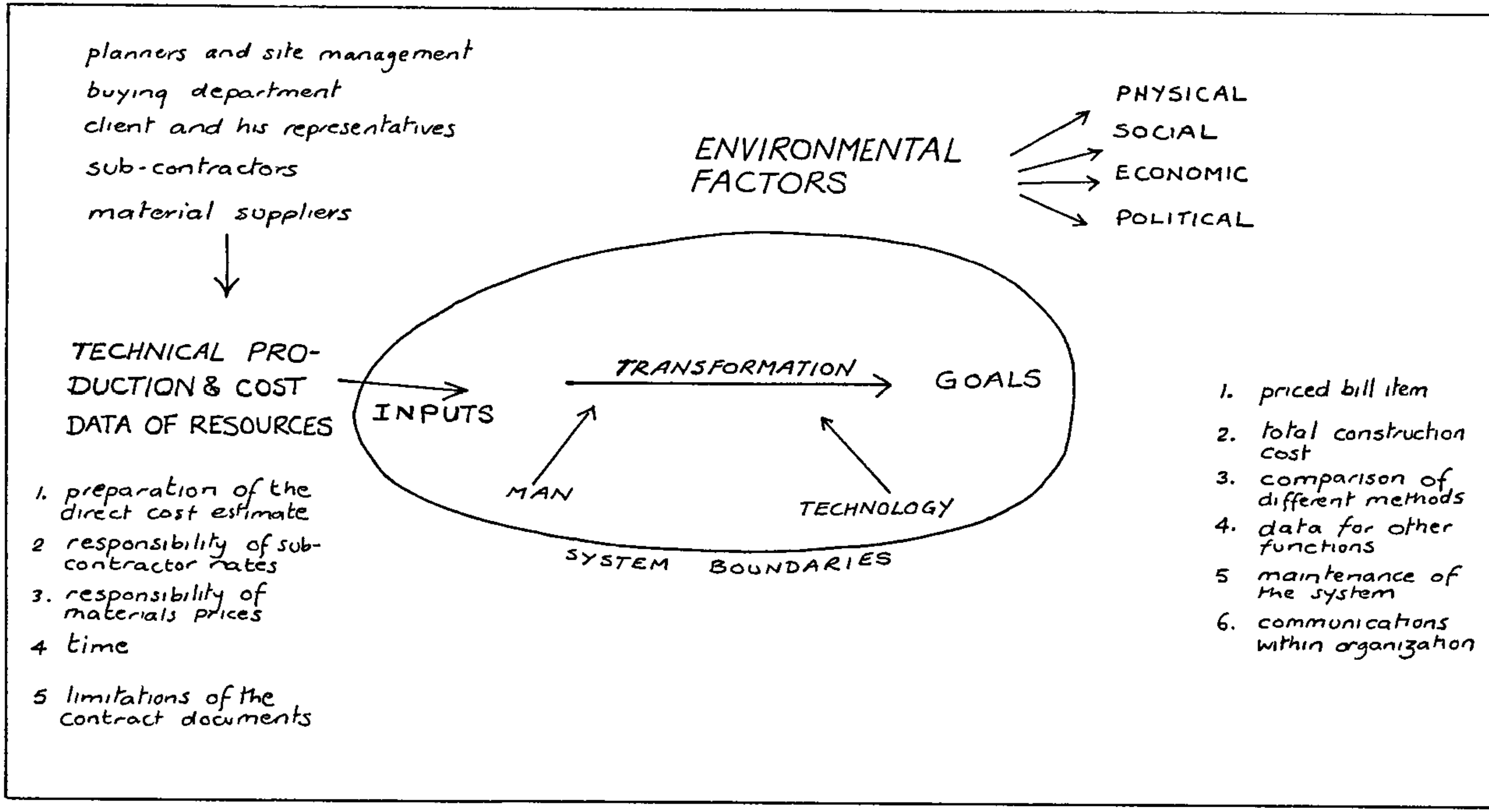


Figure 82 - A BASIC SYSTEMS MODEL FOR THE TASK OF THE ESTIMATOR

(xi) SIGNAL FLOW GRAPH ANALYSIS

Signal Flow Graph Analysis has been developed by Beishon (160) from a method developed by electrical engineers for the analysis of electrical networks.

The method consists of drawing a diagram consisting of circles representing system variables which are called nodes. Nodes are connected together by lines or branches which represent the dependancy of the two variables. Quantitative values of the variables may be written in as node values and the quantitative relation between the variables expressed as a transmittance.

A simple example is shown in figure 83 page 437 which shows a signal flow graph for a system for controlling room temperature by either a thermostat or human regulation.

This may be contrasted with the normal block diagram approach to the problem shown in figure 84 page 437.

The advantages of the signal flow graph approach is that the process must be clearly understood and all variables to the system taken into consideration. The relationship between man and machine is clearly identified.

This form of task analysis is well suited to the analysis of control skills where there is a lack of suitable techniques for either analysis or description. Control skills are difficult to describe and analyse because:

(i) they are mental skills which involve cognitive processes about which little is known.

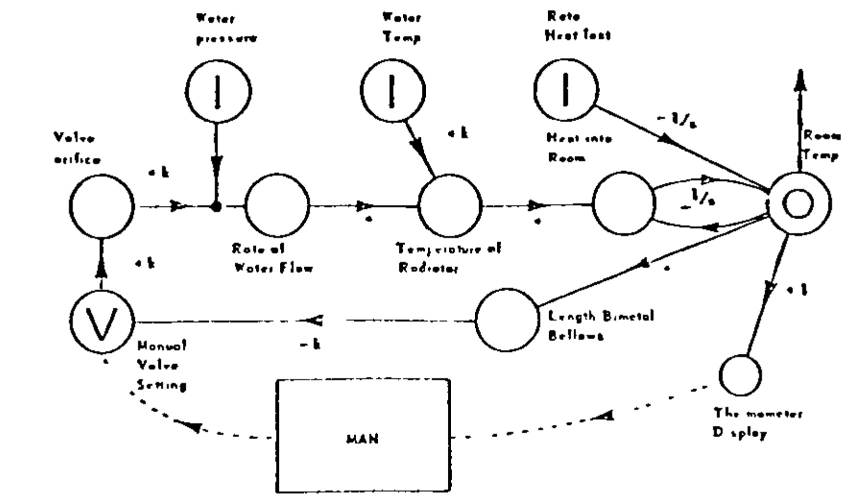


Figure 83 - A SIGNAL FLOW GRAPH FOR THE CONTROL OF ROOM TEMPERATURE - BEISHON (160)

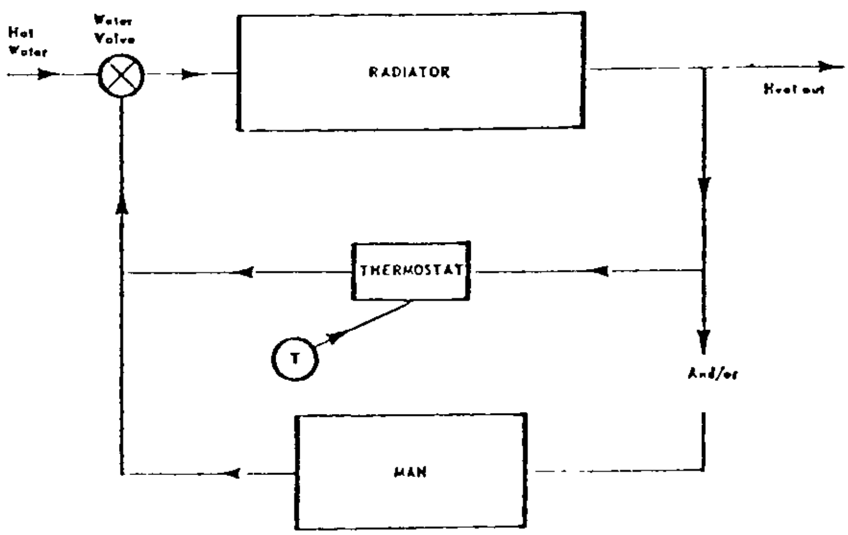


Figure 84 - A BLOCK DIAGRAM FOR THE CONTROL OF ROOM TEMPERATURE - BEISHON (160)

(ii) they involve men in complex feedback systems where the dynamic properties of the system are particularly important.

Analysis of feedback control systems is complicated even for conventional servo-systems but for systems that involve men, non-linear and human characteristics analysis is particularly difficult. The combination of an activity graph and a signal flow graph enables the investigator to draw up a list of control loops or strategies which indicate task description at the next level.

Examples are given in figures 85 and 86 pages 439 and 440 of the analysis of a control system for the manufacture of paper.

The estimating and tendering process is not a control process and therefore the signal flow graph analysis method is not suited to the analysis of the estimator's tasks. Whereas it is possible to identify the flow of the estimating process the tasks of the estimator are not those of regulation but the assembly of data and the performance of specific calculations. The method could be used to study certain aspects of the estimator's tasks (eg the obtaining of materials and sub-contractor quotations) but otherwise the parameters of the estimator's task are unsuitable for monitoring by this method.

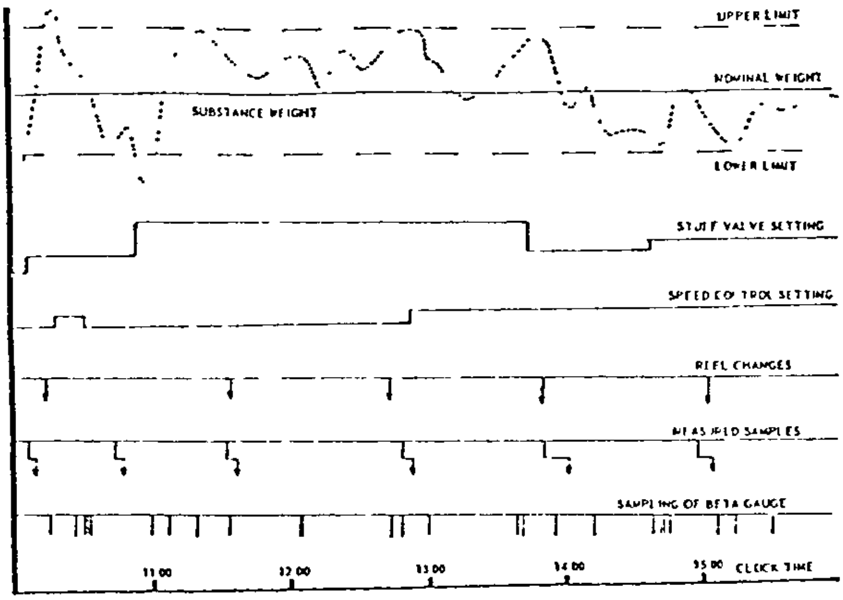
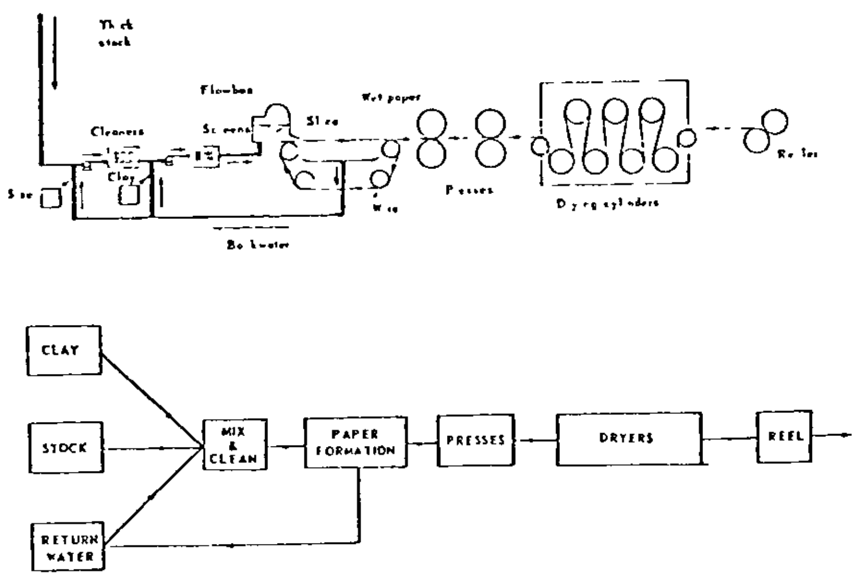


Figure 5 Typical record of a machineman's activity in a paper mill



<u>Figure 85 - A FLOW DIAGRAM FOR A PAPER MILL - BEISHON (160)</u>

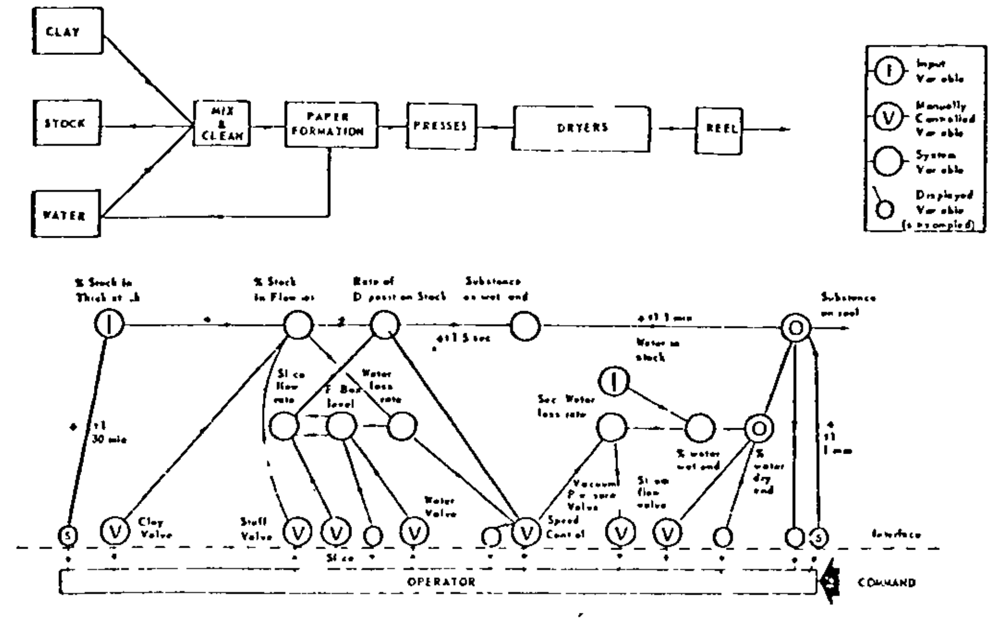


Figure 86 - A SIGNAL FLOW GRAPH FOR A PAPER MILL - BEISHON (160)

APPENDIX V

EXAMPLES OF DIALOGUES STYLE

This appendix contains outline details of the main types of dialogue style. (Note: within the examples given, all input by the user is underlined).

(i) NATURAL LANGUAGE BASED DIALOGUE

The ability to communicate with computers in a natural language is obviously an attractive concept. An example is given in figure 87 below of the system "ROBOT" produced by Harris[161].

	1.	LOS ANGELES AREA MANAGERS
INPUT	or 2.	WHAT AREA MANAGERS LIVE IN LOS ANGELES
	or 3.	WHICH ARE THE AREA MANAGERS WHO LIVE IN LOS ANGELES.
		R. BECKMANN
OUTPUT		H. LLOYD
		A. COLEMANN

Figure 87 - AN EXAMPLE OF A NATURAL LANGUAGE BASED DIALOGUE

Any of the types of input shown are acceptable to the system and are interpreted as the meaning: Print the name of any employee with a job = area manager and city = Los~~s~~ Angeles. Consequently the output consists of a list of names.

Addis[162] considers that 'in due course' a universal natural language processing system could be developed. Longuet-Higgins and Isard[163] state that natural language may well mislead unexperienced users.

Hill [120] indicates the difficulties and ambiguities of natural language. The problem at present in natural language systems is their implementation and they cannot be considered viable in a commercial system at present.

(ii) CONSTRAINED LANGUAGE SYSTEMS

Constrained language systems enable the user to give instructions to the computer via menus, prompting or form filling. Cuff [164] concludes that constrained language systems have shown their worth in well understood but limited application. Their drawback is that the nature of the questions that can be answered is limited by the designers foresight. This emphasizes the need for user participation in the development of the system. Examples of different types of constrained language systems are given below.

MENU SELECTION

The user selects the car required from the menu of possible choices.

DISPLAY

WOODWARD GARAGES LIMITED

MODEL	ENGINE C.C.	NO.OF DOORS	COLOUR
1. SALOON	4. 1300	8. TWO DOOR	10. WHITE
2. COUPE	5. 1600	9. FOUR DOOR	11. BEIGE
3. ESTATE	6. 2000		12. BLUE
	7. 2800		13. RED

SPECIFY ORDER DETAILS:

The user inputs his selection and confirms the order.

```
SPECIFY ORDER DETAILS:  3, 6, 9, 13.

2000 C.C. Estate car with four-doors, colour red.

Please confirm (YES/NO)    YES
```

DISPLAYED FORMAT STYLE OF DIALOGUE

The user is asked to input information in a specified order.

```
         MOTOR VEHICLE ORDER

DISPLAY  ENTER  MAKE/TYPE/ENGINE CAPACITY/NUMBER OF DOORS/
                NAME/ ADDRESS/DELIVERY DATE.

         ENTER:
```

The user enters the information as follows:

```
ENTER:  FORD/ESTATE/2000/4/SMITH/38 STATION STREET,
        LEICESTER/16 MAY 82.
```

All data entries must be in the correct order and of the correct type before the system will accept the input.

FORM FILLING DIALOGUE

Where the software has been written to incorporate cursor control the user is guided over the display on the screen and may enter the required data at each point in the display.

```
ORDER FOR MOTOR VEHICLE

ORDER NUMBER : 116/82   NAME : J. SMITH

MAKE: FORD       TYPE: ESTATE

No. DOORS: 4     ENGINE CAPACITY: 2000

ADDRESS: 38 STATION STREET, LEICESTER

DELIVERY DATE:  16 MAY 1982
```

The format 'map' is protected and cannot be inadvertantly altered by the user. At the end of data input a send facility transmits only the data that has been entered.

Where data is input in fixed-length fields the cursor automatically moves to the next input field when the last character is entered. With variable field widths (eg customer name) the user has to press the tab key at the end of data entry to move the cursor to the next item.

INSTRUCTION AND RESPONSE DIALOGUE

Within instruction and response dialogue, the user is asked to enter information in a predetermined order as a response to a specific question. Each data entry is checked and validated before it is accepted by the system and the next inslruction displayed.

ENTER ORDER NO.   (OR END)

<u>116/82</u>

NAME

<u>J. SMITH</u>

MAKE OF CAR (FORD, AUSTIN, DATSUN)

<u>FORD</u>

TYPE OF CAR (SALOON, COUPE, ESTATE)

<u>ESTATE</u>

NUMBER OF DOORS (2 or 4)

<u>4</u>

ENGINE CAPACITY (1300, 1600, 2000, 2800)

<u>2000</u>

ADDRESS

<u>38 STATION STREET, LEICESTER</u>

DELIVERY DATE (DD/MM/YR)

<u>16/05/82</u>

The dialogue usually displays in full the details entered and then gives the user the facility to confirm the input or amend any of the input data.

(iii) <u>LINEAR LANGUAGE STRUCTURES</u>

The well known general purpose programming languages such as Fortran, Basic, Algol etc. are examples of linear language structures. This style of dialogue is rarely relevant for any other type of user other than programmers or personnel specifically trained in computer studies.

Even in the production of systems for this type of user careful consideration should be given to its use.

```
UPDATE PERSONAL FROM SOURCE 1;
STRUCTURE SEGOL FROM SEGB;
EQUATE;
EMPNO TO MANNO;
SALARY TO WAGE;
END EQUATE;
IF ACTION EQ 'D';
LIST PERSONAL RECORD;
REMOVE SEGOL;
ELSE;
DECREASE TAX RATE BY 5;
INCREASE BENEFITS BY 100;
IF ACTION EQ 'I';
INSERT SEGOL;
IF ACTION EQ 'R';
REPLACE SEGOL;
```

Languages of this type are terse with no redundancy. They require training by the user to understand and use them in order to obtain specific answers.

(iv) DIAGRAMMATIC LANGUAGES

Diagrammatic techniques such as "Query by Example" (165) are used when an enquiry or search is made on a data base. The data set involved is indicated by the user and the system responds by displaying the relevant data elements. This style is consequently best suited for the output of data for managers, process controllers and some forms of public display. An example is given below in Figure 88 page 448.

The user makes two distinct requests from the system relating to information on personnel. The first is an enquiry query relating to personnel number 47863. The second relates to all sales personnel earning a salary between 18000 and 22000.

EXAMPLE OF AN ENQUIRY QUERY

DATABASE: PERSONNEL

ELEMENTS;

NUMBER	NAME	DEPARTMENT	SALARY
47863			

NUMBER	NAME	DEPARTMENT	SALARY
	CHATTERIS, CHRISTOPHER	PROMOTIONS	COMMISSIONS ONLY

EXAMPLE OF A SEARCH QUERY

DATABASE: PERSONNEL

ELEMENTS:

NUMBER	NAME	DEPARTMENT	SALARY
*	*	SALES	18000- 22000

NUMBER	NAME	DEPARTMENT	SALARY
47402	SUTHERLAND, MARK	SALES	18450.00
47863	WILSON, FRED	SALES	21500.00

NB UNDERLINED = INPUT

Figure 88 : Query by Example Dialogues - after Zloof (165)

APPENDIX VI

COMPANIES WHO HAVE REVIEWED THE INTEREST SYSTEM AND DISCUSSED ASPECTS OF COMPUTER AIDED ESTIMATING

LIST OF COMPANIES WHO HAVE REVIEWED AND COMMENTED ON THE INTEREST SYSTEM

William Townson and Sons Ltd.

Tarmac International Ltd.

Tarmac Construction Ltd.

Stemmos Ltd.

Sheldon Contracting Ltd.

Alex Shaw and Co. Ltd.

J. Lawson and Co. Ltd.

W. S. Try Ltd.

Murray Roberts Engineering (Transvaal) PTY.

Sir Robert McAlpine.

IDC Construction.

F. J. C. Lilley (Contractors) Ltd.

Lehane Mackenzie and Shand Ltd.

French Kier Ltd.

Cementation International.

General Site Services.

Joynes Pike and Assoc.

Shephards (York) Ltd.

Weir Construction.

G. L.James (Heathfield) Ltd.

Leeds City Council.

Carlton Brent Ltd.

Taylor Woodrow Ltd.

William Tomkinson and Sons Ltd.

Norwest Holst Ltd.

Cementation Piling Ltd.

LIST OF COMPANIES(contd.)

Balfour Beatty Ltd.

J.M. Jones Ltd.

Reed and Mallik Ltd.

Costain Civil Engineering Ltd.

Monk Ltd.

Gilbert Ash (Scotland) Ltd.

A. McAlpine Ltd.

Glenegan Ltd.

W. Moss Ltd.

C. P. Roberts Ltd.

Kind and Co. Ltd.

Willett Construction Ltd.

Hawker Siddley Power Engineering Ltd.

Cementation Piling Ltd.

Redpath Dorman and Long.

APPENDIX VII

THE TESTING OF THE INTEREST SYSTEM WITHIN THE CONTRACTORS ORGANIZATION

This Appendix contains the results of the testing of the INTEREST system within the estimating department of a contractor's organization. The results are divided into three sections:

(i) An analysis of the priced Bill of Quantities;

(ii) The comments from the informal interviews and the system diary;

(iii) The structured interview and the replies of the user.

AN ANALYSIS OF THE PRICED BILL OF QUANTITIES

The Bill of Quantities priced was that for the Bitterne By-Pass contract. A total of 150 bill items were included. These were priced in the following manner.

METHOD OF PRICING	%
WORK GROUP	NIL
OPERATIONAL RATES	NIL
UNKNOWN	60
GASH RATE	37
OTHERS	3

TABLE 17 : THE PRICING OF BILL ITEMS IN THE TEST BILL OF QUANTITIES

Within the time available no work groups suitable for pricing the items contained in the Bill had been built up on the company library. Consequently this facility was not used to price any Bill items.

A total of ten operational rate groups were built up to price the earthworks on the contract. The decision to sub-contract this work meant that this method of pricing was un-used and the gash rate facility was used to price the twenty-three relevant items.

The high percentage of subcontract work meant that a total thirty-seven percent of the items were priced using the gash rate facility.

The remaining items were priced using the 'Unknown' facility to build up a suitable group of resources.

One hundred and one different resources were used of which thirty-six per cent required quotations to be obtained.

From the above results it is evident that close examination is required of the feasibility of pricing bill items from work groups stored on a company library. No use of this facility was made in this estimate and there appeared some reluctance on the part of the users to set up the data within the library.

The decision to subcontract all the work that had been priced on an operational basis meant a full appreciation of the operational estimating facilities within the system was not possible.

A SYNOPSIS OF THE COMMENTS MADE DURING INFORMAL DISCUSSIONS OR ABSTRACTED FROM THE SYSTEM DIARY

These comments have been listed with reference to the Task Analysis carried in Chapter 4. They are grouped under the following headings:

(i) The calculating, filing and reporting facilities designed to support the operations of the estimator;

(ii) The constraints on the estimator;

(iii) The communication pattern surrounding the estimator;

(iv) User support requirements.

THE CALCULATING, FILING AND REPORTING FACILITIES DESIGNED TO SUPPORT THE OPERATIONS OF THE ESTIMATOR

1. A data library based upon the CESMM presents problems when it is required to price non CESMM bill of quantities. A more practical alternative is a coding system set up by the individual company.

2. Only a small amount of information may be stored in the Work Groups in the company library. This feature is more suited to the pricing of Bill items for building works.

3. The Operational Estimating approach to estimating calculations was particularly important and the facility should be extended.

4. The facilities available for pricing bill items were in the main satisfactory but some additions are necessary to handle prime cost and provisional sum items.

5. The reporting facilities available with the system should be far more flexible with the estimator given greater choice of both the contents and their format.

6. At present reports are totally orientated towards the printer. It should be possible to obtain reports on the V.D.U.

7. The standard build up display for a bill item needs to be more comprehensive showing details of wastage, number of usages, labour and plant rates etc.

8. The ability must be present to obtain both net and gross listings of priced bill items.

9. A 'copy-on' facility is necessary so that the estimator may obtain a full record of the calculation he has performed.

10. The facility to obtain a complete listing of the bill items is only rarely required.

11. Extra mark up facilities should be provided to enable on-costs to be assessed and added to particular bill items.

12. The data library could be used to store specific data on drainage and manhole quantities and requirements.

13. The system enabled full 'comping' to be obtained at any stage of the estimate which was not possible manually.

14. The system should have the facility to hold bill item descriptions that may be changed by the estimator as he considers necessary.

15. It should be possible to automatically transfer build ups from the contract file to the company library.

16. It should be possible for all data on the bill items to be entered onto the system at the start of the estimate.

17. Minor dialogue problems exist. These are mainly inconsistancies that need to be corrected.

THE CONSTRAINTS ON THE ESTIMATOR

1. The system performance time was far too slow to be acceptable in a normal working system.

2. The system should be orientated around the build up of the bill item and not the method of pricing as this more closely represents the way in which the estimator works manually.

3. The requirement to keep resetting the bill section and page number caused numerous errors as this was an operation alien to the estimator's normal task.

4. The interaction mode of menu selection combined with instruction and response is satisfactory although the facility should be present to remove the menu and command lists from the display when the user is familiar with them.

5. Problems occurred where non standard units had been used by the quantity surveyor to prepare the bill of quantities. This invalidated the use of standard work groups used from the library.

6. The INTEREST system bases resource requirements on usage rates. The estimator is more familiar with output or production rates when plant and labour resources are being used for some operations, (eg Earthworks).

THE COMMUNICATION PATTERN SURROUNDING THE ESTIMATOR

1. The introduction of the system produced on 'expert' on computing within the company. This person became the established authority on the system and was approached to solve problems as and when they arose.

2. No appreciable change was noted in the communication pattern within the estimating department.

USER SUPPORT REQUIREMENTS

1. A detailed training programme and full user support is required by the users of the system. Where an estimator is called upon to use the system after a period of time working totally manually, some form of retraining or revision is required.

2. Although the system documentation is comprehensive with detailed examples it would be better if more user support was system based.

3. The user manual although a comprehensive reference manual needs to be better structured to reflect the varying needs of different types of user at different stages of development.

4. After spells of inactivity with the system some relearning was necessary before proper use of the system could be made again.

5. Rather than make full reference to the manual the users preferred to examine different alternatives on the system to find a suitable solution to the immediate problem.

6. User training should include both implemented and operational training programmes.

THE STRUCTURED INTERVIEW

The purpose of the interview was to examine any constraints the system put upon the performance of the operations within the estimator's task. It was important to find out whether the estimator always felt in control of the system and to discover areas of the dialogue that were unfamiliar or misleading to the user. The comments recorded in the informal interviews and diary reflected mainly the facilities offered by the system to support the operations carried out by the estimator. The structured interview concentrated on the overall acceptability of the system to the estimator.

From the structured interview it was possible to ascertain that:

- the system closely reflected the estimator's method of working but required him to memorize more information than he would normally do with manual methods;
- errors and mistakes made while learning to use the system did not result in a major loss of data but in time consuming corrections;
- the user could obtain the same results as manually but slower. More information could be produced to improve the quality of the results;
- the system required the user to memorize information that would not normally be necessary;
- the user needed to re-learn the system to become familiar with the facilities each time it was required to use the system for a protracted period;

- while the estimator never felt completely lost within the system there were instances when he was uncertain what operation could be performed next and some guidance was required.

1. Did the system reflect the way that you work as an estimator?

   - No.

2. Did the system enable you to obtain the same results as you do manually?

   - Yes, but slower.

3. Do you think the system could be changed to make qualitative and quantitative improvements in the results?

   - Yes, more reports should be produced. These should include more detailed information (eg net value of bill items).

4. Did the operation of the system distract you from your task as an estimator?

   - Yes, initially.

   Would this be overcome after a period of time?

   - Yes, as I became more familiar with the system and its facilities.

5. What sort of errors did you find you were making in the operation of the system?

   - Errors on the input of information.
   - Forgetting to reset the bill page and section.
   - Forgetting which resources were included in 'build-ups'.

6. Any user of a computer system will make mistakes when operating it. Did you find this frustrating?

   - Yes, very.

   Did this result in a loss of data?

   - No, only data that had to be changed later.

7. Did you find the system 'friendly' or was it awkward to use?

   - 'friendly'.

8. Are the terms and language used acceptable?

   - Yes.

   What parts of the dialogue would you change?

   - Only the few dialogue anomalies.

9. Everytime you started up the system did you require some review of procedures or information before pricing items?

   - Yes, it was necessary to re-learn the facilities. The ability to examine the exact status of the estimate would have been useful.

10. Did you always feel in control of the system?

   - Yes.

11. Did you always understand;

   What you had done?

   - Yes.

   What you were doing now?

   - Yes.

   What you were able to do next?

   - Not when first using the system.

   Were the steps within the process self-explanatory?

   - Yes.

   Were there any responses by the computer that were meaningless?

   - No.

APPENDIX VIII

A USER MANUAL FOR THE INTEREST - C.E.3 COMPUTER AIDED ESTIMATING SYSTEM

INTEREST - C.E.3 COMPUTER AIDED ESTIMATING SYSTEM FOR CIVIL ENGINEERING USER MANUAL

FOREWARD

INTEREST C.E.3 is a computer program that has been produced by the Computer Aided Estimating Research and Development Group at the Department of Civil Engineering, Loughborough University of Technology.

The information contained in this manual and any information received as a consequence of using this program is provided on the understanding that, whilst every effort is made to ensure its accuracy, the Computer Aided Research and Development Group makes no warranty of any kind nor should be under any liability in any way for any loss, damage or injury arising from such use.

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ASSUMPTIONS

The "INTEREST C.E." system and this manual have been designed and produced under the assumption that the user has no previous knowledge of computers or computing. The use of jargon and specialist terms have been eliminated wherever possible. A section on terminology is included in the rear of the manual.

The system and the contents of the manual do assume that the user has knowledge of detailed analytical cost estimating based upon Bills of Quantities and the tender procedure for the award of construction contracts for civil engineering work.

Contained in the manual are examples of the dialogue between the user and the system to undertake various operations and obtain certain reports. It is important to note that all input by the user has been underlined. Everything else is information presented by the system.

1.0 INTRODUCTION

1.1 GENERAL

The software package described in this manual has been produced as part of a research project in the Department of Civil Engineering at Loughborough University of Technology.

The system has been designed to reflect the manual estimating practices found within the United Kingdom Civil Engineering Industry. The objective in producing the system has been to provide civil engineering estimators with computer facilities that include presently available computer technology without requiring major and unacceptable changes in estimators' current practice.

The system is called "INTEREST C.E." which stands for INTERACTIVE ESTIMATING for Civil Engineers, and is designed to aid the estimator produce a direct cost estimate based upon the Bill of Quantities contract document. Bills of Quantities prepared by all methods of measurement may be processed. Facilities are included for the addition of mark-up allowances in order to convert the estimate into a tender.

1.2 KEY FEATURES OF THE SYSTEM

The key features of the system are:

(i) It is a computer system that aids the estimator. The system does not replace or automate his task.

(ii) The system is interactive, ie the estimator communicates directly with the computer by the input of data via a key-board and observing messages displayed on a Visual Display Unit (VDU). The calculations and progress of the system are therefore performed at the pace and sequence determined by the estimator.

(iii) The system is based upon a series of detailed prompts or instructions communicated to the estimator via the VDU. These prompts explain the various options that may be selected at each stage. This procedure reduces the likelihood of the user making errors in the running of the program. If incorrect information is entered (eg a number where a letter was expected) or an incorrect response is made to a prompt, the system will not allow further progress to be made until the correct information has been entered.

(iv) It is a very flexible system. The program is operated via a 'menu' of commands which allow the user to select the operation that is required. These commands may be used in any order, recalled or the system halted and then restarted.

(v) The system provides the facility to store performance and cost data on groups of resources commonly used for undertaking construction work. The estimator may use this data to price items found in the Bill of Quantities. If the data is unsuitable it may be modified to suit or replaced by data input by the user.

(vi) The full range of requirements needed by the estimator to price bill items are included. These include:

- unit rate estimating;
- operational estimating;
- entry of spot rates;
- entry of item sums.

(vii) The estimator may retrieve and re-work any bill item at any stage in the estimating process and tendering process.

(viii) The total rate for a bill item may be divided into the following cost code categories:

- Labour;
- Plant;
- Direct Materials;
- Auxiliary Plant;
- Domestic Subcontractions;
- Additional (a spare cost code);
- Provisional Sums, Prime Cost Items.

(ix) Following the tender adjudication sums of money may be added into the bill as individual itemsare apportioned throughout the whole bill, a section of the bill, or a particular classification of work. It is also possible to add percentages to the cost code categories to cover mark-up requirements.

(x) The mark-up allowances may be readily examined and easily changed to reflect different ideas. The system therefore may be used as a cost model for the project.

(xi) Having determined the total tender sum it is possible to rate-load bill items, ie increase their rate while reducing all other item rates proportionately to keep the total tender sum the same.

(xii) Calculations and reports of the Bill of Quantities may be produced at any stage during the estimating and tendering process. The reports reflect the direct cost and tender price of the bill items already considered. It is also possible to obtain reports of the quantities of each resource used in the project.

(xiii) Accurate records are held on the contract file of the estimator's build-up of each bill item and the decisions taken at the adjudication meeting. These may be retrieved for reference at any stage.

(xiv) The estimator may proceed with his calculations before having obtained Materials and Sub-contractor quotations. These resources may be marked as "Awaiting Quotes". As and when prices become available they are entered into the system via a separate command. All occurrences of the resource in different bill items are then automatically updated. At any stage the user may obtain a list of resources for which quotations are still awaited.

(xv) It is possible to price similar bill items scattered throughout the bill automatically after pricing one typical item. This facility is extremely useful for bills presented in an 'elemental' format.

1.3 IMPORTANT COMMANDS

The system is command driven. The user selects the command required from a list (or 'menu') of commands depending on which task he wishes to perform with the system. It is important to note the following points.

(i) It is unnecessary to enter the complete command. Entering the first two letters will enable the system to recognise the command required.

(ii) In certain instances the system will request a YES or NO command. In such cases it is necessary only to enter Y or N as the case may be.

(iii) Following any input the RETURN key must be pressed. (Pressing the RETURN key instructs the computer of the instruction entered. If the RETURN key is not pressed nothing will happen.

(iv) If, at any stage during the operation of the system, the user wishes to exit from the particular section of the program he is working in, AB should be keyed in. This command instructs the system to ABORT the work it is performing and return the user to the relevant Main Menu of commands.

1.4 TRADE CLASSIFICATIONS

The INTEREST system allows the user to list which bill items are contained within various trade classifications. At the end of bill listings a printout is given of the sum of money currently within each trade classification. To ensure the maximum benefits of these facilities bill items should be allocated to a Trade Classification. Items priced directly from the data library will automatically assume the classification of the relevant Work Group. Bill items priced by other methods will require a trade classification to be entered by the user. The INTEREST system assumes a Trade Classification as listed in the Civil Engineering Standard Method of Measurement (CESMM). A listing of the classes of work is given in Figure 36 page 701. To ensure relevance of reports, users should adopt this classification when entering trade classification references.

2. AN OUTLINE OF THE SYSTEM

2.1 GENERAL

The system is divided into four stages as shown in figure 1 below

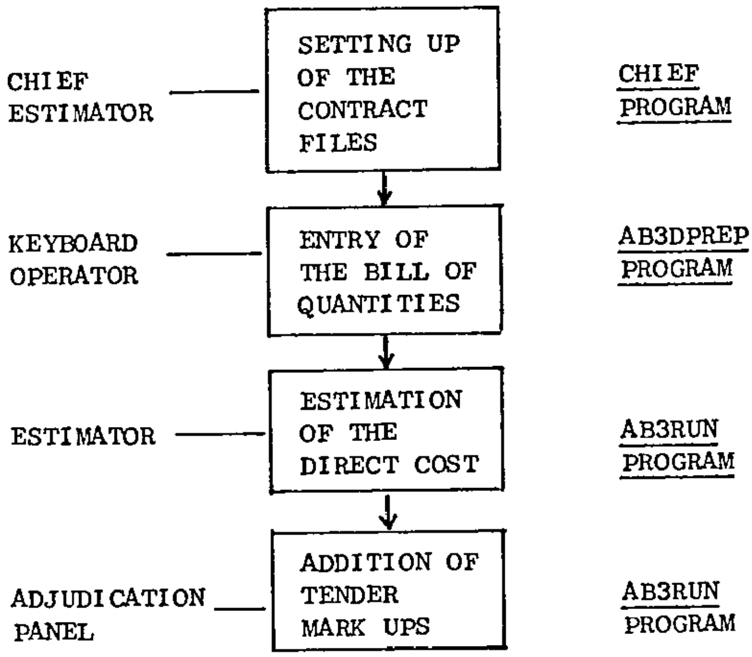


Figure 1 : The Stages of the Estimating System

On receipt of the contract documents and the decision to tender, the chief estimator must set up the contract files using the CHIEF program. Once this has been done the details of the Bill of Quantities may be entered onto the computer files. This will require details to be abstracted from the bill together with information obtained from the estimator responsible for the tender. Once bill items have been entered for a contract, the estimator may inspect and price them. The additional of tender mark-up factors may then be introduced to convert the direct cost estimate into a tender.

Figure 1 suggests a sequential relationship between the various stages. This is not necessarily the case. The system is command driven and these commands may be selected at any time to undertake the task required. There is no set order for the system to run. The entry of details of the Bill of Quantities can only take place after the Chief estimator has set up the contract files. Once bill items have been entered into the system the estimator is free to inspect and price them. The Bill of Quantities does not have to have been completely entered into the system before the estimation of the direct cost can start. Calculation of the direct cost total and the printing of reports may be obtained at any stage to obtain the current estimate for the project. The addition of mark-up factors may be made at any stage and changed at a later date.

Each stage of the system is outlined below.

2.2 SETTING UP THE CONTRACT FILES

Before any work on the tender may begin it is necessary for the chief estimator to set up the files on the system that will store the contract data. This task is performed by the use of the CHIEF or System Control Program which is described in detail in Section 8. The menu of commands available to the chief estimator in the system control program are:

AD	-	Add a new Contract
DE	-	Delete a Contract
CH	-	Change a Contract Details
MP	-	Change the Master Password
LC	-	List current Contracts
EW	-	Edit the Work Groups File
LW	-	List the Work Groups File
ER	-	Edit the master Resource and Resource Gangs File
LR	-	List the master Resource and Resource Gangs File
HE	-	Set HELP Level
ST	-	Stop program

Each command is now outlined below:

ADD A NEW CONTRACT	:	This command requests details of the project for which the tender is being prepared and sets up the file space to store the contract data.
DELETE A CONTRACT	:	This command deletes contract data from the computer files.
CHANGE A CONTRACT DETAILS:	:	It is possible to amend details of the contract (title, reference number etc) held on file by the use of this command.
CHANGE THE MASTER PASSWORD:	:	The password to the CHIEF program may be changed via this command.

LIST CURRENT CONTRACTS	:	Using this command the user may obtain a print out giving a list of all the contracts for which data is currently held on the system.
EDIT THE WORK GROUPS FILE	:	Data on groups of resources may be held by the system as a company library. This command enables the chief estimator to edit the Work Groups stored.
LIST THE WORK GROUPS FILE	:	This command lists all the Work Groups that are held on the company library files.
EDIT THE MASTER RESOURCE AND RESOURCE GANGS FILE	:	On the company library lists of resources that commonly occur in civil engineering construction are held. This command allows the chief estimator to add, change and delete these resources.
LIST THE MASTER RESOURCE AND RESOURCE GANGS FILE	:	This command lists all the resources and resource gangs held on the company library files.
SET HELP LEVEL	:	When the user is familiar with the commands in the program he may use this command to suppress the prompts.
STOP PROGRAM	:	This command calls a halt to the running of the program.

2.3 THE ENTRY OF BILLS OF QUANTITIES DETAILS

This procedure is described in detail in Section 4. Before the estimator may inspect and price bill items it is necessary for information on the items to have been entered into the computer. The task of data entry calls for competance in the use of the keyboard to effect a quick and accurate entry of data. Consequently this operation will usually be performed by someone with keyboard skills. (A typist or a comptometer operator). The data to be entered consists of information directly available from the bill, (such as the quantity of each item) and information provided by the estimator, (such as which bill items require to be marked as subcontract items).

The menu of commands available within the AB3DPREP program for the entry of Bills of Quantities details is shown below.

MAIN MENU

FU - Full Page

SI - Single Item

LI - List Bill Item References

ST - Stop Program.

Each command is now outlined below:

FULL PAGE	:	This command enables the user to input details on all the bill items contained on one page of the bill into the computer files.
SINGLE ITEM	:	Using this command enables details on a single bill item to be entered into the system or an item already entered to be edited.
LIST BILL ITEM REFERENCES	:	By instigating this command a list of all the items already entered for the contract may be produced.
STOP PROGRAM	:	This command calls a halt to the running of the program.

2.4 ESTIMATION OF THE DIRECT COST

To produce a direct cost estimate for the project, the estimator must use the AB3RUN program. The commands within this program are shown below. The program is described in detail in Section 5.

MAIN MENU

IN - Inspect Bill Item

OP - Create/Edit Operational Group

UP - Update Prices

SC - Enter Sub-contract Quotes

MA - Apply Mark-ups

PR - Print Reports

HE - Set HELP Level

DE - Delete Bill Item

ST - Stop

Each command is now outlined below:

INSPECT BILL ITEM : Once an item has been entered into the computer via the DPREP program it may be inspected.

This command enables the estimator to inspect the item build up for any bill item by entering the appropriate item reference. Within this command there exist the facilities to add, delete or edit the details of the item build up. The estimator is provided with several ways he may price the item ranging from using a Work Group stored on the company library to entering a single sum of money. The system always holds on the contract file the latest build-up of the item. At any point during the direct cost estimate or the addition of mark-ups the estimator may inspect an item and re-work it to produce a latest build-up.

CREATE/EDIT OPERATIONAL GROUP: : The estimator may decide to price a particular class of work on an operational basis ie. calculating the item rate on the total resource requirement for a certain lapsed time and assuming an average output rate. This command enables the estimator to build up groups of resources on an operational basis and store the calculated rate for use in pricing bill items.

UPDATE PRICES : At the start of each estimate the estimator is provided with a copy of each priced resource on the company library. Using this command the estimator may amend details of the resources, their prices and other details, as necessary for his particular tender. It should be noted that these revisions apply to the tender under consideration and that the original resources on the company library remain unchanged for use on other contacts.

ENTER SUB-CONTRACT QUOTES	:	This command enables the user to enter quotations for items marked as awaiting subcontract quotes. Information is entered on each subcontractor and then an appropriate rate applied to the relevant item.
APPLY MARK-UPS	:	See Section 2.5
PRINT REPORTS	:	At any stage during the preparation of the estimate the user may call upon this command to provide him with details of the tender. It enables the estimator to obtain reports detailing the cost of the work priced, the resources required and will also identify those resources for which quotes are required.
SET HELP LEVEL	:	When the user is familiar with the commands in the program he may use this command to suppress the prompts.
STOP	:	This command calls a halt to the running of the program.

2.5 ADDITION ON TENDER MARK-UPS

The user may convert the direct cost estimate into a tender by applying mark-ups using the ADD MARK-UPS command within the AB3RUN program. The addition of monies may be performed in a number of ways. A single sum of money may be added directly or the sum apportioned throughout a part or all of the bill items. Alternatively percentage additions may be made to various cost code categories. When the total tender sum has been decided it is possible to rate-load bill items, ie increase the rates of specified items while the system automatically reduces all the others to keep the total tender sum the same.

The PRINT REPORTS command of the AB3RUN program enables the estimator to obtain Nett or Gross rate calculations so the full extent of the mark-ups may be printed out.

This aspect is considered in detail in Section 6.

3.0 HOW THE SYSTEM WORKS

3.1 GENERAL

This section outlines the operation of the estimating system. The system outline is shown in the schematic diagram in figure 2 page 488. This shows the relationship between various files of information within the computer system. The files are divided into those which contain COMPANY DATA and CONTRACT SPECIFIC DATA.

COMPANY DATA includes performance data and cost data on the resources in the company library. This data may be accessed by all estimators using the system. CONTRACT SPECIFIC DATA relates only to each estimator's individual tender.

Within the contract specific files used by the estimator the files may be divided into those that support the estimator's calculations and those which store the results of his calculations.

3.2 COMPANY FILES SUPPORTING THE ESTIMATOR

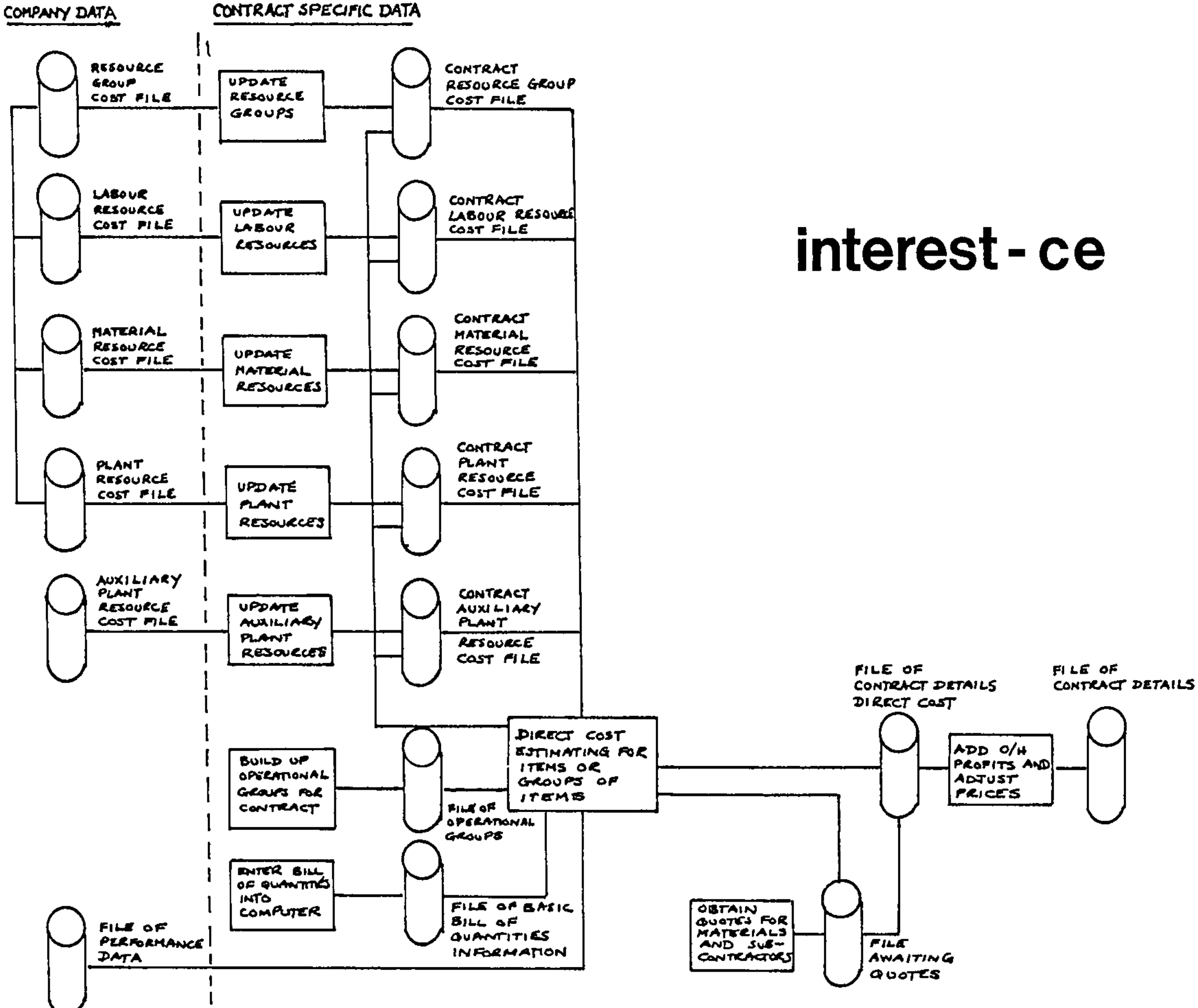
The company files supporting the estimators calculations are the COMPANY RESOURCE COST FILE and the FILES OF PERFORMANCE DATA.

3.2.1 COMPANY RESOURCE COST FILES

Data and costs are stored for resources that are categorized under the following cost code categories:

- Labour;
- Plant;
- Auxiliary Plant (scaffolding etc);
- Materials.

Resources may be considered as single resources or resource gangs (groups of resources). Resources of the same type (eg all labour) may be grouped into Gangs or Mixed Gangs may be formed by adding resources together from different cost code categories.



COMPANY DATA
CONTRACT SPECIFIC DATA
RESOURCE GROUP COST FILE
UPDATE RESOURCE GROUPS
CONTRACT RESOURCE GROUP COST FILE
LABOUR RESOURCE COST FILE
UPDATE LABOUR RESOURCES
CONTRACT LABOUR RESOURCE COST FILE
MATERIAL RESOURCE COST FILE
UPDATE MATERIAL RESOURCES
CONTRACT MATERIAL RESOURCE COST FILE
PLANT RESOURCE COST FILE
UPDATE PLANT RESOURCES
CONTRACT PLANT RESOURCE COST FILE
AUXILIARY PLANT RESOURCE COST FILE
UPDATE AUXILIARY PLANT RESOURCES
CONTRACT AUXILIARY PLANT RESOURCE COST FILE
BUILD UP OPERATIONAL GROUPS FOR CONTRACT
FILE OF OPERATIONAL GROUPS
DIRECT COST ESTIMATING FOR ITEMS OR GROUPS OF ITEMS
FILE OF CONTRACT DETAILS DIRECT COST
ADD O/H PROFITS AND ADJUST PRICES
FILE OF CONTRACT DETAILS
ENTER BILL OF QUANTITIES INTO COMPUTER
FILE OF BASIC BILL OF QUANTITIES INFORMATION
FILE OF PERFORMANCE DATA
OBTAIN QUOTES FOR MATERIALS AND SUB-CONTRACTORS
FILE AWAITING QUOTES

interest - ce

The costs of Labour and Plant resources may be stored as hourly or weekly all-in rates. Auxiliary plant is always priced on a weekly basis. The materials costs relate to the actual units specified. The alphabetical prefix to the resource code number indicates which types of resource is being used:

L	Hourly Priced Labour
LW	Weekly Priced Labour
LG	Hourly Priced Labour Gang
LWG	Weekly Priced Labour Gang
P	Hourly Priced Plant
PW	Weekly Priced Plant
PG	Hourly Priced Plant Gang
PWG	Weekly Priced Plant Gang
M	Material
AW	Weekly Priced Auxiliary Plant
MG	Material Gang
AWG	Weekly Priced Auxiliary Plant Gang
XG	Mixed Gang
XWG	Weekly Priced Mixed Gang

L - Labour;

P - Plant;

M - Material;

A - Auxiliary Plant.

TABLE 1 - A FULL LIST OF RESOURCE TYPES

G denotes that it is a resource gang.

W denotes that the resource is weekly priced.

A full list of resource types is shown in Table 1, page 489.

Typical extracts from the cost files are shown in figure 3, page 491.

3.2.2 THE FILE OF PERFORMANCE DATA

This file contains typical resource build-ups for commonly occurring items of construction work. The build-ups contain details of resources, their output or usage rates and where applicable their wastage factors. The build-ups are known as WORK GROUPS. Each WORK GROUP must be given a unique code reference refered to as the WORK GROUP CODE. This code is usually based upon the Civil Engineering Standard Method of Measurement (CESMM) although companies may wish to adopt other coding systems.

A detailed description of the formation and contents of WORK GROUPS is given in Section 8-6

3.3. CONTRACT SPECIFIC FILES SUPPORTING THE ESTIMATOR

The following contract specific files support the estimator in the preparation of the direct cost estimate and allowance of mark-up additions:

- Contract Resource Cost Files;
- File of Basic Bill of Quantities Information;
- File of Mark-up additions.

3.3.1 CONTRACT RESOURCE COST FILES

At the start of the estimate for the contract the estimator is provided with a copy file of all the resources held on the company data files.

Date : 14/05/82

Interest CE 3 Master Resource Listing

Labour (Hourly)

```
   L1        Description - LABOUR
(used)       Cost        -        £2.15/HR

   L2        Description - DRIVER
(used)       Cost        -        £3.50/HR

   L3        Description - GANGER CONCRETE
(used)       Cost        -        £5.00/HR

   L101      Description - LABOUR
(used)       Cost        -        £3.65/HR

   L102      Description - TRADESMAN
(used)       Cost        -        £4.20/HR

   L500      Description - TRADESMAN
             Cost        -        £5.50/HR

   L502      Description - GANGER
(used)       Cost        -        £3.50/HR
             *********** Awaiting Quotes **********

   L513      Description - MIXER DRIVER
(used)       Cost        -        £3.41/HR
```

Figure 3 - TYPICAL EXTRACTS FROM THE LABOUR (HOURLY) FILES

From that point, these represent the resources and costs for his particular contract. Using the appropriate command from the menu of commands available the estimator may amend the details of the resources required in his estimate. Resources may be deleted, their costs and descriptions changed, and new resources specific to the individual project added. The updating of GANG RESOURCES may be achieved by updating the costs of the constituent single resources.

If the original company rates are satisfactory then they may be used throughout the tender. Normally the estimator will calculate his all-in labour rates for the contract and change the resource rates on the resource cost file to suit. Prices for major items of plant will be obtained and the costs on the resource file amended as required. Due to the volatile nature of materials prices it is normally necessary for the estimator to obtain quotations for all materials to be used within the construction of the project. The "awaiting quotes" facility within the system allows the estimator to mark the materials resources for which prices are being obtained. He may proceed with the preparation of his estimate using existing materials prices and perform all appropriate calculations. Messages within displays and printouts will signify that relevant resources have still not received final prices.

Quotations for these material prices are then obtained in the normal manner and, as and when they become available they may be introduced into the estimate via the update resources command. All occurrences of that material in any bill item build-up are then automatically updated.

The "awaiting quotes" system is described in detail in Section 7.

3.3.2 FILE OF BASIC BILL OF QUANTITIES INFORMATION

Details of all the items within the Bill of Quantities must be entered into the system. For each item the following data is required:

- Bill number;
- Section number;
- Page number;
- Item letter/number/CESMMcode;
- WORK GROUP code (where applicable);
- Percentage of the WORK GROUP code (where applicable);
- Domestic sub-contract item (if applicable);
- Item description (if required).

A detailed discription of the bill item information that is entered may be found in Section 4.

3.3.3 FILE OF MARK-UP ADDITIONS

The estimator may store details of the mark-up additions that he wishes to apply to his direct cost estimate. These figures are unique for each estimate and are held as factors to be applied to the direct cost total for each item. The mark-up factors include allowances for:

- Surcharges;
- Profits;
- Overheads;
- On-costs;
- Distributed Sum;
- Rate Load

The application of mark-up factors is described in detail in Section 6.

3.4 CONTRACT FILES STORING THE ESTIMATORS DATA

The estimator's data is held on:

- the File of Bill Item Details;
- the File of Awaiting Quotes.

Their function is to retain the estimator's calculations and build-ups in order that details of the direct cost estimate may be retrieved, reviewed and re-worked at any stage.

3.4.1 FILE OF BILL ITEM DETAILS

This file holds the details of the build of each bill item within the Bill of Quantities. The details held result from the pricing of the bill item in one of the following methods:

(i) Item Priced by a WORK GROUP from the Company Data Library

The cost of the item is calculated from a suitable WORK GROUP on the company library. To this performance data the contract costs are applied from the CONTRACT RESOURCE COST FILES, to give the bill item cost. The build-up is displayed on the V.D.U. and the estimator has the choice of whether to accept it or modify it to suit his exact requirements.

When the estimator is satisfied with the build-up of the bill item the details are stored in one of two files. If all the resource prices in the item are final prices the data is stored in the FILE OF BILL ITEM DETAILS. If some resources are marked as "Awaiting Quotes" the work group details are stored in the FILE OF AWAITING QUOTES. When quotations are received they are introduced into the system, the resource costs updated and the WORK GROUP details passed to the FILE OF BILL ITEM DETAILS.

(ii) ITEM PRICED BY BUILDING UP INDIVIDUAL RESOURCES

Where no appropriate WORK GROUP exists on the company library the estimator may create his own build-up for the item by combining individual resources (or resource gangs) and applying appropriate output, usage and wastage factors. If resources that are required do not already exist on the CONTRACT RESOURCE COST FILES then these may be introduced by the estimator under appropriate codes. When the estimator is satisfied with the bill item build-up the item details are tranfered to the FILE OF BILL ITEM DETAILS or the FILE OF AWAITING QUOTES as appropriate.

(iii) ITEM PRICED BY THE CALCULATION OF OPERATIONAL RATES

The estimator may decide to calculate the cost of the labour and plant resources for a particular part of the construction work by determining the lapsed time the resources will be required on site, calculating the total cost of the operation and using the total amount of work within the operation to produce an average cost rate. This is called OPERATIONAL ESTIMATING. No attempt is made to calculate individual machine outputs. The rate covers any down time the plant or labour group may experience while on site.

Operational Groups of labour and plant resources may be formed by the estimator using the CREATE/EDIT OPERATIONAL GROUP command. Details of Operational Groups are held in the FILE OF OPERATIONAL GROUP DATA and are unique to each individual contract. No Operational Group data is held on the company library.

A bill item may be priced solely on Operational Rates. Alternatively the Operational Rates calculated may be applied to items already priced by a WORK GROUP or a build-up of individual resources created by the estimator.

When the estimator is satisfied with the complete bill item build-up the item details are transfered to the File of Bill Item Details or the File of Awaiting Quotes as appropriate.

(iv) <u>ITEMS PRICED BY USING SPOT RATES</u>

The estimator may decide not to price a bill item from a consideration of the actual resources required but by applying cost rates against each of the cost code categories (Labour, Plant, Mat. etc.). These SPOT RATES are used to price the bill item and details are stored in the FILE OF BILL ITEM DETAILS.

3.4.2 <u>FILE OF AWAITING QUOTES</u>

The FILE OF AWAITING QUOTES stores details of the build-ups of bill items which contain resources that have not yet been allocated a confirmed price for the contract. When quotations are received and confirmed by the estimator they are entered into the system and all occurrences of the resource are automatically updated. The build-ups of the respective items are then transfered from the FILE OF AWAITING QUOTES to the FILE OF BILL ITEM DETAILS.

Section 7 describes the "Awaiting Quotes" facility in detail.

4. THE ENTRY OF BILL OF QUANTITIES DETAILS ONTO THE COMPUTER FILES

4.1 DATA REQUIRED TO BE ENTERED

This section describes the entry of details of the items within the Bill of Quantities onto the computer files. This task will probably be performed by someone with keyboard skills (eg typing or comptometer operation) to enable the task to be performed as quickly as possible.

The information that may be entered for each bill item is:

- Bill number (if applicable);
- Section number;
- Page number;
- Item letter/number/code;
- Item description (if applicable);
- Work Group Code (if applicable);
- Percentage of the Work Group Code (if applicable);
- Sub-contractor status (if applicable);
- Item quantity;
- Units of measurement.

Of the details mentioned above some will be directly available from the Bill of Quantities itself. Other details will need to be supplied by the estimator.

4.1.1 DETAILS FROM THE BILL OF QUANTITIES

From the Bill of Quantities document it is possible to ascertain for each item:

- item reference;
- quantity;

- units of measurement;
- item description.

The item reference may take a number of different forms, depending on the method of measurement used by the client's quantity surveyor. (This is described in detail in Section 8).

The form of item reference used for the contract estimate is preset by the chief estimator when the contract details are input via the system control program (see Section 8). Likewise the chief estimator will have decided whether or not it is required to store details on bill item descriptions.

4.1.2 INFORMATION SUPPLIED BY THE ESTIMATOR

Where appropriate the estimator must supply the following information:

- the Work Group Code;
- the percentage of the Work Group Code;
- the bill item description;
- the identification of domestic subcontract items.

It should be noted that these details are optional. The estimator will need to annotate a copy of the Bill of Quantities to link the information to the correct bill item.

THE WORK GROUP CODE

The INTEREST-CE system allows performance data to be stored on the computer files and used to price appropriate bill items found within the Bill of Quantities. To locate the required data from the computer files some form of identification code is necessary.

Different forms of this coding system are described in detail in Section 9.

In many cases no Work Group Code will be provided for the bill item. No suitable data may exist on the library files. The estimator may not be aware of the data or may wish to price the item by another method. The estimator may decide not to code up the bill at this stage. He will then have to enter the Work Group Code himself when inspecting and pricing the various bill items. Up to two Work Group Codes may be allocated to a single bill item.

THE WORK GROUP CODE PERCENTAGE

The estimator can determine the contribution the stored data, identified by the Work Group Code, will make to the cost of the bill item. The Work Group Code Percentage is in effect a multiplier which is applied to all the performance data included within the Work Group. The percentage may be any figure. If a percentage of 110 is entered this will increase the usage rates and decrease the output rates of the resources used within the Work Group. If a percentage of less than 100% is entered the requirement of the resources in the Work Group is reduced accordingly. Where two Work Groups are allocated to a single bill item the total percentage does not have to be 100. Where no Work Group Code has been entered it is not possible to enter a percentage figure.

THE BILL ITEM DESCRIPTION

For an individual bill item it is possible to store a description of up to 80 alphanumeric characters. If a Work Group Code has been allocated to a bill item no description may be input. The description of the Work Group stored on the library is automatically used to describe the bill item.

It is probable that the actual bill description will be longer than that allowed by the system. The estimator should mark key words that can be input and will enable him to recognise the bill item.

THE IDENTIFICATION OF DOMESTIC SUB-CONTRACT ITEMS

The estimator should identify which items within the bill will be priced by a domestic sub-contractor quotation. This will enable the system to recognise such items and produce necessary prompts and the insertion of quotes at a later stage. Up to two domestic sub-contract quotes may be allocated to one item. An item may be marked as awaiting a sub-contractor quotation and allocated a Work Group Code.

4.2 THE ENTRY OF THE BILL OF QUANTITIES DETAILS

The details of the Bill of Quantities are entered by using the AB3DPREP program. This incorporates the following set of commands:

FU - Full Page;

SI - Single Item;

LI - List Bill Item References;

ST - Stop.

Each of these commands will now be explained in detail with appropriate examples. There is no set order for the program to run. The user may enter the bill item details in any order; start at one page, stop, continue on another page etc. It is hoever recommended that work commences at the start of the first bill section and continues through the bill in the logical order. In this manner the user is less likely to omit isolated pages.

The examples that follow relate to the two sample bill pages shown in figures 4 and 5 , pages 502 and 503 These have been annotated where appropriate as the estimator would in practice mark the Bill of Quantities prior to the entry of bill details.

SECTION 1 PAGE 1

ITEM	DESCRIPTION OF WORK	UNIT	QUANTITY	RATE	AMOUNT	
1.	Provide Bond	ITEM				
2.	Diversion of existing stream	ITEM				
3.	Temporary works for diversion of stream	ITEM				
4.	Allow Provisional Sum of £10 000 for additional work in connection with statutory bodies to be executed by Main Contractor	SUM			10 000	
	<u>P C. Sums</u>					
	Provide the following P.C. Sum for work to be executed by a Nominated Subcontractor					
5.	Work to electrical services in Boiler Room	-			5 000	00
6.	Add for Profit	-				
7.	Add for Attendance	-				
	Provide the following P.C. Sum for material to be supplied by a Nominated Supplier					
8.	Pumps to Boiler Room	-			10 000	00
9.	Add for Profit	-				

<u>Figure 4 - SAMPLE BILL PAGE - I</u>

SECTION 2 PAGE 20

ITEM	DESCRIPTION OF WORK	UNIT	QUANTITY	RATE	AMOUNT	
1.	Excavate and cart away unsuitable material	256	M3		E444.	0
2.	Supply and place imported fill	256	M3		E645.	0
3.	Break out existing concrete	2.5	M3		—	
4.	Mild steel bar reinforcement, 16mm dia. to B.S.	37.5	TNNE		G516.	0
5.	In-situ concrete class E blinding 75mm or less in thickness	26	M3			
6.	Provide and place ordinary structural concrete to Table 50 CP110 class 20. 20 sulphate resisting cement	310	M3		F237.	0
7.	Class F1 Formwork more than 300mm wide at any inclination more than 85° up to and including 90° to the horizontal	40	M2		S/C	
8.	Precast concrete manhole 1067mm dia. - depth 1.9m	1	No		Z999 Z999.	9 8
9.	Supply Precast Concrete Beams Type T1	18	NR		S/C	

Figure 5 - SAMPLE BILL PAGE - II

4.2.1 STARTING THE PROGRAM

The procedure for switching on the computer depends upon the actual computer being used to run the program. Details of this procedure will be available in a separate user manual provided by the supplier.

The dataprep program is called by keying in the name AB3DPREP.

The user will then be asked to enter the CONTRACT IDENTIFIER. If an incorrect CONTRACT IDENTIFIER is entered the message "CONTRACT DOES NOT EXIST" will be displayed and the program stopped.

If a meaningful CONTRACT IDENTIFIER is entered the user will be asked to enter a PASSWORD. If an incorrect PASSWORD is entered the user is allowed another attempt to enter the correct PASSWORD before the message "Access denied" is displayed and the program halted.

NOTE: The CONTRACT IDENTIFIER and PASSWORD are set up by the Chief Estimator using the CHIEF program and should be supplied to the user prior to data input.

When the program is successfully accessed, details of the contract will be displayed together with the main menu of commands. This is shown in figure 6 page 505.

Details of the Bill of Quantities items are entered by using the commands in the main menu. To instigate a command it is only necessary to enter the two "command letters" eg FU for Full Page.

```
AB3DPREP

INTEREST-CE System 3.00
Data Preparation Program

Contract Identifier ? MAN1

Password ? RED

££££££

Contract Title          :- NARBOROUGH BRIDGES
Reference Code          :- MAN1
Tender Submission Date:- 30/06/82
Client                  :- NARBOROUGH C.C.
Consulting Engineers  :- R.P.T.
Estimator's Name        :- BLACK
Planner's Name          :- WHITE
Estimated Tender Value:- 2,500,000

WAIT
      Commands are :-
                 FU - Full Page
                 SI - Single Item
                 LI - List Bill Item References
                 ST - Stop
Command ?
```

Figure 6 - DATAPREP PROGRAM MAIN MENU OF COMMANDS

The system is designed to ensure no items on the page are omitted at the input stage. If the bill items are lettered, the system will ask for the last item on the page in question. This enables the system to 'know' how many items are on the page and prompt the user for details on each one. If the bill items are numbered then the first and last item numbers are requested and the user prompted between these two.

For each item on the page the user will be asked to enter data. This occurs in a strict order prompted by the system. When details of the item have been entered they will be displayed and the user given the opportunity to check the data. If the data is satisfactory, the input YES (or Y) will enable the system to file the data and prompt the user for data relevant to the next bill item. If the user has made a mistake, NO (or N) should be entered. The facilities to enable changes to be made are described in below.

Details of the Bill of Quantities items are entered by using the commands in the main menu. To instigate a command it is only necessary to enter the two "command letters" eg FU for Full Page.

4.2.2 FULL PAGE

This command permits the user to enter a full page of Bill of Quantities details. The user must first enter the page reference. This enables the system to identify the bill page being processed. There are two types of page reference permitted. Where the contract divided into a number of different Bills of Quantities the full reference Bill Number, Section and Page must be entered.

eg 1 / 12 / 102

Bill No. Page No.

Section No.

When the Bill of Quantities is treated as a single bill the Bill Number need not be entered.

eg 4 / 36

Sect No. Page No.

NOTE:

On completion of the entry of data for a specified bill page the menu of commands is displayed again. The user may proceed to enter details of the next page by entering FU or alternatively select any of the other commands. When entering the next full page the system will again request a PAGE REFERENCE. The same bill number and section number will be assumed if / / is entered instead of the full details. Similarly, where only section number and page number are being used, the system will assume the previous section if / is entered instead of the section number.

```
Section 1  Page 1/4
Quantity ? [RETURN for no quantity] __

Description ? ADDITIONAL WORK STATUTORY BODIES

      Commands :-
                 IT - Item
                 SP - Prime Cost - Nominated Supplier
                 SC - Prime Cost - Nominated Sub-Contractor
                 PS - Provisional Sum
                 AT - Attendance Allowance
                 PR - Profit Allowance
Command ? PS

Provisional Sum ? 10000

Section 1  Page 1/4
ADDITIONAL WORK STATUTORY BODIES
Prov. Sum
  $10,000.00

OK ? Y

Item Filed


Section 1  Page 1/5
Quantity ? [RETURN for no quantity] __

Description ? P.C. SUM NOM. S/C ELECTRICAL SERVICES

      Commands :-
                 IT - Item
                 SP - Prime Cost - Nominated Supplier
                 SC - Prime Cost - Nominated Sub-Contractor
                 PS - Provisional Sum
                 AT - Attendance Allowance
                 PR - Profit Allowance
Command ? SC

Prime Cost ? 5000

Section 1  Page 1/5
P.C. SUM NOM. S/C ELECTRICAL SERVICES
Prime Cost
(Nominated Sub-Contractor)
   $5,000.00

OK ? Y

Item Filed

Section 1  Page 1/6
Quantity ? [RETURN for no quantity] __

Description ? ADD FOR PROFIT

      Commands :-
                 IT - Item
                 SP - Prime Cost - Nominated Supplier
                 SC - Prime Cost - Nominated Sub-Contractor
                 PS - Provisional Sum
                 AT - Attendance Allowance
                 PR - Profit Allowance
Command ? PR

Profit Allowance on:- 1/1/5

Section 1  Page 1/6
ADD FOR PROFIT
P.C. Profit  on Section 1  Page 1/5

OK ? Y

Item Filed
```

```
Section 1  Page 1/7
Quantity ? [RETURN for no quantity] __

Description ? ADD FOR ATTENDANCE

      Commands :-
                    IT - Item
                    SP - Prime Cost - Nominated Supplier
                    SC - Prime Cost - Nominated Sub-Contractor
                    PS - Provisional Sum
                    AT - Attendance Allowance
                    PR - Profit Allowance
Command ? AT

Attendance Allowance on:- 1/1/5

Section 1  Page 1/7
ADD FOR ATTENDANCE
Attendance   on Section 1  Page 1/5

OK ? Y

Item Filed

Section 1  Page 1/8
Quantity ? [RETURN for no quantity] __

Description ? P.C. SUM PUMPS TO BOILER ROOM

      Commands :-
                    IT - Item
                    SP - Prime Cost - Nominated Supplier
                    SC - Prime Cost - Nominated Sub-Contractor
                    PS - Provisional Sum
                    AT - Attendance Allowance
                    PR - Profit Allowance
Command ? SP

Prime Cost ? 10000

Section 1  Page 1/8
P.C. SUM PUMPS TO BOILER ROOM
Prime Cost
(Nominated Supplier)
  $10,000.00

OK ? Y

Item Filed
```

```
Section 1  Page 1/9
Quantity ? [RETURN for no quantity]  ___

Description ? ADD FOR PROFIT

      Commands :-
                IT - Item
                SP - Prime Cost - Nominated Supplier
                SC - Prime Cost - Nominated Sub-Contractor
                PS - Provisional Sum
                AT - Attendance Allowance
                PR - Profit Allowance
Command ? PR

Profit Allowance on:- 1/1/8

Section 1  Page 1/9
ADD FOR PROFIT
P.C. Profit  on Section 1  Page 1/8

OK ? Y

Item Filed

      Commands are :-
                FU - Full Page .
                SI - Single Item
                LI - List Bill Item References
                ST - Stop


Command ? FU


FULL PAGE option


Page Reference ? 2/20

First Item on Page ? 1

Last Item on Page ? 8


Section 2  Page 20/1
Quantity ? [RETURN for no quantity] 256

Units of Measurement ? M3

Work Group Code ? [RETURN for no Code] E444.0

Percentage ? [RETURN for 100%] __

Sub-Contract Item ? N


Section 2  Page 20/1
Quantity    256     M3

Work Group E444.0        100.00%
OK ? Y

Item Filed
```

Section 2 Page 20/2
Quantity ? [RETURN for no quantity] 256

Units of Measurement ? M3

Work Group Code ? [RETURN for no Code] E645.0

Percentage ? [RETURN for 100%] __

Sub-Contract Item ? N

Section 2 Page 20/2
Quantity 256 M3

Work Group E645.0 100.00%
OK ? Y

Item Filed

Section 2 Page 20/3
Quantity ? [RETURN for no quantity] 2.5

Units of Measurement ? M3

Work Group Code ? [RETURN for no Code] __

Description ? BREAK OUT EXISTING CONCRETE

Sub-Contract Item ? N

Section 2 Page 20/3
Quantity 2.5 M3
BREAK OUT EXISTING CONCRETE
OK ? Y

Item Filed

Section 2 Page 20/4
Quantity ? [RETURN for no quantity] 37.5

Units of Measurement ? TNNE

Work Group Code ? [RETURN for no Code] G516.0

Percentage ? [RETURN for 100%] __

Sub-Contract Item ? N

Section 2 Page 20/4
Quantity 37.5 TNNE

Work Group G516.0 100.00%
OK ? Y

Item Filed

Section 2 Page 20/5
Quantity ? [RETURN for no quantity] 26

Units of Measurement ? M3

Work Group Code ? [RETURN for no Code] F237.0

Percentage ? [RETURN for 100%] __

Sub-Contract Item ? N

Section 2 Page 20/5
Quantity 26 M3

Work Group F237.0 100.00%
OK ? Y

Item Filed

```
Section 2  Page 20/6
Quantity ? [RETURN for no quantity] 310

Units of Measurement ? M3

Work Group Code ? [RETURN for no Code] ___

Description ? ORDINARY STRUCT.CONC. CLASS 20.20 SRC

Sub-Contract Item ? N


Section 2  Page 20/6
Quantity    310     M3
ORDINARY STRUCT.CONC. CLASS 20.20 SRC
OK ? N

       Commands :-
                    QU - Change Quantity
                    UN - Change Units of Measurement
                    DS - Change Description
                    AD - Add Work Group
                    FI - File Item
                    SU - Change to Sub-contract Item
Command ? AD

Work Group Code ? F237.0

Percentage ? [RETURN for 100%] ____


Section 2  Page 20/6
Quantity    310     M3
ORDINARY STRUCT.CONC. CLASS 20.20 SRC
Work Group F237.0         100.00%
OK ? Y

Item Filed

Section 2  Page 20/7
Quantity ? [RETURN for no quantity] 40

Units of Measurement ? M2

Work Group Code ? [RETURN for no Code] ___

Description ? CLASS F1 FORMWORK >300MM WIDE

Sub-Contract Item ? Y


Section 2  Page 20/7
Quantity     40     M2
CLASS F1 FORMWORK >300MM WIDE
) Sub-contractor Required
OK ? Y

Item Filed
```

```
Section 2  Page 20/8
Quantity ? [RETURN for no quantity] 1

Units of Measurement ? NR

Work Group Code ? [RETURN for no Code] Z999.9

Percentage ? [RETURN for 100%] ___

Sub-Contract Item ? N


Section 2  Page 20/8
Quantity      1      NR

Work Group Z999.9          100.00%
OK ? N

      Commands :-
                  QU - Change Quantity
                  UN - Change Units of Measurement
                  DS - Change Description
                  AD - Add Work Group
                  CH - Change Percentage
                  DE - Delete Work Group
                  FI - File Item
                  SU - Change to Sub-contract Item
Command ? AD

Work Group Code ? Z999.8

Percentage ? [RETURN for 100%] 90


Section 2  Page 20/8
Quantity      1      NR

Work Group 1 Z999.9        100.00%
Work Group 2 Z999.8         90.00%
OK ? Y

Item Filed

      Commands are :-
                  FU - Full Page
                  SI - Single Item
                  LI - List Bill Item References
                  ST - Stop
```

CHANGING THE FULL PAGE DATA

The program provides full editing facilities to enable the user to amend any data that has been input incorrectly. The following examples give details of these facilities.

CHANGING AN ITEM QUANTITY

The bill item quantity is changed from $256m^3$ to $156m^3$.

```
Section 3   Page 32/1
Quantity     256      M3

Work Group E444.0          100.00%
OK ? N

       Commands :-
                      QU - Change Quantity
                      UN - Change Units of Measurement
                      DS - Change Description
                      AD - Add Work Group
                      CH - Change Percentage
                      DE - Delete Work Group
                      FI - File Item
                      SU - Change to Sub-contract Item
Command ? QU

Quantity ? 156

Section 3   Page 32/1
Quantity     156      M3

Work Group E444.0          100.00%
OK ? Y

Item Filed
```

CHANGING THE UNITS OF MEASUREMENT

The units of measurement are changed from M^3 to M^2 .

```
        Commands are :-
                        FU - Full Page
                        SI - Single Item
                        LI - List Bill Item References
                        ST - Stop
Command ? SI

SINGLE ITEM option

Item Reference ? 3/32/1

Section 3   Page 32/1
Quantity     156      M3

Work Group E444.0          100.00%
OK ? N

        Commands :-
                        QU - Change Quantity
                        UN - Change Units of Measurement
                        DS - Change Description
                        AD - Add Work Group
                        CH - Change Percentage
                        DE - Delete Work Group
                        FI - File Item
                        SU - Change to Sub-contract Item
Command ? UN

Units of Measurement ? M2

Section 3   Page 32/1
Quantity     156      M2

Work Group E444.0          100.00%
OK ? Y

Item Filed
```

ADDING A WORK GROUP

It is possible to add two WORK GROUPS together to price a bill item. It has previously been shown how to add a Work Group to a bill item already priced in this manner. See the entry of bill item 2/20/8 on page 514.

CHANGING THE PERCENTAGE OF A WORK GROUP

The percentage of Work Group F237.0 is changed from 100% to 50%.

```
Section 2  Page 32/1
Quantity    145     M3

Work Group F237.0          100.00%
OK ? N

      Commands :-
                 QU - Change Quantity
                 UN - Change Units of Measurement
                 DS - Change Description
                 AD - Add Work Group
                 CH - Change Percentage
                 DE - Delete Work Group
                 FI - File Item
                 SU - Change to Sub-contract Item
Command ? CH

Percentage ? [RETURN for 100%] 50


Section 2  Page 32/1
Quantity    145     M3

Work Group F237.0           50.00%
OK ? Y

Item Filed
```

Where two Work Groups have been entered it is possible to select which percentage applied to which Work Group should be changed. This is done by selecting the Work Group and entering the percentage required.

```
Item Reference ? 2/32/1

Section 2  Page 32/1
Quantity    145     M3

Work Group 1 F237.0          50.00%
Work Group 2 F247.0         100.00%
OK ? N

      Commands :-
                 QU - Change Quantity
                 UN - Change Units of Measurement
                 DS - Change Description
                 CH - Change Percentage
                 DE - Delete Work Group
                 FI - File Item
                 SU - Change to Sub-contract Item
Command ? CH

Work Group 1 or 2 ? 1

Percentage ? [RETURN for 100%] 75


Section 2  Page 32/1
Quantity    145     M3

Work Group 1 F237.0          75.00%
Work Group 2 F247.0         100.00%
OK ? Y

Item Filed
```

DELETING A WORK GROUP

The Work Group E444.0 is deleted from the bill item 2/20/1.

```
SINGLE ITEM option

Item Reference ? 3/32/1

Section 3   Page 32/1
Quantity     156      M2

Work Group E444.0         100.00%
OK ? N

       Commands :-
                    QU - Change Quantity
                    UN - Change Units of Measurement
                    DS - Change Description
                    AD - Add Work Group
                    CH - Change Percentage
                    DE - Delete Work Group
                    FI - File Item
                    SU - Change to Sub-contract Item
Command ? DE

Section 3   Page 32/1
Quantity     156      M2

OK ? Y

Item Filed
```

Where the bill item has been priced with two Work Groups it is possible to select either one to be deleted.

```
SINGLE ITEM option

Item Reference ? 2/32/1

Section 2   Page 32/1
Quantity     145      M3

Work Group 1 F237.0         75.00%
Work Group 2 F247.0        100.00%
OK ? N

       Commands :-
                    QU - Change Quantity
                    UN - Change Units of Measurement
                    DS - Change Description
                    CH - Change Percentage
                    DE - Delete Work Group
                    FI - File Item
                    SU - Change to Sub-contract Item
Command ? DE

Work Group 1 or 2 ? 2

Section 2   Page 32/1
Quantity     145      M3

Work Group F237.0         75.00%
OK ? Y
```

CHANGING AN ITEM TO A SUB-CONTRACT ITEM

A bill item may be changed to requiring a sub-contractor quotation.

```
Command ? SI

SINGLE ITEM option

Item Reference ? 3/32/1

Section 3   Page 32/1
Quantity     156      M2

OK ? N

       Commands :-
                    QU - Change Quantity
                    UN - Change Units of Measurement
                    DS - Change Description
                    AD - Add Work Group
                    FI - File Item
                    SU - Change to Sub-contract Item
Command ? SU

Section 3   Page 32/1
Quantity     156      M2

1 Sub-contractor Required
OK ? Y

Item Filed
```

CHANGING A SUB-CONTRACT ITEM TO A NON SUB-CONTRACT ITEM

An item previously designated as requiring a sub-contractor may be changed to an ordinary item.

```
Section 3   Page 32/1
Quantity     156      M2

1 Sub-contractor Required
OK ? N

       Commands :-
                    QU - Change Quantity
                    UN - Change Units of Measurement
                    DS - Change Description
                    AD - Add Work Group
                    FI - File Item
                    NS - Change to Non-Sub-contract Item
                    SN - Change Number of Sub-contractors
Command ? NS

Section 3   Page 32/1
Quantity     156      M2

OK ? Y

Item Filed
```

CHANGING THE NUMBER OF SUB-CONTRACTORS

It is possible to allocate up to two sub-contractors to a bill item. The system will allow the number of sub-contractors against the bill item to be readily changed.

```
Section 3  Page 32/2
Quantity      43      NR
INSTALL PUMPS
1 Sub-contractor Required
OK ? N

       Commands :-
                    QU - Change Quantity
                    UN - Change Units of Measurement
                    DS - Change Description
                    AD - Add Work Group
                    FI - File Item
                    NS - Change to Non-Sub-contract Item
                    SN - Change Number of Sub-contractors
Command ? SN

Number of Sub-contractors ? 5

1 or 2 Sub-contractors allowed
Number of Sub-contractors ? 2


Section 3  Page 32/2
Quantity      43      NR
INSTALL PUMPS
2 Sub-contractors Required
OK ? Y

Item Filed
```

CHANGING A P.C. OR PROVISIONAL SUM

The sum entered for a P.C. sub-contractor, P.C. suppliers and Provisional sums may be changed in a manner similar to the example given below.

```
Section 3  Page 32/3
DIVERT STREAM
Prov. Sum
   $2,000.00

OK ? N

Commands :-
                          DS - Change Description
                          CS - Change Sum
                          CT - Change Type
                          FI - File Item
Command ? CS

Sum ? 12000

Section 3  Page 32/3
DIVERT STREAM
Prov. Sum
   $12,000.00

OK ? Y

Item Filed
```

CHANGING A 'NO-QUANTITY' ITEM

A no quantity item may be changed from one type to another. In the example below the item is changed from a P.C. profit to a P.C. attendance item.

```
Section 3  Page 32/4
PROFIT
P.C. Profit  on Section 3  Page 32/2

OK ? N

Commands :-
                    DS - Change Description
                    CI - Change Item this is Profit on
                    CT - Change Type
                    FI - File Item
Command ? CT

      Commands :-
                    IT - Item
                    SP - Prime Cost - Nominated Supplier
                    SC - Prime Cost - Nominated Sub-Contractor
                    PS - Provisional Sum
                    AT - Attendance Allowance
                    PR - Profit Allowance
Command ? AT

Section 3  Page 32/4
PROFIT
Attendance   on Section 3  Page 32/2

OK ? Y

Item Filed
```

The item which has been referred to in Profit and Attendance items may be changed.

```
Item Reference ? 3/32/4

Section 3  Page 32/4
PROFIT
Attendance   on Section 3  Page 32/2

OK ? N

Commands :-
                    DS - Change Description
                    CI - Change Item this is Attendance on
                    CT - Change Type
                    FI - File Item
Command ? CI

Bill Item this is Attendance on ? 3/32/1

Section 3  Page 32/4
PROFIT
Attendance   on Section 3  Page 32/1

OK ? Y

Item Filed
```

4.2.3 SINGLE ITEM

The SI - SINGLE ITEM command enables bill items details to be input one at a time. However its main use is not for the input of items but to review, check and amend details of bill items already held on file. These changes are likely to occur due to changes in the contract documents notified from the client's quantity surveyor or incorrect data entry that needs to be amended. This may be performed in the following manner.

```
Command ? SI

SINGLE ITEM option

Item Reference ? 2/20/9

Section 2  Page 20/9
Quantity ? [RETURN for no quantity] 18

Units of Measurement ? NR

Work Group Code ? [RETURN for no Code]

Description ? SUPPLY PRECAST CONC. BEAMS

Sub-Contract Item ? Y

Section 2  Page 20/9
Quantity     18     NR
SUPPLY PRECAST CONC. BEAMS
1 Sub-contractor Required
OK ? Y

Item Filed

      Commands are :-
                FU - Full Page
                SI - Single Item
                LI - List Bill Item References
                ST - Stop
```

It should be noted that item details may only be amended before the item has been inspected by the estimator. After the estimator has reviewed the item, the user will not be able to make any changes. This is shown below.

```
       Commands are :-
                    FU - Full Page
                    SI - Single Item
                    LI - List Bill Item References
                    ST - Stop
Command ? SI

SINGLE ITEM option

Item Reference ? 2/20/4

Section 2  Page 20/4
Quantity     27.5   TNNE
16MM DIA MILD STEEL REBAR
Work Group G516.0        100.00%
Priced by Estimator
                                                 Press RETURN to continu
```

4.2.4 LIST BILL ITEM REFERENCES

The command LI - LIST BILL ITEM REFERENCES enables the user to obtain a list of the bill items for which details have been entered. This enables a check to be made that all the bill items for the contract are on file. An example of the printout given is shown in figure 7, page 526. For each page of the bill the item references are listed and the total number of items given.

It is unnecessary to printout all the bill item references each time a check has been made. After instigating the command the system will enquire which portion of the contract is to be listed. If the RETURN key is pressed the whole contract is listed. By entering a section reference all the relevant details will be listed. By entering a page reference details of only that page will be given.

For example 1/20/176 would list

Bill 1, Section 20, page 176

1/20 would list

Bill 1, Section 20.

If the page reference contains only section and page numbers,

4/36 would list

Section 4, page 36

4/ would list all Section 4.

The user will be asked to check that the printer is available before the listing is instigated. If the user has decided a listing is not required by entering AB for abort the system will return to the main menu. While the report is being prepared the following messages are given:

*** Scanning Contract File ***

*** List Item References in Progress ***

The following printout relates to the production of figure

```
      Commands are :-
                    FU - Full Page
                    SI - Single Item
                    LI - List Bill Item References
                    ST - Stop
Command ? LI

WAIT
Portion of Contract to be Listed ? [RETURN for Whole Contract]

Make sure Printer is available (press RETURN) ___



*** Scanning Contract File ***



*** List Item References in Progress ***
```

CAE. COMPUTER-AIDED ESTIMATING - NARBOROUGH BRIDGES

TIME:

DATE:

Consulting Engineers: R.P.T.

Reference Code: MAN1

Client: NARBOROUGH C.C.

Estimator: BLACK

Tender Submission Date: 30/06/82

Planner: WHITE

PAGE: 1

ITEM REFERENCE LISTING :

											No of Items
Section 1 Page 1											
	1	2	3	4	5	6	7	8	9	1/1	9
Section 2 Page 20											
	1	2	3	4	5	6	7	8	9	2/20	9
Section 3 Page 30											
	1	2	3	4						3/30	4
Section 4 Page 40											
	1	2	3	4						4/40	4

Figure 7 - LIST OF BILL ITEM REFERENCES

4.2.5 STOP

The command ST - STOP allows the user to stop work. This may be done at any stage of the entry of bill item details. The items that have already been entered are retained on the computer files. Upon restarting work the user may carry on exactly where he left off, the remaining items being entered by the commands described above.

```
WAIT
      Commands are :-
                  FU - Full Page
                  SI - Single Item
                  LI - List Bill Item References
                  ST - Stop
Command ? ST

End of Run
 STOP
```

5.0 CALCULATION OF BILL ITEM RATES

5.1 GENERAL

This section reviews the methods available to the estimator for pricing bill items. These include:

- Unit Rate Estimating from Work Groups held on the company library;
- Unit Rate Estimating from the build-ups of resources on the estimator's cost files;
- Operational Estimating;
- Entry of Spot Rates;
- Pricing on Item as "Included In";
- Entry of an Item Price.

The examples given relate to the sample bill shown in Section 4.

Before giving detailed examples of each of the above facilities a description of Unit Rate and Operational Estimating is given.

5.2 "UNIT RATE" AND "OPERATIONAL" ESTIMATING

There are two basic ways of estimating.

5.2.1 UNIT RATE ESTIMATING

In this method the calculation of a labour, plant or material rate is based upon a predetermined output or usage rate and the quantity of work stated against the bill item.

ITEM	DESCRIPTION OF WORK	UNIT	QTY	RATE	AMOUNT
A	Supply and Fix High Yield Rebar to BS4447 - 20mm dia.	TNNE	6.35	·	

The estimator decides to employ the following resources:

- 20mm diameter High Yield Steel - Cut, Bent and deliviered;
- Steelfixer.

The output or usage rate is taken from company data and amended to reflect the specific contract conditions:

- 20mm dia. High Yield Steel 1.000 TNNE/TNNE
- Steelfixer 20.500 HR/TNNE

A quotation is received for the supply of the steel £320.00/TNNE.

The all-in rate is calculated by the estimator to be £4.50/hr.

To calculate the total cost for each resource multiply:

Quantity x usage rate x cost price

eg for 20mm diameter Hifh Yield Steel this is:

6.35 x 1.00 x £320.00 = 2032.00

eg for the steelfixer this is:

6.35 x 20.50 x £4.50 = 585.78

To calculate the Item cost, sum each resource cost total:

$$\frac{\text{Total Cost}}{\text{Resource A}} + \frac{\text{Total Cost}}{\text{Resource B}} + \frac{\text{Total Cost}}{\text{Resource C}} + \text{etc}$$

eg 2032 + 585.78 = 2617.78

To calculate the Item rate divide the total cost by the Quantity:

eg $2617.78/_{6.35}$ = £412.25/TNNE

5.2.2 OPERATIONAL ESTIMATING

Operational estimating calculates item rates by considering the total quantity of work and the total lapsed time that the resources for the operation are required on site. The total cost of the labour and plant resources required is calculated based upon an average output or usage rate. The rate for the work is then the Total Cost divided by the Total Quantity.

Consider the following example:

An estimator is pricing the plant required to place concrete on a particular contract. From the bill he knows that the total volume of concrete in the job is 7600m3. He decides that concrete will be placed at an average rate of 200m3/week. This gives a total time for placing concrete for 38 weeks. Concrete will be delivered by 'Ready Mix'. He decides that the plant he will need for the placing of the concrete will be:

- 2 NO. 22 RB cranes
- 4 NO. Concrete Skips
- 6 NO. Dumpers
- 6 NO. Vibrators

The plant will be hired from the company plant yard at a weekly rate, held on site for the full 38 weeks, and used solely for the purpose of placing concrete. The total cost for the operation is therefore:

Item	No.		Weekly rate		No. weeks		Cost £
22 RB crane	2	x	220.0	x	38	=	16720.00
Concrete Skip	4	x	10.0	x	38	=	1520.00
Dumper	6	x	25.0	x	38	=	5700.00
Vibrators	6	x	10.0	x	38	=	2280.00
					TOTAL COST		£26220.00
					COST PER M3	=	£3.28

This rate can then be applied to each bill item involving the placing of concrete on a pro rata basis related to the quantity involved. For example, the estimator prices bill item F722.1 at £3.28/M3 giving an item total of £183.68.

ITEM	DESCRIPTION OF WORK	UNIT	QTY	RATE	TOTAL
F722.1	Place concrete to bases	M3	56.0	3.28	183.68

'INTEREST' can handle both 'Unit Rate' and 'Operational' estimating calculations. The two facilities can be used separately or combined by the user as follows:

(i) By adding operational rates to the work groups held on the contract database. (See Section 5.4.3)

(ii) By making up work groups using the CREATE ITEM BUILD UP option and combining operational rates with resources priced on a unit rate bases. (See Section 5.4.3)

5.3 STARTING THE AB3RUN PROGRAM

The computer should be started using the standard procedure. This will depend on the actual computer being used to run the program and the user should refer to the documentation supplied by the computer manufacturer.

When the computer is started it is necessary to select the program which allows the estimating calculations to be performed. To do this AB3RUN must be entered via the input keyboard. The system will then request the CONTRACT IDENTIFIER and PASSWORD for the contract in question. These details must be obtained from the person in charge of the estimating system. Providing the correct PASSWORD is entered the system will respond by displaying a menu of commands.

This is the Main Menu from which the user may select any facility to assist him with the preparation of the estimate.

```
                    MAIN MENU
                    ---------
       Commands:-
                    IN - Inspect Bill Item
                    OP - Create/Edit Operational Group
                    UP - Update Prices
                    SC - Enter Sub-contract Quotes
                    MA - Apply Mark-ups
                    PR - Print Reports
                    HE - Set HELP Level
                    DE - Delete Bill Item
                    ST - Stop
    Command ?
```

To instigate the required option the first two letters of the appropriate command need to be input by the user.

5.4 INSPECTING BILL ITEMS

Using this command the estimator may inspect the build-up of the bill items within the project. After entering the IN command the estimator must enter the ITEM REFERENCE of the bill item he wishes to examine.

Two types of ITEM REFERENCE are permitted:

1 / 1 / 1 / A

BILL NUMBER ITEM LETTER/NUMBER/CESMM CODE

SECTION NUMBER PAGE NUMBER

1 / 1 / A

ITEM LETTER/NUMBER/CESMM CODE

SECTION NUMBER PAGE NUMBER

The bill numbering method will have been determined by the chief estimator and input into the system after an initial study of the contract documents.

Having input the bill item reference the response of the system will depend on whether or not the item has already been priced. If this is the case, the build-up of the item will be displayed followed by the commands enabling details to be amended. If the item has not been priced a list of commands is displayed allowing the estimator to price the item by a number of methods.

5.4.1 UNIT RATE ESTIMATING FROM WORK GROUPS HELD ON THE COMPANY LIBRARY

The estimator may price a bill item from a WORK GROUP held on the company data library. In the following example the bill item 2 / 20 / 4 has been priced by the WORK GROUP G516.0 at the bill entry stage. (See Section 4).

When the estimator uses the IN command to inspect bill item 2 / 20 / 4 the following display is given.

```
Item Reference ? [RETURN to End] 2/20/4

WAIT
Pricing from Data Library

WAIT

Section 2  Page 20/4
Quantity      37.5    TNNE
100    % of Work Group G516.0
16MM DIA MILD STEEL REBAR
------------------------------------------------------------------------------------
                                                              Weight
Code         Description              Cost/Hour    Usage      Factor      Cost/TNN
----         -----------              ---------    -----      -------     --------
L524    STEELFIXER          -           $4.50     18.000      100.0%       $81.00
                                      Net.                     Wastages
Code         Description              Cost/Unit    Usage      Per Unit    Cost/TNN
----         -----------              ---------    -----      ---------   --------
M529    16 MM DIA MILD STEEL          $304.00/TN   1.050       10.0%      $351.12
         -CUT,BENT & DELIVER-
------------------------------------------------------------------------------------
                      TOTAL LABOUR     COST/TNNE                $81.00
                      TOTAL MATERIAL   COST/TNNE               $351.12
                                                           ------------
                      TOTAL NET COST/TNNE                      $432.12
------------------------------------------------------------------------------------
OK to File ? [RETURN for Yes] N
```

This represents the pricing of the bill item based upon the data in the company library. The estimator is asked OK to File? If the RETURN key is pressed the answer is assumed to be YES and the item is filed onto the contract file. If the estimator enters N or NO then the following options are given:

```
WAIT
                          Bill Item EDIT option
                          ---------------------

          Commands:-
                          QU - Change Quantity
                          UN - Change Units of Measurement
                          DS - Change Description
                          AD - Add Work Group
                          CH - Change Percentage of Work Group
                          DE - Delete Work Group
                          ED - Edit Work Group
                          RR - Resource Reconciliation
                          LU - Lump other Bill Items with this one
                          FI - File Bill Item
                          VI - View Bill Item
                          PR - Print Bill Item
Command ?
```

The estimator may choose any of the above commands to amend his build-up as required. This will not change the main library of data only the build-up of this particular bill item.

If the estimator wishes to amend the build-up of the item by:

- changing the usage rate of the steelfixer to 16.5 hr/tnne;
- changing the wastage factor on the reinforcement to 7%;
- adding crane to unload the reinforcement;

this is done with the aid of the Ed - EDIT Work Group command.

```
Command ? ED

     Commands:-
                 AR - Add Resource
                 AO - Add Operational Group
                 CH - Change Resource / Operational Group Details
                 DR - Delete Resource
Command ? CH

WAIT

CHANGE RESOURCE / OPERATIONAL GROUP DETAILS option


Resource Code to Change ? [RETURN to End] M529

                                      Net.                      Wastages
Code         Description              Cost/Unit    Usage        Per Unit   Cost/TN
----         -----------              ---------    -----        --------   -------
M529    16 MM DIA MILD STEEL          $304.00/TN   1.050         10.0%     $351.1
          -CUT,BENT & DELIVER-
     Commands :-
                 EX - Change Extension
                 US - Change Usage Rate
                 WA - Change Wastage
                 VI - View Resource
     Press RETURN to exit
```

```
  Command ? WA

                 10.0%
  Wastage (%) ? 7

        Commands :-
                    EX - Change Extension
                    US - Change Usage Rate
                    WA - Change Wastage
                    VI - View Resource
        Press RETURN to exit

  Command ?


Resource Code to Change ? [RETURN to End] L524

                                                                    Weight
Code           Description               Cost/Hour    Usage         Factor     Cost/TN
----           -----------               ---------    -----         -------    -------
L524   STEELFIXER          -               $4.50     18.000         100.0%     $81.0
      Commands :-
                    EX - Change Extension
                    US - Change Usage Rate
                    WF - Change Weight Factor
                    VI - View Resource
      Press RETURN to exit

Command ? US

                 18.000
Usage Rate ? 16.5

      Commands :-
                    EX - Change Extension
                    US - Change Usage Rate
                    WF - Change Weight Factor
                    VI - View Resource
      Press RETURN to exit

Command ?

Resource Code to Change ? [RETURN to End]

WAIT

Section 2  Page 20/4
Quantity      37.5    TNNE
100    % of Work Group G516.0
16MM DIA MILD STEEL REBAR
--------------------------------------------------------------------------------------
                                                                    Weight
Code           Description               Cost/Hour    Usage         Factor     Cost/TN
----           -----------               ---------    -----         -------    -------
L524   STEELFIXER          -               $4.50     16.500         100.0%     $74.25
                                         Net.                       Wastages
Code           Description               Cost/Unit    Usage         Per Unit   Cost/TN
----           -----------               ---------    -----         --------   -------
M529   16 MM DIA MILD STEEL              $304.00/TN   1.050            7.0%    $341.54
        -CUT,BENT & DELIVER-
--------------------------------------------------------------------------------------
                          TOTAL LABOUR     COST/TNNE               $74.25
                          TOTAL MATERIAL   COST/TNNE              $341.54
                                                              ------------
                          TOTAL NET COST/TNNE                     $415.79
--------------------------------------------------------------------------------------
OK to File ? [RETURN for Yes] N

WAIT
```

```
                         Bill Item EDIT option
                         ---------------------

           Commands:-
                         QU - Change Quantity
                         UN - Change Units of Measurement
                         DS - Change Description
                         AD - Add Work Group
                         CH - Change Percentage of Work Group
                         DE - Delete Work Group
                         ED - Edit Work Group
                         RR - Resource Reconciliation
                         LU _ Lump other Bill Items with this one
                         FI - File Bill Item
                         VI - View Bill Item
                         PR - Print Bill Item


Command ? ED

       Commands:-
                      AR - Add Resource
                      AO - Add Operational Group
                      CH - Change Resource / Operational Group Details
                      DR - Delete Resource
Command ? AR

WAIT
ADD RESOURCE option


Resource Code to Add ? [RETURN to End] P17

    (master)      Description - CONC SKIP 0.80M3
                  Cost        -        $0.22/HR
OK ? N

Resource Code to Add ? [RETURN to End] P147

    (master)      Description - 22 RB TRACKED CRANE
    (used)        Cost        -        $6.18/HR
OK ? Y

Description Extension ? ___

Outrut Rate ? 4.0

Weight Factor ? [RETURN for 100%]  ___

                                                        Weight
Code        Description           Cost/Hour   Output    Factor    Cost/TNN
----        -----------           ---------   ------    -------   --------
P147   22 RB TRACKED CRANE -        $6.18      4.000    100.0%       $1.55
Resource Code to Add ? [RETURN to End] ___

WAIT
```

Section 2 Page 20/4
Quantity 37.5 TNNE
100 % of Work Group G516.0
16MM DIA MILD STEEL REBAR

Code	Description	Cost/Hour	Usage	Weight Factor	Cost/TN
L524	STEELFIXER -	$4.50	16.500	100.0%	$74.2
Code	**Description**	**Cost/Hour**	**Output**	**Weight Factor**	**Cost/TN**
P147	22 RB TRACKED CRANE -	$6.18	4.000	100.0%	$1.5
Code	**Description**	**Net. Cost/Unit**	**Usage**	**Wastages Per Unit**	**Cost/TN**
M529	16 MM DIA MILD STEEL -CUT,BENT & DELIVER-	$304.00/TN	1.050	7.0%	$341.5

TOTAL LABOUR	COST/TNNE	$74.25
		Press RETURN to continue
TOTAL PLANT	COST/TNNE	$1.55
TOTAL MATERIAL	COST/TNNE	$341.54
TOTAL NET COST/TNNE		$417.34

OK to File ? [RETURN for Yes] ____

Using the ED - EDIT Work Group command the build-up of the bill item may be changed by:

- deleting resources;
- adding resources;
- changing details of the existing resources.

When the estimator is satisfied with the item build-up he should use the FI - Bile Bill Item command to file the item onto the contract file. A message will be given that this has been satisfactorily completed and he will be asked for the next item he wishes to inspect.

```
Command ? FI

        ** Bill Item 2/20/4          Filed **

WAIT
INSPECT BILL ITEM option

Item Reference ? [RETURN to End]
```

Displayed in the menu of commands below the item build-up are other options open to the estimator. These are now described.

QU - CHANGE QUANTITY

The estimator may notice that the wrong quantity for the item has been input. He may change this to the correct quantity by using the QU command. The existing quantity will be displayed and the user inputs the new figure.

```
Command ? QU
                37.5
Quantity ? 27.5
```

UN - CHANGE UNITS OF MEASUREMENT

The estimator may similarly note that the units of measurement have been incorrectly input. This may be changed using the UN command.

```
Command ? UN
                              M3
Units of Measurement ? TNNE
```

DS - CHANGE DESCRIPTION

It is possible to change the bill item description to that required at any stage.

```
Command ? DS

16MM DIA MILD STEEL REBAR
Description ? MILD STEEL REBAR UP TO 16MM DIA.
```

AD - ADD WORK GROUP

Up to two WORK GROUPS may be used to price a bill item. The estimator may decide to add another Work Group to the item build-up. This is done by using the AD - Add Work Group Command. The Work Group added may be taken from the data library or built-up by the estimator from single resources or resource gangs:

```
         Commands:-
                        QU - Change Quantity
                        UN - Change Units of Measurement
                        DS - Change Description
                        AD - Add Work Group
                        CH - Change Percentage of Work Group
                        DE - Delete Work Group
                        ED - Edit Work Group
                        RR - Resource Reconciliation
                        LU - Lump other Bill Items with this one
                        FI - File Bill Item
                        VI - View Bill Item
                        PR - Print Bill Item
    Command ? AD

         Commands:-
                        DA - Data Library Build-up
                        CR - Create Item Build-up
    Command ? DA

    Work Group Code ? 6517.0

    Percentage ? [RETURN for 100%] 100

    WAIT

    Pricing from Data Library
```

If the DA - Data Library Build-up is selected the estimator will be asked to enter the Work Group Code. In this case the item will be displayed as priced from the library. If the Work Group Code does not exist then a message to this effect will be displayed and the user asked if he wishes to enter another code.

CH - CHANGE PERCENTAGE OF WORK GROUP

This facility allows the estimator to change the percentage factor which is applied to the whole Work Group. This multiplier is used to globally amend the library standard build-up to the individual contract conditions. It is possible to have a percentage figure greater or less than 100%.

```
Command ? CH

                                100
Percentage ? [RETURN for 100%] 80
```

Where more than one Work Group exists the user is asked which Work Group he wishes to change the percentage figure.

DE - DELETE WORK GROUP

The estimator may decide to delete a Work Group from the item build-up. This is done using the DE command. Where there is more than one Work Group within the build-up the estimator is asked which Work Group it is required to remove from the item.

In the example on the following page only one Work Group exists. When the item build-up is then viewed a message is given that there are no Work Groups in the bill item.

```
        Commands:-
                          QU - Change Quantity
                          UN - Change Units of Measurement
                          DS - Change Description
                          AD - Add Work Group
                          CH - Change Percentage of Work Group
                          DE - Delete Work Group
                          ED - Edit Work Group
                          RR - Resource Reconciliation
                          LU _ Lump other Bill Items with this one
                          FI - File Bill Item
                          VI - View Bill Item
                          PR - Print Bill Item
Command ? DE

        Commands:-
                          QU - Change Quantity
                          UN - Change Units of Measurement
                          DS - Change Description
                          AD - Add Work Group
                          FI - File Bill Item
                          VI - View Bill Item
                          PR - Print Bill Item
Command ? VI

WAIT

Section 2  Page 20/4
Quantity      27.5    TNNE
There are no Work Groups in this Bill Item
                                                        Press RETURN to continue
```

RR - RESOURCE RECONCILIATION

The RR - Resource Reconciliation command gives the estimator the total quantity of each resource within the item build-up.

```
Command ? RR

WAIT

RESOURCE RECONCILIATION option
```

Code	Description	Amount
L524	STEELFIXER	618.75 HR
P147	22 RB TRACKED CRANE	9.375 HR
M529	16 MM DIA MILD STEEL -CUT,BENT & DELIVER	42.131 TNNE

Press RETURN to continue

LU - LUMP OTHER BILL ITEMS WITH THIS ONE

The estimator may wish to price other bill items within the contract at the same rate and with the same resources as the item under consideration at that moment. This may be done using the LU command. The estimator will be asked:

Do you wish to locate like items?

If he replies YES, the computer system searches for all bill items that have been entered into the system with the same Work Group Code as the item being currently priced. These items are then priced automatically at the same rate.

It is also possible to add additional bill references to the list of items to be priced in a similar manner. To this list the estimator may make necessary deletions if particular items are to be considered separately.

When the estimator is satisfied with the list of items to be priced, he should use the command FI to FILE the list.

NOTE:

Any bill item that has been LUMPED may be inspected and edited at a later date. This will change the build-up of every lumped item.

Examples are now given below:

```
        Commands:-
                   QU - Change Quantity
                   UN - Change Units of Measurement
                   DS - Change Description
                   AD - Add Work Group
                   CH - Change Percentage of Work Group
                   DE - Delete Work Group
                   ED - Edit Work Group
                   RR - Resource Reconciliation
                   LU - Lump other Bill Items with this one
                   FI - File Bill Item
                   VI - View Bill Item
                   PR - Print Bill Item
  Command ? LU

        ** Bill Item 2/20/1          Filed **

  WAIT

  LUMP ITEMS option

  Do you wish to locate like items ? Y

  Searching
      List of Bill References
      -----------------------

     Section 3  Page 30/1                        52      M3
     Section 4  Page 40/1                       202      M3
       Commands :-
                  AD - Add Bill Reference
                  DE - Delete Bill Reference
                  FI - File all References
  Command ? AD

  Item Reference ? 3/30/3

  Percentage [RETURN for 100%] ? __

      List of Bill References
      -----------------------

     Section 3  Page 30/1                        52      M3
     Section 3  Page 30/3                        10.8    M3
     Section 4  Page 40/1                       202      M3
       Commands :-
                  AD - Add Bill Reference
                  DE - Delete Bill Reference
                  FI - File all References

  Command ? FI

     Reference Filed - Section 3  Page 30/1
     Reference Filed - Section 3  Page 30/3
     Reference Filed - Section 4  Page 40/1

  All References have been Filed
```

FI - FILE BILL ITEM

When the estimator is satisfied with the item build-up he should use the FI command to file the bill item details. A message will be given that this has been completed and a request made for the next item to be inspected.

```
        Commands:-
                        QU - Change Quantity
                        UN - Change Units of Measurement
                        DS - Change Description
                        AD - Add Work Group
                        CH - Change Percentage of Work Group
                        DE - Delete Work Group
                        ED - Edit Work Group
                        RR - Resource Reconciliation
                        LU _ Lump other Bill Items with this one
                        FI - File Bill Item
                        VI - View Bill Item
                        PR - Print Bill Item
 Command ? FI


           ** Bill Item 2/20/4           Filed **


 WAIT

 INSPECT BILL ITEM option


 Item Reference ? [RETURN to End]
```

VI - VIEW BILL ITEM

At any time the estimator may use the VI command to display the latest build-up details for the bill item under consideration.

PR - PRINT BILL ITEM

The estimator may decide that he requires a printed copy of the bill item build-up. This is obtained by using the PR command. A copy of a typical bill item build-up is given in figure 8, page 548.

5.4.2 UNIT RATE ESTIMATING FROM THE BUILD-UP OF RESOURCES ON THE ESTIMATORS COST FILES

A bill item may have been entered at the dataprep stage without reference to a Work Group on the company library.

When the estimator inspects the bill item, the following message is displayed.

```
                PRICE BILL ITEM menu
                --------------------

Commands :-
                DA - Data Library Build-up
                CR - Create Item Build-up
                SP - Spot Rate Build-up
                ST - Single Sum
                IN - Included in
or press RETURN to return to Main Menu
```

The estimator may use any of the methods shown to price the bill item. If he wishes to build-up a rate for the item by unit rate estimating from the resources on the contract file this may be done by the CR - Create Item Build-up command.

The example below relates to the pricing of the bill item:

2 / 20 / 3 BREAK OUT EXISTING CONCRETE 2.5M3

Interest CE 3 Bill Item

Contract Identifier		Date
MAN1	NARBOROUGH BRIDGES	06/06/82

Section 2 Page 20/4
Quantity 27.5 TNNE
100 % of Work Group G516.0
16MM DIA MILD STEEL REBAR

Code	Description	Cost/Hour	Usage	Weight Factor	Cost/TNNE
L524	STEELFIXER -	£4.50	16.500	100.0%	£74.25

Code	Description	Cost/Hour	Output	Weight Factor	Cost/TNNE
P147	22 RB TRACKED CRANE -	£6.18	4.000	100.0%	£1.55

Code	Description	Net. Cost/Unit	Usage	Wastages Per Unit	Cost/TNNE
M529	16 MM DIA MILD STEEL -CUT,BENT & DELIVER-	£304.00/TN	1.050	7.0%	£341.54

TOTAL LABOUR	COST/TNNE	£74.25
TOTAL PLANT	COST/TNNE	£1.55
TOTAL MATERIAL	COST/TNNE	£341.54
TOTAL NET COST/TNNE		£417.34

Figure 8 - A TYPICAL BILL ITEM

The estimator decides to use the following resources:

- Labourer 1.5 hours/M3
- Dumper 0.67 M3/hr
- Compressor 0.67 M3/hr
- Roadbreaker 0.67 M3/hr

Each resource is entered into the system in turn in a similar manner to that shown in

The estimator uses the CR command, and must enter a suitable classification for the bill item.

```
Command ? CR

WAIT

CREATE ITEM Build-up option

Classification ? F

WAIT
ADD RESOURCE option

Resource Code to Add ? [RETURN to End] L1

    (contract)    Description - LABOUR
                  Cost        -          $3.25/HR
OK ? Y

Description Extension ? __

Usage Rate ? 1.5

Weight Factor ? [RETURN for 100%]  ___

                                                                  Weight
Code          Description                   Cost/Hour   Usage     Factor      Cost/M3
----          -----------                   ---------   -----     -------     --------
L1      LABOUR                    -            $3.25    1.500     100.0%        $4.88
Resource Code to Add ? [RETURN to End] P19

    (contract)    Description - DUMPER      1.20M3
                  Cost        -          $2.98/HR
OK ? Y

Description Extension ? __

Output Rate ? .67

Weight Factor ? [RETURN for 100%]  ___

                                                                  Weight
Code          Description                   Cost/Hour   Output    Factor      Cost/M3
----          -----------                   ---------   ------    -------     --------
P19     DUMPER       1.20M3       -            $2.98     .670     100.0%        $4.45
```

```
Resource Code to Add ? [RETURN to End] P174

    (master)      Description - ROADBREAKER
                  Cost        -          $0.20/HR
OK ? Y

Description Extension ? ____

Output Rate ? .67

Weight Factor ? [RETURN for 100%] __

                                                          Weight
Code          Description            Cost/Hour   Output   Factor     Cost/M
----          -----------            ---------   ------   -------    ------
P174   ROADBREAKER              -      $0.20       .670    100.0%       $0.
Resource Code to Add ? [RETURN to End] P175

    (master)      Description - COMPRESSOR
                  Cost        -          $1.10/HR
OK ? Y

Description Extension ? ___

Output Rate ? .67

Weight Factor ? [RETURN for 100%] ___

                                                          Weight
Code          Description            Cost/Hour   Output   Factor     Cost/M
----          -----------            ---------   ------   -------    ------
P175   COMPRESSOR               -      $1.10       .670    100.0%       $1.
Resource Code to Add ? [RETURN to End] ____

WAIT
```

When the estimator has entered details of all the resources he requires within the item build-up he presses the RETURN key. The full build-up of the item will then be displayed. The format of the build-up is identical to that previously given for items priced from the company library. From this point the estimator may make any changes he wishes as described in Section 5.4.1. When he is satisfied with the item build-up he uses the FI command to file the details onto the contract file.

```
Section 2  Page 20/3
Quantity       2.5    M3
100    % of Classification F
BREAK OUT EXISTING CONCRETE
--------------------------------------------------------------------------------------------
                                                                   Weight
Code          Description                Cost/Hour    Usage        Factor       Cost/M3
----          -----------                ---------    -----        -------      -------
L1      LABOUR                   -         $3.25      1.500        100.0%         $4.8
                                                                   Weight
Code          Description                Cost/Hour    Output       Factor       Cost/M3
----          -----------                ---------    ------       -------      -------
P19     DUMPER      1.20M3       -         $2.98       .670        100.0%         $4.4
P174    ROADBREAKER              -         $0.20       .670        100.0%         $0.3
P175    COMPRESSOR               -         $1.10       .670        100.0%         $1.6
--------------------------------------------------------------------------------------------
                    TOTAL LABOUR      COST/M3                   $4.88
                    TOTAL PLANT       COST/M3                   $6.39
                                                           -------------
                    TOTAL NET COST/M3                          $11.26
--------------------------------------------------------------------------------------------
OK to File ? [RETURN for Yes] N
```

```
        WAIT
                          Bill Item EDIT option
                          ---------------------

             Commands:-
                          QU - Change Quantity
                          UN - Change Units of Measurement
                          DS - Change Description
                          AD - Add Work Group
                          CH - Change Percentage of Work Group
                          DE - Delete Work Group
                          ED - Edit Work Group
                          RR - Resource Reconciliation
                          LU - Lump other Bill Items with this one
                          FI - File Bill Item
                          VI - View Bill Item
                          PR - Print Bill Item
        Command ? FI

                  ** Bill Item 2/20/3          Filed **
```

5.4.3 OPERATIONAL ESTIMATING

To estimate in the operational estimating manner the user must:

(i) Create an operational group of resources;

(ii) Apply the calculated rate to the relevant bill items.

This involves the use of the CREATE/EDIT OPERATIONAL GROUPS command and the IN - INSPECT BILL ITEM command.

CREAT/EDIT OPERATIONAL GROUPS

To create an OPERATIONAL GROUP of resources the estimator uses the OP command from the main menu. The system will ask for the Operational Group Code. This is a number prefixed by OP.

The estimator should enter an appropriate code. If the Operational Group is alreadyon file the build-up will be displayed. If not the estimator will be asked if he wishes to create a new group.

If this is the case the estimator will be asked to enter:

- a description;
- units of measurement;
- the total quantity of work;
- average output per week.

The system will calculate the total number of weeks in the operation and ask whether this is acceptable.

The estimator may enter any output until the total number of weeks is satisfactory. When he enters YES this is assumed to be the total duration for the operation.

The system then requests the Number of Hours per week. The estimator should enter the average hours worked per week on the operation. Operational Groups may be made up of hourly or weekly priced plant. The estimator is then asked to enter the resources required. It is required to enter:

- the resource code;
- the number of units;
- the number of weeks;
- the allocation percentage.

Any number of the resource may be used in the operational group. The number of weeks the resource will be employed must be equal or less than the duration of the operation. Not all the cost of the resource need be allocated to one particular operational group. (eg if only 50% of the crane is to be used for operation during the period the figure should be entered and the remainder of the crane cost entered elsewhere in the estimate).

NOTE: A resource may be entered more than once. If the same type of resource is to be used within the group but for different time periods they should be entered as single resources with a different time period.

When the estimator has finished entering the resources he should type RETURN to END the listing. He will then be presented with the following list of commands.

```
Commands:-
                 DS - Change Description
                 UN - Change Units of Measurement
                 QU - Change Total Quantity
                 AV - Change Average Output
                 HR - Change Hours / Week
                 AD - Add Resource
                 VI - View Operational Group
                 PR - Print Operational Group
                 AR - Display Average Resource Requirement
                 FI - File Operational Group
Command ?
```

By entering VI the estimator may view the Operational Group Build-up. This will give details of:

- the resources within the Operational Group;
- their cost, allocation and time on the operation;
- the total cost of the operation;
- the total quantity used in the operation;
- the total number of weeks in the operation;
- the average hours worked per week;
- the average output per week;
- the plant rate for the operation;
- the labour rate for the operation;
- the total rate for the operation.

In the example given below the estimator combines the resources described in Section 5.2.2 into an Operational Group OP1 described as Plant for Placing Concrete. The build-up of the group is then displayed.

```
                    MAIN MENU
                    ---------
      Commands:-
                    IN - Inspect Bill Item
                    OP - Create/Edit Operational Group
                    UP - Update Prices
                    SC - Enter Sub-contract Quotes
                    MA - Apply Mark-ups
                    PR - Print Reports
                    HE - Set HELP Level
                    DE - Delete Bill Item
                    ST - Stop
Command ? OP

WAIT

CREATE/EDIT OPERATIONAL GROUP option


Operational Group Code ? [RETURN to End] OP2

Operational Group not on File
Do you wish to create a new Operational Group ? Y

Description ? PLANT FOR PLACING CONCRETE

Units of Measurement ? M3

Total Quantity ? 7600

Average Output per Week ? 200

Total number of Weeks in the Operation =       38.0
OK ? Y
```

```
Resource Code ? [RETURN to End] P147

22 RB TRACKED CRANE
Number of units ? 2

Number of Weeks ? 38

Allocation Percentage ? [RETURN for 100%] ___


 Code     Description           Nr.      $/Week   No Week   Alloc.       Cost
 ----     -----------           ---      ------   -------   ------       ----

 P147     22 RB TRACKED CRANE    2       $346.08     38.0     100%     $26,302.
Resource Code ? [RETURN to End] P17

CONC SKIP 0.80M3
Number of units ? 4

Number of Weeks ? 38

Allocation Percentage ? [RETURN for 100%] ___


 Code     Description           Nr.      $/Week   No Week   Alloc.       Cost
 ----     -----------           ---      ------   -------   ------       ----

 P17      CONC SKIP 0.80M3       4        $12.32     38.0     100%      $1,872.6
Resource Code ? [RETURN to End] P19

DUMPER     1.20M3
Number of units ? 6

Number of Weeks ? 38

Allocation Percentage ? [RETURN for 100%] ___


 Code     Description           Nr.      $/Week   No Week   Alloc.       Cost
 ----     -----------           ---      ------   -------   ------       ----

 P19      DUMPER     1.20M3      6       $166.88     38.0     100%     $38,048.6
Resource Code ? [RETURN to End] P516

VIBRATOR (PETROL)
Number of units ? 6

Number of Weeks ? 38

Allocation Percentage ? [RETURN for 100%] ___


 Code     Description           Nr.      $/Week   No Week   Alloc.       Cost
 ----     -----------           ---      ------   -------   ------       ----

 P516     VIBRATOR (PETROL)      6         $8.40     38.0     100%      $1,915.2
Resource Code ? [RETURN to End] ___
```

```
Commands:-
            DS - Change Description
            UN - Change Units of Measurement
            QU - Change Total Quantity
            AV - Change Average Output
            HR - Change Hours / Week
            AD - Add Resource
            CH - Change Resource Details
            DE - Delete Resource
            VI - View Operational Group
            PR - Print Operational Group
            AR - Display Average Resource Requirement
            FI - File Operational Group
Command ? VI
```

OP2 - PLANT FOR PLACING CONCRETE

Code	Description	Nr.	$/Week	No Week	Alloc.	Cost
P17	CONC SKIP 0.80M3	4	$12.32	38.0	100%	$1,872.
P19	DUMPER 1.20M3	6	$166.88	38.0	100%	$38,048.
P147	22 RB TRACKED CRANE	2	$346.08	38.0	100%	$26,302.
P516	VIBRATOR (PETROL)	6	$8.40	38.0	100%	$1,915.
			Total Cost for the Operation			$68,138.

Total Quantity used in Calculation	7600.0	M3
Total Number of Weeks in Operation	38.0	Weeks
Average Hours Per Week	56.0	
Average Output per Week	200.00	M3/Week
Plant rate for the operation	$8.97/M3	
Total Rate for the Operation	$8.97/M3	

Press RETURN to continue

The estimator may amend the operational group build-up as he requires.

Using the commands given in the menu it is possible to:

- change the basic quantities time and output for the operation;
- add, delete or change individual resources and their requirements within the group.

In the example below the estimator changes the number of 22 RB cranes required from two to three.

```
      Commands:-
                  DS - Change Description
                  UN - Change Units of Measurement
                  QU - Change Total Quantity
                  AV - Change Average Output
                  HR - Change Hours / Week
                  AD - Add Resource
                  CH - Change Resource Details
                  DE - Delete Resource
                  VI - View Operational Group
                  PR - Print Operational Group
                  AR - Display Average Resource Requirement
                  FI - File Operational Group
Command ? CH

Resource Code ? P147

 Code     Description         Nr.     $/Week   No Week  Alloc.      Cost
 ----     -----------         ---     ------   -------  ------      ----

 P147     22 RB TRACKED CRANE   2     $346.08     38.0   100%   $26,302.0
      Commands:-
                  NU - Change Number of units
                  WE - Change number of Weeks
                  AL - Change Allocation
                  VI - View Resource
      or press RETURN
Command ? NU

    2
Number of units ? 3

      Commands:-
                  NU - Change Number of units
                  WE - Change number of Weeks
                  AL - Change Allocation
                  VI - View Resource
      or press RETURN
Command ? ___
```

```
Commands:-
          DS - Change Description
          UN - Change Units of Measurement
          QU - Change Total Quantity
          AV - Change Average Output
          HR - Change Hours / Week
          AD - Add Resource
          CH - Change Resource Details
          DE - Delete Resource
          VI - View Operational Group
          PR - Print Operational Group
          AR - Display Average Resource Requirement
          FI - File Operational Group
Command ? VI
```

OP2 - PLANT FOR PLACING CONCRETE

Code	Description	Nr.	$/Week	No Week	Alloc.	Cost
P17	CONC SKIP 0.80M3	4	$12.32	38.0	100%	$1,872.6
P19	DUMPER 1.20M3	6	$166.88	38.0	100%	$38,048.6
P147	22 RB TRACKED CRANE	3	$346.08	38.0	100%	$39,453.1
P516	VIBRATOR (PETROL)	6	$8.40	38.0	100%	$1,915.2
				Total Cost for the Operation		$81,289.6

Total Quantity used in Calculation	7600.0 M3
Total Number of Weeks in Operation	38.0 Weeks
Average Hours Per Week	56.0
Average Output per Week	200.00 M3/Week
Plant rate for the operation	$10.70/M3
Total Rate for the Operation	$10.70/M3

Press RETURN to continue

DISPLAY AVERAGE RESOURCE REQUIREMENT

Using the AR command the estimator may display the Average Resource Requirement for the Operational Group. This gives details of the resources used within the group and their average output.

The example below relates to the Operational Group already built-up.

```
        Commands:-
                   DS - Change Description
                   UN - Change Units of Measurement
                   QU - Change Total Quantity
                   AV - Change Average Output
                   HR - Change Hours / Week
                   AD - Add Resource
                   CH - Change Resource Details
                   DE - Delete Resource
                   VI - View Operational Group
                   PR - Print Operational Group
                   AR - Display Average Resource Requirement
                   FI - File Operational Group
Command ? AR

 Average Resource Requirement
 ----------------------------
 Code      Description
 ----      -----------

                                                       Average
                                                   Nr. Output   Units
                                                   --- -------  -----
 P17       CONC SKIP 0.80M3                          4     .89  M3/HR
 P19       DUMPER      1.20M3                        6     .60  M3/HR
 P147      22 RB TRACKED CRANE                       3    1.19  M3/HR
 P516      VIBRATOR (PETROL)                         6     .60  M3/HR
                                                 Press RETURN to continu
```

PRINT OPERATIONAL GROUP

If the estimator decides he wishes to keep a separate record of the operational group build up he may use the command PR to obtain a printed copy. A typical copy is shown in figure 9 page 560.

Interest CE 3 Operational Group

Contract Identifier		Date
MAN1	NARBOROUGH BRIDGES	06/06/82

OP2 - PLANT FOR PLACING CONCRETE

Code	Description	Nr.	£/Week	No Week	Alloc.	Cost
P17	CONC SKIP 0.80M3	4	£12.32	38.0	100%	£1,872.64
P19	DUMPER 1.20M3	6	£166.88	38.0	100%	£38,048.64
P147	22 RB TRACKED CRANE	3	£346.08	38.0	100%	£39,453.12
P516	VIBRATOR (PETROL)	6	£8.40	38.0	100%	£1,915.20
					Total Cost for the Operation	£81,289.60

Total Quantity used in Calculation	7600.0 M3
Total Number of Weeks in Operation	38.0 Weeks
Average Hours Per Week	56.0
Average Output per Week	200.00 M3/Week
Plant rate for the operation	£10.70/M3
Total Rate for the Operation	£10.70/M3

Figure 9 - A PRINTED COPY OF AN OPERATIONAL GROUP

FILE OPERATIONAL GROUP

When the estimator is satisfied with the operational group build-up he may file the details using the FI command. The group is then stored on the computer files and may be used to price bill items from within the IN - INSPECT BILL ITEM OPTION. After filing an operational group details the user may return to the main menu by pressing the RETURN key.

NOTES:

- Operational groups may contain labour or plant or a combination of labour and plant resources.
- No material resources may be used in an operational group.
- Weekly or hourly resources may be used in an operational group.
- Labour or Plant Gangs may be used in an operational group.
- A total number of ten resources or resource gangs may be used within an operational group.
- Details of the operational groups build up may be changed at any time until the group has been used to price a bill item.
- Up to 1000 different operational groups may be held on a single contract.

USING OPERATIONAL GROUPS TO PRICE BILL ITEMS

Operational Groups may be used to price bill items by:

- adding the rate to an existing item build up;
- pricing the item solely on operational rates.

An example of each of these is given below.

Everytime that an operational group is used to price a bill item a check is made of the total quantity which the operational group has been used to price to date. This is displayed to the user along with the quantity on which the operational group is calculated. This is to ensure that the estimator does not price items over and above the original quantity envisaged so underpricing bill item rates.

ADDING AN OPERATIONAL RATE TO AN EXISTING ITEM BUILD-UP

In the example below, the operational group OP2 is used to price a bill item relating to the provision and placing of concrete. The provision of the concrete has been priced from a unit rate Work Group on the company library files. The estimator adds the operational group to cover the placing of the concrete.

The bill item is first inspected via the IN - INSPECT BILL ITEM OPTION. This displays the provision of the concrete. The estimator then adds the operational group OP1 via the ED - EDIT BILL ITEM OPTION.

MAIN MENU

Commands:-

- IN - Inspect Bill Item
- OP - Create/Edit Operational Group
- UP - Update Prices
- SC - Enter Sub-contract Quotes
- MA - Apply Mark-ups
- PR - Print Reports
- HE - Set HELP Level
- DE - Delete Bill Item
- ST - Stop

Command ? IN

WAIT

INSPECT BILL ITEM option

Item Reference ? [RETURN to End] 2/20/6

WAIT
Pricing from Data Library

WAIT

Section ? Page 20/6
Quantity 310 M3
•00 % of Work Group P237.0
DESIGN STRUCT. CONC. 20 MPA 20 MM AGGR. SRC

Code	Description	Cost/Hour	Usage	Weight Factor	Cost/M3
L513	MIXER DRIVER -	$3.41	.160	100.0%	$0.5
L514	SHOVEL OPERATOR -	$4.10	.160	100.0%	$0.6

Code	Description	Cost/Hour	Output	Weight Factor	Cost/M3
P500	21/14 MIXER -	$1.88	.160	100.0%	$11.7
P501	3M3 READY-CRETE TRUCK (1 MILE HAUL) -	$2.40	.140	100.0%	$17.1
P512	SILO (50 TONNE) -	$0.50	.160	100.0%	$3.1

Code	Description	Net. Cost/Unit	Usage	Wastages Per Unit	Cost/M3
M504	SULPHATE RESISTANT CEMENT -	$0.00/TN	.320	0.0%	$0.0

Press RETURN to continue

Code	Description	Net. Cost/Unit	Usage	Wastages Per Unit	Cost/M3
M505	SAND -	$0.00/M3	.350	0.0%	$0.0
M508	20 MM AGGR. -	$0.00/TN	1.100	0.0%	$0.0

TOTAL LABOUR	COST/M3	$1.20
TOTAL PLANT	COST/M3	$32.02
TOTAL NET COST/M3		$33.22

OK to File ? [RETURN for Yes] N

```
WAIT
                        Bill Item EDIT option
                        ---------------------


      Commands:-
                        QU - Change Quantity
                        UN - Change Units of Measurement
                        DS - Change Description
                        AD - Add Work Group
                        CH - Change Percentage of Work Group
                        DE - Delete Work Group
                        ED - Edit Work Group
                        RR - Resource Reconciliation
                        LU - Lump other Bill Items with this one
                        FI - File Bill Item
                        VI - View Bill Item
                        PR - Print Bill Item
Command ? ED

      Commands:-
                        AR - Add Resource
                        AO - Add Operational Group
                        CH - Change Resource / Operational Group Details
                        DR - Delete Resource
Command ? AO


WAIT

ADD OPERATIONAL GROUP option


Operational Group Code to Add ? [RETURN to End] OP2

 OP2     - PLANT FOR PLACING CONCRETE
 ----------------------------------------------------

 Code     Description            Nr.      $/Week  No Week  Alloc.         Cost
 ----     -----------            ---      ------  -------  ------         ----

 P17      CONC SKIP 0.90M3        4       $12.32    38.0    100%     $1,872.64
 P19      DUMPER      1.20M3      6      $166.88    38.0    100%    $38,048.64
 P147     22 RB TRACKED CRANE     3      $346.08    38.0    100%    $39,453.12
 P516     VIBRATOR (PETROL)       6        $8.40    38.0    100%     $1,915.20
                                                                   -----------
                                  Total Cost for the Operation      $81,289.60
                                                                   -----------

 Total Quantity used in Calculation    7600.0  M3
 Total Number of Weeks in Operation      38.0  Weeks
 Average Hours Per Week                  56.0
 Average Output per Week               200.00 M3/Week
 Plant rate for the operation          $10.70/M3

 Total Rate for the Operation          $10.70/M3
 ----------------------------------------------------
                                                   .Press RETURN to continue :

This increases the use of this operational group to     310.00 M3
Group was calculated on the basis of                   7600.00 M3   total use
OK ? Y

Description Extension ?

Code          Description                                              Cost/M3
----          -----------                                              -------
OP2     PLANT FOR PLACING CO                                            $10.70
        NCRETE              -
Operational Group Code to Add ? [RETURN to End] ___
```

WAIT

Section 2 Page 20/6
Quantity 310 M3
100 % of Work Group F237.0
DESIGN STRUCT. CONC. 20 MPA 20 MM AGGR. SRC

Code	Description		Cost/Hour	Usage	Weight Factor	Cost/M3
L513	MIXER DRIVER	-	$3.41	.160	100.0%	$0.5
L514	SHOVEL OPERATER	-	$4.10	.160	100.0%	$0.6

Code	Description		Cost/Hour	Output	Weight Factor	Cost/M3
P500	21/14 MIXER	-	$1.88	.160	100.0%	$11.7
P501	2M3 READY-CRETE TRUCK (1 MILE HAUL)	-	$2.40	.140	100.0%	$17.1
P512	SILO (50 TONNE)	-	$0.50	.160	100.0%	$3.1

Code	Description		Net. Cost/Unit	Usage	Wastages Per Unit	Cost/M3
M504	SULPHATE RESISTANT CEMENT	-	$0.00/TN	.320	0.0%	$0.00

Press RETURN to continue

Code	Description		Net. Cost/Unit	Usage	Wastages Per Unit	Cost/M3
M505	SAND	-	$0.00/M3	.350	0.0%	$0.00
M508	20 MM AGGR.	-	$0.00/TN	1.100	0.0%	$0.00

Code	Description		Cost/M3
OP2	PLANT FOR PLACING CONCRETE	-	$10.70

TOTAL LABOUR	COST/M3	$1.20
TOTAL PLANT	COST/M3	$42.71
TOTAL NET COST/M3		$43.92

OK to File ? [RETURN for Yes] __

** Bill Item 2/20/6 Filed **

PRICING A BILL ITEM SOLELY ON OPERATIONAL RATES

The estimator may price a bill item directly by applying operational rates. To do this he must:

- inspect the bill item via the IN command;
- use the CR - Create Item Build-up command;
- add the Operational rates via the AO command in the Edit Work Group Option.

This is shown in the example below.

The extimator prices an item

5 / 50 / 4 Placing of Concrete 150 M3

by applying the operational group rate OP2. It should be noted that when using the CR - Create Item Build Up command the system automatically asks which single resources the estimator wishes to enter. If none are to be added into the build-up then the user should immediately press RETURN. The system will indicate that the item at present contains no resources at all, and then present the usual list of options. The estimator should select the Ed - Edit Work Group Option and then add the operational group via the AO command.

```
Section 5  Page 50/4
Quantity      56      M3
WAIT
                        PRICE BILL ITEM menu
                        --------------------

       Commands :-
                        DA - Data Library Build-up
                        CR - Create Item Build-up
                        SP - Spot Rate Build-up
                        SI - Single Sum
                        IN - Included in
       or press RETURN to return to Main Menu
Command ? CR

WAIT

CREATE ITEM Build-up option

Classification ? F

WAIT
ADD RESOURCE option

Resource Code to Add ? [RETURN to End]  __

WAIT

Section 5  Page 50/4
Quantity      56      M3
100     % of Classification F

-----------------------------------------------------------------------------
There is nothing in this Work Group
OK to File ? [RETURN for Yes] N

WAIT
                        Bill Item EDIT option
                        ---------------------

       Commands:-
                        QU - Change Quantity
                        UN - Change Units of Measurement
                        DS - Change Description
                        AD - Add Work Group
                        CH - Change Percentage of Work Group
                        DE - Delete Work Group
                        ED - Edit Work Group
                        RR - Resource Reconciliation
                        LU _ Lump other Bill Items with this one
                        FI - File Bill Item
                        VI - View Bill Item
                        PR - Print Bill Item
```

```
Commands:-
                    AR - Add Resource
                    AO - Add Operational Group
Command ? AO

WAIT

ADD OPERATIONAL GROUP option


Operational Group Code to Add ? [RETURN to End] OP2

 OP2      - PLANT FOR PLACING CONCRETE
 -------------------------------------------------

 Code      Description           Nr.      $/Week   No Week  Alloc.        Cost
 ----      -----------           ---      ------   -------  ------        ----

 P17       CONC SKIP 0.80M3       4       $12.32     38.0    100%      $1,872.64
 P19       DUMPER     1.20M3      6      $166.88     38.0    100%     $38,048.64
 P147      22 RB TRACKED CRANE    3      $346.08     38.0    100%     $39,453.12
 P516      VIBRATOR (PETROL)      6        $8.40     38.0    100%      $1,915.20
                                                                      -----------
                                         Total Cost for the Operation $81,289.60
                                                                      -----------

 Total Quantity used in Calculation   7600.0  M3
 Total Number of Weeks in Operation     38.0  Weeks
 Average Hours Per Week                 56.0
 Average Output per Week              200.00 M3/Week
 Plant rate for the operation         $10.70/M3

 Total Rate for the Operation         $10.70/M3
 -------------------------------------------------
                                               Press RETURN to continue

This increases the use of this operational group to      366.00 M3
Group was calculated on the basis of                    7600.00 M3   total use
OK ? Y

Description Extension ?

Code         Description                                           Cost/M3
----         -----------                                           ---------
OP2     PLANT FOR PLACING CO                                          $10.70
        NCRETE               -
Operational Group Code to Add ? [RETURN to End]  ___


WAIT

Section 5  Page 50/4
Quantity       56      M3
100     % of Classification F

------------------------------------------------------------------------------
Code         Description                                           Cost/M3
----         -----------                                           ---------
OP2     PLANT FOR PLACING CO                                          $10.70
        NCRETE               -
------------------------------------------------------------------------------
                    TOTAL PLANT       COST/M3              $10.70
                                                       -------------
                    TOTAL NET COST/M3                      $10.70
------------------------------------------------------------------------------
OK to File ? [RETURN for Yes]    ___


        ** Bill Item 5/50/4           Filed **
```

NOTE:

In the above example the estimator, after pricing the item by the application of the operational rate OP2 immediately files the item. However, there is no reason why, if required, he should not add individual resources to the build-up via the normal menu of commands.

5.4.4 ENTRY OF "SPOT RATES"

The estimator may not wish to price a bill item by consideration of resources but by the addition of monies under the cost code categories. The SPOT RATE option allows the estimator to insert sums of money against the cost code categories of:

- Labour;
- Plant;
- Materials;
- Aux. Plant;
- Domestic Sub-contractors;
- Additional.

These sums of money are then totalled to form the item rate.

As with the CREATE ITEM BUILD-UP facility it is necessary to insert a WORK GROUP classification for the item.

```
Section 3  Page 30/5
Quantity       4.5   M3
WAIT
                       PRICE BILL ITEM menu
                       --------------------

       Commands :-
                       DA - Data Library Build-up
                       CR - Create Item Build-up
                       SP - Spot Rate Build-up
                       SI - Single Sum
                       IN - Included in
       or press RETURN to return to Main Menu
Command ? SP

WAIT

SPOT RATE Build-up option


Classification ? F

WAIT
```

ADDING A RATE

The command AD allows the estimator to enter a sum of money into the item under a chosen cost code category. It is only necessary to enter the first two letters of a category when entering it into the system.

```
Cost Code ? LAB

Rate (in $/M3  )? 12.5

     Commands :-
                    AD - Add Rate
                    CH - Change Rate
                    DE - Delete Rate
                    VI - View Item
                    DS - Change Description
                    QU - Change Bill Item Quantity
                    UN - Change Units of Measurement
                    FI - File Item
```

the estimator may then contrive to add sums under another cost code.

```
Command ? AD

Cost Code ? FLT

Rate (in $/M3  )? 15.75

     Commands :-
                    AD - Add Rate
                    CH - Change Rate
                    DE - Delete Rate
                    VI - View Item
                    DS - Change Description
                    QU - Change Bill Item Quantity
                    UN - Change Units of Measurement
                    FI - File Item
Command ? AD

Cost Code ? AUX

Rate (in $/M3  )? 4.9

     Commands :-
                    AD - Add Rate
                    CH - Change Rate
                    DE - Delete Rate
                    VI - View Item
                    DS - Change Description
                    QU - Change Bill Item Quantity
                    UN - Change Units of Measurement
                    FI - File Item
```

CHANGING A RATE

At any time the estimator may change a rate already entered via the CH command.

```
Section 3  Page 30/5
Quantity      4.5   M3
Classification : F
Description : BREAK OUT EXISTING CONCRETE
             Category                             Rate in $/M3
             --------                             ------------
               LAB.                                      12.50
               PLT.                                      15.75
               AUX.                                       4.90
                                                    ----------
                                   Item Rate          33.15 $/M3
                                   Item Cost         $149.18
           Commands :-
                              AD - Add Rate
                              CH - Change Rate
                              DE - Delete Rate
                              VI - View Item
                              DS - Change Description
                              QU - Change Bill Item Quantity
                              UN - Change Units of Measurement
                              FI - File Item
Command ? CH

Cost Code ? LAB

Rate is       12.50 $/M3
New Rate ? 13.5
```

DELETING A RATE

To delete a rate the estimator uses the DE command.

```
Command ? DE

Cost Code ? AUX

           Commands :-
                              AD - Add Rate
                              CH - Change Rate
                              DE - Delete Rate
                              VI - View Item
                              DS - Change Description
                              QU - Change Bill Item Quantity
                              UN - Change Units of Measurement
                              FI - File Item
Command ? VI

Section 3  Page 30/5
Quantity      4.5   M3
Classification : F
Description : BREAK OUT EXISTING CONCRETE
             Category                             Rate in $/M3
             --------                             ------------
               LAB.                                      13.50
               PLT.                                      15.75
                                                    ----------
                                   Item Rate          29.25 $/M3
                                   Item Cost         $131.63
           Commands :-
                              AD - Add Rate
                              CH - Change Rate
                              DE - Delete Rate
                              VI - View Item
                              DS - Change Description
                              QU - Change Bill Item Quantity
                              UN - Change Units of Measurement
                              FI - File Item
Command ? FI
```

CHANGING THE BILL ITEM QUANTITY

The estimator may decide to correct the item quantity that has been entered at the Dataprep stage. This is done in a similar manner to that described in Section

CHANGING THE UNITSOF MEASUREMENT

Similarly the estimator may wish to change the units of measurement. This has already been shown in Section 5.4.1.

CHANGING THE ITEM DESCRIPTION

If it is required to change the item description the DS command is used. This is described in Section 5.4.1.

VIEWING THE ITEM

At any time the estimator may use the VI command to view the build-up of the item rate. The following example relates to the above additions.

```
Command ? VI

Section 3   Page 30/5
Quantity      4.5    M3
Classification : F
Description : BREAK OUT EXISTING CONCRETE
      Category                          Rate in $/M3
      --------                          -------------
        LAB.                                   12.50
        PLT.                                   15.75
        AUX.                                    4.90
                                           ----------
                        Item Rate              33.15 $/M3
                        Item Cost            $149.18
     Commands :-
                  AD - Add Rate
                  CH - Change Rate
                  DE - Delete Rate
                  VI - View Item
                  DS - Change Description
                  QU - Change Bill Item Quantity
                  UN - Change Units of Measurement
                  FI - File Item
Command ? FI
```

5.4.5 PRICING AN ITEM AS 'INCLUDED IN'

The estimator may not wish to price an item at all but mark it as 'Included In' another bill rate.

This is done via the IN command.

```
Section 3  Page 30/6
Quantity     12      M3
WAIT
                    PRICE BILL ITEM menu
                    --------------------

      Commands :-
                    DA - Data Library Build-up
                    CR - Create Item Build-up
                    SP - Spot Rate Build-up
                    SI - Single Sum
                    IN - Included in
      or press RETURN to return to Main Menu
Command ? IN

WAIT

INCLUDED IN option


WAIT
Section 3  Page 30/6
BLINDING TO BASES
Quantity     12      M3

Item this is Included in with ? 3/30/4

Commands :-
                    DS - Change Description
                    CI - Change Item this is Included in with
                    QU - Change Bill Item Quantity
                    UN - Change Units of Measurement
                    FI - File Item

Command ? FI


          ** Bill Item 3/30/6           Filed **
```

5.4.6 ENTRY OF AN ITEM PRICE

The estimator may wish to price a bill item by entering a single sum of money against one of the cost code categories:

- Labour;
- Plant;
- Materials;
- Auxiliary Materials;
- Domestic Subcontractors;
- Additional.

This is done by using the SI - Single Sum command. In the example below, the estimator prices an item by entering £5000.00 against the Additional Cost Code category. Having entered the amount a simple build-up for the item is displayed and the user has the normal facilities to change his pricing details as appropriate.

```
Section 5   Page 50/5
Quantity        1       NR
WAIT
                          PRICE BILL ITEM menu
                          --------------------
        Commands :-
                          DA - Data Library Build-up
                          CR - Create Item Build-up
                          SP - Spot Rate Build-up
                          SI - Single Sum
                          IN - Included in
        or press RETURN to return to Main Menu
Command ? SI

WAIT

SINGLE SUM option


Classification ? Z

WAIT
Cost Code ? MAT

Sum ? 2500


Quantity        1       NR
Classification : Z
Description : ELECTRONIC SIGN
        Category                          Sum

           MAT.                       $2,500.00
       Commands :-
                         CH - Change Sum
                         CC - Change Cost Code
                         DS - Change Description
                         QU - Change Bill Item Quantity
                         UN - Change Units of Measurement
                         FI - File Item
Command ? FI
```

5.5 THE DE - DELETE BILL ITEM COMMAND

This command from within the Main Menu of commands of AB3RUN allows the estimator to delete a bill item from the contract file. This should not be confused with repricing items which should be performed by removing pricing data from bill items from within the INSPECT BILL ITEM COMMAND. The Delete Bill Item command removes all reference of the item from the contract files and the item will no longer appear in any print out.

```
                    MAIN MENU
                    ---------
        Commands:-
                    IN - Inspect Bill Item
                    OP - Create/Edit Operational Group
                    UP - Update Prices
                    SC - Enter Sub-contract Quotes
                    MA - Apply Mark-ups
                    PR - Print Reports
                    HE - Set HELP Level
                    DE - Delete Bill Item
                    ST - Stop
Command ? DE

WAIT

DELETE BILL ITEM option


Item Reference ? [RETURN to End] 5/50/5

Section 5  Page 50/5
Quantity        1      NR
ELECTRONIC SIGN
OK ? Y


      ** Bill Item 5/50/5            Deleted **
```

5.6 ADDING BILL ITEMS

During the tender preparation period, the estimator may be required to add additional bill items to the contract that were not evident at the dataprep stage. This is done by using the IN - Inspect Bill Item command and then inputing the bill item details in the normal fashion.

The example below relates to the addition of a bill item.

Section 5, Page 50, Item 5.

```
                    MAIN MENU
                    ---------
          Commands:-
                    IN - Inspect Bill Item
                    OP - Create/Edit Operational Group
                    UP - Update Prices
                    SC - Enter Sub-contract Quotes
                    MA - Apply Mark-ups
                    PR - Print Reports
                    HE - Set HELP Level
                    DE - Delete Bill Item
                    ST - Stop
Command ? IN

WAIT

INSPECT BILL ITEM option

Item Reference ? [RETURN to End] 5/50/5

Bill Item not on File
Do you wish to create a new Bill Item ? Y

Quantity ? 1

Units of Measurement ? NR

Work Group Code 1 ? [RETURN for no Code] ___

Description ? ELECTRONIC SIGN

Number of Sub-contractors ? [RETURN for none] ___
```

5.7 SET HELP LEVEL

After the estimator has become fully conversant with the menus of commands within the system he may suppress their display on the V.D.U. by the use of the SET HELP LEVEL command. This is shown below:

```
    Commands:-
                IN - Inspect Bill Item
                OP - Create/Edit Operational Group
                UP - Update Prices
                SC - Enter Sub-contract Quotes
                MA - Apply Mark-ups
                PR - Print Reports
                HE - Set HELP Level
                DE - Delete Bill Item
                ST - Stop
Command ? HE

         Help levels
     0 - Suppress Menus
     1 - Display Menus
Help Level ? [RETURN for 1] 0
```

With the commands suppressed the prompts presented to the estimator are minimal. Below is an example of selecting a bill listing with the system.

```
Command ? IN

WAIT

INSPECT BILL ITEM option

Item Reference ? [RETURN to End] 2/20/1

WAIT

Already Priced

WAIT
```

If at any point the estimator is unsure which command to input he should input HE and the appropriate commands available for that point in the program will be displayed.

```
WAIT
                    Bill Item EDIT option
                    ---------------------

Command ? ED

Command ? QW

Command not on Menu
        Commands:-
                    AR - Add Resource
                    AO - Add Operational Group
                    CH - Change Resource / Operational Group Details
                    DR - Delete Resource
Command ?
```

Likewise, if an incorrect command is entered the commands available will be displayed.

If the estimator wishes to have all the menus displayed he should re-set the HELP level to 1.

```
Item Reference ? [RETURN to End]

WAIT

                    MAIN MENU
                    ---------
Command ? HE

          Help levels
     0 - Suppress Menus
     1 - Display Menus
Help Level ? [RETURN for 0] 1

     Commands:-
                    IN - Inspect Bill Item
                    OP - Create/Edit Operational Group
                    UP - Update Prices
                    SC - Enter Sub-contract Quotes
                    MA - Apply Mark-ups
                    PR - Print Reports
                    HE - Set HELP Level
                    DE - Delete Bill Item
                    ST - Stop
Command ? PR
```

6.0 REPORTS AND MARK-UPS

GENERAL

This section describes the reports that may be obtained from the system and the facilities available for the conversion of the direct cost estimate into a tender by the addition of mark-up allowances. Access to these facilities is through the Main Menu of Commands of the AB3RUN program.

6.1 REPORT PRINT OUTS

Various reports may be obtained from the system. These range from formal listings of the bill items and calculated rates, to details of the estimate required for the tender adjudication meeting. The calculation of bill totals and printing of reports may be obtained by the estimator at any time during the estimating and tendering process.

In order to select the reporting facility required the user should request the PR command from the Main Menu of Commands shown below.

```
Commands:-
                        IN - Inspect Bill Item
                        OP - Create/Edit Operational Group
                        UP - Update Prices
                        SC - Enter Sub-contract Quotes
                        MA - Apply Mark-ups
                        PR - Print Reports
                        HE - Set HELP Level
                        DE - Delete Bill Item
                        ST - Stop
Command ? PR
```

Examples of each type of Print out are now given. The user should note the following important points which refer to all the print outs.

(i) It is not necessary to obtain a listing of all the items that have been priced for the contract when obtaining a report. The user will be asked the following question before any printing is instigated:

Portion of Contract to be Listed? [RETURN for whole Contract]

It is possible to obtain details of:

- all the items within the contract;
- the items in a single bill (where the contract consists of a number of bills);
- the items within a bill section;
- the items on a particular page.

To obtain details of all the items within the contract the RETURN key should be pressed. To obtain information from part of the contract the appropriate reference is input. The exact reference is dependant on the bill numbering method. Assume the items have been referenced in Bill Numbering Method 1

1 / 1 / 10 / 1

Bill Number

Section Number

Page Number

Item reference

By entering 1/ all Bill Number 1 would be listed

1/1 all Bill Number 1 Section 1 would be listed

1/1/10 would list all the items on Bill Number 1 Section 1 page 10.

If items have been referenced by Bill numbering method 1

1 / 1 / 10

Section Number

Page Number

Item Number

Entering 1/ would give all Section 1 items

1/1 would give all Page 1 items.

(ii) The System may ask the user:

Do you wish to include item build-ups not yet inspected?

Where the estimator has decided to price bill items with reference to Work Groups on the company library the bill item does not become formally priced until it has been inspected by the estimator. However print outs including data from the library may be obtained by answering YES to the above question. If NO is entered following this prompt the listings produced will only reflect those items inspected by the estimator. The print out produced will not contain any money against other items. A message will indicate the items that have not been inspected.

(iii) When a report is requested it will be necessary for the system to sort bill item details and perform calculations. The length of time taken will depend upon the computer being used and the number of bill items on the contract file. Messages will be displayed to the user in order that he may be certain that the system is performing satisfactorily and has not halted due to a malfunction. Typical messages are:

WAIT

*** Bill of Quantities Sort in Progress ***

*** Searching Contract Resources ***

*** Resource Reconciliation in Progress ***

As information is totalled messages will be given to the user eg:

"126 Sorted Bill Items now on File."

When a bill calculation is in progress the Page and Section Totals will be displayed on the screen as shown below:

```
*** Bill of Quantities Calculation ***
*** Nett Costs ***

 Nett cost of bill page  1/1                        $25,000.00
                                              --------------------
    Nett cost of bill section  1                    $25,000.00

 Nett cost of bill page  2/20                       $32,799.79
                                              --------------------
    Nett cost of bill section  2                    $32,799.79

 Nett cost of bill page  3/30                       $10,557.86
                                              --------------------
    Nett cost of bill section  3                    $10,557.86

 Nett cost of bill page  4/40                       $20,144.78
                                              --------------------
    Nett cost of bill section  4                    $20,144.78

 Nett cost of bill page  5/50                        $5,000.00
                                              --------------------
    Nett cost of bill section  5                     $5,000.00

                 Nett cost of Contract                       $93,502.43
```

(iv) When requesting calculations and listings of bill items the user must select whether to have Nett or Gross cost totals produced. This is done by entering the appropriate answer to the question

```
Command ? II
NETT or GROSS costs ? GROSS
```

(v) Within the report listing the following special markers are used to indicate to the estimator where information is still outstanding and the pricing of the bill item is not complete.

SC - Sub-contract Quote (s) outstanding .

AQ - One or more resources within the build-up are still flagged as "Awaiting Quotes".

NP - The Item is not priced at present. Either no pricing information at all has been supplied, OR the bill item has been allocated a Work Group Code or codes at the data prep stage, the item has NOT been inspected, and the user has answered "NO" to the question: "Do you wish to include Item Build-ups not yet inspected?"

The following messages can only occur when the user opts to: "Include Item Build-ups not inspected" within the bill listing totals.

NV - Not Valid. The Work Group Code has an invalid format. The software has failed or the file is corrupt.

Examples : NV1* - First Code Invalid.

NV2* - Second Code Invalid.

NV12 - Both Codes Invalid.

NF - Not Found. The Work Group Specified is not in the library.

Examples : NF1* - First Code not in Library.

NF2* - Second Code not in Library.

NF12 - Neither Code in Library.

DL - Priced Directly from Data Library.

NV and NF are so important that they over-ride other messages. So, for example, if an item has sub-contract quotes outstanding and a Work Group Code not on file only the latter fact will be displayed.

(vi) After the calculations have been performed the user will be asked to check that the printer is available for use. The message:

"Make sure printer is available (press RETURN)" will be displayed. Printing will only commence after the RETURN key has been pressed.

(vii) When listing resources, it is unnecessary to list each type of resource within the cost code category. The user is given the facility to select the range of resource numbers for which details are required. In the example below the user selects details of Material resources between numbers 1 and 50.

```
Command ? UP

WAIT

LIST UPDATE PRICES option

      Commands :-
                  WH - Whole File
                  SI - Single Resource Type
                  PA - Part of Resource Type
Command ? PA

Begin Listing at (Resource Code) ? M1

End Listing at (Resource Code) ? M50

** Sort in Progress **

There are     4 resources requiring about
        1 page(s) for Full listing
or      1 page(s) for Brief Listing
WAIT
FULL or BRIEF Listing ? FULL

Make sure Printer is available (press RETURN) ___
```

Alternatively the user may be asked to state which type of resource is required and the numbers from which he requires details.

6.1.1 LIST UPDATED PRICES

In the course of preparing the direct cost estimate for the project the estimator will need to amend the file of resource prices to suit the particular contract. This report enables him to list those amended prices. The estimator may list:

- the whole resource file;
- a single type of resource;
- part of a single resource type.

In the example below the estimator decides to list out the items that have been updated within the first twenty-five items of the plant file.

```
Command ? UP

WAIT

LIST UPDATE PRICES option


       Commands :-
                       WH - Whole File
                       ST - Single Resource Type
                       PA - Part of Resource Type
Command ? PA

Begin Listing at (Resource Code) ? P1

End Listing at (Resource Code) ? P25

** Sort in Progress **

There are     12 resources requiring about
       2 page(s) for Full listing
or     1 page(s) for Brief Listing
WAIT
FULL or BRIEF Listing ? BR

Make sure Printer is available (press RETURN)  ___
```

The print out gives the resource code, description and cost. A copy is given in figure 10, page 588.

6.1.2 LIST OPERATIONAL GROUPS

Operational groups of resources are created to price bill items on the basis of the lapsed time that groups of labour and plant resources will be required on site to undertake specific operations. These groups are unique to each contract. No data is permanently stored on the company file giving details of operational resource groups. However the user may access contract files and obtain a full breakdown of each operational group used within the contract. An example is given below and figure 11, page 589, give a copy of a typical operational group.

```
                  PRINT REPORTS Menu
                  ------------------
      Commands:-
                  UP - List Updated Prices
                  OP - List Operational Groups
                  IT - List Bill of Quantities Item Totals
                  PA - List Bill of Quantities Page Totals
                  SE - List Bill of Quantities Section Totals
                  RR - List Resource Reconciliation
                  CO - List Contract Resources
                  OU - List Contract Resources Awaiting Quotes
                  NQ - List Contract Resources Not Awaiting Quotes
                  WU - List Where Resources Used
                  CR - List Where Created Build-ups Used
                  SC - List Where Outstanding Sub-contract Quotes are
                  UN - List Unpriced Bill Items
                  TR - List Bill Items by Trade Classification
                  ST - Stop
      or press RETURN to return to Main Menu
Command ? OP

WAIT

LIST OPERATIONAL GROUPS option


** Sort in Progress **

There are      1 Operational group(s) requiring the same number of page(s)
WAIT
Make sure Printer is available (press RETURN)
```

Date : 20/06/82

Interest CE 3 Contract Resource Listing

Page 1

Plant (Hourly)

P2 Description - BAR BEND MACHINE PWR DRV UP TO 55MM BARS
Cost - £4.12/HR

P3 Description - BAR SHEAR MACHINE PWR DRV UP TO 55 MM BA
Cost - £3.45/HR

P4 Description - PORTBLE COMPRESSOR 11.43M3 /MIN INC HOSE
Cost - £8.75/HR

P5 Description - CONC MIXER/BTCH WEIGHER /LOADING SHOVEL
Cost - £3.45/HR

P6 Description - PAN MORTAR MIXER (0.91M DIA)
Cost - £1.34/HR

P10 Description - POWER FLOAT
Cost - £0.75/HR

P12 Description - EXC CRANE TRCKD UP TO 6 TONNES (DERV
Cost - £14.85/HR

P18 Description - CHAIN SLING 10MM DOUBLE
Cost - £0.02/HR

P19 Description - DUMPER 1.20M3
Cost - £2.98/HR

P21 Description - DUMP TRUCK 10.5M3
Cost - £12.98/HR

P24 Description - GENERATOR 1KVA
Cost - £0.85/HR

P25 Description - TRANSFORMER 1KVA
Cost - £0.05/HR

Figure 10 - A SECTION FROM THE LIST UPDATED PRICES PRINT OUT

Date : 20/06/82

Interest OF 3 Contract Resource Listing

Operational Rate

OP1 - PLANT FOR PLACING CONCRETE

Code	Description	Nr.	£/Week	No Week	Alloc.	Cost
P17	CONC SKIP 0.60M3	4	£12.32	38.0	100%	£1,872.64
P19	DUMPER 1.20M3	6	£108.64	38.0	100%	£24,769.92
P147	22 RB TRACKED CRANE	3	£346.08	38.0	100%	£39,453.12
P516	VIBRATOR (PETROL)	6	£8.40	38.0	100%	£1,915.20
			Total Cost for the Operation			£68,010.89

Total Quantity used in Calculation	7600.0 M3
Total Number of Weeks in Operation	38.0 Weeks
Average Hours Per Week	56.0
Average Output per Week	200.00 M3/Week
Plant rate for the operation	£8.95/M3
Total Rate for the Operation	£8.95/M3

Figure 11 - A PRINT OUT OF AN OPERATIONAL GROUP BUILD-UP

6.1.3 LIST BILL OF QUANTITIES ITEM TOTALS

The command IT enables the user to produce a list of the total of each bill item within the whole or part of the project. The user will be asked whether NETT rates or GROSS rates are required. It is possible to select whether the print out produced will include:

- the rate of each item within the different cost code categories ; or
- the sum of money within the different cost code categories together with a total of the additions added for each item and the gross cost.

Examples of the different printouts are shown in figures 12 to 16 inclusive, page 592 to 596.

At the start of each printout details of any mark-up additions to the bill items are given in order that the user may be fully aware of the make-up of the item prices. At the start of the NETT cost printout details of any surcharges are given. At the start of the GROSS cost printout details of any surcharges, on-costs, distributed sums and rate loading are given. Where a GROSS cost printout is requested the NETT cost is first calculated and the total displayed.

After the listing of bill item totals a trade summary is given of the portion of the bill printed out with the monies in each cost category listed.

At the end of the printout the option is given to the user of obtaining further reports from the calculations that have been made. Where the calculation of the complete bill has been made the user may obtain:

- a summary of item totals;
- a summary of page totals;
- a summary of section totals.

In the example below the estimator has already obtained a printout of the NETT item sums for the contract. He then selects a Summary of Section Totals.

```
Command ? IT

NETT or GROSS costs ? NETT

                    PRINT-OUT FORMAT
                    ----------------
                    RA - Rates
                    SU - Nett Sums and Additions
Command ? SU

Portion of Contract to be Listed ? [RETURN for Whole Contract] __

WAIT
*** Bill of Quantities Sort in progress ***

                     28 Sorted bill items now on file

WAIT
*** Resource Calculation in Progress ***
```

Interest CE 3

```
CAE. COMPUTER-AIDED ESTIMATING  -  NARBOROUGH BRIDGES          TIME:          DATE: 20/06/82

Consulting Engineers: R.F.T.                  Reference Code: MAN1

Client: NARBOROUGH C.C.                       Estimator: BLACK

Tender Submission Date: 30/06/82              Planner: WHITE

                                                                   PAGE:    1

BILL LISTING :

MARK - UPS  (NETT. )

                 Surcharges
                 ----------
                 LAB.        0    %
                 PLT.        0    %
                 AUX.        0    %
                 MAT.        0    %
                 DOM.        0    %
                 ADD.        0    %
WAIT

Print Bill Item Descriptions [RETURN for No] ? Y

Make sure Printer is available (press RETURN)


*** Bill of Quantities Item Summary( Sums) Listing in Progress ***
```

Figure 12 - BILL LISTING - MARK-UPS (NET)

Interest CE 3

CAE. COMPUTER-AIDED ESTIMATING - NARBOROUGH BRIDGES   TIME: DATE: 20/06/82

Consulting Engineers: R.P.T.   Reference Code: MAN1

Client: NARBOROUGH C.C.   Estimator: BLACK

Tender Submission Date: 30/06/82   Planner: WHITE

PAGE: 6

BILL LISTING :

TRADE SUMMARY(NETT SUMS+)

		Nett.Cost	Additions	Gross Cost
E: Earthworks	-	£6,298.50		
F: In situ concrete	-	£24,447.41		
G: Concrete ancillaries	-	£32,409.00		
Z: Miscellaneous work	-	£6,460.00		

Figure 13 - BILL LISTING TRADE SUMMARY

Interest CE 3

CAE. COMPUTER-AIDED ESTIMATING - NARBOROUGH BRIDGES   TIME: DATE: 20/06/82

Consulting Engineers: R.P.T.   Reference Code: MAN1

Client: NARBOROUGH C.C.   Estimator: BLACK

Tender Submission Date: 30/06/82   Planner: WHITE

PAGE: 2

BILL LISTING :

ITEM SUMMARY(NETT SUMS+)

Section 2 Page 20

ITEM	P C.& PROV.	LABOUR	PLANT	AUX.PLANT	MATERIALS	DOM. S/C	OTHER	NETT. COST	ADDITIONS	GROSS COST	
1		£299.52	£619.52	£0.00	£0.00	£0.00	£0.00	£919.04			DL
2		£808.96	£128.00	£0.00	£1,305.60	£0.00	£0.00	£2,242.56			DLAO
3	BREAK OUT EXISTING CONCRETE	£8.08	£5.40	£0.00	£0.00	£0.00	£0.00	£13.48			
4		£3,037.50	£0.00	£0.00	£13,167.00	£0.00	£0.00	£16,204.50			DL
5	INCLUDED IN										
6	DESIGN STRUCT. CONC. 20 MPA 20 MM AGGR. SRC	£372.00	£12,700.70	£0.00	£0.00	£0.00	£0.00	£13,072.70			AO
7	CLASS F1 FORMWORK >300MM WIDE Not yet Inspected										SCNP
8		£80.62	£38.15	£0.00	£228.75	£0.00	£0.00	£347.52			DLAO
9	SUPPLY PRECAST CONC. BEAMS Not yet Inspected										SCLF
PAGE TOTAL	£0.00	£4,606.68	£13,491.77	£0.00	£14,701.35	£0.00	£0.00	£32,799.80			
SECT TOTAL	£0.00	£4,606.68	£13,491.77	£0.00	£14,701.35	£0.00	£0.00	£32,799.80			

Figure 14 - BILL LISTING - ITEM SUMMARY

Interest CE 3

CAE. COMPUTER-AIDED ESTIMATING - NARBOROUGH BRIDGES	TIME:	DATE: 30/06/82

Consulting Engineers: R.F.T. — Reference Code: MAN1

Client: NARBOROUGH C.C. — Estimator: BLACK

Tender Submission Date: 30/06/82 — Planner: WHITE

PAGE: 1

BILL LISTING :

SECT SUMMARY(NETT SUMS+)

SECT	P.C.& PROV.	LABOUR	PLANT	AUX.PLANT	MATERIALS	DOM. S/C	OTHER	NETT. COST	ADDITIONS	GROSS COST	
1	£30,000.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£30,000.00			
2	£0.00	£4,606.68	£13,491.77	£0.00	£14,701.35	£0.00	£0.00	£32,799.80			AQ
3	£0.00	£1,287.54	£5,211.00	£0.00	£4,057.30	£0.00	£0.00	£10,557.86			AQ
4	£0.00	£3,258.16	£6,481.52	£0.00	£10,405.10	£0.00	£0.00	£20,144.79			AQ
5	£5,000.00	£0.00	£0.00	£0.00	£0.00	£0.00	£5,000.00	£5,000.00			
BILL TOTAL	£35,000.00	£9,154.39	£25,184.29	£0.00	£29,163.75	£0.00	£5,000.00	£98,502.44			

Figure 16 - BILL LISTING - SECTION SUMMARY

6.1.4 LIST OF BILL OF QUANTITIES PAGE TOTALS

The estimator may not require a listing of all the item prices in the bill but a printout giving the Page Totals. These may be obtained by using the PA command. The user may select whether NETT or GROSS cost totals are printed.

In the example below the estimator selects the NETT rate Page Totals listing for the contract. An example of the printout is given in figure 17 page 598. As before a Trade Summary listing is also produced for the portion of the bill requested.

```
                    PRINT REPORTS Menu
                    ------------------
    Commands:-
                    UP - List Updated Prices
                    OP - List Operational Groups
                    IT - List Bill of Quantities Item Totals
                    PA - List Bill of Quantities Page Totals
                    SE - List Bill of Quantities Section Totals
                    RR - List Resource Reconciliation
                    CO - List Contract Resources
                    QU - List Contract Resources Awaiting Quotes
                    NQ - List Contract Resources Not Awaiting Quotes
                    WU - List Where Resources Used
                    CR - List Where Created Build-ups Used
                    SC - List Where Outstanding Sub-contract Quotes are
                    UN - List Unpriced Bill Items
                    TR - List Bill Items by Trade Classification
                    ST - Stop
    or press RETURN to return to Main Menu
Command ? PA

NETT or GROSS costs ? NETT

Portion of Contract to be Listed ? [RETURN for Whole Contract] 2/

WAIT
*** Resource Calculation in Progress ***
```

6.1.5 LIST OF BILL OF QUANTITIES SECTION TOTALS

In a similar manner to the List of Bill of Quantities Page Totals it is possible to obtain a list of Bill Section Totals. The totals given may be NETT or GROSS. An example of the printout is given in figure 16, page 596.

Interest CE 3

CAE. COMPUTER-AIDED ESTIMATING - NARBOROUGH BRIDGES

TIME:

DATE: 20/06/82

Consulting Engineers: R.P.T.

Reference Code: MAN1

Client: NARBOROUGH C.C.

Estimator: BLACK

Tender Submission Date: 30/06/82

Planner: WHITE

PAGE: 2

BILL LISTING :

PAGE SUMMARY(NETT SUMS+)

Section 2

PAGE	P.C.& PROV.	LABOUR	PLANT	AUX.PLANT	MATERIALS	DOM. S/C	OTHER	NETT. COST	ADDITIONS	GROSS COST
20	£0.00	£4,606.68	£13,491.77	£0.00	£14,701.35	£0.00	£0.00	£32,799.80		
SECT.TOTAL	£0.00	£4,606.68	£13,491.77	£0.00	£14,701.35	£0.00	£0.00	£32,799.80		

AO

Figure 17 - BILL LISTING - PAGE SUMMARY

6.1.6 LIST RESOURCE RECONCILIATION

Because the complete build-up of each bill item is stored on the contract file it is possible to obtain the total amount of each resource (say Concrete Class E) that is required within a particular section or the whole project. It is possible to select which type of resource (Labour, Plant, Materials etc) for which information is required to be listed and within that resource type a range of resource numbers (ie all materials coded M1 to M30 say Reinforcement).

In the example below a reconciliation listing is produced for all Materials coded between M1 and M500 in Section 2 of the contract. A copy of the printout produced is shown in figure 18, page 601 . For each resource the basic amount is given and the direct cost. Also printed out is the total wastage allowance and the direct cost of this wasted resource.

After this listing it is possible to obtain other reports for that portion of the contract without having to wait while the calculations are performed. These reports are:

- List of resources awaiting quotations;
- List of resources not awaiting quotations;
- List of Contract resources.

In this example the user decides to select a listing of all the resources that were awaiting quotations in Section 2. A copy of the printout is shown in figure 19, page 603.

```
Command ? RR
Portion of Contract to be Listed ? [RETURN for Whole Contract] 2/
WAIT
Do you wish to Include Item Build-ups not yet Inspected ? Y
```

```
*** Resource Reconciliation Calculation in Progress ***

*** Searching Contract Resources ***

Scanning 2/20/1
              E444.0        - EXCAVATE AND CART AWAY
Scanning 2/20/2
              E645.0        - SUPPLY AND COMPACT IMPORTED FILL
Scanning 2/20/3
              F             - BREAK OUT EXISTING CONCRETE
Scanning 2/20/4
              G516.0        - 16MM DIA MILD STEEL REBAR
Scanning 2/20/6
              F237.0        - DESIGN STRUCT. CONC. 20 MPA  20 MM AGGR.  SRC
Scanning 2/20/8
              Z999.9        - MANHOLE 1067MM DIA 1.5M DEEP
Scanning 2/20/8
              Z999.8

WAIT

                  Section 2

Specify which Type of Resource [RETURN for All] ?.M

Specify Resource listing Limits [RETURN for NO] ?   500

Make sure Printer is available (press RETURN)

*** Resource Reconciliation Listing in Progress ***
```

Interest CE 3

CAE. COMPUTER-AIDED ESTIMATING - NARBOROUGH BRIDGES

TIME: DATE: 20/06/82

Consulting Engineers: K.P.T.

Client: NARBOROUGH C.C.

Tender Submission Date: 30/06/82

Reference Code: MAN1

Estimator: BLACK

Planner: WHITE

PAGE: 1

Section 2

Material Resource Reconciliation

Resource	Description	Basic Amount	Direct Cost	Wastage	Direct Cost
M172	IMPORTED GRANULAR MATERIAL TYPE A	256.00 T	£1,305.60*	256.00 T	£1,305.60*
M191	CONCRETE CLASS E	1.96 M3	£54.88*	1.96 M3	£54.88*
M382	PRECAST CONC RING 1067MM DIA	1.97 M	£59.10*	1.97 M	£59.10*
M383	FORMWORK TO M/H 1067 MM DIA	9.51 M2	£47.55	9.51 M2	£47.55
M384	COMMONS	.07 THOU	£4.09*	.07 THOU	£4.09*
M385	MANHOLE COVER AND FR AME	1.00 NR	£27.00*	1.00 NR	£27.00*
M386	STEP IRONS	5.97 NR	£9.13*	5.97 NR	£9.13*
M387	COVER SLAB TO M/H 1067MM DIA	1.00 NR	£27.00*	1.00 NR	£27.00*

Figure 18 - RESOURCE RECONCILIATION LISTING

```
                    List Menu for: Section 2
                    --------------

      Commands:-
                    QU - List Resources Awaiting Quotes
                    NQ - List Resources Not Awaiting Quotes
                    CO - List Contract Resources
Command [RETURN to Exit] ? QU


                    Section 2

Specify which Type of Resource [RETURN for All] ? M

Specify Resource listing Limits [RETURN for NO] ? 500

Make sure Printer is available (press RETURN)


*** Awaiting Quotes Resource Listing in Progress ***
```

Interest CE 3

CAE. COMPUTER-AIDED ESTIMATING - NARBOROUGH BRIDGES

TIME:

DATE: 20/06/82

Consulting Engineers: R.P.T.

Client: NARBOROUGH C.C.

Tender Submission Date: 30/06/82

Reference Code: MAN1

Estimator: BLACK

Planner: WHITE

PAGE: 1

Section 2

Material Resources Awaiting Quotes

Resource	Description	Cost/Unit	Discount	Supplier's Name
M172	IMPORTED GRANULAR MATERIAL TYPE A	£5.10 *T		
M191	CONCRETE CLASS E	£28.00 *M3		
M382	PRECAST CONC RING 1067MM DIA	£30.00 *M		
M384	COMMONS	£58.00 *THOU		
M385	MANHOLE COVER AND FR AME	£27.00 *NR		
M386	STEP IRONS	£1.53 *NR		
M337	COVER SLAB TO M/H 1067MM DIA	£27.00 *NR		

Figure 19 - MATERIAL RESOURCES AWAITING QUOTES LISTING

6.1.7 LIST CONTRACT RESOURCES

Using the CO command the estimator may obtain a listing of all the resources required for the complete contract or a portion of the contract. After having selected the portion of the contract to be listed, and whether the listing should include item build-ups not yet inspected the system displays the number of bill items within the file and the Bill of Quantities items as they are scanned.

In the example below, the estimator requests a listing of all the resources required in Section 2 of the bill to be listed.

```
Command ? CO

Portion of Contract to be Listed ? [RETURN for Whole Contract] 2/

WAIT
Do you wish to Include Item Build-ups not yet Inspected ? Y

*** Searching Contract Resources ***


Specify which Type of Resource [RETURN for All] ? M


Specify Resource listing Limits [RETURN for NO] ? 500

Make sure Printer is available (press RETURN)



*** Contract Resource Listing in Progress ***
```

A copy of the printout is shown in figure 20, page 605. Details are given of the Resource Code, description and cost per unit. At the end of the printing of the resources the estimator may select alternative reports on those resources that are awaiting or not awaiting quotations.

Interest CE 3

CAE. COMPUTER-AIDED ESTIMATING - NARBOROUGH BRIDGES   TIME: DATE: 20/06/82

Consulting Engineers: R.P.T.   Reference Code: MAN1

Client: NARBOROUGH C.C.   Estimator: BLACK

Tender Submission Date: 30/06/82   Planner: WHITE

PAGE: 1

Section 2

Material Contract Resources

Resource	Description	Cost/Unit	Discount	Supplier's Name
M172	IMPORTED GRANULAR MATERIAL TYPE A	£5.10 *T		
M191	CONCRETE CLASS E	£28.00 *M3		
M3C2	PRECAST CONC RING 1067MM DIA	£30.00 *M		
M383	FORMWORK TO M/H 1067 MM DIA	£5.00 M2		
M3P4	COMMONS	£58.00 *THOU		
M305	MANHOLE COVER AND FR AME	£27.00 *NR		
M386	STEP IRONS	£1.53 *NR		
M3P7	COVER SLAB TO M/H 1067MM DIA	£27.00 *NR		

Figure 20 - CONTRACT RESOURCES MATERIALS

6.1.8 LIST CONTRACT RESOURCES AWAITING QUOTES

The QU command enables the estimator to list the resources within the contract for which quotations are still required. A list may be prepared for all the contract or a particular portion of the contract.

In the example below the estimator requests a list of the resources for which quotes are outstanding within Section 2 of the Bill. The printout produced is shown in figure 21, page 607. It should be remembered that when a resource quotation has been received the resource may still be left as awaiting quotations while an alternative cheaper price is sought. The printout therefore contains the resource code, description and present suppliers name and discount.

```
Command ? QU
Portion of Contract to be Listed ? [RETURN for Whole Contract] 2/
WAIT
Do you wish to Include Item Build-ups not yet Inspected ? Y


              Section 2

Specify which Type of Resource [RETURN for All] ? M

Specify Resource listing Limits [RETURN for NO] ? 500
Make sure Printer is available (press RETURN)      ___


*** Awaiting Quotes Resource Listing in Progress ***
```

Interest CE 3

CAE. COMPUTER-AIDED ESTIMATING - NARBOROUGH BRIDGES

TIME: DATE: 20/06/82

Consulting Engineers' R.F.T.

Reference Code: MAN1

Client: NARBOROUGH C.C.

Estimator: PLACK

Tender Submission Date: 30/06/82

Planner: WHITE

PAGE: 1

Section 2

Material Resources Awaiting Quotes

Resource	Description	Cost/Unit	Discount	Supplier's Name
M172	IMPORTED GRANULAR MATERIAL TYPE A	£5.10 *T		
M191	CONCRETE CLASS E	£28.00 *M3		
M382	PRECAST CONC RING 1067MM DIA	£30.00 *M		
M384	COMMONS	£58.00 *THOU		
M385	MANHOLE COVER AND FR AME	£27.00 *NR		
M386	STEP IRONS	£1.53 *NR		
M387	COVER SLAB TO M/H 1067MM DIA	£27.00 *NR		

Figure 21 - CONTRACT RESOURCES AWAITING QUOTES LISTING

After the completion of the printout the user is given the option of obtaining:

- List of Resources Not Awaiting Quotes;
- List of Contract Resources;

for the same portion of the bill. This saves having to wait while the scanning sorting of the respective resources is undertaken.

6.1.9 LIST RESOURCES NOT AWAITING QUOTES

In a similar manner the NQ command enables the estimator to obtain a listing of resources that are not awaiting quotations.

In the following example the estimator requests a printout of these resources for bill section number 2. A copy of the printout is given in figure 22, page 610.

```
                    PRINT REPORTS Menu
                    ------------------
      Commands:-
                    UP - List Updated Prices
                    OP - List Operational Groups
                    IT - List Bill of Quantities Item Totals
                    PA - List Bill of Quantities Page Totals
                    SE - List Bill of Quantities Section Totals
                    RR - List Resource Reconciliation
                    CO - List Contract Resources
                    QU - List Contract Resources Awaiting Quotes
                    NQ - List Contract Resources Not Awaiting Quotes
                    WU - List Where Resources Used
                    CR - List Where Created Build-ups Used
                    SC - List Where Outstanding Sub-contract Quotes are
                    UN - List Unpriced Bill Items
                    TR - List Bill Items by Trade Classification
                    ST - Stop
      or press RETURN to return to Main Menu
Command ? NQ

Portion of Contract to be Listed ? [RETURN for Whole Contract] 2/

WAIT
Do you wish to Include Item Build-ups not yet Inspected ? Y

*** Searching Contract Resources ***


Scanning 2/20/1
              E444.0       - EXCAVATE AND CART AWAY
Scanning 2/20/2
              E645.0       - SUPPLY AND COMPACT IMPORTED FILL
Scanning 2/20/3
              F            - BREAK OUT EXISTING CONCRETE
Scanning 2/20/4
              R516.0       - 16MM DIA MILD STEEL REBAR
Scanning 2/20/6
              F237.0       - DESIGN STRUCT. CONC. 20 MPA  20 MM AGGR.  SRC
Scanning 2/20/8
              Z999.9    .  - MANHOLE 1067MM DIA 1.5M DEEP
Scanning 2/20/8
              Z999.8

WAIT


                    Section 2


Specify which Type of Resource [RETURN for All] ? M


Specify Resource listing Limits [RETURN for NO] ? 500

Make sure Printer is available (press RETURN)   ___
```

Interest CE 3

CAE. COMPUTER-AIDED ESTIMATING - NARBOROUGH BRIDGES

TIME: DATE: 20/06/82

Consulting Engineers: R.F.T.

Reference Code: MAN1

Client: NARBOROUGH C.C.

Estimator: BLACK

Tender Submission Date: 30/06/82

Planner: WHITE

PAGE: 1

Section 2

Material Resources Not Awaiting Quotes

Resource	Description	Cost/Unit		Discount	Supplier's Name
M383	FORMWORK TO M/H 1067 MM DIA	£5.00	M2		
M529	16 MM DIA MILD STEEL -CUT,BENT & DELIVER	£304.00	TNNE		

Figure 22 - RESOURCES NOT AWAITING QUOTES

6.1.10 LIST WHERE RESOURCES USED

This report produces for the estimator a listing showing where in the bill resources are used. The estimator may scan all the bill or a particular section or page. He is asked which type of resource (Labour, Plant, Material etc) a report is required for and the range of resource numbers for which he demands details. That portion of the bill is then scanned and a printout produced showing for each resource:

- the resource code;
- the resource description;
- the net cost;
- in which items the resource has been used;
- the quantity required;
- the total quantity and total nett cost.

The example below relates to Labour resources. A portion of the printout is given in figure 23, page 612.

```
                    PRINT REPORTS Menu
                    ------------------
      Commands:-
                    UP - List Updated Prices
                    OP - List Operational Groups
                    IT - List Bill of Quantities Item Totals
                    PA - List Bill of Quantities Page Totals
                    SE - List Bill of Quantities Section Totals
                    RR - List Resource Reconciliation
                    CO - List Contract Resources
                    OU - List Contract Resources Awaiting Quotes
                    NQ - List Contract Resources Not Awaiting Quotes
                    WU - List Where Resources Used
                    CR - List Where Created Build-ups Used
                    SC - List Where Outstanding Sub-contract Quotes are
                    UN - List Unpriced Bill Items
                    TR - List Bill Items by Trade Classification
                    ST - Stop
      or press RETURN to return to Main Menu
Command ? WU

Portion of Contract to be Listed ? [RETURN for Whole Contract] __

WAIT
Do you wish to Include Item Build-ups not yet Inspected ? Y

Specify which Type of Resource ? L

List Resources from [RETURN for 1] ? __

To [RETURN for Highest] ? 10
```

Interest CE 3

CAE. COMPUTER-AIDED ESTIMATING - NARBOROUGH BRIDGES TIME: DATE: 20/06/82

Consulting Engineers: R.F.T. Reference Code: MAN1

Client: NARBOROUGH C.C. Estimator: BLACK

Tender Submission Date: 30/06/82 Planner: WHITE

PAGE: 2

Labour Where-Used Listing Resources Between L1 and L10

L1	LABOUR		Nett Cost	£2.14/HR		
		Section 2 Page 20/2			376.32 HR	
		Section 2 Page 20/3			3.75 HR	
		Section 3 Page 30/2			76.44 HR	
		Section 4 Page 40/2			296.94 HR	
				Total Quantity	753.45 HR	
					Total Nett Cost	£1,612.38
L2	DRIVER		Nett Cost	£3.50/HR		
		Section 2 Page 20/1			85.504 HR	
		Section 3 Page 30/1			17.368 HR	
		Section 4 Page 40/1			67.468 HR	
				Total Quantity	170.34 HR	
					Total Nett Cost	£596.19

Figure 23 - LISTING OF WHERE RESOURCES USED

6.1.11 LIST WHERE CREATED BUILD-UPS USED

During the course of preparing the estimate for the project the estimator will inevitably create build-up of resources in order to price bill items on a unit rate basis. This report enables the estimator to list which bill items have been priced with created build-ups. Should he then require a printout of the respective bill item for record purposes or for entry onto the library files the estimator may inspect the respective bill item and obtain a printout of item build-up.

An example of the listing obtained by the CR command is given in figure 24, page 614.

6.1.12 LIST WHERE OUTSTANDING SUBCONTRACT QUOTES ARE

As the title suggests this command instigated by entering SC provides the user with a listing of all the bill items that have been labelled as due to be priced by subcontractor quotation but as yet have not been priced. The quantity of work involved in the item is printed out. An example is given in figure 25, page 615.

6.1.13 LIST UNPRICED BILL ITEMS

The command UN produces a report of all the unpriced items within the estimate. This may of course be produced for the complete bill or a subsection. Where items have been referenced to Work Groups on the company library this is indicated by the message

(Library Codes) printed alongside the item.

Figure 26, page 616, shows an example of this report.

Interest CE 3

CAE. COMPUTER-AIDED ESTIMATING - NARBOROUGH BRIDGES   TIME: DATE: 20/06/82

Consulting Engineers: R.P.T.   Reference Code: MAN1

Client: NARBOROUGH C.C.   Estimator: BLACK

Tender Submission Date: 30/06/82   Planner: WHITE

PAGE: 1

Where Created Build-ups Used Listing

Section 2 Page 20/3   Quantity 2.5 M3
BREAK OUT EXISTING CONCRETE

Figure 24 - WHERE CREATED BUILD-UPS USED LISTING

Interest CE 3

CAE. COMPUTER-AIDED ESTIMATING - NARBOROUGH BRIDGES TIME: DATE: 20/06/82

Consulting Engineers: R.F.T. Reference Code: MAN1

Client: NARBOROUGH C.C. Estimator: BLACK

Tender Submission Date: 30/06/82 Planner: WHITE

PAGE: 1

Unpriced Bill Items Listing

Section 1 Page 1/1 PROVIDE BOND	Item
Section 1 Page 1/2 DIVERSION OF EXISTING STREAM	Item
Section 1 Page 1/3 TEMPORARY WORKS FOR DIVERSION OF STREAM	Item
Section 1 Page 1/7 ADD FOR ATTENDANCE	Attendance on Section 1 Page 1/5
Section 1 Page 1/9 ADD FOR PROFIT	P.C. Profit on Section 1 Page 1/8
Section 2 Page 20/1	Quantity 256 M3 (Library Codes)
Section 2 Page 20/2	Quantity 256 M3 (Library Codes)
Section 2 Page 20/4	Quantity 37.5 TNNE (Library Codes)

Figure 25 - UNPRICED BILL ITEMS LISTING

Interest CE 3

CAE. COMPUTER-AIDED ESTIMATING - NARBOROUGH BRIDGES   TIME: DATE: 20/06/82

Consulting Engineers' R.F.T.   Reference Code: MAN1

Client: NARBOROUGH C.C.   Estimator: BLACK

Tender Submission Date: 30/06/82   Planner: WHITE

PAGE: 1

Outstanding Sub-contract Quotes Listing

Section 2 Page 20/7 CLASS F1 FORMWORK >300MM WIDE	Quantity	40	M2
Section 2 Page 20/9 SUPPLY PRECAST CONC. BEAMS	Quantity	18	NR

Figure 26 - OUTSTANDING SUB-CONTRACTOR QUOTES LISTING

6.1.14 LIST BILLS BY TRADE CLASSIFICATION

This command is instigated by using the command TR from the PRINT REPORT Menu. A report is produced giving details of all the bill items within the portion of the bill requested that belong to a specific trade classification.

Figure 27 page 618 shows part of a report that listed the bill items that were classified under the class E - Earthworks.

6.1.15 STOP

This command stops the program and after closing all the files returns to the operating system.

If the user wishes to return to the main menu of the program the RETURN key should be pressed.

6.2 MARK-UPS

This section describes the facilities that exist within the system to add a mark-up allowance to a direct cost estimate in order to produce a tender sum. This may be performed by either adding a sum of money and apportioning that money throughout the items in the bill or by adding a percentage addition to various cost categories within the estimate. When the total tender sum has been produced it is possible to rate-load bill items ie increase individual item rates by a percentage while other item rates are proportionally reduced to keep the total tender sum constant.

To apply MARK-UPS the command MA is used from the Main Menu of commands. This provides the estimator with the facility to add:

- SU Surcharges;
- PR Profits:

Interest CE 3

CAE. COMPUTER-AIDED ESTIMATING - NARBOROUGH BRIDGES

TIME:

DATE: 20/06/82

Consulting Engineers: R.F.T.

Client: NARBOROUGH C.C.

Tender Submission Date: 30/06/82

Reference Code: MAN1

Estimator: BLACK

Planner: WHITE

PAGE: 1

Bill Items of Trade Classification E: Earthworks

Section 2 Page 20/1	Quantity	256	M3
Section 2 Page 20/2	Quantity	256	M3
Section 3 Page 30/1	Quantity	52	M3
Section 3 Page 30/2	Quantity	52	M3
Section 4 Page 40/1	Quantity	202	M3
Section 4 Page 40/2	Quantity	202	M3

Figure 27 - LISTING OF BILL ITEMS BY TRADE CLASSIFICATION

- OV Overheads:
- ON On-costs:
- DS Distributed Sum:
- RL Rate Load.

The estimator may enter or change MARK-UP factors at any stage during the estimating and tendering process. Where factors have already been added before, their values will be displayed to enable the estimator to check item.

NOTE: Each mark-up figure is calculated separately based upon the direct cost total. These separate mark-up allowances are then totalled and added to the direct cost (or NETT cost) to produce a GROSS cost figure.

Mark-up factors may be positive or negative as the user wishes. If it is wished to DEDUCT a certain percentage of a sum of money a minus sign must be input before the allowance.

The selection of the MARK-UP command is shown below and then each of the facilities is described in detail.

```
                    MAIN MENU
                    ---------
      Commands:-
                    IN - Inspect Bill Item
                    OP - Create/Edit Operational Group
                    UP - Update Prices
                    SC - Enter Sub-contract Quotes
                    MA - Apply Mark-ups
                    PR - Print Reports
                    HE - Set HELP Level
                    DE - Delete Bill Item
                    ST - Stop
Command ? MA

WAIT

APPLY MARK-UPS option


      Commands:-
                    SU - Surcharges
                    PR - Profits
                    OV - Overheads
                    ON - On-Costs
                    DS - Distributed Sum
                    RL - Rate Load
      or press RETURN to return to Main Menu
```

6.2.1 SURCHARGES

The command SU enables the estimator to make an adjustment to Direct Cost of resources contained in the cost code categories. This adjustment only figures in the printout reports produced. No adjustment is made to the individual bill item build-ups. Therefore even after making adjustments using the SURCHARGE command using the INSPECT BILL ITEM command will still show the original build-up and cost of the bill item as priced by the estimator. It is possible to enter a negative percentage SURCHARGE. This will reduce the cost of all resources within the chosen cost code category and will display the reduced figures in the relevant reports.

The following cost code categories may be SURCHARGED:

LAB	-	Labour
PLT	-	Plant
AUX	-	Auxiliary Plant
MAT	-	Materials
DOM	-	Domestic Subcontractors
ADD	-	Additional

In the example below five percent is added via the SURCHARGE option to the direct cost of Labour.

```
Command ? SU

                    Surcharges
                    ----------
                    LAB.    0     %
                    PLT.    0     %
                    AUX.    0     %
                    MAT.    0     %
                    DOM.    0     %
                    ADD.    0     %
      Commands :-
                    AD - Add Percentage
                    CH - Change Percentage
                    DE - Delete Percentage
                    VI - View Percentages
                    FI - File Information

Command ? AD

Cost Code ? [RETURN to End] LAB

Percentage Mark-up ? 5

Cost Code ? [RETURN to End]

      Commands :-
                    AD - Add Percentage
                    CH - Change Percentage
                    DE - Delete Percentage
                    VI - View Percentages
                    FI - File Information

Command ? FI

Information Filed
```

6.2.2 PROFITS

Percentages may be added to the following categories of bill items to allow for PROFITS:

OWN	-	All work completed by the main contractor;
DOM	-	All work completed by the domestic sub-contractor;
SP	-	Nominated suppliers;
SC	-	Nominated Subcontractors.

Percentages entered under these categories will automatically be applied to all work undertaken within them. The adjustments made are shown in the GROSS figures given in the printed reports. No adjustments due to PROFITS are shown in the DIRECT costs or the item build-ups as indicated via the INSPECT BILL ITEM command.

NOTE: The facility for adding a profit figure to Nominated Suppliers and Nominated Subcontractors may be undertaken as described in Section Where this has already been done the figures entered will not be over-ridden by those of the PROFITS command.

In the example below the following profit allowances are entered:

Main Contractors own work	-	8%
Domestic Subcontractors	-	5%
Nominated Suppliers	-	5%
Nominated Subcontractors	-	5%

```
      Commands:-
                 SU - Surcharges
                 PR - Profits
                 OV - Overheads
                 ON - On-Costs
                 DS - Distributed Sum
                 RL - Rate Load
      or press RETURN to return to Main Menu
 Command ? PR

                 Profits
                 ----------
                 OWN    0    %
                 DOM.   0    %
                 SP.    0    %
                 SC.    0    %
      Commands :-
                 AD - Add Percentage
                 CH - Change Percentage
                 DE - Delete Percentage
                 VI - View Percentages
                 FI - File Information

 Command ? AD

 Cost Code ? [RETURN to End] OWN

 Percentage Mark-up ? 8.0

 Cost Code ? [RETURN to End] DOM

 Percentage Mark-up ? 5.0

 Cost Code ? [RETURN to End] SP

 Percentage Mark-up ? 5.0

 Cost Code ? [RETURN to End] SC

 Percentage Mark-up ? 5.0

 Cost Code ? [RETURN to End] __

      Commands :-
                 AD - Add Percentage
                 CH - Change Percentage
                 DE - Delete Percentage
                 VI - View Percentages
                 FI - File Information
 Command ? FI

 Information Filed
```

Where Profit figures have already been entered via the PROFIT command, it is always possible to change them. When the command is called the latest figures input for PROFIT will be displayed. Using the CH - Change Percentage command a figure previously entered may be amended.

In the example below the profit allowance on the contractor's own work is changed from 8 percent to 8.5 percent.

```
        Commands:-
                        SU - Surcharges
                        PR - Profits
                        OV - Overheads
                        ON - On-Costs
                        DS - Distributed Sum
                        RL - Rate Load
        or press RETURN to return to Main Menu
   Command ? PR


                        Profits
                        ----------
                        OWN     8    %
                        DOM.    5    %
                        SP.     5    %
                        SC.     5    %
        Commands :-
                        AD - Add Percentage
                        CH - Change Percentage
                        DE - Delete Percentage
                        VI - View Percentages
                        FI - File Information

   Command ? CH

   Cost Code ? OWN

   Percentage is    8    %
   New Percentage ? 8.5

        Commands :-
                        AD - Add Percentage
                        CH - Change Percentage
                        DE - Delete Percentage
                        VI - View Percentages
                        FI - File Information

   Command ? FI

   Information Filed
```

6.2.3 OVERHEADS

In a similar manner to PROFITS, percentage additions may be made to the direct cost totals to allow for OVERHEADS. Overhead percentages may be added to work undertaken in each of the following cost code categories:

LAB	-	Labour
PLT	-	Plant
AUX	-	Auxiliary Plant
MAT	-	Materials
DOM	-	Domestic Subcontractors
ADD	-	Additional

As for PROFITS, the GROSS costs reflect these additions but not the Direct Cost Totals.

In the example below, five percent is added to Labour and 12 percent added to Materials to cover overheads.

```
Command ? OV


                     Overheads
                     ----------
                     LAB.    0    %
                     PLT.    0    %
                     AUX.    0    %
                     MAT.    0    %
                     DOM.    0    %
                     ADD.    0    %
          Commands :-
                     AD - Add Percentage
                     CH - Change Percentage
                     DE - Delete Percentage
                     VI - View Percentages
                     FI - File Information

Command ? AD

Cost Code ? [RETURN to End] LAB

Percentage Mark-up ? 5.0

Cost Code ? [RETURN to End] MAT

Percentage Mark-up ? 12.0

Cost Code ? [RETURN to End] ___

          Commands :-
                     AD - Add Percentage
                     CH - Change Percentage
                     DE - Delete Percentage
                     VI - View Percentages
                     FI - File Information
```

6.2.4 ON-COSTS

The ON-COST facility enables percentage additions to be made to all the items in the bill or to items in particular sections or classifications of the work. This facility is therefore very useful if the company policy is to always add a notional mark-up to all bill items or decides that when reviewing tenders all "Earthworks" or "Section 5" of the bill must allow for mark-ups of a different percentage.

When the ON command is used the on-costs already specified by the user are displayed. A sub-menu of commands then allows the user to:

AD	-	Add a Reference
CH	-	Change the References
DE	-	Delete References
VI	-	View References
FI	-	File References.

When adding on-costs the user will be asked:

- Portion Reference or Classification? (END to END)

the user may add on-costs to:

- a particular bill, (where numbering System 1 has been used);
- a particular bill section;
- an individual bill page;
- an individual class of work.

NOTE: Where an individual class of work is to be subject to on-costs the appropriate CESMM code should be added.

If bill items are subjected to on-costs under more than one reference the results are cumulative.

It is always possible to change the on-cost percentages that have been applied using the CH - change references command.

In the following example an on-cost of three percent is added to Section 2, five percent to Section 3 page 30 and four percent to all the items in the bill classified under class E.

```
        Commands:-
                        SU - Surcharges
                        PR - Profits
                        OV - Overheads
                        ON - On-Costs
                        DS - Distributed Sum
                        RL - Rate Load
        or press RETURN to return to Main Menu
Command ? ON


                        On-Cost Percentages
                        --------------------
                        None Specified
        Commands:-
                        AD - Add Reference
                        VI - View References
                        FI - File References
Command ? AD

Portion Reference or Classification ? [END to End] 2/

Percentage ? 3.0

Portion Reference or Classification ? [END to End] 3/30

Percentage ? 5.0

Portion Reference or Classification ? [END to End] E

Percentage ? 4.0

Portion Reference or Classification ? [END to End] END

        Commands:-
                        AD - Add Reference
                        CH - Change Percentage
                        DE - Delete Reference
                        VI - View References
                        FI - File References
Command ? VI


                        On-Cost Percentages
                        --------------------
                        Section 2                                  3    %
                        Section 3  Page 30                         5    %
                        Classification E                           4    %
        Commands:-
                        AD - Add Reference
                        CH - Change Percentage
                        DE - Delete Reference
                        VI - View References
                        FI - File References
Command ? FI
```

6.2.5 DISTRIBUTED SUM

The DS command enables the user to add a single sum of money to the direct cost total and apportion the sum throughout all the bill, a particular portion of the bill or a particular trade classification. The sum of money is apportioned throughout in bill items in relation to the direct cost total of each item.

The distributed sum does not appear in the direct cost of the bill item build-up only within the GROSS cost totals as given in the printouts.

Shown below is the distribution of £12,500.00 spread over Section 4 of the bill.

```
Information Filed

      Commands:-
                   SU - Surcharges
                   PR - Profits
                   OV - Overheads
                   ON - On-Costs
                   DS - Distributed Sum
                   RL - Rate Load
      or press RETURN to return to Main Menu
Command ? DS

                   Distributed Sum
                   ---------------
                   Not Specified
      Commands:-
                   AD - Add Distributed Sum
                   FI - File Distributed Sum
Command ? AD

Sum ? 12500.0

Portion Reference or Classification ? 4/

                   Distributed Sum
                   ---------------
      $12,500.00 spread over Section 4
      Commands:-
                   CH - Change Distributed Sum
                   DE - Delete Distributed Sum
                   RE - Change Reference
                   FI - File Distributed Sum
Command ? FI

Information Filed
```

6.2.6 RATE LOAD

The RATE LOAD command can be used to move sums of money around the Bill of Quantities to enable the company to benefit the contract cashflow by making the best advantage of the system of contract payments. Depending on the general economic climate and rate of inflation it may benefit the contractor to 'load' bill items that will be completed early or late in the project.

By using this command a bill item can be increased/decreased by an percentage. At the same time all other bill items are decreased/ increased in proportion to their contribution to the final tender sum so keeping the overall tender price the same.

In this manner full flexibility is given as to which areas of the bill are given the main financial emphasis. The calculations are performed as in the following example. Consider a simple bill of only five items:

ITEM	DESCRIPTION OF WORK	UNIT	QTY	RATE	AMOUNT
A	Class F3 'Formwork'	m^2	8	16.23	129.84
B	High Tensile Rebar 20mm dia.	TNNE	28.39	273.27	7758.13
C	Excavate Unsuitable Material	m^3	40	6.77	270.80
D	Insitu Concrete Class E	m^2	20	80.86	1617.20
E	Two coats tar sprayed or brushed on water-proofing	m^2	303	1.75	530.25
	TOTAL TENDER SUM				10306.22

It is decided to increase the rate for the bill item D by 20 percent and adjust the other bill items accordingly to keep the total tender sum the same.

Bill item D is increased by 20%

i.e. item rate (D) = 97.03
item amount (D) = 1940.64

Increase in total tender sum = 1940.64 - 1617.20

= 323.44

$$\text{Difference} = \frac{\text{CHANGE IN ITEM D}}{\text{total tender sum - original item amount (D)}}$$

$$= \frac{323.44}{8689.02}$$

$$= 0.0372$$

1 - Difference = 0.9627

This then becomes the multiplier for all bill items except item D, i.e.

Item A	=	129.84	x	0.9627	=	124.99
Item B	=	7758.13	x	0.9627	=	7468.75
Item C	=	270.80	x	0.9627	=	260.70
Item E	=	530.25	x	0.9627	=	510.23

The item rates become:

Item A	15.62
Item B	263.08
Item C	6.52
Item E	1.68

and the re-adjusted bill becomes as below:

ITEM	DESCRIPTION OF WORK	UNIT	QTY	RATE	AMOUNT
A	Class F3 'Formwork'	m^2	8	15.62	124.96
B	High Tensile Rebar 20mm dia.	TNNE	28.39	263.15	7470.78
C	Excavate Unsuitable Material	m^3	40	6.52	260.80
D	Insitu Concrete Class E	m^3	20	97.03	1940.04
E	Two coats tar sprayed or brushed on water-proofing	m^2	303	1.68	509.04
	TOTAL TENDER SUM				10306.14

Note that in this example a minor adjustment has been made to item B to bring the bill total back to £10306.

In the example below it is decided to Rate Load Section 1 Page 1 of the bill by 10% and all items within classification E by 7%.

```
       Commands:-
                       SU - Surcharges
                       PR - Profits
                       OV - Overheads
                       ON - On-Costs
                       DS - Distributed Sum
                       RL - Rate Load
       or press RETURN to return to Main Menu
  Command ? RL

                       Rate Load Percentages
                       ---------------------
                       None Specified
       Commands:-
                       AD - Add Reference
                       VI - View References
                       FI - File References
  Command ? AD

  Portion Reference or Classification ? [END to End] 1/1

  Percentage ? 10.0

  Portion Reference or Classification ? [END to End] E

  Percentage ? 7.0

  Portion Reference or Classification ? [END to End] END

       Commands:-
                       AD - Add Reference
                       CH - Change Percentage
                       DE - Delete Reference
                       VI - View References
                       FI - File References
  Command ? FI

  Information Filed

       Commands:-
                       SU - Surcharges
                       PR - Profits
                       OV - Overheads
                       ON - On-Costs
                       DS - Distributed Sum
                       RL - Rate Load
       or press RETURN to return to Main Menu
  Command ?

  WAIT
```

<u>NOTE:</u> <u>Rate load additions do not affect the overall total tender sum.</u>

The percentage rate-loading additions may be made to a par:

- a particular bill (where applicable);
- on bill section;
- a page within the bill;
- an individual class of work.

7.0 THE UPDATING OF PRICES AND AWAITING QUOTES SUBSYSTEM

7.1 GENERAL

Within the preparation of an estimate for a particular contract it is possible for the estimator to update the prices of the resources he is to use for the contract and to add new resources that were previously not stored on the contract files. This task is performed by the UP-UPDATING PRICES command from the Main Menu of the AB3RUN program. The system also provides an "Awaiting Quotes" facility that has been designed to deal with the obtaining of prices for Materials and Sub-contractor resources. INTEREST enables the estimator to proceed with the inspection and build-up of item rates before having received detailed final resource prices. As and when these become available they may be entered into the system and the price of all such resources in all relevant bill items changed accordingly.

Reports identifying Materials and Sub-contractors as "Awaiting Quotes" may be obtained using the PRINT facilities described in Section 6. These reports serve as a reminder of those resources for which prices have not yet been finalised.

The facilities described for marking Materials resources as "Awaiting Quotes" are also available for Labour, Plant and Auxiliary Plant resources. However it is envisaged that they will be primarily used for Materials.

7.2 UPDATING CONTRACT RESOURCE PRICES

At the start of preparing an estimate for a particular contract the estimator automatically receives a "copy" of all the resources on the company library files. During the course of the direct cost estimate the estimator will find it necessary to:

- add particular resources for the contract;
- change the prices shown on the file to reflect the individual contract requirements.

This may be performed using the UP-UPDATE PRICES command. Some prices may be available very early in the tender period, (eg all-in labour and plant rates). Others will only arrive in the latter stages of the estimate. The UPDATE PRICES command may be called upon at any time to enter or amend prices.

The example below shows the changing of a Labour rate previously held on the files and the entry of a new resource unique to the particular contract.

```
INSPECT BILL ITEM option

Item Reference ? [RETURN to End]

WAIT

                     MAIN MENU
                     ---------
        Commands:-
                     IN - Inspect Bill Item
                     OP - Create/Edit Operational Group
                     UP - Update Prices
                     SC - Enter Sub-contract Quotes
                     MA - Apply Mark-ups
                     PR - Print Reports
                     HE - Set HELP Level
                     DE - Delete Bill Item
                     ST - Stop
Command ? UP

UPDATE PRICES option

Resource Code ? [RETURN to End] L1

     (master)      Description - LABOUR
     (used)        Cost        -          $2.15/HR
       Commands :-
                   DS - Change Description
                   CO - Change Cost
                   MA - Mark as Awaiting Quotes
                   VI - View Resource
                   PR - Print Resource
                   FI - File Resource
Command ? CO

     $2.15/HR
Cost in $/HR   ? 3.25
```

```
        Commands :-
                        DS - Change Description
                        CO - Change Cost
                        MA - Mark as Awaiting Quotes
                        VI - View Resource
                        PR - Print Resource
                        FI - File Resource
   Command ? FI

                        * Resource L1       Filed *


   Resource Code ? [RETURN to End] L11

   Resource not on File
   Do you wish to create a new Resource ? Y


   Description ? CONCRETE FINISHER

   Cost in $/HR    ? 4.0

   Awaiting Quotes ? N


      (contract)   Description - CONCRETE FINISHER
                   Cost        -         $4.00/HR
        Commands :-
                        DS - Change Description
                        CO - Change Cost
                        MA - Mark as Awaiting Quotes
                        VI - View Resource
                        PR - Print Resource
                        FI - File Resource
   Command ? FI

                        * Resource L11      Filed *
```

Where additional resources unique to a contract have been added a listing of the resources may be obtained from the PRINT REPORTS menu. See Section 6.

In the example below the suppliers name for the provision of Ready Mixed Concrete Class E is changed together with the discount allowed.

```
Resource Code ? [RETURN to End] M1

     (contract)   Description - READY MIXED CONCRETE CLASS E
                  Cost          -       $32.98/M3
                  Price with  5.00 % Discount =      $31.33/M3
                  Supplier's Name - R.M.C.
        Commands :-
                  DS - Change Description
                  CO - Change Cost
                  MA - Mark as Awaiting Quotes
                  UN - Change Units of Measurement
                  SU - Change Supplier's Name
                  DC - Change Discount
                  VI - View Resource
                  PR - Print Resource
                  FI - File Resource
Command ? SU

                    R.M.C.
Supplier's Name ? TILCON


 Command ? DC

      5.00%
 Discount (%) ? 6.5
```

If an item is marked as "Awaiting Quotes" within the system this is clearly shown when the item is displayed using the UPDATE PRICES command.

```
(contract)   Description - READY MIXED CONCRETE CLASS E
             Cost          -       $32.98/M3
             Price with  6.50 % Discount =      $30.84/M3
             *********** Awaiting Quotes *********
             Supplier's Name - TILCON
  Commands :-
             DS - Change Description
             CO - Change Cost
             MA - Mark as NOT Awaiting Quotes
             UN - Change Units of Measurement
             SU - Change Supplier's Name
             DC - Change Discount
             VI - View Resource
             PR - Print Resource
             FI - File Resource
```

In addition, whenever the resource is included within a bill item build-up the resource is marked with an asterisk to indicate that this is not the final price. An example is shown in Figure 28, page 638.

When printouts and bill totals are obtained, see Section 6, if resources are still "Awaiting Quotes" this will be clearly indicated. Consequently two important factors emerge:

(i) It is the responsibility of the estimator to inspect the resource prices to be used on the contract and mark resources as "Awaiting Quotes" as necessary;

(ii) The estimator should carefully check towards the end of the tender preparation period that all quotations have been received and where they have the resource adjusted accordingly.

Section 2 Page 20/6
Quantity 310 M3
100 % of Work Group F237.0
DESIGN STRUCT. CONC. 20 MPA 20 MM AGGR. SRC

Code	Description		Cost/Hour	Usage	Weight Factor	Cost/M3
L513	MIXER DRIVER	-	$3.41	.160	100.0%	$0.55
L514	SHOVEL OPERATER	-	$4.10	.160	100.0%	$0.66

Code	Description		Cost/Hour	Output	Weight Factor	Cost/M3
P500	21/14 MIXER	-	$1.88	.160	100.0%	$11.75
P501	2M3 READY-CRETE TRUCK (1 MILE HAUL)	-	$2.40	.140	100.0%	$17.14
P512	SILO (50 TONNE)	-	$0.50	.160	100.0%	$3.13

Code	Description		Net. Cost/Unit	Usage	Wastages Per Unit	Cost/M3
M504	SULPHATE RESISTANT CEMENT	-	$0.00/TN	.320	0.0%	$0.00*

Press RETURN to continue :

M505	SAND	-	$0.00/M3	.350	0.0%	$0.00*
M508	20 MM AGGR.	-	$0.00/TN	1.100	0.0%	$0.00*

Code	Description		Cost/M3
OP2	PLANT FOR PLACING CONCRETE	-	$10.70

TOTAL LABOUR	COST/M3	$1.20
TOTAL PLANT	COST/M3	$42.71
TOTAL NET COST/M3		$43.92

Is This Ok ? [RETURN for Yes]

Figure 28 - EXAMPLE OF AN ITEM BUILD-UP WITH RESOURCES AWAITING QUOTES

7.3 DOMESTIC SUB-CONTRACTOR RESOURCES "AWAITING QUOTES"

DOMESTIC SUB-CONTRACTORS are sub-contractors selected by the main contractor following the submission of quotations and the appraisal of the company. They should not be confused with NOMINATED SUB-CONTRACTORS who are specified by the client or his representative. Wherever the term sub-contractor is used in this manual it refers to DOMESTIC SUB-CONTRACTORS unless stated otherwise.

During the entry of bill item details (see Section 4) it is possible to identify bill items which require sub-contractor quotations. It is important that items are identified at this stage in order that:

- sub-contract quotations may be quickly and easily entered via the ENTER SUB-CONTRACT QUOTES command;
- the system is able to provide reports of all the bill items which are awaiting sub-contract quotations.

This system does not provide facilities for storing sub-contract resource costs in the Company Resource Cost Files. Sub-contractor prices are considered as unique for each contract estimate.

7.4 ENTERING SUB-CONTRACT QUOTATIONS

Sub-contractor quotations are entered into the system by the use of the SC - SUBCONTRACT QUOTES command in the Main Menu of the AB3RUN program.

```
                    MAIN MENU
                    ---------
        Commands:-
                    IN - Inspect Bill Item
                    OP - Create/Edit Operational Group
                    UP - Update Prices
                    SC - Enter Sub-contract Quotes
                    MA - Apply Mark-ups
                    PR - Print Reports
                    HE - Set HELP Level
                    DE - Delete Bill Item
                    ST - Stop
Command ? SC

WAIT

ENTER SUB-CONTRACT QUOTES option
```

The system will request the user to input a sub-contract code. This code enables the system to identify all items priced by a particular sub-contractor. It is therefore necessary to have a unique sub-contract code for each sub-contractor. A sub-contract contract code consists of the prefix letter S followed by a number ranging from 1 to 1999. The user is asked to enter:

- the sub-contractor's name;
- the percentage discount applicable;
- the items that the sub-contractor is included in;
- the respective classification;
- the item rate.

This is shown clearly in the example below.

```
Sub-contractor Code ? [RETURN to End] S1

Sub-contractor not on File
Do you wish to create a new Sub-contractor ? Y

Name ? PRECAST CONC.LTD

Discount (%) ? 5
     (contract)   Name          - PRECAST CONC.LTD
                   5.00 % Discount
         Commands :-
                  SC - Change Sub-contractor's Name
                  DC - Change Discount
                  VI - View Resource
                  PR - Print Resource
                  FI - File Resource
Command ? FI
```

It is then possible to continue entering sub-contract quotations for the particular sub-contractor in question.

```
Item Reference ? [RETURN to End] 2/20/9

Section 2  Page 20/9
SUPPLY PRECAST CONC. BEAMS
Description Extension ? __

Sub-contractor Rate ? 350.0

Sub-contractor S1      added to Section 2  Page 20/9
```

When the estimator has finished entering quotes for a particular sub-contractor he may exit from the command in the following manner.

For any one bill item it is possible to enter up to two sub-contractor quotations using the sub-contractor quotes command. These quotations may be from the same sub-contractor or different sub-contractors. If more than two sub-contractor rates are to be entered against a bill item this must be done via the IN-Inspect Item Command.

7.5 THE DISPLAY OF SUB-CONTRACTOR PRICES WITHIN BILL ITEM BUILD-UPS

After sub-contractor quotes have been entered for a bill item the rates are displayed in the item build-up when inspected via the INSPECT BILL ITEM command.

Where the item build-up already contains resource data the display will be similar to that shown below.

```
                                                           Weight
Code        Description              Cost/Hour   Usage     Factor    Cost/M3
----        -----------              ---------   -----     -------   -------
L513   MIXER DRIVER          -         $3.41      .160     100.0%      $0.5
L514   SHOVEL OPERATER       -         $4.10      .160     100.0%      $0.6
                                                           Weight
Code        Description              Cost/Hour  Output     Factor    Cost/M3
----        -----------              ---------  ------     -------   -------
P500   21/14 MIXER           -         $1.88      .160     100.0%     $11.7
P501   2M3 READY-CRETE TRUC            $2.40      .140     100.0%     $17.1
       K (1 MILE HAUL)       -
P512   SILO (50 TONNE)       -         $0.50      .160     100.0%      $3.1
                                     Net.                  Wastages
Code        Description              Cost/Unit   Usage     Per Unit  Cost/M3
----        -----------              ---------   -----     --------  -------
M504   SULPHATE RESISTANT             $0.00/TN   .320        0.0%      $0.0
       CEMENT                -
                                                Press RETURN to continue

M505   SAND                  -        $0.00/M3   .350        0.0%      $0.0
M508   20 MM AGGR.           -        $0.00/TN  1.100        0.0%      $0.0
Code        Description                                             Cost/M3
----        -----------                                             -------
S4     FERGUS AND HAYNES     -                                        $16.8
---------------------------------------------------------------------------
                 TOTAL LABOUR     COST/M3              $1.20
                 TOTAL PLANT      COST/M3             $32.02
                 TOTAL SUB. CON.  COST/M3             $16.80
                                                  -----------
                 TOTAL NET COST/M3                    $50.02
```

If the item rate consists solely of a sub-contractor rate, a different build-up is given:

```
Item Reference ? [RETURN to End] 2/20/9

WAIT

Already Priced

WAIT

Section 2  Page 20/9
Quantity      18      NR
---------------------------------------------------------------------------
Code        Description                                              Cost/NR
----        -----------                                              -------
S4     FERGUS AND HAYNES     -                                         $56.
---------------------------------------------------------------------------
                 TOTAL SUB. CON.  COST/NR             $56.00
                                                  -----------
                 TOTAL NET COST/NR                    $56.00
---------------------------------------------------------------------------
Is This Ok ? [RETURN for Yes] Y
```

7.6 EDITING INFORMATION STORED FOR A SUB-CONTRACTOR

Using the UPDATE PRICES command it is possible to edit information that has previously been entered for a particular sub-contractor. The estimator may change:

- the sub-contractor description;
- discount rate;
- view resource details;
- file resource details.

This is shown in the example below. Details stored for a particular sub-contractor S4 are reviewed and the discount sum changed before filing the resource details.

```
UPDATE PRICES option

Resource Code ? [RETURN to End] S4

    (contract)    Name          - FERGUS AND HAYNES
                   0.00 % Discount
      Commands :-
                  SC - Change Sub-contractor's Name
                  DC - Change Discount
                  VI - View Resource
                  PR - Print Resource
                  FI - File Resource
Command ? DC

    0.00%
Discount (%) ? 5

      Commands :-
                  SC - Change Sub-contractor's Name
                  DC - Change Discount
                  VI - View Resource
                  PR - Print Resource
                  FI - File Resource
Command ? FI
```

7. EDITING SUB-CONTRACTOR RATES

After a bill item that is awaiting sub-contractor quotes has been priced using the ENTER SUB-CONTRACT QUOTES command it is not possible to amend the rates using this command. If the user attempts to enter the item reference a message will be given stating that the bill item contains already its sub-contract quotes.

To change the rate or the sub-contractor used the estimator must access the item using the INSPECT BILL ITEM command. In the example below the estimator changes the sub-contractor rate previously applied.

```
Section 3  Page 31/4
Quantity      69      M3
100     % of Work Group F237.0
DESIGN STRUCT. CONC. 20 MPA  20 MM AGGR.  SRC
-------------------------------------------------------------------------------------
                                                                   Weight
Code          Description               Cost/Hour    Usage         Factor     Cost/M
----          -----------               ---------    -----         -------    ------
L513    MIXER DRIVER            -         $3.41       .160         100.0%       $0.
L514    SHOVEL OPERATER         -         $4.10       .160         100.0%       $0.
                                                                   Weight
Code          Description               Cost/Hour   Output         Factor     Cost/M
----          -----------               ---------   ------         -------    ------
P500    21/14 MIXER             -         $1.88       .160         100.0%      $11.
P501    2M3 READY-CRETE TRUC              $2.40       .140         100.0%      $17.
        K (1 MILE HAUL)         -
P512    SILO (50 TONNE)         -         $0.50       .160         100.0%       $3.
                                        Net.                       Wastages
Code          Description               Cost/Unit    Usage         Per Unit   Cost/M
----          -----------               ---------    -----         --------   ------
M504    SULPHATE RESISTANT               $0.00/TN     .320           0.0%       $0.
        CEMENT                  -
                                                          Press RETURN to continue

M505    SAND                    -        $0.00/M3     .350           0.0%       $0.
M508    20 MM AGGR.             -        $0.00/TN    1.100           0.0%       $0.
Code          Description                                                    Cost/M3
----          -----------                                                    -------
S4      FERGUS AND HAYNES       -                                               $6.
-------------------------------------------------------------------------------------
                   TOTAL LABOUR      COST/M3                 $1.20
                   TOTAL PLANT       COST/M3                $32.02
                   TOTAL SUB. CON.   COST/M3                 $6.80
                                                      -------------
                   TOTAL NET COST/M3                        $40.02
-------------------------------------------------------------------------------------
Is This Ok ? [RETURN for Yes] N

 WAIT
                    Bill Item EDIT option
                    ---------------------


      Commands:-
                    QU - Change Quantity
                    UN - Change Units of Measurement
                    DS - Change Description
                    AD - Add Work Group
                    CH - Change Percentage of Work Group
                    DE - Delete Work Group
                    ED - Edit Work Group
                    RR - Resource Reconciliation
                    LU _ Lump other Bill Items with this one
                    FI - File Bill Item
                    VI - View Bill Item
                    PR - Print Bill Item
```

```
Command ? ED

     Commands:-
                    AR - Add Resource
                    AO - Add Operational Group
                    CH - Change Resource / Operational Group Details
                    DR - Delete Resource
Command ? CH

WAIT

CHANGE RESOURCE / OPERATIONAL GROUP DETAILS option


Resource Code to Change ? [RETURN to End] S4

Code         Description                                               Cost/M3
----         -----------                                               -------
S4      FERGUS AND HAYNES   -                                             $6.8
     Commands :-
                    EX - Change Extension
                    RA - Change Sub-contractor Rate
                    VI - View Resource
     Press RETURN to exit

Command ? RA

                  6.800
Sub-contractor Rate ? 16.8


     Commands :-
                    EX - Change Extension
                    RA - Change Sub-contractor Rate
                    VI - View Resource
     Press RETURN to exit

Command ? _

Resource Code to Change ? [RETURN to End] _
```

7.8 THE INSPECTION OF BILL ITEMS THAT ARE AWAITING SUB-CONTRACTOR QUOTATIONS

If the estimator uses the INSPECT item command to review a bill item that is awaiting a quotation before that quotation is received then he will receive item build-ups similar to those shown below.

(i) ITEM PRICED BY SUB-CONTRACTOR AND A WORK GROUP

It is possible to price a bill item by a Work Group and a sub-contractor rate combined. The example below gives details of the item build-up and states that a sub-contractor rate is still required.

```
Section 3  Page 31/3
Quantity      34      M3
100    % of Work Group F237.0
DESIGN STRUCT. CONC. 20 MPA  20 MM AGGR.  SRC
----------------------------------------------------------------------
                                                        Weight
Code        Description              Cost/Hour   Usage   Factor    Cost/M3
----        -----------              ---------   -----   -------   -------
L513   MIXER DRIVER          -         $3.41     .160    100.0%      $0.5
L514   SHOVEL OPERATER       -         $4.10     .160    100.0%      $0.6
                                                        Weight
Code        Description              Cost/Hour  Output   Factor    Cost/M3
----        -----------              ---------  ------   -------   -------
F500   21/14 MIXER           -         $1.88     .160    100.0%     $11.7
F501   2M3 READY-CRETE TRUC            $2.40     .140    100.0%     $17.1
       K (1 MILE HAUL)       -
F512   SILO (50 TONNE)       -         $0.50     .160    100.0%      $3.1
                                     Net.               Wastages
Code        Description              Cost/Unit   Usage   Per Unit  Cost/M3
----        -----------              ---------   -----   --------  -------
M504   SULPHATE RESISTANT              $0.00/TN   .320      0.0%     $0.0
       CEMENT                -
                                                   Press RETURN to continue

M505   SAND                  -         $0.00/M3   .350      0.0%     $0.0
M508   20 MM AGGR.           -         $0.00/TN  1.100      0.0%     $0.0
----------------------------------------------------------------------
                     TOTAL LABOUR     COST/M3            $1.20
                     TOTAL PLANT      COST/M3           $32.02
                                                   ------------
                     TOTAL NET COST/M3                  $33.22
----------------------------------------------------------------------
Sub-contract Quote Outstanding
Is This Ok ? [RETURN for Yes] __
```

(ii) ITEM PRICED BY SUB-CONTRACTOR RATE ONLY

If an item has been entered requiring only a sub-contractor rate then, when the item is inspected by the IN - Inspect Item Command, the following display is given:

```
Item Reference ? [RETURN to End] 5/51/5

Section 5  Page 51/5
Quantity      12      NR
Sub-contract Quote Outstanding
WAIT
                    PRICE BILL ITEM menu
                    --------------------


        Commands :-
                    DA - Data Library Build-up
                    CR - Create Item Build-up
        or press RETURN to return to Main Menu
```

The estimator may use the CR - Create Item Build-up Command to add resources to cover sub-contractor attendance. In the example below labour time is included to cover offloading of materials for the sub-contractor.

648

```
Command ? CR

WAIT

CREATE ITEM Build-up option


Classification ? Z

WAIT
ADD RESOURCE option


Resource Code to Add ? [RETURN to End] L1

    (contract)   Description - LABOUR
                 Cost        -        $3.25/HR
OK ? Y

Description Extension ? OFFLOAD

Usage Rate ? 1.0

Weight Factor ? [RETURN for 100%] ___

                                                              Weight
Code         Description               Cost/Hour    Usage     Factor    Cost/N
----         -----------               ---------    -----     -------   ------
L1      LABOUR              -OFFLOAD    $3.25       1.000     100.0%      $3.
Resource Code to Add ? [RETURN to End]  ___

WAIT

Section 5  Page 51/5
Quantity      12      NR
100     % of Classification Z
INSTALL PUMPS
------------------------------------------------------------------------------
                                                              Weight
Code         Description               Cost/Hour    Usage     Factor    Cost/N
----         -----------               ---------    -----     -------   ------
L1      LABOUR              -OFFLOAD    $3.25       1.000   · 100.0%      $3.
------------------------------------------------------------------------------
                  TOTAL LABOUR      COST/NR                  $3.25
                                                        ------------
                  TOTAL NET COST/NR                          $3.25
------------------------------------------------------------------------------
Sub-contract Quote Outstanding
OK to File ? [RETURN for Yes]


      ** Bill Item 5/51/5           Filed **
```

8. THE SYSTEM CONTROL PROGRAM

The System Control Program controls the entire estimating system. This program will be operated by the chief estimator or the estimator placed in charge of the estimating system. Within this program are the commands which enable the user to:

- add a new contract to the system;
- delete a contract from the system;
- change the details of the contracts on the system;
- change the Master password;
- list the contracts currently held on file within the system;
- edit the library of Work Groups;
- list the Work Groups on the library files;
- edit the library of Master resources and resource gangs;
- list the resources and resource gangs held on the library files;
- set the level of 'help' required within the operation of the program;
- stop the program.

Access to the system control program is by entering the program name AB3CHIEF. The user is then required to enter the master password.

```
AB3CHIEF

INTEREST-CE System 3.00
Chief Estimator's Program
Password ? TOPMAN
```

The Main Menu of commands of the program will then be displayed.

```
                MAIN MENU
                ---------
Commands :-
                AD - Add a new Contract
                DE - Delete a Contract
                CH - Change a Contract Details
                MP - Change the Master Password
                LC - List current Contracts
                EW - Edit the Work Groups File
                LW - List the Work Groups File
                ER - Edit the master Resource and Resource Gangs file
                LR - List the master Resource and Resource Gangs file
                HE - Set HELP Level
                ST - Stop program
Command ?
```

Each of these commands is described below with suitable examples.

8.1 ADDING A NEW CONTRACT

The AD command enables the user to input details on the contract for which it is wished to prepare an estimate and set up the relevant file space to store data on the contract.

The user must enter details giving information of:

- the contract identifier;
- the contract title;
- the contract reference code;
- the tender submission date;
- the client;
- the consulting engineers;
- the estimators name;
- the planners name;
- the estimated tender value;
- the estimators password;
- the dataprep password.

The contract identifier is the coding reference which enables the estimator to retrieve information on the contract under consideration.

The contract title is the name of the project for which a tender is being prepared.

The contract reference code is a reference relating to the contractors organization's own internal contract referencing system.

The tender submission date, client and consulting engineers information will all be written on the contract documents.

The chief estimator may enter the names of the estimator and planner who are to be responsible for the tender.

Different passwords should be entered to give the estimator and the dataprep personnel access to the contract within the system.

The table below gives details of the characters allowed in the above data and the maximum length of the information.

The program will ask for information on the approximate number of bill items within the contract. This is to enable sufficient storage space to be allocated on the files.

Different Bills of Quantities will be numbered in different ways. The following information must be entered:

- Bill Numbering Method Section/Page/Item or Bill/Section/Page/Item;
- whether the bill items are referenced by Letters, Numbers or CESMM codes;
- whether the letters I and O are included in the item referencing.

The Bill Numbering method determines the manner in which the page and item reference are entered by the user. Where the Bill of Quantities consists of one document the bill numbering method is usually Section/Page/Item,

ie:

7/162/A

section page item

Where the Bill of Quantities consists of several documents the method Bill/Section/Page/Item will probably be employed,

ie:

1/11/169/C

bill section page item

When the user is presented with a Bill of Quantities produced in a completely different manner, a suitable method of referencing should be selected and the Bill of Quantities documents renumbered manually accordingly.

Within the INTEREST C.E. system it is possible to include bill item descriptions. A decision must be taken at this stage as to whether they will be required within the contract.

The program will display the computer code for the contract. This should be recorded for use when preserving contract data.

While the files for the contract are being set up the message:

"File Initialisation in Progress"

will be displayed.

When this operation is complete the program returns to the Main Menu.

```
File Initialisation in Progress
                  MAIN MENU
                  ---------
      Commands :-
                  AD - Add a new Contract
                  DE - Delete a Contract
                  CH - Change a Contract Details
                  MP - Change the Master Password
                  LC - List current Contracts
                  EW - Edit the Work Groups File
                  LW - List the Work Groups File
                  ER - Edit the master Resource and Resource Gangs file
                  LR - List the master Resource and Resource Gangs file
                  HE - Set HELP Level
                  ST - Stop program
```

An example is now given of the entry of data for a typical contract.

```
                    MAIN MENU
                    ---------
        Commands :-
                    AD - Add a new Contract
                    DE - Delete a Contract
                    CH - Change a Contract Details
                    MP - Change the Master Password
                    LC - List current Contracts
                    EW - Edit the Work Groups File
                    LW - List the Work Groups File
                    ER - Edit the master Resource and Resource Gangs file
                    LR - List the master Resource and Resource Gangs file
                    HE - Set HELP Level
                    ST - Stop program
Command ? AD


ADD CONTRACT option
Contract Identifier ? RM10

Contract Title ? BITTERNE BY-PASS

Reference Code ? RM10

Tender Submission Date ? 31/05/82

Client ? WILTSHIRE COUNTY COUNCIL

Consulting Engineers ? S.W.R.C.U.

Estimator's Name ? BLACK

Planner's Name ? WHITE

Estimated Tender Value ? 2.5 MILLION

Estimator's Password ? BLACK

Data Prep. Password ? RED

Approximate Number of Bill Items  ? 100

                  BILL NUMBERING METHOD
For     Section / Page / Item            enter   1
For     Bill / Section / Page / Item     enter   2
Option ? 1

LETTERS, NUMBERS or CESMM Codes ? LE

Is the letter I used ? N

Is the letter O used ? N

Are Bill Item Descriptions Required ? Y

Computer Code for this Contract:- AAS
```

8.2 DELETING A CONTRACT

When a tender has been completed it will become necessary to delete the contract files in order to provide storage space within the system for current contracts. If it is likely that information on this contract will be required at a later date it will be necessary to preserve the contract data. Contract data may be preserved on floppy-discs, or cartridge cassette back-up. The exact method will be dependant on the system on which the software is being run.

When using the DE-DELETE CONTRACT command the program will display a list of the files that should be copied to preserve contract data. The user is then asked whether it is "OK to proceed."

If the answer is YES, contract data is deleted.

If the answer is NO, the system returns to the Main Menu.

8.3 CHANGE CONTRACT DETAILS

The user may change any of the details that have previously been set up relating to the estimate by using the CH - CHANGE CONTRACT DETAILS command.

When this command is instigated the user is given a sub-menu of commands enabling him to amend the appropriate information.

```
Command ? CH

CHANGE CONTRACT DETAILS option
Contract Identifier ? RM10

      Commands :-
                ES - Change Estimator's Password
                DA - Change Data Prep Password
                TI - Change Contract Title
                RE - Change Reference Code
                TE - Change Tender Submission Date
                CL - Change Client
                EN - Change Estimator's Name
                PN - Change Planner's Name
                CE - Change Consulting Engineers
                VA - Change Estimated Tender Value
                ME - Change Numbering Method
      Press RETURN to return to Main Menu
```

On the selection of these commands the existing contract information is displayed and the new data requested. It should be noted that it is only possible to change the bill numbering method before data has been input.

Examples are given below of changing contract details.

(a) Changing the Estimator's password.

The estimator's password is changed from BLACK to BROWN

```
Command ? ES

                          BLACK
Estimator's Password ? BROWN
```

(b) Changing the Contract Title

The contract title is changed from BITTERNE BY-PASS to A501

BITTERNE BY-PASS

```
Command ? TI

                   BITTERNE BY-PASS
Contract Title ? A501 BITTERNE BY-PASS
```

(c) Changing the Estimated Tender Value

The estimated tender value is changed from the

for 2.5 MILLION to 2,500,000

```
Command ? VA

                          2.5 MILLION
Estimated Tender Value ? 2,500,000
```

(d) Changing the Numbering Method

The bill numbering method is changed to Numbers and not Letters.

```
Command ? ME

Numbering method is:-
Section / Page / Item
Items lettered (I and O not used)

For     Section / Page / Item              enter 1
For     Bill / Section / Page / Item       enter 2
Option ? 1

LETTERS, NUMBERS or CESMM Codes ? NU
```

Information within the Contract Details is displayed at the start of each page of print out and the user should decide exactly which details are required to be stated.

8.4 CHANGE THE MASTER PASSWORD

The Master Password giving access to the system control program may be changed by using the MP command. The old password is displayed and the user allowed to input the new password which may be up to 6 characters in length. If a longer password is entered only the first six characters are recognised.

```
                    MAIN MENU
                    ---------
       Commands :-
                    AD - Add a new Contract
                    DE - Delete a Contract
                    CH - Change a Contract Details
                    MP - Change the Master Password
                    LC - List current Contracts
                    EW - Edit the Work Groups File
                    LW - List the Work Groups File
                    ER - Edit the master Resource and Resource Gangs file
                    LR - List the master Resource and Resource Gangs file
                    HE - Set HELP Level
                    ST - Stop program
 Command ? MP

 CHANGE MASTER PASSWORD option
                     TOPMAN
 Master Password ? TOPDOG
```

8.5 LISTING THE CURRENT CONTRACTS

This command enables the user to produce a listing via the printer of details of the contracts for which information is currently held on file. An example is given in Figure 29 page 661.

```
INTEREST-CE System 3.00
Chief Estimator's Program
Password ? TOHMAN

[illegible]


WAIT

                    MAIN MENU
                    ---------
       Commands :-
                    AD - Add a new Contract
                    DE - Delete a Contract
                    CH - Change a Contract Details
                    MP - Change the Master Password
                    LC - List current Contracts
                    EW - Edit the Work Groups File
                    LW - List the Work Groups File
                    ER - Edit the master Resource and Resource Gangs fil
                    LR - List the master Resource and Resource Gangs file
                    HE - Set HELP Level
                    ST - Stop program
Command ? LC


LIST CURRENT CONTRACTS option
SCREEN or PRINTER ? PR

Make sure Printer is available (press RETURN) __



*** Current Contracts Listing in Progress ***
```

```
Interest CE 3 Current Contracts Listing                                                      PAGE  1

CONTRACT    CONTRACT                                          TENDER SUBMISSION   ESTIMATED TENDER
IDENTIFIER  REF. CODE                    TITLE                DATE                VALUE
----------  ---------                    -----                -----------------   ----------------

ABT1        ABT1      C. E. TEST 1                            31/04/81            100,000
CLIENT: G.L.C
CONSULTING ENGINEERS: G.L.C
ESTIMATOR'S NAME: C BLACK
PLANNER'S NAME: A WHITE


ABT2        ABT2      TEST BILL NO. 2                         31/04/82            1,000,000
CLIENT: A RICHMAN
CONSULTING ENGINEERS: A RIPOFF &PRTNRS
ESTIMATOR'S NAME: BLACK
PLANNER'S NAME: WHITE


DEM1        DEM1      C.I.C.A. DEMONSTRATION                  30/06/82            1,000,000
CLIENT: A RICHMAN
CONSULTING ENGINEERS: CON SULTANT &PTRNS
ESTIMATOR'S NAME: BLACK
PLANNER'S NAME: WHITE


MAN1        MAN1      NARBOROUGH BRIDGES                      30/06/82            2,500,000
CLIENT: NARBOROUGH C.C.
CONSULTING ENGINEERS: R.P.T.
ESTIMATOR'S NAME: BLACK
PLANNER'S NAME: WHITE


RM10        RM10      A501 BITTERNE BY-PASS                   31/05/82            2,500,000
CLIENT: WILTSHIRE COUNTY COUNCIL
CONSULTING ENGINEERS: S.W.R.C.U.
ESTIMATOR'S NAME: BLACK
PLANNER'S NAME: WHITE
```

Figure 29 - LISTING OF CURRENT CONTRACTS PRINT OUT

8.6 EDITING THE WORK GROUPS FILE

The system control file enables the user to edit the performance data on the company library. This is done by using the EW command to edit the Work Groups file.

Performance data is held on the library files in Work Groups. Each Work Group consists of up to ten resources or resource gangs. These must be coded under a suitable reference system. (A full description of the company data library is included in Section 9).

The user may wish to:

- create a Work Group on the company library;
- edit a Work Group on the company library;
- delete a Work Group from the company library.

(i) CREATING A NEW WORK GROUP

The user decides which item of construction work the Work Group relates to, the most suitable coding reference is taken from the coding system and a check is made that the resources which are required within the group are already on the master resource file. (A Work Group can only be made up from existing resources). The user enters the Work Group reference number, the program checks that the Work Group is not already on file and then allows the build-up of resources within the group.

This is best illustrated by the following example. The user wishes to set up a Work Group under the CESMM coding reference F611.0 to cover the use of Blinding Concrete Class E.

Two resources are to be used from the resources file:

- L1 Labour
- M1 Ready Mixed Concrete Class E.

The command EW is instigated.

```
                    MAIN MENU
                    ---------
      Commands :-
                    AD - Add a new Contract
                    DE - Delete a Contract
                    CH - Change a Contract Details
                    MP - Change the Master Password
                    LC - List current Contracts
                    EW - Edit the Work Groups File
                    LW - List the Work Groups File
                    ER - Edit the master Resource and Resource Gangs file
                    LR - List the master Resource and Resource Gangs file
                    HE - Set HELP Level
                    ST - Stop program
Command ? EW

WAIT

WORK GROUPS EDIT option


Work Group Code ? [RETURN to End] F611.0

Work Group not on File
Do you wish to create a new Work Group ? Y

Description ? PLINDING N.E. 150MM

Units of Measurement ? M3

WAIT

ADD RESOURCE option


Resource Code to Add ? [RETURN to End] L1

    (master)     Description - LABOUR
    (used)       Cost        -        $2.15/HR
OK ? Y
```

On studying the build-up for the Work Group, the user may check that he is happy with the details of the resources within the group. If that is the case the user should input FI, and this will file the Work Group data.

The program will then ask for the next Work Group Code. If the user has completed inputing details on all the Work Groups then by entering AB the system will abort to the Main Menu.

If the user wishes to amend any details of the Work Group build-up this may easily be achieved by using the commands available. This is described in detail below.

(ii) EDITING A WORK GROUP

It may be necessary to edit the details of a Work Group within the data library. Using the commands available it is a simple matter to add resources, delete resources or change details of the resources that already exist. Similarly, the description of the Work Group or the units of measurement may be amended.

Using the EW command, the user inputs the Work Group code for the group that it is required to edit.

```
Commands :-
                  AD - Add a new Contract
                  DE - Delete a Contract
                  CH - Change a Contract Details
                  MP - Change the Master Password
                  LC - List current Contracts
                  EW - Edit the Work Groups File
                  LW - List the Work Groups File
                  ER - Edit the master Resource and Resource Gangs file
                  LR - List the master Resource and Resource Gangs file
                  HE - Set HELP Level
                  ST - Stop program
Command ? EW

WAIT

WORK GROUPS EDIT option

Work Group Code ? [RETURN to End] F611.0
```

The existing build-up of the Work Group will be displayed together with the list of commands enabling amendments to be made.

```
Work Group F611.0
BLINDING N.E. 150MM
Units of Measurement M3
--------------------------------------------------------------------------

Code        Description                Cost/Hour   Usage              Cost/M3
----        -----------                ---------   -----              -------
L1     LABOUR                -CONC.     $2.15       .330                 $0.71
                                       Net.                   Wastages
Code        Description                Cost/Unit   Usage      Per Unit  Cost/M3
----        -----------                ---------   -----      --------  -------
M1     READY MIXED CONCRETE             $22.75/M3  1.000       20.0%     $27.30
        CLASS E              -
--------------------------------------------------------------------------
                     TOTAL LABOUR   COST/M3             $0.71
                     TOTAL MATERIAL COST/M3            $27.30
                                                   ------------
                     TOTAL NET COST/M3                 $28.01
--------------------------------------------------------------------------
                                              Press RETURN to continue :
```

In this example the user changes the description of the Work Group to PLACING BLINDING 150MM THICK.

```
        Commands :-
                         DS - Change Description
                         UN - Change Units of Measurement
                         AD - Add Resource
                         CH - Change Resource Details
                         DE - Delete Resource
                         VI - View Work Group
                         PR - Print Work Group
                         FI - File Work Group
                         DF - Delete Work Group from File
    Command ? DS

                  BLINDING N.E.150MM
    Description ? PLACING BLINDING 150MM THICK
```

The command CH is then used to change the wastage allowance on the concrete from 20.0% to 15.0%.

```
Command ? CH

WAIT

CHANGE RESOURCE DETAILS option

Resource Code to Change ? [RETURN to End] M1

                                            Net.                            Wastages
Code          Description                   Cost/Unit    Usage              Per Unit   Cost/M3
----          -----------                   ---------    -----              --------   --------
M1       READY MIXED CONCRETE               $22.75/M3    1.000              20.0%        $27.30
           CLASS E
      Commands :-
                    EX - Change Extension
                    US - Change Usage Rate
                    WA - Change Wastage
                    VI - View Resource
      Press RETURN to exit

Command ? WA

                 20.0%
Wastage (%) ? 15.0

      Commands :-
                    EX - Change Extension
                    US - Change Usage Rate
                    WA - Change Wastage
                    VI - View Resource
      Press RETURN to exit

Command ? VI
```

It is decided to add a Ganger to the build-up using the command AD.

```
      Commands :-
                    DS - Change Description
                    UN - Change Units of Measurement
                    AD - Add Resource
                    CH - Change Resource Details
                    DE - Delete Resource
                    VI - View Work Group
                    PR - Print Work Group
                    FI - File Work Group
                    DF - Delete Work Group from File
Command ? AD

WAIT

ADD RESOURCE option

Resource Code to Add ? [RETURN to End] L3

    (master)     Description - GANGER CONCRETE
                 Cost        -        $5.00/HR
OK ? Y

Description Extension ?

Usage Rate ? 0.33

Code         Description             Cost/Hour   Usage              Cost/M3
----         -----------             ---------   -----              -------
L3     GANGER CONCRETE        -        $5.00      .330                $1.6

Resource Code to Add ? [RETURN to End]
```

The build-up of the Work Group is redisplayed. Satisfied with this the estimator uses the FI command to file the Work Group information.

```
         Commands :-
                     DS - Change Description
                     UN - Change Units of Measurement
                     AD - Add Resource
                     CH - Change Resource Details
                     DE - Delete Resource
                     VI - View Work Group
                     PR - Print Work Group
                     FI - File Work Group
                     DF - Delete Work Group from File
   Command ? FI

                     * Work Group F611.0 Filed *
```

```
                                          Net.                        Wastages
Code        Description                   Cost/Unit     Usage         Per Unit   Cost/M3
----        -----------                   ---------     -----         --------   --------
M1      READY MIXED CONCRETE              $22.75/M3     1.000          15.0%      $26.1(
          CLASS E              -
      Commands :-
                   EX - Change Extension
                   US - Change Usage Rate
                   WA - Change Wastage
                   VI - View Resource
      Press RETURN to exit
```

The description of the resource M1 is extended to include the size

of the aggregate.

```
  Command ? EX

  Description Extension ? 20MM AGG

        Commands :-
                   EX - Change Extension
                   US - Change Usage Rate
                   WA - Change Wastage
                   VI - View Resource
        Press RETURN to exit

  Command ? _

  Resource Code to Change ? [RETURN to End] _
```

The build-up of the Work Group is redisplayed.

```
Work Group F611.0
PLACING BLINDING 150MM THICK
Units of Measurement M3
------------------------------------------------------------------------------------------

Code        Description                   Cost/Hour     Usage                    Cost/M3
----        -----------                   ---------     -----                    --------
L1      LABOUR                 -CONC.      $2.15        .330                       $0.71
                                          Net.                        Wastages
Code        Description                   Cost/Unit     Usage         Per Unit   Cost/M3
----        -----------                   ---------     -----         --------   --------
M1      READY MIXED CONCRETE              $22.75/M3     1.000          15.0%      $26.16
          CLASS E              -20MM AGG
------------------------------------------------------------------------------------------
                       TOTAL LABOUR   COST/M3                   $0.71
                       TOTAL MATERIAL COST/M3                  $26.16
                                                            ------------
                       TOTAL NET COST/M3                       $26.87
------------------------------------------------------------------------------------------
                                                        Press RETURN to continue :
```

(iii) TO DELETE A WORK GROUP FROM THE COMPANY DATA LIBRARY

To delete a Work Group from the company data library use the EW command from the Main Menu as if to edit the Work Group and after having checked the display of the group to ensure you have selected the correct one, use the command DF to delete the Work Group from File. A message stating that the Work Group has been deleted will be displayed.

```
        Commands :-
                   DS - Change Description
                   UN - Change Units of Measurement
                   AD - Add Resource
                   CH - Change Resource Details
                   DF - Delete Resource
                   VI - View Work Group
                   PR - Print Work Group
                   FI - File Work Group
                   DF - Delete Work Group from File
Command ? DF

                   * Work Group E611.0 Deleted *
```

(iv) OBTAINING A PRINT OUT OF A WORK GROUP ON THE LIBRARY FILES

To obtain a full print out of the build-up of a Work Group on the company library, use the command EW as if to edit the Work Group and then the command PR. A check is asked that the printer is available and when the RETURN key is pressed the build-up of the Work Group will be printed out.

```
     Commands :-
                    DS - Change Description
                    UN - Change Units of Measurement
                    AD - Add Resource
                    CH - Change Resource Details
                    DE - Delete Resource
                    VI - View Work Group
                    PR - Print Work Group
                    FI - File Work Group
                    DF - Delete Work Group from File
 Command ? PR

 Make sure Printer is available (press RETURN) __
```

An example is shown in figure 30 page 671.

Interest CE 3 Library Work Group

Work Group F611.0
PLACING BLINDING 150MM THICK
Units of Measurement M3

Code	Description		Cost/Hour	Usage	Cost/M3
L1	LABOUR	-CONC.	£2.15	.330	£0.71

Code	Description		Net. Cost/Unit	Usage	Wastages Per Unit	Cost/M3
M1	READY MIXED CONCRETE CLASS E	-20MM AGG	£22.75/M3	1.000	15.0%	£26.16*

TOTAL LABOUR COST/M3	£0.71
TOTAL MATERIAL COST/M3	£26.16
TOTAL NET COST/M3	£26.87

Figure 30 : A PRINT OUT OF THE WORK GROUP F611.0

8.7 LISTING THE WORK GROUPS FILE

The estimator in control of the system may at any time obtain a listing of Work Groups held in the company data library by using the LW command in the Main Menu.

When this command is selected the user is asked whether the whole file of Work Groups is to be listed or just a single CESMM classification. (If it is the latter, the classification code must be entered). The system will then sort the Work Groups file and display the number of Work Groups to be printed and the approximate number of pages of print out that will be produced. The date of the print out must be entered and then the listing will be produced.

An example of this is given below together with an extract from a typical print out in figure 31 on page 673.

```
                    MAIN MENU
                    ---------
    Commands :-
                    AD - Add a new Contract
                    DE - Delete a Contract
                    CH - Change a Contract Details
                    MP - Change the Master Password
                    LC - List current Contracts
                    EW - Edit the Work Groups File
                    LW - List the Work Groups File
                    ER - Edit the master Resource and Resource Gangs file
                    LR - List the master Resource and Resource Gangs file
                    HE - Set HELP Level
                    ST - Stop program
Command ? LW

WAIT

 WORK GROUPS LIST option
       Commands :-
                     WH - Whole File
                     SI - Single CESMM classification
 Command ? SI

 CESMM Classification ? F

 Sort in progress

 There are      20 Work Groups requiring about      1 page(s)

 WAIT
 Today's Date ? 20/04/82

 Make sure Printer is available (press RETURN) __



 *** Work Groups Listing in Progress ***
```

Date : 20/04/82

Interest CE 3 Work Group(s) Listing

Page 1

F: In situ concrete

F235.0	MIX TO TABLE 50 CONC. 20 MPA 10 MM AGGR. SRC	Units M3
F236.0	MIX TO TABLE 50 CONC. 20 MPA 14 MM AGGR. SRC	Units M3
F237.0	DESIGN STRUCT. CONC. 20 MPA 20 MM AGGR. SRC	Units M3
F237.1	DESIGN STRUCT CONC. 20MPA 20MM AGG SRC (READY MIX)	Units M3
F241.0	DESIGN STRUCT. CONC. 25 MPA 10 MM AGGR. OPC	Units M3
F244.0	DESIGN STRUCT. CONC. 25 MPA 40 MM AGGR. OPC	Units M3
F245.0	DESIGN STRUCT. CONC. 25 MPA 10 MM AGGR. SRC	Units M3
F246.0	DESIGN STRUCT. CONC. 25 MPA 14 MM AGGR. SRC	Units M3
F471.0	SPECIAL DESIGN CONC. 50 MPA 10 MM. AGGR. OPC	Units M3
F472.0	SPECIAL DESIGN CONC. 50 MPA 14 MM. AGGR. OPC	Units M3
F473.0	SPECIAL DESIGN CONC. 50 MPA 20 MM. AGGR. OPC	Units M3
F474.0	SPECIAL DESIGN CONC. 50 MPA 40 MM. AGGR. OPC	Units M3
F475.0	SPECIAL DESIGN CONC. 50 MPA 10 MM. AGGR. SRC	Units M3
F476.0	SPECIAL DESIGN CONC. 50 MPA 14 MM. AGGR. SRC	Units M3
F477.0	SPECIAL DESIGN CONC. 50 MPA 20 MM. AGGR. SRC	Units M3
F478.0	SPECIAL DESIGN CONC. 50 MPA 40 MM. AGGR. SRC	Units M3
F481.0	SPECIAL DESIGN CONC. 60 MPA 10 MM. AGGR. OPC	Units M3
F611.0	PLACING BLINDING 150MM THICK	Units M3
F681.0	MASS CONC. CLASS 10/20 BED AND HAUNCH	Units M3
F682.0	LEAN MIX CONC. TO PAVEMENT 75MM THICK	Units M2

Figure 31 : AN EXTRACT FROM A TYPICAL LISTING FROM THE WORK GROUPS ON THE COMPANY LIBRARY

8.8 EDITING THE MASTER RESOURCE AND RESOURCE GANGS FILE

The command ER in the Main Menu enables the user to:

- input resources or gangs of resources into the master resource files;
- edit existing resources in the master resource files;
- delete existing resources in the master resource files.

(i) THE INPUT OF NEW RESOURCES SINGLE RESOURCES

Having determined the resource which the estimator wishes to be entered onto the library files the user must select a suitable coding reference that has not already been used. The ER command is chosen and the coding reference entered. The system will state that the resource is not on file and ask for confirmation that a new resource is to be entered.

```
Resource Code ? [RETURN to End] M11

Resource not on File
Do you wish to create a new Resource ? Y
```

The following information must then be entered:

- resource description;
- units of measurement (where applicable);
- cost per unit;
- discount % (materials only);
- suppliers name (materials only);
- whether the resource is "awaiting quotations".

Any percentage discount is automatically applied to the cost entered. The appropriate net cost is then used in <u>all</u> subsequent calculations using the resource.

The example below relates to the entry of data for resource M11-

Ready Mixed Concrete Class E.

```
Description ? READY MIXED CONCRETE CLASS E

Units of Measurement ? M3

Cost in $/M3    ? 22.75

Discount (%) ? 5

Supplier's Name ? R.M.C.

Awaiting Quotes ? Y

   (master)      Description - READY MIXED CONCRETE CLASS E
                 Cost        -     $22.75/M3
                 Price with  5.00 % Discount =     $21.61/M3
                 *********** Awaiting Quotes **********
                 Supplier's Name - R.M.C.
      Commands :-
                 DS - Change Description
                 CO - Change Cost
                 MA - Mark as NOT Awaiting Quotes
                 UN - Change Units of Measurement
                 SU - Change Supplier's Name
                 DC - Change Discount
                 VI - View Resource
                 PR - Print Resource
                 FI - File Resource
Command ? FI

                 * Resource M11     Filed *
```

For a detailed description of the "Awaiting Quotations" facility

reference should be made to Section 7 of the manual.

RESOURCE GANGS

Within the INTEREST system it is possible to combine single resources into resource gangs. A typical example is given below. Two single resources:

- P74 10 TNNE LORRY SITE TIPPER
- P58 JCB 7C EXCAVATOR

are combined to form the Plant Group PG1 which consists of 3 tippers and an excavator and is given the name "Excavation Gang 1".

```
MASTER RESOURCES EDIT option

Resource Code ? [RETURN to End] PG1

Resource not on File
Do you wish to create a new Resource ? Y

Description ? EXCAVATION GANG 1

Single Resource Code ? [RETURN to End] P74
                      LORRY SITE TIPPER    10 TNNE
Quantity ? 3

Single Resource Code ? [RETURN to End] P58
                      JCB 7C EXCAVATOR
Quantity ? 1

Single Resource Code ? [RETURN to End]
```

It is necessary to enter a GANG DIVISION RATE. This division factor divides the gang in accordance with the resources in question. For example, a gang comprising of 5 steelfixers and 1 labourer could be divided by 6 to give an equivalent steelfixer rate as a member of a (5 + 1) gang.

After entering the gang division factor, the build-up of the gang is displayed. If this is satisfactory, the command FI is used to file the details. If further changes are necessary, these may be made using the available commands. The command PR from the sub-menu will provide a print out of the resources within the gang.

```
Division Factor ? 1

*************************************************************************************

(master)         EXCAVATION GANG 1

P58         JCB 7C EXCAVATOR
                                           $12.50 * 1.00 HR    *AO*       $12.50
P74         LORRY SITE TIPPER    10 TNNE
                                           $12.00 * 3.00 HR    *AO*       $36.00
                                                                    -----------
                                              Gang Cost /HR               $48.50
*************************************************************************************

                                                       Press RETURN to continue *

     Commands :-
                 DS - Change Description
                 AD - Add Resource
                 CH - Change Quantity
                 DE - Delete Resource
                 VI - View Gang
                 PR - Print Gang
                 FI - File Gang
Command ? FI

                 * Gang PG1      Filed *
```

Should it be required to enter a resource not yet on file while producing a resource gang this procedure is allowable and proceeds in the manner already described for a single resource.

It should be noted that:

- Plant gangs may only consist of plant resources;
- Labour gangs may only consist of labour resources;
- Material gangs may only consist of material resources.

Resources of the same type but with prices relating to weekly and hourly time periods cannot be combined into gangs.

Where the user wishes to combine different types of resources into a resource gang this may be done under the gang coding of XG for a mixed gang.

A maximum number of eight resources may be included in a resource gang.

(ii) THE EDITING OF RESOURCES
SINGLE RESOURCES

The ER command allows the user to edit details of resources that already exist on the file of company resource data.

Having input the resource code, details of the resource are displayed. It is then possible to edit these details from the sub-menu of commands available. In the example on the following page, the price of resource M11is changed from 22.75 to 27.75 £/M3.

The resource is also changed from being marked as awaiting quotes to not awaiting quotes. In a similar manner the other commands in the sub-menu allow the user to:

- change the resource description;
- change the suppliers name;
- change the discount.

In each case the existing value for the resource is displayed.

```
Command ? ER

WAIT

MASTER RESOURCES EDIT option


Resource Code ? [RETURN to End] M11

     (master)      Description - READY MIXED CONCRETE CLASS E
                   Cost          -       $22.75/M3
                   Price with  5.00 % Discount =      $21.61/M3
                   *********** Awaiting Quotes **********
                   Supplier's Name - R.M.C.
      Commands :-
                   DS - Change Description
                   CO - Change Cost
                   MA - Mark as NOT Awaiting Quotes
                   UN - Change Units of Measurement
                   SU - Change Supplier's Name
                   DC - Change Discount
                   VI - View Resource
                   PR - Print Resource
                   FI - File Resource
                   DF - Delete Resource from File
Command ? CO
     $22.75/M3
 Cost in $/M3    ? 27.75

      Commands :-
                   DS - Change Description
                   CO - Change Cost
                   MA - Mark as NOT Awaiting Quotes
                   UN - Change Units of Measurement
                   SU - Change Supplier's Name
                   DC - Change Discount
                   VI - View Resource
                   PR - Print Resource
                   FI - File Resource
Command ? MA

      Commands :-
                   DS - Change Description
                   CO - Change Cost
                   MA - Mark as Awaiting Quotes
                   UN - Change Units of Measurement
                   SU - Change Supplier's Name
                   DC - Change Discount
                   VI - View Resource
                   PR - Print Resource
                   FI - File Resource
Command ? VI


     (master)      Description - READY MIXED CONCRETE CLASS E
     (used)        Cost          -       $27.75/M3
                   Price with  5.00 % Discount =      $26.36/M3
                   Supplier's Name - R.M.C.
      Commands :-
                   DS - Change Description
                   CO - Change Cost
                   MA - Mark as Awaiting Quotes
                   UN - Change Units of Measurement
                   SU - Change Supplier's Name
                   DC - Change Discount
                   VI - View Resource
                   PR - Print Resource
                   FI - File Resource
Command ? FI

                   * Resource M11      Filed *
```

The command VI enables the user to view the full details of the resource. When all the changes have been made the user must file away the resource details.

NOTE: The message (master) printed alongside the resource description indicates that the user is editing a resource on the main library of resources.

The message (used) printed alongside the cost of the resource indicates that the resource has been used within the build-up of a work group. In this situation it is impossible to delete the resource. The user should check however that any changes to the units or description of a resource do not invalidate the contents of a work group.

EDITING RESOURCE GANGS

In a similar way to the editing of single resources, the contents of a resource gang may be edited. In the example below the number of labourers within the labour gang LG1 is changed from three to four.

```
MASTER RESOURCES EDIT option

Resource Code ? [RETURN to End] LG1

   ******************************************************************************

   (master)        EXCAVATION GANG

   L1          LABOUR
                                         $2.15 * 3.00 HR                $6.45
   L3          GANGER CONCRETE
                                         $5.00 * 1.00 HR                $5.00
                                                                   ------------
                                            Gang Cost /HR               $11.45
   ******************************************************************************

                                                  Press RETURN to continue

      Commands :-
                      DS - Change Description
                      AD - Add Resource
                      CH - Change Quantity
                      DE - Delete Resource
                      DV - Change Division Factor
                      VJ - View Gang
                      PR - Print Gang
                      FJ - File Gang
                      DF - Delete Gang from File
Command ? CH

Single Resource Code ? L1

    3.000 HR
Quantity ? 4.0
```

```
    Commands :-
                  DS - Change Description
                  AD - Add Resource
                  CH - Change Quantity
                  DE - Delete Resource
                  DV - Change Division Factor
                  VI - View Gang
                  PR - Print Gang
                  FI - File Gang
                  DF - Delete Gang from File
Command ? VI

  ***************************************************************************

  (master)        EXCAVATION GANG

  L1          LABOUR
                                          $2.15 * 4.00 HR            $8.6
  L3          GANGER CONCRETE
                                          $5.00 * 1.00 HR            $5.0
                                                                -----------
                                           Gang Cost /HR             $13.6
  ***************************************************************************

                                                  Press RETURN to continue

    Commands :-
                  DS - Change Description
                  AD - Add Resource
                  CH - Change Quantity
                  DE - Delete Resource
                  DV - Change Division Factor
                  VI - View Gang
                  PR - Print Gang
                  FI - File Gang
                  DF - Delete Gang from File
Command ? FI

                  * Gang LG1     Filed *
```

In a similar manner it is possible to delete:

- delete a resource from the GANG;
- change the division factor;
- view the full details of the resource gang.

(iii) TO DELETE A RESOURCE OR RESOURCE GANG FROM THE LIBRARY FILES

To delete a resource or resource gang from the company main library resource file the ER command should be used from the Main Menu. After having displayed the details of the resource code that has been input the list of command options available will be displayed.

The command DF will delete the resource or the resource gang from the file.

If the resource is still being used to form part of a Resource Gang or within a Work Group build-up the note "(used)" will be displayed as part of the resource details and the command DF will not be displayed or allowed to be entered, making it impossible to delete the resource. (Similarly if a Resource Gang is still being used within a Work Group build-up).

When the resource has been deleted a message will be displayed.

In the following example the resource P71 is deleted from the resource file.

```
ER

WAIT

MASTER RESOURCES EDIT option


Resource Code ? [RETURN to End] P71

    (master)      Description - 22 RB TRACKED CRANE
                  Cost        -      $95.00/HR
      Commands :-
                  DS - Change Description
                  CO - Change Cost
                  MA - Mark as Awaiting Quotes
                  VI - View Resource
                  PR - Print Resource
                  FI - File Resource
                  DF - Delete Resource from File
Command ? DF

                  * Resource P71     Deleted *
```

(iv) <u>OBTAINING A PRINT OUT OF A RESOURCE OR RESOURCE GANG</u>

Within the sub-menu of commands contained in the editing resources facility there is the command:

PR-PRINT RESOURCE

This enables the user to obtain a printed copy of the resource or resource gang in question which may be filed within the estimators notes.

8.9 LISTING THE MASTER RESOURCE AND RESOURCE GANGS FILE

The command LR within the CHIEF program Main Menu enables the user to obtain listings of the resources and resource gangs on the main company library. It is possible to obtain:

- a complete listing of the whole file;
- a list of a single resource type (eg Plant);
- a list of a part of a part of a single resource type (eg all Plant between P1 and P50).

Full details of the resource may be printed out or a list of brief details.

In the example below the user requests brief details on the resources held within the category of Labour.

```
                    MAIN MENU
                    ---------
       Commands :-
                    AD - Add a new Contract
                    DE - Delete a Contract
                    CH - Change a Contract Details
                    MP - Change the Master Password
                    LC - List current Contracts
                    EW - Edit the Work Groups File
                    LW - List the Work Groups File
                    ER - Edit the master Resource and Resource Gangs file
                    LR - List the master Resource and Resource Gangs file
                    HE - Set HELP Level
                    ST - Stop program
 Command ? LR

 WAIT
```

```
MASTER RESOURCES LIST option

          Commands :-
                         WH - Whole File
                         SI - Single Resource Type
                         PA - Part of Single Resource Type
Command ? SI

Resource Type to be Listed ? L

Sort in Progress
There are    18 resources requiring about
        2 pages for Full listing
or      1 pages for Brief Listing
WAIT
Today's Date ? 14/04/82

FULL or BRIEF Listing ? BR

Make sure Printer is available (press RETURN)



*** Master Resource Listing in Progress ***
```

A section of the print out obtained is shown in figure 32 page 688.

If full details had been requested, the print out would have taken the form shown in figure 33 page 689.

When requesting part of a single resource type to be printed out, it is necessary to input the first and last resource reference of which you require details.

In the following example a full listing of Labour resources between L1 and L5 is requested. See figure 34 page 690.

```
Command ? LR

WAIT

MASTER RESOURCES LIST option


      Commands :-
                  WH - Whole File
                  SI - Single Resource Type
                  PA - Part of Single Resource Type
Command ? PA

Begin Listing at (Resource Code) ? L1

End Listing at (Resource Code) ? L5

Sort in Progress
There are     3 resources requiring about
       1 pages for Full listing
or     1 pages for Brief Listing
WAIT
Today's Date ? 14/04/82

FULL or BRIEF Listing ? FU

Make sure Printer is available (press RETURN)



*** Master Resource Listing in Progress ***
```

Date : 14/04/82 Interest CE 3 Master Resource Listing Page 1

Labour (Hourly)

L1	Description - LABOUR Cost - £2.15/HR		(used)
L2	Description - DRIVER Cost - £3.50/HR		(used)
L3	Description - GANGER CONCRETE Cost - £5.00/HR		(used)
L101	Description - LABOUR Cost - £3.65/HR		(used)
L102	Description - TRADESMAN Cost - £4.20/HR		(used)
L500	Description - TRADESMAN Cost - £5.50/HR		
L502	Description - GANGER Cost - £3.50/HR		(used) *AO*
L513	Description - MIXER DRIVER Cost - £3.41/HR		(used)
L514	Description - SHOVEL OPERATER Cost - £4.10/HR		(used)
L518	Description - CARPENTER Cost - £4.50/HR		(used)
L519	Description - CARPENTER'S LABOURER Cost - £3.00/HR		(used)
L524	Description - STEELFIXER Cost - £4.50/HR		(used)
L525	Description - STEELFIXER'S LABOURER Cost - £3.50/MH		

Figure 32 Resource Listing - Brief Output

Interest CE 3 Master Resource Listing

Date : 30/06/82 Page 1

Material

```
M1        Description - READY MIXED CONCRETE CLASS E
(used)    Cost        -       £27.75/M3
          Price with  5.00 % Discount =      £26.36/M3
          Supplier's Name - R.M.C.

M11       Description - READY MIXED CONCRETE CLASS E
          Cost        -       £27.75/M3
          Price with  5.00 % Discount =      £26.36/M3
          Supplier's Name - R.M.C.

M45       Description - IMPORTED   ROCK
          Cost        -       £11.50/T

M46       Description - MELDED FIBRE NETT WEIGHT 140 G/M2
          Cost        -         £0.25/M2

M47       Description - CEMENT BS12
          Units of M. - T
          *********** Awaiting Quotes **********

M48       Description - 20MM   AGGREGATE
          Units of M. - T
          *********** Awaiting Quotes **********

M49       Description - 40MM  AGGREGATE
          Units of M. - T
          *********** Awaiting Quotes **********
```

Figure 33 Resource Listing, Full Output

Date : 14/05/82

Interest CE 3 Master Resource Listing

Page 1

Labour (Hourly)

L1 (used)	Description	- LABOUR
	Cost	- £2.15/HR
L2 (used)	Description	- DRIVER
	Cost	- £3.50/HR
L3 (used)	Description	- GANGER CONCRETE
	Cost	- £5.00/HR

Figure 34 Resource Listing, Labour Resources L1 to L5

8.10 SETTING THE 'HELP' LEVEL

The system control program is supplied with a listing at each stage of the program of which commands may be accepted. As the user becomes more proficient with the system there will become less need to refer to these listings. When a sufficient level of expertise has been reached the user may opt to use the HELP command to suppress the command listings from the display.

```
                    MAIN MENU
                    ---------
        Commands :-
                    AD - Add a new Contract
                    DE - Delete a Contract
                    CH - Change a Contract Details
                    MP - Change the Master Password
                    LC - List current Contracts
                    EW - Edit the Work Groups File
                    LW - List the Work Groups File
                    ER - Edit the master Resource and Resource Gangs file
                    LR - List the master Resource and Resource Gangs file
                    HE - Set HELP Level
                    ST - Stop program
Command ? HE

           Help levels
      0 - Suppress Menus
      1 - Display Menus
Help Level ? [RETURN for 1] 0
```

If within the running of the program the user now enters an incorrect command the appropriate command menu for that point in the program will be displayed to give assistance.

If the user should wish to display in full all the command menus this may be achieved by re-setting the HELP facility.

```
                    MAIN MENU
                    ---------
Command ? HE

          Help levels
      0 - Suppress Menus
      1 - Display Menus
Help Level ? [RETURN for 0] 1

                    MAIN MENU
                    ---------
      Commands :-
                    AD - Add a new Contract
                    DE - Delete a Contract
                    CH - Change a Contract Details
                    MP - Cnange the Master Password
                    LC - List current Contracts
                    EW - Edit the Work Groups File
                    LW - List the Work Groups File
                    ER - Edit the master Resource and Resource Gangs file
                    LR - List the master Resource and Resource Gangs file
                    HE - Set HELP Level
                    ST - Stop program
```

8.11 TO STOP THE PROGRAM

To stop the program the command ST should be used.

```
WAIT

                    MAIN MENU
                    ---------
      Commands :-
                    AD - Add a new Contract
                    DE - Delete a Contract
                    CH - Change a Contract Details
                    MP - Change the Master Password
                    LC - List current Contracts
                    EW - Edit the Work Groups File
                    LW - List the Work Groups File
                    ER - Edit the master Resource and Resource Gangs file
                    LR - List the master Resource and Resource Gangs file
                    HE - Set HELP Level
                    ST - Stop program
Command ? ST
 STOP
```

9.0 THE DATA LIBRARY

This chapter gives details of the files which hold COMPANY RESOURCE COSTS and PERFORMANCE DATA. These files form the DATA LIBRARY of the estimating system. Resources from the COMPANY RESOURCE cost files are used with appropriate performance data to form WORK GROUPS. These WORK GROUPS may then be used to price bill items as described in Section 5

COMPANY RESOURCE COST FILES

Resources may be allocated into one of the following cost code categories:

- L - Labour;
- P - Plant;
- A - Auxiliary Plant;
- M - Material;
- S - Domestic Subcontractors.

The extra cost code "Additional" may be used to allocate sums of money but not to hold individual resources. Resources may be grouped into GANGS

- LG - Labour Gangs
- PG - Plant Gangs
- XG - Mixed resource Gangs.

The resources may be further divided into hourly priced and weekly priced. The weekly priced resources cannot be formed into WORK GROUPS but are held on file for addition into OPERATIONAL GROUPS. The full listing of types of resources is shown in Table 2 page 695 together with the resource code range. The maximum number of resources that may be held by the system is 30 000. Within this number, the resources within each category may be altered according to the user's specific requirements.

PREPARATION OF RESOURCE DATA FOR ENTRY INTO THE COMPUTER SYSTEM

The principal skill required for the entry of resources into the company resource files is that of competence in the operation of the keyboard. Consequently it is unlikely that the estimator will personally perform this task. A typist or other keyboard operator would be more suitable.

To assist the keyboard operator in his/her task the estimator should prepare the data on forms such as that shown in figure 35 page 697.

For each resource the following data should be assembled. Note that a character may be a letter, number, decimal place, space, etc.

RESOURCE CODE : Up to 6 characters are allowed in accordance with the requirements of Table 2

RESOURCE DESCRIPTION : Up to 40 characters are permitted. NOTE: With the screen displays of the system the resource description is presented as two lines each of 20 characters length. Care should be taken to ensure that each block of 20 characters is meaningful to the user.

UNITS OF MEASUREMENT : Up to 4 characters are allowed.

COST : A number in the range 0.01 to 99 999.99.

For material resources it is possible to store a discount figure. For all resources it is possible to mark them as awaiting quotations. The user may wish to add these categories to the forms.

RESOURCE CODE	RESOURCE DESCRIPTION	UNIT	RATE

Figure 35 Example of form to be used for the arrangement of SINGLE resources for entry onto the system

RESOURCE GANGS

It is possible for the resources to be grouped together to form gangs. These gangs may include up to eight single resources. For each resource gang it is necessary to input

RESOURCE CODE	:	Up to 6 characters
DESCRIPTION	:	Up to 40 characters
UNITS OF MEASUREMENT	:	Up to 4 characters allowed. NOTE: In some cases the units required will be assumed from the type of resource gang ie LWG = weekly priced Labour Gang.
GANG DIVISION FACTOR	:	Number by which the gang is divided to produce an average rate.

For each RESOURCE within the GANG it is necessary to enter:

RESOURCE CODE	:	A code of up to sic characters representing the single resource that is required to be part of the gang.
QUANTITY	:	The number of the RESOURCE required in the gang.

FILE OF PERFORMANCE DATA

Performance data is held within the company library in the form of WORK GROUPS. This section describes the structure and coding of the WORK GROUP FILES. The entry of data into the WORK GROUPS is described and sample input forms provided.

THE FUNCTION OF THE WORK GROUP

The function of the WORK GROUP is to store unit rate build-ups for commonly recurring items of construction work in order that the estimator may use them as a basis for pricing bill items. A typical WORK GROUP build-up is shown below. This relates to the fixing of 20mm Mild Steel Reinforcement.

LABOUR			
STEELFIXER	18 hrs @ £4.50/hr	=	81.00
LABOURER	2 hr @ £2.75/hr	=	5.50
			86.50
PLANT			
22 RB crane	0.5 hrs @ £25.00/hr	=	12.50
MATERIAL			
20mm Mild Steel Rebar cut, bent and delivered	1.0 tnne @ £300.00/tnne	=	300.00
Wastage on above	7% @ £300.00/tnne	=	21.00
	TOTAL UNIT RATE/TNNE		£420.00

It is necessary to be able to store this data in the computer files and readily access the data for use in pricing the relevant bill item. To do this each WORK GROUP must be given a unique reference number which will enable the user to locate the build-up on the data library. This requires a WORK GROUP CODE and a suitable CLASSIFICATION SYSTEM.

THE INTEREST CE program has been supplied with the data files structured for use with a CLASSIFICATION SYSTEM based upon the Civil Engineering Standard Method of Measurement (CESMM).

This divides construction work into twenty four different classes. (The full list is given in figure 36 page 701). Each class of work is divided into systematic structure of work items. An example is given in figure 37 page 702 of the subdivision of CLASS F "In-situ concrete". Each work item is given an alphanumeric code of the type Annn.n The alphabetical prefix indicates the class of work. The numbers locate the work item. For example, from figure 37 page 702 , Placing Reinforced Concrete to Bases exceeding 500mm thick would be coded F624.0.

NOTE: The use of a WORK GROUP coding system based upon the CESMM does not mean that only CESMM Bills of Quantities may be processed. See Section 8 for details of the bill numbering systems allowable.

The user need not store his library data using the CESMM coding system. If it is required to use an alternative coding system the supplier of the INTEREST package should be contacted for advice on any amendments that may be required on how to structure data.

THE PREPARATION OF WORK GROUP DATA FOR ENTRY INTO THE LIBRARY FILES

The method of entry of WORK GROUP data into the computer system is described in detail in Section 8. . This section describes the preparation of data for entry.

The user should review the list of trade classifications given in figure 36 page 701 and decide for which classes of work it is wished to store data.

SECTION 8. WORK CLASSIFICATION

Class A: General items,

Class B: Site investigation,

Class C: Geotechnical and other specialist processes,

Class D: Demolition and site clearance,

Class E: Earthworks,

Class F: In situ concrete,

Class G: Concrete ancillaries,

Class H: Precast concrete,

Class I: Pipework—pipes,

Class J: Pipework—fittings and valves,

Class K: Pipework—manholes and pipework ancillaries,

Class L: Pipework—supports and protection, ancillaries to laying and excavation,

Class M. Structural metalwork,

Class N: Miscellaneous metalwork,

Class O: Timber,

Class P: Piles,

Class Q: Piling ancillaries,

Class R. Roads and pavings,

Class S: Rail track,

Class T: Tunnels,

Class U: Brickwork, blockwork and masonry,

Class V: Painting,

Class W. Waterproofing,

Class X: Miscellaneous work,

Figure 36 CESMM Work Group Classification

CLASS F: IN SITU CONCRETE

Excludes In situ concrete for:

- capping of boreholes (included in class B)
- diaphragm walls (included in class C)
- drainage and pipework (included in classes K and L)
- piles (included in classes P and Q)
- roads, pavings and kerbs (included in class R)
- rail track foundations (included in class S)
- tunnel and shaft linings (included in class T)
- foundations for fences and gates (included in class X)

FIRST DIVISION	SECOND DIVISION	THIRD DIVISION
Provision of concrete 1 Designed mix for ordinary structural concrete m³ 2 Prescribed mix for ordinary structural concrete taken from Table 50 of CP 110 Part 1 m³ 3 Prescribed mix for ordinary structural concrete not taken from Table 50 of CP 110 Part 1 m³	*Grades of concrete* 1 7 or 10 2 15 3 20 4 25 5 30 6 40 7 50 8 60	*Cement to BS 12 or BS 146* 1 10 mm aggregate 2 14 mm aggregate 3 20 mm aggregate 4 40 mm aggregate *Cement to BS 4027 (sulphate resisting)* 5 10 mm aggregate 6 14 mm aggregate 7 20 mm aggregate 8 40 mm aggregate
Provision of concrete 4 Designed mix for special structural concrete m³		*Cement to BS 12 or BS 146* 1 10 mm aggregate 2 14 mm aggregate 3 20 mm aggregate 4 40 mm aggregate *Other cements* 5 10 mm aggregate 6 14 mm aggregate 7 20 mm aggregate 8 40 mm aggregate
Provision of concrete 5 Prescribed mix for special structural concrete m³		
Placing of concrete 6 Mass m³ 7 Reinforced m³ 8 Prestressed m³	1 Blinding 2 Bases, footings and ground slabs 3 Suspended slabs 4 Walls	1 Thickness not exceeding 150 mm 2 150–300 mm 3 300–500 mm 4 exceeding 500 mm
	5 Columns and piers 6 Beams 7 Casing to metal sections	1 Cross sectional area not exceeding 0.03 m² 2 0.03–0.1 m² 3 0.1–0.25 m² 4 0.25–1 m² 5 exceeding 1 m² 6 Special beam sections
	8 Other concrete forms	

Figure 37 CESMM Class F - Insitu Concrete

This will depend on the individual company but for the civil engineering contractor undertaking general construction work there should be no need to store WORK GROUP data on say "Tunnels" or "Rail Track". For other classes of work it will not be worth storing data because of the uniqueness of bill items found (eg Precast Concrete) or because that type of work is normally sub-contracted.

Having determined which classes of work data is going to be stored the appropriate pages of the CESMM should be studied. It should be remembered that the CESMM is a Standard Method of Measurement and NOT a standard method of estimating. The user may well wish to amend the descriptions to suit his estimating technique.

The WORK GROUPS on the library are used to store details for UNIT RATE estimating. Where the company uses OPERATIONAL ESTIMATING techniques to price particular types of work there is no point in preparing data to be stored on the library.

Having determined which items of work data is required to be stored this must be assembled in a form suitable for entry into the system. Several hundred WORK GROUPS may well be entered into the system and this must be organized in an orderly manner. It is probable that someone other than the estimator will perform this entry of data and it is therefore essential that the estimator presents the data in a clear and legible fashion.

The forms shown in figures 38 and 39 , pages 704 and 705 may be used to prepare data for input. These may then be passed to the keyboard operator who can enter the data into the system using the System Control Program.

WORK GROUP CODE

WORK GROUP DESCRIPTION

UNITS OF MEASUREMENT

RESOURCE CODE	RESOURCE DESCRIPTION EXTENSION	OUTPUT/USAGE	% WASTAGE

Figure 39 Proforma for Entry of Work Group Data Type A

WORK GROUP CODE

WORK GROUP DESCRIPTION

UNITS OF MEASUREMENT

RESOURCE CODE	RESOURCES DESCRIPTION EXTENSION	USAGE	NUMBER OF USER (FWK)	% WASTAGE

Figure 38 Proforma for Entry of Work Group Data Type B

There are two different types of forms A and B. A should be used for WORK GROUPS other than those relating to formwork. B should be used for formwork WORK GROUPS. The number of characters allowed for each entry are given below. It should be noted that letters, numbers, spaces etc are recognised by the system as a character.

WORK GROUP CODE	:	Fixed Length, 6 characters. Must start with an alphabetical letter. Must include a decimal point and a numeric level after the decimal point in the range 0 to 9.
DESCRIPTION	:	Up to 80 characters. These are displayed in one line by the system.
UNITS OF MEASUREMENT	:	Up to 4 characters.
RESOURCE CODE	:	Variable between 2 to 8 characters.
DESCRIPTION EXTENSION		Up to 8 characters.
USAGE RATE	:	A number between 0.001 and 999.999. Up to 7 characters allowed.
OUTPUT RATE (Plant only)	:	A number between 999.999 and 0.999 Up to 7 characters allowed.
NUMBER OF USES	:	A number between 0.1 and 99.9. Up to 4 characters allowed.
WASTAGE	:	A number between 0.1 and 999.9. Up to 5 characters allowed.

NOTE: Up to 10 resources may be entered into any WORK GROUP. Labour and Material resources require usage rates to be allocated (ie HR/M3). Plant resources are allocated output rates (ie M3/HR or M3/WK).

THE USE OF RESOURCE GANGS IN WORK GROUPS

A WORK GROUP may contain RESOURCE GANGS. By using RESOURCE GANGS the number of resource references stored within the WORK GROUP may be kept to a minimum. Up to 8 resources may be stored in a gang. This gives a maximum number of 80 resources within a single WORK GROUP.

AN EXAMPLES OF A CODED WORK GROUP

The following example relates to the build-up of a unit rate for fixing 20mm Mild Steel Reinforcement as shown on page

Information is assembled for the WORK GROUP and the Resource Code Numbers are obtained from the list of resources on the company library files. The WORK GROUP CODE is determined from the CESMM.

WORK GROUP CODE: G516.0

DESCRIPTION : Fix 20mm dia. Mild Steel Rebar supplied cut, and bent.

UNITS OF MEASUREMENT : TNNE

RESOURCE CODE NUMBER	DESCRIPTION EXTENSION	USAGE/OUTPUT RATE	WASTAGE RATE
L1	-	2.0	-
L524	-	18.0	-
P147	-	2.0	-
M530	-	1.0	7

Figure Data required for entry of a WORK GROUP relating to reinforcement

An example of the coded form type A for this WORK GROUP is given in figure 41 page 708.

WORK GROUP CODE

G516.0

WORK GROUP DESCRIPTION

FIX 20MM DIA MILD STEEL REBAR SUPPLIED
CUT AND BENT

UNITS OF MEASUREMENT

TNNE

RESOURCE CODE	RESOURCE DESCRIPTION EXTENSION	OUTPUT/USAGE	% WASTAGE
L1		2.0	
L524		18.0	
P147		2.0	
M530		1.0	7.0

Figure 41 Example of a coded form Type A

10.0 PRIME COSTS, PROVISIONAL SUMS AND ITEMS

This section of the manual describes:

- how the system handles PRIME COSTS, Provisional Sums, and Items;
- how profits and attendances may be added to PRIME COSTS.

10.1 THE ENTRY OF PRIME COST, PROVISIONSL SUMS INTO THE COMPUTER

The entry of the details of the Bill of Quantities items for the contract has been described in detail in the section This included details of the entry of PRIME COST, PROVISIONAL SUMS and ITEMS together with examples. The system allows the user to distinguish between NOMINATED SUPPLIERS (SP) and NOMINATED SUB-CONTRACTORS (SC). At the entry of data stage the sum of money associated with the PRIME COST or PROVISIONAL SUM may be entered.

10.2 THE INSPECTION AND EDITING OF THE PRIME COSTS, PROVISIONAL SUMS AND ITEMS

Using the INSPECT BILL ITEM command from the Main Menu of the commands in the AB3RUN program it is possible for the estimator to check the pricing of PRIME COSTS, PROVISIONAL SUMS and ITEMS. Where sums of money have already been entered at the data-prep stage for PRIME COSTS and PROVISIONAL SUMS it is not necessary for the estimator to inspect them in order that they are included in the bill item printouts. However should the estimator wish to edit any information relevant to these items or change the type of item then this may be done using the INSPECT BILL ITEM command.

The following examples show how it is possible to change the sum of money previously entered against a PRIME COST and PROVISIONAL SUM item using the CS command from the sub-menu of commands supplied.

```
       Commands:-
                      IN - Inspect Bill Item
                      OP - Create/Edit Operational Group
                      UP - Update Prices
                      SC - Enter Sub-contract Quotes
                      MA - Apply Mark-ups
                      PR - Print Reports
                      HE - Set HELP Level
                      DE - Delete Bill Item
                      ST - Stop
 Command ? IN

 WAIT

 INSPECT BILL ITEM option


 Item Reference ? [RETURN to End] 1/1/4

 WAIT
 Section 1  Page 1/4
 ADDITIONAL WORK STATUTORY BODIES
 Prov. Sum
   $10,000.00

 Commands :-
                      DS - Change Description
                      CS - Change Sum
                      CT - Change Type
                      FI - File Item
 Command ? CS

 Sum ? 12000

 Section 1  Page 1/4
 ADDITIONAL WORK STATUTORY BODIES
 Prov. Sum
   $12,000.00

 Commands :-
                      DS - Change Description
                      CS - Change Sum
                      CT - Change Type
                      FI - File Item
 Command ? FI


          ** Bill Item 1/1/4            Filed **
```

```
INSPECT BILL ITEM option


Item Reference ? [RETURN to End] 1/1/5

WAIT
Section 1  Page 1/5
P.C. SUM NOM. S/C ELECTRICAL SERVICES
Prime Cost
(Nominated Sub-Contractor)
   $5,000.00

Commands :-
                    DS - Change Description
                    CS - Change Sum
                    CT - Change Type
                    FI - File Item
Command ? CS

Sum ? 6000

Section 1  Page 1/5
P.C. SUM NOM. S/C ELECTRICAL SERVICES
Prime Cost
(Nominated Sub-Contractor)
   $6,000.00

Commands :-
                    DS - Change Description
                    CS - Change Sum
                    CT - Change Type
                    FI - File Item
Command ? FI


           ** Bill Item 1/1/5              Filed **
```

ITEMS may be priced by:

- including the ITEM within another bill item price; or
- the insertion of a lump sum of money.

After an ITEM has been marked as "INCLUDED IN" another bill item it is always possible to:

- change the item in which it is included; or
- reprice the ITEM completely.

```
WAIT

INSPECT BILL ITEM option


Item Reference ? [RETURN to End] 1/1/7

WAIT
Section 1  Page 1/7
Description : ADD FOR ATTENDANCE
Item
      Category                          Sum
      --------                          ---
        LAB.                        $500.00
        PLT.                        $500.00
                                 ----------
                 Item Cost        $1,000.00
     Commands :-
                    AD - Add Sum
                    CH - Change Sum
                    DE - Delete Sum
                    VI - View Item
                    FI - File Item
                    CT - Change Type
                    DS - Change Description
Command ? CT

      Commands :-
                    IT - Item
                    IN - Included in
                    SP - Prime Cost - Nominated Supplier
                    SC - Prime Cost - Nominated Sub-Contractor
                    PS - Provisional Sum
                    AT - Attendance Allowance
                    PR - Profit Allowance
Command ? IN

Item Included in with :- 1/1/6

Section 1  Page 1/7
ADD FOR ATTENDANCE
Included in  Section 1  Page 1/6

Commands :-
                    CT - Change Item this is Included in
                    DS - Change Description
                    CT - Change Type
                    FI - File Item

Command ? FI


         ** Bill Item 1/1/7            Filed **
```

ENTERING LUMP SUMS OF MONEY AGAINST AN ITEM.

The estimator may decide that he wishes to enter a lump sum of money against one or all of the following cost code categories:

LAB - Labour

PLT - Plant

AUX - Auxiliary Plant

MAT - Materials

DOM - Domestic Sub-contractors

ADD - Additional.

To do this the estimator should, when asked

"This is a no quantity item

Do you wish to include it with another item?" -

enter NO (or N).

The system will then present a sub-menu of commands enabling him to add, change, delete etc sums of money for the ITEM. The facilities provided are described on following page.

In this example a sum of money is added under the LABOUR, PLANT and MATERIAL categories.

```
INSPECT BILL ITEM option

Item Reference ? [RETURN to End] 1/1/3

WAIT
Section 1   Page 1/3
Description : TEMPORARY WORKS FOR DIVERSION OF STREAM
Item
     Commands :-
                  AD - Add Sum
                  CH - Change Sum
                  DE - Delete Sum
                  VI - View Item
                  FI - File Item
                  CT - Change Type
                  DS - Change Description
Command ? AD

Cost Code ? LAB

Sum ? 1000

     Commands :-
                  AD - Add Sum
                  CH - Change Sum
                  DE - Delete Sum
                  VI - View Item
                  FI - File Item
                  CT - Change Type
                  DS - Change Description
Command ? AD

Cost Code ? PLT

Sum ? 2000

     Commands :-
                  AD - Add Sum
                  CH - Change Sum
                  DE - Delete Sum
                  VI - View Item
                  FI - File Item
                  CT - Change Type
                  DS - Change Description
Command ? AD

Cost Code ? MAT

Sum ? 1000
```

It is decided to view the ITEM to check the ITEM cost

```
     Commands :-
                  AD - Add Sum
                  CH - Change Sum
                  DE - Delete Sum
                  VI - View Item
                  FI - File Item
                  CT - Change Type
                  DS - Change Description
Command ? VI

Section 1  Page 1/3
Description : TEMPORARY WORKS FOR DIVERSION OF STREAM
Item
      Category                        Sum
      --------                        ---
        LAB.                   $1,000.00
        PLT.                   $2,000.00
        MAT.                   $1,000.00
                               ----------
              Item Cost        $4,000.00
     Commands :-
                  AD - Add Sum
                  CH - Change Sum
                  DE - Delete Sum
                  VI - View Item
                  FI - File Item
                  CT - Change Type
                  DS - Change Description
```

By using the CHANGE SUM command and selecting the appropriate cost code category the sum for LABOUR is altered.

```
              Commands :-
                          AD - Add Sum
                          CH - Change Sum
                          DE - Delete Sum
                          VI - View Item
                          FI - File Item
                          CT - Change Type
                          DS - Change Description
      Command ? CH

      Cost Code ? LAB

      Sum is  $1,000.00
      New Sum ? 3000
```

By using the DELETE SUM command the sum of money allocated under MATERIALS is deleted.

```
           Commands :-
                       AD - Add Sum
                       CH - Change Sum
                       DE - Delete Sum
                       VT - View Item
                       FI - File Item
                       CT - Change Type
                       DS - Change Description
   Command ? DE

   Cost Code ? MAT
```

The command CHANGE TYPE allows the estimator to re-define completely the type of item pricing as shown below.

```
Commands :-
              AD - Add Sum
              CH - Change Sum
              DE - Delete Sum
              VI - View Item
              FI - File Item
              CT - Change Type
              DS - Change Description
Command ? CT
```

ATTENDANCE ON NOMINATED SUB-CONTRACTORS

The facilities provided by the system for pricing ATTENDANCE ON NOMINATED SUBCONTRACTORS are similar to those just described for ITEMS. Sums of money to cover ATTENDANCE may be entered under appropriate cost code categories. Attendance may be allowed for by including the item cost within another. It is possible to change an item that ATTENDANCE is to be priced on or edit the sums of money already entered.

```
INSPECT BILL ITEM option

Item Reference ? [RETURN to End] 1/1/7

WAIT
Section 1  Page 1/7
ADD FOR ATTENDANCE
Included in  Section 1  Page 1/5

Commands :-
                    CI - Change Item this is Included in
                    DS - Change Description
                    CT - Change Type
                    FI - File Item

Command ? CT

       Commands :-
                    IT - Item
                    IN - Included in
                    SP - Prime Cost - Nominated Supplier
                    SC - Prime Cost - Nominated Sub-Contractor
                    PS - Provisional Sum
                    AT - Attendance Allowance
                    PR - Profit Allowance
Command ? IT

Section 1  Page 1/7,
Description : ADD FOR ATTENDANCE
Item
      Commands :-
                    AD - Add Sum
                    CH - Change Sum
                    DE - Delete Sum
                    VI - View Item
                    FI - File Item
                    CT - Change Type
                    DS - Change Description
Command ? AD

Cost Code ? LAB

Sum ? 500

      Commands :-
                    AD - Add Sum
                    CH - Change Sum
                    DE - Delete Sum
                    VI - View Item
                    FI - File Item
                    CT - Change Type
                    DS - Change Description
Command ? AD

Cost Code ? PLT

Sum ? 500

      Commands :-
                    AD - Add Sum
                    CH - Change Sum
                    DE - Delete Sum
                    VI - View Item
                    FI - File Item
                    CT - Change Type
                    DS - Change Description
Command ? FI


          ** Bill Item 1/1/7             Filed **
```

10.3 THE ADDITION OF MARK-UPS ON PRIME COSTS, PROVISIONAL SUMS AND ITEMS

The addition of Mark-ups is described in detail in Section 6 . Except where stated below, PRIME COSTS, PROVISIONAL SUMS and ITEMS are exempt from any Mark-up additions made under the categories of:

- Profits;
- Overheads;
- Surcharges;
- On-costs;
- Distributed Sums;
- Rate Loading.

PROFITS

Facilities are provided within the INSPECT BILL ITEM command of the Main Menu of AB3RUN to enter profit percentages for NOMINATED SUPPLIERS and NOMINATED SUBCONTRACTORS. Where items have not been inspected using this command any profit percentages entered within the addition of Mark-up facilities described in Section 6 will apply. Where profit percentages have been entered at the inspect stage these figures will over-ride any of those entered at the Mark-up stage.

No profit allowance may be applied to PROVISIONAL SUMS.

PROFITS added under the Mark-up facilities will be applied to the relevant cost code sums entered for ITEMS.

Similarly, PROFITS added via the Mark-up facilities will be applied to the sums of money added to the cost code categories to cover ATTENDANCE.

OVERHEADS, SURCHARGES, ON-COSTS, DISTRIBUTED SUMS and RATE LOADING

It is NOT possible to add these mark-up factors to PRIME COST or PROVISIONAL SUM ITEMS.

These mark-up factors will affect the relevant cost code categories of money entered for ITEMS and ATTENDANCE.

TERMINOLOGY

FILE	- an organised collection of inter-related units of data.
INTERACTIVE DISPLAY	- any display which allows the user to input data in response to the information displayed.
FLOW CHART	- the diagrammatic representation of a sequence of events.
COMMAND DRIVEN	- the running of a program by the instruction of commands selected by the user from a list of 'menu'.
V.D.U.	- visual display unit. A display unit consisting of a cathode ray tube used to display characters or graphs representing data read from the main memory of the computer.
DATA LIBRARY	- a collection of resources and work groups stored on the system's files.
WORK GROUP	- a build-up stored in the data library.
WORK GROUP CODE	- a code used for identifying each work group.
RESOURCE CODE	- a code used for identifying each resource.
HARDWARE	- the physical components of the computer system.
SOFTWARE	- the programs needed to make the system work.