APPLICATION OF MATHEMATICAL MODEL TECHNIQUES TO THE PLANNING AND CONTROL OF OVERHEAD COSTS IN THE CONSTRUCTION INDUSTRY

by

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ABSTRACT

For the purposes of cost planning and control and efficient execution of construction projects, overhead costs - head office overhead costs of construction companies and site overhead costs of construction projects - are important to companies in the industry as these costs sometimes amount to ten to twenty per cent of project costs. The aim of this research has been to study methods of overhead costs planning and control that are in use in the construction industry, the limitations of these methods as effective tools, and to propose new methods which could be practical to apply.

The method of overhead costs planning and control developed in this work is called the 'safe zone method'. This method defines lower and upper bound limits of safe zones within which costs should lie at planning stages and lower and upper bound limits of sub safe zones for actual costs at cost examination stages. The safe zone method has been developed for planning and control of the head office overhead costs of construction companies, site overhead costs of construction projects and the cost components of these costs.

Three mathematical models, based on the statistical technique of multiple regression analysis, have been developed in this work for determining the overhead costs of a construction project. The first model is for the head office overhead costs apportioned to a project at the tender stage. The second model is for the site overhead costs at the tender stage and the third model is

for the proportion of the head office overhead costs incurred for a period of time that is apportioned to a project during the construction stage of the project.

A definition of overhead costs in the construction industry has been given in this work. This has been based on the behavioural and functional characteristics of these costs. A way of grouping the overhead cost items into cost centres or cost components for planning and control purposes have also been proposed in this work.

NOTATIONS AND SYMBOLS

GENERAL NOTATIONS

$A_0 \ldots\ldots A_m$	Regression constants for the head office overhead costs apportioned to the Kth project at the tender stage.
$B_0 \ldots\ldots B_m$	Regression constants for the head office overhead costs apportioned to the Kth project during the construction stage.
C	Total overhead costs of the company.
C_1	Head office overhead costs of the company for the planning period.
C_2	Total site overhead costs.
C_k	Overhead costs of a project (referred to as the Kth project).
C_{1ko}	Head office overhead costs apportioned to the Kth project at the tender stage.
C_{1ki}	Head office overhead costs apportioned to the Kth project for the Ith month during the construction stage.
C_{1i}	Head office overhead costs incurred for the Ith month.
$\frac{C_{1ki}}{C_{1i}}$	Proportion of head office overhead costs apportioned to the Kth project during construction for the Ith month.
C_{2ko}	Site overhead costs of the Kth project.

C_{2ki}	Site overhead costs of the Kth project for the Ith month.
$D_1 \ldots\ldots D_m$	Rëgression constants for the site overhead costs of the Kth project.
E	Expenditure on the Kth project.
I	Income to the company from the Kth project.
L	Loss made on the project.
M	Mark-up value.
P_i	Number of months after physical start of the Kth project.
Pr	Profit to the company.
Pu	Planned duration of the project.
Du	Duration of planning period.
Di	Duration since start of planning period.
T	Tender value.
Tu	Turnover on project.
Ri	Risks.
$X_1 \ldots\ldots X_m$	Set of independent variables for the head office overhead costs apportioned to the Kth project at the tender stage.
$U_1 \ldots\ldots U_m$	Set of independent variables for the head office overhead costs apportioned during the construction stage.
$V_1 \ldots\ldots V_m$	Set of independent variables for the site overhead costs.

STATISTICAL SYMBOLS

SS_{res}	Sum of squared residuals
SS_{reg}	Sum of squares explained by the regression
σ	Standard deviation
r	Coefficient of correlation
R	Coefficient of multiple correlation
R^2	Coefficient of determination
σ_{EE}	Standard error of estimate
F	Ratio of variance in the regression/ variance in the residuals
N	Number of observations
m	Number of independent variables.
SS	Sum of squares
MS	Mean squares

COMPUTATIONAL SYMBOLS

YTURN	Yearly turnover of the company.
HCOST	Head office overhead costs.
HCOSTI	Lower bound value of HCOST.
HCOST2	Upper bound value of HCOST.
HCOSTP	Planned HCOST.
HCOSTAI	Actual HCOST incurred after I months.
Di/Du	Scaling factor head office overhead costs and cost components.
H J	Lower and upper bound equation constants for the head office overhead costs and the head office overhead cost components.
L K	Lower and upper bound equation constants for the site overhead costs and the site overhead costs components.
PCOST	Estimated direct costs of the project.
SCOST	Site overhead costs.
SCOSTI	Lower bound value of SCOST
SCOST2	Upper bound value of SCOST.
SCOSTP	Planned SCOST
SCOSTAI	Actual SCOST after I months
Pi/Pu	Scaling factor for the site overhead costs and the site overhead costs components.

Notations and symbols used in the study which are not listed here are defined in footnotes in the body of the thesis.

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DEFINITIONS

Construction company:	Company that undertakes the construction of buildings and civil engineering projects.
Costs of a project:	To a construction company; costs of labour, plant, material, head office and site overheads.
Direct or Basic Costs:	Costs of labour, plant and material of projects.
Prime costs:	Direct costs plus site overhead costs.
Overhead costs:	As defined on page 14
Turnover on a project:	Costs of project plus profit.
Cost centres or cost components:	Groups of items of costs for the purposes of cost planning and control.
Duration of project:	Time period between physical start and physical finish of construction projects.
Planning period:	Time period for planning the head office overhead costs. Normally twelve months.
Profit on a project:	To a construction company; difference between turnover and costs of projects.
Profitability:	Ratio of profit/turnover.
Planned capital outlay:	Positive difference between planned expenditure and expected income on construction projects.
Safe Zone Method:	A method of cost planning and control of overhead costs developed in this work.
Safe Zone:	Cost range within which planned costs should lie.
Sub Safe Zone:	Cost range within which actual costs should lie at cost examination stages.

CHAPTER ONE

INTRODUCTION

1.1 Problems.

Over the last two decades, considerable progress has been made in the improvement of management techniques based on mathematical and scientific concepts but the construction industry relies heavily on short term empirical methods for solving the everyday problems that confront the industry (ref. 39)*. This is the case in determining construction contracts overheads. Not only does management not use mathematical techniques, there is hardly any known quantitative approach for dealing with these aspects of costs in the industry.

Overhead costs are costs of production, for they are the costs incurred in undertaking and carrying out construction projects. They arise because of the prohibitive costly accounting procedures that would otherwise be required to charge all items of overhead costs directly to elements or units of production. The increasing importance of these costs as an element of costs of construction projects and of the construction industry itself indicates the desirability of laying greater emphasis not only on their planning, but also on their coordination and control. The problems, therefore, highlighted by these costs to management, have stimulated many people to carry out work on this subject either wholly or partially in their work on other subjects. These works have, however, not fully provided solutions to the ever-increasing problems

*The numbers in brackets refer to similarly numbered entries in the References and Bibliography.

associated with overhead costs. Bristor's work on site overhead costs focussed attention on the growing problems and the importance of site overhead costs in the industry, but his qualitative approach to analysing these problems and drawing conclusions still leaves the problems unsolved (ref. 5). He made no attempt to analyse quantitatively, the percentage addition made by construction companies which he states is normally five per cent. The method of analysis and control discussed by Hart takes these problems further, but his bias towards the manufacturing industry and the production industry makes its application to the construction industry a limited one (ref. 26).

Lee and others, in their study of twenty-five companies in the building industry established that companies which ranked the best in their measure of efficiency in terms of growth were those that apportioned their overhead costs, and even suggested that the successful companies were the ones that best controlled their overhead costs. Yet, from their study, only a few companies costed their overheads to individual projects and even those with a departmental analysis of overhead costs had generally introduced it only recently. It is not, therefore, surprising for them to have observed that:

> "There would appear to be scope for a further study of overhead costs and their effect on profits."
>
> (ref. 41).

Jones, in his work on Finance and Cost, edited by Brech, stresses the inadequacy in the existing methods of apportioning overhead costs (ref. 6). He states,

> "Possibly, a much more sophisticated approach is something which is long overdue in the industry."

He suggested taking into consideration such major factors as the size and complexity of projects in apportioning overhead costs to improve the accuracy. He further suggested the cutting down of the number of items that make up the overhead costs to lessen the problems of cost allocation to overhead cost centres. He argues that the fewer in number the overhead cost items, the less the degree of uncertainty and errors in the apportioning methods. Whether this in fact solves the problems remains to be investigated. It can be said that this method of treating overhead costs could only provide a short-term solution, in that few items remain under the overhead costs, but thereby moving the other items to other cost areas. Rowe (ref. 58), has this to say:

> "High overhead costs either as direct or indirect charge will reduce profits ....."
>
> "It will be acknowledged, therefore, that careful control of overhead elements of costs is essential as it is an indication of efficiency."

There is the general understanding adopted in the industry that it will be costly to try to investigate a real method of determining these costs both at the tender and construction stages of projects. Whilst this may be true in view of the nature of the overhead costs, it has perhaps been underestimated that the nature of management among companies in the construction industry and of construction projects are similar. It is only the scale, the complexity and technical contents of administration that differ from one construction company to the other and from one construction project to another.

Overhead costs account for about 10 per cent to 20 per cent of the value of construction work. In the United Kingdom, both in the public and private sectors of the industry, these amount to £1614.7 million to £3229.4 million of the £16147 million value of construction work done in 1978 and between £1895.9 millions and £3791.8 millions of the value of work done in 1979 (ref. 30).

There is therefore the need for management to be provided with a tool which could be used to determine these costs, and also ways of planning and controlling overhead costs, which has often in the past been given a blanket cover approach.

1.2. OBJECTIVES

1.2.1 OVERHEAD COSTS MODELS

The aim of this work is to develop mathematical models having the overhead costs of the head office and the site overhead costs as the dependent or criterion variables and a number of other factors as the independent or predictor variables. If successful, these models could be used to determine the overhead costs at the tender stage and also during construction of projects of both general building and civil engineering works. Final estimates must be very close to the actual costs since these are, in most cases, used for bidding and tendering purposes. Detailed analysis of costs is time-consuming and therefore expensive. Cost of detailed estimating may vary from 0.6 per cent to 3 per cent of the actual project cost in order for the estimated cost to lie in the range of 3 per cent to 12 per cent of the actual project cost (Ref. 39). It is, therefore, useful to have an easy, quick and rational basis for primary estimating.

1.2.2 SAFE ZONE METHOD OF PLANNING AND CONTROL OF OVERHEAD COSTS

Management is the planning and coordination of the activities of a person or group of people in an effective manner, conduct and performance towards achieving a given set of objectives. This is embodied in the four broad classification elements of planning, control, coordination and motivation. Whilst the author recognises the importance of all these four elements of any management system, this work has, however, been limited to the planning and control of overhead costs. It can be argued that coordination and motivation, with regard to overhead costs, could be attributed to individual management and can only be fully achieved through the dedication and ambition of the management and the work-force and hardly by any standard method of performance.

The safe zone method of planning and control, developed by the author and discussed in this work, could also be an important tool for not only cost planners and controllers of overhead costs, but also to other personnel dealing with other areas of costs in the industry. Its flexibility could reduce the time-lag between the discovery of an error and the subsequent application of a corrective action, thereby making control measures more effective.

1.3 STRUCTURE

The text of this research is divided into six chapters. This is done so as to make the understanding and realisation of the problems, the solutions derived and the conclusions arrived at, much easier.

An abstract is given to the work in which a brief presentation of the problems under study the methodology of research and the findings are stated so as to give an insight into the contents of the work.

A list of symbols, and notations used throughout the text of this work is included. Some are already in use and well established and are standard notations. Others are the author's inventions and the meanings thereby attached are purely for the better understanding of this work.

A list of definitions, explaining the meanings of the key words as applied to this research is given. The meanings attached to these words might not necessarily be the meanings they carry to the general public, but they are as used in this work.

Chapter One gives an outlined introduction and Chapter Six an overall summary and conclusions to the contents of the work.

Chapters Two, Three, Four and Five comprise the body of this research. Each of these chapters begins with an introduction and concludes with a summary. A brief guide to the various chapters is given as follows.

CHAPTER ONE	Includes an introduction and describes the objectives and the structure of the thesis.
CHAPTER TWO	Describes the problem areas concerned with overhead costs, both at the tender and construction stages of projects.
CHAPTER THREE	Describes the existing methods of planning and control of overhead costs and the limitations of these methods as effective tools for dealing with these costs.
CHAPTER FOUR	Describes the method of research adopted in this work, the reasons for adopting this method and its limitations.
CHAPTER FIVE	Describes the empirical evaluations of the data collected. It also includes an analysis of the data and assesses the suitability of the determined models and the safe zones.
CHAPTER SIX	Includes the conclusions of the research and discusses areas for further research.

CHAPTER TWO

PROBLEM DESCRIPTION

2.1. INTRODUCTION

In this chapter, the difficulties encountered when dealing with both head office and site overhead costs in the construction industry which has given rise to this work are discussed.

Firstly, the terms used in cost planning and control in the industry are not clearly defined and standardised. Secondly, there are also problems concerned with estimating overhead costs and allocating overhead cost items to cost centres or cost components. Thirdly, there are problems encountered in overhead costs documentation and also as a result of variations, in organisational structures of construction companies and in diversity and size of construction projects.

An attempt has been made in this chapter to outline and discuss these problems.

2.2 DEFINITION OF OVERHEAD COSTS

Various definitions are given for overhead costs in different industries (ref 7.). The meanings and hence the interpretations also differ between professionals. To the accountants, overhead costs are the costs of indirect elements of material, labour and expenses. To the economists, they are the costs of production, for economists consider cost as a function of output with the exclusion of other independent variables (ref. 18). Even within the construction industry itself, the definition of overhead costs varies diversely even though they are in most cases taken to mean the costs of the items which cannot be allocated directly to elements or units of production. Both the accountants' and the economists' definitions of overhead costs cannot be suitably applied to the construction industry. Clearly, it is not all indirect costs of labour, plant and material that are included in the construction overhead costs and to consider overhead costs in the industry as a function of output alone might probably not have a very well-founded basis. It also remains in question whether in fact leaving out other important factors or variables would lead to an acceptable definition. To present a definition of overhead costs in the industry that might be acceptable is to look at the problem from a different perspective. For this, two approaches are adopted in this work.

(a) The functional characteristics, and

(b) The behavioural characteristics

of the overhead costs.

The functional characteristics of these costs suggests defining the overhead costs on the basis of administration, production and marketing and also taking into account constituent parts of labour, plant and material costs. The behavioural characteristics on the other-hand suggests defining overhead costs in the contents of the various components of overhead cost items being either fixed, variable, semi-variable, avoidably or unavoidably fixed, or whether they are direct or indirect costs.

To give an overall definition for overhead costs is to take into consideration the nature of the overhead costs. On examination of overhead cost elements, these costs fall into three main categories: fixed costs, variable costs and semi-variable or semi-fixed costs. Fixed overhead costs are the costs which are unaffected by variations in the volume of output or in turnover. These costs will still exist even at a zero turnover. On the other-hand, variable overhead costs are those costs which tend to vary with the output of work done. Semi-variable or semi-fixed costs are the costs that fall between fixed and variable costs. These costs are basically fixed or variable but not as a continuous function of the output of the work done.

The functional characteristics and the behavioural characteristics can both be used to give a definition for overhead costs in the construction industry. Basing the definition on the above two characteristics, overhead costs can be defined as:

> The costs of administration, of formulating the objectives and policies, planning, financing, directing and controlling the various operations of projects; costs which have both fixed and variable components and which cannot be related directly to elements or units of production.

This definition of overhead costs for the construction industry highlights two important aspects.

(a) They are partly managerial costs. That is, they are the costs of formulating the objectives and policies, and the costs of planning these objectives and policies to implement them.

(b) They are partly costs of directing and controlling the operations of projects.

Construction companies tend to follow this pattern. The costs of formulating the planning of the objectives and policies can be associated with the head office overhead costs, and the costs of directing and controlling the various operations of projects with the site overhead costs. These two, the head office and the site overhead costs, form the two main constituent parts of the overhead costs in the construction industry.

2.3 ORGANISATION OF CONSTRUCTION COMPANIES AND OVERHEAD COSTS

The costs of construction company organisation are overhead costs. For these reasons the author has attempted to present an organisational pattern of companies in the industry.

2.3.1 HEAD OFFICE ORGANISATION

Many different organisational structures are suggested by people who have made studies of this subject and are also found in many construction companies (ref. 4, 50). There is no hard and fast rule or any standard form of organisational pattern that is observed

Indeed, the choice of the structure that would best suit a company depends on many factors such as the level of technical skills of both management and operatives, the size of the company, capital and plant available, location of the company, specialisation of the type of work to undertake, the company's objectives and policies for its short and long term plans, and maybe many other factors. It is not the author's intention to discuss or describe all these organisational structures and the ways of divisions, at least not for the purpose of this work.

In broad terms, companies in the industry can be described as small, medium and large.

These descriptions are normally based on the level of output achieved in terms of turnover and or the number of employees engaged by the companies.

At the top of the organisational structure is the managing director, who is responsible for carrying out the policies and meeting the objectives of the company. Duties are generally delegated to various sections or departments such as engineering, plant and estimating, which are technical, and administration, accounts and personnel which are non-technical. These sections or departments tend to combine together for small companies and expand into further divisions for large ones.

The pattern of relations observed in these companies are those of direct or line relation between the managing director and the departments, and functional and lateral relations between departments. The structure of organisation forms in these companies are given in Fig.(2.3a) for small companies, Fig.(2.3b) for medium sized companies and Fig.(2.3c) for large companies.

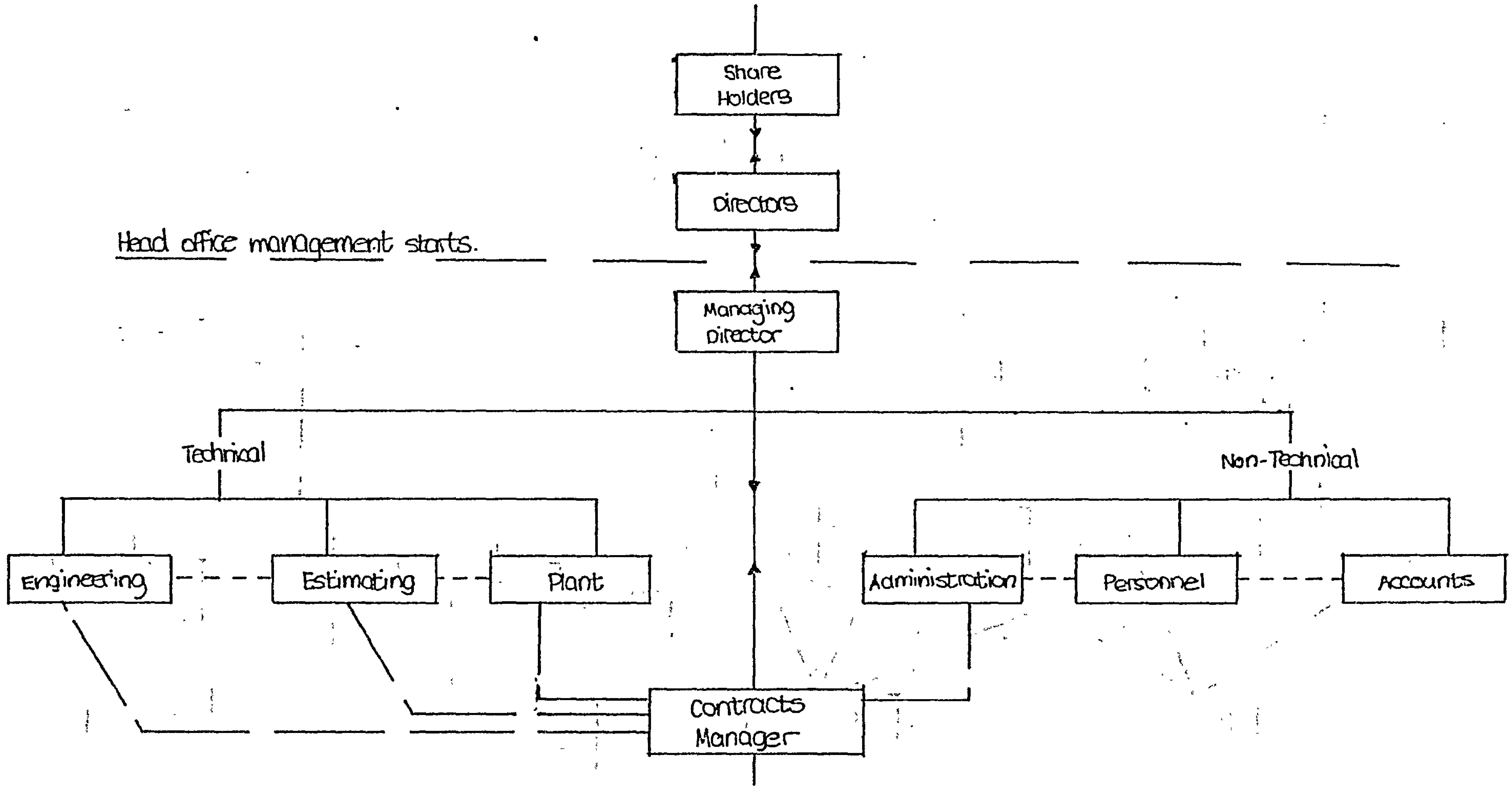


Figure (2.3a) The orgnisational structure of a small company

Direct or line relation
Functional relation
Lateral relation.

Fig. (2.3b) Organisational structure of a medium sized company

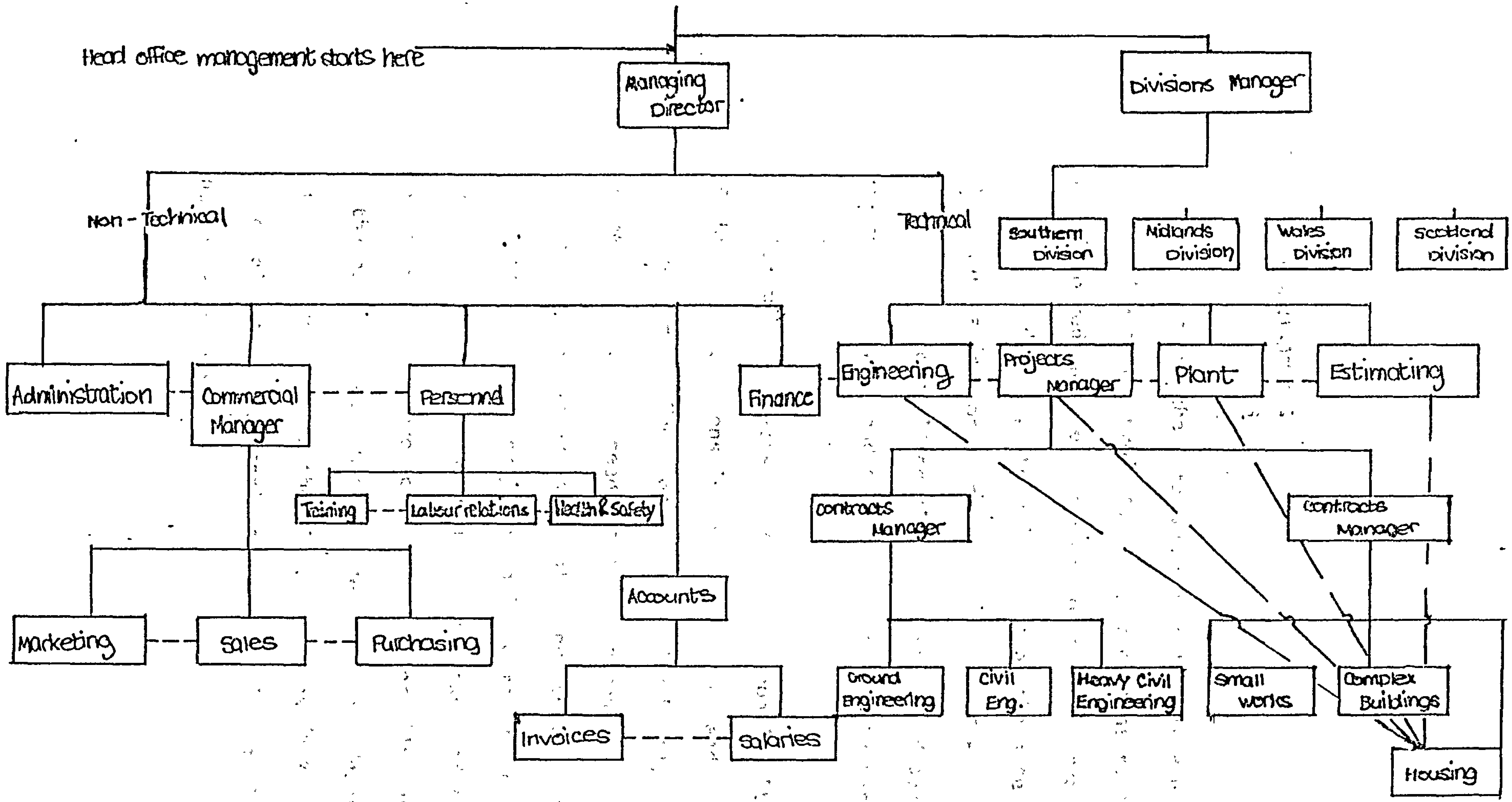


Figure (2.3c) Organisational structure of a large Construction Company showing subdivision by Function Region and by type of work.

Direction or line relation

Functional relation

Lateral relation

2.3.2 SITE ORGANISATION

The size of the site management largely depends on the size of the project, the type of construction work involved and the remoteness of the construction site. The duties performed on site by the site staff varies from ordinary supervision by foremen up to almost centralised site organisation, depending on the engineering and supervision work to be performed on site.

For small projects the overall responsibility of the site operations is normally in the hands of the site agent. The agent, who is site based, liaises between the site and head office management.

Because of the extent of planning, control and co-ordination, large projects would normally require a project manager or contracts manager assigned to the project. The project manager is normally based at the head office. Most of the functional departments would have sections on the site. Figures (2.3d) and (2.3e) give the organisational patterns for small and large projects.

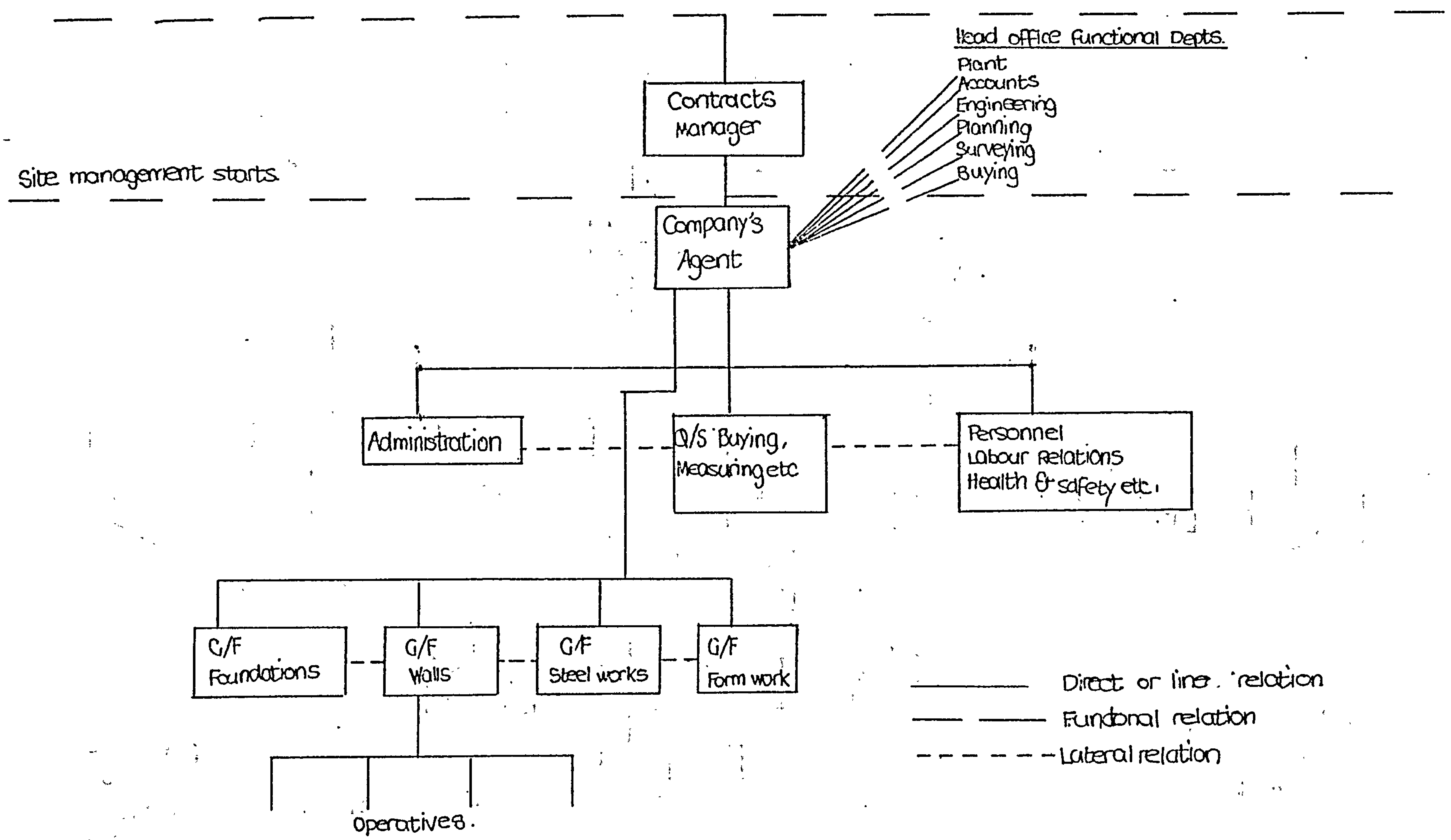


Fig. (2.3d) Project site management structure of a small project

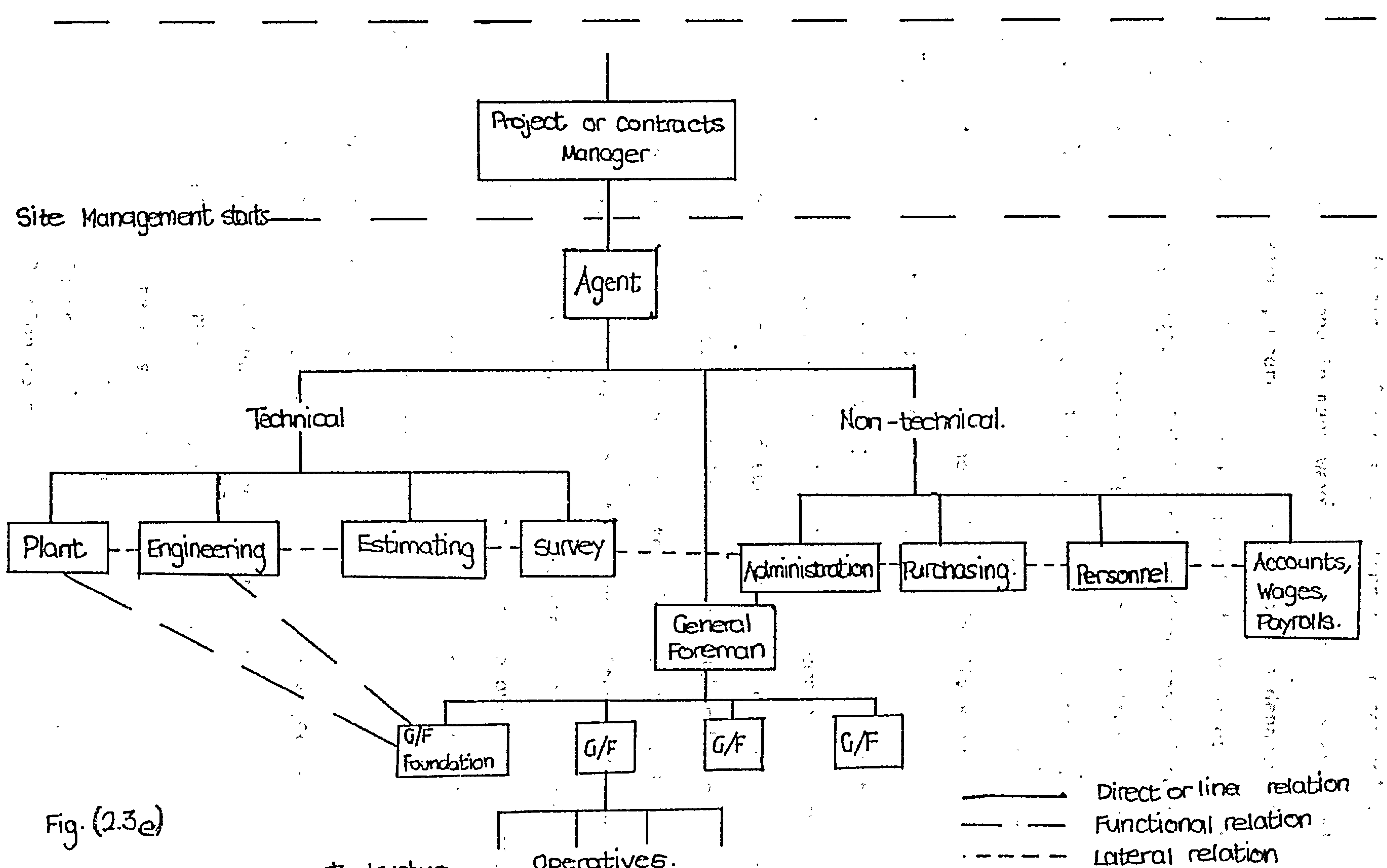


Fig. (2.3e)

Project site management structure of a large Project.

2.3.3 OVERHEAD COST CENTRES

The divisions of costs for planning and control purposes are done in many ways. There are departmental cost divisions, where cost divisions are on departmental basis. Cost divisions could also be based on operational or product groups. Division of overhead costs into cost centres or cost components is based on cost items being grouped together for planning and control purposes. Construction companies in the industry adopt, for planning and control of their overhead costs, the divisions into cost centres or cost components.

There is hardly any standard method in use in the industry and because of this, different companies have adopted different ways of subdividing their overhead costs into cost centres. In this study, the author has grouped the head office overhead cost items into eleven cost centres or cost components and the site overhead items into ten. This is given below. If, however, some cost components are found to form minor percentages of the overhead costs, the cost components will be rearranged and reduced in numbers.

2.3.3.1 HEAD OFFICE OVERHEAD COST CENTRES

SENIOR STAFF COSTS

These are the costs of top management staff and trained professionals with more than three years experience. These include the costs of:

Directors' remuneration
Allowances and fees
Salaries
Pension contributions
Recruitment costs
Redundancy payments

OTHER STAFF COSTS

These include junior staff costs and costs of staff with less than three years experience. They also include the costs of:

Salaries
Wages
Temporary staff costs
Allowances
Recruitment fees
Pension contributions
Redundancy payments

HEAD OFFICE ACCOMMODATION COSTS

Rents and building costs
Rates
Furniture and fittings
Property maintenance
Cleaning
Stationery and printing

TRANSPORT COSTS

Staff and directors' travelling expenses
Vehicle running costs
Pick-ups and vans
Repairs and maintenance costs
Replacement costs

COMMUNICATION COSTS

Telephones
Telex and teletype
Postage
Messengers
Mail handling
Two-way radios
Leased telephone lines

MARKETING COSTS

Publications
Advertising
Subscriptions and donations
Presents and gifts
Organised dinners
Tendering costs

INSURANCE COSTS

These are costs for providing cover for damages or losses incurred by the company. They include office accommodation, insurance and personnel accidents.

SERVICE COSTS

Lighting
Heating -
Water
First aid
Sanitation
Canteen/Food vouchers

RESEARCH, TRAINING AND DEVELOPMENT COSTS

Research work undertaken
Training of graduates and workers
Short courses/organised lectures
Tests

FINANCE COSTS

Bank charges
Loan interest
Interest on overdue tax
Lost income on company's own capital tied up in projects

GENERAL AND UNALLOCATED COSTS

- Professional and legal fees
- External auditors
- Bad debts
- Computer costs
- Unallocated costs etc.

These divisions are only found in the medium-sized and large companies. Small companies have fewer cost centres or cost components.

2.3.3.2. SITE OVERHEAD COST CENTRES

STAFF COSTS

- Agents/assistants
- Engineers
- Quantity surveyors
- Clerks/typists
- Cleaners
- Recruitment costs
- Redundancy payments

SITE ACCOMMODATION COSTS

- Rents and building costs for company, staff and engineer or client's representative
- Furniture and fittings
- Property maintenance
- Minor repairs and decorations
- Cleaning
- Printing and stationery
- Depreciation

TRANSPORT COSTS

- Cars for staff
- Vans and pick-ups
- Repair and maintenance costs
- Replacement costs or depreciation

COMMUNICATION COSTS

- Telephones
- Leased telephone lines
- Postage
- Mail handling and messengers
- Two-way radios

INSURANCE COSTS

- Works insurance
- Staff insurance
- Personnel accidents

SERVICE COSTS

- Lighting
- Heating
- Water supply
- Sanitation
- First aid
- Canteen/food vouchers

MINOR AND GENERAL PLANT COSTS

- Pumps
- Small lifts
- Generators
- Repairs and maintenance costs
- Transport costs of plant (to and from site)
- Scaffolding etc.

TEMPORARY SITE COSTS

- Temporary and access roads
- Temporary pipes and cables
- Fencing and site protection
- Site clearance

GENERAL AND UNALLOCATED COSTS

- All items not listed above
- All unallocated costs

The method of cost planning and control developed in this work is based on these cost centres.

2.4 ESTIMATION OF OVERHEAD COSTS OF PROJECTS

Overhead costs in the construction industry are not direct costs of production. It is, therefore, not possible to relate these costs directly to elements of production, as it is normally done with the direct costs like material costs, labour costs and plant costs. A company must, however, include in its estimates for a project, the cost of its overheads. The problem encountered here is how accurately these costs incurred by the company could be recovered from the client so that the company does not undertake the project at a loss.

2.4.1 HEAD OFFICE OVERHEADS

A company's head office co-ordinates the operations of many projects at the same time. Construction projects are of different duration for different types of civil engineering and building works. Projects have varying degrees of risks and uncertainties of many types associated with them and, therefore, need different levels of the head office management attention. This causes the overhead costs of one project to be different from another even though they might be of the same type of civil engineering or building works, or of the same duration. The problem encountered here is how to successfully apportion the head office overhead costs to individual projects.

The planning periods in the construction industry for the head office overhead costs planning purposes is normally one year; mostly from the beginning of a financial year to the end. A company plans for the coming year, the level of expansion of its activities, the volume of work expected and the availability of capital required. Taking these into consideration the company plans for the level of its head office expenditure. Projects, on the other hand. have different durations. ranging from a few months for small projects to years for larger ones. The projects have different starting and completion times. Each project undertaken creates a demand on the head office management resources and sometimes necessitates an increase in staff and other management resources. The overlap of project-duration between planning periods, the different start and completion of projects, and the different duration of the projects can sometimes cause serious problems to the company in trying to apportion the head office overhead costs to individual projects. Many attempts have been made in the industry to find ways of apportioning head office overhead costs to individual projects, but these have not been wholly successful. It could, therefore, be seen that a suitable method for head office overhead costs planning and also a method of apportioning these costs to individual projects is still to be searched for.

2.4.2 SITE OVERHEADS

One of the problems which confronts a construction company when planning the site overhead costs at the estimating stages of projects is the diversity of the cost items which make up these costs. The composition of the site overhead costs is also not clearly defined. The items which are considered as overhead items by a construction company might not be considered as overhead items by the client or his representative. There is therefore a need for a standard method for including specific cost items into the site overhead costs.

2.4.3 MARK-UP

Competitive tendering is the method by which the bulk of the work is distributed in the construction industry (ref.71). About 80 per cent of all construction contracts, both new works and repair and maintenance works in both the public and private sectors in the United Kingdom are tendered for. Similar patterns are also observed in Sierra Leone. The construction companies submit their tenders for the project, and the client, in consultation with the engineer, decides on the company to be awarded the contract.

Most companies follow a standard practice in preparing tenders. Firstly, the direct costs of the project are estimated and to these is added a certain mark-up value by the management to cover the company's overhead costs, risks undertaken and also its profit margin. That is:

$$T = C + M \qquad \text{eqn (2.4a)}$$

and

$$M = OH + Ri + Pr \qquad \text{eqn(2.4b)}$$

where

T is tender value

C is estimated direct costs of the project

M is mark-up value

OH is overhead costs

Ri is the risk value

Pr is the profit margin

In the mark-up addition, the companies are in fact taking into consideration the type of services provided to the client. These are:

(a) The permanent allocation of the client's funds into direct costs which comprise of the labour costs, plant costs and material costs.

(b) The temporary allocation of managerial and technical resources of the company's personnel. In doing this, the company incurs costs. These are the overhead costs of both the head office and site office.

(c) The taking of risks associated with the project.

Most competitive bidding theories developed and in use in the industry concentrate on the level of mark-up to be added to the estimated direct costs of the projects so as to increase the company's chances of submitting the lowest and worthwhile tender (ref. 8, 21, 22, 71). In trying to win contracts the companies take many factors into consideration. These are:

(a) The number of competitors bidding for the contract.
(b) The profit margin required by the company.
(c) The need to win new contracts.
(d) The number of projects already in operation.
(e) The performance of the other competitors, and
(f) The amount of work available in the market.

In taking these factors into consideration the companies determine the lowest mark-up at which it is worthwhile to bid for the contract. Because of the competitive nature of the companies in the industry, in order to submit the lowest worthwhile bid to increase their chances of being selected for the contract, companies sometimes lower their mark-up to such an extent that even though a mark-up is added to the direct estimated costs of the project, this does not cover the company's overhead costs, let alone the profit margin. That is:

$$M < OH \qquad \text{eqn (2.4c)}$$

In a situation like this, sometimes quite unknown to the company, if the tender is accepted the contract will be initiated at a loss, right from the commencing stages.

Another point which has perhaps been overlooked, is that the constituent parts of the mark-up, the overhead costs, the risk value and the profit margin are three different items. Profit on the project is the increase in the real value of a company's financial resources in undertaking the project (ref. 68). It represents a potential change in the levels of the resources deployed on the project on completion of the project. The profit margin allowed for by a company on construction projects is influenced by many factors such as the source of the capital, its distribution, the market forces, shareholders' demand on their shares and many other factors sometimes quite unrelated to the nature of the work on the project. Profit objectives which need taking into consideration are that, firstly, there should be a return on the assets employed on the project. Secondly, this should not be less than the amount necessary to provide the satisfactory return on the net asset. Other objectives, therefore, should be seen to relate to the company's capital and profit margin. Determining the profit margin on a particular project requires the understanding of the nature of the profit, factors such as inflation, the interest rate on borrowed capital, the loss of interest on own capital tied up in the project and a knowledge of the profit levels of the other competitors. When work is scarce, tender prices are reduced by cutting down on the profit. When there is sufficient work available on the market, tender prices rise by increasing the profit margin.

Risks and uncertainties undertaken by a company are characteristics of individual projects and sometimes of the conditions of contract under which the contract is won.

On the other hand, head office overhead costs are the costs of general management. Just as labour, plant and material are resources provided by the company management and the technical skills are also resources provided by the company. These resources are marketed by the company to the client in many ways.

(a) With the design of the project on package deal contracts, the company becomes responsible for the design, the management and the construction of the project.

(b) Together with the purchase or provision of other resources of labour, plant and material on construction projects.

(c) The skills in themselves as in a management contract.

These resources are of a special significance and cannot easily expand if there is a sudden increase in the work-load in the industry. When work is short, it is not easy to cut down on staff or the head office accommodation costs or indeed any of the other overhead cost components. Clearly, the client enters into contractual arrangements with a company for the skills, knowledge and the experience of the management; for they can directly purchase all the other resources for the project - labour, plant and material. It is for the resources of the management to combine effectively, the other resources that the client enters into contractual arrangements with the construction company.

It also becomes clear from this argument that the probability of initiating the project from a loss state will be reduced if a way can be found of determining the overhead costs separately and added to the estimated direct costs of the project, thereby leaving the mark-up to cover the risk value and the profit margin desired. Equations (2.4a) and (2.4b) now become:

$$T = [C + OH] + M \qquad \text{eqn(2.4d)}$$

and

$$M = Pr + Ri \qquad \text{eqn(2.4e)}$$

where

T is tender value

C is estimated direct costs of the project

OH is overhead costs

M is mark-up margin

Ri is the risk value

Pr is profit margin.

Also, there are disadvantages in treating together the overhead costs and the profit in the mark-up at the tender stage of projects, as discussed above. The accuracies of the various competitive bidding techniques, of improving the chances of the companies producing the lowest worthwhile bid have always been questioned and challenged (ref. 13,59). If, from this work, a method of determining the overhead costs separately is developed, competitive bidding theory researchers will be left with only the problems of risk and profit margin to be added. Maybe by reducing the problems they would have to be concerned only with risk and profit. Hence the accuracies of their various methods can be improved.

2.4.4 OVERHEAD DOCUMENTATION IN THE TENDER DOCUMENTS

The conditions of contracts in use at present in both the building and civil engineering sectors of the industry - I.C.E. Conditions of Contract, R.I.B.A. Conditions of Contract (with and without quantities) ref(10,11), -

make no provisions for separate accountability of overhead costs and of direct costs. Even the international conditions of contract make no provisions for this (ref. 32). While this can be considered to be correct in view of the fact that the conditions of contract stipulates the financial and other agreements between the client and the company and is therefore interpreted in the contents of price to the client and not as costs to the company, it must, however, be stressed that on certain types of contracts like 'Cost plus a percentage fee' and 'Cost plus a fixed fee', where the cost is presented as an item of the price, the inclusion of a separate items in the price for overhead costs cannot be said to be a wrong approach.

The bills of quantity, which are prepared to be in line with the conditions which will apply in the contracts, are simply itemisations, maybe in a logical or sequential manner, of the various operations so that the activities can be priced by the companies tendering for the project. The bill of quantities (ref. 60,61,33), prepared in accordance with the standard method of measurement, bears little relation to the way these operations or activities are organised; the way they are carried out and the composition of the costs of labour, plant, material and overheads and maybe profit contributions. This has raised many questions about the usefulness of present bills of quantity and even of the conditions on contracts. Goodlad, on this point, has this to say:

> "There would seem to be opportunity for more exactness as to the cost of the constituent operations and processes than seems to be the case at the present time." (ref.24).

The Operational Bill, developed by the Building Research Establishment is indeed a move in this direction (ref.33). This bill suggests itemising the whole works operations into compositions such as plant, material and labour contents and this is subsequently priced in the tender. There could also be an argument in favour of the overhead costs being presented separately in the bills so that the client or his representative could, in viewing the various tenders of the companies, know the total level of management service costs allocated to his job, and the cost to him of these services. Indeed, by putting such a bill into effect, there could be an increase in the awareness of planning and control of the company's overhead costs and the way these are apportioned to the various projects.

Overhead costs are normally spread over other elements of costs and are presented to the client in the form of unit costs of production. There could also be a strong argument in support of overhead costs being allocated separately in the bill of quantities and other tender documents, especially on certain types of contracts, so that the client will be knowledgeable about the overhead costs actually planned for his project. In addition, high profits and losses envisaged by the construction company cannot be hidden in the overhead costs.

2.5 OVERHEAD COSTS CONTROL

Although overhead costs are indirect costs, their planning and control is essential. This is because overhead costs sometimes amount to 20 per cent of the direct project costs. The control of these costs during the construction period could not only lead to savings on the overhead costs alone, but also on the project as a whole.

The control of overhead costs is the measuring of the actual costs incurred against the planned costs at the tender or subsequent stages of the projects, so that satisfactory progress and performance can be achieved and maintained. Indeed, no matter which method of estimating or planning is used, its success and accuracy in achieving the desired targets, in both time and cost, becomes less effective unless it is integrated with a consistent feed-back and control technique.

Most cost control methods in the industry could not easily enable management to detect a deteriorating trend in the overhead costs during construction. Even when this is apparent, the temporary nature of the works and the on/off way in which the industry carries out its production, makes projects differ from one another and makes the application of any corrective action of little use to the company once a loss has been made on a particular project. Coupled with this is also the time-lag between realising an error and full application of the corrective measures.

The unit cost method of cost control, the standard cost method (ref.23), the percentage of completion method, the completion method, and maybe many other methods of cost control in the industry may not be fully adequate for overhead costs control. The inadequacies of some or all of these methods of cost control may be attributed to many factors. Firstly, most of these control methods were developed for the control of direct costs and for overhead costs of a different nature in other industries. The developments which have taken place in improving these techniques have been based on these lines. Secondly, added to this is the nature and composition of the items of the overhead costs. Some overhead cost items, because they do not form a greater proportion of the project costs and even of the overhead costs, their control to the company is not economical. On the other hand, certain overhead items form a greater proportion of the overhead costs and of the project costs. This diverse nature of the overhead cost items is a problem in itself.

There is, therefore, the need for an effective control method to be developed for the control of the overhead costs. This could make:

(a) The realisation of a deteriorating trend during construction become much more easily apparent than present methods.

(b) The minimisation of the time lag response between the realisation of these trends and the subsequent application of the effective corrective actions.

2.6. SUMMARY

In this chapter, the definitions of the problem areas associated with the overhead costs, both the head office and site overhead costs, which have given rise to this research, are discussed and presented. The first problem is concerned with the definition of overhead costs. There is also the problem concerned with the sub-divisions of the overhead costs into cost centres or cost components for the purposes of planning and control. The need for recommendation to the industry of a standard method of overhead costs allocation is also argued in this chapter. The inadequacies of the present methods of determining these costs is discussed and from this it becomes apparent that there is the need for a method of determining the overhead costs, especially at the tender and cost planning stages of projects. Also, the awareness of the limitations of the existing methods of control is presented, and this draws attention to the need to develop an effective control system for the overhead costs.

The disadvantages of treating together the overhead costs, risk and profit in the mark-up at the tender stages are discussed. Next, the inaccuracies of the various techniques, recommended by people who have carried out research work on this subject, of improving the chances of a company producing the lowest worthwhile bid is discussed and a suggestion for the separate allocation of overhead costs at the tender stage of certain types of contracts.

A case is argued in this chapter in support of separate documentation of the overhead costs, especially on 'Cost plus' contracts so that the client can actually know the overhead costs incurred on his project. This could clear the suspicious beliefs of small clients towards the large companies of high overhead costs on small projects. If this could be achieved, it would bridge the gap between the clients' methods relying on unit costs of production and the companies' methods of relying on operational costs.

CHAPTER THREE

ANALYSIS OF EXISTING METHODS OF PLANNING AND CONTROL OF OVERHEAD COSTS

3.1 INTRODUCTION

Not much has been done in the way of research into the study of overhead costs, especially in the construction industry; at least not to the knowledge of the author at the time of this research. Because there is hardly any standard method in practice or recommendations on how to plan and control these costs, construction companies have developed various methods of their own and these methods differ from one construction company to the other.

In this chapter some of the methods used in estimating overhead costs, both the head office overhead costs and the site overhead costs, at the estimating or tender stages of projects are discussed. The limitations of these methods as effective tools, which places their acceptance and accuracies in doubt are also discussed and presented.

3.2 EXISTING METHODS OF ESTIMATING OVERHEAD COSTS

There are many types of estimates. There are rough estimates and others which are more detailed. Whilst some estimates are used for planning purposes, some are used only as standard or checking points at further stages during the construction of projects.

The precision of these estimates depends not on the type of work, but rather on the intended use to which the estimate is to be put. Estimates are used in the tender or cost planning stages of projects by construction companies to forecast the cash flow. This is done on the basis of the estimated costs, the schedule of operations of the projects, and the expected payments. The scale of the difficulties in preparing estimates is measured in terms of the nature of the estimates, the purpose for which they are to be used and the accuracy desired. This clearly indicates uncertainty in the process.

The number of assumptions made in the estimating methods are many and as such, none could be considered to give a perfect solution. The uncertainties in supervision policies, the accuracies desired, the changing nature of construction works and construction costs; the political and economical variations, together with other factors (such as cost of project, the size and complexity of projects) also complicate estimating.

3.2.1 ESTIMATION BASED ON PROJECT COSTS

By this method the total cost of plant, labour and material is first estimated. To this is added a percentage figure to cover the head office and site overhead costs. In most cases, the percentage added to cover the overhead costs (decided upon by management) is arbitrary. In other cases this percentage addition is based on some other statistical criteria.

3.2.2 ESTIMATION BASED ON THE COSTS OF EITHER LABOUR, PLANT OR MATERIAL

The method of estimating based on the costs of either labour, plant or material or any combinations of the above three direct costs are sometimes used by construction companies, especially by specialist companies, to estimate their overhead costs. Sometimes overhead costs are expressed as fixed percentages of the labour costs of projects. The companies which adopt this method have the understanding that it is the supervision costs of the labour force that account for a larger proportion of the overhead costs. The labour cost method is mostly used by companies which are more labour-orientatated.

Basing overhead cost estimations on plant costs is adopted by plant hiring companies and on projects where the cost of plant predominates or forms a substantial proportion of the cost of the project. Fixed percentages based on the material contents' cost of projects is adopted by the companies mainly concerned with production for the industry, sometimes considered as suppliers to the construction companies.

3.2.3 ESTIMATION BASED ON THE PRIME COSTS OF PROJECTS

The prime costs of projects include the costs of labour, plant, material and site overhead costs. These costs can be directly related to a specific project for which they are incurred, even though the site overhead costs cannot be expressed directly in terms of units of production. By this method, the head office overhead costs to be apportioned to a project are taken care of by adding a flat rate percentage to the estimated prime costs of the project. The percentage added is determined from some relation between the prime costs and the total head office overhead costs. In some cases, this is an arbitrary figure decided upon by the management.

Whilst some writers have suggested a percentage addition of 5 per cent of the estimated prime costs, (ref. 5), others in their works have come up with different set of figures (ref. 5,26,41).

3.2.4 ESTIMATION BASED ON PROJECT TURNOVER

Some companies in the construction industry use the turnover method to determine their overhead costs. There are many ways in which this method is used. In one of these ways, the companies decide on the percentage to be added to the estimated direct costs to cover the overhead costs by basing the percentage addition on either the turnover expected from the project or on the company's planned turnover. Sometimes the addition is based on other factors such as the expected level of work forecast for the current planning period.

In some companies a ratio method of overhead costs/turnover is used to determine the overhead costs for projects. What is taken into consideration by different companies in deciding on the ratio factor differs greatly. In other cases, in order to make the best use of the head office resources, the overhead/turnover ratio is used to set a target when planning the overall turnover, or the turnover on the individual projects.

3.2.5 ESTIMATION BASED ON GRAPHICAL METHODS

By this method the estimation of the overhead costs is based on values obtained from a particular set of investigated cases, or from records of past performances on projects undertaken by the company and expressed in graphical forms. These graphs show either linear or non-linear relations between the overhead costs and the costs of the projects or whatever factor is used as the independent variable.

3.2.6 ANALYTICAL METHODS

Using the analytical method, every item of the overhead costs is actually calculated systematically. This is done for both the head office overhead costs and site overhead costs for every job tendered for by the company. The values obtained from these calculations are then added to the estimated direct costs of the project.

3.2.7 ESTIMATION BASED ON EXPERIENCE

In the construction industry many companies, especially small ones, keep fewer records on their estimating and tendering behaviour and on the success rate on projects for which they have tendered in the past. Lee and her colleagues (ref. 41) were able to observe this in their study of twenty-five companies in the building industry.

In these companies personnel tend to rely on their experience in dealing with these matters. Those responsible for the estimating of the costs of projects rely on their judgement and decide on the additions to be made to the estimated costs to cover the overhead costs. In this process the estimator makes use of any known trend and relies on his judgement when required data is not available. He then develops a subjective estimate for the overhead costs.

3.2.8 DECENTRALISATION OF THE HEAD OFFICE

The head office overhead costs are incurred by a company on behalf of all the construction projects under construction by the company at any particular time, for it is the centre of the machine from which the overall administration of all the various projects under construction are conducted. The head office overhead costs incurred by the company have to be recovered from the individual projects. This is normally done by apportioning these costs to the individual projects' prime costs and included in the cost of the contract.

In order to overcome this problem of apportioning the head office overhead costs to individual projects, some companies almost completely decentralise their head office activities. By this method, these companies disperse to the site operations as many personnel as possible who are concerned with the project, leaving the head office with the minimum staff to carry out the clerical and other works of the company. The components of the head office overhead costs, such as the staff costs, communication costs, accommodation costs, services costs etc., become greatly reduced. This therefore leads to low head office overhead costs. The individual projects become almost independent of the head office management and exist as small separate management units at the site level.

The relatively small head office overhead costs which result from this arrangement present very little difficulty for apportioning purposes. Because the overhead costs incurred are small, the errors which could occur, due to any method of apportioning, would be on a small scale. Some companies do not even bother to apportion these costs to the individual projects, but rather make a nominal percentage addition to the mark-up for all projects.

3.3 LIMITATIONS OF THE EXISTING METHODS OF OVERHEAD COSTS DETERMINATION

Although some of the existing methods of estimating overhead costs are widely used in the industry, they are not without limitations with regard to the degree of accuracy for acceptance. Whatever method of estimating is used should be able to reflect the behaviour and functional pattern of the overhead costs. This is, however, lacking in some of the methods discussed earlier. To obtain a more successful result the method used should be able to reflect the specific factors associated with each project.

3.3.1 LIMITATIONS OF THE DIRECT COSTS METHOD

This method is widely used in the construction industry, even though it has, in the past, come under criticism by writers on the subject. This is because a blanket cover approach of a flat percentage addition for the overhead costs to the estimated direct costs of projects which are different from one another, might not actually be reflecting the characteristics of the projects, which influences the overhead costs.

There are many types of civil engineering and building construction projects and these are subject to varying degrees of risks and uncertainties of contractual arrangements, labour relations, economic and environmental conditions. The demand by these projects on the efforts and attention of the management also differs. Conditions such as the political climate and the policies of government, social and environmental, do influence construction costs and will therefore influence the overhead costs. It is, therefore, inevitable that the lack of all these factors, or at least some of the important ones, in a method of determining overhead costs would make it difficult for acceptance of the method. This leaves the conclusion that this method of estimating overhead costs might not be accurate to the desired standard and may be an ill-defined method.

3.3.2 LIMITATIONS OF THE METHOD OF EITHER LABOUR, PLANT OR MATERIAL COSTS.

The labour costs method of estimating overhead costs has many advantages. This method also takes into account the time factor, although this sometimes obscures the actual costs if not applied correctly. Indeed, it could be a good method if there were a standard labour rate and if direct labour is the principal component of the labour costs. About 30 to 50 per cent of the overhead costs on most construction projects are incurred towards the supervision of the labour force (ref.6). This, therefore, makes this method a popular one in the construction industry. But this does not make it free of limitations or disadvantages. What is perhaps overlooked by the companies which adopt the labour costs method, is that the overhead/labour costs ratio is not constant. Fluctuations can occur in the labour content of a project. Projects of similar direct costs and durations could have different labour contents. If these labour contents become higher or lower than they should otherwise be, the overhead costs estimations based on the method could be subject to wide fluctuations.

Labour costs on projects are often affected by strikes, disputes and union action (such as higher wage settlements) which are unrelated to the nature of the construction work involved on the project. A strong union can win high wage settlements which a weaker and less powerful union cannot. This could affect the labour costs on projects to a great extent. Other factors like overtime costs can also influence the labour costs on projects. It is also clear that not all projects have labour costs forming the largest proportion of the total cost of a project. If a project is one on which the use of heavy plant and equipment are unavoidable, and perhaps uses expensive material for construction, the use of the labour costs method to determine the overhead costs might not appear to be adequate. Also, a large number of sub-contractors might have to be employed on a construction project, and the costs of supervision and control of the sub-contractors might even exceed that of the company's own labour costs.

There are also limitations in the methods of either plant or material costs or any combination of the plant, material and labour costs, in that these methods can only be used effectively on certain types of work or operation. The plant costs method is mostly adopted by plant hiring companies and on projects where the costs of plant predominate and material costs, mostly by material-producing or supplying companies. The greatest limitations to these methods, therefore, is the fact that they cannot be used by a majority of companies in the industry, which are general and broadly-based.

3.3.3 LIMITATIONS OF THE PRIME COSTS METHOD

The simplicity of these methods, which is a decisive factor in giving it preference over other methods, makes it a widely used method by companies engaged in construction work.

However, the addition of a flat rate percentage for the overhead costs, adopted in using the prime costs method, has also got limitations with regard to its effectiveness and acceptance as discussed in 3.4.1. Also, the management may include an addition for the site overhead costs which is already included in the prime costs.

3.3.4 LIMITATIONS OF THE TURNOVER METHOD

A large number of companies in the industry make use of the turnover of the company or of a project to determine the overhead costs. This is also explained in 3.2.4. In one way this is done by the addition of a flat percentage based on either the turnover of the company or the turnover of the project. Some companies use an overhead/turnover ratio to determine the overhead costs of the project and of the head office.

The turnover on a project is made up of the costs of the project plus the profit made on it. That is

$$Tu = C + Pr \qquad \text{eqn(3.3a)}$$

where

Tu is turnover on the project
C is cost of project
Pr is profit on the project.

This method takes the profit element into consideration. But profit made on a project bears little or no relation to the overhead costs incurred on the project. This is because, in determining the profit margin to be allowed on a project, certain factors are sometimes taken into account, many of which are quite unrelated to the nature of the project itself.

With regard to the overhead/turnover ratio method, because the turnover is much greater than the overhead costs and since this becomes the denominator in the overhead/turnover ratio, small changes in the turnover are unlikely to cause noticeable changes in this ratio. It could only be a large change in the turnover that could produce a significant change in the overhead costs determined.

There are many other disadvantages in using the turnover as the only factor to be taken into consideration in determining the overhead costs. A global percentage based on the overhead/turnover ratio has no strong correlation with the size of the project. In fact, Hart (ref 26) suggests that it is tempting to state that the overhead costs vary directly with turnover, and he refers to the turnover method as "an ill-defined method" of estimating overhead costs. Jones' work edited by Brech (ref.6) has this to say:

> "Unfortunately, this is not necessarily a reliable and accurate calculation. Many variable factors will affect the capital which a particular project contract requires. The contract conditions relating to retention and payment dates, the length of the contract, the degree to which nominated sub-contractors are involved in all these things and others vary from project to project, causing capital expressed as a percentage of turnover to vary."

Lee and her colleagues (ref.41) were able to observe that in trying to relate the overhead costs to the turnover of the company, as found in their study, there was a large variation for the individual companies from 18.4 to 4.1 per cent. If the results of their study is assumed to be correct, it can be said that these variations partly serve as evidence that relating overhead costs to turnover alone might not be a totally acceptable method.

It can be concluded, therefore, that even though the turnover method is widely used in the industry for estimating overhead costs, many have raised doubts over its accuracy in reflecting the causal factors of the overhead costs. This method lacks a well-determined basis and can hardly be acceptable as a reliable method of estimating overhead costs.

3.3.5 LIMITATIONS OF THE GRAPHICAL METHOD

The graphical method of determining overhead costs is not a widely-used method in the industry. It has been found to be inadequate in the sphere of the costs of projects and overheads which are influenced by change from time to time. If the conditions change after the graphical data are prepared, changes will occur in the overhead costs determined by this method and these changes can sometimes fail to lie within acceptable limits.

It is also possible to prepare the graphical data from only a few projects. In this case, generalisation of such methods could therefore not be without serious limitations. The graphical method, if not correctly applied or frequently updated, could lead to incorrect estimates of the overhead costs.

3.3.6 LIMITATIONS OF THE ANALYTICAL METHOD

Although an accurate method of determining the overhead costs in the construction industry, especially at the estimating stages of projects, this method is not without limitations. The major disadvantage associated with this method is that detailed estimating is time-consuming and therefore not economical at the estimating stages.

The analytical method requires a great deal of staff time which, in the end, will result in higher overhead costs. In a very competitive situation a company's chances of winning each contract tendered for can sometimes be as low as one in ten and, using analytical methods to determine the overhead costs, could only lead to higher costs.

It can be seen that the analytical method, as a method of determining the overhead costs, especially at the tender and cost planning stages of projects, could be greatly criticised from the point of view of overhead cost control. This, therefore, limits its use in the construction industry to very few companies.

3.3.7 THE PAST EXPERIENCE METHOD

For overhead costs, quite a number of construction companies rely to a great extent on the judgement and experience of one or more people to determine the additions to be made to the estimated direct costs of projects. There are, however, limitations to its use. Added to the other mentioned disadvantages of the percentage additions, in relying on the judgement and past experience of one man alone, a situation can sometimes arise when the person who has for years been applying his own judgement and making arbitrary percentage additions to the costs of projects to cover the overhead costs may not be available to the company, either through death, retirement, ill-health or for some other reason. This, in most cases, creates a vacuum situation which may take a long time to fill. When dealing with certain types of projects which the company has not undertaken in the past, there is hardly any past situation from which the estimator draws ideas of experience, and relying on only this method of determining the overhead costs could, to many, present difficulties and sometimes produce inaccurate results.

This does not, however, discard the fact that experience in the industry; in any form of discipline, is a valuable asset.

3.3.8 LIMITATIONS OF THE HEAD OFFICE DECENTRALISATION METHOD

With the aim of having only comparatively small head office costs for individual project, the method of decentralisation of the head office costs suggests dispersing to individual project sites as many personnel as possible. It is a method that is used by a fairly large number of companies in the industry.

In trying to decentralise the various head office activities to the projects sites, staff and personnel whose services could otherwise have been effectively shared on a number of projects, had they been based at the company's head office, are attached to single projects. This inevitably leads to higher cost, overmanning and inefficient management.

It is arguable that, while this method might succeed in producing comparatively low head office overhead costs, it in fact does not provide a solution for overhead cost apportionment, but rather creates a shift in the problem area. While, because of this method, the head office overhead costs are apparently reduced through having more staff and head office activities dispersed to the project sites, the site overhead costs could be higher than would otherwise be necessary. It also becomes apparent that this sort of arrangement leads to poor communication between different project sites and less feedback to the head office management. As such, the individual projects exist as almost separate management units with very little overall and effective administration and control of the company's head office.

When the operations of one project are completed and there are no immediate project sites requiring the services of the staff and the facilities from the completed project, these staff would either be kept at the head office, performing minor duties, or else be laid off, which is generally a loss to the company. It could be difficult for the company to employ the services of these people once they have been laid off, and recruiting people of similar skills and experience can sometimes involve much higher costs than would have been the case had the original workers been kept on.

The method of decentralisation of the head office activities, for reasons stated above, could not be a reliable method of determining the overhead costs.

3.4 SUMMARY

The methods of determining the overhead costs in the construction industry at the tender and cost planning stages of projects are discussed in this chapter. Even though some of these methods are widely used by companies, they do not lack limitations, and the disadvantages of these methods clearly indicate that they are lacking in their attempts to provide complete or optimum solutions to the problems outlined. It is seen that what is therefore needed is a system which is flexible; able to reflect the common factors; one which can accommodate changes in the type and nature of projects.

CHAPTER FOUR

METHODOLOGY OF RESEARCH

4.1 INTRODUCTION

In this chapter the method of approach(adopted in this research) towards developing new methods of planning and control to provide solutions to the problems outlined in chapters two and three are discussed. This is based on the authors proposals to use thematical model techniques for planning and control of overhead costs and overhead cost components of both the head office and the site overhead costs.

In order to achieve this aim, this study has been carried out in three broad areas. These are: the study of available literature on the subject; the visits to construction companies in England and Sierra Leone and the discussion of these matters with personnel in the companies; and finally, the completion of questionnaires by construction companies in Sierra Leone.

Also discussed in this chapter are tne methods used in providing optimum solutions for the problems concerned and the limitations of the approach used in this study.

4.2 THE APPROACH

The difficulty of availability of literature on this subject in the construction industry can be a great hindrance to any person undertaking, or intending to undertake, research work in this field. In the past, construction industry management has not been given the level of management attention it requires. As Hillebrandt (ref.27) points out, economists have barely involved themselves in this field. In fact, it is not only economic principles and theories which are not adapted to the need of the construction industry, management and accounting principles are still to be made suitable for construction operations.

The people concerned with dealing with these principles - accountants, economists and the like - sometimes gain their training in other industries like the manufacturing industry. Economics and accounting theories, as they are in their original form, would need a great deal of tailoring to be applied successfully to the construction industry.

There are many reasons for this delay. The construction industry is different from other industries, and the technological constraints are many and sometimes more complex, and the factors involved are unlimited. The idea of considering construction management as a subject of importance and one to be given consideration has been realised only in the last thirty years (ref.68). Yet, it is only in the last decade that further attention has been focussed on this subject by managers in the industry, academics and operational researchers.

4.2.1 STUDY OF EXISTING METHODS

The author's practical experience in this field is minimal; two years of working with a construction company. It was therefore thought that a primary step in this research would be to study the literature available to the author. A large proportion of the time spent on this work, especially in the early stages, was devoted to the study of the existing methods, advantages and disadvantages associated with them and their limitations as effective methods for use in planning and controlling overhead costs of construction projects.

Some of the literature available was found to contain important sources of material. The search for literature in other fields which were initially thought to be of value to the research were found to be of little use, because of the diverse nature of the construction industry.

4.2.2 VISITING OF CONSTRUCTION COMPANIES

The study of overhead costs in the construction industry is considered to be of practical importance and not just another academic exercise. A practical approach, therefore, was to carry out part of this study at the places where the costs are incurred. That is, the head offices of construction companies and also the sites of construction projects. The author decided that a realistic approach to this study would be to visit companies and discuss with relevant personnel, the planning, estimating, accounting and control of the overhead costs.

The various methods adopted by the companies visited; the problems these methods present and the approaches made to finding optimum solutions were also discussed at the time of these visits. Visits were also made to project sites and here the stress of the study was more on how the various cost components of the site overhead costs are incurred and the methods of control applied.

Approaches were made to the companies in both the civil engineering and building sectors of the industry by letter and by other means of contact. Forty construction companies in and around London were contacted by the University by letter on behalf of the author but only eighteen of these companies made favourable and encouraging replies. All the remaining companies turned down the author's request. These companies gave various reasons for their refusals. Some refused on the grounds that they were too busy and therefore could not spare the time. Some replied that their companies were not well equipped for this sort of study. Ten of the companies which turned down the request stated frankly that they considered the details involved in this kind of study to be highly confidential to their companies and they were not prepared to discuss these matters with an outsider or disclose any documents connected with their overhead costs. Four of the companies did not reply at all.

In Sierra Leone, through the help of the Ministry of Education, twenty-three companies were contacted by letter. Thirteen agreed to give assistance, six refused, two replied that they did not have the necessary records, and two did not reply at all.

The companies which agreed, allowed the author into their offices to talk to their personnel and also to study any data which might be required at further stages of the study.

Whilst the author understands the various reasons for some companies not wishing to co-operate in this study, it became clear that construction companies in general do not willingly want to discuss the problems of cost planning and control in their companies with outsiders. Even some of the companies which agreed to co-operate, seemed at times to be reluctant to discuss certain information. Whilst not making any accusations, it might be quite likely that some companies refused to become involved for fear that the information obtained from them could be made available to competitors in the industry.

In an industry such as the construction industry there are sometimes problems over such matters like taxation and with local and central governments over what is to be observed. It is possible that there could be fear that financial matters and others, might be made available to authorities. If this is correct, then while understanding the reasons for this, it can still be described as not a positive attitude on the part of the companies.

Some of the companies in the industry, especially the large companies, have developed effective systems of cost planning and control, not only for the overhead costs, but also for other cost areas in the industry. These companies have managed to achieve this through the availability of finance and internal research. On the other hand, smaller and medium-sized companies do not have the finance to embark on well-researched and effective planning and control systems. If these methods can be made available to the companies which cannot afford the cost of developing such methods, there is no doubt that this will be of great benefit to the companies concerned. Secondly, no matter to what extent the accuracy of these methods might be, it is possible that they are not without limitations as effective methods. If other companies could be allowed to use these methods, valuable contributions could be made by studying them in conjunction with their own and in this way try to come up with a better system which would be of benefit to all the companies, including the small, medium and large companies.

Researchers and institutions could do even more in this line. They could, in their studies, develop efficient and effective methods which are easy to apply. It is hoped that these problems will become apparent with time and that companies will therefore realise that it would be to their own advantage to supply the required data for research.

However, the eighteen companies visited in England and the thirteen in Sierra Leone which assisted the author in completing the questionnaires, provided a cross-section of the companies in the industry in both countries. In England, eight could be considered to fall in the group of small companies, seven of the medium-size and the remaining three in the large-size companies. In Sierra Leone, five could be considered as small companies, five as medium-sized and three as large companies.

4.2.3 QUESTIONNAIRES

Two sets of questionnaires were prepared by the author(see App.A The first set, four for each company, was concerned with the head office overhead costs of these companies between the financial years, 1975/76 to 1978/79. The second set of questionnaires, ten for each company, were concerned with the site overhead costs of projects, one questionnaire for each project. The data requested in the second set was for projects which had already been undertaken and completed.

The questionnaires could have been posted to the companies by the author but by taking into consideration the fact that the industry is vast and complex, and that the incorrect type of data might be supplied, the author decided to take the quesionnaires in person, and together with the personnel concerned, completed the questionnaires.

The data rendered accessible by the companies in the United Kingdom were not complete and sufficient enough. Out of the eighteen companies visited, only five supplied the required data. It was therefore not possible to develop overhead costs models and safe zone equations from these data. As a result of this the United Kingdom data have not been included in further analysis of this work and the intended comparisons between models and safe zone equations based on the United Kingdom data and those based on Sierra Leone data were not possible.

The overall response of the companies in Sierra Leone was satisfactory. In all, forty-six of the first set of questionnaires were completed. However, only information of thirty-four of these was used in later stages of this work. Twelve of the questionnaires completed, mostly from the small companies, were not detailed enough to be included in further analysis. Fifty-two out of sixty-five of the second set of questionnaires completed were also useful in further development of this work. The questionnaires completed provided a good set of data on which the analysis and results of this work greatly depends.

The currency referred to in this study as "the Leone" (Le) is the currency of Sierra Leone. The official exchange rate at the time of this research was Le 2.34 to £1.00.

4.3 DEVELOPMENT OF THE OVERHEAD COST MODELS

In studying the various existing methods of estimating overhead costs and the limitations of these methods, it becomes evident that there is a need in the industry for a well-investigated and better method of estimating and planning these costs, especially at the tender stage of projects. Discussions held with various personnel, both at head office and at site offices of many construction companies visited gave support to this argument, much more in favour of a better and a more acceptable method of dealing with the overhead costs.

Almost all did not hesitate to express the view that a new method and a new approach to treating the overhead costs, both at tender stage and during the construction stage of projects is one which will be welcomed in the industry. Most did admit the problems overhead costs have presented to their companies and many disputes have occurred in the past between their management and the clients or clients' representatives as a result of these problems. Most did welcome the idea of investigating a new approach.

However, not all shared this view and some presented an almost different understanding and different arguments. They put forward the argument that an investigation or a research of this nature would be an academic exercise. They suggested that a more reliable approach would be to rely on the experience of one man or a few personnel to deal with these problems. In reply to these, the author stated the disadvantages and limitations of wholly relying on the experience of one or a few people in the company. Although the author's line of argument was accepted, these people would not agree that a new approach was needed in the industry.

After taking all the various points of the arguments into consideration, the methods and limitations to them, as discussed in previous chapters, and the data obtained from the companies, it was concluded by the author that a new method and the search for one would be welcomed in the industry. It therefore became one of the aims of this work to try to develop a more acceptable system, which will treat individual projects in a realistic discrete way.

Various ways were looked at here, but the idea of applying a mathematical approach was considered to be one that could provide a method and solution to problems which would be more and readily acceptable. The application of mathematical or scientific techniques to solving economic, accounting and managerial problems are nothing new to industry. Econometric and operational research are mostly geared to using mathematical or quantitative approaches to managerial problems (ref.43). By means of these techniques, management problems are expressed in mathematical forms, solved using mathematical principles and the mathematical results obtained, interpreted in managerial contexts. This approach, however, has not, in the construction industry, been exploited to the same extent as in other industries. In the construction industry more attention is focussed on short-term empirical methods which are, in most cases, inadequate for the purpose for which their uses are exploited.

The author has attempted to deplore the use of these techniques by developing mathematical models based on more realistic factors, for use in planning and estimating ovehead costs of the head office and construction projects at the tender stages and during the construction stages of projects. The accuracies to be gained from the application of such techniques to providing solutions to problems of this kind cannot be guaranteed before it is fully and effectively applied. If it becomes successful by achieving the desired results, it is true that the guesses can be taken out of contract work and the limitations and disadvantages associated with some of the methods already in use in the industry (as discussed in previous chapters) can be minimised.

There are, however, difficulties to be met in trying to develop mathematical models to plan the overhead costs. This leads to five clearly defined problem areas. In order to be successful in the application of mathematical techniques, these problems are first to be overcome by management. An attempt has been made here to define these problem areas.

1. Selection of the set of factors or variables which are to be used in the models.
2. Selection of mathematical expressions or units for the variables so that a quantitative approach can be taken to solving the problems.
3. Selection of the functional relations between the dependent and independent variables.
4. Availability of requried data for determining the models constant values.
5. Testing of the derived models.

4.3.1 OVERHEAD COST MODELS

Overhead costs of a construction company can be described by equation (4.3a)

$$C_{OH} = C_1 + C_2 \qquad \text{(eqn(4.3a)}$$

where

C_{OH} is the total overhead costs of the company's head office and all the projects undertaken within a planning period.

C_1 is the total head office overhead costs.

C_2 is the total site overhead costs of projects undertaken by the company.

Since C_1 is the total head office overhead costs of the company for a planning period, C_1 is composed of overhead costs incurred in carrying out all the construction projects undertaken by the company in the planning period. Therefore, each project undertaken within the planning period by the company can be apportioned a certain proportion of the total head office overhead costs. The summation of all these costs make up the total head office overhead costs for the planning period. That is:

$$C_1 = \sum_{r=1}^{n} C_{1r} \qquad \text{eqn(4.3b)}$$

where

C_1 is the total head office overhead costs for the planning period.

C_{1r} is the overhead costs apportioned to individual projects.

r 1,2,3, ... n

n is the number of projects undertaken within the planning period.

Similarly, the total site overhead costs for a particular period of time C_2 is composed of the site overhead costs of all the site offices of construction projects undertaken by the company. Summation of all the site overhead costs of these projects make up the total site overhead costs of the company. These are expressed in equation (4.3c) given below.

$$C_2 = \sum_{r=1}^{n} C_{2r} \qquad \text{eqn(4.3c).}$$

where

C_2 is the total site overhead costs.

C_{2r} are the site overhead costs of the various construction projects.

r 1,2,3, ... n

n is the number of construction projects undertaken.

4.3.2 OVERHEAD COSTS OF A PROJECT (The Kth Project)

For every project, two types of overhead costs are incurred: the site overhead costs and the head office overhead costs apportioned for the head office staff and facilities. The overhead costs for a project, say the Kth project, can be represented by equation (4.3d).

$$C_K = C_{1Ko} + C_{2ko} \qquad \text{eqn(4.3d)}$$

where

- C_K is the total planned overhead costs of the Kth project,
- C_{1Ko} is the head office overhead costs apportioned to the Kth project,
- C_{2Ko} is the site overhead costs of the Kth project.

Having established the equation which characterises the overhead costs of a construction project, the next problem area is how these costs could be functionally defined.

4.3.3 FUNCTIONAL DEFINITION OF THE HEAD OFFICE OVERHEAD COSTS APPORTIONED TO A PROJECT

The head office overhead costs are planned normally on twelve monthly periods. One reason for this is the uncertainty of the workload. The tendering system by which work is distributed in the industry makes it very difficult, if not impossible, to anticipate in advance, the percentage of tenders which will be successful. The success rate for most companies is normally one in six, or worse still, one in ten (ref. 17). It is, therefore, more risky to try to adopt longer planning periods for the head office overhead costs. As a result of this, construction companies adopt a method whereby planning periods for the head office overhead costs begin at the start of the financial year through to its end.

The head office overhead costs are incurred for all the projects under construction. These costs have to be apportioned to the construction projects. These projects, however, have different duration periods and do not all start at the same time. Projects from preceding planning periods might extend into the present planning and some might extend over the end of the present planning period into the next. This is shown in fig.(4.3a), where a, b, c and e are different projects.

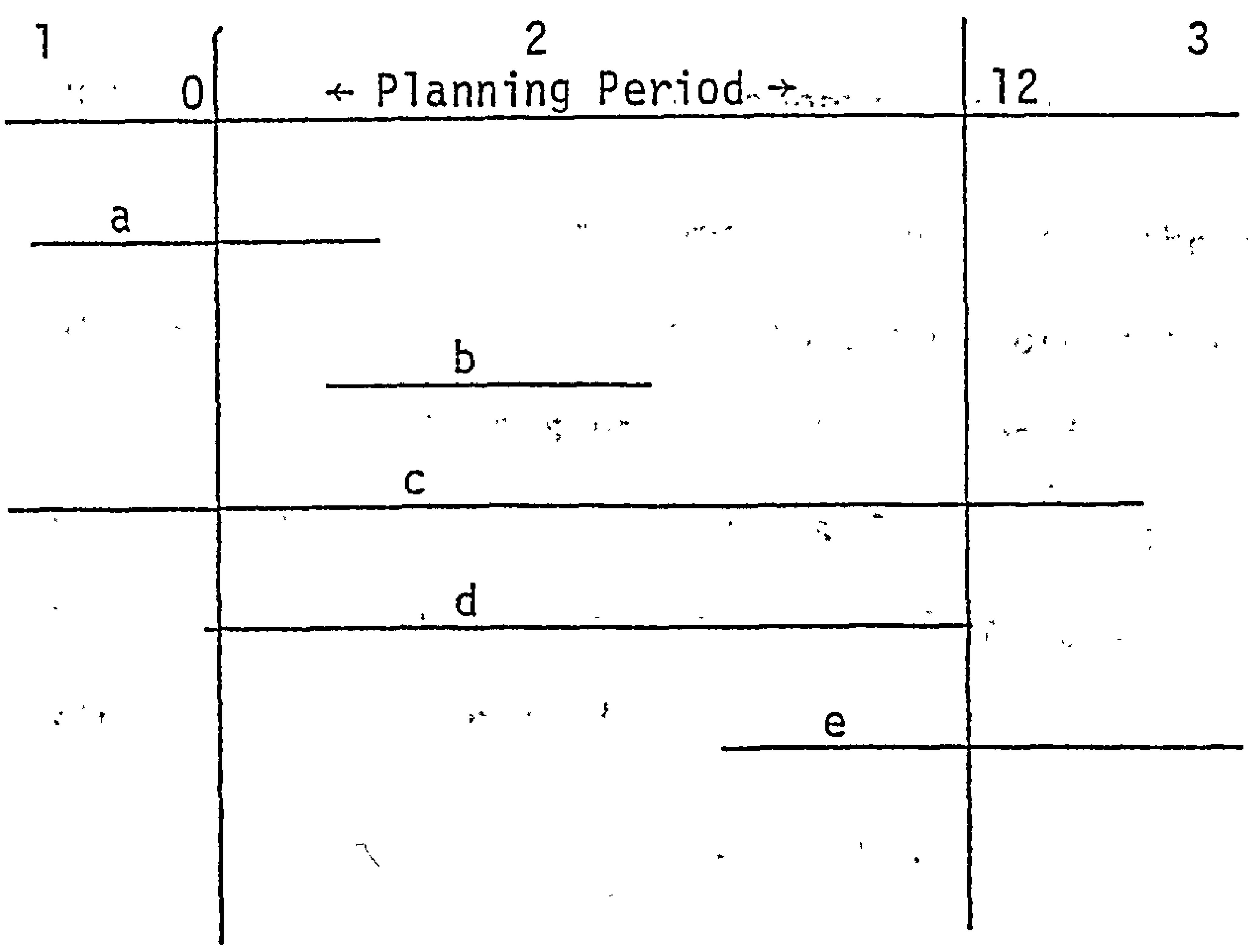


Fig.(4.3a)

These variations in project duration and in the start and completion times, create a problem in apportioning head office overhead costs (planned and incurred on a yearly basis) to the various construction projects.

In order to overcome these problems, two mathematical models have been developed by the author for the head office overhead costs apportioned to projects.

The first model, which is to be applied at the tender stage of the project, takes into consideration factors that are only related to the project and not the head office overhead costs.

The second model is to be applied during the construction stage of the project. This model considers factors which are related to the project itself, the head office overhead costs and the specific planning periods.

4.3.3.1 HEAD OFFICE OVERHEAD COSTS APPORTIONED AT THE TENDER STAGE

In developing a mathematical model for the head office overhead costs apportioned to a project at the tender stage, it is supposed that there is a functional relationship between these costs for a project (the Kth project) and certain defined sets of factors, or variables, as expressed.

$$C_{1KO} = \int(X_1, X_2, X_3, \ldots, X_m)$$

where

C_{1KO} is the head office overhead costs apportioned to the Kth project at the tender stage.

$X_1,\ldots,X_m$ is the set of independent variables.

m is the number of independent variables.

C_{1KO} is the dependent variable which is considered to be functionally related to the set of independent variables $(X_1, X_2, X_3, \ldots, X_m)$ in many different ways. For simplicity, this functional relation is taken in this work to be multi-linear. That is, it is assumed that the dependent variable is linearly related to the set of the independent variables, as

$$C_{1KO} = A_0 + \sum_{i=1}^{m} A_i X_i$$

where

C_{1KO} is the head office overhead costs apportioned to the Kth project at the tender stage.

X_i are the independent variables.

$A_0 \ldots A_i$ are the equation constants.

m is the number of independent variables.

Expanding

$$C_{1KO} = A_0 + A_1X_1 + A_2X_2 + \ldots + A_mX_m \qquad \text{eqn(4.3e)}$$

4.3.3.2 HEAD OFFICE OVERHEAD COSTS APPORTIONED DURING THE CONSTRUCTION STAGE

During the construction stages of projects, the head office costs incurred are apportioned in stages to the projects under construction. In most construction companies this is done monthly at the times when costs are examined and evaluation certificates prepared. A model for the head office overhead costs apportioned at the construction stage should therefore be based on this practice.

The head office overhead costs C_{1ki} apportioned to the Kth project at the end of the ith month ($i = 1,2,\ldots,12$ months) is therefore considered to be multi-linearly related to the set of independent variables $(U_1, U_2, \ldots, U_m)$ as

$$C_{1Ki} = B_0 + B_1U_1 + B_2U_2 + \ldots + B_mU_m)C_{1i}$$

where

C_{1Ki} is the head office overhead costs apportioned to the Kth project at the end of the ith month of the planning period.

$U_1,\ldots,U_m$ is the set of independent variables.

m is the number of independent variables.

C_{1i} are the head office overhead costs incurred by the company for the ith month.

i is the period for which the costs are apportioned.

$B_0 \ldots, B_m$ is the set of equation constants.

Since the head office overhead costs are apportioned to the projects under construction within the planning period, it is considered appropriate to express these costs to be apportioned in terms of the proportion of the head office overhead costs incurred for the same period C_{1i}. This can therefore be written as

$$\frac{C_{1ki}}{C_{1i}} = B_0 + B_1U_1 + B_2U_2 + \ldots + B_mU_m \qquad \text{eqn(4.3f)}$$

where

$\frac{C_{1Ki}}{C_{1i}}$ now becomes the proportion of the head office overhead costs incurred for the ith month, apportioned to the Kth project.

4.3.4 FUNCTIONAL DEFINITION OF SITE OVERHEAD COSTS OF A PROJECT

The site overhead cost incurred in undertaking a project can be multi-linearly expressed as

$$C_{2KO} = D_0 + D_1V_1 + D_2V_2 + \ldots + D_mV_m \qquad \text{eqn(4.3g)}$$

where

C_{2KO}	is the site overhead cost at the tender stage
$D_0 \ldots D_m$	are equation constants
$V_1 \ldots V_m$	are the independent variables
m	is the number of independent variables.

4.4 SELECTION OF THE INDEPENDENT OR PREDICTOR VARIABLES

After deciding on the mathematical function which should relate the dependent variables to their sets of independent variables, the next problem area is selecting the relevant factors (the sets of independent variables) on which the development of the dependent variables will depend.

There are many factors which can be selected for use as independent variables in the models for head office overhead costs and the site overhead cost of the Kth project. It is true to say that many factors considered as independent variables would show correlation with the dependent variable for which they are to be used, but what really matters is the extent and the way in which a factor considered affects the dependent variable. Some factors will have less significant effects on the dependent variables and because of this, their inclusion in the model will have only a marginal effect.

Secondly, it is not possible to include in the models all the factors which can be considered to have an effect on the dependency variables. Apart from making the models impracticable, there are other reasons which can be given in support of refraining from including all the factors which can be considered in the models. Some factors are quantitative, which means that they can be expressed in numerical forms for the model equations.

Others are qualitative and these types of factors cannot easily be expressed in numerical terms. This makes their use impossible or at least limited in a mathematical model.

Thirdly, even the factors which can be expressed in quantitative terms cannot all be included as independent varibles in the models. This is because overhead costs account for ten to twenty per cent of construction projects costs; and to include all these factors in a mathematical model to determine a part of the cost of construction projects would not be practicable or economical. A model of this sort can hardly be acceptable by its users in the industry. Furthermore, it can be said that the accuracy of the method towards achieving its goal can hardly be improved upon beyond a certain limit, irrespective of the number of independent variables included in the model. If indeed it does, the cost of achieving such an accuracy could far outweigh the advantages to be gained from the application of the model.

The fourth reason for not including all the factors considered is that some of these factors, when considered on their own in a bi-variate model, their singular effect on the overhead costs becomes less significant. Because of this, the contribution made by these factors towards improving the accuracy of the model will also be insignificant. This, therefore, makes their use in the model not fully acceptable.

Lastly, a detailed analysis of some of the factors show that although they are important to the project undertaken (whose overhead costs are to be determined), these factors might not be important enough for them to be included as independent variables.

The various points discussed above could therefore be a limitation in the choice of factors to be considered as independent variables in the models.

4.4.I FACTORS FOR THE OVERHEAD COST MODELS

4.4.1.1 FACTORS FOR C_{1KO}

Various factors were considered at the preliminary stages of developing the model. These factors were then discussed in detail and analysed to see how their use in the model would affect the dependent variables. The factors considered for the head office overhead costs, C_{1KO}, apportioned to a construction project (the Kth project) at the tender stage are

(1) The planned capital outlay of the Kth project

(2) The estimated direct costs of the project.

(3) The planned duration of the project.

(4) The inflation factor.

(5) The value of work done by subcontractors.

(6) The type of project.

4.4.1.2 FACTORS FOR $\frac{C_{1Ki}}{C_{1i}}$

$\frac{C_{1Ki}}{C_{1i}}$ is the proportion of the head office overhead costs apportioned to the Kth project during the construction stage of the project. The factors considered as independent variables are

(1) The ratio of direct costs of project/turnover of the company for the period for which apportionment is made.

(2) The ratio of duration of the project for which apportionment is made/the planning period of the company.

(3) The number of projects undertaken within the period for which the apportionment is made.

(4) The value of work subcontracted.

(5) The type of project.

4.4.1.3 FACTORS FOR C_{2KO}

In developing a model to determine the site overhead costs of construction projects, the factors considered as independent variables for a project (the Kth project) are

(1) The planned capital outlay of the project.

(2) The estimated direct costs of the project.

(3) The duration of the project.

(4) The inflation factor.

(5) The type of project.

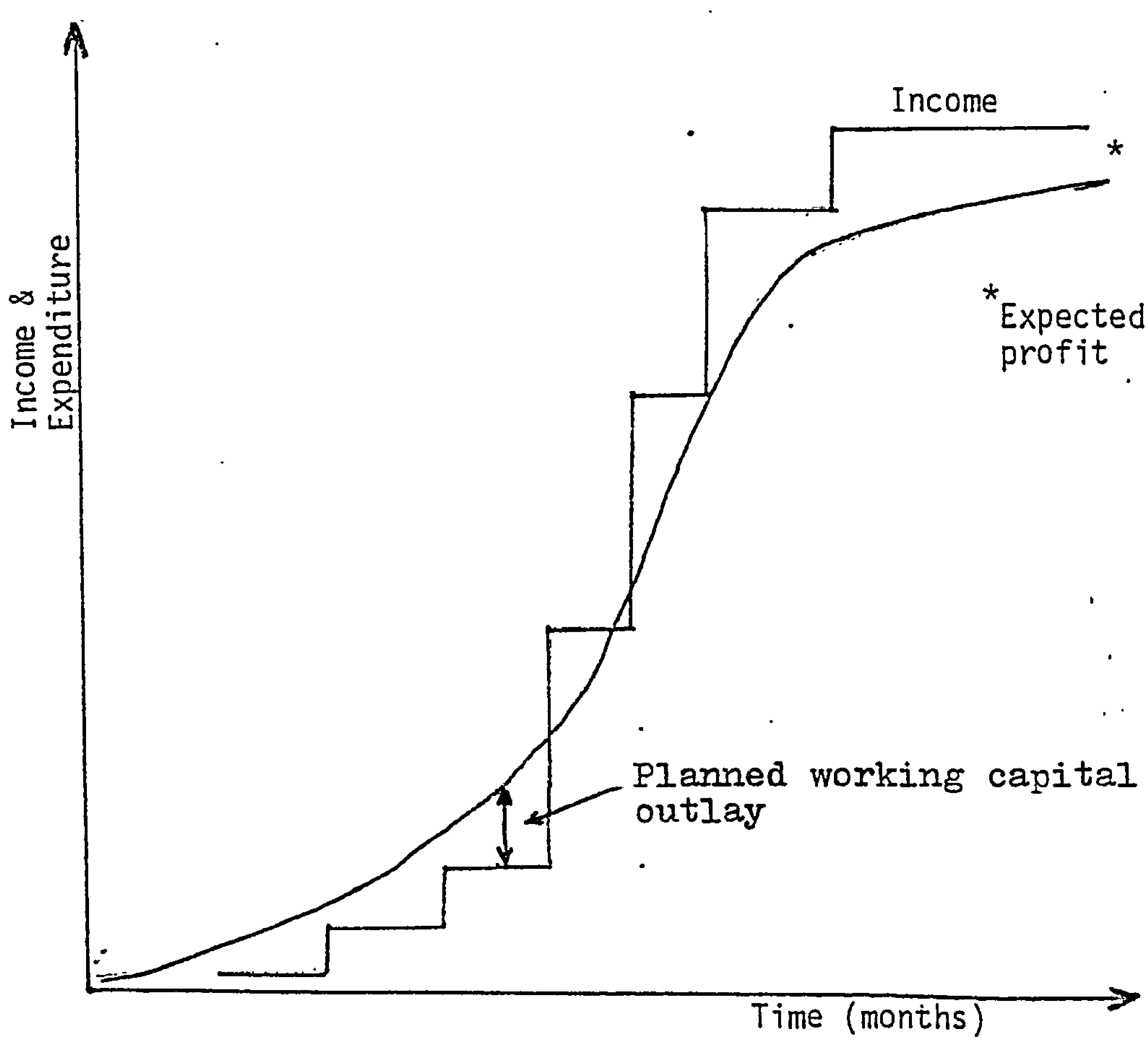
(6) The value of work subcontracted.

4.4.2 DETERMINATION OF THE INDEPENDENT VARIABLES

4.4.2.1 THE PLANNED CAPITAL OUTLAY OF A PROJECT

Figure (4.4a) is used here to give a clearer definition and understanding of the planned capital outlay of a construction project. As shown in the figure, during the execution of a construction project costs are incurred on the part of the construction company in providing for the project, the resources of labour, plant and material, and administration and management of the project as it progresses. At interim stages, which are normally monthly, payments are made by the client to the company for the work already completed. In the process of expenditure by, and receipts of payments to the company, there is a time-lag between the expenditure and income to the company from the project.

Fig.(4.4a)



The expenditure incurred by the company on the project is continuous. This is so because, unless unexpected difficulties and constraints become inevitable, the work on a construction project is a continuous process and therefore the costs of providing labour, plant and material and supervision are also continuous in nature. This can be seen as represented by the S curve in fig(4.4a). The company is paid at interim stages for work which has already been completed and evaluation carried out. The payment to the company for the completed work is discrete, as shown, since the payment is made in stages. However, some have presented this as a continuous process (ref.39).

Since the company is paid only for completed and evaluated parts of the project, the company has to wait for a period of time to elapse in order to be able to recover the expenditure already incurred on the project. There is also retention, which means that part of the payment due to the company is retained by the client against default. In the early stages of construction work on the project, the receipt of payment to the company falls short of the expenditure on the project. Taking this into consideration in giving a definition, the maximum planned capital outlay for a construction project is the largest planned expenditure on the project by the company, while waiting for the evaluation and payment for the completed part of the project. In explaining this further, it means that the company has to provide this amount at a certain stage during construction of the project. If the company can meet this expenditure, either from its own funds or from borrowed funds, then the company can meet the financial responsibilities of the project.

The planned capital outlay has been considered as one of the independent variables for the models. This takes into consideration the cash-flow situation facing the company on a particular project. Several reasons can be given to justify this.

Under all conditions which could prevail for any construction project, the company needs working capital, for it incurrs costs before the client makes payment for completed work. The demand which a construction company creates for working capital, either on the company's own capital or on borrowed resources, could be a deciding factor in the type of projects a company can undertake and the sort of management services which can be provided.

Secondly, a construction company can continue to stay in business for quite a reasonable period of time without making a profit, as long as it has a well-planned and carefully monitored cash flow system (ref.64). At times when work in the industry is scarce, companies sometimes take on projects with little or no profit margin allowed on the estimated costs, in the hope of having an adequate cash-flow system and thereby providing employment for its staff. Sometimes, a profitable project, but without adequate cash-flow planning, can result in a loss-making project. Indeed, many of the failures of companies in the industry can be basically due to either lack of required working capital or lack a well-planned cash-flow system (ref.25). A construction company's ability to undertake and carry out a project would depend not only on the turnover yielded or the profit margin achieved by the project, but on the availability of the finance needed to carry out the project. Construction projects are cancelled each year because of the lack of liquid cash and companies are known to have gone into bankruptcy because of the mismanagement of their cash flow system (ref.64).

On large construction projects large capital outlay could be required, resulting in high overhead costs. There is the restraining effect of large amounts of capital required on large projects due to the high rates of interest charged over short-term loans, or on the company's own capital tied up in the project, which money could otherwise have been earning interest in some other area of investment.

Also, construction projects' duration vary from month to month for small projects and from year to year for larger ones. Large projects require the expenditure of large sums of money for several years and this makes the cash-flow system an important factor to any company.

Lastly, cash-flow influences the overall liquidity of all the projects right from the preliminary stages. Because of this, the planned capital outlay can become a crucial decision factor on the number of projects the company can undertake. For if the company cannot afford the capital outlay for the projects it wants to undertake, then its chances of making a profit become remote.

The planned capital outlay has been considered to be an important factor for overhead costs planning because, in order for the company to be able to provide the outlay for a project, costs are incurred which can be considered to be overhead costs. Overhead costs are incurred:

(a) In planning the capital outlay for a project.

(b) Through interest on borrowed capital If the planned capital outlay is raised through borrowing, either by long or short-term loan or through any other credit scheme, there are interest charges to be paid on the borrowed capital. In times of high interest rates the interest charges can be substantial and can lead to high overhead costs on the project and for the company.

Various methods are used by construction companies to determine the cash-flow and hence the planned capital outlay of a project. A method suggested by Shelmo (ref 64) is to:

(a) Analyse the construction planned expenditure.

(b) Analyse the expected income on the project.

(c) Estimate the time-lag between the planned cost and the expected income.

This analysis can be carried out for a project. Shelmo has developed a model which he claims can be used to predict the expenditure on a construction project. It has yet to be proved through the practical application to construction projects. Indeed, if Shelmo's model can mark a high degree of accuracy, research into developing similar models for the receipts and payments to a company on a project will be important for cash-flow predictions. For through the application of the models the planned capital outlay for any project can be determined.

A method suggested by the author is to determine the cash-flow, basing this on the Net Work Planning techniques, especially the Critical Path Method (CPM). The use of CPM has played a great part in helping management towards planning and control of projects, but as Reinschmidt (ref.57) points out, this technique has not been extensively used in the early stages of the finance planning of construction contracts. The technique of net-work analysis can be used to solve cash-flow problems. The cumulative costs of labour, plant and material are first estimated for each of the activities against timely intervals. The same is carried out for the expected income or payments to be made to the company. Although it can be said that this method of determining the planned expenditure and the expected income and hence the planned capital outlay is tedious and involves a great deal of mathematical manipulation, it could lead to a high degree of accuracy.

4.4.2.2 DURATION OF THE PROJECT

Time is always of great importance to any construction company. In fact, as Hart points out:

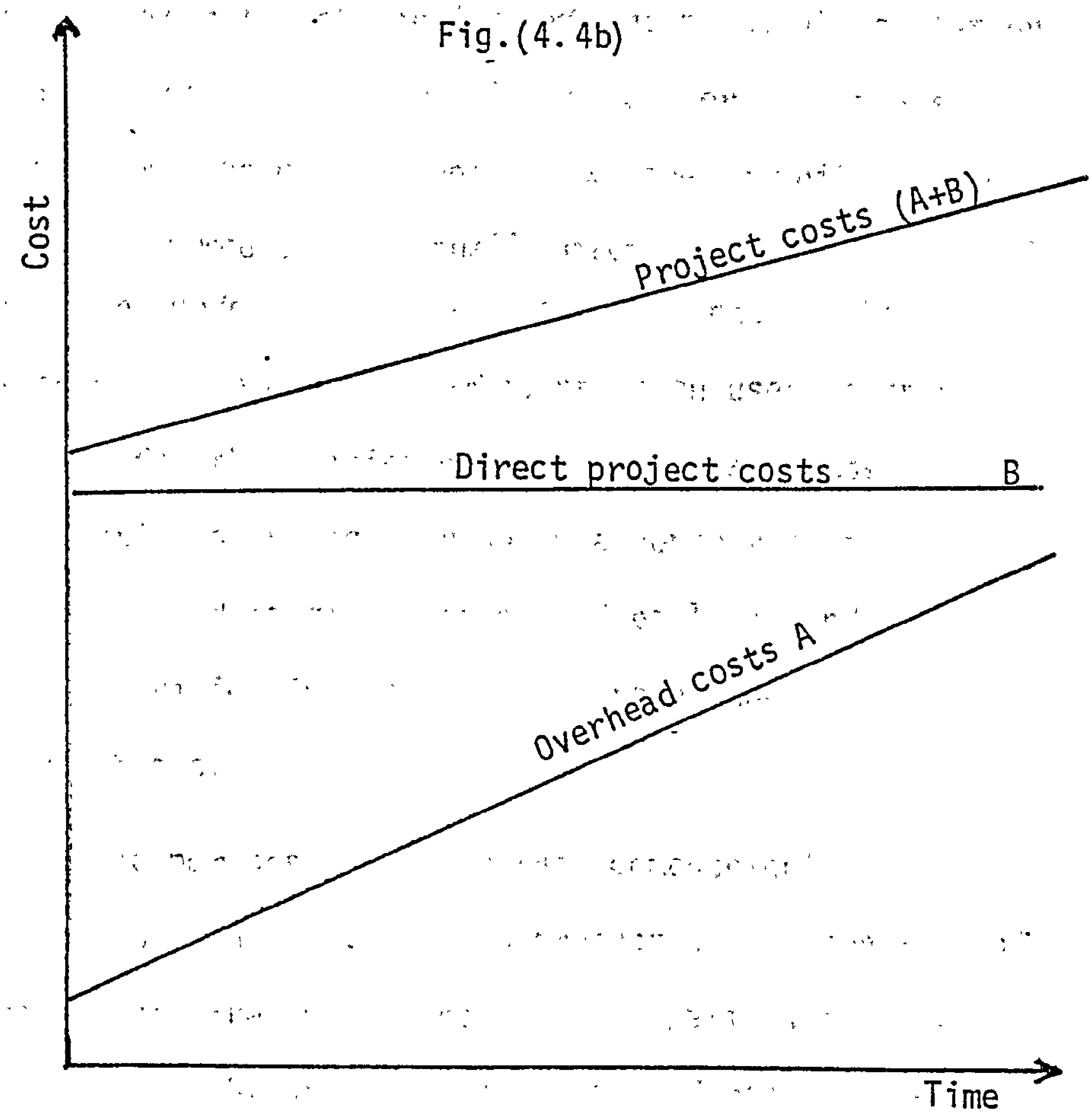
> "Time is the greatest single causative factor for most overhead costs and most fixed costs." (ref.26).

The longer a construction project takes to complete, over and above the planned time, the more costs the company incurs in its overheads. On certain construction projects like 'Turnkey projects', where the main criterion in the conditions of contract is the timely completion of the work, clauses are sometimes introduced in the conditions of contract and other related contractual documents which could cause the company to pay large sums of money in the form of damages if the time target stated in the contract is not achieved. The time period has therefore been considered as an independent variable for the overhead costs models.

Apart from this, in the case where the project is not completed in the time set by the contract can be viewed by the client or his representative as being caused by poor supervision, lack of effective communication, and mismanagement by inefficient staff. This could strain future relations between the company and the client. The client could be reluctant to commission the company to undertake future projects.

If a project takes longer to complete than the time period stipulated in the contract, in addition to the charges which the company might pay in the form of damages, overhead costs are incurred in providing the staff and facilities for the project. It will cost the company more in running both the head and site offices. If the project is completed before the agreed completion time, in addition to the bonuses which could be won, overhead costs on the project could fall. Fig.(4.4b) shows the effect of the duration of projects on the overall costs.

Fig.(4.4b)



The graph shows the way the costs of project will behave in relation to the duration of the project if the effects of inflation are held constant, assuming the estimated costs of the project are fixed as given by line B. No matter how long the project takes to complete, the actual project costs remain the same (not counting the effect of inflation), but the overhead costs continue to increase as shown by line A. The combined effect is shown by the summation of lines A and B, which shows an overall increase in the project costs with the duration of the project.

The duration of a project is considered as the period between the physical start and physical completion of the project. This variable can either be expressed in weeks, months or even years. Whichever unit is used in the model would not actually matter as these would only affect the model coefficients or constants of the variables. The monthly period has been used in this research for this variable. This is because most construction planning is done on a monthly basis. Evaluation and payments, as stated earlier, and most other activities in the industry are planned on a monthly basis.

The periods preceding the commencement of construction activities on projects, when contractual arrangements are being made, and the periods after the physical finish, when retention is in force, are not included in this variable. The duration period, as used in this work, is the period during which the actual construction activities are carried out.

4.4.2.3 INFLATION

The construction industry is one of many which are experiencing a high rate of inflation at the present time.

There have been many studies made of the effect of inflation on the efficiency and growth of companies in the industry (refs.45,49).

Study and analysis of inflation show that its effects on companies can be far more complex than would at first appear. Pilcher stated:

> "The cause of inflation is rarely assigned in satisfactory way. So complex is the matter that it has become fertile ground on which many economists'(and other) theories have flourished." (ref.52).

Various factors can affect the prevailing rates and there is a greater risk of incorrectly predicting the inflation rate and its effect on construction projects and on construction companies far into the future. The longer the duration of the project the more it is influenced by inflation.

In certain cases, when the effects of inflation are significant, the addtional capital required for a project can be larger than when compared with the 'before-inflation' costs of the project. Hence a public sector limit of maximum of one year's duration for fixed price contracts (ref.57). Inflation affects the investments made by construction companies and the returns on these investments.

Because of the way in which contractual arrangements are made in estimating the costs of construction projects which could take years to complete, in the initial stages, careful consideration should be given to the current rate of inflation before estimating any aspect of the construction costs and indeed, of the overall cost of the project. It was therefore thought that a realistic model, developed for determining the overhead costs of construction projects, should include the factor of inflation as one of the independent variables.

The inflation variable is a qualitative variable and this in itself presents the problem of expressing this variable quantitatively in the model equations. However, ways and methods are already in existence, of expressing the variable in numerical terms. Indices have been developed and these take account of inflation on a comparative basis - normally one of the years of operation. The most commonly used indices in the construction industry in the United Kingdom are the Osbourne Indices for building, and the Baxter Indices for civil engineering, which are both published monthly. The Department of Statistics of the Sierra Leone Government also publishes inflation indices for the construction industry (ref.12). For this work, any of the above indices can be used. The important point to note here is that consistency should be maintained in deciding on the type of indices to be used in the models, as each type of index will yield a different set of model coefficients or constants. The indices used in this work in developing the models are those published by the Sierra Leone Government. The data used in developing the models is obtained from past projects, and the indices are averaged over the construction period. But since the model will be used to determine the overhead costs for projects at the planning stages, this index should be projected into the future to cover the duration of the whole of the construction period before being averaged and accommodated into the model equations.

4.4.2.4 DIRECT COST OF PROJECTS

The direct costs of construction projects - the costs of labour, plant and material - have been considered as one of the independent variables for the overhead cost models. The costs of projects can be taken to be a good measure of the level of overhead costs of construction companies. This is because, being direct or basic costs of a project, the cost of project factor is hardly distorted by other factors like profit, as it is observed with other factors.

Estimating is the process used to determine the direct costs of construction projects. The costs of projects can be estimated by adding up the individual costs of the three major components of construction direct costs of projects. These are the labour costs, plant costs and material costs. Once the project is planned the costs could be estimated separately and added up.

The direct costs of construction projects can also be determined by summing up the direct costs of operations or activities of the projects. By this method the project is planned into activities using the techniques of network analysis or the conventional bar charts or grant charts methods. The costs of carrying out the various activities can then be summed up to give the estimated direct costs of the project.

It should be noted that the direct project costs are the cost of labour, plant and material and do not include the additions for risks, profit and overheads.

4.4.2.5 TYPE OF PROJECT

The construction industry, which comprises both the civil engineering and general building sectors, is a vast and complex industry. Even within the two main sectors there are various types of construction work. While some companies remain as general construction companies likely to take on any project which can be tendered for on the market, some are more specific and carry out only certain types of projects for which they have the resources and expertise.

The degree of risk and uncertainty differs between technical contents of projects and labour and management services. Efficiency achieved in terms of productivity also differs with the type of project undertaken. As a result of these, the attention paid by the company to these projects, in providing staff and other administrative facilities, differs from project to project. This influences the overhead costs for each project.

The uniqueness of the procedure of work and of contractual arrangements also carries weight in this argument. The products of the industry - houses, roads, bridges, etc., - are sold before they are produced. That is, the prices for contracts are determined at the tender stage before they are constructed and made available to the clients. This creates uncertainty in meeting the conditions of the contract. It has, therefore, been considered important by the author to include this factor as an independent variable in the model. It can help localise the uncertainties mentioned above to individual projects.

The type of project variable, unlike the other variables, is a qualitative variable. As explained in earlier chapters, in order to include this variable in the regression analysis for developing the models, a way has to be found to present it in numerical units. This variable was therefore considered as a dummy variable.

Data from the completed questionnaires were categorised as either general building or civil engineering. For the regression analysis, these were attached the arbitrary values of 2 for general building and 1 for civil engineering.

4.4 2.6 NUMBER OF PROJECTS UNDERTAKEN

The number of projects undertaken by a company has been considered in this work as an independent variable in the model for determining the head office overhead costs apportioned to a construction project (Kth project). Since the head office overhead costs are to be recovered from the projects, all other factors being equal, the more projects a company undertakes within a planning period the less apportionment is made to each project's prime costs for the head office overhead costs. As new projects are taken on, provided there are no extra head office overhead costs incurred as a result of this, the new projects will also take on a proportion of the head office overhead costs. If, however, there are few projects undertaken, the apportionment made to each increases. Because of this effect, it was considered important to take the number of projects undertaken within a planning period as an independent variable in developing a model for the head office overhead costs apportioned to a project.

For developing the model, the data used to determine this constant is the number of projects undertaken within a specific period and for which the apportionment of the head office overhead cost is made. In applying the models, this variable is the number of projects undertaken by the company in the period for which the apportionment is made.

4.4.2.7 RATIO OF DIRECT COST OF PROJECT / TURNOVER OF COMPANY FOR THE PERIOD FOR WHICH APPORTIONMENT IS MADE.

The ratio of the actual direct costs of a project/ turnover of the company for the period for which the apportionment is made is considered as an independent variable for the proportion of the head office overhead costs apportioned to the Kth project during the construction stages of the project.

This factor introduces into the model the effects of the turnover, which is a measure of the size of the company, for the period for which the apportionment is made. As an independent variable, this factor was included in the model so as to take account of the variations in the performance of the company during the construction stages of the project.

For this variable, the actual direct costs of projects, incurred for the period for which the apportionment is made, is divided by the turnover of the company, achieved within the same periods.

4.4.2.8 THE RATIO OF THE PROJECT'S DURATION FOR WHICH APPORTIONMENT IS MADE / THE PLANNING PERIOD OF THE COMPANY

The ratio of the project's duration for which apportionment is made / the planning period of the company is taken as an independent variable for the proportion of head office overhead costs apportioned to the project during the construction stage. This factor takes into account the overall planning period of the head office overhead costs of construction companies.

For this variable the period for which the apportionment is made is divided by the planning period for the head office. If the apportionment for the head office overhead costs is made for monthly periods and the planning period is twelve months, this variable becomes a constant.

4.4.2.9 SUBCONTRACTORS

Subcontracting parts of construction operations by main construction companies to other companies is a practice that is in use in the industry. Recent trends do indicate that the industry is to see an escalation of this practice in the future. Various reasons can be given for this, both on the part of the main construction company which subcontracts parts of project operations to other companies, and also on the part of the subcontractor who takes on the subcontracted work.

For the main company, work subcontracted depends on the management policy of the company. As companies differ in policies, the amount of work out to subcontract also differs. Some large companies, with an adequate workforce and high own-plant availability, offer to subcontractors around 10 per cent of the total value of projects. In smaller companies the value of work sub-contracted can sometimes amount to 60 per cent of the total value of the project. These companies subcontract operations of the project for which they are either less well-equipped or not prepared to undertake for other reasons.

The labour force is one area which normally comes under subcontracting in the industry. The reasons for this are apparent. Many factors influence the costs of labour on construction projects and these cause large fluctuations to occur in the labour costs. Strikes and poor labour relations can lead to higher costs. Inadequate planning and wage settlements also do add to this. In times of fewer jobs, there are the costs of laying off part of the workforce. Further, there are the costs of employing the labour force and the costs of motivating the labour operations. Costs are increased in labour administration. Sub-contracting the require-ments of plant is also applied, especially amongst the smaller companies which cannot afford the capital costs and runnning repairs of heavy plant. A company may want to avoid all these and therefore subcontracts most of the operations requiring these services.

All these factors, therefore, lead to the practice of subcontracting amongst the main and general construction companies.

For the companies which undertake the work as subcontractors, various reasons can be given for these practices and the increase in the number of subcontracting companies. Firstly, the business of subcontracting is mostly at the lower end of the construction market and this makes it easier for small companies to enter and leave the industry. Secondly, as construction works become more industrialised and complex in nature, specialisation in certain types of work and operations begin to play a dominant role in the type of work engaged in. There is a greater advantage to be gained from this. As companies become more specialised in certain types of operations they earn a high degree of experience and become better equipped for the job than a general construction company. Also, subcontractors meet demands on a number of projects and thus maintain a steady workload in the locality. They are capable of maintaining a mobile labour force in a more efficient manner than a general construction company. This encourages individuals to organise themselves into labour-only subcontractors.

With regard to overhead costs, the more subcontractors commissioned on a project, the more complex the functions of management becomes. Management has to plan, co-ordinate and control the activities of the subcontractors. The cost of these management services is part of the overhead costs and this factor has therefore been considered as an independent variable.

For this factor, the data for the regression analysis is the total value of work done by subcontractors between the physical start and the physical finish of the project. This variable also includes the cost of labour subcontracted.

After functionally defining the models and selecting the independent variables, the next stage in developing the models is the analysing of the collected data. This is deliberated on in the next chapter.

4.5 DEVELOPMENT OF THE SAFE ZONE METHOD OF PLANNING AND CONTROL OF OVERHEAD COSTS

There are four broad classification elements of any management system. These are: planning, control, co-ordination and motivation. As stated in earlier chapters, this work limits itself to the planning and control of overhead costs. Performance can be hindered by introducing poor planning and control methods. Whilst in the planning of direct work, the final plan consists of charts and schedules, accompanied by method statements for projects, for the overhead cost planning, the final plan consists of cost limits of the cost centres or cost components and of cost limits of the total overhead costs.

There are many cost planning and control methods in-use in the construction industry and in other industries but these methods do not lend themselves easily to the planning and control of overhead costs in the construction industry.

Whilst the limitations of the present methods are being acknowledged, a new method to be investigated and recommended to the industry should have the advantage of overcoming the limitations of the other methods; then only will it be appreciated fully. This calls for the introduction of a more flexible metnod, which would be simple to apply. If this were achieved, it could make valuable contributions in this field.

The cost planning and control method, which is suggested, discussed and developed in this chapter could be a move in this direction. This method is referred to as the 'Safe Zone Method'. If successful, this idea could be extended to other costs like direct costs of labour, plant and material.

In its application to the planning and control of overhead costs, the safe zone method can be used to:

(a) Plan the head office overhead costs of a construction company's head office for a planning period and the cost centres or cost components of the head office overhead costs. Similarly, it can also be used to plan the site overhead costs and the site overhead cost centres or cost components of projects. This could be done in conjunction with the derived model for the site overhead cost to provide an all-round check and an effective method.

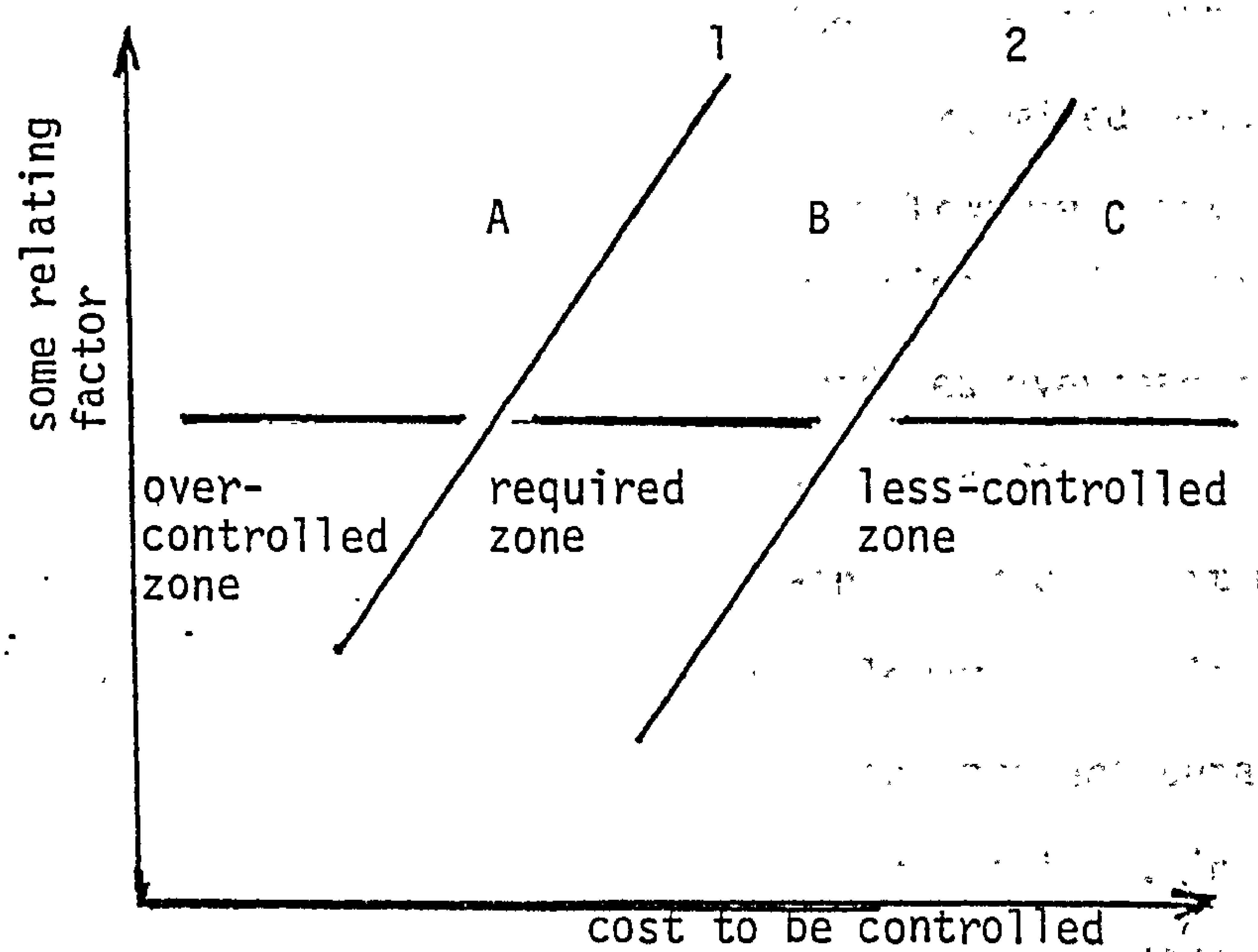
(b) Control the head office overhead costs, the head office overhead cost components, the site overhead cost of projects and the site overhead cost components.

The advantage of the safe zone method as an effective control method is to be appreciated in its application as a continuous method. Through the application of this method, reduction could be achieved in the lag-response time which is a major limitation to most cost control systems.

For the overhead costs, planning could be defined as a process of making advance decisions on the level of expenditure, and the way this should be incurred to achieve the desired targets. At the outset of planning, the main objectives are the extent of expenditure on the head office, site overhead costs, and the cost components of these costs.

Let us suppose it is the intention of personnel in a company to plan and control a cost component of the head office overhead costs; for example the senior staff costs or the head office accommodation cost, and it is envisaged to keep this cost centre within a certain cost range which can be considered acceptable to management. If this planned cost is not adhered to, actual costs incurred might increase and fall outside the desired range. This would show that the control measures used have not been effective. On the other hand, if too much control action is exerted on this cost centre, the actual costs incurred can be greatly reduced and, again, allowed to fall outside the desired range. This would imply that more control measures are applied than are warranted. In this latter case the cost of implementing such control actions becomes more than the savings to be made or the advantages to be gained as a result of the application of the control measures. Both cases are presented in fig(4.5a) below.*

Fig(4.5a)



What this method does, is to set both lower and upper bound limits for the particular cost components.

This is, however, a deviation from traditional methods of planning which set a desired standard for comparing the actual costs; a target which is hardly ever achieved in

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* In figure (4.5a) and appendix (D I), the dependent variables (the overhead costs to be planned and controlled) are on the horizontal axis and the independent variables (the relative factor) on the vertical axis. Normally in graph plotting this is done the other way round. This is to present a clearer graphical illustration of the safe zones. However, the safe zone equations developed have been re-arranged to take this into consideration.

practice. Other forms of cost planning methods are based on setting upper bound values below which the particular planned cost should be kept. To the standards of these methods, keeping the actual costs to any extent below the set upper bound value, is acceptable. Indeed, it is found during the vists to construction companies that they embark on this method and personnel are determined and encouraged to reduce overhead costs as low as they can. Whilst this may be acceptable to these companies (and perhaps to the author, for the fact that it reduces overhead costs and may, therefore, increase the company's profit margins), on certain types of contracts like 'All-in contracts', it must be realised that failing to set a lower bound limit when planning and incurring costs might present unfavourable situations. Arguable though this might be, in attempting to reduce these costs, there is the possibility that this could be done to such an extent as to result in the provision of poor accommodation facilities, understaffing, poor communications, less employment, less plant and equipment utilisation and many other deteriorating factors. All in all, these could lead to inefficient production.

The author has recognised this and has made attempts to define lower bound values for the head office overhead costs, site overhead costs and the cost centres of these overhead costs. It recognises the resistance by management to the acceptance of lower bound values for incurred costs.

It can be seen from fig(4.5a) that in trying to set a desired range for any cost, either whole or component costs, there are three zones to be observed in the control field. These are referred to in fig(4.5a) as Zones A, B and C. The B-Zone defining the range within which the planned costs and the actual costs should lie, is called 'the safe zone'. The A-Zone is the over-controlled zone, and this defines the zone in which the actual cost will lie if more control measures than necessary are applied. The third zone, the C-Zone, defines the zone for the costs when an ineffective control measure is applied. As described, it is the ineffective control zone. This idea is drawn upon and used in this work to try to develop a method of planning and control for the overhead costs in the industry. The method developed can be effectively used for planning and control of the overhead costs.

In developing the safe zone method, a difficulty encountered is how to successfully define the three zones so that the required safe zone can be determined. To overcome this, the author has used data on past performances and completed projects. These data were obtained from the completed questionnaires. In each case, a graphical plot was made between the overhead costs to be planned and its relating factor as given in appendices (D1) and (D2). Two straight lines were then drawn to enclose the points plotted on the graphs. These lines were taken to be the lines defining the three zones.

An assumption has been made at this stage which could come under heavy criticism. That is, that the lines defining the three zones are linear. This may not necessarily be correct and it is possible to have the zones defined by non-linear boundaries. This assumption was made so as to simplify the method, especially at the initial stages of developing the system.

4.5.1 HEAD OFFICE OVERHEAD COSTS PLANNING

In planning the overall head office overhead costs for a construction company for a planning period, it is considered to relate the head office overhead costs to the company's planned turnover for the planning period. This is considered to be the most suitable relating factor.

The straight lines defining the safe zones can be expressed as

$$YTURN = h_a + j_a X \text{ HCOST } 1$$

$$YTURN = h_b + j_b X \text{ HCOST } 2$$

where

YTURN	is the company yearly turnover
h_a, j_a	are constants of the lower bound equation
h_b j_b	are constants of the upper bound equation
HCOST 1	is the lower bound value of the head office overhead costs
HCOST 2	is the upper bound value of the head office overhead costs.

rearranging,

$$\text{HCOST } 1 = \frac{1}{j_a}(YTURN - h_a)$$

$$\text{HCOST } 2 = \frac{1}{j_b}(YTURN - h_b)$$

these can be written as

$$HCOST\ 1 = J_a(YTURN - H_a) \qquad eqn(4.5a)$$

$$HCOST\ 2 = J_b(YTURN - H_b) \qquad eqn(4.5b)$$

The head office overhead costs should be planned to lie within the zone range HCOST 1 and HCOST 2. That is,

$$HCOST\ 1 < HCOST\ P^1 < HCOST\ 2$$

4.5.2 PLANNING THE HEAD OFFICE OVERHEAD COST COMPONENTS

The method can be extended to planning the various cost components of the head office overhead costs. Here, the most appropriate relating factor for the cost components is the planned head office overhead costs. This is because it is the components which make up the total head office overhead costs.

The head office overhead cost items are grouped into eleven cost components. These are:

Senior staff costs
Other staff costs
Head office accommodation costs
Communication costs
Transport costs
Marketing costs
Insurance costs
Service costs
Research training of personnel costs
Finance costs
General and unallocated costs

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[1] HCOST P is the planned head office overhead costs for a particular planning period.

From the data obtained from the questionnaires completed (see Appendix C.) a graphical plot was made in each case of actual head office overhead costs against a particular cost component. These graphical plots are given in Appendix D. For each of these graphs the safe zone is defined by two lines. The safe zone equations are given below.

For the senior staff costs (HSSCOST)

$$HSSCOST\ 1 = J_c(HCOST\ P - H_c) \qquad \text{eqn}(4.5c)$$

$$HSSCOST\ 2 = J_d(HCOST\ P - H_d) \qquad \text{eqn}(4.5d)$$

For the other staff costs (HSCOST)

$$HSCOST\ 1 = J_e(HCOST\ p - H_e) \qquad \text{eqn}(4.5e)$$

$$HSCOST\ 2 = J_f(HCOST\ P - H_f) \qquad \text{eqn}(4.5f)$$

For the head office accommodation costs (HACOST)

$$HACOST\ 1 = J_g(HCOST\ P - H_g) \qquad \text{eqn}(4.5g)$$

$$HACOST\ 2 = J_h(HCOST\ P - H_n) \qquad \text{eqn}(4.5h)$$

For the head office Transport costs (HTCOST)

$$HTCOST\ 1 = J_i(HCOST\ P - H_i) \qquad \text{eqn}(4.5i)$$

$$HTCOST\ 2 = J_j(HCOST\ P - H_j) \qquad \text{eqn}(4.5j)$$

For head office communication cost (HCCOST)

$$HCCOST\ 1 = J_k(HCOST\ P - H_k) \qquad \text{eqn}(4.5k)$$

$$HCCOST\ 2 = J_l(HCOST\ P - H_l) \qquad \text{eqn}(4.5L)$$

For the head office marketing costs (HMCOST)

$$HMCOST\ 1 = J_k(HCOST\ P - H_k) \qquad \text{eqn}(4.5m)$$

$$HMCOST\ 2 = J_L(HCOST\ P - H_L) \qquad \text{eqn}(4.5n)$$

For the head office insurance costs (HICOST)

$$HICOST\ 1 = J_m(HCOST\ P - H_m) \qquad \text{eqn(4.5o)}$$

$$HICOST\ 2 = J_n(HCOST\ P - H_n) \qquad \text{eqn(4.5p)}$$

For the head office service costs (HSECOST)

$$HSECOST\ 1 = J_o(HCOST\ P - H_o) \qquad \text{eqn(4.5q)}$$

$$HSECOST\ 2 = J_p(HCOST\ P - H_p) \qquad \text{eqn(4.5r)}$$

Head office research and training costs (HRTCOST)

$$HRTCOST\ 1 = J_q(HCOST\ P - H_q) \qquad \text{eqn(4.5s)}$$

$$HRTCOST\ 2 = J_r(HCOST\ P - H_r) \qquad \text{eqn(4.5t)}$$

For the head office finance costs (HFCOST)

$$HFCOST\ 1 = J_s(HCOST\ P - H_s) \qquad \text{eqn(4.5u)}$$

$$HFCOST\ 2 = J_t(HCOST\ P - H_t) \qquad \text{eqn(4.5v)}$$

For the general and unallocated costs (HGCOST)

$$HGCOST\ 1 = J_u(HCOST\ P - H_u) \qquad \text{eqn(4.5w)}$$

$$HGCOST\ 2 = J_v(HCOST\ P - H_v) \qquad \text{eqn(4.5x)}$$

4.5.3 PLANNING THE SITE OVERHEAD COSTS

Similar method is adopted for planning the site overhead costs and site overhead costs centres. The relating factor for the site overhead cost is the direct costs of project. The safe zone equations developed are

$$SCOST\ 1 = K_a(PCOST - L_a) \qquad (4.5.3a)$$

$$SCOST\ 2 = K_b(PCOST - L_b) \qquad (4.5.3b)$$

For planning purposes, the site overhead cost items were grouped into ten cost centres. These are

Staff costs
Site accommodation costs
Transport costs
Communication costs
Insurance costs
Service costs
Minor plant costs
Test costs
Site temporary costs
General and unallocated costs

For these cost centres the relating factor in each case is the planned site overhead costs. Because of the scaler of the plots (see appendix fig.D2i) it was not possible to determine safe zone equations for the site test costs. This was however, not a constraint on the method as this cost centre amounted to minor percentages of the site overhead costs on most projects.

For the site staff costs (SSCOST)

$$SSCOST\ 1 = k_c(SCOST\ P - L_c) \qquad \text{eqn(4.5.1c)}$$

$$SSCOST\ 2 = k_d(SCOST\ P - L_d) \qquad \text{eqn(4.5.1d)}$$

For the site accommodation costs (SACOST)

$$SACOST\ 1 = k_e(SCOST\ P - L_e) \qquad \text{eqn(4.5.1e)}$$

$$SACOST\ 2 = k_f(SCOST\ P - L_f) \qquad \text{eqn(4.5.1f)}$$

For the site transportation costs (STCOST)

$$STCOST\ 1 = k_g(SCOST\ P - L_g) \qquad \text{eqn(4.5.1g)}$$

$$STCOST\ 2 = k_h(SCOST\ P - L_h) \qquad \text{eqn(4.5.1h)}$$

For the site communication costs (SCCOST)

$$SCCOST\ 1 = k_i(SCOST\ P - L_i) \qquad \text{eqn(4.5.1i)}$$

$$SCCOST\ 2 = k_j(SCOST\ P - L_j) \qquad \text{eqn(4.5.1j)}$$

For the site insurance costs (SICOST)

$$SICOST\ 1 = k_k(SCOST\ P-L_k) \qquad eqn(4.5.1k)$$

$$SICOST\ 2 = k_l(SCOST\ P-L_l) \qquad eqn(4.5.1\ell)$$

For the site service costs (SSECOST)

$$SSECOST\ 1 = k_m(SCOST\ P-L_m) \qquad eqn(4.5.1m)$$

$$SSECOST\ 2 = k_n(SCOST\ P-L_n) \qquad eqn(4.5.1n)$$

For the minor plant costs (SMCOST)

$$SMCOST\ 1 = k_o(SCOST\ P-L_o) \qquad eqn(4.5.1o)$$

$$SMCOST\ 2 = k_p(SCOST\ P-L_p) \qquad eqn(4.5.1p)$$

For the temporary site costs (STMCOST)

$$STMCOST\ 1 = k_s(SCOST\ P-L_s) \qquad eqn(4.5.1q)$$

$$STMCOST\ 2 = k_t(SCOST\ P-L_t) \qquad eqn(4.5.1r)$$

For the site general and unallocated costs (SGCOST)

$$SGCOST\ 1 = k_u(SCOST\ P-L_u) \qquad eqn(4.5.1s)$$

$$SGCOST\ 2 = k_v(SCOST\ P-L_v) \qquad eqn(4.5.1t)$$

The next stage in the development of the safe zone method for planning the overhead costs is the determination of the constants in the equations. This is discussed in the next chapter.

4.5.4 CONTROL OF OVERHEAD COSTS

4.5.4.I HEAD OFFICE AND SITE OVERHEAD COSTS

Control is the counterpart of planning and it is an important and an essential part of management. Planning and control are counterpart in that planning is the setting of the process and control is the instrument through which this process is portrayed, monitored and achieved; for in control, information is obtained and thereafter corrective actions applied.

There are two fundamental aspects of control with regard to overhead costs. These are:

(a) the control of the whole overhead costs, and

(b) the control of the performance of the individual cost components.

The safe zone method can be used not only for planning the head office and site overhead costs and their cost components, but could, with the incorporation of the percentage of completion method of cost control, be used as a control method for the overhead costs and the overhead cost components of the head office during a planning period and the site overhead cost during the construction stages of projects.

In the application of the safe zone method for control purposes, it is assumed that there is direct linear relation between costs incurred at any point in time and the proportion of the planned time that has elapsed. This assumption might not necessarily be correct especially in the case of the site overhead costs. This is because costs of construction projects do not generally have a linear relation with the duration of the projects. However, the linear relation has been used in this work and further research in this area is recommended in chapter six.

For the head office overhead costs and the head office overhead cost components, the proportion of elapsed planned time is used in each case, as a scaling factor on the established lower and upper bound values of the safe zone to determine sub-safe zones. That is, in the case of the head office overhead costs incurred at the end of the i^{th} month, the sub-safe zone limits are

$$\text{Lower bound} \doteq \frac{D_i}{D_u} \text{ H COST 1}$$

$$\text{Upper bound} = \frac{D_i}{D_u} \text{ H COST 2}$$

where

D_i is the number of months (i months) since the start of the planning period

D_u is the planning period in months.

The actual head office overhead costs incurred after i months, HCOST Ai should lie in the defined sub-safe zone. That is:

$$\frac{D_i}{D_u} \text{HCOST 1} < \text{HCOST Ai} < \frac{D_i}{D_u} \text{HCOST 2*}$$

This procedure is followed for the head office overhead cost components.

Similar approach is adopted for the site overhead costs and the site overhead cost components. The scaling factor used in these cases to determine the sub-safe zones is the proportion of the planned project duration that has elapsed since physical start of project. That is, for the site overhead costs

$$\text{Lower bound} = \frac{P_i}{P_u} (\text{SCOST 1})$$

$$\text{Upper bound} = \frac{P_i}{P_u} (\text{SCOST 2})$$

where P_i is the elapsed time in months since physical start of project

P_u is the planned duration of project

---

* Sometimes overhead costs like insurance costs are paid in bulk or at six monthly or quarterly intervals and not in monthly stages. In order to accommodate this cost component into the safe zone method of control, these costs can be imagined to be incurred in monthly stages as the rest of the other cost components.

At cost examination stages, the actual costs incurred in each case is compared with the sub-safe zone determined for the particular overhead costs or cost components. If the actual cost lies within the defined sub-safe zone, management should be satisfied that this cost has been incurred according to plan.

If the actual cost is greater than the upper bound limit of the sub-safe zone, the variance is the difference between the actual cost and the upper bound limit. If on the other hand the actual cost is less than the lower bound, the variance is the difference between the actual and the lower bound.

In either case, where the actual cost is outside the sub-safe zone, one of three corrective actions can be implemented*. These are:

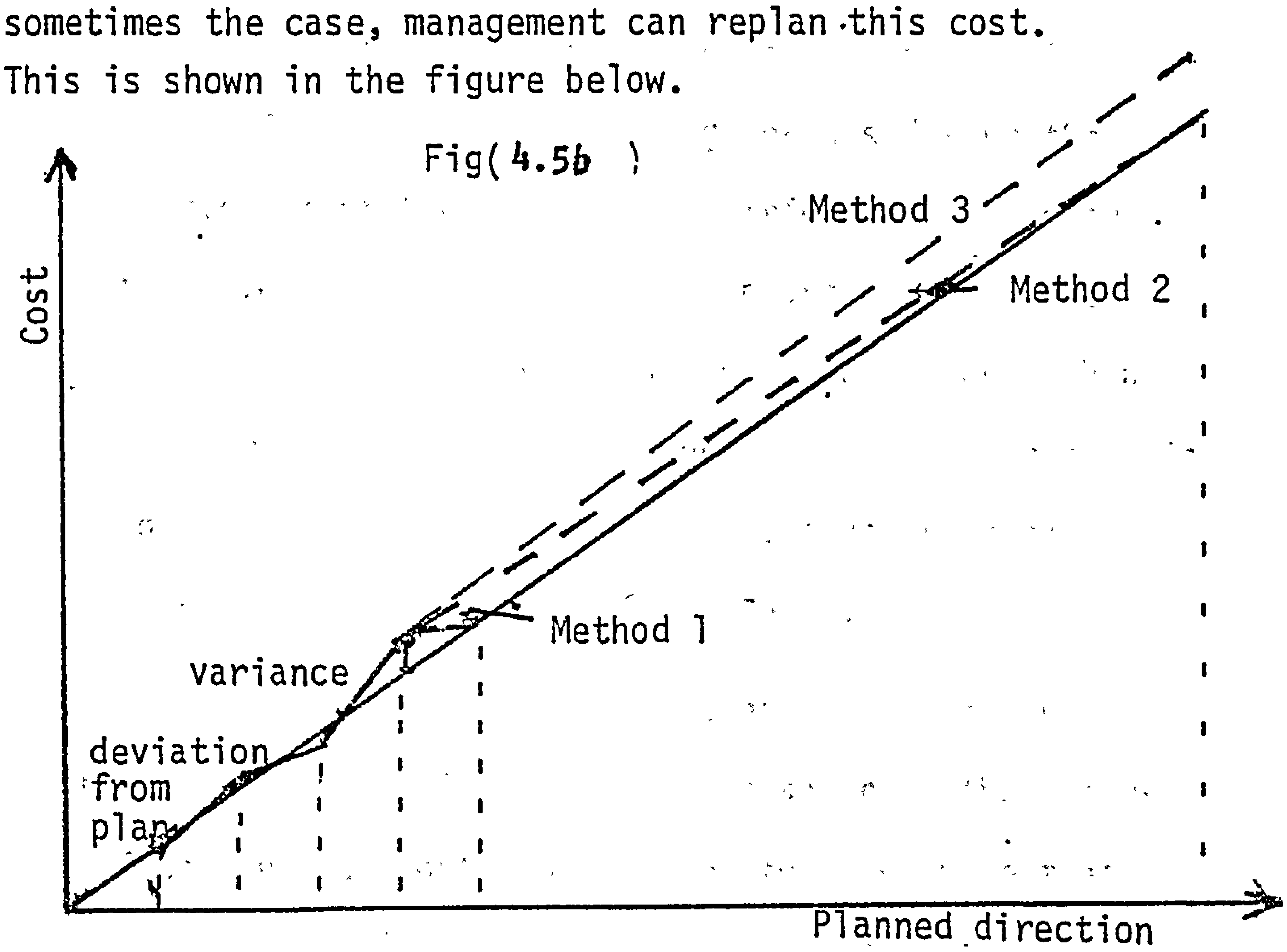
* Here there could be a conflict between economics and the application of mathematical principles for solving managerial problems. When the incurred cost is less than the lower bound value of the defined sub-safe zone, mathematical principles would suggest that this cost be increased to lie in its sub-safe zone while management, in common practice, would be reluctant to do this. However, for simplicity and understanding, the mathematical principles are followed in this work.

1. The management can decide to correct this deviation from the planned costs at the next costs examination stage. In this case, if the actual cost is more than the upper bound value, the variance, which is the difference between the actual cost and the upper bound value, is subtracted from the planned cost for the next cost examination stage. If the actual cost is less than the lower bound, the variance (the difference between the lower bound and the actual cost) is added to the planned cost for the next cost examination stage.

2. The management, on the other hand, can decide to correct this cost gradually throughout the remaining planning period. If this alternative is preferred, the variance is spread over the remaining planning period.

3. If it is not possible to improve this cost, as is sometimes the case, management can replan this cost. This is shown in the figure below.

Fig(4.5b)



4.5.4.2. CONTROL OF THE HEAD OFFICE OVERHEAD COSTS APPORTIONED TO A PROJECT (THE KTH PROJECT)

The safe zone method of control cannot be used as a control method of the head office overhead costs apportioned to a construction project during the construction stage. This is because safe zone limits are not defined for these costs.

The head office overhead costs apportioned to a project are planned during the tender stage of the project and apportioned during the construction stage. At the tender stage, the model does not take into account the overall head office overhead costs which will be incurred for subsequent planning periods during the construction of the project. Therefore, as the head office overhead costs are being apportioned at cost examination stages, the actual costs apportioned should be compared with what the planned cost should be at this stage. The necessary corrective actions are then applied. This is shown in fig(4.5c).

When work on the project has progressed up to the start of planning period 2, as shown in the figure, head office overhead costs apportioned to this project at this stage is C_{ik1}, C_{ik2},C_{ik3},C_{ik4}. That is:

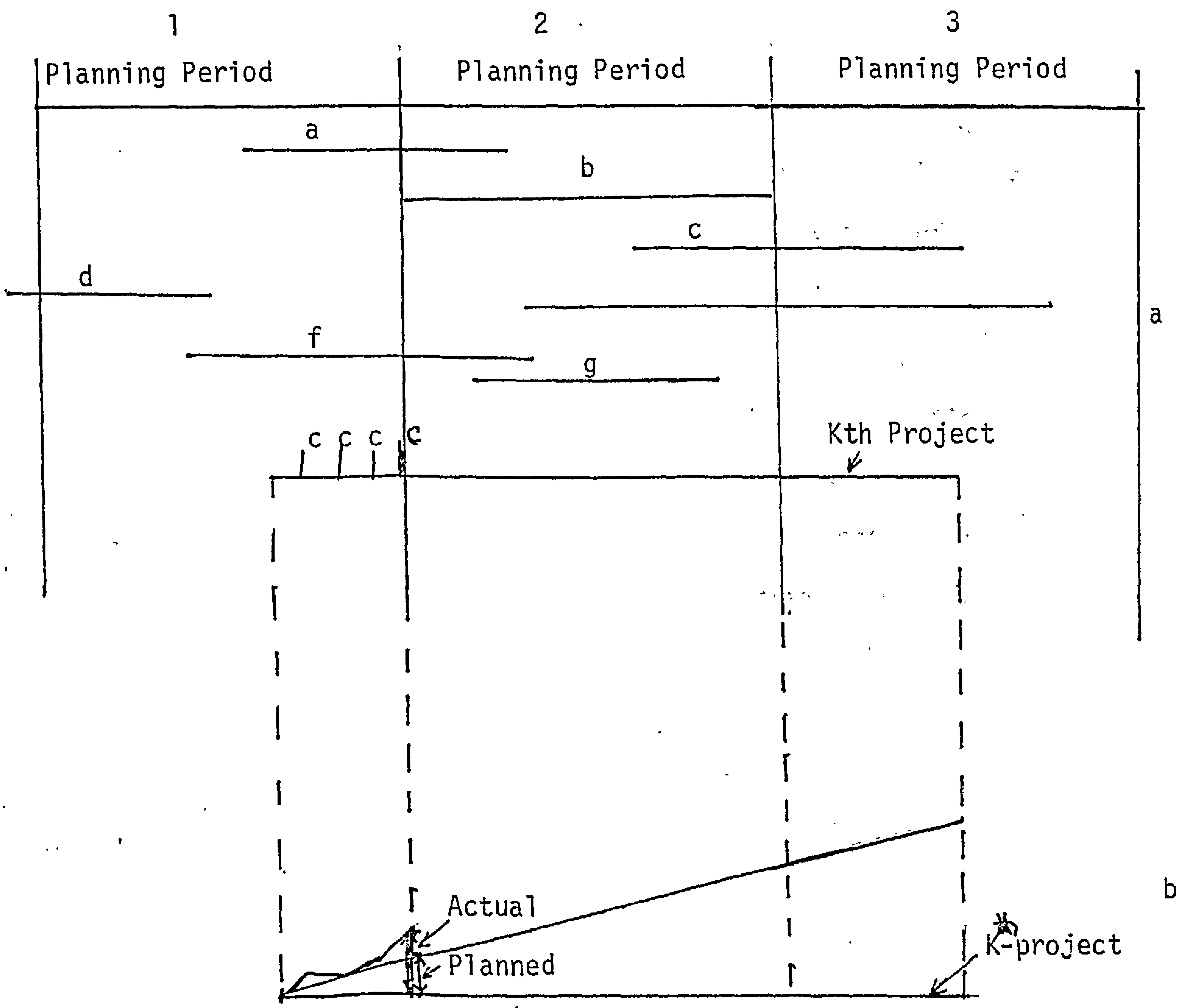
$$\begin{array}{l}\text{actual cost} \\ \text{apportionment after} \\ \text{4 months}\end{array} = \sum_{i=1}^{4} C_{1ki}$$

The costs which according to the tender stage model should have been apportioned are

$$\begin{array}{l}\text{Planned Cost} \\ \text{After 4 months}\end{array} = \frac{4}{Du} \times C_{1ko}$$

These are as shown in figure (4.5c). The actual costs are compared with the planned costs and the necessary corrective actions implemented.

Fig(4.5c)



The head office overhead costs apportioned to a project during construction can also be controlled by comparing the head office overhead costs apportioned to all the projects at a cost examination stage to the overall head office overhead costs incurred at that stage. The variance is then spread over the projects in the proportion in which the apportionment is made.

It must, however, be noted that strictly speaking this is not a control procedure. This is because there is no comparison between planned and actual costs incurred, which is the fundamental procedure in cost control methods.

4.6. SUMMARY

The method of study adopted in this research, has been discussed - study of existing literature, visiting of construction companies, and preparation and completion of questionaires. The safe zone method is developed for planning and control of overhead costs. Mathematical models, based on the technique of Multiple Regression Analysis, for determining overhead costs of construction projects, both at the tender and construction stages of projects are also discussed.

CHAPTER FIVE

EMPIRICAL EVALUATION AND ANALYSIS OF RESULTS

5.I INTRODUCTION

The statistical technique of Multiple Regression Analysis is used in determing the model equations for the overhead costs of projects after eliminating certain independent variables. This is based on the assumption that there is a linear relation between the dependent variable and the set of independent variables, and that the effects of the independent variables on the dependent variable are additive. For each of the three models developed, it is assumed that the independent variables are linearly related to the dependent variable. In each case, the output of the analysis is studied to select the optimum model equation.

The constants of the safe zone equations are determined. Adjustments are also made in the number of cost centres for the head office and site overhead costs.

5.2. ELIMINATION OF CERTAIN VARIABLES

The variables outlined in 4.4.1.1/2/3and the ways by which these could be determined were discussed with personnel in the companies visited. After discussing the importance and the practical application of these variables, the author decided to remove some of the variables from the regression equations. The variables removed from the regression and the reasons for removing these variables are outlined below.

Although the variables removed from the regression could have significant effects on the overhead costs, the author decided not to include them in the regression because of difficulties in obtaining data for these variables. Another factor also taken into consideration is the difficulty which could be encountered during the practical applications of the developed models.

5.2.1. THE PLANNED CAPITAL OUTLAY

The removal of this variable from the regression equations was decided upon by the author on the grounds that many construction companies in Sierra Leone (data were collected in Sierra Leone) do not pay greater attention to the planned capital outlay of either projects or of the company as a whole. Some of the companies visited planned their work so that the planned capital outlay required is small and the effects on the overhead costs minimal. On the other hand, four of the companies refused to undertake projects requiring large capital outlay. The author observed that in Sierra Leone, payments are made by clients to construction companies for projects before work on the projects are commenced. This minimises cash-flow difficulties.

5.2.2 SUBCONTRACTORS

The value of work done by subcontractors was one of the independent variables selected for the regression analysis. This was included in the second questionnaire. The thirteen companies in the study which took part in completing the questionnaires did not engage the services of subcontractors as is done in the United Kingdom and other European countries. It was observed from the questionnaires completed and from discussions (with personnel at head offices of these companies and at construction project sites) that construction companies in Sierra Leone, in most cases, provided all the services for projects undertaken. In cases where subcontractors were commissioned on projects, there were few operatives employed for a short period, with the main construction company providing labour, plant and material. The value of work done by subcontractors in these cases amounted to only 2 per cent of the direct costs of projects.

This factor was therefore not included in the regression analysis for developing the models. It must, however, be emphasised that this is not a general pattern and the reasons given above could be attributed only to the environment in which the data werecollected. Perhaps a different situation could have been observed had the data been collected in another area. This could be considered as a limitation of the models developed.

5.3 SOLVING OF REGRESSION EQUATIONS

After having removed the variables which were considered to have less significant effects on the dependent variables or which are considered to have practical difficulties in obtaining and using them in the models, the regression equations were rearranged with the remaining variables in the order in which they are entered into the equations.

5.3.1 REGRESSION EQUATION FOR THE HEAD OFFICE OVERHEAD COSTS APPORTIONED TO THE Kth PROJECT AT THE TENDER STAGE OF PROJECTS.

The dependent variable is C_{1ko}. The independent or predictor variables selected are:

(1) The direct costs of the project, called the variable X_1.

(2) The duration of the project in months. This is called X_2.

(3) The inflation variable called the variable X_3.

(4) The type of project variable, X_4.

The regression equation for the dependent variable C_{1ko} now becomes

$$C_{1ko} = A_0+A_1X_1+A_2X_2+A_3X_3+A_4X_4 \qquad \text{eqn(5.3a)}$$

5.3.2 REGRESSION EQUATION FOR THE HEAD OFFICE OVERHEAD COSTS APPORTIONED TO THE Kth PROJECT DURING THE CONSTRUCTION STAGE.

The dependent variable here is $\frac{C_{1ki}}{C_{1i}}$, the proportion of the head office overhead costs incurred which is apportioned to a project, the Kth project. The independent variables selected for the regression equation are

(1) The ratio of Direct costs of project/Turnover of the company for the period for which apportionment is made. This is called variable U_1.

(2) The ratio of Duration of project for which apportionment is made/The planning period of the company, called variable U_2.

(3) The number of projects undertaken within the period for which the apportionment is made. This is the variable U_3.

(4) Inflation variable U_4.

(5) Type of project, variable U_5.

The regression equation now becomes

$$\frac{C_{1ki}}{C_{1i}} = B_0+B_1U_1+B_2U_2+B_3U_3+B_4U_4+B_5U_5 \qquad \text{eqn}(5.3'b)$$

5.3.3 REGRESSION EQUATION FOR THE SITE OVERHEAD COSTS OF THE Kth PROJECT.

The dependent variable is C_{2k} and the independent variables are:

(1) The direct costs of the project referred to as variable V_1.

(2) The duration of the project, called variable V_2.

(3) The inflation variable V_3.

(4) The type of project variable called V_4.

The regression equations now becomes:

$$C_{2k} = D_0 + D_1 V_1 + D_2 V_2 + D_3 V_3 + D_4 V_4 \qquad \text{eqn}(5.3c)$$

5.4. MULTIPLE REGRESSION ANALYSIS

5.4.1. SPSS 7600 COMPUTER PROGRAM

The data sets used to solve the regression equations for the head office overhead costs apportioned at the tender stage; the head office overhead costs apportioned during construction; and the site overhead costs of the Kth project are given in Appendix (D). In these tables the letters A to K refer to the companies and P the project number. For example, AP1 refers to project one of Company A. Attempts were first made to solve the regression equations using the regression program in Fortran IV on the Honeywell system at The City University Computer Centre but these proved to be inadequate for the data set for the three cases.

The SPSS 7600 programme on regression was used at the University of London Computer Centre. This sub-program performed four different types of regression analysis on different combinations of the independent variables. These are: the forward (stepwise) inclusion, the stepwise solution, the backward elimination methods and ordinary regression.

5.4.1.1 THE FORWARD (STEPWISE) INCLUSION

In this method the independent variables are selected and entered into the regression equations one at a time. Their inclusion into the regression has to meet certain statistical criteria. These criteria are based on the F-test. Once an independent variable has entered the regression it is no longer removed.

5.4.1.2 THE STEPWISE SOLUTION

Here the forward inclusion method is combined with the removal of independent variables which no longer meet the set statistical criteria.

5.4.1.3 THE BACKWARD ELIMINATION

In this sub-program all the independent variables are entered into the regression equations at the same time. The independent variables which fail to meet the statistical criteria are removed from the regression equations. Independent variables removed may be entered at later stages if they meet the criteria set.

5.4.1.4 ORDINARY REGRESSION

In this sub-program all the variables are entered into the regression equation without eliminating any variable even if it fails to meet the statistical criteria.

The outlined master program which incorporated the SPSS 7600 sub-program is given in Appendix G1

5.4.2. DEVELOPED MODELS

Regression analyses were performed in each case on the dependent variable with each of the independent variables. This was done to examine the singular effect of each of the independent variables on the dependent variable.

In the second round of regression analysis, two independent variables were entered in each case into the regression equation. The independent variables taken in different steps for the head office overhead costs apportioned at the tender stage are:

(a) X_1 X_2
(b) X_1 X_3
(c) X_1 X_4
(d) X_2 X_3
(e) X_2 X_4
(f) X_3 X_4

For the head office overhead costs apportioned during the construction stage:

(a) U_1 U_2
(b) U_1 U_3
(c) U_1 U_4
(d) U_1 U_5
(e) U_2 U_3
(f) U_2 U_4
(g) U_2 U_5
(h) U_3 U_4
(i) U_3 U_5
(j) U_4 U_5

For the site overhead costs:

(a) V_1 V_2
(b) V_1 V_3
(c) V_1 V_4
(d) V_2 V_3
(e) V_2 V_4
(f) V_3 V_4

The third stage of regression analysis was performed using three independent variables in each case. For the head office overhead costs apportioned at the tender stage, the variables entered are:

(a) X_1 X_2 X_3
(b) X_1 X_2 X_4
(c) X_1 X_3 X_4
(d) X_2 X_3 X_4

For the head office overhead cost apportioned during the construction stage:

(a) U_1 U_2 U_3
(b) U_1 U_2 U_4
(c) U_1 U_2 U_5
(d) U_1 U_3 U_4
(e) U_1 U_3 U_5
(f) U_1 U_4 U_5
(g) U_2 U_3 U_4
(h) U_2 U_4 U_5
(i) U_3 U_4 U_5
(j) U_3 U_2 U_4

For the site overhead costs of project:

(a) V_1 V_2 V_3
(b) V_1 V_2 V_4
(c) V_1 V_3 V_4
(d) V_2 V_3 V_4

In the fourth round of regression analysis, four independent variables were entered into the regression equations in each case. These are:

For the head office overhead costs apportioned at the tender stage

(a) X_1 X_2 X_3 X_4

For the head office overhead costs apportioned during the construction stage:

(a) U_1 U_2 U_3 U_4
(b) U_1 U_2 U_3 U_5
(c) U_1 U_2 U_4 U_5
(d) U_2 U_3 U_4 U_5
(e) U_1 U_3 U_4 U_5

For the site overhead costs:

(a) V_1 V_2 V_3 V_4

In the fifth round of regression analysis, all the independent variables for the head office overhead costs apportioned during the construction stage were entered into the regression equation

(a) U_1 U_2 U_3 U_4 U_5

A general regression analysis was first performed in each case, allowing all the independent variables to remain in the regression equations. The variables were then entered in a specified order and the independent variables either remained in the regression or were removed, depending on the determined F values obtained. The F values set for these regression analyses are 0.01 for entering the regression and 0.005 for removal from the regression. These are the default values in the SPSS sub-program used. A variable is rejected if the F value calculated is less than 0.005 and entered if the F value is greater than 0.01. This low F values were chosen at the beginning of the regression analysis so as to allow most of the independent variables to enter and remain in the regression.

Coefficient or correlation matrices were determined for:

(a) The head office overhead costs apportioned at the tender stage and its independent variables. See Table (5.4a)

(b) The head office overhead costs apportioned during the construction stage. See Table (5.4b)

(c) The site overhead costs. See Table (5.4c)

This was done so as to examine the relations between a dependent variable and its independent variables, and also between independent variables. The effects of scrupulous correlation can also be detected from analysing the correlation coefficient matrices. The following parameters were also calculated for each regression analysis performed:

Coefficient of multiple correlations
Standard deviations
Variances due to regression and residuals
Coefficient of variability
Sum of squares
Standard error of estimates
Coefficient of determinations
F values
Regression constants

After the model has been developed in each case of the regression analysis, the data used to develop the model and extrapolated data were used to determine the dependent variable. The residuals were calculated and the standard error of estimate plotted against the mean.

The statistical parameters calculated, the determined model equation and the graphical plots of the dependent variable and residuals for each combination of variables entered into the regression equation are given in Appendix E.

5.4.2.1 HEAD OFFICE OVERHEAD COSTS APPORTIONED TO THE Kth PROJECT AT THE TENDER STAGE

A table of correlation coefficients for this dependent variable is given below.

C_{1ko}	-				
X_1	.9945				
X_2	.81991	0.84008	-		
X_3	.02757	0.02547	0.06248	-	
X_4	-067611	-0.67582	-.40431	-.07539	-
	C_{1ko}	X_1	X_2	X_3	X_4

Table (5.4a) Correlation coefficient for C_{1ko}.

The entry of the costs of project variables X_1 into the regression equation yielded a multiple correlation coefficient of 0.99455 and an F-value of 4094.9085. This shows that there is a good relation between the dependent variable and the independent variable. For the degrees of freedom of the variances, this F-value is greater than the standard F-value of 3.841 at 0.05 probability level and 6.635 at 0.01 probability level (see appendix (F)). This implies that there is less than 5 per cent to 1 per cent chance of a non-significant regression having F-value greater than 3.841 and 6.635. Thus the regression is significant at both the 0.05 and 0.01 probability levels. The coefficient of determination yielded is 0.98913. This gives the absolute amount of variation in the dependent variable that can be explained by the inclusion of the independent variable into the regression equation. The 0.9813 coefficient of determination indicates that 98.13 per cent of the variation in the dependent variable is accounted for by the regression equation. The standard deviation from the regression analysis is 23248.97799 and a coefficient of variability 11.5 per cent.

On adding, the second independent variable (i.e. the planned duration of the project, X_2) increased the multiple correlation coefficient to 0.99497, the coefficient of determination to 98.91 per cent and reduced the standard deviation to 23572.9200 and the coefficient of variability to 11.2 per cent.

The addition of the third independent variable, the inflation variable X_3, increased the multiple coefficient to 0.99498; the coefficient of determination to

98.99 per cent, increased the standard deviation to 23822.1158 and the coefficient of variability to 11.3 per cent.

The last independent variable to be entered into the regression equation was the type of project variable X_4. The multiple correlation coefficient increased to 0.995, the coefficient of determination to 99.03 per cent, the standard deviation to 24035.1207 and the coefficient of variability to 11.4 per cent.

It can be seen that the inclusion of variable X_3 made very little improvement to the accuracy of the model. This variable merely increased the multiple correlation coefficient by 0.0001 and the coefficient of determination by 0.0002 per cent. The single correlation coefficient matrix in Table (5.4a) also indicates that there is a poor correlation (0.02757) between this variable and the dependent variable. It was concluded that this variable would only introduce noise into the regression. The inflation variable was therefore removed from the regression.

The variables remaining in the model were X_1 X_2 and X_4. High correlations of 0.9945, 0.81991 and -0.67611 were yielded with the dependent variable. The inclusion of variable X_4 is not on grounds of accuracy alone, but as a dummy variable it will indicate the type of project to which the model is applied.

The final model equation for C_{1ko} is:

$$C_{1ko} = 834.25306+0.07334699(X_1)-1542.9251(X_2)+5411.8901(X_4)$$

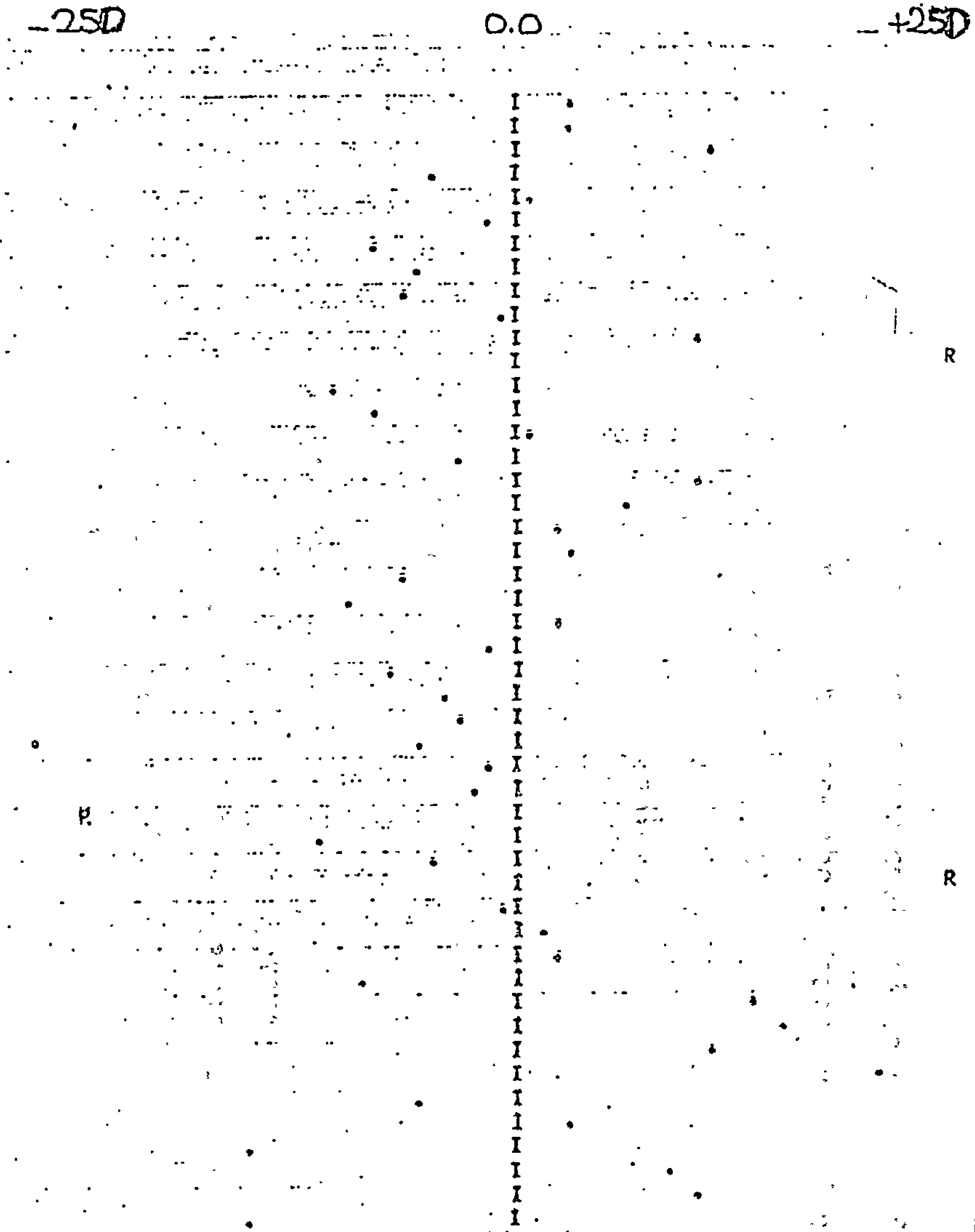
eqn.(5.4a)

where

C_{1ko}, X_1, X_2 and X_4 have their usual meanings.

The plot of the residuals about the mean is given in Fig.(5.4a). This showed only three out of forty-eight observations outside the $2 \times \sigma$ range. This indicates a good fit.

Observation	Ciko Value	Ciko Estimate	Residual
1.	106126.0	100562.0	5563.963
2.	62049.00	55784.87	6264.131
3.	106624.0	85950.42	20673.58
4.	46078.00	55445.91	-9367.913
5.	187504.0	186642.1	861.8549
6.	35886.00	38192.94	-2306.938
7.	110079.0	125125.3	-15046.35
8.	53493.00	63400.99	-9907.985
9.	145983.0	157144.2	-11161.18
10.	84584.00	85450.27	-866.2727
11.	202575.0	182358.5	20216.46
12.	271694.0	219313.3	52380.67
13.	137931.0	158030.1	-20099.06
14.	59971.00	75407.88	-15436.88
15.	88622.00	87652.14	969.8617
16.	38127.00	43646.43	-5519.429
17.	106797.0	87255.20	19541.80
18.	103892.0	91210.81	12681.19
19.	172530.0	168828.1	3701.945
20.	51787.00	46362.99	5424.010
21.	64357.00	76371.52	-12014.52
22.	202903.0	220878.6	-17975.63
23.	68325.00	64019.89	4305.109
24.	59274.00	61240.40	-1966.398
25.	95275.00	109307.3	-14032.26
26.	67431.00	74032.20	-6601.196
27.	45642.00	51109.27	-5467.274
28.	57836.00	68356.52	-10520.52
29.	23208.00	26376.51	-3168.514
30.	14338.00	18652.41	-4314.413
31.	486328.0	577168.3	-90840.27
32.	164800.0	186234.8	-21434.83
33.	405156.0	413209.2	-8053.227
34.	305789.0	253313.5	52475.48
35.	71126.00	71507.88	-381.8790
36.	123317.0	121317.6	1999.380
37.	264585.0	261018.7	3566.295
38.	174483.0	191781.1	-17298.12
39.	710086.0	683331.4	26754.58
40.	530880.0	501891.1	28988.88
41.	205587.0	184139.8	21447.25
42.	933960.0	894273.2	39686.80
43.	1006398.	1017259.	-10860.79
44.	186395.0	181559.0	4836.030
45.	200526.0	230355.0	-29828.96
46.	453443.0	436105.0	17337.96
47.	151536.0	131974.1	19561.95
48.	700700.0	729782.8	-29082.81



NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
R INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED 47.
NUMBER OF 2 S.D. OUTLIERS 3. OR 6.38 PERCENT OF THE TOTAL

DETERMINATION ON OF HEAD OFFICE OVERHEAD COST TO DC 05/06/81 17.00.08. PAGE 59

Figure (5.4a) Regression Analysis For Ciko with $X_1 X_2$ and X_4

5.4.2.2. HEAD OFFICE OVERHEAD COSTS APPORTIONED TO THE Kth PROJECT DURING THE CONSTRUCTION STAGE

A table of correlation coefficient matrix of the dependent variable and the independent variables is given below in Table (5.4b).

Table (5.4b)

$\frac{C_{1ki}}{C_{1i}}$	-					
U_1	.74895	-				
U_2	.66710	.18649	-			
U_3	-.51506	-.58400	-.12536	-		
U_4	-.01234	-.09081	.01284	.01758	-	
U_5	-.19443	-.61561	-.17146	.35013	-.00328	-
	$\frac{C_{1ki}}{C_{1i}}$	U_1	U_2	U_3	U_4	U_5

From the correlation matrix Table (5.4b) it can be seen that both the inflation variable U_4 and the type of project variable U_5 showed poor correlation with the dependent variable; -0.01234 for variable U_4 and -0.19443 for variable U_5.

These variables made little improvement to the accuracy of the model. The addition of both variables only increased the multiple correlation coefficient by 0.00038 and the coefficient of determination by 0.16 per cent. There is a 0.1 per cent increase in the coefficient of variability as opposed to an expected decrease. These variables were therefore removed from the regression equation.

The remaining variables in the regression equation U_1, U_2 and U_3 all showed high correlation with the dependent variable; 0.74895 for U_1, 0.66710 for U_2 and -0.51506 for U_3. The final model equation is:

$$\frac{C_{1ki}}{C_{1i}} = -0.06715239+0.42492474(U_1)+0.17638210(U_2) -0.0038698389(U_3) \qquad \text{eqn(5.4b)}$$

The derived value from the model is multiplied by the head office overhead costs incurred for the period for which the apportionment is made to determine the actual costs to be apportioned. That is

$$C_{1ki} = (Z)C_{1i}$$

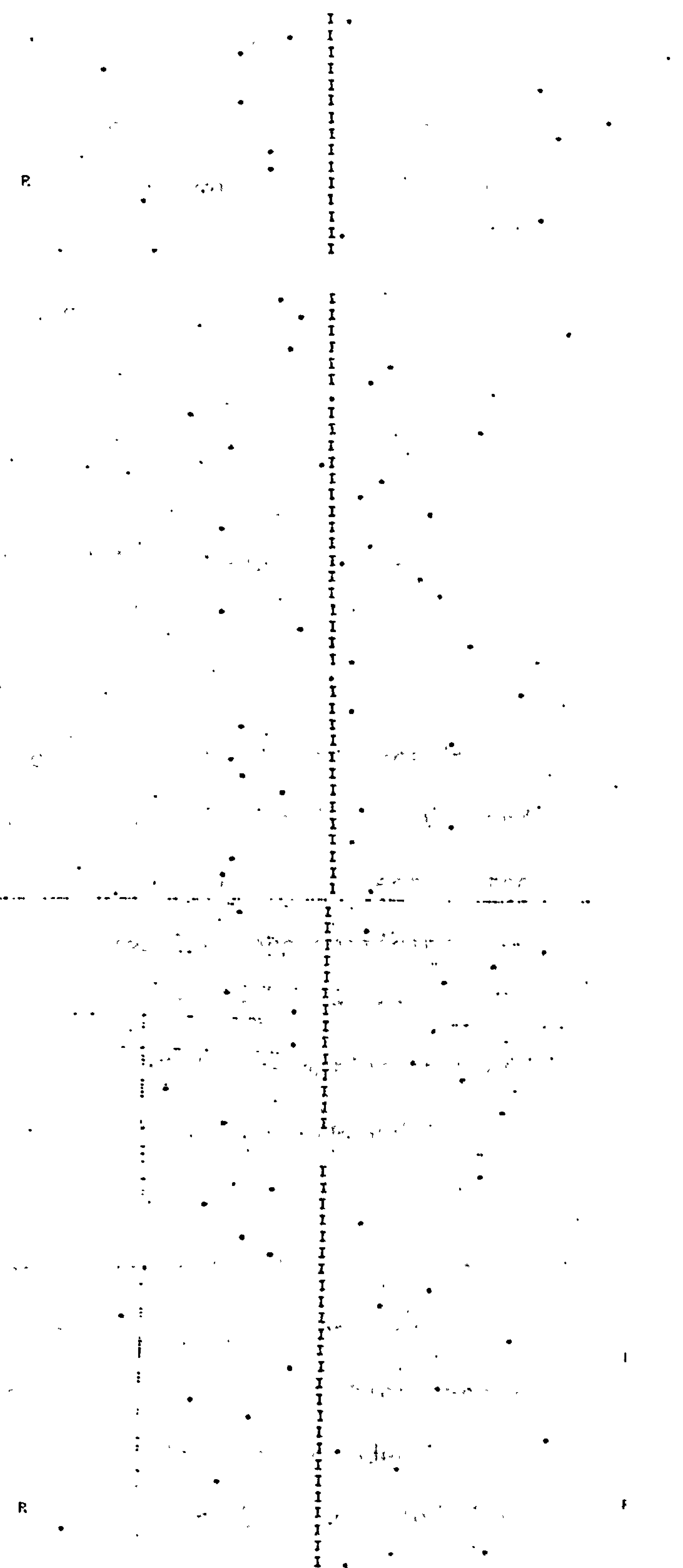
where

Z is the value obtained from the model.

The minus sign of the constant, B_3, of variable U_3, shows that as the number of projects for which apportionments are made increases, the proportion of the head office overhead costs apportioned to each project, in this case the Kth project, decreases. The coefficient of variability observed for the three variables left in the model is 25.8 per cent. This implies that the results which can be obtained from the application of this model are subject to 25.8 per cent variation. This is a high variability as compared with the variability of 11.8 per cent for the C_{1ko} model. However, analysis of the residuals from the regression runs showed that only 4 out of 93 cases fell outside the $2x\sigma$ range. (see Fig.5.4b)

Observation	$\frac{C_{ki}}{C_{ji}}$ Value	$\frac{C_{ki}}{C_{ji}}$ Estimate	Residual
1.	.2653150	.2608914	.4423561E-02
2.	.1965300	.2055570	-.9027830E-02
3.	.7231800E-01	.9185879E-01	-.1954079E-01
4.	.9996000E-01	.1514785	-.5151859E-01
5.	.3208590	.2733131	.4754595E-01
6.	.8228200E-01	.1006862	-.1840416E-01
7.	.2893590	.2267327	.6262626E-01
8.	.3590210	.3085874	.5043365E-01
9.	.1254620	.1383473	-.1288526E-01
10.	.1474270	.1598496	-.1242263E-01
11.	.1376000	.2166822	-.7908220E-01
12.	.1440890	.1865907	-.4250172E-01
13.	.3828220	.3369478	.4587415E-01
14.	.1283860	.1266898	.1696210E-02
15.	.6343500E-01	.1028508	-.3941577E-01
16.	.9864600E-01	.1092173	-.1057126E-01
17.	.1397750	.1456748	-.5899797E-02
18.	.1426000E-01	-.3809487E-01	.5235487E-01
19.	.1227060	.1313547	-.8648749E-02
20.	.1481340	.1354416	.1269243E-01
21.	.7147800E-01	.6321782E-01	.8260182E-02
22.	.5037500E-01	.5031509E-01	.5990745E-04
23.	.1180140	.1492482	-.3123420E-01
24.	.6473000E-02	-.2685243E-01	.3332543E-01
25.	.6754400E-01	.8855796E-01	-.2101396E-01
26.	.1332290	.1341913	-.9623181E-03
27.	.5051000E-01	.4015205E-01	.1035795E-01
28.	.9021300E-01	.8559580E-01	.4617115E-02
29.	.4013800E-01	.1967467E-01	.2046333E-01
30.	.1171390	.1406887	-.2354973E-01
31.	.1041000	.9564667E-01	.8453333E-02
32.	.1204220	.1194412	.9808485E-03
33.	.6052300E-01	.4088544E-01	.1963756E-01
34.	.2947740	.2705058	.2426816E-01
35.	.9616900E-01	.1208679	-.2469892E-01
36.	.1976390	.2028099	-.5170909E-02
37.	.1929300	.1625848	.3034515E-01
38.	.4857500E-01	.4598354E-01	.2591455E-02
39.	.1013650	.1014126	-.4756297E-04
40.	.2714920	.2305920	.4090002E-01
41.	.3533600E-01	.3174458E-01	.3591418E-02
42.	.1552940	.1743773	-.1908328E-01
43.	.2397000E-01	-.1610500E-02	.2558050E-01
44.	.1167110	.1376259	-.2091485E-01
45.	.9028400E-01	.1089609	-.1867693E-01
46.	.1144050	.1250247	-.1061965E-01
47.	.4655700E-01	.4034829E-01	.6208714E-02
48.	.2836200E-01	.2204000E-02	.2615000E-01
49.	.4167900E-01	.3715241E-01	.4526593E-02
50.	.1494630	.1708402	-.2137716E-01
51.	.1459520	.1701091	-.2415711E-01
52.	.5421600E-01	.4661658E-01	.7599424E-02
53.	.1324540	.1525265	-.2007249E-01
54.	.8140900E-01	.7349500E-01	.7913921E-02
55.	.2322080	.1844076	.4780041E-01
56.	.1981170	.1611229	.3699415E-01
57.	.6144300E-01	.3589523E-01	.2554777E-01
58.	.4876500E-01	.7102837E-01	-.2226337E-01
59.	.9426800E-01	.1003619	-.6093896E-02
60.	.3239300E-01	.9153134E-02	.2323987E-01
61.	.1469330	.1530127	-.6079695E-02
62.	.3797400E-01	.1920035E-01	.1877365E-01
63.	.1884100E-01	-.1268401E-01	.3152581E-01
64.	.9933900E-01	.1335282	-.3419319E-01
65.	.2223100E-01	-.1785494E-01	.4008594E-01
66.	.1847380	.2059524	-.2121438E-01
67.	.3470010	.3113325	.3574847E-01
68.	.4755000E-01	.5865953E-01	-.1110953E-01
69.	.8632300E-01	.1114243	-.2510131E-01
70.	.2594870	.2519325	.7554524E-02
71.	.8807300E-01	.1050039	-.1692895E-01
72.	.1496700	.1600796	-.1040957E-01
73.	.7608500E-01	.1153941	-.3929910E-01
74.	.2953350	.2718742	.2346079E-01
75.	.2681600	.2549504	.1320959E-01
76.	.9131800E-01	.1373737	-.4605563E-01
77.	.3477120	.3061753	.4153669E-01
78.	.3533040	.2208594	.1324446
79.	.1355080	.1421119	-.6603911E-02
80.	.1653110	.1382169	.2709413E-01
81.	.2078460	.2351102	-.2726425E-01
82.	.1697210	.1838007	-.1407967E-01
83.	.2192290	.1674579	.5177114E-01
84.	.3052700E-01	.2727560E-01	.3251402E-02
85.	.1088210	.9268972E-01	.1613128E-01
86.	.1815700	.2040088	-.2243879E-01
87.	.3107200	.2100086	.1007114
88.	.1266100E-01	.1557844	-.1431234
89.	.1281570	.1885650	-.6040790E-01
90.	.2456000	.2074182	.3818185E-01
91.	.2122700E-01	.1449576E-01	.6731238E-02

_2SD 0.0 +2SD



NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
R INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED 87.
NUMBER OF 2 S.D. OUTLIERS 3. OR 3.45 PERCENT OF THE TOTAL

VON NEUMANN RATIO 2.52894 DURBIN-WATSON TEST 2.49987

NUMBER OF POSITIVE RESIDUALS 44.
NUMBER OF NEGATIVE RESIDUALS 43.
NUMBER OF RUNS OF SIGNS 49.

Figure. (5.4b) Regression Analysis for $\frac{C_{lki}}{C_{11}}$ with u_1 u_2 and u_3

5.4.2.3. SITE OVERHEAD COSTS OF THE Kth PROJECT

A table of correlation coefficients of the site overhead costs and its independent variables is given below:

Table(5.4.c)

C_{2ko}	-				
V_1	0.99038	-			
V_2	0.79555	0.80089	-		
V_3	0.12492	0.15459	.15509	-	
V_4	-0.71568	-0.08588	-0.49804	-0.13924	-
	C_{2ko}	V_1	V_2	V_3	V_4

Examination of Table (5.4c) shows that there is a poor correlation between the inflation variable V_3 and the dependent variable, 0. 12492. The improvement in the other parameters calculated are also nonsignificant. The coefficient of multiple correlation increased by only 0.00044, the coefficient of determination increased by 0.083 per cent and the variability increased by 0.4 per cent.

The duration of project variable V_2 also made little significant improvement to the accuracy of the regression equation. Although it yielded a high correlation coefficient of 0.79555 with the dependent variable, the inclusion of this variable increased the multiple correlation coefficient by only 0.0001, the coefficient of determination by 0.0001 per cent. The coefficient of variability in fact increased to 17.5

per cent and the standard deviation decreased to 37635.44065. On further examination of the correlation matrix of table(5.4c), the duration project variable yielded a higher correlation coefficient of 0.80089 with the cost of project variable V_2 than the correlation of 0.795555 yielded with the dependent variable. This indidcated scrupulous correlation between variables V_2 and V_1. Hence the poor contribution to the regression equation by variable V_2.

Because of the poor contributions made by variables V_2 and V_3 to improving the accuracy of the model, these variables were removed from the regression equation. Regression analysis was performed with the remaining variables V_1 and V_4. The coefficient of variability was reduced from 17.5 per cent for V_1 to 16.5 per cent for both V_1 and V_4. The final model equation for the site overhead costs is therefore

$$C_{2ko} = 53905.181+0.085086193(V_1)-41620.820(V_4) \qquad \text{eqn}(5.4c)$$

Examination of the residuals of 78 observations (see page 141) showed that there are 5 out of 78 which fell outside the $2x\sigma$ range. The multiple correlation for the final model equation is 0.99158 and the coefficient of determination is 98.273 per cent.

Observation	C_2ko Value	C_2ko Estimate	Residual
1.	111342.0	109594.1	1747.929
2.	52268.9	54070.57	-1802.563
3.	83119.00	78324.30	4794.105
4.	50867.00	37568.52	13298.49
5.	213492.0	214820.9	-1328.932
6.	33938.00	15164.73	18819.27
7.	128905.0	129139.2	-234.2208
8.	54721.00	50376.55	4344.452
9.	150447.0	171652.5	-21205.45
10.	76918.00	83114.31	-6196.312
11.	209134.0	213431.5	-4297.475
12.	234840.0	267040.1	-32200.12
13.	189779.0	176251.4	13518.64
14.	63700.00	55355.79	8344.208
15.	76648.00	76719.23	-71.23397
16.	34076.00	18510.92	15565.08
17.	85525.00	85208.11	316.887
18.	109450.0	95166.43	14283.57
19.	155477.0	183416.5	-27939.47
20.	55434.00	28821.75	26612.25
21.	53110.00	54347.52	-1237.521
22.	28795.00	12402.58	16392.42
23.	97475.00	134572.3	-37097.31
24.	16077.00	-26779.61	42856.61
25.	144234.0	154648.8	-10414.85
26.	94895.00	86671.09	8223.915
27.	174820.0	199155.7	-24335.71
28.	94979.40	92557.01	2422.392
29.	28120.00	11559.87	16560.13
30.	138400.0	156375.2	-17975.23
31.	58230.00	44223.37	14006.63
32.	33244.00	11957.58	21286.42
33.	117414.0	113996.3	3417.654
34.	65367.00	50666.78	14700.22
35.	85957.00	84931.29	1025.703
36.	50076.00	35319.10	14756.90
37.	59946.00	44542.03	15403.97
38.	42200.00	25315.25	16884.75
39.	84276.00	75374.87	8901.129
40.	63356.00	54624.48	8731.517
41.	88723.00	63633.15	25089.85
42.	232160.0	265276.2	-33116.19
43.	61216.00	54674.25	6541.749
44.	53736.00	44290.42	9445.582
45.	107712.0	108999.7	-1287.746
46.	74456.00	66289.03	8166.972
47.	49160.00	34327.68	14832.32
48.	54035.00	52545.48	1489.52
49.	[illegible]	[illegible]	[illegible]
50.	11290.00	-12273.27	23563.27
51.	816932.0	740907.9	76024.07
52.	179278.0	194659.8	-15381.86
53.	404464.0	468700.8	-64236.78
54.	251643.0	281423.9	-29780.45
55.	60349.00	57991.08	2357.919
56.	129179.0	165561.6	-36382.64
57.	252610.0	299311.6	-46701.61
58.	196740.0	213622.9	-16882.92
59.	859996.0	851433.3	8562.664
60.	639986.0	630729.7	8875.341
61.	220965.0	236639.2	-15674.24
62.	1492140.	1506820.	-14680.33
63.	681430.0	542754.2	138675.8
64.	1247990.	1251335.	-3345.892
65.	182460.0	235344.6	-52884.63
66.	246690.0	290161.1	-43471.07
67.	474518.0	555689.0	-81171.04
68.	138735.0	172454.0	-33719.02
69.	929760.0	916395.9	13364.12
70.	512376.0	583323.4	-71252.44
71.	122111.0	147588.4	-25477.43
72.	288922.0	278050.2	10871.74
73.	766324.0	638639.9	127684.1

NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
R INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED 70.
NUMBER OF 2 S.D. OUTLIERS 5. OR 7.14 PERCENT OF THE TOTAL

VON NEUMANN RATIO 1.58257 DURBIN-WATSON TEST 1.55996

NUMBER OF POSITIVE RESIDUALS 39.
NUMBER OF NEGATIVE RESIDUALS 31.
NUMBER OF RUNS OF SIGNS 35.

Figure (5.4c) Regression Analysis for Coko with V_1 and V_4

5.5. DETERMINED SAFE ZONES

The safe zones for the head office overhead costs and the head office overhead costs components were developed using equations (4.5a) to (4.5x) and appendice figures (Dla) to (Dlm). For the site overhead costs and the site overhead cost components, equations (4.5.la) to (4.5lt) and appendice figures (D2a) to (D2k) were used. In each case two point values are taken from the graphs to determine the constant values in the equations.

The scatter of the plots for the site test costs made it impossible to define safe zones for this cost component.

The constant values determined are given below.

Constants

Head office overhead costs

$H_a = 0.09804$	$J_a = 860000$
$H_b = 0.11111$	$J_b = 200000$

Head office overhead cost components

$H_c = 0.3125$	$J_c = 40000$
$H_d = 0.3214$	$J_d = -3351$
$H_e = 0.2550$	$J_e = 21568$
$H_f = 0.2703$	$J_f = -2500$
$H_g = 0.1111$	$J_g = 30000$
$H_h = 0.1250$	$J_h = -20ooo$
$H_i = 0.1543$	$J_i = 38000$
$H_j = 0.1750$	$J_j = -14287$
$H_k = 0.0400$	$J_k = 50000$
$H_L = 0.0410$	$J_L = -19767$
$H_m = 0.00421$	$J_m = 65000$
$H_n = 0.00567$	$J_n = 8823$
$H_o = 0.0105$	$J_o = 42857$
$H_p = 0.0107$	$J_p = -31250$
$H_q = 0.0293$	$J_q = 49412$
$H_r = 0.0300$	$J_r = -13333$
$H_s = 0.0016$	$J_s = 375000$
$H_t = 0.00457$	$J_t = 212500$
$H_u = 0.0400$	$J_u = 00000$
$H_v = 0.05330$	$J_v = -25000$
$H_w = 0.0222$	$J_w = 30000$
$H_x = 0.02674$	$J_x = 30870$

SITE OVERHEAD COSTS

K_a = 0.08333	L_a = 8000000
K_b = 0.08666	L_b = 766000

Site overhead cost components:

K_c = 0.1984	L_c = 88000
K_d = 0.2222	L_d = 5000
K_e = 0.0200	L_e = 30000
K_f = 0.02553	L_f = −17500
K_g = 0.4524	L_g = 27900
K_h = 0.4857	L_h = − 4712
K_i = 0.01636	L_i = 16667
K_j = 0.01875	L_j = -50000
K_k = 0.2222	L_k = 25000
K_L = 0.2500	L_L = -40000
K_m = 0.0191	L_m = 92500
K_n = 0.0204	L_n = -16363
K_o = 0.02239	L_o = 20000
K_p = 0.3429	L_p = −16667
K_s = 0.0268	L_q = 10812
K_t = 0.03158	L_r = -36667
K_u = 0.00769	L_s = 35000
K_v = 0.00865	L_t = -50000

Substituting the values of the constants into equations (4.5a) to (4.5x) for the head office overhead costs and the head office overhead cost components, and into equations (4.5.1a) to (4.5.1t) for the site overhead costs and the site overhead cost components give the safe zone equations.

SAFE ZONES

Head Office

Head Office Overhead Costs (HCOST)

HCOST.1 = 0.09804 (YTURN-860000) eqn(5.5.1a)

HCOST.2 = 0.11111 (YTURN-2000000) eqn(5.5.1b)

Head Office Senior Staff Cost (HSSCOST)

HSSCOST.1 = 0.3125 (HCOST-40000) eqn(5.5.1c)

HSSCOST.2 = 0.3214 (HCOST+3351) eqn(5.5.1d)

Head Office Other Staff Cost (HSCOST)

HSCOST.1 = 0.2550(HCOST-21568) eqn(5.5.1e)

HSCOST.2 = 0.2703 (HCOST+2500) eqn(5.5.1f)

Head Office Accommodation Cost (HACOST)

HACOST.1 = 0.1111 (HCOST-30000) eqn((5.5.1g)

HACOST.2 = 0.1250 (HCOST+20000) eqn(5.5.1h)

Head Office Transport Cost (HTCOST)

HTCOST.1 = 0.1543 (HCOST-38000) eqn(5.5.1i)

HTCOST.2 = 0.1750 (HCOST+14287) eqn(5.5.1j)

Head Office Communication Cost (HCCOST)

HCCOST.1 = 0.0400 (HCOST-50000) eqn(5.5.1k)

HCCOST.2 = 0.0410 (HCOST+19767) eqn(5.5.1l)

Head Office Marketing Cost (HMCOST)

HMCOST.1 = 0.00421 (HCOST-65000) eqn(5.5.1m)

HMCOST.2 = 0.00567 (HCOST-8823) eqn(5.5.1n)

Head Office Insurance Cost (HICOST)

HICOST.1 = 0.0293 (HCOST-49412) eqn(5.5.1o)

HICOST.2 = 0.0300 (HCOST+13333) eqn(5.5.1p)

Head Office Service Cost (HSECOST)

HSECOST.1 = 0.0105 (HCOST-42857) eqn(5.5.1q)

HSECOST.2 = 0.0107 (HCOST+31250) eqn(5.5.1r)

Head Office Research, Training & Dev. Cost (HRTCOST)

HRTCOST.1 = 0.0016 (HCOST-375000) eqn(5.5.1s)

HRTCOST.2 = 0.00457 (HCOST-212500) eqn(5.5.1t)

Head Office Finance Cost (HFCOST)

HFCOST.1 = 0.0400 (HCOST-0000) eqn(5.5.1u)

HFCOST.2 = 0.05330 (HCOST+25000) eqn(5.5.1v)

Head Office General and Unallocated Cost (HGCOST)

HGCOST.1 = 0.0222 (HCOST-30000) eqn(5.5.1w)

HGCOST.2 = 0.02674 (HCOST-30870) eqn(5.5.1x)

Site Overhead Costs (SCOST)

SCOST.1 = 0.08333 (PCOST-800000) eqn(5.5.2a)

SCOST.2 = 0.08666 (PCOST-76600) eqn(5.5.2b)

Site Staff Cost (SSCOST)

SSCOST.1 = 0.1984 (SCOST-88000) eqn(5.5.2c)

SSCOST.2 = 0.2222 (SCOST-5000) eqn(5.5.2d)

Site Accommodation Cost (SACOST)

SACOST.1 = 0.0200 (SCOST-30000) eqn(5.5.2e)

SACOST.2 = 0.02553 (SCOST+17500) eqn(5.5.2f)

Site Transport Cost (STCOST)

STCOST.1 = 0.4524 (SCOST-27900) eqn(5.5.2g)

STCOST.2 = 0.4857 (SCOST+4712) eqn(5.5.2h)

Site Communication Cost (SCCOST)

SCCOST.1	=	0.01636 (SCOST-16667)	eqn(5.5.2i)
SCCOST.2	=	0.01875 (SCOST+50000)	eqn(5.5.2j)

Site Insurance Cost (SICOST)

SICOST.1	=	0.2222 (SCOST-25000)	eqn(5.5.2k)
SICOST.2	=	0.2500 (SCOST+40000)	eqn(5.5.2l)

Site Service Cost (SSECOST)

SSECOST.1	=	0.0191 (SCOST-92500)	eqn(5.5.2m)
SSECOST.2	=	0.0204 (SCOST+16363)	eqn(5.5.2n)

Site Minus Plant Cost (SMPCOST)

SMPCOST.1	=	0.02239 (SCOST-20000)	eqn(5.5.2o)
SMPCOST.2	=	0.03429 (SCOST+16667)	eqn(5.5.2p)

Site Temporary Cost (STECOST)

STECOST.1	=	0.0268 (SCOST-10812)	eqn(5.5.2q)
STECOST.2	=	0.03158 (SCOST+36667)	eqn(5.5.2r)

Site General and Unallocated Cost (SGCOST)

SGCOST.1	=	0.00769 (SCOST-35000)	eqn(5.5.2s)
SGCOST.2	=	0.00865 (SCOST+50000)	eqn(5.5.2t)

Safe zone equations have been developed for the cost components of both the head office and site overhead costs except for the site-tests costs. Because of the scatter of the plots (See appendix D2i), it was not possible to define safe zone equations for this cost component.

As stated earlier, the cost items of the overhead costs were grouped into eleven cost components for the head office overhead costs and ten cost components for the site overhead costs, so as to include all possible overhead cost items. However, it was observed that some of the cost components accounted for minor percentages of the overhead costs. In the case of the head office overhead costs, the communication costs amounted to 3 to 4 per cent of the head office overhead costs, marketing costs about 0.2 to 1.2 per cent, service costs about 0.5 to 1.2 per cent, and research and development costs 0.1 to 0.35 per cent. It would not be economical for the purposes of cost planning and control of the overhead costs to have these as cost components. The four cost components mentioned above were therefore included in the general and unallocated costs. This reduced the cost components of the head office overhead costs to seven. New safe zone equations developed for the adjusted general and unallocated costs.

$$\text{HGCOST 1} = 0.07143\ (\text{HCOST P}-10000) \qquad \text{eqn(5.5.1y)}$$

$$\text{HGCOST 2} = 0.08333\ (\text{HCOST P}+7200) \qquad \text{eqn(5.5.1z)}$$

Similarly, for the site overhead costs, 4 cost components: site accommodation costs, site communication costs, site service costs and site tests costs were included in the general and unallocated costs, thereby reducing the site costs components from ten to six.

For the site general and unallocated costs, the adjusted equations are;

SGCOST 1 = 0.06035 (SCOST P-2287) eqn(5.5.2u)

SGCOST 2 = 0.07083 (SCOST P+22353) eqn(5.5.2v)

The computer programs for planning and control of the overhead costs and cost components (see appendices G2, G3 & G4) were developed for the original number of cost components. However, only minor adjustments to these programs and the input data are necessary for the programs to handle different numbers of cost components.

5.6. SUMMARY

The three model equations for the overhead costs of a construction project; the head office overhead costs apportioned at the tender stage; the head office overhead costs apportioned during the construction stage and site overhead costs are developed in this chapter.

The equations of the safe zones for the head office overhead costs of construction companies, the site overhead costs of projects and the cost components of these costs are determined in this chapter. The cost components of the head office overhead costs are reduced to seven and the site overhead costs to six.

CHAPTER SIX

CONCLUSIONS

The problems of overhead costs in the construction industry are diverse and far from being completely solved in this research work. Indeed many aspects of these costs are yet to be studied in depth as very little in the way of research has been done in this field in the past. The time scope within which this work has been carried out and the difficulties encountered by the author in the availability and collection of data made it impossible to undertake detailed study in all areas of overhead costs.

The author has however tried to focus attention on some of the important aspects of these costs in the construction industry and has proposed new methods of solutions to these problems which could be acceptable to some, mostly large and medium sized, companies in the industry.

6.1 SAFE ZONE METHOD

This work has been focused mainly on the planning and control of overhead costs; head office overhead costs of construction companies and site overhead costs of construction projects. This is essential as overhead costs can sometimes amount to 10 to 20 per cent of construction projects costs. There are however difficulties encountered in planning and controlling overhead costs and there are inadequacies in the present methods used in the industry as discussed in text of this thesis. As a result of this, the author decided that a new approach and a new method of overhead costs planning and control, which could be more accurate, practical and above all easy and economical to apply, is one that is needed in the industry.

The 'safe zone method' discussed and developed by the author in this work is an attempt to look at aspects of overhead costs from a different and new perspective. The safe zone method defines lower and upper bound limits within which costs should lie to be acceptable to management and cost planners. This is a new approach in that it is a deviation from traditional methods of cost planning and control which set standard values for comparing actual costs. Indeed as most cost planners are aware, these are hardly ever achieved in practice.

The safe zone method can be used to plan and control:

(1) The head office overhead costs and the head office overhead cost components of construction companies at the beginning and during planning periods.

(2) The site overhead costs and the site overhead cost components of construction projects at the tender and construction stages of projects.

For the head office overhead costs, two equations were developed (see page 146). Using the planned company turnover for a specific planning period, these equations can be used to determine the lower and upper bound values within which the planned head office overhead costs for the planning period should lie.

The head office overhead costs items were originally grouped into eleven cost components and safe zone equations developed for these cost components. Analysis of the data showed that four of these cost components: Communication costs, Marketing costs, Service costs and Research and Training costs, accounted for minor percentages of the head office overhead costs. These cost components were included in the General and unallocated costs, thereby reducing the head office overhead costs components to seven. These are:

Senior staff costs

Other staff costs

Head office accommodation costs

Head office transport costs

Head office insurance costs

Finance costs

General and unallocated costs

For each of these cost components two equations were developed for determining the lower and upper bound values within which a particular cost component should lie. The ratio of Elapsed planned time/Planning period is used as a scaling factor at subsequent cost examination stages to define sub-safe zones within which the actual costs at a cost examination stage should lie for control purposes.

Similar equations were developed for the site overhead costs and the site overhead costs components of construction projects. The site overhead cost items originally grouped into ten cost components were reduced to six because four of the cost components: Accommodation costs, Service costs, Communication costs and Tests costs, formed only minor percentages of the site overhead cost components. These four cost components were included in the General and unallocated costs and new safe zone equations developed for the General and unallocated costs. The remaining six cost components are:

Site staff costs

Site transport costs

Insurance costs

Minor plant costs

Temporary site costs

General and unallocated costs

At subsequent cost examination stages (during the construction stages of the project) the ratio of Elapsed duration of project/Planned duration of the project is used as a scaling factor on the determined safe zone limits to define sub-safe zones within which actual costs should lie.

The values of the constants in the safe zone equations for the overhead costs and the overhead cost components were determined from data obtained from companies that took part in discussions concerning this work and companies that completed the questionnaires. These companies differ in size and sometimes undertake different types of construction works. Some were found to be well organised and some not well organised. These could be considered as disadvantages, not of the safe zone method but of the constant values determined in this work. A company could determine constant values for the safe zone equations basing this on its own operations.

It must however be stressed that control techniques, in themselves, do not control costs. These techniques only indicate how costs are being incurred and what is likely to happen if corrective actions are not applied in time. The implementations of corrective actions are the responsibilities of management and cost planners. In order for the corrective actions to be effective, the personnel involved with the application of the control method and the corrective actions should be familiar with the system and its methods of working. Also, efficiency in cost control methods can best be achieved by:

(1) The person who has the authority and responsibility to incur the cost,

(2) The person who can influence cost by his own actions,

(3) The person who can reduce or cut down on the cost, and

(4) At the place of incurrence of the cost.

6.2 OVERHEAD COSTS MODELS

For a construction project, the Kth project, head office overhead costs are apportioned to the estimated direct costs of the project at the tender stage. Head office overhead costs are apportioned to the actual direct costs of the project (at cost examination stages) during the construction stage of the project. Site overhead costs are also incurred for the project. In order to determine the values of these costs, the statistical technique of multiple regression analysis has been used in this work to develop three mathematical models. The first of these models is to be applied at the tender stage to determine the head office overhead costs to be apportioned to the project. This model is:

$$C_{1ko} = 834.25306 + 0.07334699(X_1) - 1542.9251(X_2) + 5411.89010(X_4)$$

where

C_{1ko}	is the head office overhead costs to be apportioned to the Kth. project at the tender stage,
X_1	is the estimated direct costs of the project,
X_2	is the planned duration of the project,
X_4	is the type of project - Building = 2, Civil Engineering = 1.

The second model is for planning the site overhead costs of the Kth. project at the tender stage. The model is:

$$C_{2ko} = 53905.18100 + 0.08508619(V_1) - 41620.820(V_4)$$

where

C_{2ko}	is the site overhead costs of the project,
V_1	is the estimated direct costs of the project,
V_4	is the type of project - Building = 2, Civil Engineering = 1.

Since these are the two constituent parts of the overhead costs of the project, the summation of C_{1ko} and C_{2ko} gives the overhead costs of the project (k) at the tender stage.

$$C_k = C_{1ko} + C_{2ko}$$

The third model is for the head office overhead costs to be apportioned to the project during the construction stage. Here, the dependent variable is the proportion of the head office overhead costs incurred that is to be apportioned to the Kth. project. This model is:

$$\frac{C_{1ki}}{C_{1i}} = -\,0.06715239 + 0.42492474(U_1) + 0.17638210(U_2) - 0.003869839(U_3)$$

where

$\frac{C_{1ki}}{C_{1i}}$ is the proportion of head office overhead costs incurred for the ith month apportioned to the Kth. project,

U_1 is the ratio of Direct costs of project/ Turnover of the company for the ith month (or for the period for which apportionment is to be made if this is different from monthly intervals),

U_2 is the ratio of Duration of project for which apportionment is to be made/Planning period of the company,

U_3 is the number of projects undertaken in the period for which apportionment is to be made.

To determine the actual head office overhead costs to be apportioned, the value obtained from applying the third model is multiplied by the actual head office overhead costs incurred for the ith month. That is:

$$C_{1ki} = (Z)C_{1i}$$

where

Z is the value obtained from applying the model.

The accuracies of these models can fully be established through their practical applications on construction projects. This takes time and the time scope within which this study has been carried out did not permit this. However, if statistical inferences are anything to go by, the multiple correlation coefficients of 0.99500 for the first model, 0.99158 for the second model, and 0.92536 for the third, and coefficients of variability of 11.3 per cent for the first model, 16.5 per cent for the second, and 25.8 per cent for the third model are indications that acceptable levels of accuracies can be expected from the applications of these models to planning overhead costs of construction projects.

It cannot, however, be taken for granted that the technique of multiple regression analysis is without limitations. The method of collection of data and the independent variables used in the regression analysis can no doubt affect the accuracy of the model.

With regards to the models developed in this work, two factors discussed as independent variables were not included in the regression analysis in developing the models. These factors are the planned capital outlay and the value of work done by sub-contractors. The reasons stated for not including these factors in the regression analysis can be attributed only to the environment in which the data were collected. Maybe, it is possible that these variables would have been included in the analysis had the data been collected from another area or by some other means. Also, it has not been possible to establish the behaviour of these models when applied to multi-million pounds projects as it was not possible to collect data on these types of projects. All these factors could be considered as limitations of the models. The author hopes that further study of this subject in the future will present a clear and definite pattern.

Although originally not one of the aims of this research, the author has attempted in this work to give a new definition of overhead costs in the construction industry in terms of the functional and behavioural characteristics of these costs and also proposed a method of grouping the overhead costs items into cost centres or cost components. This is because the industry lacks a clear and meaningful definition of overhead costs. Different items are considered as overhead costs by different companies. This has been the cause of disputes in the past between construction companies and clients on certain types of contracts like 'Cost plus a fixed fee' and 'Cost plus a percentage fee.' It is hoped that this definition of overhead costs and these groupings of overhead cost items would minimise the difficulties mentioned.

6.3 AREAS FOR FURTHER RESEARCH

The safe zone method developed in this work is for planning and control of overhead costs. This method could be extended to planning and control of other aspects of construction costs especially at the estimating stages of projects.

In attempting to use the safe zone as a control method for the site overhead costs of projects, the author has assumed a direct linear relation between actual costs incurred at any point in time and the time spent in incurring such costs. This assumption might not be correct in view of the fact that construction activities on sites do not vary linearly with duration of projects.

It is hoped that further research into these areas would be of benefit to companies in the industry.

APPENDICES

APPENDICES

A. QUESTIONNAIRES

A.1 HEAD OFFICE OVERHEAD

1. The head office overhead cost elements have been grouped into ten cost centres or cost components. Please insert into the appropriate boxes, percentage approximations (rough estimates) of the proportion of the actual head office overhead costs incurred on the cost centres within a planning period. (Planning period, e.g. from the beginning of a financial year to the end.)

COST CENTRES

1.1a Senior Staff Cost

(This includes managers, trained personnel with more than 3 years experience)

% of Head Office Overhead Costs

Directors' Remuneration
Salaries
Allowances and fees
Pension contributions
Recruitment cost
Redundancy payments

1.1b Other Staff Cost

(This includes junior staff and staff with less than 3 years' experience.)

% of Head Office Overhead Costs

Salaries
Wages
Temporary Staff
Allowances
Recruitment Cost
Redundancy Payments

1.2 Head Office Accommodation Cost

% of Head Office Overhead Costs

Rents and building cost
Rates
Furniture and Fittings
Property Maintenance
Cleaning
Stationery and Printing

1.3 Transport Cost

% of Head Office Overhead Costs

All car costs

Staff & Director travelling expenses

Vehicle & Running cost

Pick-ups/Vans

Repairs & maintenance

Replacement cost

1.4 Communication Cost

% of Head Office Overhead Costs

Telephones

Telex & teletypes

Postage

Messengers

Mail handling

Two-way radios

Leased telephone lines

1.5 Marketing Cost

% of Head Office Overhead Costs

Publications

Advertisements

Subscriptions & donations

Presents and gifts

Organised dinnners

Tendering cost

1.6 Insurance Cost

% of Head Office Overhead Costs

Office accommodation insurance

Personnel accident

1.7 Service Cost

% of Head Office Overhead Costs

Light

Heat

Water

First-aid

Sanitation

Canteen

Other sources of power

1.8 Research, Training & Development Cost

% of Head Office Overhead Costs

Research work undertaken

Training of graduates and undergraduates

Tests

Short courses/Lectures organised

1.9 Finance Cost

% of Head Office Overhead Costs

Bank charges

Loan interest

Interest on overdue tax

Lost income on Company's own capital tied up in projects etc.

1.10 General and Unallocated Cost

% of Head Office Overhead Costs

Professional & legal fees

External auditors

Bad debts

Computer cost

All other overhead costs not listed above

2.0 Planning Period

(Most Companies plan for a certain period of time e.g. from the beginning of a financial year to the end, and some other planning periods.)

The company's planning period (please tick one)

1 yr   Please specify

3.0 Total Head Office Overhead Costs

This is the total Head Office overhead cost incurred for the planned period.

£e

4.0 Yearly Turnover for the Planned Period

This is the actual turnover of the Company for the planned period.

£e

A2: SITE OVERHEAD

1.0 Type of project (Please tick one)

(This is included so as to take into account the risks and uncertainty associated with each project.)

General Building	1. Dwelling Buildings
	2. Office Blocks
	3. Factory & Commercial Buildings
	4. Schools & Colleges
	5. Hospitals
	6. Recreation Grounds
	7. Others (Please specify)

Civil Engineering	8. Road & Bridge Works
	9. Off-shore works
	10. Tunnelling
	11. Harbour/Dock
	12. Sewage Works
	13. Dams
	14. Industrial Plant Site
	15. Other (Please specify)

2.0 Duration of Project

(This refers to the physical start and physical finish of projects.)

Months

3.0 Month and Year in which Project was started

(This is included in this work to take account of inflation in the model.)

4.0 Site Overhead Cost Centres

Site overhead cost items have been grouped under ten cost centres or cost components. Please insert in the appropriate boxes, percentage approximations (rough estimates) of the actual project cost incurred on the project.

4.1	Staff Cost	% of project costs
	Agents/Assistants	
	Engineers	
	Quantity Surveyors	
	Clerks/Typists	
	Cleaners	
	Redundancy payments	
4.2	Site Accommodation Cost	% of Project costs
	Rents or building costs for both Contractor and Engineer (R.E.)	
	Furniture and fittings	
	Property Maintenance	
	Printing and stationery	
4.3	Transport Cost	% of Project Costs
	Cars for staff	
	Vans	
	Pick-ups	
	Vehicle running cost	
	Repairs & maintenance	
	Replacement cost	
4.4	Communication Cost	% of Project Costs
	Telephones	
	Teletypes	
	Postage	
	Messengers & mail handling	
	Two-way radios	
	Leased telephone lines	
4.5	Insurance Cost	% of Project Costs
	Works Insurance	
	Staff Insurance	
	Personnel accidents	

4.6	<u>Service Cost</u>	<u>% of Project Costs</u>
	Light Heat Water Sanitation First-aid Canteen/Food vouchers	
4.7	<u>Minor and General Plant</u>	<u>% of Project Costs</u>
	Pumps Small lifts Generators Repairs and maintenance Transport cost (to and from site) Scaffoldings	
4.8	<u>Tests Cost</u>	<u>% of Project Costs</u>
	Lab test Soil test Model test Surveys	
4.9	<u>Temporary Site Costs</u>	<u>% of Project Costs</u>
	Temporary and access roads Temporary pipes and cables Fencing and site protection Site clearance	
4.10	<u>General, Miscellaneous Costs</u>	<u>% of Project Costs</u>
	All items not listed above All unallocated costs	
5.0	<u>Direct Cost of Project</u> (This does not include profit and overheads.)	£e

5.1 Labour Cost — % of Project Costs

5.2 Plant Cost — % of Project Costs

(Heavy plant only. Plant which is not included in minor plant.)

5.3 Material Cost — % of Project Costs

6.0 Percentage of Work Subcontracted

(rough estimates only)

7.0 No. of Projects undertaken by the Company within the same planning period with this project

(This does not necessarily mean the number of projects completed within the planning period. This is included in this questionnaire to examine its effect on the overhead cost.)

8.0 The Company's Yearly Turnover at the time of this project's start (for the planned period)

£e

9.0 Is any apportionment made to the project cost for Head Office Overhead Cost?

Yes/No (delete one)

9.1 If yes, is the apportionment based on:

a) Percentage addition

b) An arbitrary addition.

9.2 If (a), what percentage addition is made?

1. Project Cost

___% of 2. Head Office Cost (Please tick one)

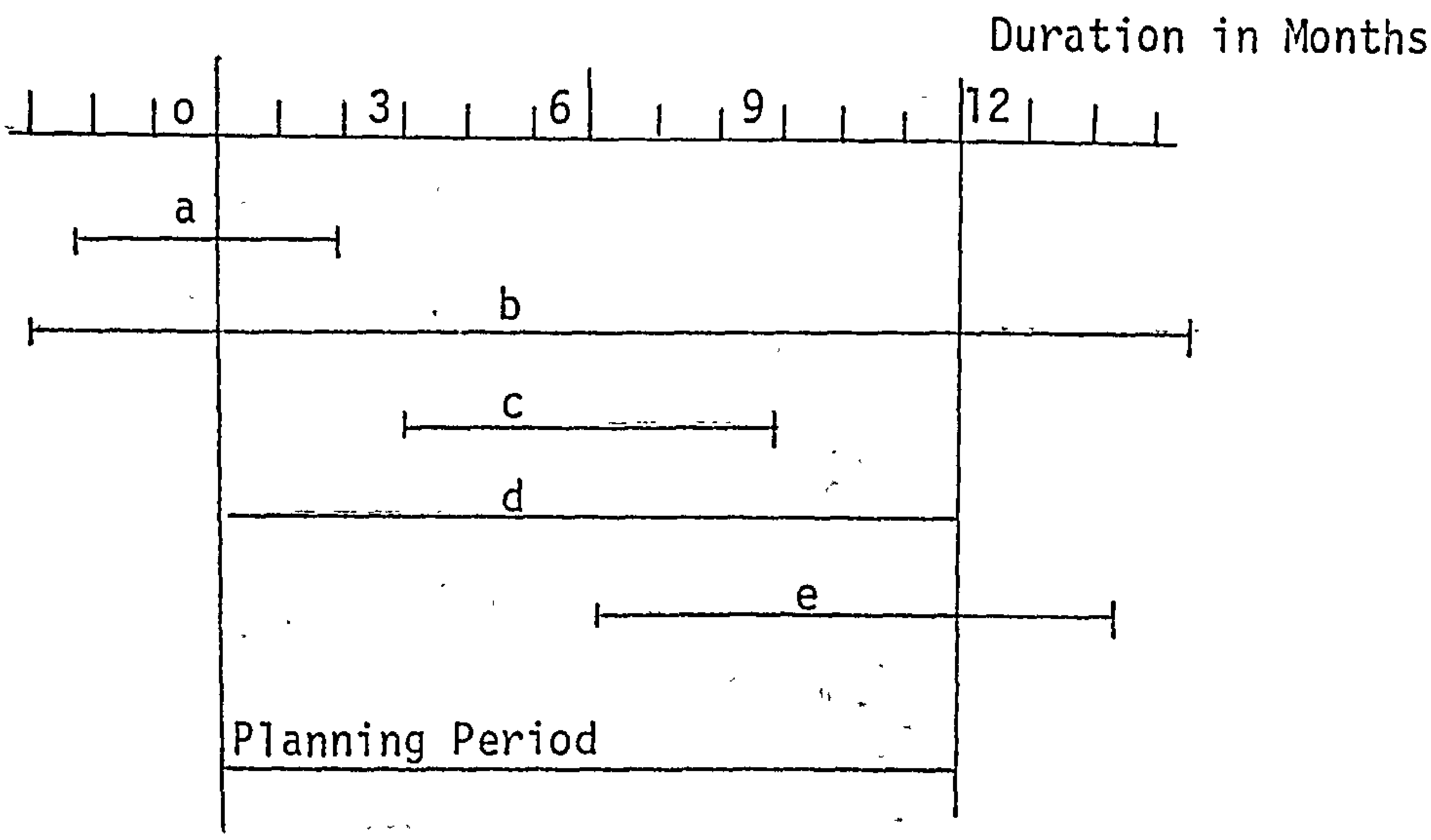
or ______________

If (b), what amount is added? £e

10.0 <u>Duration of the Project within the Planned Period</u>

(This is explained in Fig.1.) months

Fig.1.



If the planning period is say, 12 months, as shown above, projects from the last planned period (projects a & b) may continue into the present one and projects may extend into the next planning period (projects b & e). For the projects shown above, the duration of the project within the planned period is: Project (a), 2 months; Project (b), 12 months; Project (c), 6 months; Project (d), 12 months; Project (e), 6 months.

B DATA SET FOR REGRESSION ANALYSIS

Table (BI a)

BI Head Office (Tender Stage Model)

	Dependent Variable	Independent Variable			
Company & Project	Head Office Overhead Costs Apportioned to project in £e C_{1ko}	Direct costs of Project £e X_1	Duration of Project in months X_2	Type of Project C.Eng=1 Build=2 X_4	Infla-tion X_3
AP1	106,126	1,632,821	20	2	215
AP2	62,049	980,265	18	2	260
AP3	106,624	1,265,321	12	2	225
AP4	46,078	786,320	9	2	185
AP5	187,504	2,869,530	23	2	240
AP6	35,886	530,060	8	2	235
AP7	110,079	1,862,533	15	2	200
AP8	53,493	936,850	11	2	240
AP9	145,983	2,362,180	18	2	255
AP10	84,584	1,321,610	15	2	190
BP1	202,575	2,853,200	25	2	200
BP2	271,694	3,483,251	31	2	215
BP3	137,931	2,416,330	20	2	205
BP4	59,971	995,370	6	2	215
BP5	88,622	1,246,450	10	2	245
BP6	38,127	562,340	6	2	210
BP7	106,797	1,346,218	15	2	240
BP8	103,892	1,463,256	18	2	248
BP9	172,530	2,500,440	17	2	220
BP10	51,787	683521	10	2	175
	No apportionment made by Companies C & D				
EP1	64,357	1,092,652	10	2	190
EP2	202,903	3,462,520	29	2	220
EP3	68,325	987,360	13	2	215
EP4	59,274	865,321	9	2	174
EP5	95,275	1,625,836	14	2	240
EP6	67,431	1,123,866	13	2	215
EP7	45,642	748,231	10	2	210
EP8	57,836	962,341	9	2	250
EP9	23,208	326,885	6	2	215
EP10	14,338	200,540	5	2	210

Table (B1a) Continued

	Dependent Variable	Independent Variable			
Company & Project	Head Office Overhead Costs Apportioned to project in £e C_{1ko}	Direct Costs of Project £e X_1	Duration of Project in months X_2	Type of Project C.Eng=1 Build=2 X_4	Inflation X_3
FP1	486,328	8,562,183	37	1	218
FP2	164,800	2,632,581	12	2	220
FP3	405,156	5,853,326	18	2	238
FP4	305,789	3,652,300	17	2	201
FP5	71,126	1,026,342	10	2	170
FP6	123,317	1,800,260	11	1	240
FP7	264,585	3,862,531	22	2	201
FP8	174,483	2,855,450	19	2	215
GP1	710,086	9,862,341	30	1	201
GP2	530,880	7,262,400	24	1	215
GP3	205,587	2,635,730	10	1	240
GP4	933,960	12,864,500	36	1	
GP5	468,208	6,234,150	26		
HP1	1,006,398	14,562,300	37	1	215
HP2	186,395	2,621,580	11	1	210
HP3	200,526	3,265,820	10	1	201
HP4	453,443	6,386,520	25	1	220
HP5	151,536	1,882,440	8	1	238
HP6	700,700	10,600,831	35	1	215

Table (B2a)

B.2 Head Office

(Construction Stage) Model

Company & Project	$\frac{C_{1ki}}{C_{1i}}$	Independent Variables				*
		U_1	U_2	U_3	U_4	U_5
AP1	0.265315	0.4898460	0.8333333	7	201	2
AP1	0.1965296	0.341412	0.8333333	5	215	2
AP2	0.0723181	0.1867171	0.5833333	6	260	2
AP3	0.09996	0.474494	0.2500000	7	206	2
AP3	0.320859	0.5354552	0.7500000	5	210	2
AP4	0.082282	0.1747377	0.7500000	10	176	2
AP5	0.289359	0.356653	0.9166666	5	208	2
AP5	0.359021	0.5238026	1.0000000	6	238	2
AP6	0.125462	0.26153000	0.6666667	6	252	2
AP7	0.147427	0.2793798	0.8333333	10	174	2
AP7	0.137600	0.5587598	0.4166666	7	190	2
AP8	0.144089	0.365957	0.666667	5	245	2
AP9	0.382822	0.590545	1.000000	6	241	2
AP10	0.128386	0.132161	1.000000	10	175	2
AP10	0.063435	0.396484	0.250000	11	205	2
BP1	0.098646	0.1347397	0.9166666	11	178	2
BP1	0.139775	0.1677324	1.000000	9	200	2
BP1	0.014260	0.1084863	0.1666666	12	206	2
BP2	0.122706	0.1340322	1.000000	9	201	2
BP2	0.148134	0.1709713	1.000000	12	218	2
BP2	0.071478	0.146636	0.5833333	9	225	2
BP3	0.050375	0.1344855	0.583333	11	190	2
BP3	0.118014	0.1761419	1.00000	9	204	2
BP3	0.006473	0.1695349	0.083333	12	210	2
BP4	0.067544	0.3027732	0.4166666	12	215	2
BP5	0.133229	0.2098895	0.833333	9	238	2
BP6	0.05051	0.1269447	0.500000	9	180	2
BP7	0.090213	0.1228484	0.833333	12	220	2
BP7	0.040138	0.1133448	0.4166666	9	245	2
BP8	0.117139	0.1539984	1.000000	9	240	2
BP9	0.104100	0.1810922	0.750000	12	225	2
BP9	0.120422	0.2443585	0.666666	9	245	2
BP10	0.060523	0.0085215	0.833333	11	175	2
No Apportionment made by Companies C & D						
EP1	0.294774	0.4942579	0.833333	5	180	2
EP2	0.096169	0.2986838	0.500000	7	210	2
EP2	0.197639	0.320406	1.00000	11	215	2
EP2	0.192930	0.2330114	0.9166666	8	240	2
EP3	0.048575	0.1916359	0.333333	7	205	2

* where $\frac{C_{1ki}}{C_{ij}}$, U_1, U_2, U_3, U_4, and U_5 have their usual meanings (see page 123)

Table (B2a) continued

Company & Project	$\frac{C_{1ki}}{C_{1i}}$	Independent Variables U_1	U_2	U_3	U_4	U_5
EP3	0.101365	0.185543	0.7500000	11	210	2
EP4	0.271492	0.43917	0.7500000	5	185	2
EP5	0.035336	0.2291457	0.250000	11	190	2
EP5	0.155294	0.2607632	0.9166666	8	225	2
EP6	0.023970	0.1488115	0.166666	7	208	2
EP6	0.116711	0.2015953	0.916666	11	214	2
EP7	0.090284	0.1687276	0.833333	11	218	2
EP8	0.114405	0.241122	0.750000	11	210	2
EP9	0.046557	0.1182994	0.50000	8	230	2
EP10	0.028362	0.0904443	0.416666	11	212	2
FP1	0.041679	0.1380997	0.500000	11	185	1
FP1	0.149463	0.2269555	1.000000	9	201	1
FP1	0.145952	0.2343422	1.00000	10	215	1
FP1	0.054216	0.1439958	0.583333	13	225	1
FP2	0.132454	0.192964	1.000000	10	215	2
FP3	0.081409	0.2145199	0.500000	10	220	2
FP3	0.232288	0.295313	1.00000	13	240	2
FP4	0.198117	0.2040872	1.000000	9	200	2
FP4	0.061443	0.1606247	0.416666	10	210	2
FP5	0.048765	0.0794587	0.83333	11	182	2
FP6	0.094268	0.1321141	0.916666	13	223	1
FP7	0.032393	0.1067981	0.416666	11	191	2
FP7	0.146933	0.1850011	1.00000	9	201	2
FP7	0.037974	0.1213361	0.416666	10	210	2
FP8	0.018841	0.1063732	0.250000	9	205	2
FP8	0.099335	0.1482542	1.00000	10	218	2
FP8	0.022231	0.0960438	0.33333	13	223	2
GP1	0.184738	0.3168565	0.9166666	6	175	1
GP1	0.347081	0.530263	1.00000	6	200	1
GP1	0.04755	0.1268016	0.5833333	8	213	1
GP2	0.086303	0.2673525	0.500000	6	192	1
GP2	0.259487	0.3904734	1.00000	6	204	1
GP2	0.088875	0.272340	0.500000	8	210	1
GP3	0.149670	0.2525996	0.833333	7	240	1
GP4	0.076085	0.2766713	0.500000	6	221	1
GP4	0.295337	0.4556177	1.00000	8	238	1
GP4	0.26816	0.4066828	1.00000	7	216	1
HP1	0.091318	0.3976025	0.333333	6	185	1
HP1	0347712	0.5090191	1.00000	5	200	1
HP1	0.353304	0.3173474	1.00000	6	215	1

Table (B2a) continued

Company & Project	$\frac{C_{1ki}}{C_{1i}}$	Independent Variables				
		U_1	U_2	U_3	U_4	U_5
HP1	0.135508	0.2631202	0.750000	9	230	1
HP2	0.165311	0.1574506	0.9166666	6	213	1
HP3	0.207846	0.4109594	0.833333	5	204	1
HP4	0.169721	0.2902096	0.833333	5	203	1
HP4	0.219229	0.1916744	1.00000	6	215	1
HP4	0.030527	0.173093	0.250000	6	225	1
HP5	0.108821	0.1814028	0.6666666	9	250	1
HP6	0.181570	0.3031754	0.916666	5	201	1
HP6	0.31072	0.2918116	1.000000	6	218	1
HP6	0.012661	0.191524	1.00000	9	220	1
GP5	0.128157	0.241347	1.00000	6	200	1
GP5	0.245600	0.3039295	1.000000	8	215	1
GP5	0.021227	0.1867153	0.166666	7	220	1

No Apportionment made for Companies I,J,K,L & M.

Table ($B3_a$)

B3 Site Overhead Costs Model

Dependent Variable		Independent Variable			
Company & Project	C_{2ko} Site Overhead Cost in £e	Direct Cost of Project in £e	Duration of Project in Months	Inflation (Indices)	Type of Project C.Eng = 1, Build = 2
		V_1	V_2	V_3	V_4
AP1	111,382	1,632,821	20	215	2
AP2	52,268	980,265	18	260	2
AP3	83,119	1,265,321	12	225	2
AP4	50,867	786,320	9	185	2
AP5	213,492	2,869,530	24	240	2
AP6	33,988	523,060	8	235	2
AP7	128,905	1,862,531	15	200	2
AP8	54,721	936,850	11	240	2
AP9	150,447	2,362,180	18	255	2
AP10	76,918	1,321,610	15	190	2
BP1	209,139	2,853,200	25	200	2
BP2	234,840	3,483,251	31	215	2
BP3	189,770	2,416,230	24	205	2
BP4	63,700	995,370	6	215	2
BP5	76,648	1,246,450	10	245	2
BP6	34,079	562,340	6	210	2
BP7	85,525	1,346,218	15	240	2
BP8	109,450	1,463,256	18	248	2
BP9	155,877	2,500440	17	220	2
BP10	55,434	683,521	11	175	2
CP1	53,110	983,520	23	215	2
CP2	28,795	490,550	6	165	2
CP3	97,475	1,926,385	14	235	2
CP4	16,077	300,500	6	160	2
CP5	144,238	2,162,340	15	238	2
CP6	94,895	1,363,412	9	258	2
CP7	174,820	2,685,420	18	215	2
CP8	94,980	1,432,588	14	225	2
CP9	28,111	480,540	5	200	2
CP10	138,400	2,182,630	17	240	2
DP1	58,230	864,533	13	195	2
DP2	33,244	485,320	8	230	2
DP3	117,414	1,684,560	25	210	2

Table (B3a) continued

Dependent Variable		Independent Variable			
Company & Project	C_{2ko} Site Overhead Cost in £e	Direct Cost of Project in £e	Duration of Project in Months	Inflation (Indices)	Type of Project C.Eng = 1, Build. = 2
		V_1	V_2	V_3	V_4
DP4	65,367	940,261	11	175	2
DP5	85,927	1,342,612	14	205	2
DP6	50,076	759,883	9	230	2
DP7	55,846	821,267	10	170	2
DP8	42,200	642,310	11	142	2
DP9	84,176	1,230,650	14	140	2
DP10	63,336	986,540	13	235	2
EP1	88,723	1,092,652	10	190	2
EP2	232,160	3,462,520	29	220	2
EP3	61,216	987,360	13	215	2
EP4	53,736	865,321	9	174	2
EP5	107,712	1,625,836	14	240	2
EP6	74,456	1,123,866	13	215	2
EP7	49,160	748,231	10	210	2
EP8	54,035	962,341	9	250	2
EP9	19,320	326,885	6	215	2
EP10	11,390	200,540	5	210	2
FP1	816,832	8,562,183	37	218	1
FP2	179,278	2,632,581	14	220	2
FP3	404,464	5,853,326	18	238	2
FP4	251,643	3,652,300	17	201	2
FP5	60,349	1,026,342	10	170	2
FP6	129,079	1,800,260	11	240	1
FP7	252,610	3,862,531	22	201	2
FP8	196,740	2,855,450	19	215	2
GP1	859,996	9,862,340	30	201	1
GP2	639,086	7,262,345	24	215	1
GP3	220,865	2,635,620	10	240	1
GP4	1,092,180	12,864,320	30	243	1
GP5	681,430	6,234,500	26	208	1

Table (B3a) continued

Dependent Variable		Independent Variable			
Company & Project	$C_{2}ko$ Site Overhead Cost in £e	Direct Cost of Project in £e	Duration of Project in Months	Inflation (Indices)	Type of Project C.Eng. = 1, Build.=2
		V_1	V_2	V_3	V_4
HP1	1,247,990	14,562,310	36	215	1
HP2	182,460	2,621,580	11	210	1
HP3	240,690	3,265,826	10	201	1
HP4	474,518	6,386,520	25	220	1
HP5	138,735	1,882,440	8	238	1
HP6	929,760	10,625,831	35	215	1
IP1	512,076	6,711,360	34	208	1
IP2	122,111	1,590,200	21	215	1
IP3	288,922	3,123,490	23	225	1
IP4	766,324	7,361,424	37	210	1

C OVERHEAD COST CENTRES

Table (Cla)

C 1 Head Office Overhead Costs in Le

Company & Year	Senior Staff Costs	Other Staff Costs	Head Office Accommodation Costs	Transport Costs	Communication Costs	Marketing Costs	Insurance Costs	Service Costs	Research, Training & Development Costs	Finance Costs	General & Miscellaneous Costs	Total Head Office Overhead costs
A1(1975/76)	116992	142672	69888	94400	20048	5421	18884	7440	2016	30919	16520	560000
A2(1976/77)	57780	46040	24040	35000	9120	1631	7800	4200	-	9200	5200	200000
A3(1977/78)	74795	63235	39477	38396	11241	6503	8322	5800	-	13190	8040	270000
A4(1978/79)	85226	69640	41326	45330	12253	1430	5749	2217	143	14872	7814	286000
B1(1975/76)	269829	207671	112449	129583	43638	3498	25870	11637	962	30461	20022	855650
B2(1976/77)	289354	201333	110951	137939	36071	4374	30169	13318	888	45150	24330	887877
B3(1977/78)	245602	184593	98625	119942	31816	2998	3257	1696	1885	34645	18682	754837
B4(1978/79)	218190	155863	84554	99778	28007	3826	19823	9643	1996	126767	16696	665186
C1(1975/76)	19988	16710	8569	7267	2577	189	2250	707	-	4273	1742	64272
C2(1976/77)	32368	27280	13770	19231	4886	633	2776	100	-	6496	3503	111036
C3(1977/78)	57477	46432	22295	26662	6266	739	5135	480	-	10706	5059	179550
C4(1978/79)	114641	99723	42380	55972	16335	2334	11093	782	-	18836	10162	372258
D1(1978/79)	27547	26000	14166	2802	4155	218	3220	2448	-	10527	2750	103872

Table (C1a) continued

Company & Year	Senior Staff Costs	Other Staff Costs	Head Office Accommodation Costs	Transport Costs	Communication Costs	Marketing Costs	Insurance Costs	Service Costs	Research, Training & Development Costs	Finance Costs	General & Miscellaneous Costs	Total Head Office Overhead Costs
D2(1977/78	46309	42000	21050	27288	4733	369	4733	1765	-	9545	3530	160423
D3(1976/77)	46743	41800	17460	27283	5548	778	3985	148	-	7984	3938	155667
D4(1975/76)	44967	36180	18764	25066	5643	1590	3220	1402	-	6286	4434	147552
E1(1975/76)	64647	56804	27038	32149	7856	895	6332	2402	218	10170	11510	218327
E2(1976/77)	104495	82230	45373	56575	15396	1758	10198	4009	387	22857	8364	351642
E3(1977/78)	142652	134119	62170	83664	19969	2855	14762	5814	2123	25327	16531	505538
E4(1978/79)	138639	127717	62316	78268	19690	14954	14626	5633	1994	24525	10119	498481
F1(1977/78)	392332	318923	154431	194495	53013	7968	34101	12566	3752	44796	27865	1244200
F2(1978/79)	417965	339223	161716	216375	54456	8337	3925	14389	3270	50494	30349	1308149
F3(1975/76)	452150	372805	189751	220532	58488	5980	43727	16481	2992	59946	35297	1458550
F4(1976/77)	384906	286161	146785	166117	42369	5788	32413	11692	2315	52324	26740	1157611
G1(1977/78)	344600	282512	137840	191600	39712	5824	29432	9424	5712	54632	13712	1120000
G2(1978/79)	424192	360291	206200	204445	37358	5928	38082	11683	4136	55136	30466	1378597

Table (Cla): continued

Company & Year	Senior Staff Costs	Other Staff Costs	Head Office Accommodation Costs	Transport Costs	Communication Costs	Marketing Costs	Insurance Costs	Service Costs	Research, Training & Development Costs	Finance Costs	General & Miscellaneous Costs	Total Head Office Overhead Costs
G3(1976/77)	407177	323761	160602	209539	39766	5370	38360	11508	-	50635	31960	1278678
G4(1975/76)	369112	293583	117733	188880	45894	4036	33325	12684	-	58924	28945	1153117
H1(1975/76)	288418	235133	109197	148954	35726	3851	20939	9276	-	44634	21674	918402
H2(1976/77)	309198	247887	116870	146792	39784	3287	28786	9937	965	49624	11295	964780
H3(1978/79)	446064	374032	148203	196630	41300	32813	42474	16014	2785	64766	30952	1392526
H4(1977/78)	350342	302196	118618	189852	33939	3908	33775	12854	1156	55362	27399	1127543
I1(1976/77)	157229	131024	61671	90000	15904	2179	15581	5396	-	30291	31925	544800
I2(1975/76)	198854	166425	83505	117970	26948	1762	20159	6651	-	40665	29927	692766

Table (C2a)

C2 Site Overhead Costs in Le

Company & Project	Staff Costs	Site Accommodation Costs	Site Transport Costs	Communication Costs	Insurance Costs	Service Costs	Minor Plant Costs	Test Costs	Temporary Site Costs	General & Miscellaneous Costs	Total Site Overhead Costs	Project Costs (Actual)
A.P1	15022	2939	50944	2612	26614	2612	4082	179	5061	1306	111382	1632821
A.P2	9312	1568	26663	5980	1470	1568	2451	118	3137	784	52268	980265
A.P3	12147	1392	37706	2151	23535	1772	3163	126	3669	1126	83119	1265321
A.P4	7312	865	23746	1171	12660	1101	1494	79	1809	629	50867	786320
A.P5	28121	4304	100433	4878	51938	4591	6886	574	8896	2582	213492	2869530
A.P6	4603	785	15221	732	8787	837	1255	52	1308	407	33988	523060
A.P7	18066	3911	53268	3352	34662	2794	4843	391	5774	1863	128905	1862531
A.P8	7401	759	27449	843	14053	843	1405	-	1686	844	54721	936850
A.P9	21023	1498	42500	3071	37794	2598	48215	284	62396	2552	150447	2362180
A.P10	10837	1189	37137	1454	19296	1718	1982	-	2379	925	76918	1321610
B.P1	27961	4565	91302	4565	57064	5136	7133	285	8560	2568	209139	2853200
B.P2	34833	3205	102408	5225	66530	4877	7315	348	7315	2787	234840	3483251
B.P3	23196	3383	72728	2894	70312	3866	6040	338	6765	242	189770	2416230

Table (C2a) continued

Company & Project	Staff Costs	Site Accommodation Costs	Site Transport Costs	Communication Costs	Insurance Costs	Service Costs	Minor Plant Costs	Test Costs	Temporary Site Costs	General & Miscellaneous Costs	Total Site Overhead Costs	Project Costs (Actual)
B.P4	8560	1592	28168	1792	17220	1394	1991	-	2289	597	63700	985370
B.P5	10844	1745	33404	1496	26175	1371	2368	249	1870	127	79648	1246450
B.P6	5117	731	14789	899	8828	844	1293	-	1350	168	34079	562340
B.P7	12924	2423	34463	1750	24367	2154	2692	175	2962	808	85525	1346218
B.P8	13462	2927	42720	2341	37020	2488	3512	163	3366	1463	109450	1463256
B.P9	23004	3500	67661	3751	46508	3740	4750	125	6251	1750	155877	2500440
B.P10	6425	1094	19685	956	12098	1079	1640	615	1913	-	55434	683521
C.P1	8065	1180	22620	983	15343	1180	1869	-	1967	-	53110	983520
C.P2	3826	490	10301	442	7162	589	883	-	1275	-	28795	490550
C.P3	16952	1734	38528	2697	27355	2119	3468	-	3275	1349	97475	1926385
C.P4	2164	2404	6491	300	4537	270	631	-	661	2406	16077	300500
C.P5	19677	3460	63140	3027	38922	2162	4541	216	5406	1514	144238	2162340
C.P6	13634	2454	42266	2318	24814	2045	2999	-	3545	818	94895	1363412

Table (C2a) continued

Company & Project	Staff Costs	Site Accommodation Costs	Site Transport Costs	Communication Costs	Insurance Costs	Service Costs	Minor Plant Costs	Test Costs	Temporary Site Costs	General & Miscellaneous Costs	Total Site Overhead Costs	Project Costs (Actual)
C.P7	23900	4565	72237	4297	49411	3760	6445	269	5103	2417	174820	2685420
C.P8	12606	2579	39969	2149	27219	2435	3152	-	3438	716	94980	1432588
C.P9	3796	817	12300	433	7208	427	913	-	1105	-	28111	480540
C.P10	17461	3492	60022	3274	41251	2859	48018	218	5238	1091	138400	2182630
D.P1	7694	778	30258	1210	13660	692	1623	-	2075	518	58230	864533
D.P2	4174	534	15142	777	9173	874	1068	-	922	437	33244	485320
D.P3	15161	2360	52221	2190	32007	2021	3875	842	3538	1516	117414	1684560
D.P4	7429	752	27362	1599	15362	865	1693	-	2257	658	65367	940261
D.P5	12218	1611	40278	2148	21750	1208	2417	269	3222	402	85927	1342612
D.P6	6459	1368	22797	1140	14209	684	1824	-	1444	75	50076	759883
D.P7	6406	740	23160	1068	14618	825	1650	82	1889	328	55846	821267
D.P8	5845	1028	18948	900	11433	578	1220	64	1606	450	42200	642310
D.P9	11445	2215	38150	1477	22890	1600	2831	246	2338	945	84176	1230650

Table (C2a) continued

Company & Project	Staff Costs	Site Accommodation Costs	Site Transport Costs	Communication Costs	Insurance Costs	Service Costs	Minor Plant Costs	Test Costs	Temporary Site Costs	General & Miscellaneous Costs	Total Site Overhead Costs	Project Costs (Actual)
D.P10	8583	1875	28609	987	15982	1184	2466	99	2565	493	63336	986540
E.P1	11910	9943	34965	1530	21853	1311	2513	109	2622	983	88723	1092652
E.P2	38434	3809	96950	4501	65441	3462	6925	173	9003	1731	232160	3462520
E.P3	8392	1149	26165	1679	16588	1387	2074	100	1876	889	61216	987360
E.P4	7010	1125	24575	1471	14797	952	1470	-	1817	520	53736	865321
E.P5	13332	1626	47150	1951	30240	2113	3414	81	2927	1626	107712	1625836
E.P6	11126	1349	32143	1124	21354	1461	2360	56	2585	899	74456	1123866
E.P7	6744	1048	22148	673	13693	673	1961	-	1720	599	49160	748231
E.P8	8084	962	26946	1059	17322	965	2021	10	1925	674	54035	962341
E.P9	2510	295	8793	230	5426	261	490	-	621	196	19320	326885
E.P10	1624	160	4853	120	3170	100	400	-	4812	-	11390	200540
F.P1	141270	15411	393860	16268	172100	13700	33392	7706	17124	5993	816832	8562183
F.P2	29748	4212	73712	2633	48440	3422	5792	1053	6845	790	179278	2632581

Table (C2a) continued

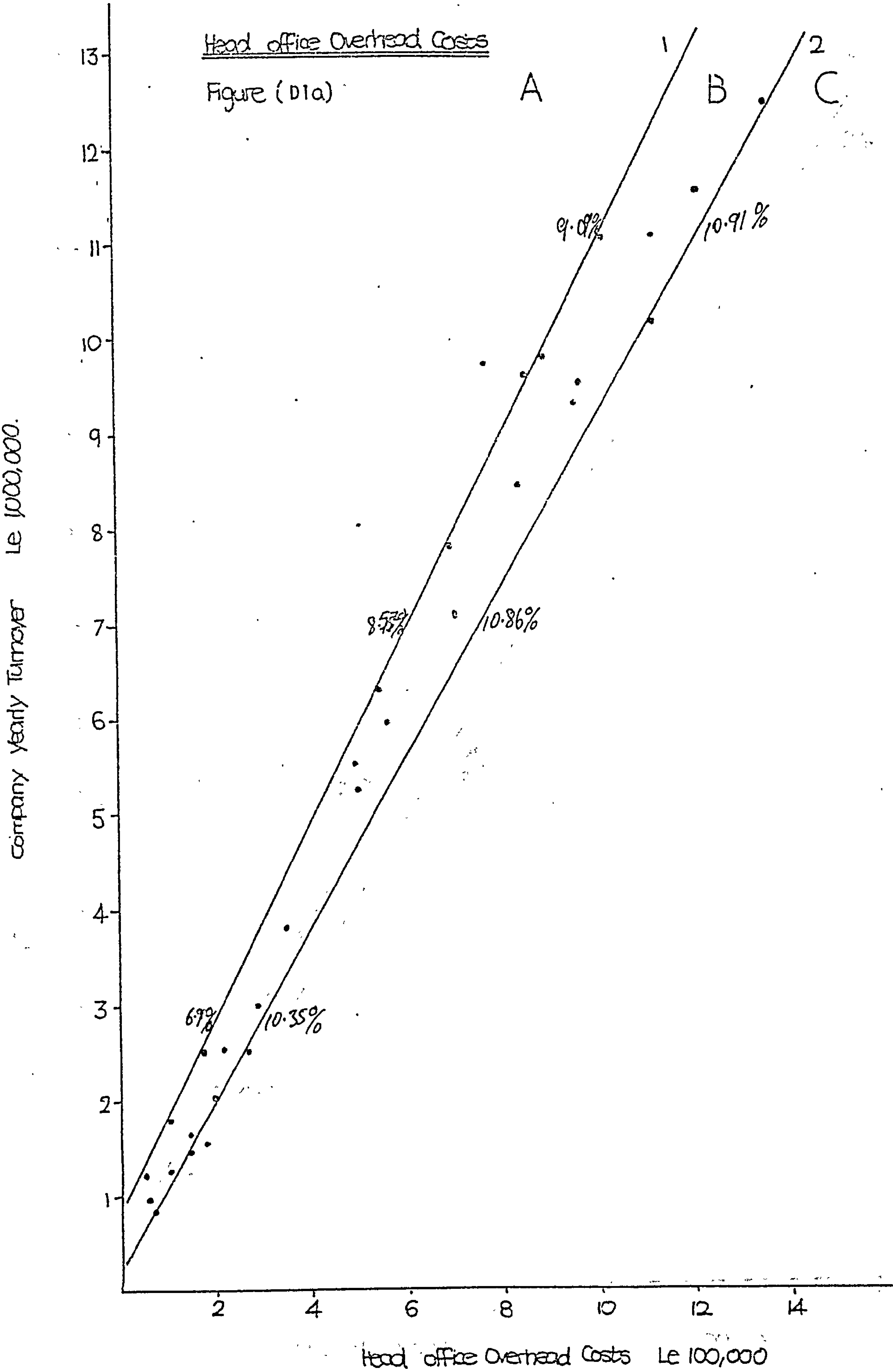
Company & Project	Staff Costs	Site Accommodation Costs	Site Transport Costs	Communication Costs	Insurance Costs	Service Costs	Minor Plant Costs	Test Costs	Temporary Site Costs	General & Miscellaneous Costs	Total Site Overhead Costs	Project Costs (Actual)
F.P3	70825	10536	167990	7024	111798	7609	12291	1756	11121	4097	404464	15853326
F.P4	46750	6574	99345	5113	68664	3652	8036	365	8766	2190	251643	3652300
F.P5	12932	1232	217585	1026	17448	924	1950	102	2155	205	60349	1026342
F.P6	25204	2700	51848	2160	34385	1800	4320	1080	4140	720	129079	1800260
F.P7	43260	6180	98880	4249	73000	3476	6950	772	9656	3090	252610	3862531
F.P8	35978	5140	79953	2855	54825	2570	5140	285	6568	1713	196740	2855450
G.P1	173577	18738	38462	13807	19823	17752	20710	1973	22683	8876	859996	9862340
G.P2	137258	13072	277422	10894	148878	10167	18155	3631	13798	4358	639086	7262345
G.P3	50604	4480	84603	3690	60620	3426	6853	1578	5798	527	220865	2635620
G.P4	276583	23156	443820	11578	257286	19296	27015	5145	19296	3860	1092180	12864320
G.P5	122196	9975	261850	4987	124690	7481	15586	1247	8104	1870	681430	6234500
H.P1	308720	32037	524243	14562	288334	18931	33493	16018	18931	5825	1247990	14562310
H.P2	35653	4195	74977	4980	49578	1835	4718	524	4456	780	182460	2621580

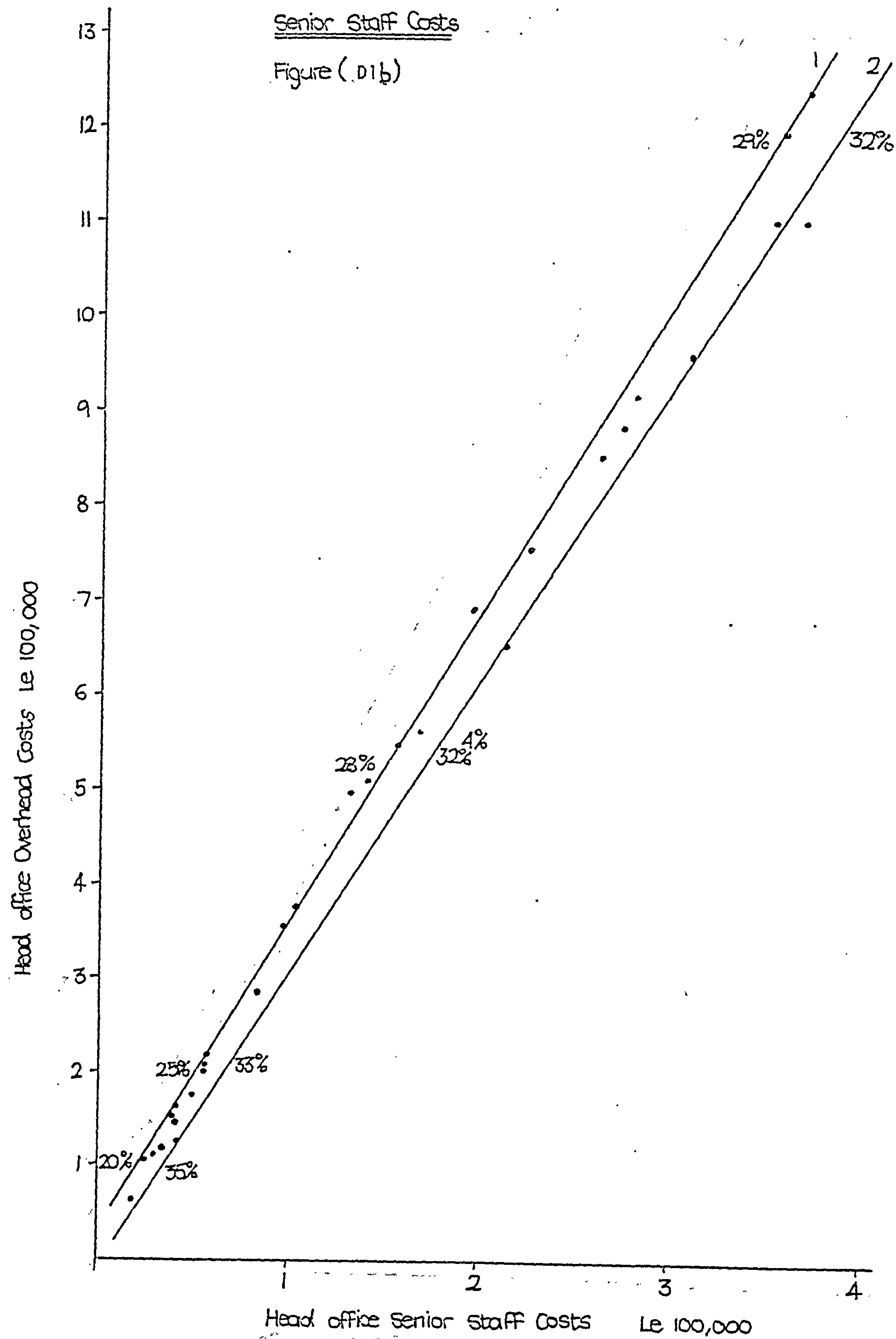
Table (C2a) continued

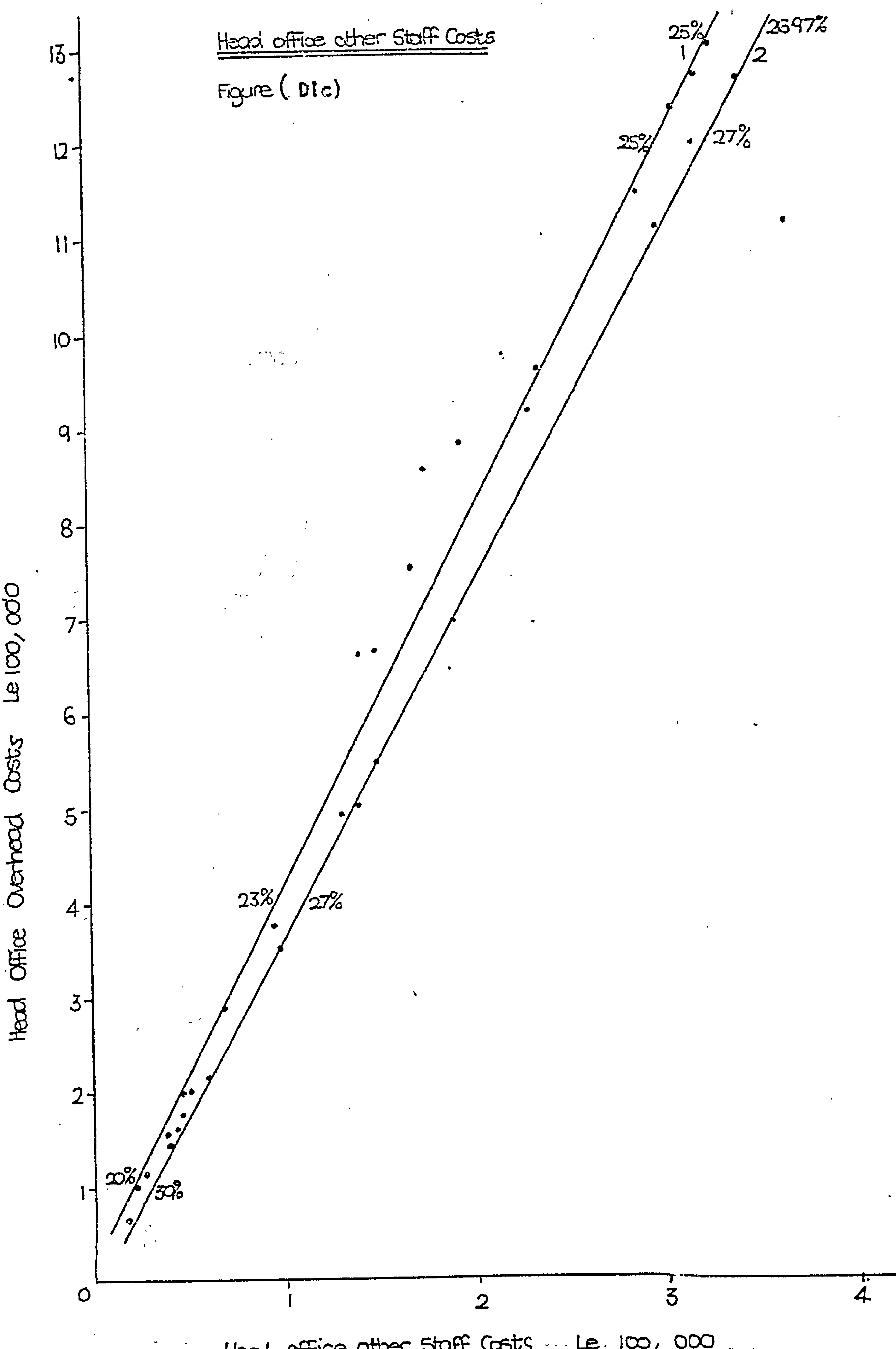
Company & Project	Staff Costs	Site Accommodation Costs	Site Transport Costs	Communication Costs	Insurance Costs	Service Costs	Minor Plant Costs	Test Costs	Temporary Site Costs	General & Miscellaneous Costs	Total Site Overhead Costs	Project Costs (Actual)
H.P3	42130	4572	111691	3267	61397	2286	5878	326	6205	1633	240690	3265826
H.P4	86856	10860	213948	7663	114318	5109	11495	3193	15966	2555	474518	6386520
H.P5	30872	3388	60230	1318	34825	1506	2823	376	3012	188	138735	1882440
H.P6	189139	18064	450535	9563	205078	8500	20189	6375	14876	2126	929760	10625831

D. GRAPHICAL PLOT OF SAFE ZONES

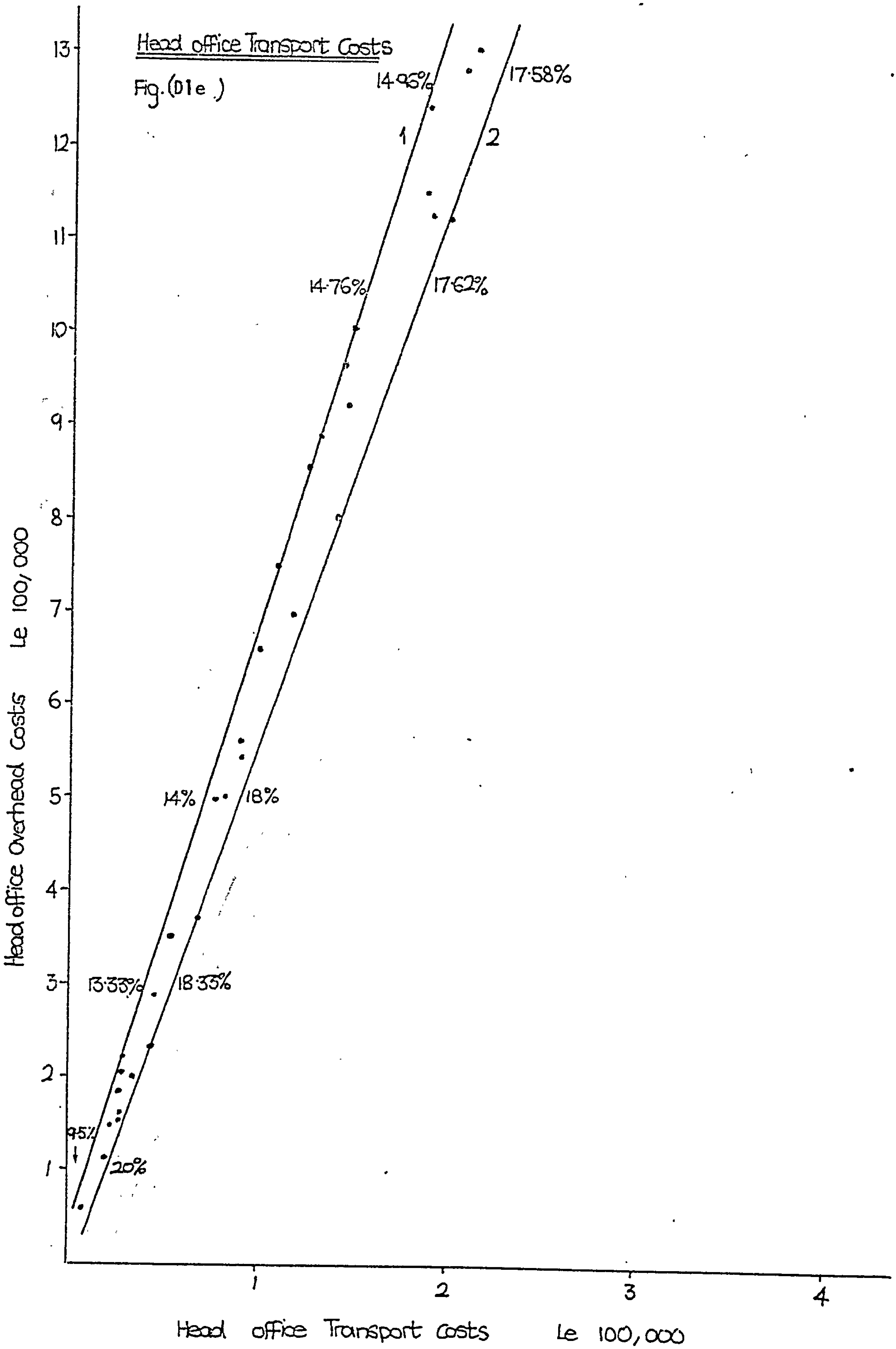
D.1 HEAD OFFICE OVERHEADS



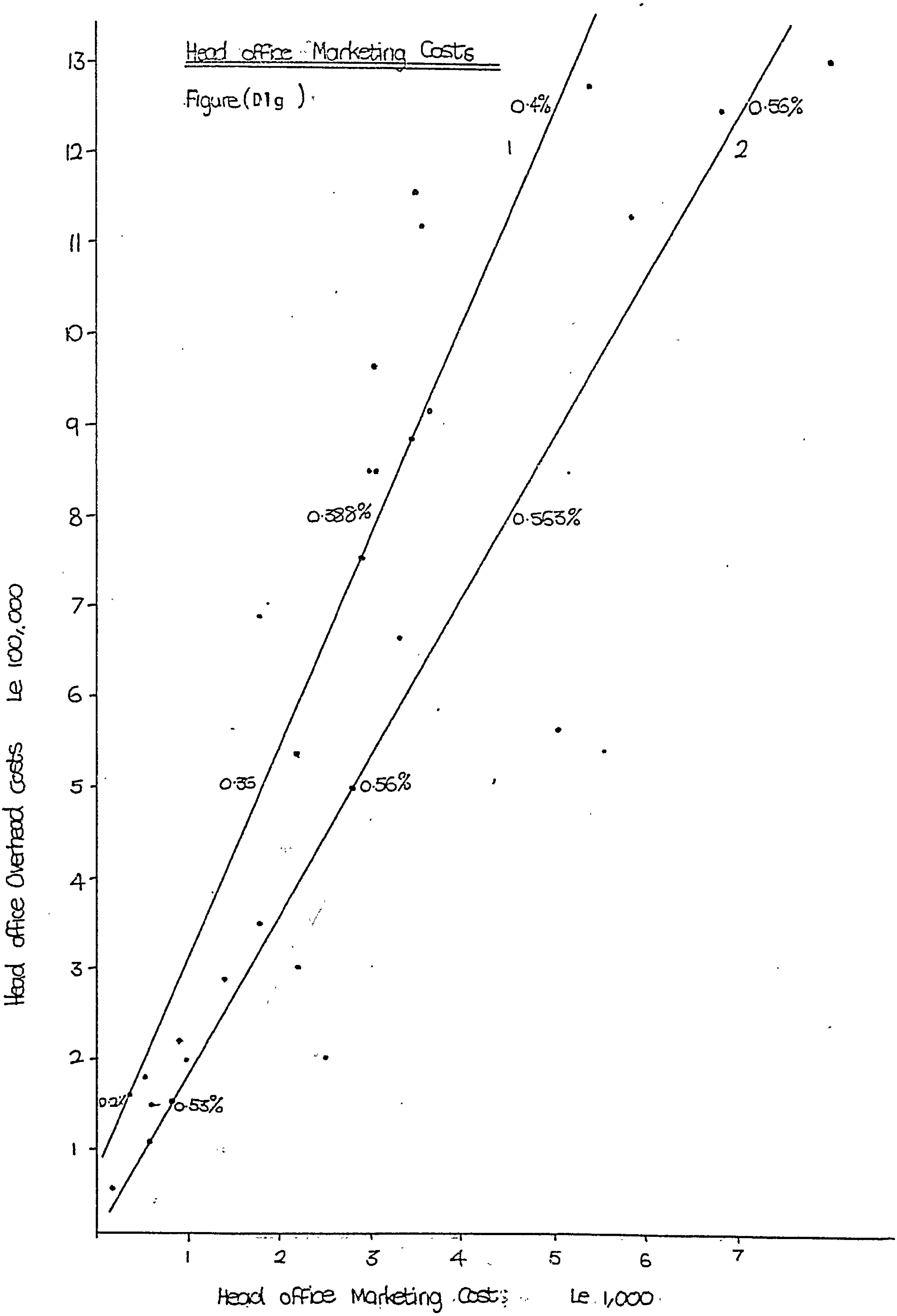

Senior Staff Costs
Figure (.D1b)
Head office Overhead Costs Le 100,000
Head office Senior Staff Costs Le 100,000
13
12
11
10
9
8
7
6
5
4
3
2
1
1
2
3
4
1
2
29%
32%
28%
4%
32%
25%
33%
20%
35%

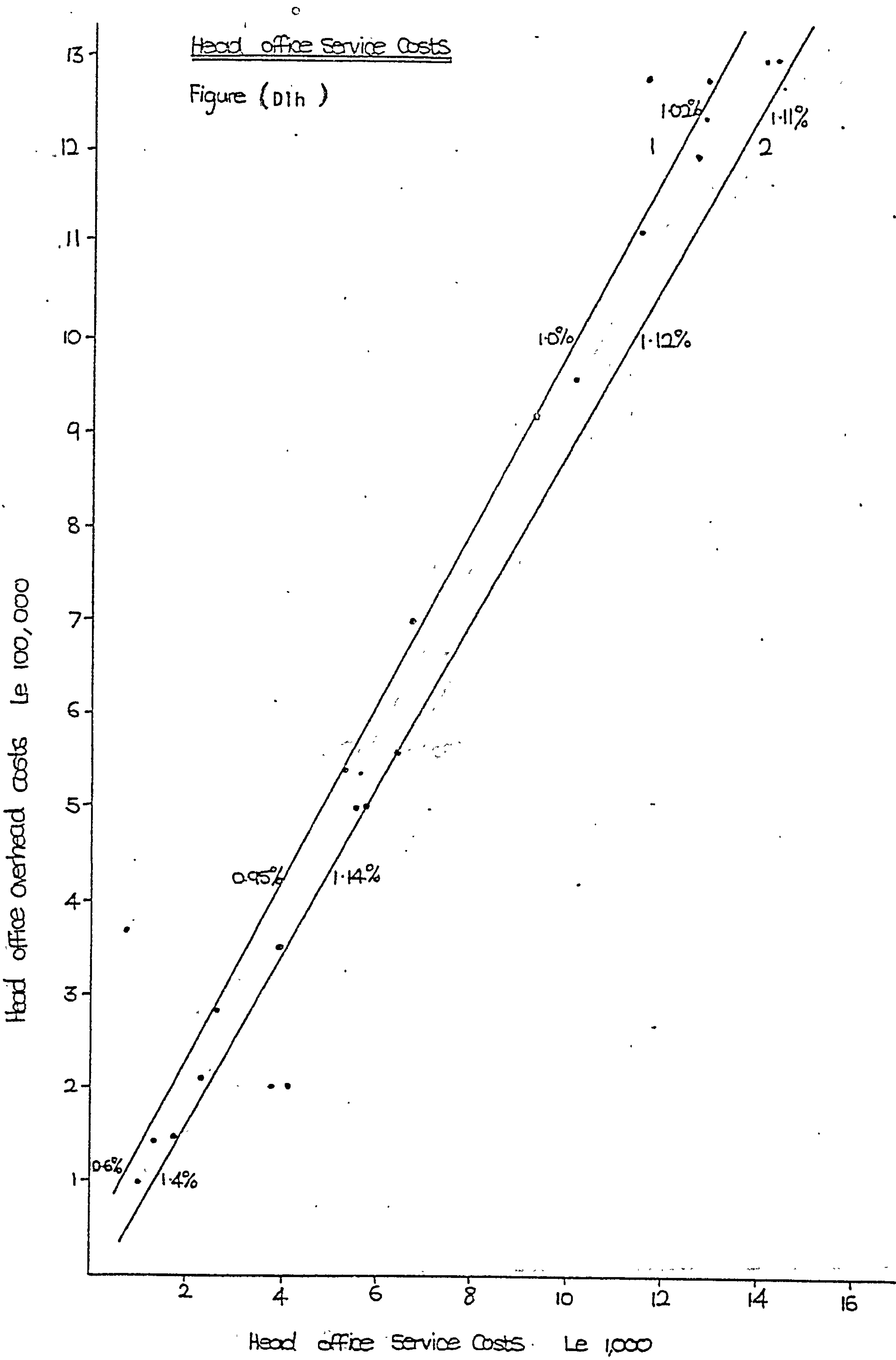

Head office other Staff Costs
Figure (D1c)
25%
1
2697%
2
25%
27%
23%
27%
20%
39%
Head Office Overhead Costs Le 100,000
Head office other Staff Costs Le. 100, 000
0
1
2
3
4
5
6
7
8
9
10
11
12
13

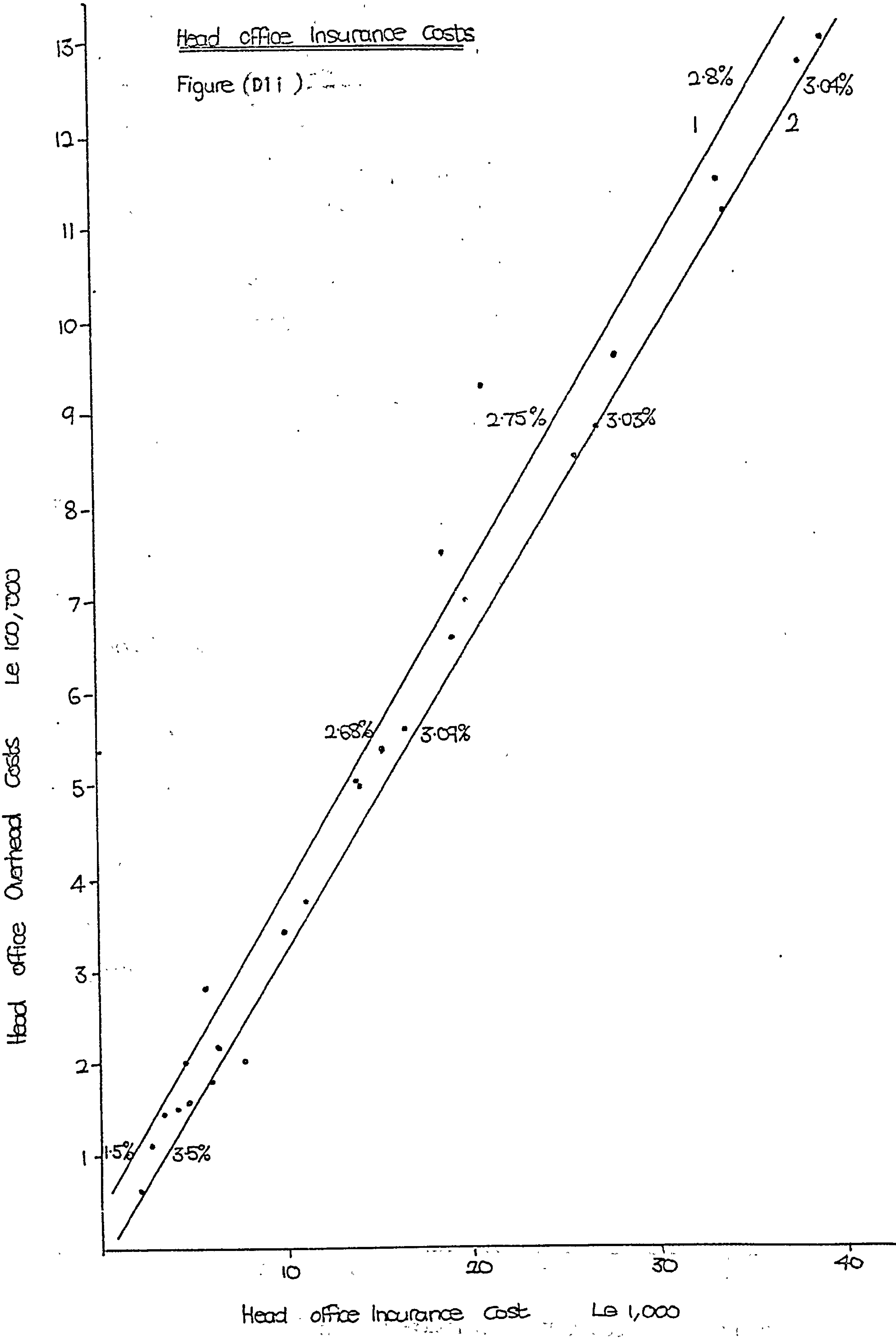

Head Office Accommodation Costs
Fig. (DId /)
10·8%
12·69%
1
2
10·70%
12·70%
10%
12%
10%
13%
15%
15%
Head office overhead Costs Le 100,000
Head office Accommodation Costs Le 100,000
13
12
11
10
9
8
7
6
5
4
3
2
1
1
2
3

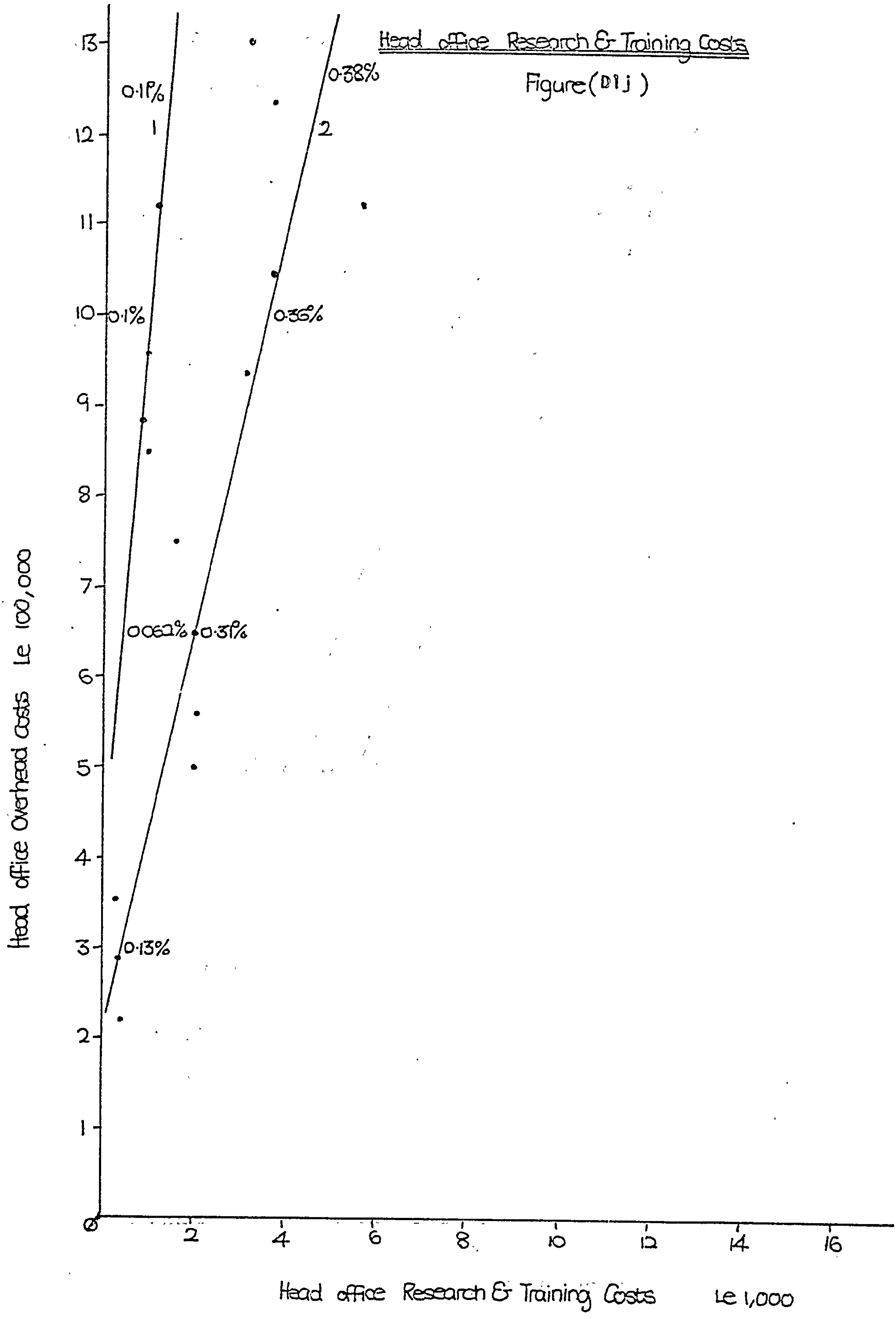

Head office Transport Costs
Fig.(D1e.)
14.95%
17.58%
1
2
14.76%
17.62%
14%
18%
13.33%
18.33%
9.5%
20%
13
12
11
10
9
8
7
6
5
4
3
2
1
1
2
3
4
Head office Overhead Costs Le 100,000
Head office Transport costs Le 100,000

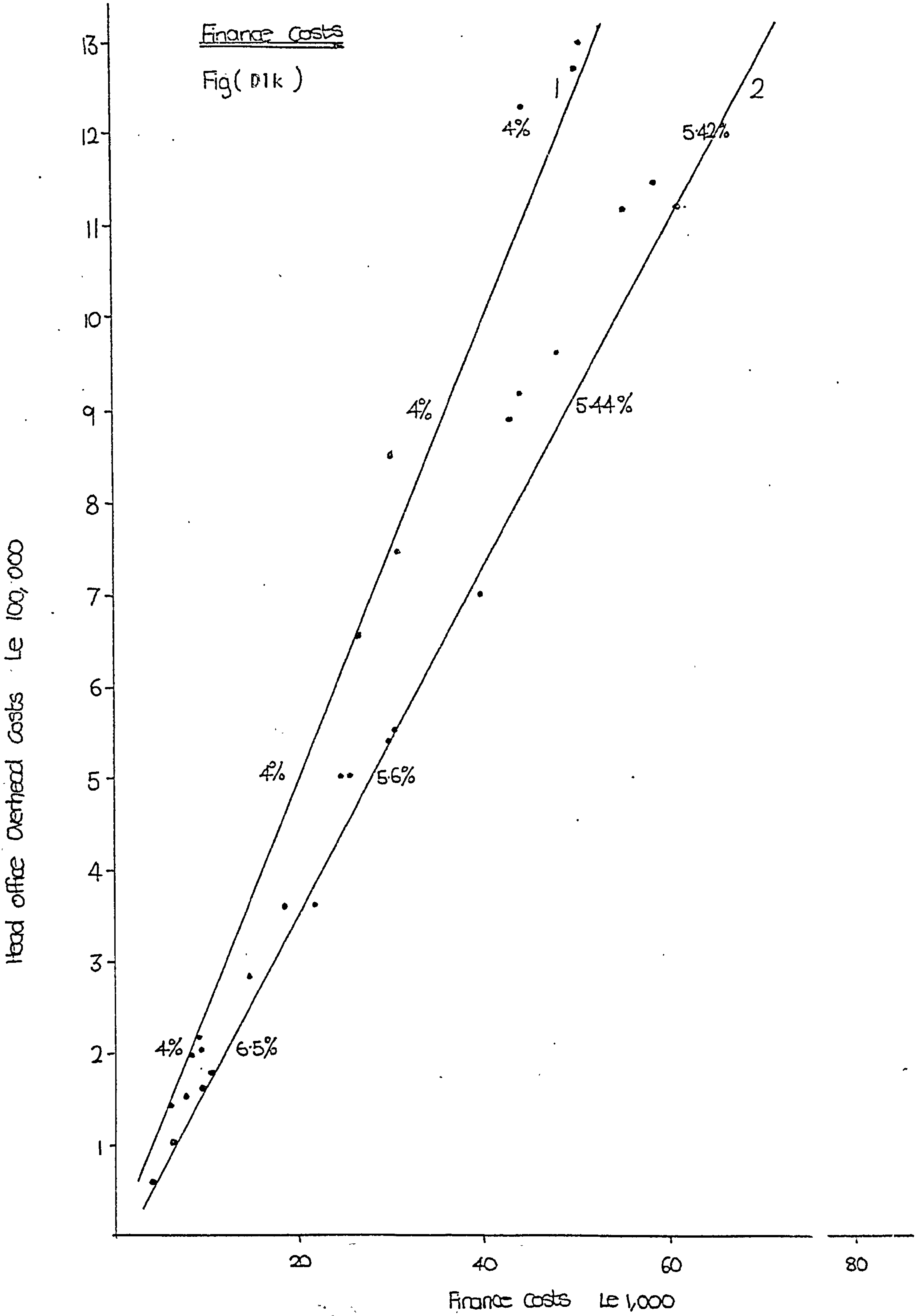

Head office Communication Costs
Figure (D1F)
1
2
3.78%
4.17%
3.74%
4.22%
3.33%
4.33%
2%
5%
Head office Overhead Costs Le 100,000
Head office comminication costs Le 1,000
13
12
11
10
9
8
7
6
5
4
3
2
1
10
20
30
40
50
60

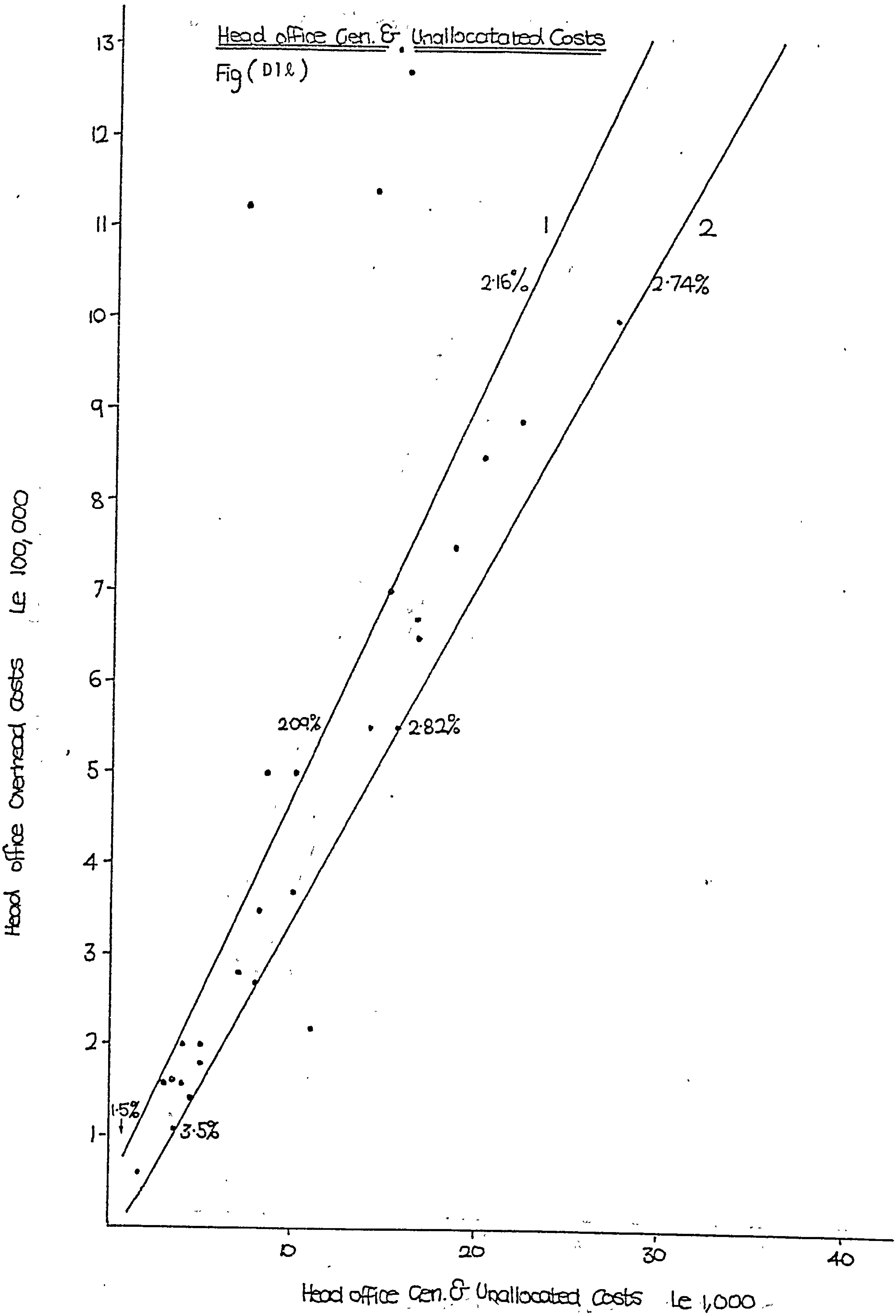

Head office Marketing Costs
Figure (D1g)
0.4%
1
0.56%
2
0.388%
0.563%
0.35
0.56%
0.2%
0.53%
13
12
11
10
9
8
7
6
5
4
3
2
1
1
2
3
4
5
6
7
Head office Overhead costs Le 100,000
Head office Marketing Costs Le 1,000


Head office Service Costs
Figure (D1h)
1·02%
1·11%
1
2
1·0%
1·12%
0·95%
1·4%
0·6%
1·4%
Head office overhead costs Le 100,000
Head office Service Costs Le 1,000
1
2
3
4
5
6
7
8
9
10
11
12
13
2
4
6
8
10
12
14
16


Head office Insurance Costs
Figure (D1i)
Head office Overhead Costs Le 100,000
Head office Insurance Cost Le 1,000
1
2
2·8%
3·04%
2·75%
3·03%
2·68%
3·09%
1·5%
3·5%
13
12
11
10
9
8
7
6
5
4
3
2
1
10
20
30
40

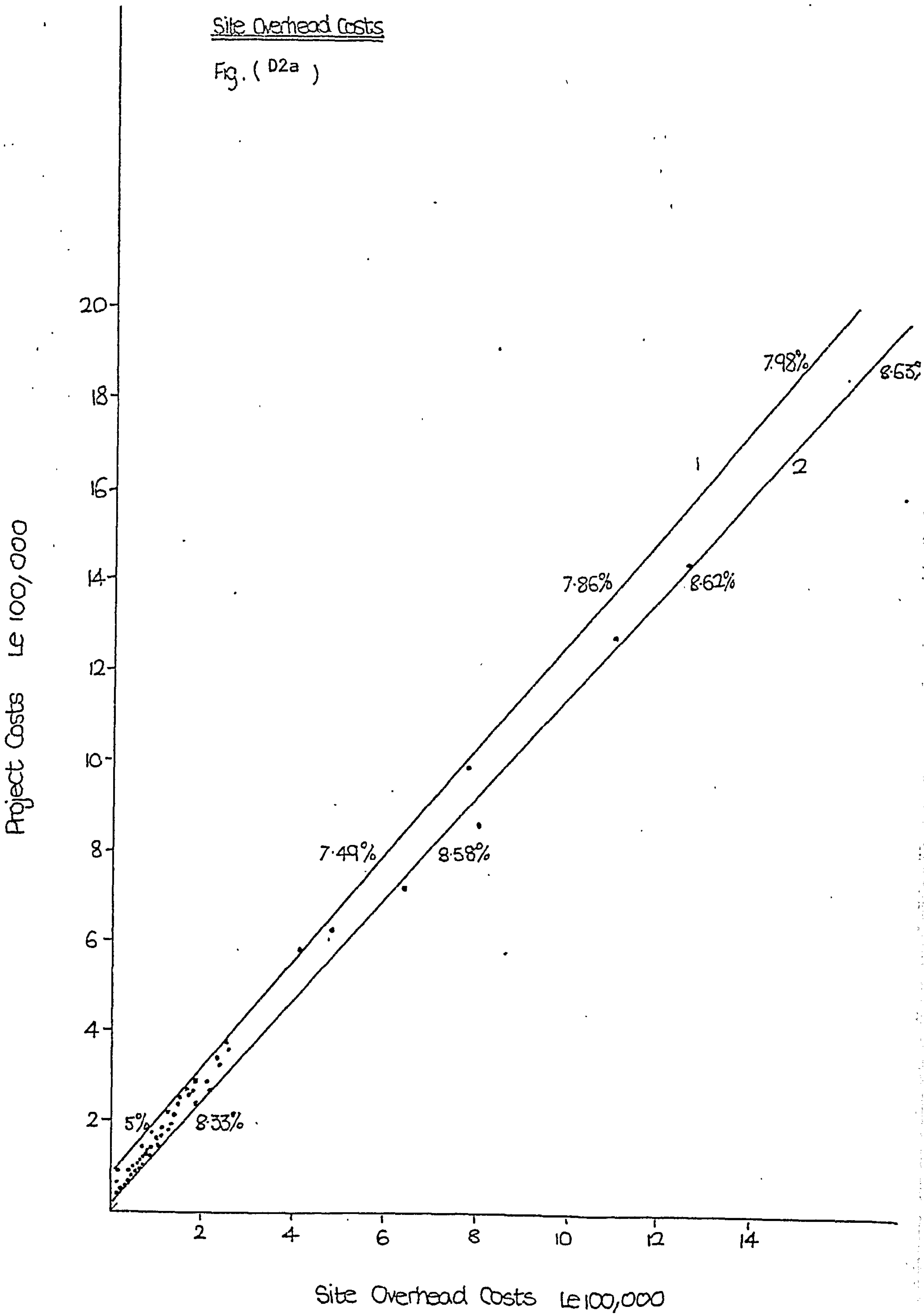

Head office Research & Training Costs
Figure(D1j)
0·1%
1
0·38%
2
0·1%
0·36%
0·062%
0·31%
0·13%
13
12
11
10
9
8
7
6
5
4
3
2
1
0
2
4
6
8
10
12
14
16
Head office Overhead costs Le 100,000
Head office Research & Training Costs Le 1,000


Finance Costs
Fig(D1k)
1
2
4%
5·42%
4%
5·44%
4%
5·6%
4%
6·5%
Head office Overhead Costs Le 100,000
13
12
11
10
9
8
7
6
5
4
3
2
1
20
40
60
80
Finance Costs Le 1,000

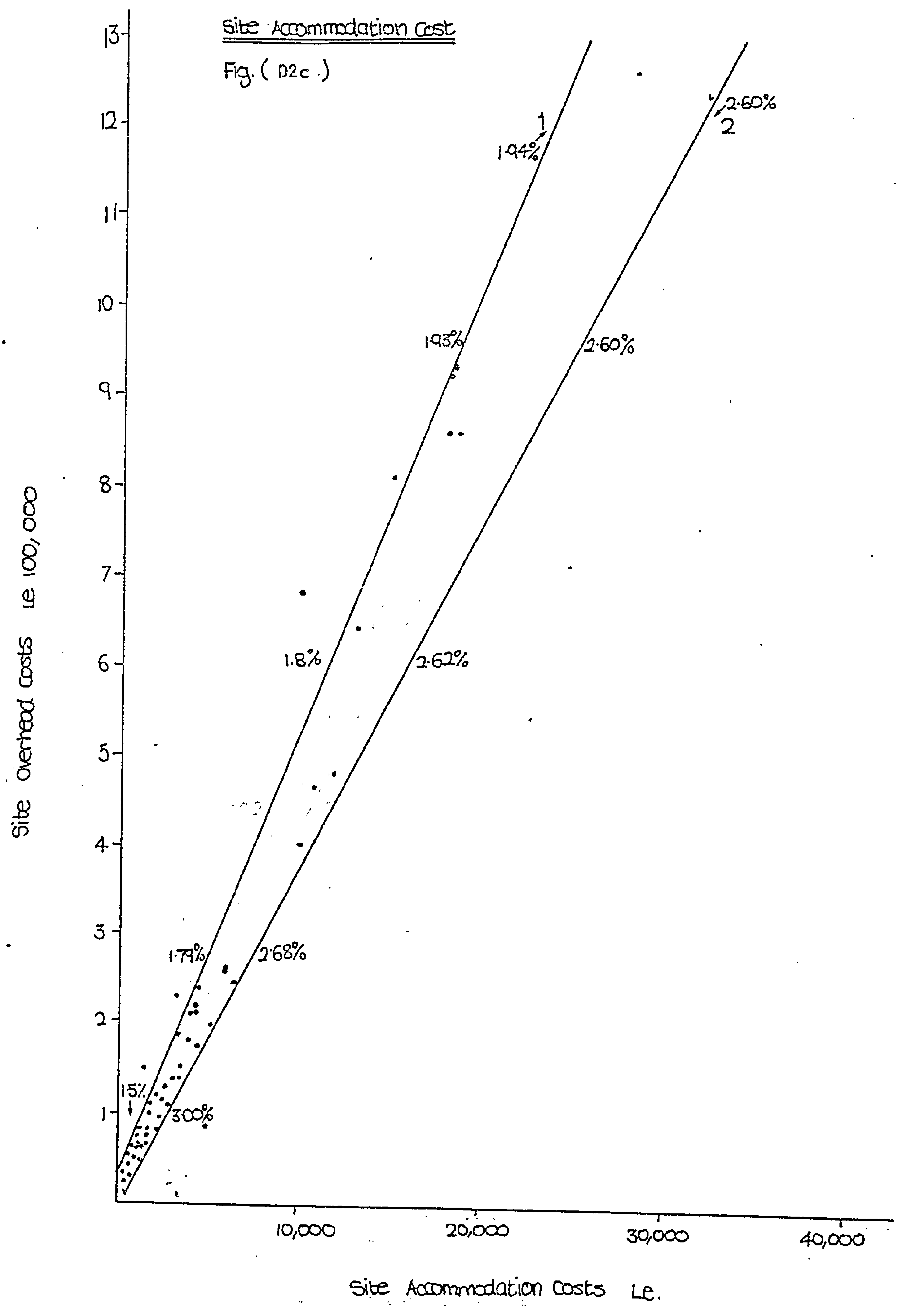

Head office Gen. & Unallocatated Costs
Fig (D1l)
1
2
2·16%
2·74%
2·09%
2·82%
1·5%
3·5%
Head office Overhead costs Le 100,000
Head office Gen. & Unallocated Costs Le 1,000
13
12
11
10
9
8
7
6
5
4
3
2
1
10
20
30
40


Head Office Gen. & Unallocated Costs (ADJUSTED)
Fig.(D1m)
Head office Overhead costs Le 100,000.
Head office General & Unallocated Costs Le 10,000
1
2
3
4
5
6
7
8
9
10
11
12
13
2
4
6
8
10
12
14

D.2 SITE OVERHEADS

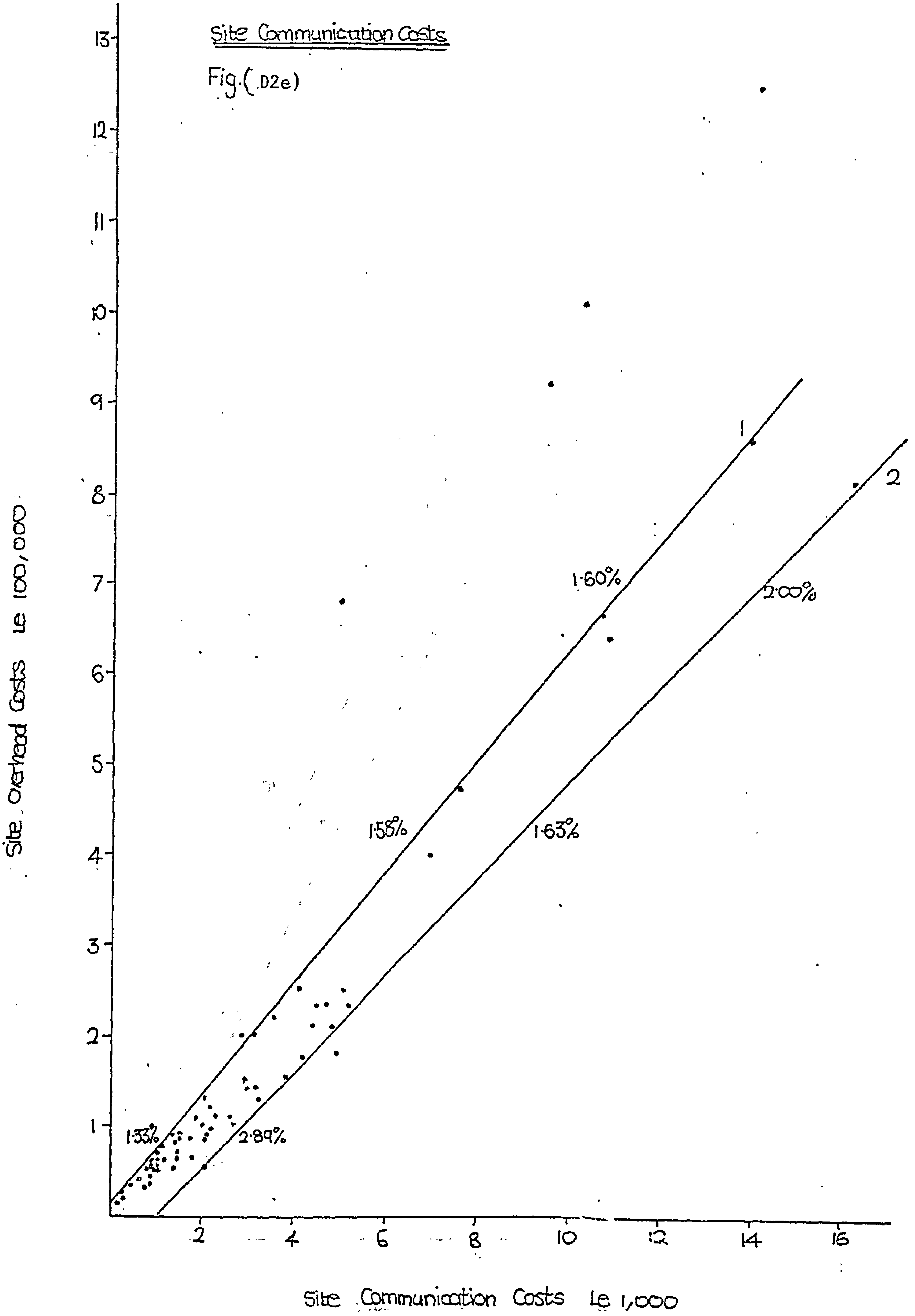


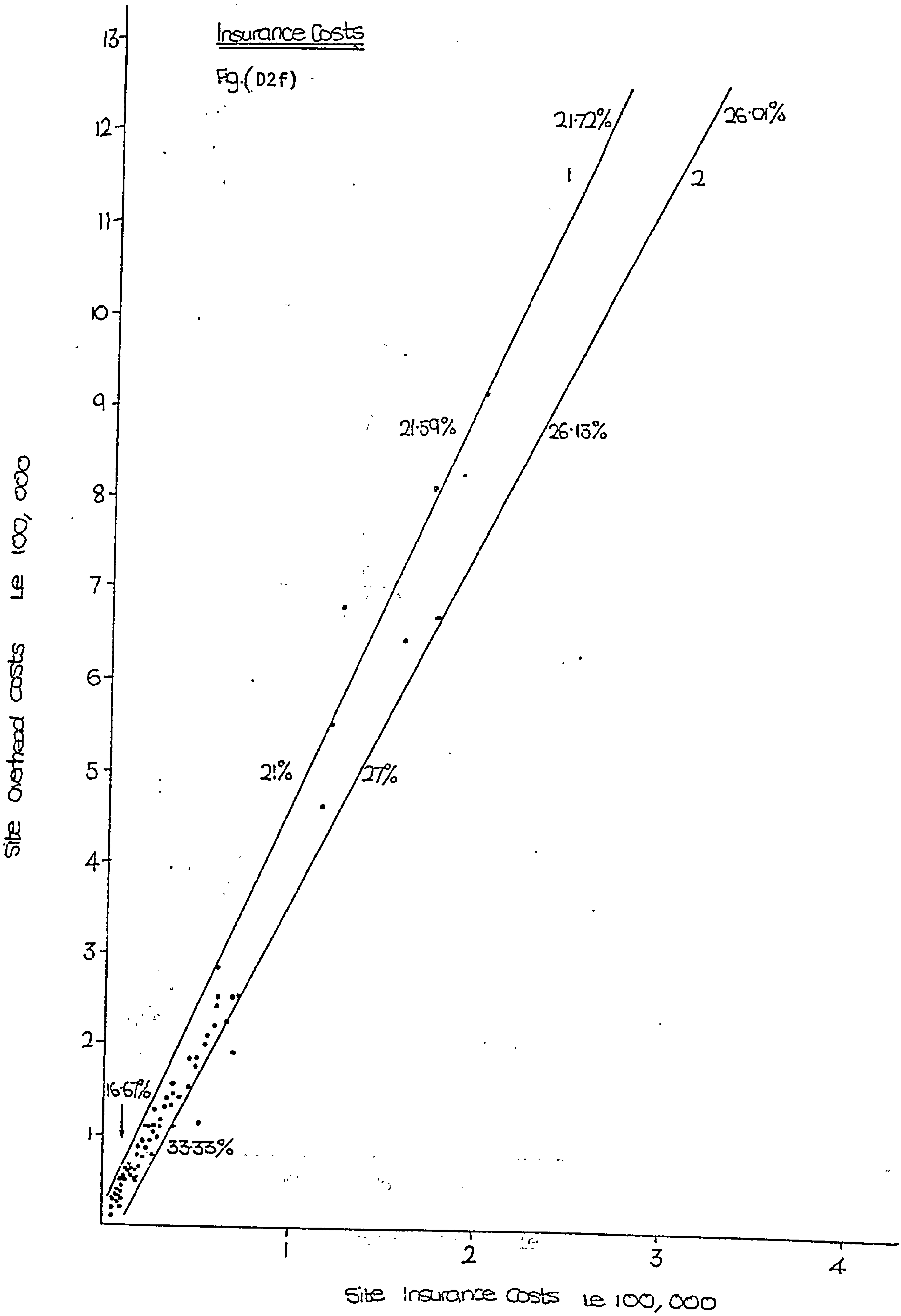

Site Staff Costs
Fig (D26 ·)
16·54%
22·22%
1
2
18·04%
22·17%
16·67%
21·93%
7·14%
21·43%
Site Overhead costs Le 100,000
Site Staff Costs Le 1,000
13
12
11
10
9
8
7
6
5
4
3
2
1
100
200
300
400

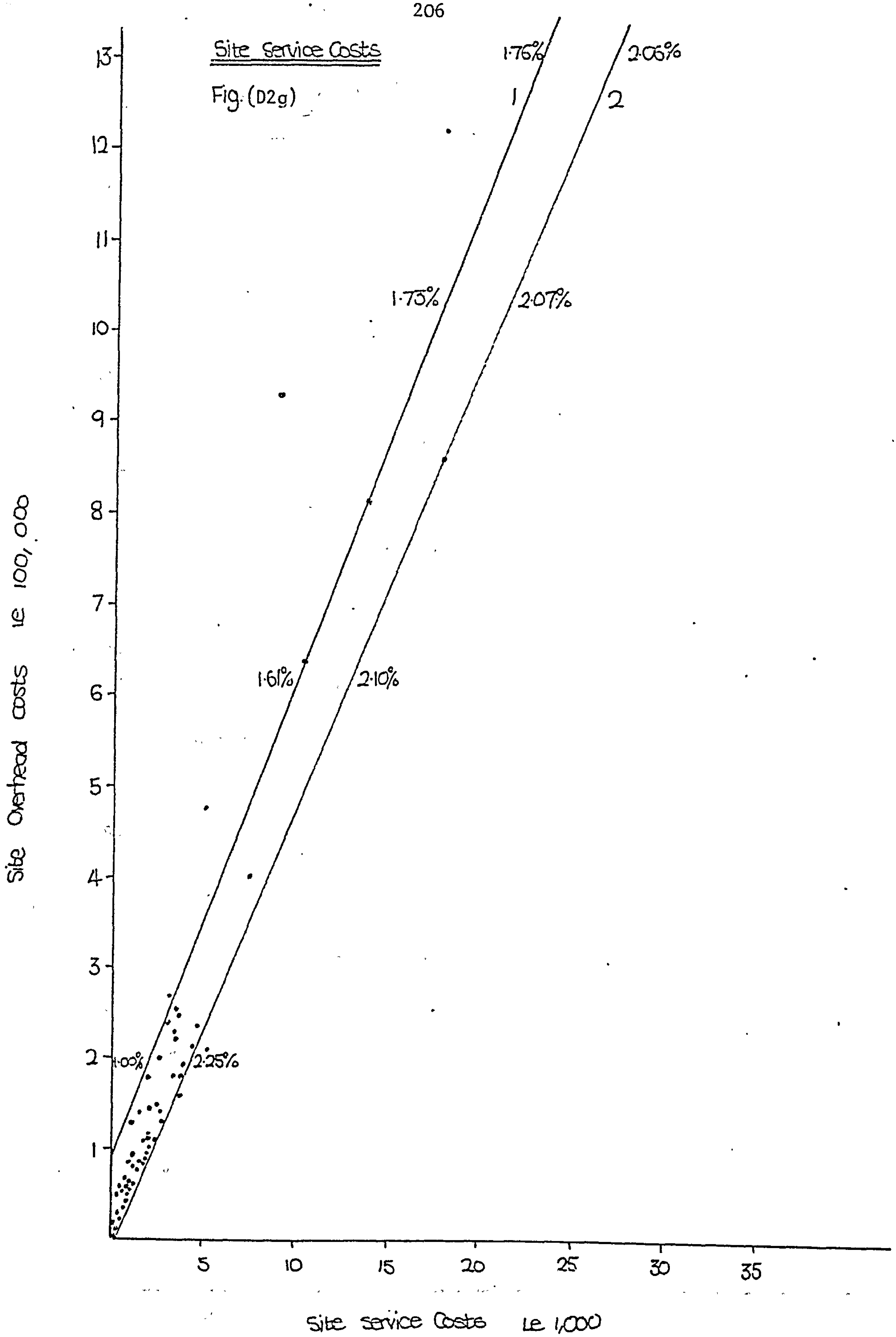


Site Accommodation Cost
Fig. (D2c)
1
1.94%
2.60%
2
1.93%
2.60%
1.8%
2.62%
1.79%
2.68%
1.5%
3.00%
Site Overhead Costs Le 100,000
13
12
11
10
9
8
7
6
5
4
3
2
1
10,000
20,000
30,000
40,000
Site Accommodation Costs Le.


Site Transport Costs
Fig.(D2d)
Site Overhead costs Le.100,000
Site Transport costs Le 100,000
44·19%
48·83%
1
2
43·75%
48·75%
42·22%
48·89%
28·37%
50·00%
1
2
3
4
5
6
7
8
9
10
11
12
13
1
2
3
4
5
6
8


Site Communication Costs
Fig.(D2e)
Site Overhead Costs LE 100,000
Site Communication Costs LE 1,000
1
2
1·60%
2·00%
1·58%
1·63%
1·33%
2·89%
1
2
3
4
5
6
7
8
9
10
11
12
13
2
4
6
8
10
12
14
16

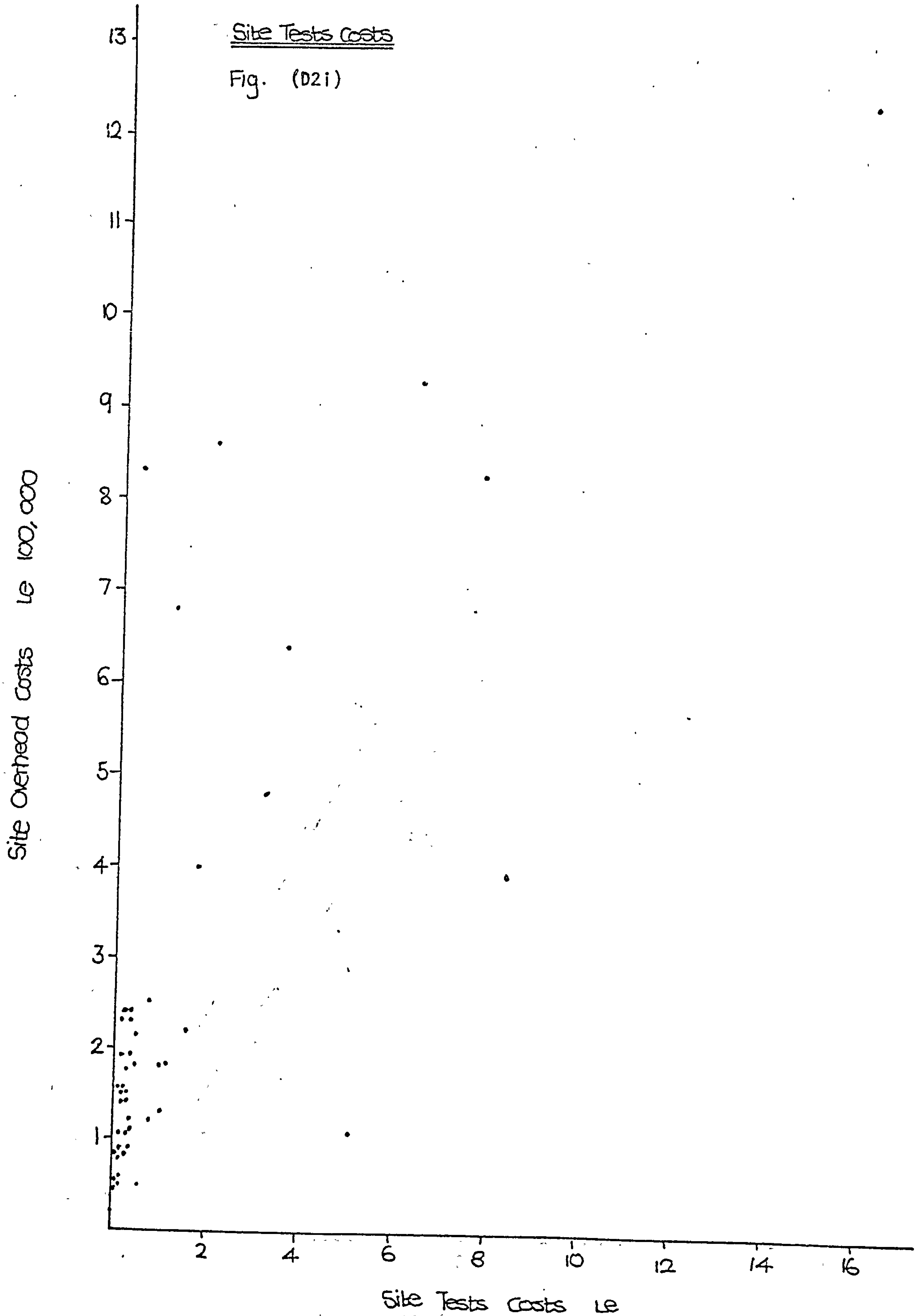

Insurance Costs
Fig.(D2f)
21·72%
26·01%
1
2
21·59%
26·13%
21%
27%
16·67%
33·33%
Site overhead costs Le 100,000
Site Insurance Costs Le 100,000
1
2
3
4
5
6
7
8
9
10
11
12
13

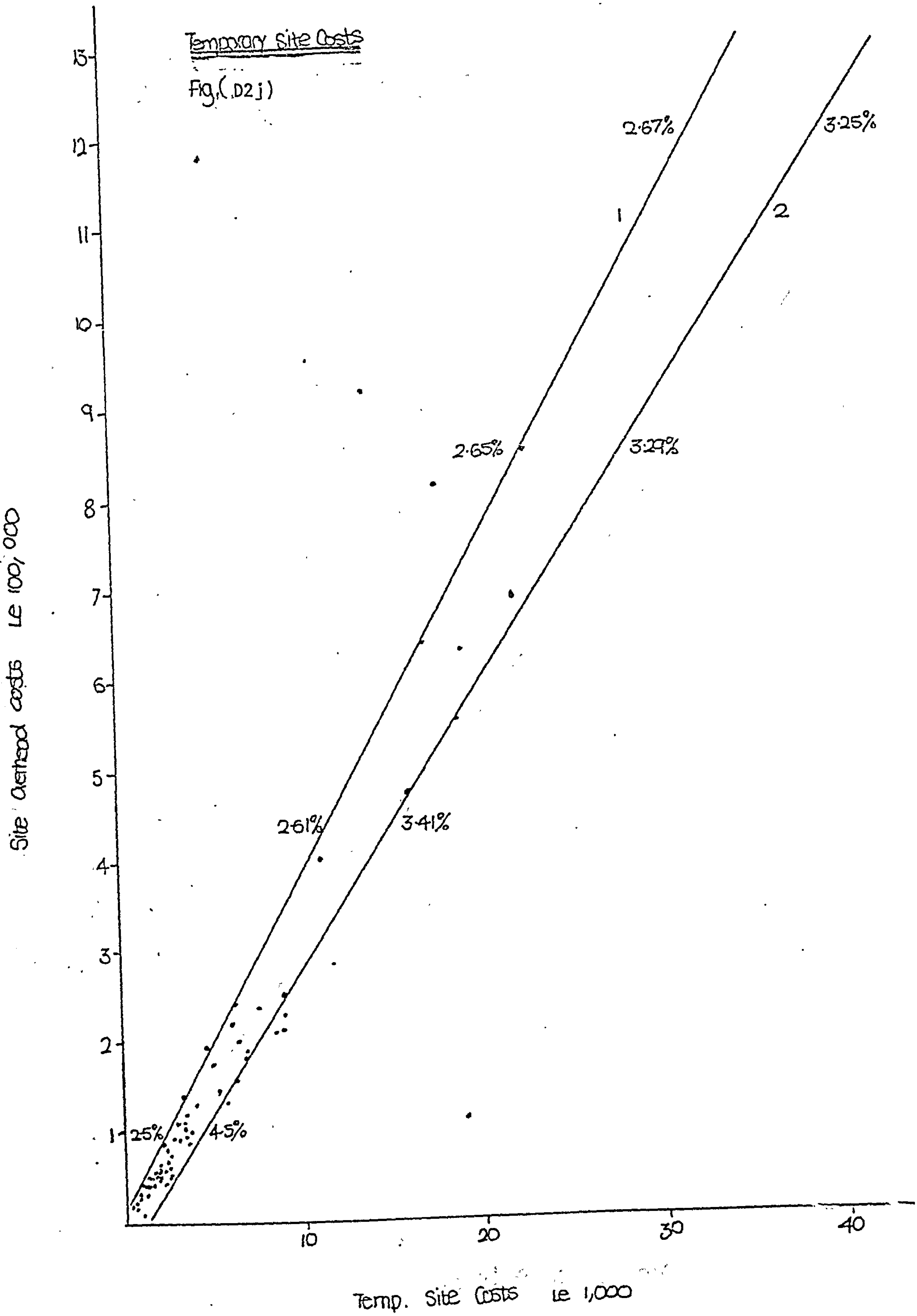

Site Service Costs
Fig. (D2g)
1·76%
2·06%
1
2
1·75%
2·07%
1·61%
2·10%
1·00%
2·25%
Site Overhead costs LE 100,000
Site service Costs LE 1,000
13
12
11
10
9
8
7
6
5
4
3
2
1
5
10
15
20
25
30
35

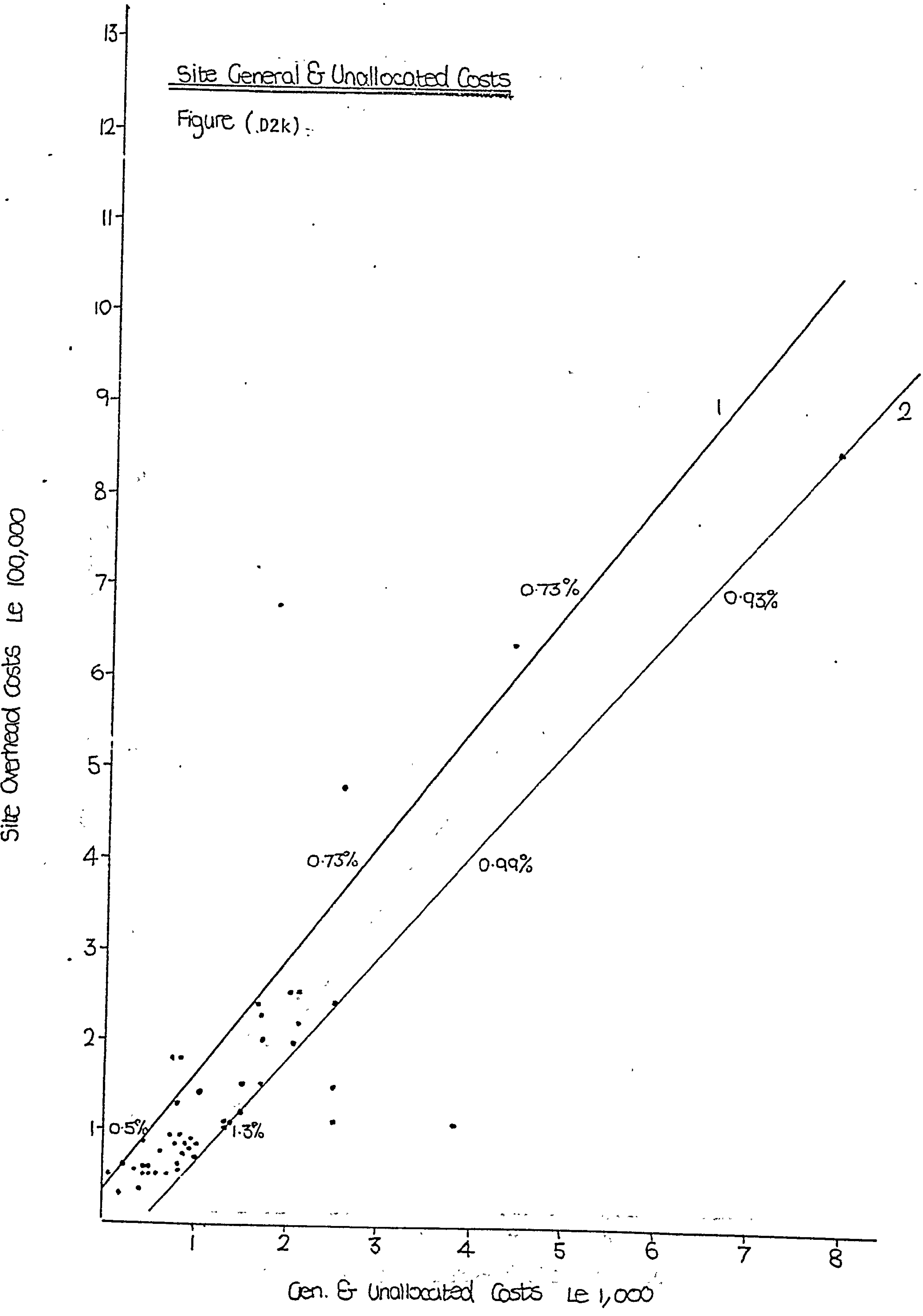

Minor plant Costs
Fig.(D2h)
1
2·20%
2
3·47%
2·18%
3·50%
2·33%
3·50%
1·88%
3·75%
Site overhead costs Le 100,000
Site Minor plant Costs Le 1,000
0
10
20
30
40
50
1
2
3
4
5
6
7
8
9
10
11
12
13

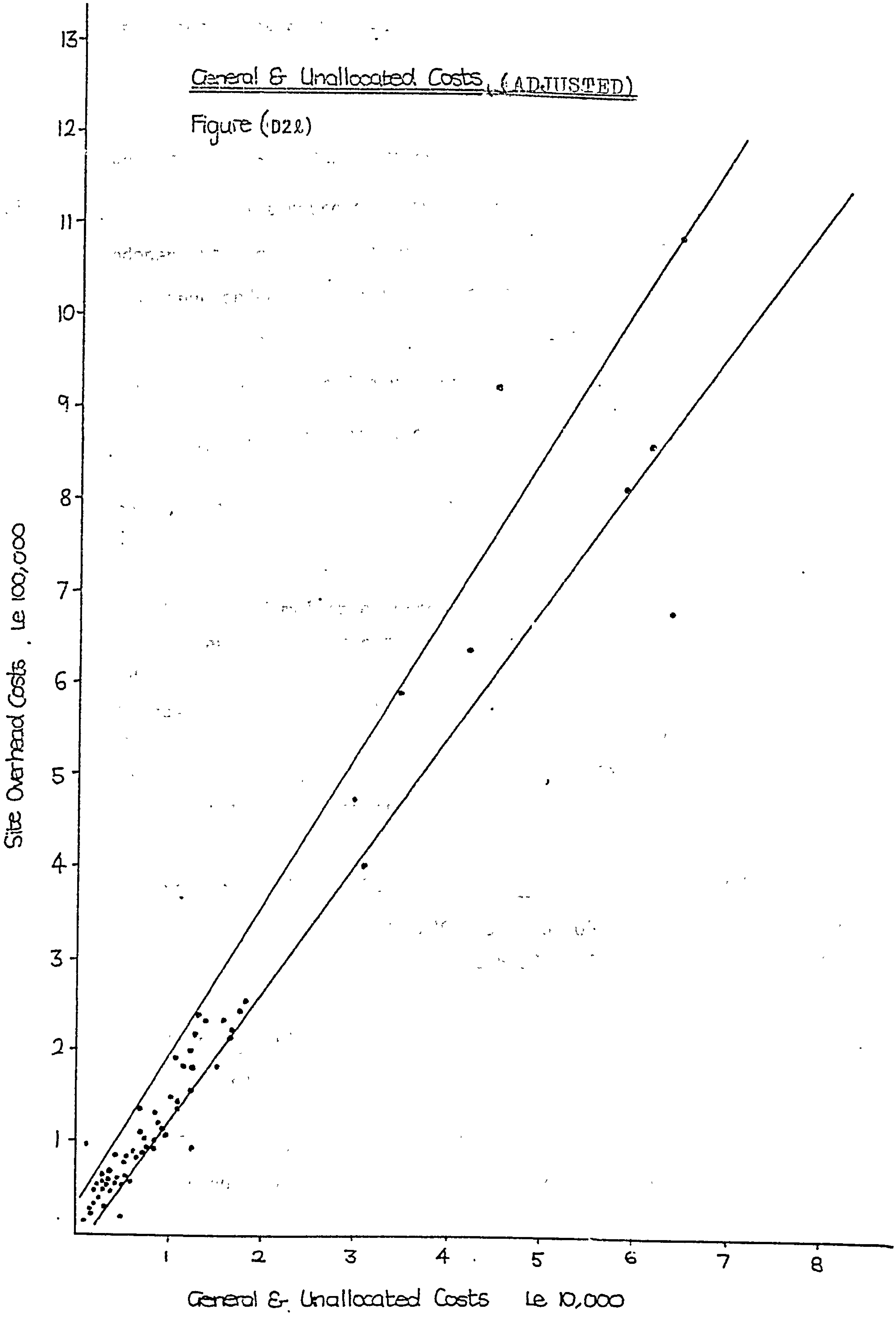
Site Tests Costs

Fig. (D2i)




Temporary Site Costs
Fig.(D2j)
2·67%
3·25%
1
2
2·65%
3·29%
2·61%
3·41%
1·25%
4·5%
13
12
11
10
9
8
7
6
5
4
3
2
1
10
20
30
40
Site Overhead costs LE 100,000
Temp. Site Costs LE 1,000


Site General & Unallocated Costs
Figure (.D2k)
Site Overhead Costs LE 100,000
Gen. & Unallocated Costs LE 1,000
13
12
11
10
9
8
7
6
5
4
3
2
1
1
2
3
4
5
6
7
8
0.73%
0.93%
0.73%
0.99%
0.5%
1.3%


General & Unallocated Costs (ADJUSTED)
Figure (D2l)
13
12
11
10
9
8
7
6
5
4
3
2
1
Site Overhead Costs , Le 100,000
1
2
3
4
5
6
7
8
General & Unallocated Costs Le 10,000

E REGRESSION ANALYSIS OUTPUT

E.1 HEAD OFFICE (Tender Stage) Model

E.1.1 In the last round of regression analysis, the independent variables were entered in a specified order. The first independent variable to be entered into the regression equation was the estimated direct costs project X_1. This gave rise the the model equation

$$C_{1ko} = -3549.3932 + 0.694139 \times 10^{-1} \times (X_1) \qquad \text{eqn}(E1.a)$$

The other parameters computed are:

Coefficient of multiple correlation	R	=	0.99455
Coefficient of determination R^2	R^2	=	0.98913
Adjusted R^2		=	0.98889
Change in R at this step		=	-
F-Value		=	4094.90850
Standard Deviation	σ	=	24248.97799
Coefficient of variability		=	11.5%

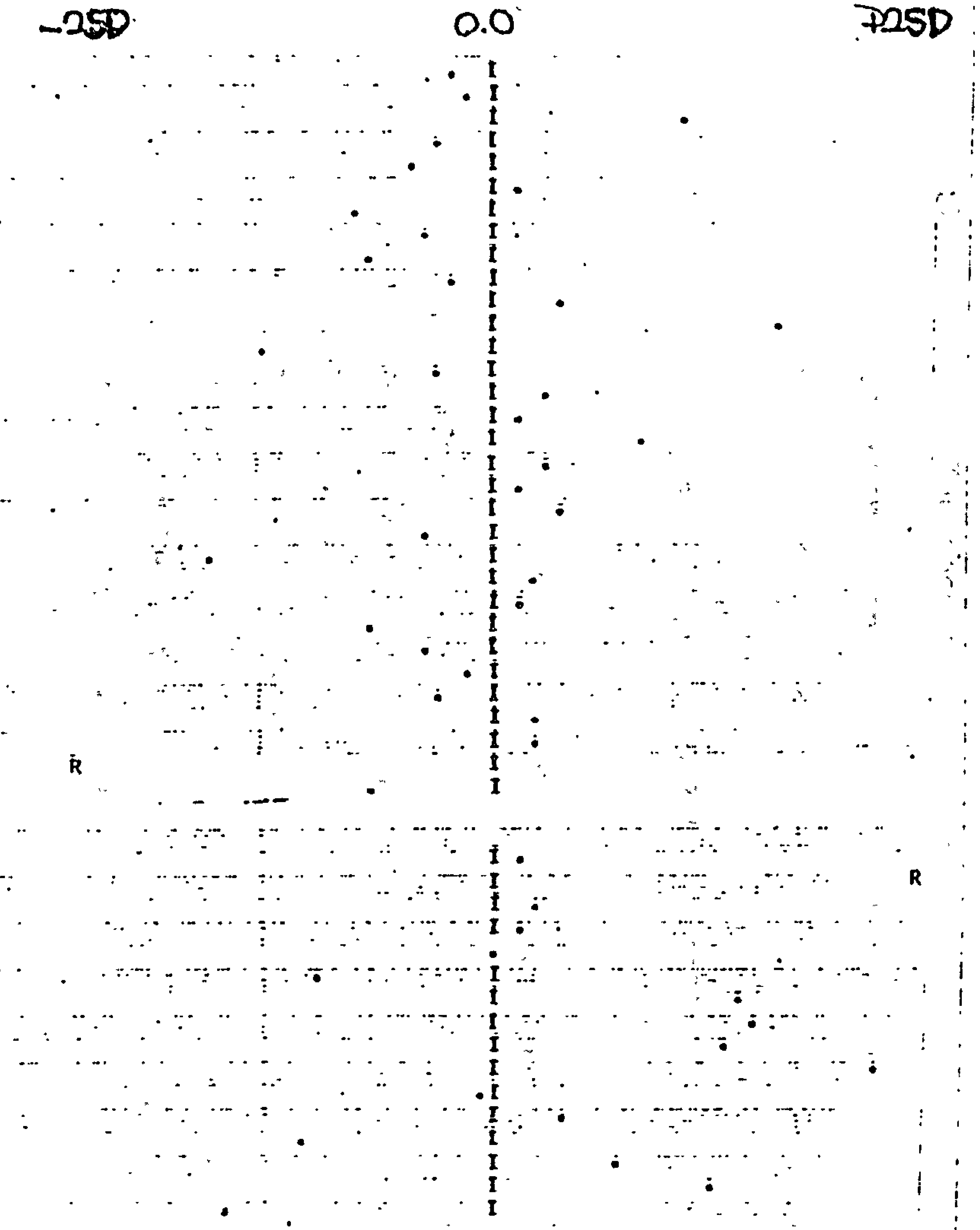
Analysis of variance	D.F	S.S	M.S
Regression	1	2407859159683.07812	2407859159583.07812
Residuals	45	26460582014.75574	388012933.66124

F-Values of Variables

X_1 = 4094.90850

The actual C_{1ko} values, the estimated C_{1ko} values and the residuals are tabulated and plotted in figure (E1a).

Observation	C_1ko Value	C_1ko Estimate	Residual
1.	106126.0	109791.1	-3665.134
2.	62049.00	64494.66	-2445.656
3.	106624.0	84281.51	22342.49
4.	46078.00	51032.17	-4954.170
5.	187504.0	195636.0	-8131.969
6.	35886.00	33244.16	2641.844
7.	110079.0	125736.3	-15657.35
8.	53493.00	61481.05	-7988.050
9.	145983.0	160418.8	-14435.81
10.	84584.00	88188.75	-3604.754
11.	202575.0	194502.4	8072.560
12.	271694.0	238236.8	33457.24
13.	137931.0	164177.6	-26246.57
14.	59971.00	65543.15	-5572.153
15.	88622.00	82971.60	5650.397
16.	38127.00	35484.84	2642.162
17.	106797.0	89896.89	16900.11
18.	103892.0	98020.96	5871.040
19.	172530.0	170016.0	2514.019
20.	51787.00	43896.49	7890.513
21.	64357.00	72295.88	-7938.879
22.	202903.0	236797.7	-33894.74
23.	68325.00	64987.15	3337.853
24.	59274.00	56515.94	2758.060
25.	95275.00	109306.3	-14031.28
26.	67431.00	74462.57	-7031.566
27.	45642.00	48388.26	-2746.263
28.	57836.00	63250.48	-5414.480
29.	23208.00	19140.98	4067.020
30.	14338.00	10370.88	3967.123
31.	486328.0	590785.4	-104457.4
32.	164800.0	179188.4	-14388.41
33.	405156.0	402753.0	2403.016
34.	305789.0	249971.1	55817.89
35.	71126.00	67693.04	3432.959
36.	123317.0	121413.7	1903.267
37.	264585.0	264564.1	20.92640
38.	174483.0	194658.6	-20175.62
39.	710086.0	681034.5	29051.52
40.	530880.0	500562.4	30317.65
41.	205587.0	179407.0	26180.01
42.	933960.0	889426.1	44533.86
43.	1006398.	1007277.	-879.1186
44.	186395.0	178424.1	7970.216
45.	200526.0	223144.0	-22618.02
46.	453443.0	439764.1	13678.92
47.	151536.0	127118.2	24417.83
48.	700700.0	732296.0	-31595.98



NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
R INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED 47.
NUMBER OF 2 S.D. OUTLIERS 2. OR 4.26 PERCENT OF THE TOTAL

DETERMINATION OH OF HEAD OFFICE OVERHEAD COST TO BE 05/06/81 17.08.06. PAGE 7

FILE NONAME (CREATION DATE = 05/06/81)

Figure (E1 a) Result of Regression Analysis for C_1ko with X4

E.1.2. The second independent variable to be entered into the regression equation was the planned duration of project X_2. This gave rise to the model equation:

$$C_{1ko} = 10286.157 + 0.7252022\times10^{-1}(X_1) - 1391.6427(X_2)$$

eqn(E1b)

The other parameters computed are:

Coefficient of multiple correlation R	=	0.99497
Coefficient of determination R^2	=	0.98996
Adjusted R^2	=	0.98950
Change in R at this step	=	0.00042
F-Value	=	2168.38702
Standard Deviation	=	23572.92008
Coefficient variability	=	11.2%

Analysis of Variance	D.F		
Regression	2	2409869709014.01563	1204934854507.00781
Residuals	44	24450032683.81262	555682560.99574

F-values of variables

X_1 = 1391.7625

X_2 = 3.61816

The actual C_{1ko} values, the estimated C_{1ko} values and the residuals are tabulated and plotted in fiture(E1b)

Fig(E7b)

Observation	C_2ko Value	C_2ko Estimate	Residual	$-2SD$ X_1X_2 0.0 $+2SD$
1.	106126.0	100865.8	5260.156	
2.	62049.00	56325.62	5723.377	
3.	106624.0	85347.80	21276.20	
4.	46078.00	54785.47	-8707.474	
5.	187504.0	186377.3	1126.673	
6.	35886.00	37593.08	-1707.084	
7.	110079.0	124482.8	-14403.82	
8.	53493.00	62918.66	-9425.657	
9.	145983.0	156542.4	-10559.41	
10.	84584.00	85254.97	-670.9668	
11.	202575.0	182409.8	20165.21	
12.	271694.0	219751.4	51942.63	R
13.	137931.0	157686.1	-19755.09	
14.	59971.00	74120.75	-14149.75	
15.	88622.00	86762.56	1859.439	
16.	38127.00	42717.32	-4590.322	
17.	106797.0	87039.54	19757.46	
18.	103892.0	91352.24	12539.76	
19.	172530.0	167960.7	4569.305	
20.	51787.00	45938.82	5848.176	
21.	64357.00	75609.10	-11252.10	
22.	202903.0	221031.2	-18128.24	
23.	68325.00	63798.37	4526.632	
24.	59274.00	60514.64	-1240.644	
25.	95275.00	108709.1	-13434.15	
26.	67431.00	73697.81	-6266.814	
27.	45642.00	50631.61	-4989.608	
28.	57836.00	67550.56	-9714.556	
29.	23208.00	25642.07	-2434.073	
30.	14338.00	17871.15	-3533.149	
31.	486328.0	579726.8	-93398.79	R
32.	164800.0	184501.8	-19701.80	
33.	405156.0	409721.1	-4565.090	
34.	305789.0	251493.8	54295.16	R
35.	71126.00	70800.28	325.7204	
36.	123317.0	125533.3	-2216.342	
37.	264585.0	259781.6	4803.377	
38.	174483.0	190922.8	-16439.81	
39.	710086.0	683756.0	26329.96	
40.	530880.0	503557.6	27322.41	
41.	205587.0	187513.5	18073.54	
42.	933960.0	893123.4	40836.58	
43.	1006398.	1014857.	-8458.603	
44.	186395.0	185095.7	1299.349	
45.	200526.0	233207.7	-32681.72	
46.	453443.0	438646.9	14796.06	
47.	151536.0	135668.0	15868.02	
48.	700700.0	730353.3	-29653.28	

NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
R INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED 47.
NUMBER OF 2 S.D. OUTLIERS 3. OR 6.38 PERCENT OF THE TOTAL

DETERMINATION ON OF HEAD OFFICE OVERHEAD COST TO BE 05/06/81 17.05.00. PAGE 24

FILE NONAME (CREATION DATE = 05/06/81)

* M U L T I P L E R E G R E S S I O N *

VON NEUMANN RATIO 1.72922 DURBIN-WATSON TEST 1.69242

NUMBER OF POSITIVE RESIDUALS 22.
NUMBER OF NEGATIVE RESIDUALS 25.
NUMBER OF RUNS OF SIGNS 22.

EXPECTED NUMBER OF RUNS OF SIGNS 24.
EXPECTED S.D. OF RUN DISTRIBUTION 3.37624

E.1.3. The third independent variable to be entered into the regression equation was the inflation variable X_3. This gave rise to the model equation

$$C_{1ko} = 84.608067 + 0.07254872\times(X_1) - 1407.9522(X_2) + 47.68469(X_3) \qquad \text{eqn(E1c)}$$

The other parameters computed are:

Coefficient of multiple correlation R	=	0.99498
Coefficient of determination R^2	=	0.98998
Adjusted R^2	=	0.98950
Change in R at this step	=	0.00001
F-Value	=	1415.53386
Standard deviation	=	23822.11583
Coefficient of variability	=	11.3%

Analysis of Variance	D.F	S.S	MS
Regression	3	2409917533980.10937	803305844660.03516
Residuals	43	2402201717.72192	567493202.73772

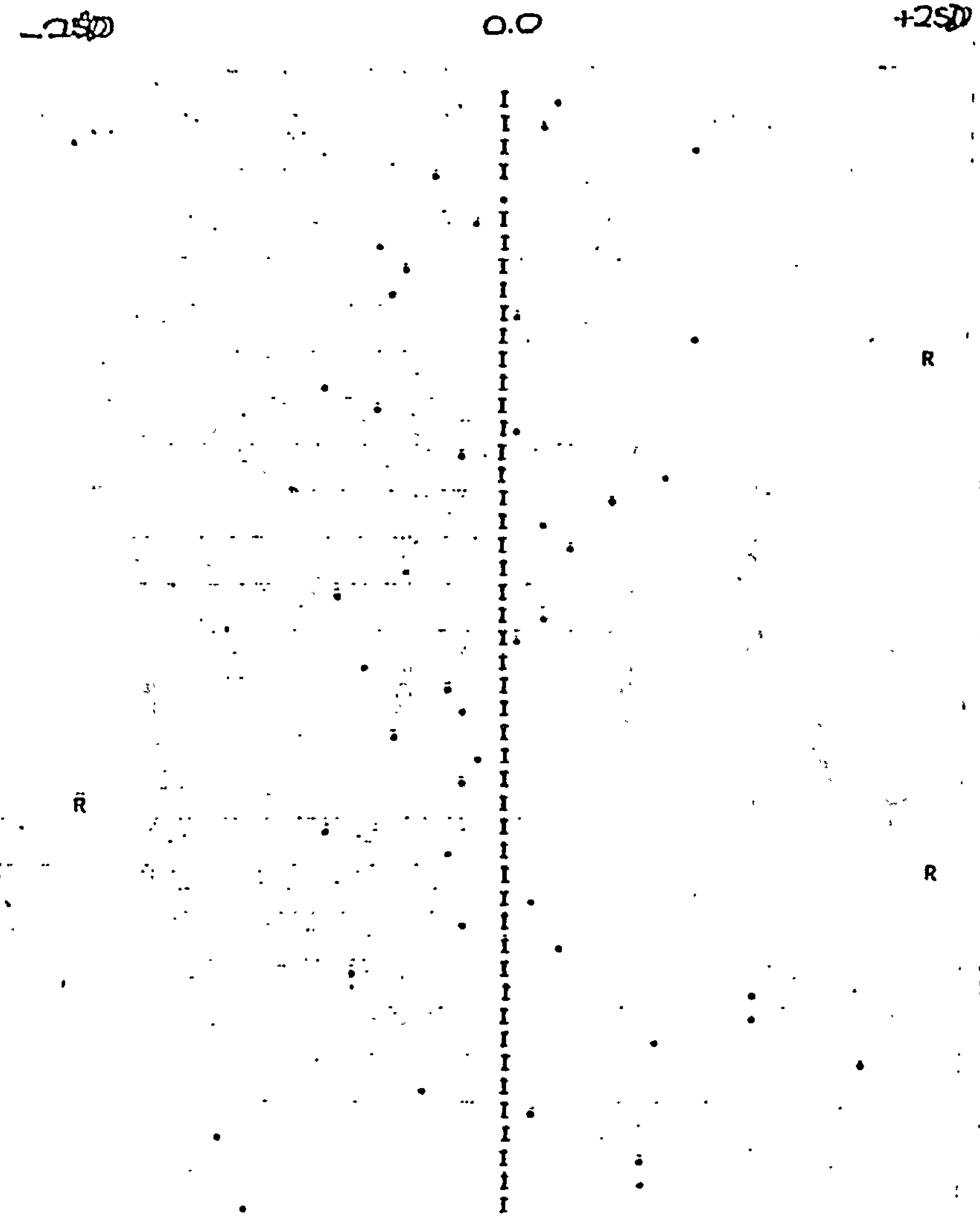
F-Values of Variables

$X_1 = 1360.47060$ $\quad X_3 = 0.084274$

X_2 $\quad 3.60557$

The actual C_{1ko} values, the estimated C_{1ko} values and the residuals are tabulated and plotted in figure(E1 c).

Observation	C_1ko Value	C_1ko Estimate	Residual
1.	106126.0	100636.9	5489.149
2.	62049.00	58256.46	3792.539
3.	106624.0	85715.66	20908.34
4.	46078.00	53281.22	-7203.218
5.	187504.0	187326.8	177.2301
6.	35886.00	38482.07	-2596.069
7.	110079.0	123626.7	-13547.65
8.	53493.00	64008.73	-10515.73
9.	145983.0	158274.2	-12291.21
10.	84584.00	83906.53	677.4663
11.	202575.0	181418.8	21156.24
12.	271694.0	219395.7	52298.29
13.	137931.0	157002.6	-19071.58
14.	59971.00	74101.93	-14130.93
15.	88622.00	88116.19	505.8093
16.	38127.00	42447.73	-4320.729
17.	106797.0	88076.05	18720.95
18.	103892.0	92724.63	11167.37
19.	172530.0	168043.8	4486.219
20.	51787.00	43938.48	7848.518
21.	64357.00	74335.63	-9978.604
22.	202903.0	220946.0	-18043.03
23.	68325.00	63665.14	4659.855
24.	59274.00	58488.11	785.8923
25.	95275.00	109769.9	-14494.93
26.	67431.00	73568.48	-6137.481
27.	45642.00	50302.07	-4660.074
28.	57836.00	69150.82	-11314.82
29.	23208.00	25604.19	-2396.192
30.	14338.00	17607.55	-3269.553
31.	486328.0	579561.1	-93233.08
32.	164800.0	184670.2	-19870.20
33.	405156.0	410741.8	-5585.751
34.	305789.0	250703.7	55085.26
35.	71126.00	68571.28	2554.715
36.	123317.0	126648.0	-3331.023
37.	264585.0	258916.0	5669.026
38.	174483.0	190745.0	-16261.98
39.	710086.0	682930.9	27155.09
40.	530880.0	503423.8	27456.19
41.	205587.0	188668.3	16918.74
42.	933960.0	893907.3	40052.72
43.	1006398.	1014719.	-8320.855
44.	186395.0	184803.2	1591.800
45.	200526.0	232473.1	-31947.03
46.	453443.0	438710.3	14732.69
47.	151536.0	136738.6	14797.44
48.	700700.0	730135.2	-29435.24



NOTE – (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
R INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED 47.
NUMBER OF 2 S.D. OUTLIERS 3. OR 6.38 PERCENT OF THE TOTAL

DETERMINATION ON OF HEAD OFFICE OVERHEAD COST TO BE 05/06/21 17.08.08. PAGE 54

Figure (E1c) Regression Analysis For C_1ko with X_1 X_2 and X_3.

E.1.4 The variable X_3 was removed from the regression equation and variable X_4, the type of project variable entered. This yielded the regression equation

$$C_{1ko} = 834.25306+0.07334699(X_1)-1542.9251(X_2)+5411.8901(X_4)$$

eqn(E1 d)

The other parameters computed are:

Coefficient of multiple correlation R	=	0.99499
Coefficient of determination R^2	=	0.99000
Adjusted R^2	=	0.98691
Change in R at this step	=	0.00002
F-Value	=	1419.68287
Standard Deviation	=	23787.62884
Coefficient of variability	=	11.3%

Analysis of Variance	D.F		
Regression	3	2409988136404.84375	803329378801.61328
Residuals	43	24331605292.98413	565851285.88335

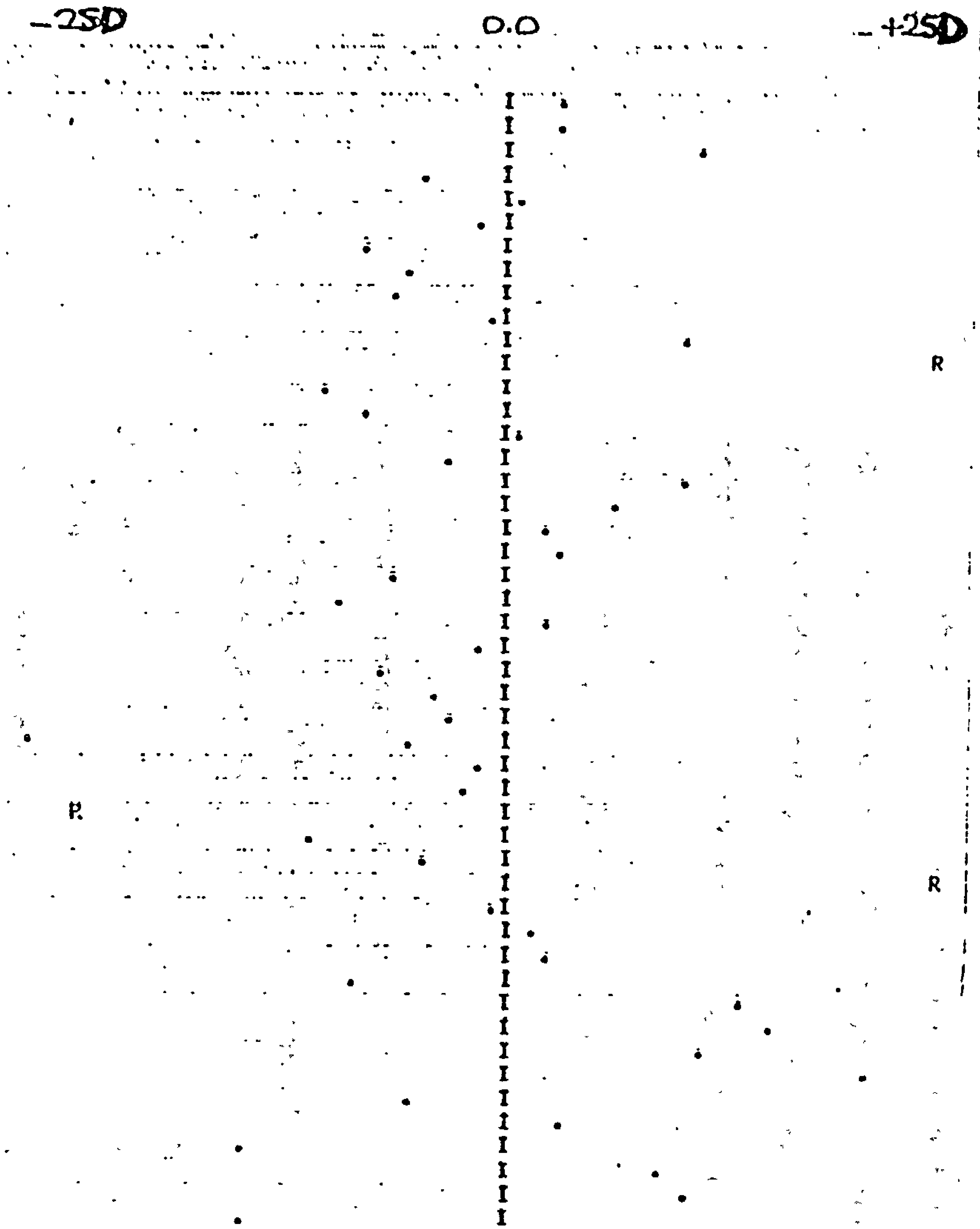
F-Values of Variables

X_1 = 756.22952 X_4 = 0.20929

X_2 = 3.63780

The actual C_{1ko} values, the estimated C_{1ko} values and the residuals are tabulated and plotted in figure (E1 d).

Observation	Ciko Value	Ciko Estimate	Residual
1.	106126.0	100562.0	5563.963
2.	62049.00	55784.87	6264.131
3.	106624.0	85950.42	20673.58
4.	46078.00	55445.91	-9367.913
5.	187504.0	186642.1	861.8549
6.	35886.00	38192.94	-2306.938
7.	110079.0	125125.3	-15046.35
8.	53493.00	63400.99	-9907.985
9.	145983.0	157144.2	-11161.18
10.	84584.00	85450.27	-866.2727
11.	202575.0	182358.5	20216.46
12.	271694.0	219313.3	52380.67
13.	137931.0	158030.1	-20099.06
14.	59971.00	75407.88	-15436.88
15.	88622.00	87652.14	969.8617
16.	38127.00	43646.43	-5519.429
17.	106797.0	87255.20	19541.80
18.	103892.0	91210.81	12681.19
19.	172530.0	168828.1	3701.945
20.	51787.00	46362.99	5424.010
21.	64357.00	76371.52	-12014.52
22.	202903.0	220878.6	-17975.63
23.	68325.00	64019.89	4305.109
24.	59274.00	61240.40	-1966.398
25.	95275.00	109307.3	-14032.26
26.	67431.00	74032.20	-6601.196
27.	45642.00	51109.27	-5467.274
28.	57836.00	68356.52	-10520.52
29.	23208.00	26376.51	-3168.514
30.	14338.00	18652.41	-4314.413
31.	486328.0	577168.3	-90840.27
32.	164800.0	186234.8	-21434.83
33.	405156.0	413209.2	-8053.227
34.	305789.0	253313.5	52475.48
35.	71126.00	71507.88	-381.8790
36.	123317.0	121317.6	1999.380
37.	264585.0	261018.7	3566.295
38.	174483.0	131781.1	-17298.12
39.	710086.0	683331.4	26754.58
40.	530880.0	501891.1	28988.88
41.	205587.0	184139.8	21447.25
42.	933960.0	894273.2	39686.80
43.	1006398.	1017259.	-10860.79
44.	186395.0	181559.0	4836.030
45.	200526.0	230355.0	-29828.96
46.	453443.0	436105.0	17337.96
47.	151536.0	131974.1	19561.95
48.	700700.0	729782.8	-29082.81



NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
R INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED 47.
NUMBER OF 2 S.D. OUTLIERS 3. OR 6.38 PERCENT OF THE TOTAL

DETERMINATION ON OF HEAD OFFICE OVERHEAD COST TO DE 05/06/81 17.00.08. PAGE 59

figure (E1 d) Regression Analysis For Ciko with $X_1 X_2$ and X_4

E.1.5 Variable X_3 was re-entered into the regression equation. Regression analysis was then performed with all the independent variables in the regression equation. This gave rise to the model equation

$$C_{1ko} = -12362.532+0.07345806(X_1)-1576.6473(X_2)+57.5893(X_3) +5913.6175(X_4) \quad \text{eqn(E1e)}$$

The other parameters computed are:

Coefficient of multiple correlation R	=	0.99500
Coefficient of determination R^2	=	0.99003
Adjusted R^2	=	0.98908
Change in R at this step	=	0.00001
F-Value	=	1042.97635
Standard Deviation	=	24035.12677
Coefficient of Variability	=	11.4%

Analysis of Variance	D.F	S.S	MS
Regression	4	2410056874312.76562	602514218578.19141
Residuals	42	24262867385.06714	577687318.69207

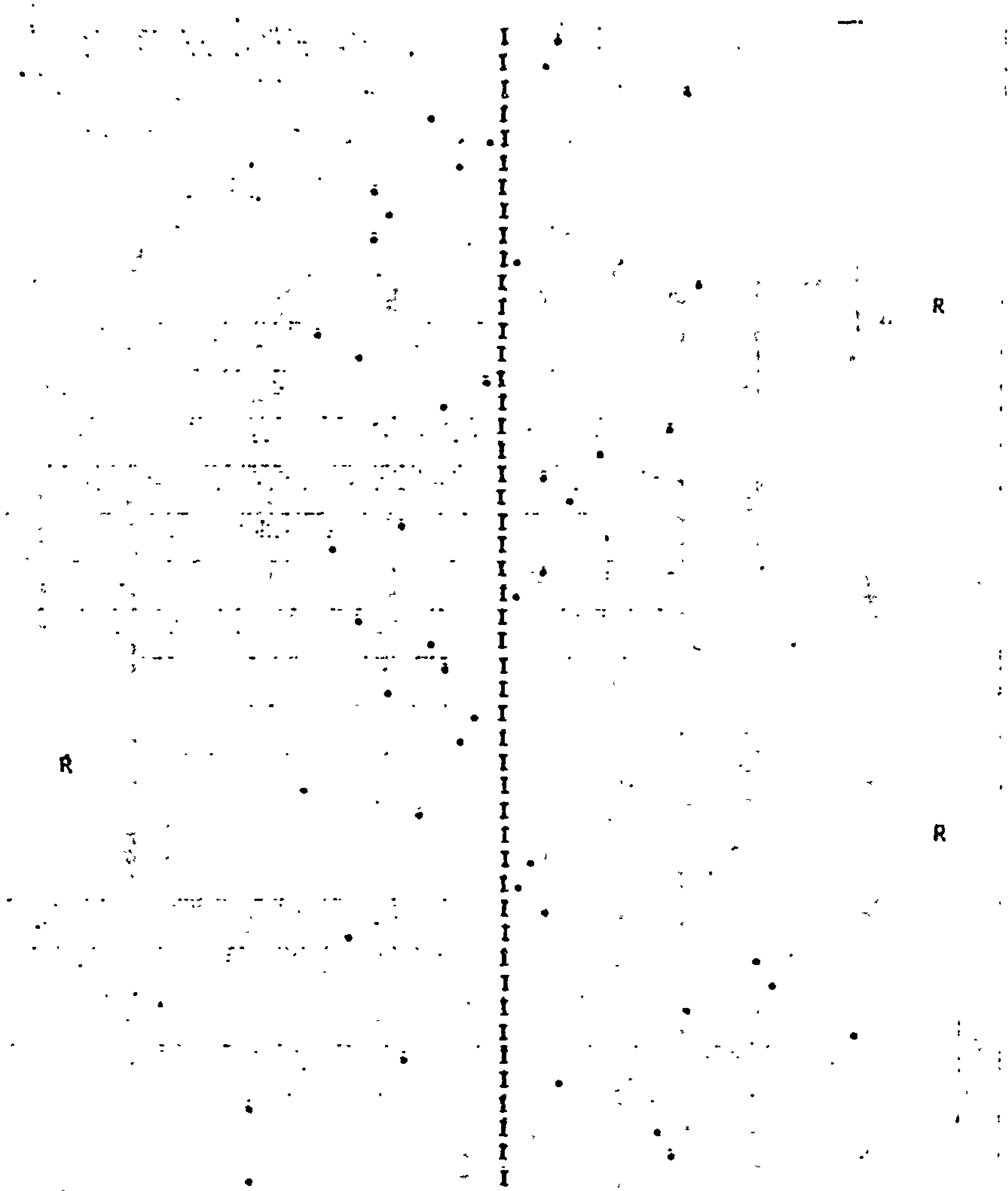
F-Values of Variables

X_1 = 732.52358 X_3 = 0.11899
X_2 = 3.66826 X_4 = 0.24120

The actual C_{1ko} values, the estimated C_{1ko} values and the residuals are tabulated and plotted in figure (E1e).

Observation	Ciko Value	Ciko Estimate	Residual
1.	106126.0	100257.3	5868.686
2.	62049.00	58066.63	3982.370
3.	106624.0	86450.55	20173.45
4.	46078.00	53690.44	-7612.436
5.	187504.0	187813.3	-309.3475
6.	35886.00	39322.19	-3436.185
7.	110079.0	124150.9	-14071.91
8.	53493.00	64762.19	-11269.19
9.	145983.0	159291.5	-13308.48
10.	84584.00	83839.86	744.1373
11.	202575.0	181156.9	21418.09
12.	271694.0	218843.2	52850.81
13.	137931.0	157236.5	-19305.47
14.	59971.00	75504.46	-15533.46
15.	80622.00	89369.40	-747.4024
16.	38127.00	43406.97	-5279.974
17.	106797.0	88526.98	18270.02
18.	103892.0	92855.14	11036.86
19.	172530.0	169008.8	3521.189
20.	51787.00	43986.48	7800.520
21.	64357.00	74904.29	-10547.29
22.	202903.0	220761.6	-17858.57
23.	68325.00	63879.53	4445.467
24.	59274.00	58860.21	413.7863
25.	95275.00	110643.8	-15368.83
26.	67431.00	73907.00	-6475.999
27.	45642.00	50755.58	-5113.577
28.	57836.00	70363.90	-12527.90
29.	23208.00	26398.85	-3190.853
30.	14338.00	18406.50	-4068.495
31.	486328.0	576730.9	-90402.94
32.	164800.0	186598.9	-21798.87
33.	405156.0	414765.3	-9609.269
34.	305789.0	252528.0	53260.99
35.	71126.00	68881.50	2244.501
36.	123317.0	122273.0	1044.001
37.	264585.0	260087.9	4497.061
38.	174483.0	191645.9	-17162.92
39.	710086.0	682295.5	27790.46
40.	530880.0	501575.1	29304.94
41.	205587.0	185221.7	20365.35
42.	933960.0	895326.5	38633.53
43.	1006398.	1017315.	-10917.13
44.	186395.0	180877.9	5517.106
45.	200526.0	229203.3	-28677.27
46.	453443.0	435945.9	17497.09
47.	151536.0	132924.5	18611.45
48.	700700.0	729466.6	-28766.69

-2SD 0.0 +2SD



NOTE – (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
R INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED 47.
NUMBER OF 2 S.D. OUTLIERS 3. OR 6.38 PERCENT OF THE TOTAL

K_R

DETERMINATION ON OF HEAD OFFICE OVERHEAD COST TO BE 05/06/81 17.00.08. PAGE 76

Figure (E1e) Regression Analysis For Ciko $X_1X_2X_3$ and X_4

E.2 HEAD OFFICE (Construction Stage) Model

E.2.1 For the last round of regression analysis for $\frac{C_{1ki}}{C_{1i}}$, the proportion of head office overhead costs apportioned to the Kth project during the construction stage, the independent variables were entered into the regression analysis in a specified order. The first variable entered was U_1, the ratio of direct cost of project/turnover of the company for the period for which apportionment is made. This yielded the regression equation:

$$\frac{C_{1ki}}{C_{1i}} = -0.24975539\times10^{-2}+0.54264138(U_1) \qquad \text{eqn}(E2a)$$

The other parameters computed are:

Coefficient of multiple correlation R	=	0.74895
Coefficient of determination R^2	=	0.56093
Adjusted R^2	=	0.55576
Change in R at this step	=	-
F-Value	=	108.59047
Standard Deviation	=	0.05877
Coefficient of variability	=	44.5%

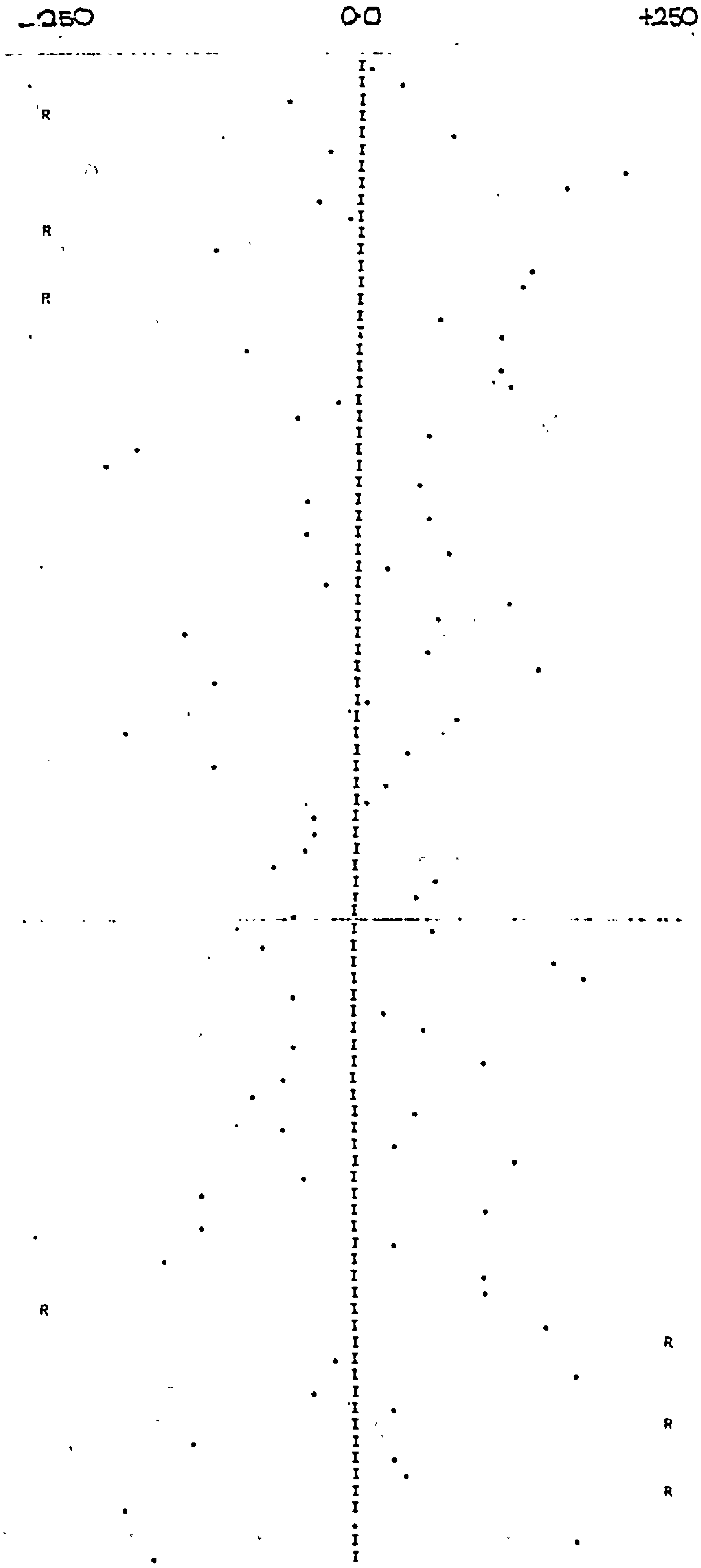
Analysis of variance	D.F	S.S	MS
Regression	1	0.37512	0.37512
Residuals	85	0.29363	0.00345

F-values of variables

U_1 = 108.59047

The actual $\frac{C_{1ki}}{C_{1i}}$ values, the estimated $\frac{C_{1ki}}{C_{1i}}$ values and the residuals are tabulated and plotted in fig(E2a).

Observation	$\frac{C_iK_i}{C_i}$ Value	$\frac{C_iK_i}{C_i}$ Estimate	Residual
1.	.2653150	.2633132	.2001844E-02
2.	.1965300	.1827667	.1376327E-01
3.	.7231800E-01	.9882287E-01	-.2650487E-01
4.	.9996000E-01	.2549825	-.1550225
5.	.3208590	.2880626	.3279640E-01
6.	.8228200E-01	.9232235E-01	-.1004035E-01
7.	.2893590	.1910371	.9832188E-01
8.	.3590210	.2817394	.7728159E-01
9.	.1254620	.1394194	-.1395745E-01
10.	.1474270	.1491055	-.1678487E-02
11.	.1376000	.3007086	-.1631086
12.	.1440890	.1960059	-.5199686E-01
13.	.3828220	.3179566	.6486540E-01
14.	.1283860	.6921047E-01	.5916753E-01
15.	.6343500E-01	.2126511	-.1492161
16.	.9864600E-01	.7061778E-01	.2802822E-01
17.	.1397750	.8852099E-01	.5125401E-01
18.	.1426000E-01	.5637160E-01	-.4211160E-01
19.	.1227060	.7023386E-01	.5247214E-01
20.	.1481340	.9027855E-01	.5705545E-01
21.	.7147800E-01	.7707321E-01	-.5595208E-02
22.	.5037500E-01	.7047984E-01	-.2010484E-01
23.	.1180140	.9308433E-01	.2492967E-01
24.	.6473000E-02	.8949910E-01	-.8302610E-01
25.	.6754400E-01	.1617997	-.9425571E-01
26.	.1332290	.1113972	.2183183E-01
27.	.5051000E-01	.6638789E-01	-.1587789E-01
28.	.9021300E-01	.6416507E-01	.2604798E-01
29.	.4013800E-01	.5900802E-01	-.1887002E-01
30.	.1171390	.8215363E-01	.3498537E-01
31.	.1041000	.9577057E-01	.8329432E-02
32.	.1204220	.1301015	-.9679480E-02
33.	.6052300E-01	.2126619E-02	.5839638E-01
34.	.2947740	.2657072	.2906676E-01
35.	.9616900E-01	.1595806	-.6341164E-01
36.	.1976390	.1713680	.2627100E-01
37.	.1929300	.1239441	.6898593E-01
38.	.4857500E-01	.1014920	-.5291702E-01
39.	.1013650	.9819159E-01	.3173112E-02
40.	.2714920	.2335064	.3798559E-01
41.	.3533600E-01	.1218464	-.8651039E-01
42.	.1552940	.1390033	.1629065E-01
43.	.2397000E-01	.7825372E-01	-.5428372E-01
44.	.1167110	.1068904	.9814602E-02
45.	.9028400E-01	.8906102E-01	.1222976E-02
46.	.1144050	.1283452	-.1394022E-01
47.	.4655700E-01	.6169660E-01	-.1513960E-01
48.	.2036200E-01	.4658127E-01	-.1821927E-01
49.	.4167900E-01	.7244106E-01	-.3076206E-01
50.	.1494630	.1206579	.2880511E-01
51.	.1459520	.1246662	.2128578E-01
52.	.5421600E-01	.7564053E-01	-.2142453E-01
53.	.1324540	.1022127	.3024130E-01
54.	.8140900E-01	.1139098	-.3250082E-01
55.	.2322880	.1577515	.7453650E-01
56.	.1981170	.1082486	.8986839E-01
57.	.6144300E-01	.8466406E-01	-.2322106E-01
58.	.4876500E-01	.4062002E-01	.8144975E-02
59.	.9426800E-01	.6919302E-01	.2507498E-01
60.	.3239300E-01	.5545551E-01	-.2306251E-01
61.	.1469330	.9789170E-01	.4904130E-01
62.	.3797400E-01	.6334444E-01	-.2537044E-01
63.	.1884100E-01	.5522495E-01	-.3638395E-01
64.	.9933500E-01	.7795131E-01	.2138369E-01
65.	.2223100E-01	.4961979E-01	-.2738879E-01
66.	.1847380	.1694419	.1529611E-01
67.	.3470810	.2852451	.5183591E-01
68.	.4755000E-01	.6631024E-01	-.1876024E-01
69.	.8632300E-01	.1425790	-.5625598E-01
70.	.2594870	.2093895	.5009753E-01
71.	.8887500E-01	.1452854	-.5641040E-01
72.	.1496700	.1345734	.1509656E-01
73.	.7608500E-01	.1476357	-.7155074E-01
74.	.2953350	.2447395	.5059554E-01
75.	.2681600	.2181854	.4997464E-01
76.	.9131800E-01	.2132580	-.1219400
77.	.3477120	.2737173	.7399473E-01
78.	.3533040	.1697033	.1835957
79.	.1355080	.1402824	-.4774355E-02
80.	.1653110	.8294166E-01	.8236934E-01
81.	.2078460	.2205060	-.1266002E-01
82.	.1697210	.1549822	.1473882E-01
83.	.2192290	.1015129	.1177161
84.	.3052700E-01	.9142987E-01	-.6090287E-01
85.	.1088210	.9593911E-01	.1288189E-01
86.	.1815700	.1620180	.1955204E-01
87.	.3107200	.1558515	.1548685
88.	.1266100E-01	.1014313	-.8877029E-01
89.	.1281570	.1284673	-.3103155E-03
90.	.2456000	.1624272	.8317283E-01
91.	.2122700E-01	.9882189E-01	-.7759489E-01



NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
R INDICATES POINT OUT OF RANGE OF PLOT

NUMBEP OF CASES PLOTTED 87.
NUMBER OF 2 S.D. OUTLIERS 6. OR 6.90 PERCENT OF THE TOTAL

VON NEUMANN RATIO 2.50090 DURBIN-WATSON TEST 2.47216

NUMBER OF POSITIVE RESIDUALS 46.
NUMBER OF NEGATIVE RESIDUALS 41.
NUMBER OF RUNS OF SIGNS 58.

Figure **(E2a)**
Regression Analysis for $\frac{C_iK_i}{C_i}$ with U_1

E.2.2. The second independent variable entered in the regression analysis was U_2, the duration of the project for which apportionments were made/ planning period of the company.

For the two independent variables U_1 and U_2 the regression equation below was determined.

$$\frac{C_{1ki}}{C_{1i}} = -0.11149242+0.4688086(U_1)+0.17695775(U_2) \quad \text{eqn}(E2b)$$

The other parameters computed are:

Coefficient of multiple correlation R	=	0.92148
Coefficient of determination R^2	=	0.84913
Adjusted R^2	=	0.84554
Change in R at this step	=	0.17353
F-Value	=	236.38028
Standard Deviation	=	0.3466
Coefficient Variability	=	26.3%

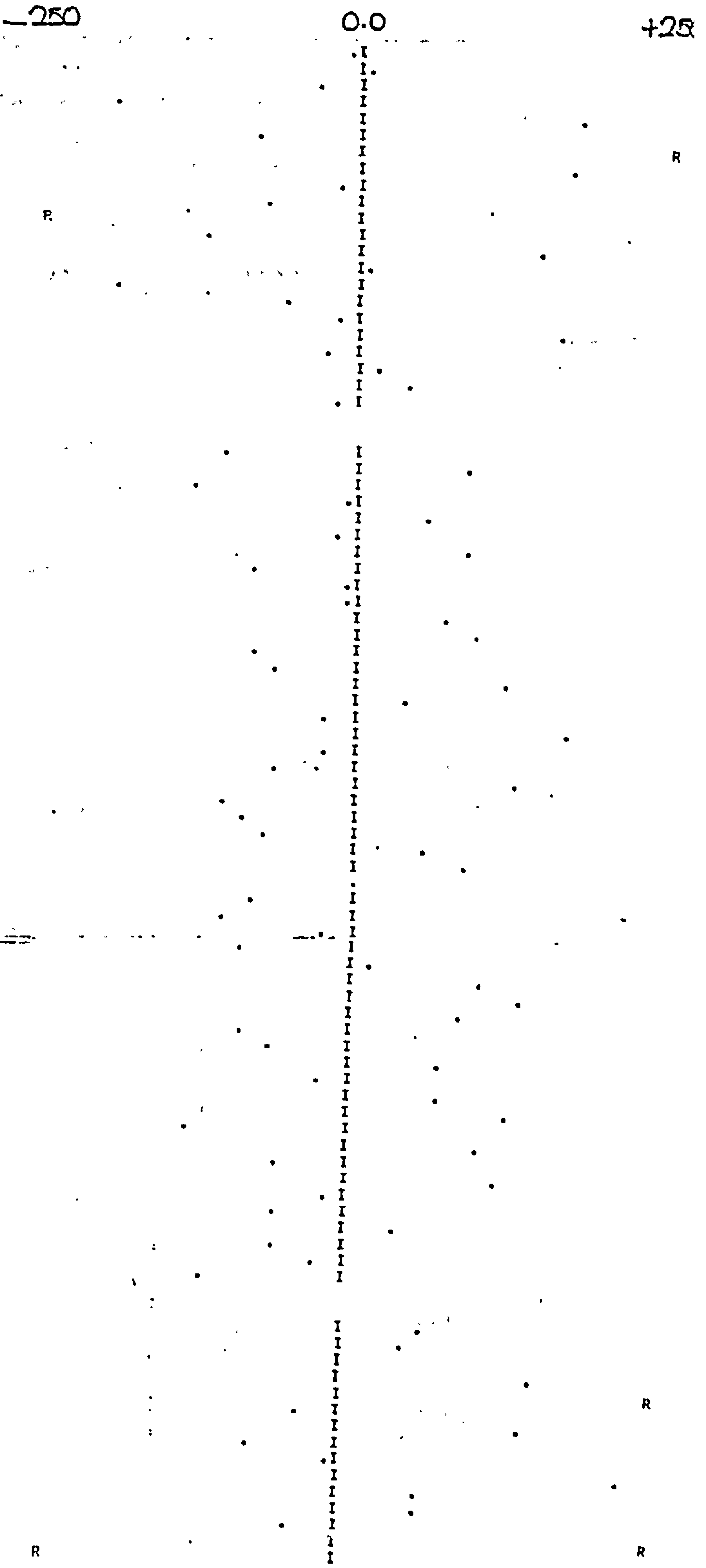
Analysis of Variance	D.F	S.S	MS
Regression	2	0.56785	0.28393
Residuals	84	0.10090	0.00120

F-Values of variables

$U_1 = 224.99266$
$U_2 = 160.45753$

The actual $\frac{C_{1ki}}{C_{1i}}$ values, the estimated $\frac{C_{1ki}}{C_{1i}}$ values and the residuals are tabulated and plotted in fig(E2b).

Observation $\frac{C_1 ki}{C_1 i}$ Value	$\frac{C_1 ki}{C_1 i}$ Estimate	Residual
1.	.2653150	.2656163	-.3013339E-03
2.	.1965300	.1960292	.5008027E-03
3.	.7231800E-01	.7926746E-01	-.6949459E-02
4.	.9995000E-01	.1551939	-.5523389E-01
5.	.3208590	.2722519	.4860710E-01
6.	.8228200E-01	.1031444	-.2036243E-01
7.	.2893590	.2179209	.7143809E-01
8.	.3590210	.3110285	.4799250E-01
9.	.1254620	.1290870	-.3624907E-02
10.	.1474270	.1669480	-.1952097E-01
11.	.1376000	.2241914	-.8659144E-01
12.	.1440890	.1780433	-.3395426E-01
13.	.3828220	.3423179	.4050409E-01
14.	.1283860	.1274235	.9624541E-03
15.	.6343500E-01	.1186221	-.5518713E-01
16.	.9864600E-01	.1138860	-.1524004E-01
17.	.1397750	.1440997	-.4324724E-02
18.	.1426000E-01	-.3114009E-01	.4540009E-01
19.	.1227060	.1283008	-.5594781E-02
20.	.1481340	.1456181	.2515851E-02
21.	.7147000E-01	.6047739E-01	.1100091E-01
22.	.5037500E-01	.5478083E-01	-.4405835E-02
23.	.1180140	.1480422	-.3002817E-01
24.	.6473000E-02	-.1726659E-01	.2373958E-01
25.	.6754400E-01	.1041827	-.3663872E-01
25.	.1332290	.1343703	-.1141317E-02
27.	.5051000E-01	.3649922E-01	.1401078E-01
28.	.9021300E-01	.9356470E-01	-.3351701E-02
29.	.4013800E-01	.1537705E-01	.2476095E-01
30.	.1171390	.1385987	-.2145972E-01
31.	.1041000	.1061235	-.2023475E-02
32.	.1204220	.1210368	-.6148401E-03
33.	.6052300E-01	.3996731E-01	.2055569E-01
34.	.2947740	.2676947	.2708933E-01
35.	.9616900E-01	.1170120	-.2084293E-01
36.	.1976390	.2156744	-.1803542E-01
37.	.1929300	.1599567	.3297334E-01
38.	.4857500E-01	.3733400E-01	.1124100E-01
39.	.1013650	.1082153	-.6850346E-02
40.	.2714920	.2251187	.4637327E-01
41.	.3533600E-01	.4017249E-01	-.4836492E-02
42.	.1552940	.1729669	-.1767294E-01
43.	.2397000E-01	-.1223524E-01	.3620529E-01
44.	.1167110	.1452285	-.2851752E-01
45.	.9028400E-01	.1150733	-.2478926E-01
46.	.1144050	.1342660	-.1986096E-01
47.	.4655700E-01	.3244623E-01	.1411077E-01
48.	.2836200E-01	.4641100E-02	.2372090E-01
49.	.4167900E-01	.4172879E-01	-.4978218E-04
50.	.1494630	.1718640	-.2240102E-01
51.	.1459520	.1753270	-.2937497E-01
52.	.5421600E-01	.5923935E-01	-.5023345E-02
53.	.1324540	.1559235	-.2347452E-01
54.	.8140900E-01	.7755523E-01	.3853770E-02
55.	.2322880	.2039106	.2837739E-01
56.	.1981170	.1611432	.3697383E-01
57.	.6144300E-01	.3754228E-01	.2390072E-01
58.	.4876500E-01	.7327324E-01	-.2445824E-01
59.	.9426800E-01	.1126551	-.1838714E-01
60.	.3239300E-01	.1230790E-01	.2008519E-01
61.	.1469330	.1521954	-.5262439E-02
62.	.3797400E-01	.1912326E-01	.1885074E-01
63.	.1884100E-01	-.1738431E-01	.3622531E-01
64.	.9933500E-01	.1349682	-.3563319E-01
65.	.2223100E-01	-.7480404E-02	.2971140E-01
66.	.1847380	.1992640	-.1452597E-01
67.	.3470810	.3140572	.3302381E-01
68.	.4755000E-01	.5117056E-01	-.3620556E-02
69.	.8632300E-01	.1023236	-.1600061E-01
70.	.2594870	.2485226	.1096438E-01
71.	.8807500E-01	.1046618	-.1578679E-01
72.	.1496700	.1543932	-.4723180E-02
73.	.7608500E-01	.1066923	-.3060734E-01
74.	.2953350	.2790628	.1627217E-01
75.	.2681600	.2561217	.1203827E-01
76.	.9131800E-01	.1338929	-.4257491E-01
77.	.3477120	.3040979	.4361413E-01
78.	.3533040	.2142405	.1390635
79.	.1355080	.1445789	-.9070907E-02
80.	.1653110	.1245331	.4077799E-01
81.	.2078460	.2286336	-.2078762E-01
82.	.1697210	.1720251	-.2304072E-02
83.	.2192290	.1553239	.6390506E-01
84.	.3052700E-01	.1389450E-01	.1663250E-01
85.	.1088210	.9152267E-01	.1729833E-01
86.	.1815700	.1928501	-.1128015E-01
87.	.3107200	.2022691	.1084509
88.	.1266100E-01	.1552534	-.1425924
89.	.1281570	.1786109	-.5045388E-01
90.	.2456000	.2079501	.3764990E-01
91.	.2122700E-01	.5534335E-02	.1569267E-01



NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
R INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED 87.
NUMBER OF 2 S.D. OUTLIERS 4. OR 4.60 PERCENT OF THE TOTAL

VON NEUMANN RATIO 2.49465 DURBIN-WATSON TEST 2.46597

NUMBER OF POSITIVE RESIDUALS 37.
NUMBER OF NEGATIVE RESIDUALS 50.

Figure (E2b) Regression Analysis For $\frac{C_1 ki}{C_1 i}$ with u_1 & u_2.

E.2.3. The third independent variable U_3, the number of projects undertaken, was entered into the regression equation. The three independent variables U_1, U_2, and U_3 gave rise to the regression equation:

$$\frac{C_{1ki}}{C_{1i}} = -.06715239+0.42492474(U_1)+0.1763821(U_2)-0.0038698389(U_3) \qquad \text{eqn}(E2c)$$

The other parameters computed are:

Coefficient of multiple correlation R	=	0.92536
Coefficient of determination R^2	=	0.85629
Adjusted R^2	=	0.85110
Change in R at this step	=	0.00388
F-Value	=	164.85054
Standard Deviation	=	0.03403
Coefficiency of variability	=	25.8%

Analysis of Variance	D.F	S.S	MS
Regression	3	0.57347	0.14337
Residuals	83	0.09528	0.00116

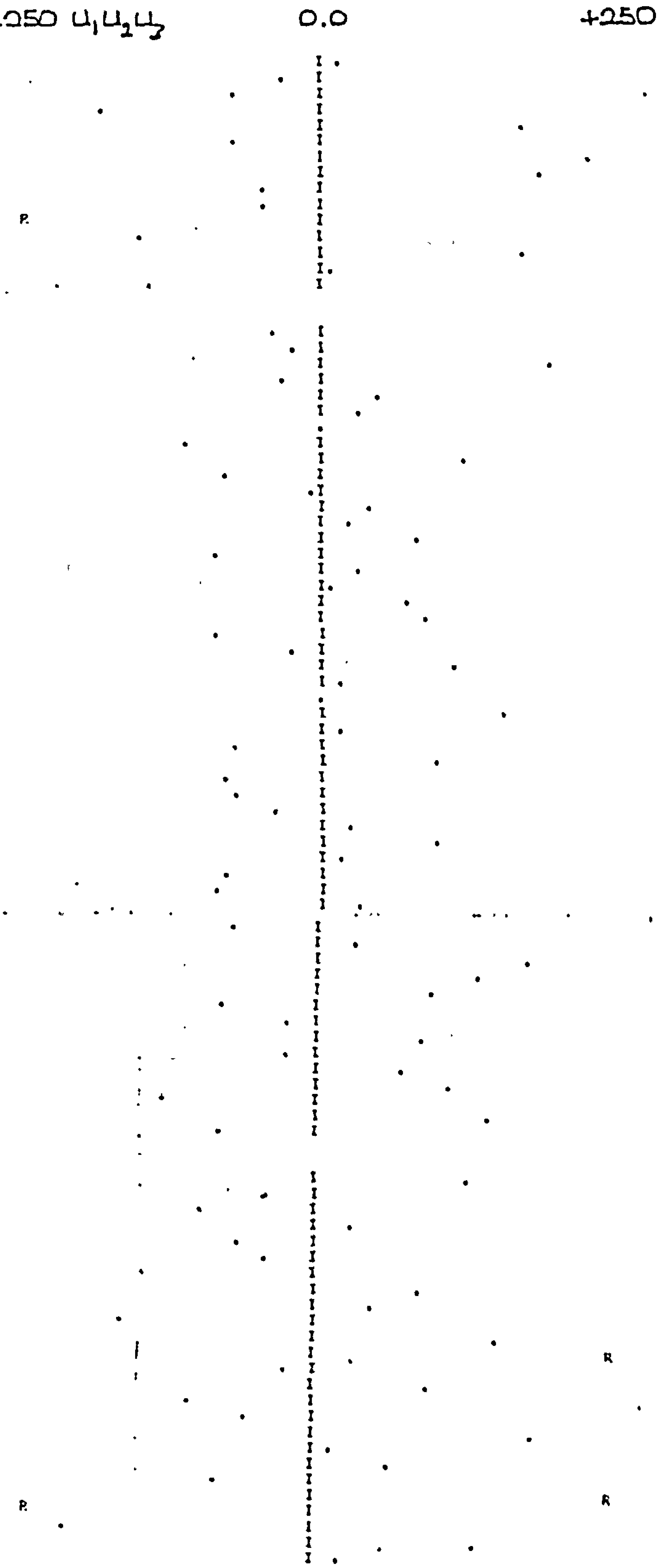
F-Values of Variables

U_1 = 128.31222 U_3 = 4.1368045

U_2 = 165.29789

The actual $\frac{C_{1ki}}{C_{1i}}$ values, the estimated $\frac{C_{1ki}}{C_{1i}}$ values and the residuals are tabulated and plotted in fig(E2c).

Observation	$\frac{C_{ki}}{C_{li}}$ Value	$\frac{C_{ki}}{C_{li}}$ Estimate	Residual
1.	.2653150	.2608914	.4423561E-02
2.	.1965300	.2055578	-.9027839E-02
3.	.7231800E-01	.9185879E-01	-.1954079E-01
4.	.9996000E-01	.1514785	-.5151850E-01
5.	.3208590	.2733131	.4754595E-01
6.	.8228200E-01	.1006862	-.1840415E-01
7.	.2893590	.2267327	.6262626E-01
8.	.3590210	.3085874	.5043365E-01
9.	.1254620	.1383473	-.1288526E-01
10.	.1474270	.1598496	-.1242263E-01
11.	.1376000	.2166822	-.7908220E-01
12.	.1440890	.1865907	-.4250172E-01
13.	.3828220	.3369478	.4587415E-01
14.	.1283860	.1266898	.1696210E-02
15.	.6343500E-01	.1028508	-.3941577E-01
16.	.9864600E-01	.1092173	-.1057126E-01
17.	.1397750	.1450748	-.5099797E-02
18.	.1426000E-01	-.3809487E-01	.5235487E-01
19.	.1227060	.1313547	-.8648747E-02
20.	.1481340	.1354415	.1269243E-01
21.	.7147800E-01	.6321782E-01	.8260182E-02
22.	.5037500E-01	.5031501E-01	.5990745E-04
23.	.1180140	.1492482	-.3123420E-01
24.	.6473000E-02	-.2685243E-01	.3332543E-01
25.	.6754400E-01	.8855796E-01	-.2101396E-01
26.	.1332290	.1341913	-.9623181E-03
27.	.5051000E-01	.4015205E-01	.1035795E-01
28.	.9021300E-01	.8559588E-01	.4617115E-02
29.	.4013800E-01	.1967467E-01	.2046333E-01
30.	.1171390	.1406887	-.2354973E-01
31.	.1041000	.9564667E-01	.8453333E-02
32.	.1204220	.1194412	.9808485E-03
33.	.6052300E-01	.4088544E-01	.1963756E-01
34.	.2947740	.2705058	.2426816E-01
35.	.9616900E-01	.1208679	-.2469892E-01
36.	.1976390	.2028099	-.5170909E-02
37.	.1929300	.1625843	.3034515E-01
38.	.4857500E-01	.4598354E-01	.2591455E-02
39.	.1013650	.1014126	-.4756297E-04
40.	.2714920	.2305920	.4090007E-01
41.	.3533600E-01	.3174458E-01	.3591419E-02
42.	.1552940	.1743773	-.1908324E-01
43.	.2397000E-01	-.1610507E-02	.2558050E-01
44.	.1167119	.1376259	-.2091485E-01
45.	.9028400E-01	.1089609	-.1867693E-01
46.	.1144050	.1250247	-.1061965E-01
47.	.4655700E-01	.4034829E-01	.6208714E-02
48.	.2836200E-01	.2204000E-02	.2615800E-01
49.	.4167900E-01	.3715241E-01	.4526593E-02
50.	.1494630	.1708402	-.2137716E-01
51.	.1459520	.1701091	-.2415711E-01
52.	.5421600E-01	.4661658E-01	.7599424E-02
53.	.1324540	.1525265	-.2007249E-01
54.	.8140900E-01	.7349509E-01	.7913921E-02
55.	.2322080	.1844076	.4780041E-01
56.	.1981170	.1611229	.3699415E-01
57.	.6144300E-01	.3589523E-01	.2554777E-01
58.	.4876500E-01	.7102837E-01	-.2226337E-01
59.	.9426800E-01	.1003619	-.6093896E-02
60.	.3239300E-01	.9153134E-02	.2323987E-01
61.	.1469330	.1530127	-.6079695E-02
62.	.3797400E-01	.1920035E-01	.1877365E-01
63.	.1884100E-01	-.1268481E-01	.3152581E-01
64.	.9933500E-01	.1335282	-.3419319E-01
65.	.2263100E-01	-.1785497E-01	.4003594E-01
66.	.1847380	.2059524	-.2121438E-01
67.	.3470010	.3113325	.3574847E-01
68.	.4755000E-01	.5865953E-01	-.1110953E-01
69.	.8632300E-01	.1114243	-.2510131E-01
70.	.2594870	.2519325	.7554524E-02
71.	.8837700E-01	.1058039	-.1692895E-01
72.	.1496700	.1500796	-.1040957E-01
73.	.7608500E-01	.1153541	-.3929910E-01
74.	.2953350	.2718742	.2346071E-01
75.	.2681600	.2549504	.1320959E-01
76.	.9131800E-01	.1373737	-.4605567E-01
77.	.3477120	.3061753	.4153669E-01
78.	.3533040	.2208594	.1324446
79.	.1355080	.1421119	-.6603111E-02
80.	.1653110	.1382169	.2709413E-01
81.	.2078460	.2351102	-.2726425E-01
82.	.1697210	.1838007	-.1407957E-01
83.	.2192290	.1674579	.5177114E-01
84.	.3052700E-01	.2727560E-01	.3251402E-02
85.	.1088210	.9268972E-01	.1613128E-01
86.	.1815700	.2040085	-.2243879E-01
87.	.3107200	.2100085	.1007114
88.	.1206100E-01	.1557844	-.1431234
89.	.1231570	.1835659	-.6040795E-01
90.	.2456000	.2074102	.3818185E-01
91.	.2122700E-01	.1449576E-01	.6731238E-02



NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
R INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED 87.
NUMBER OF 2 S.D. OUTLIERS 3. OR 3.45 PERCENT OF THE TOTAL

VON NEUMANN RATIO 2.52894 DURBIN-WATSON TEST 2.49987

NUMBER OF POSITIVE RESIDUALS 44.
NUMBER OF NEGATIVE RESIDUALS 43.
NUMBER OF RUNS OF SIGNS 49.

Figure. (E2c) Regression Analysis for $\frac{C_{lki}}{C_{li}}$ with u_1 u_2 and u_3

E.2.4. The fourth independent variable, the inflation variable, was entered into the regression equations. Regression analysis with the four independent variables U_1, U_2, U_3 and U_4 yielded the regression equation:

$$\frac{C_{1ki}}{C_{1i}} = -0.1035809+0.42826300(U_1)+0.17603153(U_2) -0.0037985422(U_3)+0.0001663916(U_4) \qquad \text{eqn}(E2d)$$

The other parameters computed are:

Coefficient of multiple correlation R	=	0.92606
Coefficient of determination R^2	=	0.85758
Adjusted R^2	=	0.85064
Change in R at this step	=	0.00060
F-Value	=	123.44335
Standard deviation	=	0.03408
Coefficient of variability	=	25.8%

<u>Analysis of Variance</u>

Regression	5	0.57351	0.14338
Residuals	81	0.09524	0.00116

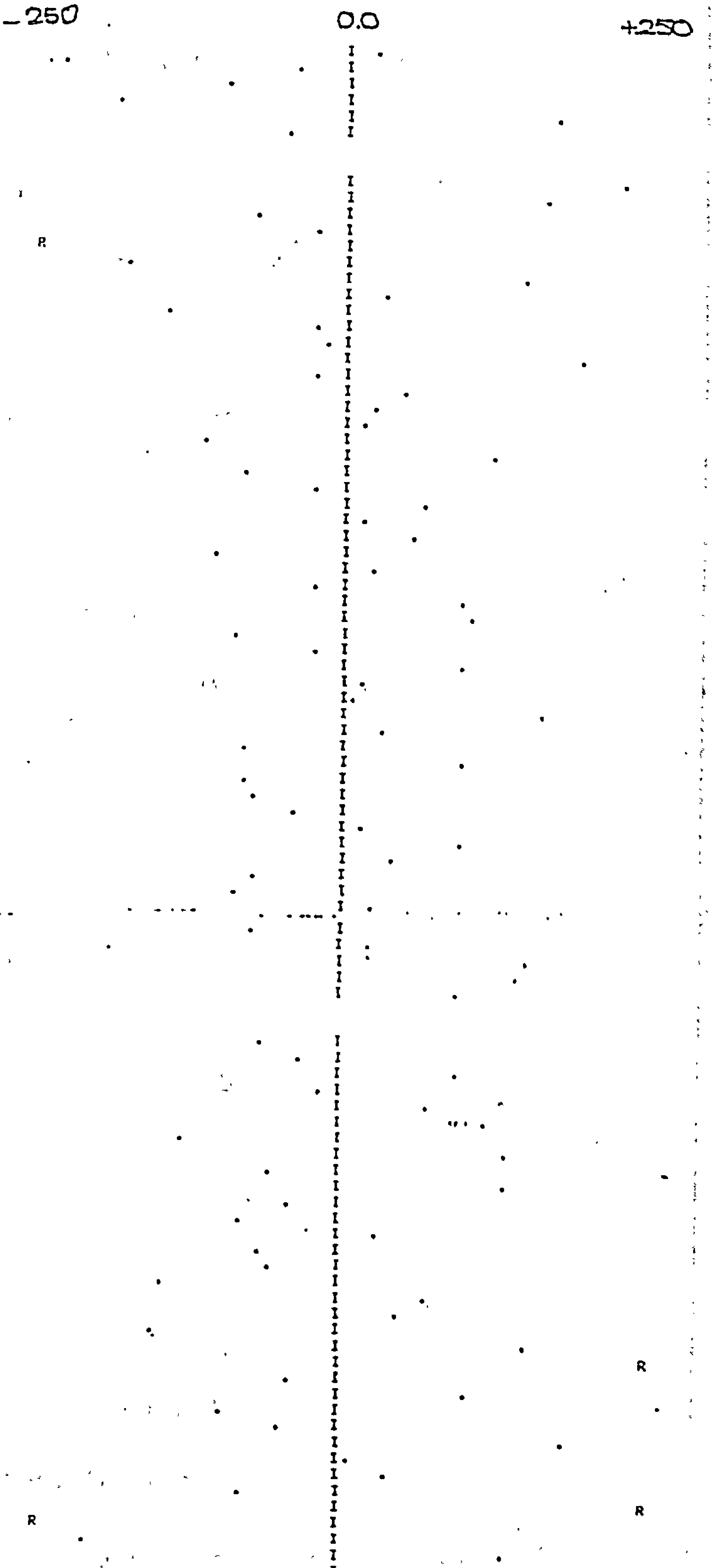
<u>F-Values of Variables</u>

U_1 = 128.57142 U_3 = 3.96605

U_2 = 163.99118 U_4 = 0.744445

The actual $\frac{C_{1ki}}{C_{1i}}$ values, the estimated $\frac{C_{1ki}}{C_{1i}}$ values and the residuals are tabulated and plotted in fig(E2d)

Observation	$\frac{C_1Ki}{C_1i}$ Value	$\frac{C_1Ki}{C_1i}$ Estimate	Residual
1.	.2653150	.2597498	.5565193E-02
2.	.1965300	.2061076	-.9577583E-02
3.	.7231800E-01	.9953868E-01	-.2722064E-01
4.	.9996000E-01	.1513221	-.5136207E-01
5.	.3208590	.2737079	.4715109E-01
6.	.8228200E-01	.9457593E-01	-.1229393E-01
7.	.2893590	.2261394	.6321959E-01
8.	.3590210	.3135959	.4543516E-01
9.	.1254620	.1449166	-.1945455E-01
10.	.1474270	.1537267	-.6299721E-02
11.	.1376000	.2140864	-.7648638E-01
12.	.1440890	.1927726	-.4018358E-01
13.	.3828220	.3426683	.4015369E-01
14.	.1283860	.1201334	.8202696E-02
15.	.6343500E-01	.1025527	-.3911771E-01
16.	.9864600E-01	.1033192	-.4673153E-02
17.	.1397750	.1433756	-.3600641E-02
18.	.1426000E-01	-.3908743E-01	.5334743E-01
19.	.1227060	.1231095	-.6403484E-02
20.	.1481340	.1363622	.1177184E-01
21.	.7147800E-01	.6515409E-01	.6323909E-02
22.	.5037500E-01	.4652969E-01	.3845308E-02
23.	.1180140	.1476427	-.2962869E-01
24.	.6473000E-02	-.2694642E-01	.3341942E-01
25.	.6754400E-01	.8962346E-01	-.2207946E-01
26.	.1332290	.1384142	-.5185200E-02
27.	.5051000E-01	.3456418E-01	.1594582E-01
28.	.9021300E-01	.8674704E-01	.3465959E-02
29.	.4013800E-01	.2488606E-01	.1525194E-01
30.	.1171390	.1450061	-.2786707E-01
31.	.1041000	.9785343E-01	.6246571E-02
32.	.1204220	.1250023	-.4580267E-02
33.	.6052300E-01	.3409602E-01	.2642699E-01
34.	.2947740	.2657421	.2903188E-01
35.	.9616900E-01	.1207025	-.2453351E-01
36.	.1976390	.2036587	-.6019885E-02
37.	.1929300	.1671172	.2581281E-01
38.	.4857500E-01	.4468725E-01	.3887746E-02
39.	.1013650	.1010670	.2979505E-03
40.	.2714920	.2264913	.4500067E-01
41.	.3533600E-01	.2839203E-01	.6943965E-02
42.	.1552940	.1765064	-.2121239E-01
43.	.2397000E-01	-.2492149E-02	.2646215E-01
44.	.1167110	.1379410	-.2123003E-01
45.	.9028400E-01	.1098612	-.1957717E-01
46.	.1144050	.1248646	-.1045964E-01
47.	.4655700E-01	.4297984E-01	.3577161E-02
48.	.2836200E-01	.1930619E-02	.2537138E-01
49.	.4167900E-01	.3257633E-01	.9102673E-02
50.	.1494630	.1689051	-.1944210E-01
51.	.1459520	.1705995	-.2464749E-01
52.	.5421000E-01	.4882922E-01	.5386777E-02
53.	.1324540	.1528787	-.2042473E-01
54.	.8140900E-01	.7492652E-01	.6482481E-02
55.	.2322880	.1894752	.4281281E-01
56.	.1981170	.1589451	.3917194E-01
57.	.6144300E-01	.3551205E-01	.2593095E-01
58.	.4876500E-01	.6564059E-01	-.1687550E-01
59.	.9426800E-01	.1020852	-.7817243E-02
60.	.3239300E-01	.5500123E-02	.2689288E-01
61.	.1469330	.1509376	-.4004578E-02
62.	.3797400E-01	.1868632E-01	.1928798E-01
63.	.1884100E-01	-.1409393E-01	.3293493E-01
64.	.9933500E-01	.1342304	-.3489536E-01
65.	.2223100F-01	-.1604751E-01	.3827851E-01
66.	.1847380	.1998066	-.1506858E-01
67.	.3470810	.3100297	.3705129E-01
68.	.4755000E-01	.5846160E-01	-.1091160E-01
69.	.8632300E-01	.1080880	-.2176497E-01
70.	.2594870	.2508286	.8658436E-02
71.	.8887500E-01	.1056219	-.1674690E-01
72.	.1496700	.1646352	-.1496522E-01
73.	.7608500E-01	.1169042	-.4081922E-01
74.	.2953350	.2767877	.1854731E-01
75.	.2681600	.2559686	.1219139E-01
76.	.9131800E-01	.1333658	-.4204784E-01
77.	.3477120	.3047303	.4298172E-01
78.	.3533040	.2213417	.1319623
79.	.1355080	.1452106	-.9702571E-02
80.	.1653110	.1378618	.2744919E-01
81.	.2078460	.2340619	-.2621585E-01
82.	.1697210	.1821828	-.1246179E-01
83.	.2192290	.1675206	.5170839E-01
84.	.3052700E-01	.2920315E-01	.1323846E-02
85.	.1088210	.9887263E-01	.9943372E-02
86.	.1815700	.2020722	-.2050219E-01
87.	.3107200	.2109048	.9981515E-01
88.	.1266100E-01	.1568925	-.1442315
89.	.1281570	.1862977	-.5814068E-01
90.	.2456000	.2079982	.3760176E-01
91.	.2122700E-01	.1573735E-01	.5489655E-02



NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
R INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED 87.
NUMBER OF 2 S.D. OUTLIERS 3. OR 3.45 PERCENT OF THE TOTAL

VON NEUMANN RATIO 2.49665 DURBIN-WATSON TEST 2.46795

NUMBER OF POSITIVE RESIDUALS 44.
NUMBER OF NEGATIVE RESIDUALS 43.
NUMBER OF RUNS OF SIGNS 49.

Figure **(E2d)** Regression Analysis for $\frac{C_1Ki}{C_1i}$ with u_1, u_2, u_3 and u_4

E.2.5 The inflation variable U_4 was removed from the regression analysis and the type of project, variable U_5 entered into the regression equation. Regression analysis performed with U_1, U_2, U_3, U_5 yielded the regression equation:

$$\frac{C_{1ki}}{C_{1i}} = -0.07484115+0.4226390(U_1)+0.17809682(U_2)-0.00440801(U_3) -0.007019165(U_5) \qquad \text{eqn}(E2e)$$

The other parameters computed are:

Coefficient of multiple correlation R	=	0.92603
Coefficient of determination R^2	=	0.85753
Adjusted R^2	=	0.85058
Change in R at this step	=	-0.00003
F-Value	=	164.8505
Standard Deviation	=	0.03403
Coefficient of Variability	=	25.8%

Analysis of Variance	D.F	S.S	MS
Regression	3	0.57347	0.14337
Residuals	83	0.09528	0.00116

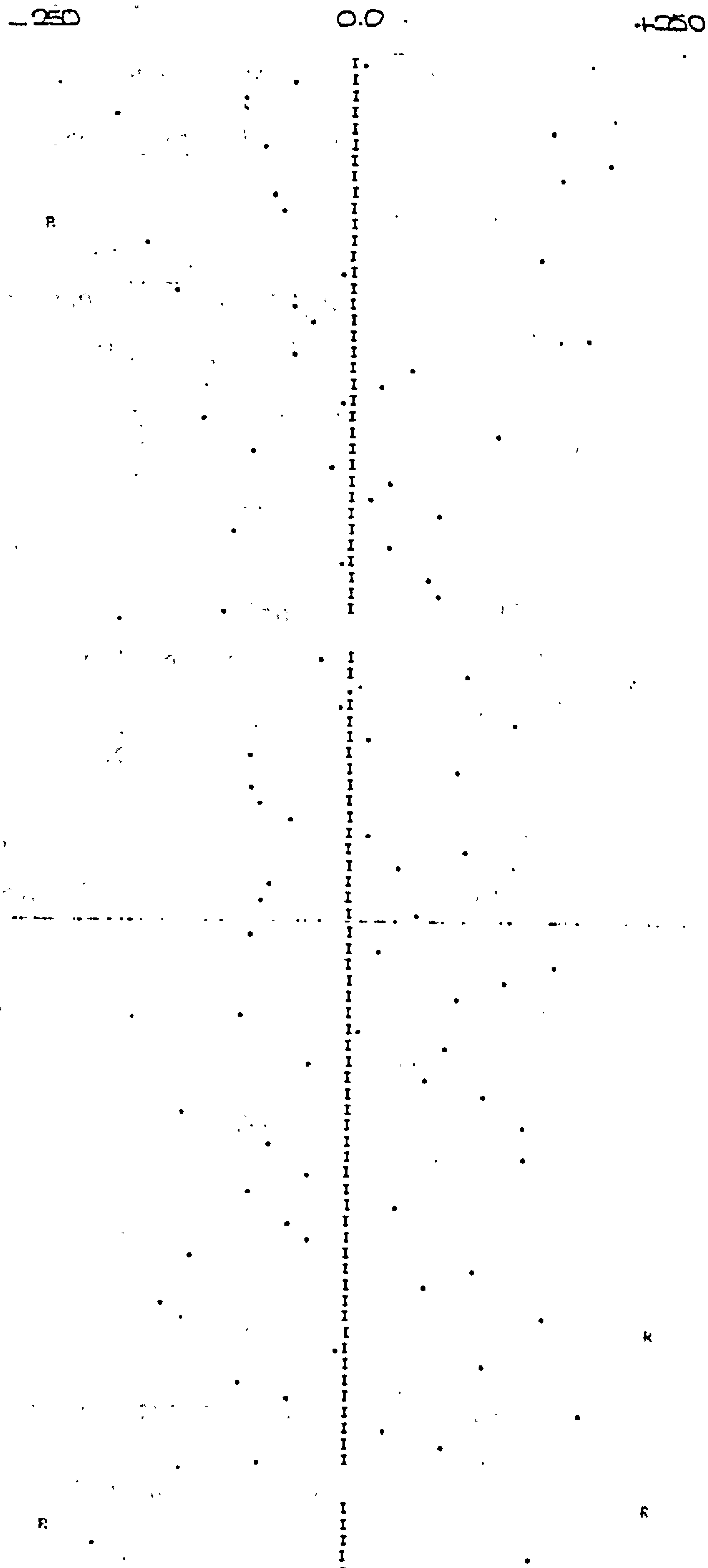
F-Values of Variables

U_1 = 125.84549 $\quad$ U_3 = 4.8114616

U_2 = 164.36140 $\quad$ U_5 = 7.993443

The actual $\frac{C_{1ki}}{C_{1i}}$ values, the estimated $\frac{C_{1ki}}{C_{1i}}$ values and the residuals are tabulated and plotted in fig(E2e).

Observation	$\frac{C_iki}{C_i i}$ Value	$\frac{C_iki}{C_i i}$ Estimate	Residual
1.	.2653150	.2637831	.1531928E-02
2.	.1965300	.2098651	-.1333510E-01
3.	.7231800E-01	.9555278E-01	-.2323478E-01
4.	.9996000E-01	.1534050	-.5344496E-01
5.	.3208590	.2770340	.4382502E-01
6.	.8228200E-01	.1025406	-.2025862E-01
7.	.2893590	.2311481	.5821094E-01
8.	.3590210	.3122253	.4679567E-01
9.	.1254620	.1420132	-.1655115E-01
10.	.1474270	.1616078	-.1418080E-01
11.	.1376000	.2187018	-.8110184E-01
12.	.1440890	.1905561	-.4646709E-01
13.	.3828220	.3404333	.4238872E-01
14.	.1283860	.1290703	-.6842547E-03
15.	.6343500E-01	.1028028	-.3936784E-01
16.	.9864600E-01	.1109108	-.1226476E-01
17.	.1397750	.1485121	-.8737130E-02
18.	.1426000E-01	-.3816558E-01	.5242558E-01
19.	.1227060	.1342691	-.1156311E-01
20.	.1481340	.1366570	.1147703E-01
21.	.7147800E-01	.6538890E-01	.6089100E-02
22.	.5037500E-01	.5143760E-01	-.1062597E-02
23.	.1180140	.1520663	-.3405231E-01
24.	.6473000E-02	-.2720558E-01	.3367858E-01
25.	.6754400E-01	.8847185E-01	-.2092785E-01
26.	.1332290	.1366465	-.3417503E-02
27.	.5051000E-01	.4222525E-01	.8284754E-02
28.	.9021300E-01	.8663550E-01	.3577504E-02
29.	.4013800E-01	.2163605E-01	.1850195E-01
30.	.1171390	.1435529	-.2641388E-01
31.	.1041000	.9641026E-01	.7689744E-02
32.	.1204220	.1215318	-.1109762E-02
33.	.6052300E-01	.4272454E-01	.1779846E-01
34.	.2947740	.2744637	.2031026E-01
35.	.9616900E-01	.1236249	-.2745592E-01
36.	.1976390	.2042219	-.6582923E-02
37.	.1929300	.1656683	.2726175E-01
38.	.4857500E-01	.4869944E-01	-.1244361E-03
39.	.1013650	.1027041	-.1339127E-02
40.	.2714920	.2345426	.3694938E-01
41.	.3533600E-01	.3207914E-01	.3256857E-02
42.	.1552940	.1773972	-.2210325E-01
43.	.2397000E-01	.9174887E-03	.2305251E-01
44.	.1167110	.1391665	-.2245554E-01
45.	.9028400E-01	.1104338	-.2014985E-01
46.	.1144050	.1261892	-.1178421E-01
47.	.4655700E-01	.4297942E-01	.3577581E-02
48.	.2836200E-01	.3141382E-02	.2522062E-01
49.	.4167900E-01	.3110459E-01	.1057441E-01
50.	.1494630	.1665230	-.1705996E-01
51.	.1459520	.1652369	-.1928485E-01
52.	.5421600E-01	.3962183E-01	.1459417E-01
53.	.1324540	.1547680	-.2231398E-01
54.	.8140900E-01	.7482993E-01	.6579072E-02
55.	.2322880	.1848006	.4748739E-01
56.	.1981170	.1638771	.3423991E-01
57.	.6144300E-01	.3721037E-01	.2423263E-01
58.	.4876500E-01	.7270533E-01	-.2394033E-01
59.	.9426800E-01	.9396588E-01	.3021168E-03
60.	.3239300E-01	.1005314E-01	.2233986E-01
61.	.1469330	.1558106	-.8877557E-02
62.	.3797400E-01	.2060530E-01	.1736870E-01
63.	.1884100E-01	-.1099328E-01	.2983428E-01
64.	.9933500E-01	.1358719	-.3653687E-01
65.	.2223100E-01	-.1814960E-01	.4038060E-01
66.	.1847380	.2029013	-.1816333E-01
67.	.3470810	.3079366	.3914442E-01
68.	.4755000E-01	.5439496E-01	-.6844957E-02
69.	.8632300E-01	.1077719	-.2144894E-01
70.	.2594870	.2488560	.1063095E-01
71.	.8887500E-01	.1010638	-.1218882E-01
72.	.1496700	.1564943	-.6824320E-02
73.	.7608500E-01	.1117104	-.3562543E-01
74.	.2953350	.2675725	.2776246E-01
75.	.2681600	.2512988	.1686124E-01
76.	.9131800E-01	.1331378	-.4181981E-01
77.	.3477120	.3033661	.4434590E-01
78.	.3533040	.2179501	.1353539
79.	.1355080	.1372834	-.1775366E-02
80.	.1653110	.1355302	.2978083E-01
81.	.2078460	.2322394	-.2439338E-01
82.	.1697210	.1812058	-.1148480E-01
83.	.2192290	.1648358	.5439317E-01
84.	.3052700E-01	.2340999E-01	.7117011E-02
85.	.1088210	.8790506E-01	.2091594E-01
86.	.1815700	.2015272	-.1995718E-01
87.	.3107200	.2071577	.1035623
88.	.1266100E-01	.1515482	-.1388872
89.	.1281570	.1858294	-.5767241E-01
90.	.2456000	.2034632	.4213681E-01
91.	.2122700E-01	.9917948E-02	.1130905E-01



NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
R INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED 87.
NUMBER OF 2 S.D. OUTLIERS 3. OR 3.45 PERCENT OF THE TOTAL

VON NEUMANN RATIO 2.54138 DURBIN-WATSON TEST 2.51217

NUMBER OF POSITIVE RESIDUALS 41.
NUMBER OF NEGATIVE RESIDUALS 46.
NUMBER OF RUNS OF SIGNS 51.

Figure (E2e) Regression Analysis For $\frac{C_iki}{C_i i}$ with U_1 U_2 U_3 and U_5.

E.2.6. In the last step of Regression Analysis, all the five independent variables were entered into the regression equation. These variables yielded the regression equation:

$$\frac{C_{1ki}}{C_{1i}} = -0.11129622+0.42597785(U_1)+0.17774712(U_2) -0.004337009(U_3)+0.0001664909(U_4)+0.007023535(U_5)$$

eqn(E2f)

The other parameters computed are:

Coefficient of multiple correlation R	=	0.92673
Coefficient of determination R^2	=	0.85882
Adjusted R^2	=	0.85011
Change in R at this step	=	0.00070
F-Value	=	98.5504
Standard Deviation	=	0.3414
Coefficient of Variability	=	25.9%

Analysis of Variance	D.F	S.S	MS
Regression	5	0.57434	0.111487
Residuals	81	0.09441	0.00117

F-Values of Variables

U_1 = 126.11121 U_4 = 0.742725

U_2 = 163.06422 U_5 = 0.712435

U_3 = 4.63533

The actual $\frac{C_{1ki}}{C_{1i}}$ values, the estimated $\frac{C_{1ki}}{C_{1i}}$ values and the residuals are tabulated and plotted in fig(E2f).

Observation	$\frac{C_1 ki}{C_1 i}$ Value	$\frac{C_1 ki}{C_1 i}$ Estimate	Residual	−.250 0.0 +.250
1.	.2653150	.2626420	.2672441E-02	
2.	.1965300	.2104179	-.1388785E-01	
3.	.7231800E-01	.1032396	-.3092155E-01	
4.	.9996000E-01	.1532496	-.5328964E-01	
5.	.3208590	.2774313	.4342770E-01	
6.	.8228200E-01	.9642790E-01	-.1414590E-01	
7.	.2893590	.2305571	.5880187E-01	
8.	.3590210	.3172291	.4179193E-01	
9.	.1254620	.1485886	-.2312665E-01	
10.	.1474270	.1554823	-.8055333E-02	
11.	.1376000	.2161057	-.7850573E-01	R
12.	.1440890	.1962438	-.5215481E-01	
13.	.3828220	.3461593	.3666267E-01	
14.	.1283860	.1225615	.5824545E-02	
15.	.6343500E-01	.1025046	-.3906958E-01	
16.	.9864600E-01	.1050102	-.6364186E-02	
17.	.1397750	.1462134	-.6438368E-02	
18.	.1426000E-01	-.3915879E-01	.5341879E-01	
19.	.1227060	.1320243	-.9318320E-02	
20.	.1481340	.1375789	.1055512E-01	
21.	.7147800E-01	.6732768E-01	.4150318E-02	
22.	.5037500E-01	.4765063E-01	.2724365E-02	
23.	.1180140	.1504616	-.3244753E-01	
24.	.6473000E-02	-.2729985E-01	.3377285E-01	
25.	.6754400E-01	.8953833E-01	-.2199433E-01	
26.	.1332290	.1408734	-.7644435E-02	
27.	.5051000E-01	.3663533E-01	.1387467E-01	
28.	.9021300E-01	.8778799E-01	.2425012E-02	
29.	.4013800E-01	.2685178E-01	.1328622E-01	
30.	.1171390	.1478746	-.3073558E-01	
31.	.1041000	.9861881E-01	.5481190E-02	
32.	.1204220	.1270975	-.6675591E-02	
33.	.6052300E-01	.3593222E-01	.2459079E-01	
34.	.2947740	.2696996	.2507436E-01	
35.	.9616900E-01	.1234611	-.2729213E-01	
36.	.1976390	.2050723	-.7433285E-02	
37.	.1929300	.1702052	.2272478E-01	
38.	.4857500E-01	.4740406E-01	.1170939E-02	
39.	.1013650	.1023592	-.9942115E-03	
40.	.2714920	.2304420	.4105002E-01	
41.	.3533600E-01	.2872480E-01	.6611198E-02	
42.	.1552940	.1795295	-.2423551E-01	
43.	.2397000E-01	.3688677E-04	.2393311E-01	
44.	.1167110	.1394829	-.2277187E-01	
45.	.9028400E-01	.1113355	-.2105154E-01	
46.	.1144050	.1260298	-.1162482E-01	
47.	.4655700E-01	.4561418E-01	.9428198E-03	
48.	.2836200E-01	.2928458E-02	.2543354E-01	
49.	.4167900E-01	.2652201E-01	.1515699E-01	
50.	.1494630	.1645841	-.1512105E-01	
51.	.1459520	.1657245	-.1977249E-01	
52.	.5421600E-01	.4183144E-01	.1238456E-01	
53.	.1324540	.1551218	-.2266783E-01	
54.	.8140900E-01	.7626305E-01	.5145946E-02	
55.	.2322880	.1898715	.4241652E-01	
56.	.1981170	.1616997	.3641729E-01	
57.	.6144300E-01	.3682778E-01	.2461522E-01	
58.	.4876500E-01	.6731529E-01	-.1855029E-01	
59.	.9426800E-01	.3568628E-01	-.1418277E-02	
60.	.3239300E-01	.6398504E-02	.2599450E-01	
61.	.1469330	.1537359	-.6802942E-02	
62.	.3797400E-01	.2009153E-01	.1788247E-01	
63.	.1884100E-01	-.1240218E-01	.3124318E-01	
64.	.9933500E-01	.1365759	-.3724091E-01	
65.	.2223100E-01	-.1634128E-01	.3857228E-01	
66.	.1847380	.1967500	-.1201195E-01	
67.	.3470810	.3066309	.4045013E-01	
68.	.4755000E-01	.5419425E-01	-.6644249E-02	
69.	.8632300E-01	.1044313	-.1810833E-01	
70.	.2594870	.2477496	.1173744E-01	
71.	.8887500E-01	.1008737	-.1200371E-01	
72.	.1496700	.1610505	-.1138046E-01	
73.	.7608500E-01	.1132292	-.3714417E-01	
74.	.2953350	.2724863	.2284874E-01	
75.	.2681600	.2523153	.1584471E-01	
76.	.9131800E-01	.1291243	-.3780693E-01	
77.	.3477120	.3019184	.4579355E-01	
78.	.3533040	.2184309	.1348731	R
79.	.1355080	.1403809	-.4872871E-02	
80.	.1653110	.1351732	.3013778E-01	
81.	.2078460	.2311886	-.2334257E-01	
82.	.1697210	.1795853	-.9864339E-02	
83.	.2192290	.1648970	.5433201E-01	
84.	.3052700E-01	.2533629E-01	.5190710E-02	
85.	.1088210	.9408869E-01	.1473231E-01	
86.	.1815700	.1995879	-.1801788E-01	
87.	.3107200	.2080527	.1026673	k
88.	.1266100E-01	.1526543	-.1399933	R
89.	.1281570	.1835531	-.5540205E-01	
90.	.2456000	.2040412	.4155885E-01	
91.	.2122700E-01	.1115742E-01	.1006958E-01	

NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
R INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED 87.
NUMBER OF 2 S.D. OUTLIERS 3. OR 3.45 PERCENT OF THE TOTAL

VON NEUMANN RATIO 2.50893 DURBIN-WATSON TEST 2.48009

NUMBER OF POSITIVE RESIDUALS 43.
NUMBER OF NEGATIVE RESIDUALS 44.
NUMBER OF RUNS OF SIGNS 51.

Figure (E25)
Regression Analysis For $\frac{C_1 ki}{C_1 i}$ with U_1, U_2, U_3, U_4 & U_5

E3 SITE OVERHEAD COSTS MODEL

E.3.1. In the last round of regression analysis the independent variables were entered in a particular order. The first independent variable to be entered into the regression equation was the estimated direct costs of project V_1. This gave rise to the model equation:

$$C_{2ko} = -30560.438+0.089235128(V_1) \qquad \text{eqn}(E3a)$$

The other parameters computed are:

Coefficient of multiple correlation R	=	0.99038
Coefficient of determination R^2	=	0.98086
Adjusted R^2	=	0.98056
Change in R at this step	=	-
F-Value	=	3484.14125
Standard Deviation	=	37372.98597
Coefficient of Variability	=	17.5%

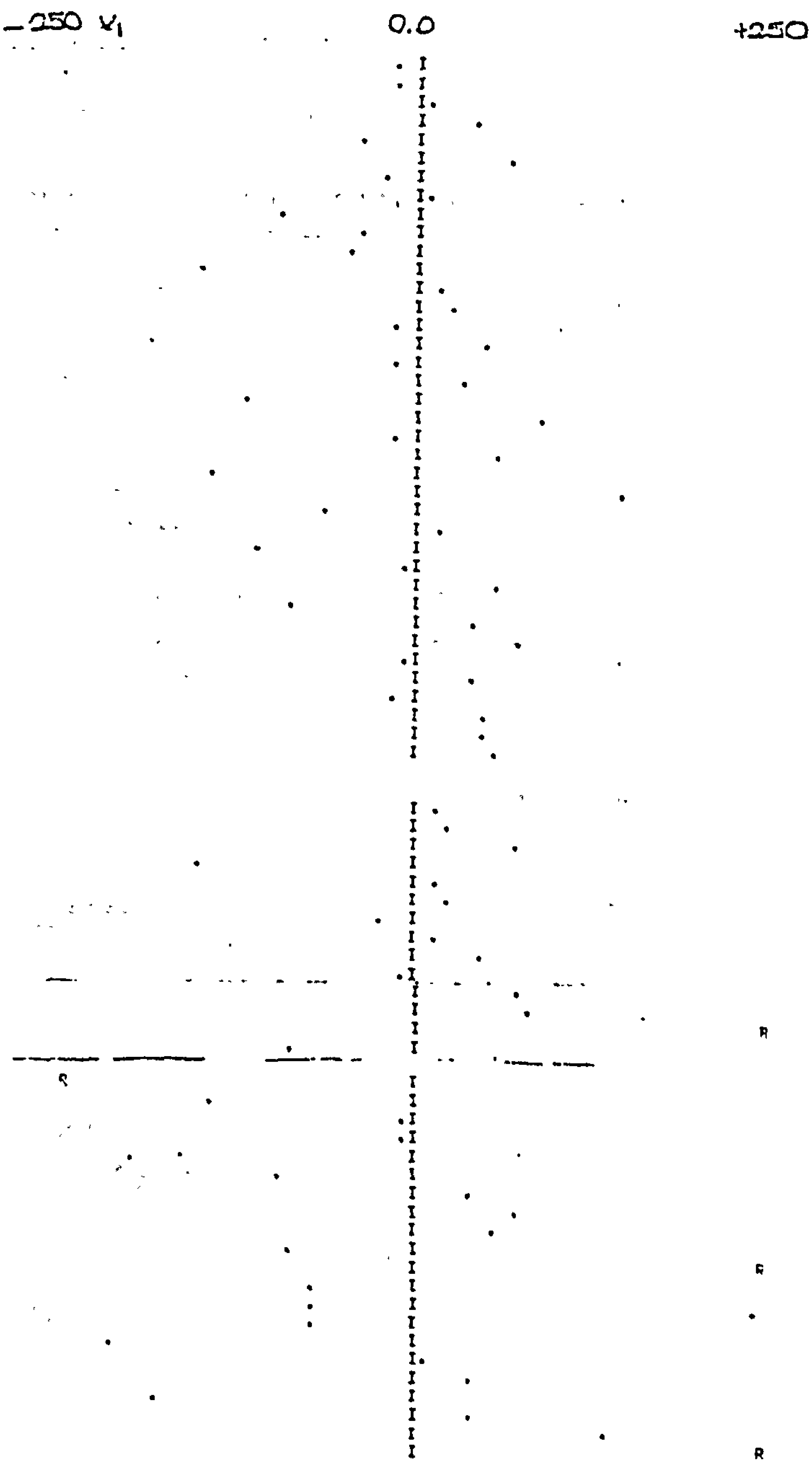
Analysis of Variance	D.F	S.S	MS
Regression	1	4866439725551. 71875	486643972551 .71875
Residuals	68	94978325448. 59814	1396740080.12644

F-Values of Variables

$V_1 = 3484.1412$

The actual C_{1ko} values, the estimated C_{1ko} values and the residuals are tabulated and plotted in fig(E3a).

Observation	C_2ko Value	C_2ko Estimate	Residual
1.	111382.0	115144.6	-3762.553
2.	52268.00	56913.63	-4645.635
3.	83119.00	82353.64	766.3567
4.	50867.00	39606.93	11260.07
5.	213492.0	225502.4	-12010.44
6.	33938.00	16114.89	17873.11
7.	128905.0	135642.8	-6737.754
8.	54721.00	53039.43	1681.568
9.	150447.1	180229.1	-29782.02
10.	76918.00	87373.60	-10455.60
11.	209139.0	224045.2	-14905.22
12.	234840.0	280267.9	-45427.91
13.	189770.0	185052.2	4717.845
14.	63700.00	58261.53	5438.469
15.	76648.00	80666.69	-4018.687
16.	34076.00	19620.04	14455.95
17.	85825.00	89569.50	-3744.497
18.	109450.0	100013.4	9436.602
19.	155877.0	192566.6	-36689.63
20.	61434.00	36433.65	25000.35
21.	53130.00	57224.10	-4094.095
22.	28795.00	13213.85	15581.15
23.	97475.00	141340.8	-43865.77
24.	16077.00	-27878.92	43955.92
25.	144238.0	162396.2	-18158.23
26.	94895.00	91103.81	3791.194
27.	174920.0	209173.4	-34253.36
28.	94980.00	97276.74	-2296.735
29.	28111.00	12320.61	15790.39
30.	138400.0	164206.8	-25806.83
31.	58230.00	46586.27	11643.73
32.	34244.00	12747.15	21496.85
33.	117414.0	119761.5	-2347.489
34.	65367.00	53343.87	12023.13
35.	85927.00	89247.72	-3320.716
36.	50076.00	37247.82	12828.18
37.	55846.00	42725.43	13120.57
38.	42200.00	26756.18	15443.82
39.	84176.00	79256.77	4919.228
40.	63336.00	57473.59	5862.415
41.	84723.00	64942.5	[illegible]
42.	232160.0	278418.0	-46257.95
43.	61216.00	57546.76	3669.242
44.	53736.00	46656.59	7079.408
45.	107712.0	114521.2	-6809.245
46.	74456.00	69727.89	4728.112
47.	49160.00	36208.05	12951.95
48.	54035.00	55314.18	-1279.184
49.	19320.00	-1391.813	20711.81
50.	11390.00	-12665.23	24055.23
51.	816832.0	733487.1	83344.94
52.	179278.0	204358.3	-25080.26
53.	404464.0	491761.9	-87297.85
54.	251643.0	295353.0	-43710.02
55.	60349.00	61025.32	-676.3217
56.	129079.0	130086.0	-1006.993
57.	252610.0	314113.0	-61503.01
58.	196749.0	224246.0	-27516.91
59.	859996.0	849506.7	10489.27
60.	639186.0	617495.8	21690.15
61.	220365.0	204629.4	15735.55
62.	1092180.	1117389.	-25208.80
63.	681430.0	525776.0	155654.0
64.	1247990.	1261979.	-13989.16
65.	182460.0	203376.0	-20916.59
66.	240690.0	260866.0	-20175.96
67.	474518.0	539341.5	-64823.49
68.	138735.0	137419.3	1315.664
69.	929760.0	917636.9	12123.09
70.	512076.0	568323.6	-56252.63
71.	122111.0	111341.3	10769.74
72.	288922.0	248164.6	40757.41
73.	766324.0	626337.2	139986.9



NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
P INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED 70.
NUMBER OF 2 S.D. OUTLIERS 4. OR 5.71 PERCENT OF THE TOTAL

VON NEUMANN RATIO 1.78647 DURBIN-WATSON TEST 1.76095

NUMBER OF POSITIVE RESIDUALS 35.
NUMBER OF NEGATIVE RESIDUALS 35.
NUMBER OF RUNS OF SIGNS [illegible]

Figure (E3a) Regression Analysis For C_2ko with V_1

E.3.2. The second independent variable V_2, planned duration of project, was entered into the regression equation. Regression analysis performed with the two variables V_1 and V_2 yielded the regression equation

$$C_{2ko} = -32729.475 + .088758063(V_1) + 209.15877(V_2) \qquad \text{eqn(E3b)}$$

The other parameters computed are:

Coefficient of multiple correlation R	=	0.99039
Coefficient of determination R^2	=	0.98087
Adjusted R^2	=	0.98030
Change in R at this step	=	0.00001
F-Value	=	1717.88577
Standard Deviation	=	37635.44065
Coefficient of Variability	=	17.7%

Analysis of Variance	D.F	S.S	MS
Regression	2	4866517482822.56250	2433258741411.28125
Residuals	67	94900568177.73584	1416426390.71247

F-Values of Variables

$V_1 = 1218.8457$
$V_2 = .054896$

The actual C_{2ko} values, the estimated C_{2ko} values and the residuals are tabulated and plotted in fig(E3b).

Observation	C_2ko Value	C_2ko Estimate	Residual
1.	11.382.	116379.7	-4997.729
2.	52268.00	58041.81	-5773.805
3.	83119.00	82087.87	1031.129
4.	50867.00	38945.19	11921.81
5.	213492.	226984.3	-13492.26
6.	33988.00	15369.59	18618.41
7.	128905.0	135722.5	-6817.551
8.	54721.00	52724.26	1996.737
9.	150447.0	180697.9	-30250.91
10.	76918.00	87711.45	-10793.45
11.	209139.	225744.	-16615.0
12.	234840.0	282921.1	-48081.06
13.	139770.0	136750.2	3019.771
14.	63700.00	56872.59	6827.403
15.	76648.00	79994.62	-3346.60
16.	34076.00	18437.59	15638.31
17.	85525.00	89895.61	-4370.608
18.	109450.0	100911.7	8538.849
19.	155877.0	192760.4	-36883.43
20.	55434.00	30239.27	25194.73
21.	53110.00	59376.51	-6266.506
22.	28795.00	12065.75	16729.25
23.	97475.00	141180.9	-43705.95
24.	16077.0	-28807.34	44884.34
25.	144238.	162333.1	-18095.02
26.	94895.00	90166.76	4728.234
27.	174820.0	209388.1	-34568.05
28.	94980.00	97352.48	-2372.481
29.	28111.00	10968.12	17142.88
30.	138400.0	164552.2	-26152.23
31.	58230.0	46723.86	11506.14
32.	33244.00	12019.85	21224.14
33.	117414.0	122017.8	-4603.770
34.	65367.00	53027.02	12339.98
35.	85927.00	89366.39	-3439.388
36.	50076.00	36598.70	13477.3
37.	55846.00	42256.18	13589.82
38.	42210.00	26591.45	15618.54
39.	84176.00	79428.86	4747.142
40.	63336.0	57552.97	5783.132
41.	88723.00	66343.79	22379.21
42.	232160.0	280662.7	-48502.72
43.	61216.00	57625.75	3590.25
44.	53736.00	45957.17	7778.830
45.	107712.0	114504.8	-6792.801
46.	74456.00	69741.76	4714.242
47.	49150.00	35773.65	13386.35
48.	54035.00	54568.49	-533.4768
49.	19320.00	-2460.843	21780.84
50.	11390.00	-13884.14	25274.14
51.	816832.0	734972.2	81859.83
52.	179278.0	203961.5	-24583.54
53.	404464.0	490565.3	-86101.26
54.	251643.0	294997.3	-43354.37
55.	60349.00	60458.24	-109.2403
56.	129079.0	129358.4	-279.8613
57.	252610.0	314702.8	-62092.78
58.	196740.0	224688.8	-27948.73
59.	859996.0	848907.5	11088.52
60.	639086.0	616882.	22203.93
61.	220865.0	203294.5	17570.33
62.	1092180.	1115357.	-23177.41
63.	681430.0	526070.8	155359.2
64.	1247990.	1267323.	-19332.66
65.	182460.0	202257.6	-19797.63
66.	240690.0	259230.5	-18540.50
67.	474518.0	539354.6	-64836.64
68.	138735.	136025.5	2709.477
69.	929760.0	917719.3	12040.73
70.	512076.	570069.2	-57993.23
71.	122211.	112895.9	9305.7
72.	288922.0	249316.1	39605.90
73.	766324.0	628395.1	137928.9

-250 0.0 +250

NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
R INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED 70.
NUMBER OF 2 S.D. OUTLIERS 4. OR 5.71 PERCENT OF THE TOTAL

VON NEUMANN RATIO 1.79639 DURBIN-WATSON TEST 1.77073

NUMBER OF POSITIVE RESIDUALS 35.
NUMBER OF NEGATIVE RESIDUALS 35.
NUMBER OF RUNS OF SIGNS 38.

Figure (E3b) Regression Analysis For C_2ko with V_1 and V_2.

E.3.3. The third independent variable, the inflation variable V_3 was entered into the regression equation. This gave rise to the regression equation

$$C_{2ko} = 31163.042+0.088980698(V_1)+289.6650(V_2)-309.50911(V_3)$$

eqn(E3c)

The other parameters computed are:

Coefficient of multiple correlation R	=	0.99081
Coefficient of determination R^2	=	0.98170
Adjusted R^2	=	0.98087
Change in R at this step	=	0.00042
F-Value	=	1180.20940
Standard Deviation	=	37089.60515
Coefficient of Variability	=	17.4%

Analysis of Variance	D.F	S.S	MS
Regression	3	487062589534.21875	1623541903178.07031
Residuals	66	90792161466.09326	1375638810

F-Values of Variables

V_1 = 1257.9628 V_3 = 2.9865446

V_2 = 0.108109

The actual C_{2ko} values, the estimated C_{2ko} values and the residuals are tabulated and plotted in fig(E3c).

Observation	$C_{1}ko$ Value	$C_{1}ko$ Estimate	Residual
1.	111382.0	115731.4	-4319.446
2.	52268.00	43129.32	9139.683
3.	83119.00	77588.62	5530.376
4.	50867.01	46478.15	4388.851
5.	213492.0	219165.5	-5673.611
6.	33998.01	7287.969	26710.03
7.	128905.0	139335.5	-10430.51
8.	54721.00	43428.74	11292.25
9.	150447.0	167641.6	-17193.62
10.	76918.01	94299.87	-17381.87
11.	209139.0	230382.5	-21243.54
12.	234840.0	283540.3	-48700.32
13.	189770.0	189663.5	106.5206
14.	63700.00	54925.23	8774.764
15.	76648.00	69139.96	7508.044
16.	34076.00	17941.53	16134.47
17.	85525.00	81013.26	4511.744
18.	109450.0	89820.33	19629.77
19.	155977.0	190486.2	-34669.25
20.	55434.00	41005.44	14428.56
21.	53110.00	58795.19	-5685.186
22.	28765.00	25451.51	3313.487
23.	97475.00	133894.8	-36419.80
24.	16077.00	-13946.55	30023.55
25.	144238.0	154251.4	-10013.39
26.	94895.00	75234.03	19660.97
27.	174820.0	208783.1	-33963.11
28.	94380.00	93851.49	1928.510
29.	28111.01	13468.33	14642.67
30.	138400.0	156017.1	-17617.11
31.	58230.00	51501.17	6728.833
32.	33244.00	5477.383	27766.62
33.	117414.0	123301.1	-5887.092
34.	65367.00	63850.35	1516.651
35.	85927.00	91235.54	-5308.545
36.	51076.0	31197.86	19878.14
37.	55846.00	54520.05	1325.949
38.	42200.00	47552.25	-5352.261
39.	84176.00	101391.1	-17215.18
40.	63336.00	49977.07	13358.93
41.	68723.00	72477.95	16245.13
42.	232,680.0	279568.8	-47478.79
43.	61216.00	56240.22	4975.783
44.	53736.00	56912.31	-3176.313
45.	107712.0	105604.2	2107.995
46.	74456.00	68386.62	6069.384
47.	49160.00	35640.93	13519.10
48.	54375.07	42022.53	12612.47
49.	19320.00	-4555.958	23876.97
50.	11390.00	-14541.35	25931.35
51.	816832.0	736276.7	80555.33
52.	179278.0	201375.3	-22097.25
53.	404464.0	483546.9	-79082.89
54.	251643.0	238860.2	-47217.23
55.	63349.00	72767.78	-12418.78
56.	129479.0	120255.6	8823.432
57.	252610.0	319015.1	-65405.05
58.	196740.0	224202.2	-27462.16
59.	859996.0	855193.5	4795.423
60.	639086.0	617779.1	21305.91
61.	220865.1	194296.8	26568.19
62.	1092180.	1109318.	-17138.47
63.	681430.0	529066.5	152363.4
64.	1247990.	1270811.	-22821.05
65.	182460.0	202622.5	-20162.47
66.	240690.0	262753.3	-22063.33
67.	474518.0	538589.7	-64071.69
68.	138735.0	127318.0	11416.99
69.	929760.0	920250.7	9509.260
70.	512076.0	573815.3	-61739.27
71.	122211.0	112299.7	9912.335
72.	288922.0	246116.1	42805.89
73.	766324.0	631908.4	134415.6

NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
R INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED 70.
NUMBER OF 2 S.D. OUTLIERS 4. OR 5.71 PERCENT OF THE TOTAL

VON NEUMANN RATIO 1.72272 DURBIN-WATSON TEST 1.69811

NUMBER OF POSITIVE RESIDUALS 39.
NUMBER OF NEGATIVE RESIDUALS 31.
NUMBER OF RUNS OF SIGNS 38.

Figure (E3c) Regression Analysis For $C_{1}ko$ with V_1, V_2 and V_3.

E.3.4. The inflation variable was removed from the regression equation and the type of project variable, V_4 entered. Regression analysis was performed with variables V_1, V_2 and V_4:

$$C_{2ko} = 50524.199+0.083788321(V_1)+524.66248(V_2)-42635.851(V_4)$$
eqn(E.3d)

The other parameters computed are:

Coefficient of multiple correlation R	=	0.99163
Coefficient of determination R^2	=	0.98333
Adjusted R^2	=	0.98025
Change in R at this step	=	0.00082
F-Value	=	1297.54351
Standard Deviation	=	35402.21425
Coefficient of Variability	=	16.6%

Analysis of Variance	D.F	S.S	MS
Regression	3	4878699143938.12500	1626233047979.37500
Residuals	66	82718907062.19971	1253316773.66969

F-Values of Variables

V_1 = 849.90845 V_4 = 9.7195389

V_2 = 0.38474

The actual C_{2ko} values, the estimated C_{2ko} values and the residuals are tabulated and plotted in fig(E3d).

Observation	C_2ko Value	C_2ko Estimate	Residual	-2SD ... 0.0 ... +2SD
1.	111382.0	112557.1	-1175.077	.I
2.	52268.00	56831.18	-4563.173	. I
3.	83119.00	77567.57	5551.432	I .
4.	50867.00	35858.89	15009.11	I .
5.	213492.0	218277.5	-4785.497	. I
6.	33988.00	13276.12	20711.83	I .
7.	128905.0	129180.9	-275.7780	.
8.	54721.00	49520.87	5230.120	I .
9.	150447.0	172619.5	-22172.52	. I
10.	76918.00	83657.95	-6739.316	. I
11.	209139.0	217433.9	-8294.895	. I
12.	234840.0	273372.8	-38532.79	. I
13.	189770.0	180296.2	9473.75	I .
14.	53710.00	51800.85	11899.15	I .
15.	76048.00	74337.07	1710.927	I.
16.	34076.00	15518.00	17958.01	I .
17.	85525.00	85919.78	-394.7780	.I
18.	119450.0	97300.18	12149.82	I .
19.	155177.0	183579.4	-27802.43	. I
20.	55434.00	28294.86	27139.14	I .
21.	53110.00	59727.22	-6617.222	. I
22.	28715.00	9532.933	19092.17	I .
23.	97475.00	134006.3	-36531.31	. I
24.	16077.00	-29081.69	45158.69	I .
25.	144238.0	154331.3	-10063.27	. I
26.	94835.00	84212.46	10682.54	I .
27.	174820.0	199703.3	-24883.29	. I
28.	94940.00	92631.91	2348.584	I.
29.	29111.00	9139.448	19971.55	I .
30.	138400.0	157050.7	-18650.65	. I
31.	58230.00	44510.89	13719.12	I .
32.	33244.00	10113.94	23130.56	I .
33.	117414.0	119515.5	-2101.512	.I
34.	65387.00	49836.67	15560.33	I .
35.	85927.00	85092.98	834.9743	I.
36.	50076.00	33643.78	16432.22	I .
37.	57846.00	39311.70	16534.39	I .
38.	42200.00	24841.86	17358.14	I .
39.	84176.00	75711.87	8464.132	I .
40.	63326.00	54733.64	8592.352	I .
41.	38723.00	52050.60	26672.40	. I
42.	232160.0	270586.4	-38426.44	. I
43.	51216.00	54802.34	6413.653	I
44.	53736.00	42478.25	11257.75	I .
45.	107712.0	108823.8	-1111.833	.I
46.	74456.00	66233.95	8216.347	I .
47.	41264.00	37192.14	15967.85	I .
48.	54035.00	50607.37	3427.605	I .
49.	19320.00	-4210.384	23530.39	I .
50.	11390.00	-15321.26	26711.24	I .
51.	816832.0	744711.9	72120.21	I
52.	179278.0	193177.2	-13899.31	. I
53.	404464.0	465136.1	-60672.73	. I
54.	251643.0	280191.8	-28548.84	. I
55.	51349.00	56494.59	3854.456	I .
56.	123079.0	164500.4	-35421.40	. I
57.	252610.0	330430.1	-47320.05	. I
58.	196740.0	214474.4	-17734.44	. I
59.	859396.0	849977.1	13018.87	I .
60.	631186.0	628979.9	10105.55	I .
61.	220865.0	233969.1	-13104.15	. I
62.	1432180.	1101538.	-9327.791	. I
63.	641439.	543307.9	137522.1	I R
64.	1247990.	1246925.	1062.303	I.
65.	182460.0	233317.4	-50857.47	. I
66.	240690.0	286773.6	-46783.65	. I
67.	474518.0	556120.7	-81602.70	R I
68.	138735.0	169812.1	-31077.12	. I
69.	929760.0	916572.1	13187.93	I .
70.	512476.0	588360.5	-75884.45	R I
71.	122111.0	152146.4	-30035.43	. I
72.	288922.0	281667.6	7254.434	I .
73.	766324.0	644102.2	122221.3	I R

NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
R INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED 70.
NUMBER OF 2 S.D. OUTLIERS 5. OR 7.14 PERCENT OF THE TOTAL

VON NEUMANN RATIO 1.50453 DURBIN-WATSON TEST 1.50167

NUMBER OF POSITIVE RESIDUALS 38.
NUMBER OF NEGATIVE RESIDUALS 32.
NUMBER OF RUNS OF SIGNS 34.

Figure (E3d) Regression Analysis for C_2ko with V_1, V_2 and V_4.

E.3.5 All the four independent variables were entered into the regression equation. This gave rise to the regression:

$$C_{2ko} = 123215.84+0.083865125(V_1)+623.32308(V_2) -338.60141(V_3)-44066.485(V_4) \qquad \text{eqn(E3e)}$$

The other parameters computed are:

Coefficient of multiple correlation R	=	0.99213
Coefficient of determination R^2	=	0.98432
Adjusted R^2	=	0.98152
Change in R at this step	=	0.00050
F-Value	=	1019.82844
Standard Deviation	=	34600.03974
Coefficient of Variability	=	16.2%

Analysis of Variance	D.F	S.S	MS
Regression	4	4883602472228.40625	1220900618057.10156
Residuals	65	77815578771.90430	1197162750.33698

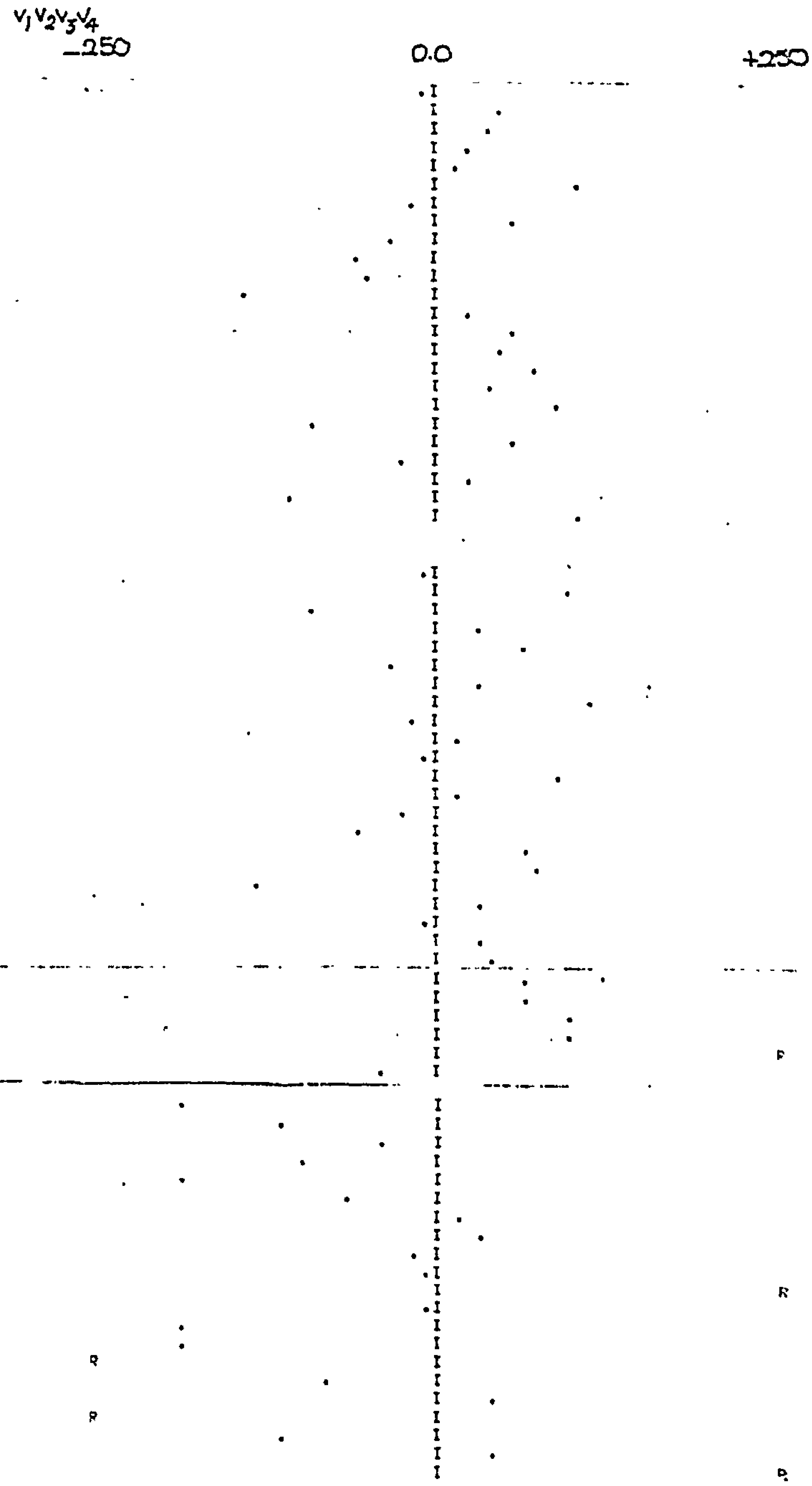
F-Values of Variables

V_1 = 891.24348 V_3 = 4.09579

V_2 = 0.566620 V_4 =10.83945

The actual C_{2ko} values, the estimated C_{2ko} values and the residuals are tabulated and plotted in fig(E3e).

Observation	C_2ko Value	C_2ko Estimate	Residual
1.	111342.0	111686.8	-304.7694
2.	52268.00	40476.37	11791.63
3.	83119.03	72493.74	10625.26
4.	5.667.0)	43996.35	6970.654
5.	213492.?	209431.8	4060.219
6.	33938.00	*4364.619	29623.33
7.	125905.?	132913.8	-4008.93?
8.	54721.0?	39244.13	15476.87
9.	150447.0	158063.9	-7616.850
10.	76913.00	90935.44	-14017.44
11.	209.39.?	222229.6	-13090.64
12.	234840.0	273729.9	-38889.87
13.	189770.0	183266.8	6503.231
14.	637 0.0	49500.34	14199.65
15.	76648.00	62892.44	13755.56
16.	34076.00	14877.23	19198.77
17.	85525.0?	76069.12	9455.878
18.	109450.0	85045.69	24404.31
19.	155477.?	180856.8	-25389.77
20.	55434.0	41007.76	15426.24
21.	53110.00	59103.03	-5993.029
22.	28745.09	24093.62	4701.383
23.	97475.0?	125794.5	-28319.58
24.	16077.00	-12833.27	28910.27
25.	144139.0	145193.5	-952.4306
26.	94895.00	67676.34	27218.65
27.	174820.0	198716.5	-23696.47
28.	94 133.0?	87768.25	7211.749
29.	28111.00	10779.75	17331.25
30.	138400.0	147461.6	-9061.565
31.	58230.0?	49662.97	8567.?33
32.	332?4.00	2892.577	30351.44
33.	117414.0	120835.5	-3421.491
34.	65367.0?	61539.29	3827.712
35.	35 327.00	36994.43	-1067.431
36.	50076.07	26542.14	23533.06
37.	55846.00	52629.52	3216.473
38.	42200.00	47725.44	-5525.435
39.	84176.0?	99613.82	-15437.82
40.	63336.0?	46351.04	16984.95
41.	88723.00	68617.23	20105.77
42.	232160.0	269051.6	-36891.61
43.	61216.0?	53191.84	8024.16
44.	53736.03	54346.39	-610.3900
45.	107712.?	98896.00	8816.002
46.	74455.0	64639.93	9816.?67
47.	49160.00	32960.29	16199.71
48.	54035.00	36749.28	17285.72
49.	19320.0	-6562.24?	25882.24
50.	11390.00	-16088.49	27478.49
51.	8?6332.?	746465.8	7?266.25
52.	179278.?	?90094.6	-10820.62
53.	404464.0	456605.5	-52141.47
54.	25?643.0	283921.1	-32278.09
55.	50349.00	69828.17	-9479.165
56.	12?179.6	155720.6	-26641.6
57.	252610.0	3 4668.7	-52158.74
58.	196740.0	213599.4	-16859.38
59.	859396.?	856896.5	3599.456
60.	63? 86.?	630367.3	8718.72
61.	220865.0	225154.9	-4289.952
62.	1092180.	1094437.	-2256.712
63.	68?430.?	547783.9	133646.?
64.	1247990.	1250060.	-2069.634
65.	182460.0	234758.6	-52298.77
66.	241690.?	?91551.2	-5? 361.2?
67.	474518.0	555846.4	-81328.42
68.	138735.?	161419.9	-22684.87
69.	929760.0	919303.0	10456.97
70.	5?2176.0	592762.3	-80686.29
71.	122?11.?	152892.2	-30691.15
72.	288322.0	279252.4	9669.649
73.	766324.0	648472.8	117851.2



NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED

R INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED 70.
NUMBER OF 2 S.D. OUTLIERS 5. OR 7.14 PERCENT OF THE TOTAL

VON NEUMANN RATIO 1.47003 DURBIN-WATSON TEST 1.44909

NUMBER OF POSITIVE RESIDUALS 36.
NUMBER OF NEGATIVE RESIDUALS 34.
NUMBER OF RUNS OF SIGNS 34.

Figure (E3e) Regression Analysis for C_2ko with V_1, V_2, V_3, and V_4.

E.3.6. Regression analysis performed with the cost of project variable V_1 and the type of project variable V_4 after removing the duration of project variable, V_2 and the inflation variable, V_3 yielded the regression equation:

$$C_{2ko} = 53905.181 + 0.085086193(V_1) - 41620.820(V_4) \qquad \text{eqn}(E.3f)$$

The other parameters computed are:

Coefficient of multiple correlation R	=	0.99158
Coefficient of determination R^2	=	0.98323
Adjusted R^2	=	0.98273
Change in R at this step	=	0.00120
F-Value	=	1964.15819
Standard Deviation	=	35239.30406
Coefficient of Variability	=	16.5%

Analysis of Variance	D.F	S.S	MS
Regression	2	4878216878115.09375	2439108439057. 54687
Residuals	67	83201172885.22803	1241808550. 52579

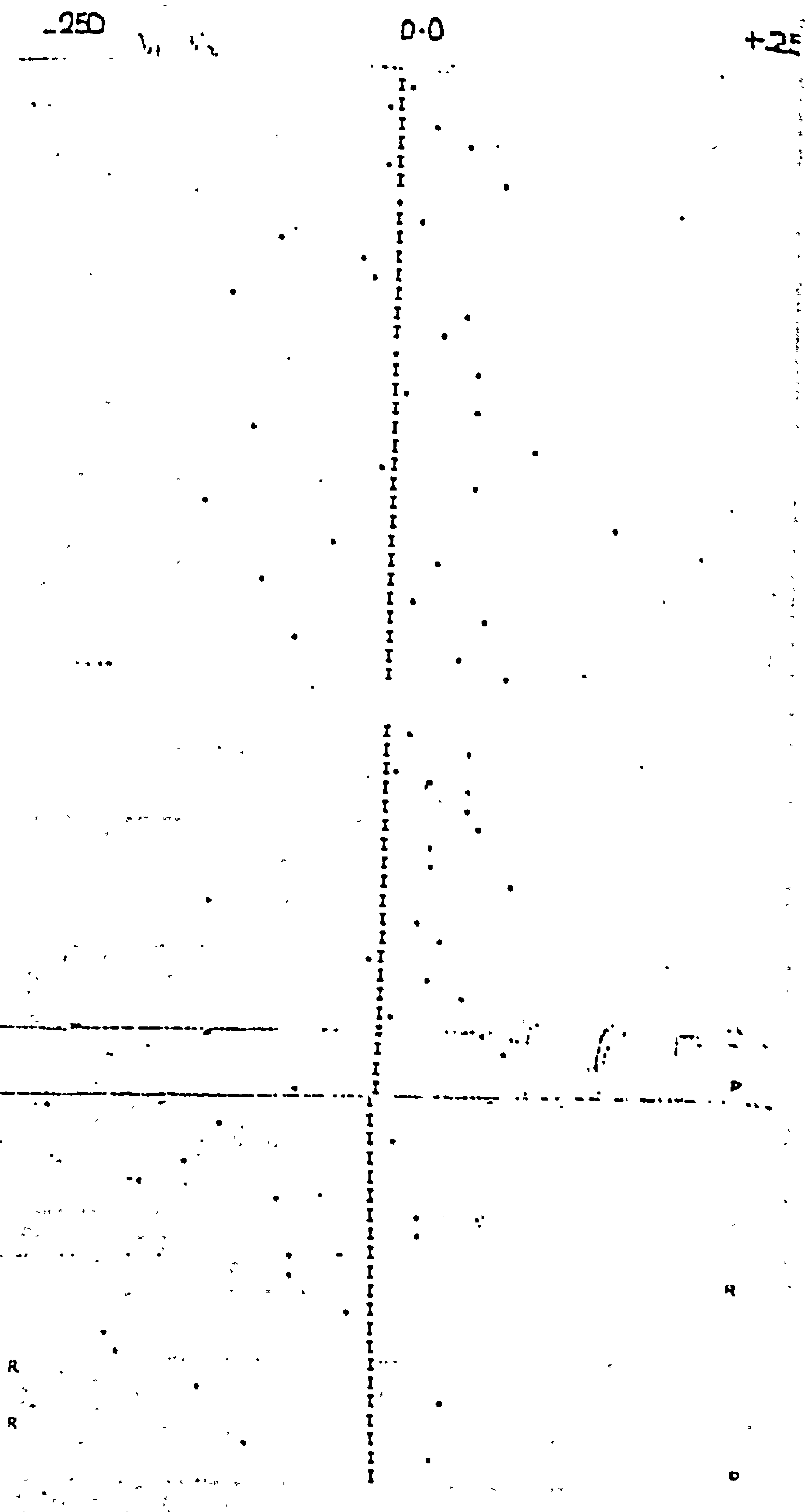
F-Values of Variables

V_1 = 1881.89540

V_4 9.48387

The actual C_{2ko} values, the estimated C_{2ko} values and the residuals are tabulated and plotted in fig(E.3f).

Observation	C_2ko Value	C_2ko Estimate	Residual
1.	111302.0	109594.1	1707.929
2.	52268.9	54070.57	-1802.550
3.	83119.00	78324.90	4794.105
4.	56867.00	37568.52	13298.49
5.	213492.0	214820.9	-1328.132
6.	33988.00	15168.73	18819.27
7.	128905.6	129139.2	-234.2208
8.	54721.00	50376.55	4344.452
9.	150447.0	171652.5	-21205.45
10.	76918.00	43114.31	-6196.312
11.	209139.0	213431.5	-4297.475
12.	234840.0	267040.1	-32200.12
13.	189770.0	176251.4	13518.64
14.	637[illegible]	55355.79	8344.208
15.	76648.00	76719.23	-71.23367
16.	34076.00	18510.92	15565.08
17.	85525.00	85208.11	316.8477
18.	109450.0	95166.43	-14283.57
19.	155877.0	183416.5	-27539.47
20.	55434.0	28821.75	26612.25
21.	53110.00	54347.52	-1237.521
22.	28795.00	12402.58	16392.42
23.	97475.00	134572.3	-37097.31
24.	16077.00	-26779.61	42856.61
25.	144232.0	154644.8	-10412.83
26.	94895.0	66671.09	8223.915
27.	174820.0	199155.7	-24335.71
28.	94980.00	92557.01	2422.992
29.	28[illegible]10.0	11559.87	16560.13
30.	138400.0	156375.2	-17975.23
31.	58230.00	44223.37	14006.63
32.	33244.0	11957.58	21286.42
33.	117414.0	113996.3	3417.654
34.	65367.00	50666.78	14700.22
35.	85927.00	84901.29	1025.703
36.	50076.00	35319.16	14756.93
37.	55846.0	40542.03	15303.97
38.	42200.00	25315.25	16884.74
39.	84176.0	75374.87	8801.128
40.	63336.00	54604.48	8732.519
41.	88723.00	63633.12	25089.85
42.	232160.0	265276.2	-33116.19
43.	61216.0	54674.25	6541.748
44.	53736.00	44290.42	9445.582
45.	107712.0	108999.7	-1287.744
46.	74456.0	66289.03	8166.972
47.	49160.00	34327.68	14832.32
48.	54035.00	52545.48	1489.52
49.	[illegible]	-[illegible]	[illegible]
50.	11390.00	-12273.27	23663.27
51.	816332.0	740307.9	76024.07
52.	179278.0	194659.8	-15381.84
53.	404464.0	468718.8	-64236.78
54.	151643.0	181423.9	-29780.89
55.	60349.00	57991.08	2357.919
56.	129079.0	165461.6	-36382.64
57.	252610.0	299311.6	-46761.61
58.	196740.0	213622.9	-16882.92
59.	859196.0	851033.3	8162.664
60.	639096.0	630723.7	8375.341
61.	220865.0	236539.2	-15674.24
62.	1092180.	1106860.	-14680.39
63.	681430.0	542754.2	138675.4
64.	1247990.	1251335.	-3345.892
65.	182460.0	235344.6	-52884.63
66.	240690.0	290161.1	-49471.07
67.	474518.0	555689.0	-81171.04
68.	138735.0	172454.0	-33719.02
69.	929760.0	916395.9	13364.12
70.	512076.0	583328.4	-71252.44
71.	122111.0	147588.4	-25477.43
72.	288922.0	278050.2	10871.74
73.	766324.0	638639.9	127684.1



NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
R INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED 70.
NUMBER OF 2 S.D. OUTLIERS 5. OR 7.14 PERCENT OF THE TOTAL

VON NEUMANN RATIO 1.58257 DURBIN-WATSON TEST 1.55395

NUMBER OF POSITIVE RESIDUALS 39.
NUMBER OF NEGATIVE RESIDUALS 31.
NUMBER OF RUNS OF SIGNS 25.

Figure (E3f) Regression Analysis for C2ko with V_1 and V_4

F: F DISTRIBUTION TABLE

Degrees of freedom —numerator	1		2		3		4		5		6		8		12	
Probability	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01
Degrees of freedom—denominator																
1	161.450	4052.100	199.500	4999.000	215.720	5403.500	224.570	5625.100	230.170	5764.100	233.970	5859.400	238.890	5981.400	243.910	6105.800
2	18.512	98.495	18.999	99.008	19.163	99.167	19.248	99.246	19.298	99.305	19.329	99.325	19.371	99.365	19.414	99.425
3	10.129	34.117	9.552	30.815	9.276	29.459	9.118	28.709	9.014	28236	8.941	27.910	8.844	27.489	8.744	27.053
4	7.710	21.200	6.945	18.001	6.591	16.693	6.388	15.978	6.257	15.521	6.164	15.208	6.041	14.800	5.912	14.374
5	6.607	16.258	5.786	13.274	5.410	12.059	5.192	11.391	5.050	10.966	4.950	10.672	4.818	10.266	4.678	9.888
6	5.987	13.744	5.143	10.924	4.756	9.779	4.534	9.149	4.388	8.746	4.284	3.465	4.147	3.101	4.000	7.718
7	5.591	12.246	4.737	9.546	4.347	8.452	4.121	7.846	3.972	7.460	3.866	7.191	3.725	6.840	3.574	6.467
8	5.317	11.259	4.450	8.649	4.067	7.591	3.838	7.006	3.688	6.631	3.580	6.371	3.438	6.029	3.284	5.667
9	5.117	10.561	4.256	8.022	3.863	6.992	3.633	6.423	3.482	6.057	3.374	5.802	3.230	5.467	3.073	5.111
10	4.965	10.044	4.103	7.560	3.708	6.552	3.478	5.994	3.326	5.636	3.217	5.386	3.072	5.057	2.913	4.706
11	4.844	9.647	3.982	7.205	3.587	6.217	3.357	5.668	3.204	5.317	3.094	5.069	2.948	4.745	2.788	4.397
12	4.747	9.330	3.885	6.927	3.490	5.953	3.259	5.412	3.106	5.064	2.999	4.820	2.848	4.500	2.686	4.156
13	4.667	9.074	3.805	6.701	3.410	5.740	3.179	5.205	3.025	4.862	2.915	4.620	2.767	4.302	2.604	3.961
14	4.600	8.862	3.739	6.514	3.344	5.563	3.112	5.035	2.958	4.695	2.848	4.456	2.699	4.140	2.534	3.800
15	4.543	8.683	3.683	6.359	3.287	5.417	3.056	4.893	2.901	4.556	2.790	4.318	2.641	4.004	2.475	3.668
16	4.494	8.532	3.634	6.227	3.239	5.292	3.007	4.772	2.853	4.437	2.741	4.201	2.591	3.889	2.424	3.553
17	4.451	8.400	3.592	6.112	3.197	5.185	2.965	4.669	2.810	4.336	2.699	4.102	2.548	3.791	2.381	3.455
18	4.414	8.285	3.555	6.013	3.160	5.092	2.928	4.579	2.773	4.248	2.661	4.015	2.510	3.706	2.342	3.370
19	4.381	8.184	3.522	5.926	3.127	5.010	2.895	4.501	2.740	4.170	2.629	3.939	2.477	3.631	2.308	3.296
20	4.351	8.096	3.493	5.849	3.098	4.938	2.866	4.431	2.711	4.103	2.599	3.871	2.447	3.565	2.278	3.231
21	4.325	8.017	3.467	5.780	3.072	4.875	2.840	4.368	2.685	4.042	2.573	3.811	2.421	3.506	2.250	3.173
22	4.301	7.944	3.443	5.719	3.049	4.816	2.817	4.314	2.661	3.988	2.549	3.759	2.397	3.453	2.226	3.121
23	4.279	7.881	3.422	5.663	3.028	4.765	2.795	4.264	2.640	3.939	2.528	3.710	2.375	3.406	2.203	3.074
24	4.260	7.823	3.403	5.614	3.009	4.718	2.777	4.218	2.621	3.895	2.508	3.666	2.355	3.363	2.183	3.031
25	4.242	7.770	3.385	5.568	2.991	4.676	2.759	4.177	2.603	3.855	2.490	3.627	2.337	3.324	2.165	2.993
26	4.225	7.722	3.369	5.527	2.975	4.637	2.743	4.140	2.587	3.818	2.474	3.591	2.321	3.288	2.148	2.938
27	4.210	7.677	3.354	5.488	2.961	4.601	2.727	4.106	2.572	3.785	2.459	3.558	2.305	3.256	2.132	2.925
28	4.196	7.636	3.340	5.453	2.947	4.568	2.714	4.074	2.558	3.754	2.445	3.528	2.292	3.226	2.118	2.896
29	4.183	7.597	3.328	5.421	2.934	4.538	2.702	4.045	2.545	3.726	2.432	3.499	2.278	3.198	2.104	2.869
30	4.171	7.563	3.316	5.390	2.922	4.510	2.690	4.018	2.534	3.699	2.421	3.474	2.266	3.173	2.092	2.843
60	4.001	7.077	3.151	4.978	2.758	4.126	2.525	3.649	2.368	3.339	2.254	3.119	2.097	2.823	1.918	2.496
∞	3.841	6.635	2.996	4.605	2.605	3.782	2.372	3 320	2.214	3.017	2.099	2.802	1.938	2.511	1.752	2.182

G COMPUTER PROGRAMMES

G.1 SPSS SUB-PROGRAMME FOR REGRESSION ANALYSIS

The SPSS sub-programme on regression analysis at the London University Computer Centre was used in developing the costs model for:

(1) The head office overhead costs apportioned to a project at the tender stage,

(2) The head office overhead costs apportioned to a project during construction stage,

(3) The site overhead costs of a project.

```
RUN NAME          DEVELOPING COST MODEL FOR THE HEAD OFFICE OVERHEAD
                  COSTS APPORTIONED TO THE Kth PROJECT AT THE TENDER
                  STAGE
VARIABLE LIST     CIKO, XI, X2, X3, X4
VAR LABELS        CIKO HEAD OFFICE OVERHEAD COSTS APPORTIONED TO THE
                       K PROJECT AT THE TENDER STAGE/
                  XI   ESTIMATED DIRECT COSTS OF THE PROJECT/
                  X2   PLANNED DURATION OF THE PROJECT/
                  X3   INFLATION
                  X4   TYPE OF PROJECT - CIVIL ENGINEERING, BUILDING/
INPUT FORMAT      FREEFIELD
N OF CASES        48
COMMENT           FIVE PER CENT OF DATA TO BE USED FOR EXTRAPOLATION
COMPUTE           WEIGHT = I
```

```
IF                  (UNIFORM(I) LE .05) WEIGHT=0
WEIGHT              WEIGHT
IF                  (X4 EQ I) CENG = I
IF                  (X4 EQ 2) BUILD = I
REGRESSION          METHOD=FORWARD/
                    VARIABLES = CIKO, XI, X2, X3, X4/
                    REGRESSION = CIKO (*,*,*,*) WITH XI(2)/
                    RESIDUALS/
                    REGRESSION = CIKO (*,*,*,*) WITH X2(4)/
                    RESIDUALS/
                    REGRESSION = CIKO (*,*,*,*) WITH X3(6)/
                    RESIDUALS/
                    REGRESSION = CIKO (*,*,*,*) WITH X4(8)/
                    RESIDUALS/
                    REGRESSION = CIKO (*,*,*,*) WITH XI(3), X2(I)/
                    RESIDUALS/
                    REGRESSION = CIKO (*,*,*,*) WITH XI(3), X2(I)/
                    RESIDUALS/
                    REGRESSION = CIKO (*,*,*,*) WITH XI(3), X4(I)/
                    RESIDUALS/
                    REGRESSION = CIKO (*,*,*,*) WITH XI(5), X2(3),
                    X3(I)/ RESIDUALS/
                    REGRESSION = CIKO (*,*,*,*) WITH XI(5), X2(3),
                    X4(I)/ RESIDUALS/
                    REGRESSION = CIKO (*,*,*,*) WITH X2(5), X3(3),
                    X4(I)/ RESIDUALS/
                    REGRESSION = CIKO (*,*,*,*) WITH XI(5), X3(3),
                    X4(I)/ RESIDUALS/
```

```
                REGRESSION = CIKO (*,*,*,*) WITH XI(9), X2(7),
                X3(5), X4(3)/ RESIDUALS/
OPTIONS         I,II,I5,I6,I8,20
STATISTICS      I,2,3,4,5,6,7,8,9
READ INPUT DATA
```

The same sub-programme is used for 2 and 3 above, after making the necessary changes in the variables and data input.

G.2 FORTRAN PROGRAMME FOR PLANNING OVERHEAD COSTS

G.2.1 Head Office Overhead Costs at the beginning of a planning period

```
C PLANNING THE HEAD OFFICE OVERHEAD COSTS OF A
C CONSTRUCTION COMPANY AT THE BEGINNING OF A
C PLANNING PERIOD
C
      READ (5,20) YTURN
  20  FORMAT (V)
      WRITE (6,30) YTURN
  30  FORMAT ('PLANNED YEARLY TURNOVER - YTURN = ',FI3.4//)
      READ (5,50) HI,JI,H2,J2
C HI,JI,H2,J2 ARE THE CONSTANTS OF THE LOWER AND UPPER
C BOUND EQUATIONS
  50  FORMAT (V)
      WRITE (6,60)
  60  FORMAT ('EQUATION CONSTANTS',8X,'HI',IOX,'j')
      WRITE (6,65) HI,JI,H2,J2
  65  FORMAT (2X, 'LOWER BOUND EQN',6X,FIO.8,4X,FIO.8/
             2X, 'UPPER BOUND EQN',6X,FIO.8,4X,FIO.8/)
      HCOSTI - HI*(YTURN - (JI))
      HCOST2 = H2*(YTURN - (J2))
      WRITE (6,75)
  75  FORMAT ('SAFE ZONE VALUES'/)
      WRITE (6,80) HCOSTI,HCOST2
```

```
80    FORMAT (2X, 'LOWER BOUND - HCOSTI = ',FI3.6/
              2X, 'UPPER BOUND - HCOST2 = ',FI3.6/)
      WRITE (6,90)
90    FORMAT ('THE PLANNED HEAD OFFICE OVERHEAD COSTS FOR THIS
     I        PERIOD SHOULD LIE IN THE COST RANGE,'
      WRITE (6,95) HCOSTI,HCOST2
95    FORMAT(IOX,FI3.6,3X,'AND',3X,FI3.6)
      WRITE (6,IOO)
IOO   FORMAT (IOX,'-',45X)
      STOP
      END

      DATA YTURN/"supply planned yearly turnover"
      DATA H I,JI,H2,J2/"     "     equation constants."
```

G.3 FORTRAN PROGRAMME FOR PLANNING THE OVERHEAD COST CENTRES

G.3.1 Head Office Overhead Cost Centres

```
C PLANNING OF HEAD OFFICE OVERHEAD COST CENTRES
C AT THE BEGINNING OF A PLANNING PERIOD.
C
      READ (5,IO) HCOSTP
   IO FORMAT (V)
      WRITE (6,I5) HCOSTP
   I5 FORMAT ('PLANNED HEAD OFFICE OVERHEAD COSTS - HCOSTP'
     I,FI3.4/)
      CALL READDATA (H3,J3,H4,J4)
      HCI = HF (H3,J3,HCOSTP)
      HC2 = HF (H4,J4,HCOSTP)
      WRITE (6,20)
   20 FORMAT ('I:  HEAD OFFICE SENIOR STAFF COSTS - HSSCOST'/)
      CALL TAB
C     TABULATING
      WRITE (6,45) H3,J3,HCI
   45 FORMAT (4X,'LOWER BOUND',5X,FIO.8,4X,FII.0,IOX,FI3.4)
      WRITE (6,50) H4,J4,HC2
   50 FORMAT (4X,'UPPER BOUND',5X,FIO.8,4X,FII.0,IOX,FI3.4/)
      WRITE (6,60)
   60 FORMAT ('2:  HEAD OFFICE OTHER STAFF COSTS - HSCOST')
      CALL TAB
```

```
      CALL READDATA (H3,J3,H4,J4)
      HCI = HF (H3,J3,HCOSTP)
      HC2 = HF (H4,J4,HCOSTP)
      WRITE (6,65) H3,J3,HCI
65    FORMAT (4X,'LOWER BOUND',5X,FIO.8,4X,FII.0,IOX,FI3.4)
      WRITE (6,70) H4,J4,HC2
70    FORMAT (4X,'UPPER BOUND',5X,FIO.8,4X,FII.0,IOX,FI3.4/)
      WRITE (6,75)
75    FORMAT ('3:  HEAD OFFICE ACCOMMODATION COSTS - HACOST')
      CALL TAB
      CALL READDATA (H3,J3,H4,J4)
      HCI = HF (H3,J3,HCOSTP)
      HC2 = HF (H4,J4,HCOSTP)
      WRITE (6,76) H3,J3,HCI
      WRITE (6,80) H4,J4,HC2
76    FORMAT (4X,'LOWER BOUND',5X,FIO.8,4X,FII.0,IOX,FI3.4)
80    FORMAT (4X,'UPPER BOUND',5X,FIO.8,4X,FII.0,IOX,FI3.4/)
      WRITE (6,85)
85    FORMAT ('4:  HEAD OFFICE TRANSPORT COSTS - HTCOST')
      CALL TAB
      CALL READDATA (H3,J3,H4,J4)
      HCI = HF (H3,J3,HCOSTP)
      HC2 = HF (H4,J4,HCOSTP)
      WRITE (6,90) H3,J3,HCI
90    FORMAT (4X,'LOWER BOUND',5X,FIO.8,4X,FII.0,IOX,FI3.4)
      WRITE (6,95) H4,J4,HC2
95    FORMAT (4X,'UPPER BOUND',5X,FIO.8,4X,FII.0,IOX,FI3.4/)
      WRITE (6,IOO)
```

```
I00  FORMAT ('5:  HEAD OFFICE COMMUNICATION COSTS - HCCOST')
     CALL TAB
     CALL READDATA (H3,J3,H4,J4)
     HCI = HF (H3,J3,HCOSTP)
     HC2 = HF (H4,J4,HCOSTP)
     WRITE (6,II0) H3,J3,HCI
II0  FORMAT (4X,'LOWER BOUND',5X,FI0.8,4X,FII.0,I0X,FI3.4)
     WRITE (6,I20) H4,J4,HC2
I20  FORMAT (4X,'UPPER BOUND',5X,FI0.8,4X,FII.0,I0X,FI3.4/)
     WRITE (6,I30)
I30  FORMAT ('6:  HEAD OFFICE MARKETING COSTS - HMCOST')
     CALL TAB
     CALL READDATA (H3,J3,H4,J4)
     HCI = HF (H3,J3,HCOSTP)
     HC2 = HF (H4,J4,HCOSTP)
     WRITE (6,I40) H3,J3,HCI
I40  FORMAT (4X,'LOWER BOUND',5X,FI0.8,4X,FII.0,I0X,FI3.4)
     WRITE (6,I50) H4,J4,HC2
I50  FORMAT (4X,'UPPER BOUND',5X,FI0.8,4X,FII.0,I0X,FI3.4/)
     WRITE (6,I60)
I60  FORMAT ('7:  HEAD OFFICE SERVICE COSTS - HSECOST')
     CALL TAB
     CALL READDATA (H3,J3,H4,J4)
     HCI = HF (H3,J3,HCOSTP)
     HC2 = HF (H4,J4,HCOSTP)
     WRITE (6,I70) H3,J3,HCI
I70  FORMAT (4X,'LOWER BOUND',5X,FI0.8,4X,FII.0,I0X,FI3.4)
     WRITE (6,I80) H4,J4,HC2
```

```
180  FORMAT (4X,'UPPER BOUND',5X,F10.8,4X,F11.0,10X,F13.4/)
     WRITE (6,190)
190  FORMAT ('8:  HEAD OFFICE INSURANCE COSTS - HICOST')
     CALL TAB
     CALL READDATA (H3,J3,H4,J4)
     HC1 = HF (H3,J3,HCOSTP)
     HC2 = HF (H4,J4,HCOSTP)
     WRITE (6,200) H3,J3,HC1
200  FORMAT (4X,'LOWER BOUND',5X,F10.8,4X,F11.0,10X,F13.4)
     WRITE (6,210) H4,J4,HC2
210  FORMAT (4X,'UPPER BOUND',5X,F10.8,4X,F11.0,10X,F13.4/)
     WRITE (6,220)
220  FORMAT ('9:  HEAD OFFICE FINANCE COSTS - HFCOST')
     CALL TAB
     CALL READDATA (H3,J3,H4,J4)
     HC1 = HF (H3,J3,HCOSTP)
     HC2 = HF (H4,J4,HCOSTP)
     WRITE (6,240) H3,J3,HC1
240  FORMAT (4X,'LOWER BOUND',5X,F10.8,4X,F11.0,10X,F13.4)
     WRITE (6,250) H4,J4,HC2
250  FORMAT (4X,'UPPER BOUND',5X,F10.8,4X,F11.0,10X,F13.4/)
     WRITE (6,260)
260  FORMAT ('10:  HEAD OFFICE GEN AND UNALLOCATED COSTS -
    1   HGCOST')
     CALL TAB
     CALL READDATA (H3,J3,H4,J4)
     HC1 = HF (H3,J3,HCOSTP)
     HC2 = HF (H4,J4,HCOSTP)
```

```
      WRITE (6,270) H3,J3,HCI
  270 FORMAT (4X,'LOWER BOUND',5X,FIO.8,4X,FII.0,IOX,FI3.4)
      WRITE (6,280) H4,J4,HC2
  280 FORMAT (4X,'UPPER BOUND',5X,FIO.8,4X,FII.0,IOX,FI3.4/)
      STOP
      END


      FUNCTION HF (H5,J5,HCOSTP)
C CALCULATING THE LOWER AND UPPER BOUND VALUES
      HF = H5* (HCOSTP-(J5))
      RETURN
      END


      SUBROUTINE READDATA (H3,J3,H4,J4)
C READING A SET OF DATA VALUES.
      READ (5,50) H3,J3,H4,J4
   50 FORMAT (V)
      RETURN
      END
```

```
      SUBROUTINE TAB
      WRITE (6,28)
   28 FORMAT (4X,' - ',37X/)
      WRITE (6,30)
   30 FORMAT (23X?'EQUATION CONSTANTS',IIX,'SAFE ZONE VALUES')
      WRITE (6,35)
   35 FORMAT (23X,'---------------------',IIX,'------------'/)
      WRITE (6,40)
   40 FORMAT (24X,' H ', I2X,' J '/)
      RETURN
      END
```

DATA

The data supplied for this programme are the planned head office overhead costs for the planning period and the constant values of the respective safe zones.

The same programmes (G2.1, G3.1) are used for the site overhead costs and cost centres of projects, with the necessary changes in the data input.

G.4 FORTRAN PROGRAMME FOR THE CONTROL OF OVERHEAD COSTS AND OVERHEAD COST CENTRES

G.4.1 Head Office Overhead Costs

```
C  PROGRAMME FOR THE CONTROL OF HEAD OFFICE AND HEAD
C  OFFICE OVERHEAD COSTS COMPONENTS DURING THE PLANNED
C  PERIOD
C
      DIMENSION ZN(IO,2), AC(IO), CC(IO)
C  ZN(IO,2) IS A DIMENSIONAL ARRAY OF LOWER AND UPPER
C  BOUND VALUES OF THE SAFE ZONES OF THE COST COMPONENTS.
C
C  AC(IO) IS AN ARRAY OF ACTUAL COSTS OF COST COMPONENTS
C
C  CC(IO) IS AN ARRAY OF THE COST COMPONENTS
C
      READ (5,5) HCOSTP
   5  FORMAT (V)
      WRITE (6,IO) HCOSTP
  IO  FORMAT ('PLANNED HEAD OFFICE OVERHEAD COSTS - HCOSTP = ',
     IFI3.4)
      WRITE (5,I5)
  I5  FORMAT ('HEAD OFFICE OVERHEAD COST COMPONENTS')
      WRITE (6,20)
  20  FORMAT (5X,'HEAD OFFICE SENIOR STAFF COSTS - HSSCOST',/
```

```
 2       5X,'HEAD OFFICE OTHER STAFF COSTS    - HSCOST',/
 3       5X,'HEAD OFFICE ACCOMMODATION COSTS  - HACOST',/
 4       5X,'HEAD OFFICE TRANSPORT COSTS      - HTCOST',/
 5       5X,'HEAD OFFICE COMMUNICATION COSTS  - HCCOST',/
 6       5X,'HEAD OFFICE MARKETING COSTS      - HMCOST',/
 7       5X,'HEAD OFFICE SERVICE COSTS        - HSECOST',/
 8       5X,'HEAD OFFICE INSURANCE COSTS      - HICOST',/
 9       5X,'HEAD OFFICE FINANCE COSTS        - HFCOST',/
 I       5X,'HEAD OFFICE UNALLOCATED COSTS    - HGCOST',//)
    WRITE (6,25)
25  FORMAT (I5X,'SAFE ZONE VALUES')
    WRITE (6,30)
30  FORMAT (35X,'LOWER BOUND',8X,'UPPER BOUND')
    READ (5,35) HCOSTI, HCOST2
35  FORMAT (V)
    WRITE (6,40) HCOSTI, HCOST2
40  FORMAT ('HEAD OFFICE OVERHEAD COSTS',IOX,FII.2,8X,FII.2/)
    WRITE (6,45)
45  FORMAT ('HEAD OFFICE OVERHEAD COSTS COMPONENTS')
    READ (5,50) ((ZN(I,J),J=I,2),I=I,IO)
50  FORMAT (V)
    WRITE (6,55) ((ZN(I,J),J=I,2),I=I,IO)
55  FORMAT (IOX,'HSSCOST --',I9X,FI4.6,6X,FI4.6/
 2       IOX,'HSCOST  --',I9X,FI4.6,6X,FI4.6/
 3       IOX,'HACOST  --',I9X,FI4.6,6X,FI4.6/
 4       IOX,'HTCOST  --',I9X,FI4.6,6X,FI4.6/
 5       IOX,'HCCOST  --',I9X,FI4.6,6X,FI4.6/
 6       IOX,'HMCOST  --',I9X,FI4.6,6X,FI4.6/
```

```
     7      IOX,'HSECOST --',I9X,FI4.6,6X,FI4.6/
     8      IOX,'HICOST  --',I9X,FI4.6,6X,FI4.6/
     9      IOX,'HFCOST  --',I9X,FI4.6,6X,FI4.6/
     I      IOX,'HGCOST  --',I9X,FI4.6,6X,FI4.6//
      READ (5,60) DU
C  DU IS THE DURATION IN MONTHS FOR WHICH THE HEAD OFFICE
C  OVERHEAD COSTS ARE PLANNED.
   60 FORMAT (V)
      WRITE (6,65) DU
   65 FORMAT ('DURATION OF PLANNING PERIOD * DU = ',F4.I,
     I3X,'MONTHS'//)
      READ (5,70) DI
C  DI IS THE DURATION IN MONTHS SINCE THE START OF THE
C  PLANNING PERIOD.  THE I HERE IS USED TO DENOTE THE
C  NUMBER OF MONTHS.  FOR EXAMPLE D" = 2 MONTHS, D6 =
C  6 MONTHS.
   70 FORMAT (V)
      WRITE (6,75) DI
   75 FORMAT ('NUMBER OF MONTHS SINCE START OF PLANNING PERIOD
     I    - DI = ',F4.I/'WHERE I IS THE NUMBER OF MONTHS'//)
      WRITE (6,80)
   80 FORMAT ('ACTUAL COSTS AT THE END OF THE I TH MONTH'/)
      READ (5,85) HCOSTAI
   85 FORMAT (V)
      WRITE (6,90) HCOSTAI
   90 FORMAT (IOX,'HCOSTAI = ',FI3.4//)
      WRITE (6,95)
   95 FORMAT ('HEAD OFFICE COST COMPONENTS')
```

```
      READ (5,I00) (AC(I),I = I,I0)
 I00  FORMAT (V)
      READ (5,I0I) (FF(I),I = I,I0)
 I0I  FORMAT (I0A7)
      WRITE (5,I05) (AC(I),I = I,I0)
 I05  FORMAT (I0X,'HSSCOSTAI= ' ,FI3.5/I0X,'HSCOSTAI= ' ,FI3.5/
     2        I0X,'HACOSTAI = ' ,FI3.5/I0X,'HTCOSTAI= ' ,FI3.5/
     3        I0X,'HCCOSTAI = ' ,FI3.5/I0X,'HMCOSTAI= ' ,FI3.5/
     4        I0X,'HSECOSTAI= ' ,FI3.5/I0X,'HICOSTAI= ' ,FI3.5/
     5        I0X,'HFCOSTAI = ' ,FI3.5/I0X,'HGCOSTAI= ' ,FI3.5/
     6        //)
C
C  CALCULATING THE SUB SAFE ZONES
C
      SF = DI/DU
C  SF IS THE SCALING FACTOR.  THIS IS USED TO SCALE DOWN
C  THE LOWER AND UPPER BOUND VALUES OF THE SAFE ZONES TO
C  DEFINE SUB SAFE SONES AT EACH COST EXAMINATION STAGE.
C
      HSI = SF*HCOSTI
      HS2 = SF*HCOST2
      IF (HCOSTAI.GT.HS2) GO TO II0
      IF (HCOSTAI.LT.HSI) GO TO I20
      VAR = 0.0
      GO TO I30
 II0  VAR = HS2 - HCOSTAI
      GO TO I30
 I20  VAR = HSI - HCOSTAI
```

```
      GO TO I30
I30   WRITE (6,I35)
I35   FORMAT ('HEAD OFFICE OVERHEAD COSTS')
      WRITE (6,I40)
I40   FORMAT ('-------------------------'/)
      WRITE (6,I45)
I45   FORMAT (23X,'SUB SAFE ZONES',I4X,'ACTUAL',5X,VARIANCE')
      WRITE (6,I50) HSI, HS2, HCOSTAI, VAR
I50   FORMAT (3X,'HCOSTAI',8X,FI0.2,4X,FI0.2,6X,FI0.2,3X,FI0.2/)
      I = 0
      J = 0
      DO 500 K = I,I0
      I = I+I
      J = J+I
      READ (5,I60) ZN(I,J)
I60   FORMAT (V)
      SI = SF*ZN(I,J)
      J = J+I
      READ (5,I65) ZN(I,J)
I65   FORMAT (V)
      S2 = SF*ZN(I,J)
      READ (5,I70) AC(I)
I70   FORMAT (V)
      READ (5,I75) CC(I)
I75   FORMAT (A7)
C  SET J EQUAL TO ZERO TO START FROM FIRST COLUMN
      J = 0
C  COMPARE THE ACTUAL COSTS WITH THE COST LIMITS OF SUB SAFE ZONES.
```

```
      IF (AC(I).GT.S2) GO TO 250
      IF (AC(I).LT.SI) GO TO 260
      VAR = 0.0
250   VAR = S2 - AC(I)
      GO TO 400
260   VAR = SI - AC(I)
      GO TO 400
400   WRITE (6,405)
405   FORMAT ('HEAD OFFICE OVERHEAD COSTS COMPONENTS')
      WRITE (6,4I0)
4I0   FORMAT ('---------------------------'/)
      WRITE (6,4I5)
4I5   FORMAT (23X,'SUB SAFE ZONE',I3X,'ACTUAL',5X,'VARIANCE')
C   SET I EQUAL TO ZERO TO START
      I = 0
500   CONTINUE



      DATA HCOSTP, HCOSTI, HCOST2/"supply required data"
      DATA HCOSTAI/
      DATA DU, DI/
      DATA (ZN(I,J),J=I,2),I=I,I0)
      DATA (CC(I),I=I,I0)/
      STOP
      END
```

The same programme is used for the site overhead costs, with the necessary changes in the data input

I.1 DESCRIPTION OF COMPANIES WHICH COMPLETED THE QUESTIONNAIRE.

Company	Size	Activity	Turnover		Comments
A	Medium	Building (local/foreign)	1975-76 1976-77 1977-78 1978-79	Le 6 000 000 2 000 000 2 560 000 3 000 000	Started as a Dutch/SL company but now mainly Sierra Leonean owned. Dwelling houses.
B	Medium	Building (local)	1975-76 1976-77 1977-78 1978-79	Le 9 625 287 8 859 600 9 862 530 7 126 320	Local company, undertakes mostly commercial buildings.
C	Medium	Building (local)	1975-76 1976-77 1977-78 1978-79	Le 856 960 1 586 240 2 565 000 4 862 500	Local company, mostly undertakes industrial buildings.
D	Small	Building (local)	1975-76 1976-77 1977-78 1978-79	Le 1 468 135 1 652 320 1 585 211 1 265 200	Local company. Constructs dwelling houses. Not very organised.

E	Medium	Building (local)	1975-76 1976-77 1977-78 1978-79	Le 2 652 830 3 864 200 5 321 462 5 526 400	Expanding local company. Constructs mostly offices, schools, hospitals, etc.
F	Large	Building/Civil Engineering (foreign)	1975-76 1976-77 1977-78 1978-79	Le 15 500 000 13 421 836 13 642 850 14 865 331	Lebanese owned. Constructs office blocks and small civil engineering works.
G	Large	Civil Engineering (foreign)	1975-76 1976-77 1977-78 1978-79	Le 10 186 550 11 624 350 10 000 000 12 521 300	Italian company. Constructs minor works.
H	Large	Civil Engineering (foreign)	1975-76 1976-77 1977-78 1978-79	Le 9 364 482 9 536 182 11 163 825 13 886 165	German Civil Engineering company. Constructs major roads, water supply tanks and pipes.
I	Medium	Civil Engineering/Building (local)	1975-76 1976-77 1977-78 1978-79	Le 7 863 411 6 364 482 - -	Local company. Constructed mainly raods and commercial buildings. Closed down in 1978.

J	Small	Building (local)	1975-76 1976-77 1977-78 1978-79	Le	169 300 284 250 701 464 829 361	Small expanding building company. Constructs dwelling houses.
K	Small	Building/Civil Engineering (local)	1975-76 1976-77 1977-78 1978-79	Le	- - 95 850 115 467	Formed in 1977. Undertakes small scale works.
L	Small	Building (local)	1975-76 1976-77 1977-78 1978-79	Le	162 771 253 100 156 834 -	Local building company. Now closing down.
M	Small	Building (local/foreign)	1975-76 1976-77 1977-78 1978-79	Le	2 518 350 - - -	Closed down in 1977. Owners now operating in Ghana.

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