Construction Planning, Programming and Control

BRIAN COOKE AND PETER WILLIAMS

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Brian Cooke and Peter Williams

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Preface

The aim of the book is to examine and describe the various stages of the construction planning process. This includes procedures in both the small, medium and large construction firm. The text follows the planning process from the pre-tender, through the pre-contract stage, to the contract planning during the project. Management checklists are included at each stage of the process.

The introduction reviews the changing face of the construction industry since the mid 1990s. The various Acts and Regulations introduced, including the implications of the Latham Report, are examined. The effects of the CDM Regulations and how they influence the various planning stages are considered.

The important link between safety hazard assessment and method statements is highlighted and working examples are presented.

Recent developments in the use of linked bar charts and precedence diagram relationships are illustrated with a series of worked examples. The book is not intended to cover the principles of the various programming techniques, but sets out to establish a series of worked examples which cover the various applications in practical situations.

The preparation of contract budgets based on cumulative value forecasts is illustrated, and the principles of cost–value reconciliation are linked in a series of case studies. Budgetary control principles are applied to labour, plant and preliminaries budgets and the importance of budgetary control is outlined.

An overview of the problems associated with business growth is considered in relation to a small, medium and large sized construction company. A number of practical case studies are presented based on companies in the North West of England.

The authors wish to acknowledge the guidance and assistance provided by the late Ivor Seeley. Once again he encouraged us to maintain his impeccable standards and the discipline required to produce a readable book.

Our special thanks go to Paul Hodgkinson for producing such clear diagrams and tables. We are also grateful to Malcolm Stewart for supporting the publication of this text which we hope will help many budding construction managers and surveyors.

B. Cooke and P. Williams (June 1997)

1 The Construction Industry

1.1 The Changing Face of Construction

The UK Construction Industry has undergone a period of unprecedented and significant change in recent years which has had a profound effect on the way the industry operates.

As a consequence of the recessionary pressures of the late 1980s and early 1990s, many construction companies have ceased to exist and those that remain have been forced to rationalise and reorganise on a scale never seen before.

A graphic example of the change sweeping construction is the 'asset swap' which took place in 1996 when Wimpey took over the housing activities of Tarmac in exchange for its contracting activities.

Other examples include the 'downsizing' of the contracts undertaken by the major contractors and changes in the nature of their business dealings with clients. One of the top-ten contractors, for instance, had an average size of contract of only £1 million in 1996 but increased its negotiated work from 10% to 40% of turnover.

Over recent years the industry has changed in other respects. For instance, there has been an increasing trend towards the private financing of public sector projects. Examples of this are the Dartford and Skye Bridge Crossings, the Channel Tunnel and the Second Severn Crossing projects which were largely privately funded Design Build Operate Transfer (DBFO) projects where the private sector investment is recovered through tolls levied during a 'concession' period before the asset transfers to public ownership.

This Private Finance Initiative (PFI) of the government is also operating in other sectors such as hospitals, court and police buildings, prisons and road building. However, the industry has been generally disappointed by the slow and bureaucratic PFI process which has failed to make up the shortfall in workload resulting from cuts in public spending and the recessionary downturn in investment generally.

Contractors have taken different approaches to the recession. Some have slimmed down their organisations, focused on their 'core' business and become 'lean and mean' in the market place. Others have moved into different markets and taken on facilities management work for government ministries, the prison service, hospitals and road and rail infrastructure maintenance.

Tender margins during the recession have been dangerously low and many contractors have been forced to take on work at zero or even negative profit just to win turnover for survival. Clearly, businesses cannot hope to succeed for long in such a fiercely competitive climate and in many cases the only way to break even on contracts, or perhaps make a small profit, has been by squeezing subcontractors' and suppliers' prices or through claims against clients.

Nevertheless, the stark reality is that profitability in construction in 1996 fell to new levels with average pre-tax profits in the industry of around 1% of turnover and return on capital employed in the order of 2%, despite interest rates on borrowings of 2-4% over a base of around 6%.

Competition from foreign contractors from Europe, the USA and the Far East has increased the pressure on UK contractors and the opening up of public sector projects to tenderers from the EU has emphasised the need for keen pricing, tight programmes and ingenuity and efficiency in production planning and execution.

The fierce competition for work has also touched the construction professions which have been subject to such keen fee bidding that many practices have either failed to survive or been taken over or merged with larger organisations.

This intensely competitive environment has done great harm to the fabric of the industry and the need to adopt a 'get tough to survive' approach has done little to change the poor image and adversarial nature of construction.

It has been clear for some time that many clients have been unhappy with the service they receive from the construction industry. Often relationships between participants in the construction process are strained by poorly planned and designed projects, lack of communication, mistrust, self interest and disputes which often results in delay, disruption and extra cost.

Happily, however, negative attitudes within the industry are slowly changing and increasingly more importance is attached to client satisfaction, both in terms of fewer disputes and less litigation and with respect to repeat business through quality and through partnering or alliancing arrangements.

There is also a greater emphasis on competence and certification and this is exemplified by the CITB's Construction Skills Certification Scheme and recent 'competence based' legislation, especially in the field of health and safety management.

Other influences which are shaping change in the industry will now be considered. These are:

- Time and money pressures
- Labour-only Subcontractors
- 'Constructing the Team' (the Latham Report 1994)
- The Housing Grants, Construction and Regeneration Act 1996 (the Latham Act)
- Health and safety management legislation (especially the CDM Regulations 1994)
- Procurement methods and the influence of major clients
- Public Sector Procurement Legislation.

1.2 Time and Money Pressures

1.2.1 Time

The management of time is a key prerequisite for a successful project and it is this single particular issue which creates many of the problems in the construction industry.

These problems arise because many projects in the UK are inadequately thought through and planned before starting on site, thereby causing frustration, delay and disruption which are the breeding grounds for claims and disputes.

There are many reasons for this phenomenon; these include pressure from clients, budgets which have to be spent before the end of the financial year and the long slow process of consultation and approvals which many public sector projects are subject to.

Also, the traditional method of procuring a building or engineering structure, which is to engage an architect or engineer to prepare a design and then to award a construction contract following a short tendering period, is too slow for some clients who want to start on site quickly.

These 'push-pressures' on the industry are counterbalanced to some extent by the 'pull-pressures' of bureaucracy. For instance, time has to be allocated in public sector projects in order to comply with rules governing the advertising of projects, minimum tender periods and the notification of results. Time also has to be allowed in order to satisfactorily comply with statutory requirements for the health and safety planning and management of construction work.

The desire for time efficiency in construction has encouraged experimentation with procurement methods and, while the traditional process is still the most popular, there is a noticeable trend towards other methods such as design and build, management contracts and project partnering which offer the prospect of faster building.

The popularity of various methods of procurement and forms of contract is shown in Figure 1.1.

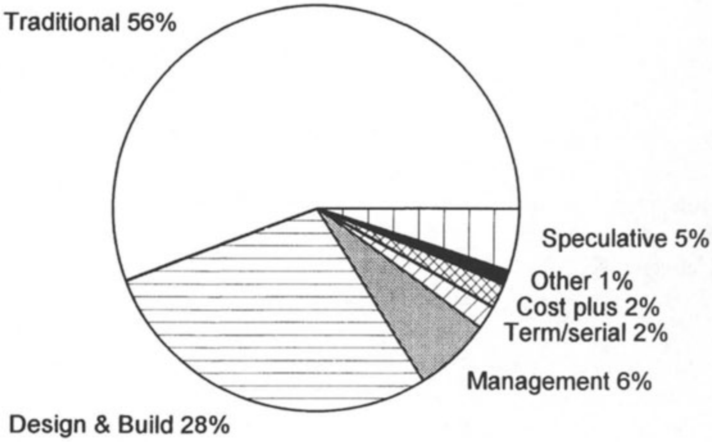
1.2.2 Money

Another key issue in construction concerns payment. Over recent years the problem has become so widespread in the industry that a culture has developed in which delaying payment to contractors, and in particular subcontractors and suppliers, has become almost a virtue.

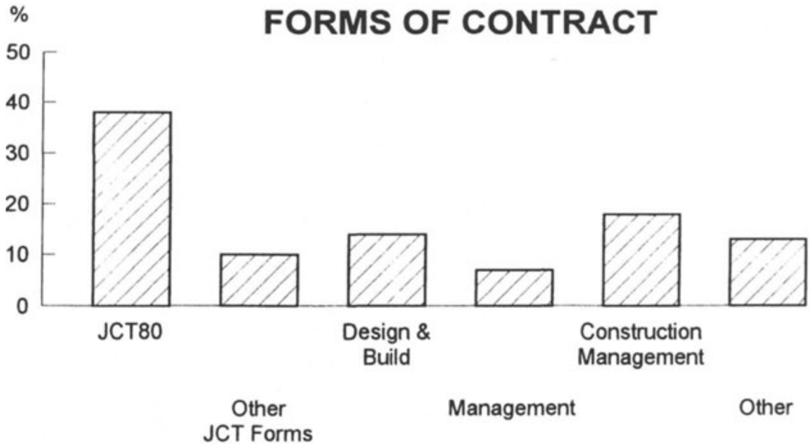
Recessionary pressures, tight or non-existent profit margins, shortage of work and pressures from the banks due to over-borrowing are some of the reasons often given.

Nevertheless the effects are the same on those waiting to be paid – shortage of cash to pay their own bills, difficulties in paying wages, taking short cuts to save money especially on health and safety and even insolvency.

PROCUREMENT METHODS



Types of Procurement for Large Contractors
By value of turnover
Source: BSIRIA



By value of turnover
Excluding civil engineering, maintenance and repair work
Source: RICS

USE OF PROCUREMENT AND CONTRACTS

Figure 1.1

Construction is largely a credit-based industry where customers expect a period of deferment before having to pay for goods or services received.

Traditionally, the construction client expects the contractor to carry out a month's work which is then valued and certified and the certificate is later honoured by cheque. The average period of credit under a JCT80 contract is illustrated in Figure 1.2, but this period can be much longer under other forms of contract.

Main contractors, of course, expect credit facilities from their subcontractors and suppliers. Credit terms under standard forms of subcontract can vary between 14 and 42 days, while suppliers will usually extend credit for 28 or 30 days from the end of the month in which delivery takes place.

The reality is often different though and subcontractors are often paid only when the main contractor receives a cheque from the client. The payment is often then subject to deduction for set-off or contra-charges, or alternatively the subcontractor is asked to accept a lower sum in exchange for faster payment.

Suppliers on the other hand are commonly kept waiting for 60 or 90 days and may be forced to suspend supplies or even withdraw credit facilities from persistent offenders. Court recovery action may well ensue!

There is nothing wrong with the credit system in the industry provided that ***everyone*** pays ***on time***. This does not happen in the real world however, and consequently problems of mistrust, ill-feeling, debt collection, litigation and insolvency are common.

Mistrust also arises over inflated and spurious contractual claims, unjustified set-off and unfair treatment of subcontractors. However, the blame does not lie entirely with contractors.

The professions must also shoulder some of the responsibility for perpetuating traditional prejudices and distinctions and taking client loyalties too far.

This is exemplified by the onerous contract conditions imposed by some clients and their professional consultants and failure to interpret the contract in a balanced and even-handed manner. Self interest and abuse of a position of trust can often result in disharmony on projects, poor standards of work and poor client satisfaction.

1.3 Labour-only Subcontractors

Over the past 25 years or so, the nature of employment in construction has largely become based on subcontract labour with relatively few 'general contractors' directly employing their own workforce. At one time, the general contractor would carry out most of a project using his own skilled labour for trades such as concreting, formwork and rebar, drainage, brickwork, joinery, plastering and plumbing.

CLIENT CREDIT TERMS (JCT80)

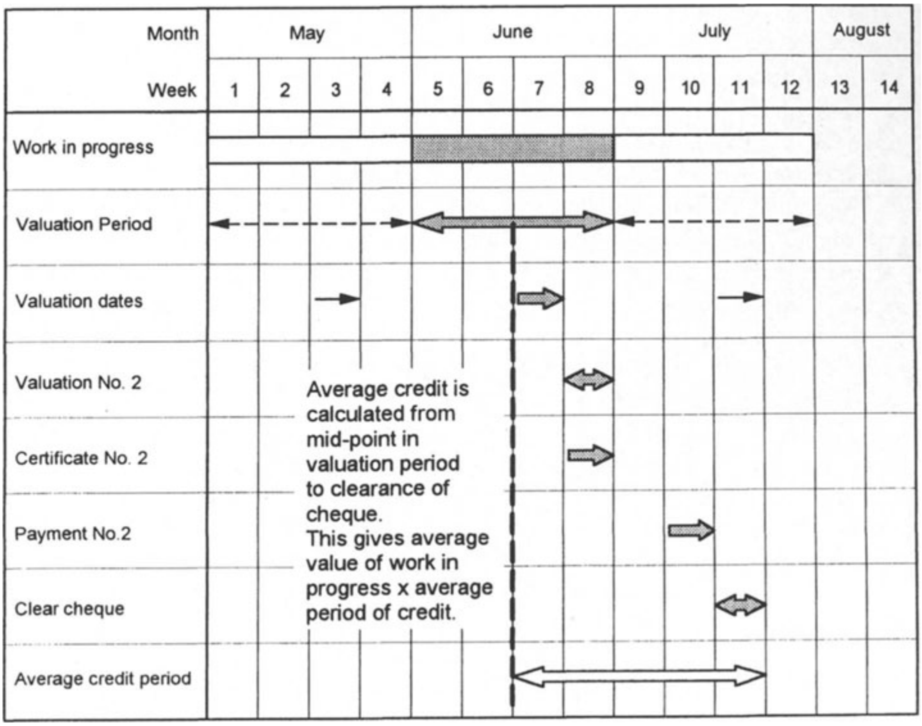


Figure 1.2

Now, most contractors use subcontractors to carry out this work. From a management point of view this creates a large number of 'interfaces' which have to be controlled and coordinated by the main contractor in order to avoid duplication, omissions and mistakes.

There are, of course, large numbers of bona fide specialist subcontracting firms which provide 'supply and fix' services, but the vast majority of subcontractors are self-employed individuals, partnerships or small firms.

Some of these small subcontractors operate under the 714 tax deduction scheme where they have 'tax exemption' status and pay their contribution at the end of the tax year. They are paid in full each week or month by the main contractor and give a 715 receipt for their payment.

Alternatively, subcontractors can have their tax deducted at source by the main contractor as SC60 subcontractors and they then claim back their tax allowances from the Inland Revenue at the end of the tax year.

Whether they are 714's or SC60's, many of these subcontractors are engaged on a regular basis and in many cases have long term continuity of work equivalent to those employed under PAYE, despite there being no contract of employment.

To all intents and purposes then, such labour is effectively 'on the books' and this is the view of both the Inland Revenue and the Contributions Agency as regards tax and national insurance contributions.

From 5 April 1997 labour-only subcontractors who are not bona fide firms have to be directly employed by the main contractor and these new tax laws will clearly have a cost effect.

The pros and cons of labour-only subcontracting are well known:

- higher earnings, causing disparities with other workers
- lower tax and national insurance contributions
- lower prices, but higher overheads for the main contractor
- lower employment costs for the main contractor (e.g. no holidays with pay, redundancy and sick pay)
- higher output and faster work leading to quality problems
- higher materials wastage
- lack of training and competence testing
- skills shortages in the industry
- lower standards of safety

However, despite these problems, directly employed or 'cards-in' labour also has disadvantages for the main contractor, both in cost and time. Therefore, employment agencies, which carry the employer's risk, are increasingly seen as one way around the problem; but it remains to be seen what the long term effect of these new tax laws will be on the way the industry operates.

Nevertheless, whatever its source, the nature of the workforce and its motivation, cost and efficiency is a major consideration for contractors when tendering for, planning and carrying out construction projects.

1.4 Constructing the Team

There are several other issues that influence the ability of the construction industry to respond effectively to its customers' requirements which may be summarised, albeit not exhaustively, as follows:

- sensitivity to changes in government spending patterns
- intense competition for work
- inability to respond to increased demand
- lack of competency testing of firms/workers entering the industry
- lack of training
- mistrust between the participants in construction projects
- inadequate capital base (i.e. most contractors are undercapitalised)
- adversarial attitudes
- 'claims conscious' contractors
- high levels of insolvency

These problems, and many others, have been recognised in several official reports since the Second World War,[1] but despite identifying the problems and proposing solutions, these reports have proved to have little influence on either government or the industry.

Perhaps the most influential of all the reports concerning the industry and its problems is *Constructing the Team*, written by Sir Michael Latham[2] who was commissioned by both Government and the Industry to 'Review the Procurement and Contractual Arrangements in the UK Construction Industry'.

Prior to final publication of his report in July 1994, Sir Michael produced an interim report in December 1993. Not surprisingly this report was called *Trust and Money*.

Constructing the Team is better known as the *Latham Report* and its purpose was to find ways to 'reduce conflict and litigation and encourage the industry's productivity and competitiveness'.

The specific terms of reference for the review were to consider:

- current procurement and contractual arrangements
- current roles, responsibilities and performance of the participants, including the client

The report took account of the structure of the industry and the need for fairness, accountability, quality and efficiency and paid particular regard to:

- client briefing
- procurement methods
- the design process
- the construction process
- contractual issues and
- dispute resolution

The report runs to some 130 pages and contains 30 main observations and recommendations with the principal emphasis being on 'teamwork' in order to achieve 'win–win' solutions.

Some of the main points made by Latham have important consequences for the planning, production and control of construction and are therefore directly relevant to this book. These include:

- the need for a set of basic principles for modern contracts
- greater use of the New Engineering Contract which could become a common contract for the whole industry
- improved tendering arrangements and more advice on partnering arrangements
- evaluation of tenders on quality as well as price
- fairer treatment of subcontractors with particular regard to tendering and teamwork on site
- a real cost reduction target in construction of 30% by the year 2000
- pay when paid contract terms to be outlawed
- adjudication to be the normal method of dispute resolution
- fair contract terms backed up by a Construction Contracts Bill
- insolvency protection by means of trust funds

One of the key issues examined by Latham was that of the productivity of the industry and it is clear that Latham considered that this is linked to the quality of design preparation and information. Inefficiency creeps in where designs are incomplete or information given to the contractor is conflicting or too late to allow proper planning of production.

'If, as a result of the client's own instructions or through some problem on the part of the design team, the design and specifications are not fully complete, and provisional sums are used, the consultants must make the client aware of the risks of incomplete design [and] *the consequences for the construction programme in terms of possible cost and delay.'* (paragraph 4.13)

An issue of major importance is that of conflict in the industry, both between clients and contractors and between contractors and their subcontractors.

Latham suggests that considerable efficiencies can be gained by making changes in '*procurement practice, contract conditions, tighter restrictions over* *set-off and the introduction of adjudicators as a normal procedure for settling disputes'.* (paragraph 9.13)

He also concludes that *'The most effective form of contract in modern conditions should include:*

- *A specific duty for all parties to deal fairly with each other, and with their subcontractors, specialists and suppliers, in an atmosphere of mutual cooperation.*

- *Taking all reasonable steps to avoid changes to pre-planned works information. But, where variations do occur, they should be priced in advance, with provision for independent adjudication if agreement cannot be reached.'* (paragraph 5.18)

and that *'Subcontractors should undertake that, in the spirit of teamwork, they will coordinate their activities effectively with each other, and thereby assist the achievement of the main contractor's overall programme. They may need to price for such interface work.'* (paragraph 6.41)

The conclusions of the review were clearly extensive and they have been implemented in two main ways.

First, the Construction Industry Board was set up in order to implement the recommendations. The CIB is currently chaired by Sir Ian Dixon and there is an ongoing programme of initiatives including:

- steps to improve productivity
- better quality design and improved briefing of designers
- changes to trade and professional training and education
- improving the image of the industry
- encouraging fewer disputes by encouraging partnering between contracting parties
- improved quality of construction professionals, contractors and sub-contractors

Secondly, some of the 'Latham' recommendations have been included in the Housing Grants, Construction and Regeneration Act 1996.

In certain respects it is disappointing that the Act is not exclusively construction specific and that parts of the Latham package, such as statutory trust funds, have not been included in the legislation. Nevertheless, it is still a major achievement to get statutory recognition for at least some of the recommendations.

The implications of the Act are now discussed.

1.5 The Housing Grants, Construction and Regeneration Act 1996

The Act is in five parts and the 'Latham' provisions are in Part II – Construction Contracts under sections 104-117. This legislation applies to all construction contracts whether main or subcontracts and also contracts for design or other professional services.

The Act confers certain statutory obligations and entitlements on parties to such construction contracts and, where suitable clauses are not present in a contract, they are provided by regulations called 'the Scheme for Construction Contracts'.

The 'Scheme' represents the backstop where perhaps the standard conditions of contract are not employed or where contracts are entered into on the basis of an exchange of letters.

The issues covered by the Act include:

- the right to refer disputes on construction contracts to immediate adjudication rather than having to wait for arbitration or litigation
- the right to stage payments for work carried out under a construction contract
- the right to proper arrangements for payment including amount, dates and how it was calculated
- the obligation to give notice of intention to withhold payment, including how much and why
- the right to suspend performance of the contract pending payment
- the prohibition of 'pay when paid' provisions (e.g. main contractor delaying payment to a subcontractor pending payment from the employer)

These 'Latham' initiatives will have an impact on the ways and means by which clients, developers, builders, contractors and subcontractors organise, plan and control their financial and construction activities. Additionally, existing standard forms of contract will require amendment to bring them into line with the Act.

1.5.1 Adjudication

The most common method of dispute resolution in construction is arbitration or, where a point of law is in question, litigation through the courts.

Settlement can sometimes take years with very high legal costs facing the losing party and often one party or the other will become insolvent before the case is concluded.

Adjudication offers a more sensible solution by appointing an appropriate person to arrive at a speedy 'commercial' decision which is binding on the parties until the matter is subsequently resolved by arbitration or litigation.

Although this may be a rough and ready path to justice, at least the project can be kept going with minimum disruption on site and cash can be released for the time being. This would be particularly important to a subcontractor who might otherwise be forced to stop work through lack of funds or have to face the prospect of insolvency.

The Act confers a statutory right to adjudication for a party to a construction contract and establishes a timetable for the appointment of the adjudicator and for deciding the dispute.

The implication is that standard forms of contract will have to include adjudication provisions and these must comply with the requirements of the Act. Where this is not the case, regulations under 'the Scheme for Construction Contracts' will apply as a default.

1.5.2 Stage Payments

The Act provides that a party to a construction contract over 45 days in duration is entitled to stage payments for work done and also that the contract should include a mechanism for determining the amount and timing of payments.

The parties are free to agree the amounts and timetable for payment, but provision has to be made for giving notice of how much will be paid and how this has been calculated.

1.5.3 Withholding Payment

Section 111 of the Act provides for notice to be given in advance should it be intended to withhold payment stating the reason why. This is similar to the set-off arrangements in some standard forms of subcontract but, of course, the provisions of the Act apply to all construction contracts.

Subcontractors in particular should benefit from these rules which will prevent main contractors withholding payment without good cause or with the aim of forcing subcontractors into 'taking a deal' just to ease cash flow pressures.

When an adjudicator decides that such amounts should be paid, then section 111 determines the timetable for release of the monies.

1.5.4 Suspension of Performance

Generally, standard construction contracts do not permit the contractor to cease working even if payment not be made by the client. The domestic form of subcontract, DOM/1 and NSC/C, the nominated subcontract form, both of which are commonly used for building works, are two of the few exceptions.

The Act, however, facilitates suspension by the injured party, subject to proper notice with reasons. This would constitute a 'valid suspension' which would not be counted as part of the time taken to complete the works and therefore liquidated and ascertained damages could not be charged.

Therefore, if a main contractor's payment were to be delayed by the client then, provided that proper notice was given by the contractor, it would be in order to stop work until payment was made without incurring liquidated damages for delay.

The effect of this statutory provision is to make a 'valid suspension' a 'relevant event' for extending the time for completing the contract.

The question of compensation for the contractor by way of damages for interest or loss and expense for additional time related costs is not dealt with under the Act. Such matters would need to be provided for in the civil contract between the parties.

1.5.5 Conditional Payment (pay-when-paid)

Some contractors use in-house forms of subcontract contract which make payment to subcontractors conditional upon receipt of payment from the construction client.

The Federation of Civil Engineering Contractors' standard form of subcontract (the Blue Form), which is used in conjunction with the ICE Conditions of Contract, has similar provisions.

The Act makes 'pay-when-paid' clauses ineffective, except where the client is insolvent and therefore main contractors may be put in the position of having to pay subcontractors before they are paid themselves. This can only be good for the industry because projects can be severely disrupted where a subcontractor is unable to continue owing to lack of money

1.6 Health and Safety Management

The Construction Industry throughout Europe has a poor health and safety record and this has been recognised in studies undertaken both by the Health and Safety Executive[3] in the UK and the European Union.

On average, two people die every week on construction sites but studies have shown that 90% of these deaths could be avoided and 70% of these lives could have been saved by Positive Management.

The European Union has published statistics on the causes of accidents and these are shown in Figure 1.3. They make interesting reading in that over 60% of accidents are attributed to poor planning and unsafe design

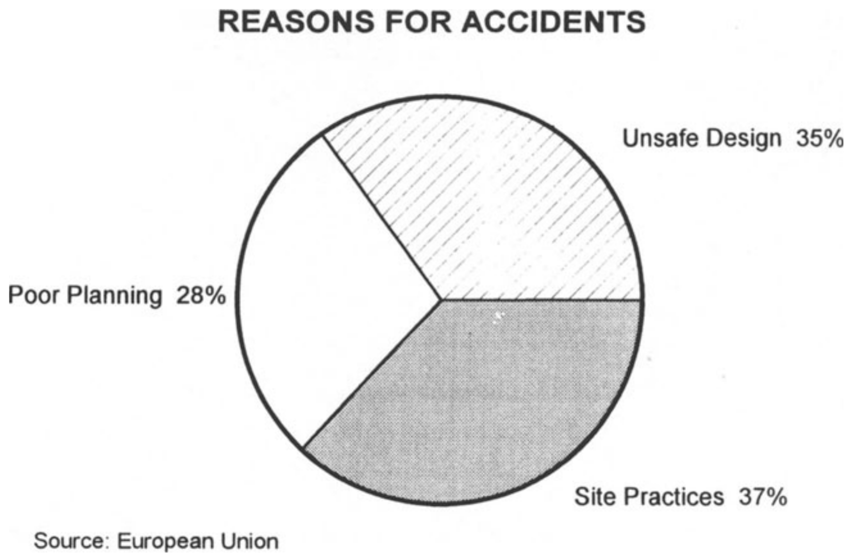


Figure 1.3

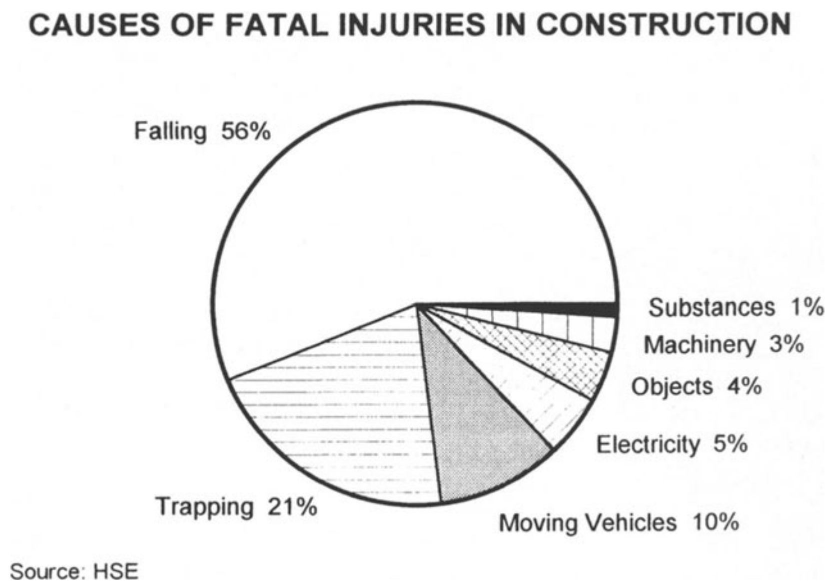


Figure 1.4

There is some dispute as to the reliability of the statistics, but the point is well made that, largely speaking, the construction process is poorly planned both during design and on site and that designers do not pay adequate regard to the consequences of their designs with respect to the erection, maintenance and future demolition of buildings and engineering structures.

As a result, European Directives on health and safety generally, and for construction in particular, have been issued over recent years and they have been implemented in the UK by various regulations.

The regulations which are particularly important in construction include:

- the Management of Health and Safety at Work Regulations 1992
- parts of the so-called 'Six-pack regulations'
- the Construction (Design and Management) Regulations 1994
- the Construction (Health, Safety and Welfare) Regulations 1996

1.6.1 Legislation

In the UK, health and safety regulations are empowered by statute which provides the 'enabling' legislation for the regulations to be implemented and enforced.

The two main statutes are the Factories Act 1961 and the Health and Safety at Work etc. Act 1974.

The Factories Act 1961 is gradually being phased out and a number of statutory instruments made under this Act have now been partially or fully replaced by the Construction (Health, Safety and Welfare) Regulations 1996.[4] The old legislation was drafted prescriptively in that specific rules applying to premises and use of equipment, etc. had to be followed.

The CDM Regulations, and other recent UK health and safety legislation, were made under the Health and Safety at Work, etc. Act 1974 and take a more 'modern' approach by setting goals to be achieved rather than prescribing what is to be done.

The HSAW Act sets out the penalties for failure to comply and confers powers on inspectors who may require site practices to be changed if they are considered to be unsafe or in breach of legislation.

Consequently, a contractor can be served with an 'improvement notice' or may even be prevented from continuing an unsafe operation through a 'prohibition notice'.

1.6.2 The Management of Health and Safety at Work Regulations 1992

So far as main contractors and subcontractors are concerned these regulations have overriding importance. For instance, they apply even in the limited circumstances where CDM does not.

The management regulations deal with assessment of risk and arrange-ments for and competence in the measures needed to protect individuals and prevent accidents at work, and so on.

The impact of this legislation is to ensure that issues identified by risk assessments are dealt with by effective planning, organisation and control and that procedures to monitor and review such arrangements are put in place.

There is no statutory requirement for safety method statements, but it is recognised good practice to prepare them in appropriate circumstances. This also applies to subcontractors' work.

A safety method statement is quite different from a construction method statement, but the two are often prepared in conjunction with each other. This is probably because it is a natural consequence to think about construction methods and plant, etc. when planning to safeguard the health and safety of the workforce.

An example of a contractor's risk assessment is given in Figure 10.12 and this may be developed into a safety method statement where the risks are considered to significant (see Figure 10.13).

The Management Regulations are also important because they impose obligations on employers to provide adequate health and safety training for employees and to communicate health and safety risks and the measures planned to deal with them.

These requirements have led to a far greater emphasis on awareness, training and competence in the workforce and it is now common practice for contractors to:

- provide regular training for operatives and management and to keep records
- conduct induction training before people are allowed to work on the site
- hold 'tool box' or 'task' talks where proposed methods of work are discussed in the site cabin
- ensure that subcontractors and others contribute to and are included in the safety management system on site.

1.6.3 The 'Six-pack' Regulations

As a consequence of EU law, a number of regulations have come into being in the UK and these have become known colloquially as the 'Six-pack' regulations. The 'Framework Regulations' are The Management of Health and Safety at Work Regulations 1992 and the other 'Six-pack regulations' comprise:

- The Workplace (Health, Safety and Welfare) Regulations 1992
- The Provision and Use of Workplace Equipment Regulations 1992
- The Personal Protective Equipment at Work Regulations 1992
- The Manual Handling Operations Regulations 1992
- The Health and Safety (Display Screen Equipment) Regulations 1992

The Workplace Regulations do not apply to construction, but some of the other regulations are important in terms of the planning of construction work and the safety of plant and equipment used:

The Provision and Use of Work Equipment Regulations 1992

These regulations apply to construction with respect to the provision and maintenance of tools and equipment and training and instruction for their proper use.

The Personal Protective Equipment at Work Regulations 1992

Where potential risks are not already regulated, the PPE Regulations impose a duty on employers to assess the risks involved and make appropriate provision (e.g. protection of employees from the health risks associated with inclement weather).

UK statutory requirements concerned with protection of employees already in force prior to the introduction of the 1992 PPE Regulations are not affected (for example, noise and head protection regulations).

The Manual Handling Operations Regulations 1992

These regulations are important in construction and contractors and sub-contractors have the obligation to assess the risks associated with potential hazards and to take steps to deal with the possibility of injury to employees.

The emphasis here is on the reduction of manual handling in construction and the greater use of appropriate equipment in order to safeguard the health of the workforce.

This is clearly and important consideration when thinking about proposed construction methods and will be influential on the estimator/planner when making decisions on :

- cranage
- hoisting and access equipment
- handling loose materials
- provision of lifting points on heavy objects
- handling sheet glass and glazed panels, particularly at height
- steel and precast concrete erection
- slinging and lifting drainage pipes and components

1.6.4 The Construction (Design And Management) Regulations 1994

Detailed consideration of the CDM Regulations is beyond the scope of this book, but they are nevertheless important from a number of points of view with respect to the planning, programming and financial control of projects:

- planning the construction process
- time for consideration and development of the health and safety plan
- planning and development of safe systems of work on site
- consideration of safety in construction methods
- safe construction sequencing
- establishing competence through prequalification
  - main contractor
  - subcontractors
- testing adequacy of resources
  - supervision
  - site personnel and organisation
  - subcontractors
  - financial provisions
  - plant and equipment

The CDM Regulations came about as a result of the Temporary or Mobile Worksites Directive (92/57/EEC) and they have proved to be an important landmark in health and safety legislation as they have focused the attention of the whole industry on the importance of managing projects safely.

CDM has also emphasised that it is not only the responsibility of contractors to be concerned with health and safety but that an important contribution needs to be made by clients and the design team to health and safety on construction projects.

Therefore, all those involved in construction, from clients to the workforce, should recognise the dangers and the causes of accidents and ill-health. Recognising the main reasons why accidents happen is a useful first step towards the effective management of health and safety. These are given in Figure 1.4.

Positive health and safety management can contribute significantly to the successful outcome of construction projects and the CDM Regulations emphasise that effective planning, communication and coordination of health and safety can reduce accidents and thereby avoid delay, disruption and unnecessary cost.

It is now widely accepted that *'...good health and safety is a part of good management'* [5] and it is important to encourage the right attitude to health and safety by everyone concerned in the construction process during both design and construction.

Principal Provisions of the CDM Regulations

The CDM Regulations apply to most construction projects with few exceptions. If the work involves demolition then the Regulations apply. For other work, if the duration of the construction phase is expected to be more than 30 days and there will be more than 4 people on site, including supervision, then CDM also applies.

In practice, the Regulations have wide ranging implications for the industry especially regarding the planning and coordination of design and construction, the notification and timing of projects, documentation and contracts and the creation of 'duty holders'.

The main provisions of the Regulations are:

- the creation of a framework in which health and safety can be managed throughout the design and construction process
- recognition of the contribution of all parties to the safe management of the construction process
- statutory duties on construction clients
- establishing widespread tests as to the competence of contributors and the adequacy of resources devoted to the management of health and safety
- creation of the Planning Supervisor role
- the statutory appointment of a Principal Contractor
- emphasis on the importance of design in health and safety
- establishing key health and safety documentation:
  - The health and safety plan
  - The health and safety file
- emphasis on advice, information and training

In particular, the Regulations impose statutory obligations on the main participants in construction projects, namely clients, architects, engineers and the like, main contractors and subcontractors.

Clients

As project initiator, clients have a duty to make two statutory appointments:

- a planning supervisor
- a principal contractor

Clients must ensure that those appointed are competent, with adequate resources to do the job including appropriate training, expertise and experience, technical backup, time and organisation.

While the planning supervisor and the principal contractor are responsible for health and safety planning and coordination, it is the client who has the statutory duty to ensure that a suitable health and safety plan has been prepared before the project starts.

The Planning Supervisor

This is a new professional role required by the CDM Regulations in the design phase of projects. It should be remembered that design often overlaps the construction process and the planning supervisor would be involved throughout. The Planning Supervisor is appointed by the client to provide management input from a health and safety point of view.

The Planning Supervisor takes no direct responsibility for health and safety in either the design or construction phases of a project, but acts as a coordinator for health and safety and has the following duties prescribed by the legislation:

- to ensure that the HSE is notified of a project
- to review design work for compliance with the Regulations
- to ensure that designers cooperate with each other
- to advise clients and contractors with respect to the Regulations, if requested
- to ensure that a health and safety plan and file are prepared and that they are adequate

The planning supervisor is not responsible for:

- preparing designs
- preparing health and safety documentation
- monitoring health and safety on site

However, in practice the planning supervisor usually prepares the pre-tender health and safety plan and can be asked by the client to check on the contractor's health and safety management performance on site.

The person or organisation appointed as planning supervisor should have considerable experience of both the design and construction processes as well as management, organisational, communication and interpersonal qualities.

Designers

Designers have a crucial role to play under CDM and they have statutory obligations for safety in design irrespective of the size of project.

The Regulations apply to all designers and specifiers whether they be architects, engineers, building surveyors, design-build contractors or quantity surveyors in ensuring that 'adequate regard' is paid to avoiding 'designing-in' foreseeable health and safety hazards which may become manifest during construction or when the building is in use.

This involves eliminating hazards altogether where possible, such as avoiding designing fragile roofs or over-elaborate construction sequences or, where design risks are unavoidable, alerting contractors to the risks through the health and safety plan.

The Principal Contractor

Under CDM the principal contractor has a key role in the management of health and safety. This appointment will usually be the main contractor in the traditional sense but could, for instance, be a construction manager or even the client where there is appropriate 'in-house' expertise.

It is common practice for the principal contractor to be preselected prior to inclusion on the tender list which is commonly done by submission of details of previous work, financial accounts and references and is often supplemented by an interview or presentation.

Contractors are also now frequently required to complete questionnaires concerning their health and safety track record for the client's scrutiny, but the questionnaires are often too long to be of any practical value in assessing competence or adequacy of health and safety management resource allocation.[6]

The key responsibilities of the principal contractor are for:

- health and safety arrangements on site
- information and training for those on site
- taking advice and views from persons at work

It should be noted that all contractors, as employers, have the duty to carry out risk assessments as part of their normal activities under the Management of Health and Safety at Work Regulations 1992 and other legislation, irrespective of CDM.

Contractors

'Contractors' under CDM would normally be subcontractors in the usual sense of the word. However, where a client organisation is 'principal contractor' the main construction contractor would also be a 'contractor' under CDM.

For example, on a power station project, the power generating company might be the principal contractor as well as the client and the main civil contractor and any subcontractors would be 'contractors' as far as CDM is concerned.

Contractors have statutory obligations to cooperate with others on site and take directions from the principal contractor. Other obligations include:

- provision of risk assessments
- compliance with site rules in the health and safety plan
- informing employees
- provision of information for the health and safety file
- accident reporting

The Health and Safety Plan

The health and safety plan required under CDM is an important means of communication which is intended as a continuous theme through the project.

In practice, the health and safety plan is in two main parts:

- Stage 1 Pre-tender health and safety plan
- Stage 2 Construction health and safety plan

The stage 1 plan is prepared by the 'design team' in conjunction with the planning supervisor, while stage 2 is developed from this by the principal contractor into a *safety management system* for organising, implementing and monitoring health and safety arrangements on site.

The Health and Safety File

The planning supervisor is responsible for ensuring that a health and safety file is prepared for every CDM project.

There is no general agreement as to what the file should contain, but it is likely to include project specific information such as design information, as-built drawings, records of existing services and technical specifications and data sheets relevant to the maintenance, cleaning and future alteration of the structure.

The file should also include details of specific erection sequences and any designed stressing of the structure which would be important should demolition be necessary in the future.

1.6.5 The Construction (Health, Safety and Welfare) Regulations 1996

The Construction (Health, Safety and Welfare) Regulations are intended to further implement the Temporary and Mobile Worksites Directive and they are written in the 'goal setting' style.

These Regulations introduce requirements for 'suitable and sufficient' provision for health, safety and welfare in 'construction work', but the detailed sets of rules contained in the old style Construction Regulations (1961/1966) relating, for instance, to the construction of scaffolding or supporting the sides of excavations have now largely disappeared.

Therefore, the Regulations contain little prescription, but there are exceptions, an example being the new requirements for intermediate guard rails. Nevertheless, the new Regulations are mainly drafted so as to recognise the impact of modern construction techniques and proprietary systems within a framework of regulation which encourages 'duty holders' to be pro-active in providing a safe working environment without un-necessary prescription.

This involves, for instance, the provision of safe access/egress routes, traffic movement and site welfare facilities, as well as the provision of safe working environments in excavations, cofferdams and at heights.

The Regulations cover 'places of work' and this includes site welfare facilities such as messrooms and cabins as well as excavations, scaffolding and working platforms and temporary works, etc.

The requirements include that certain places of work, excavations and working platforms for example, shall be inspected regularly and written reports prepared.

The CDM concept of 'duty holders' and requirements for cooperation and training are continued in these Regulations.

1.7 Procurement and the Influence of Major Clients

When a client is considering a decision to build, a number of important strategic decisions have to be made, including:

- choosing an appropriate strategy for managing the project
- choosing the client's principal advisor
- the appointment of other consultants
- establishing the client's brief and technical feasibility of the project
- obtaining the necessary finance
- choosing how to procure and manage design and construction
- determining the timing of the project

These and other issues are discussed by Turner (1997).[7]

The client's lead consultant will frequently be a designer (architect or engineer) or a project manager who will interpret and develop the client's brief and carry out initial feasibility studies or prepare outline designs.

At this stage the client must be advised of his statutory duties as a client under the Construction (Design and Management) Regulations[8] and it is advisable that a Planning Supervisor is appointed.

The procurement of construction projects requires a balance of time, cost and quality consistent with the client's requirements and budgetary constraints. This necessitates effective briefing, design and cost control and the choice of an appropriate procurement methodology tailored to the project. Consideration of the health and safety issues arising is now, of course, a statutory requirement under CDM.

Procurement methodology concerns not only the contractual arrangements for construction work but also the sourcing of professional services for design, project administration and health and safety management.

The choice is largely a question of the risk aversion of the client organisation and a successful outcome is reliant on an understanding of the culture and methodologies of the UK Construction Industry.

Turner (1997) considers who should carry the risk and how the right choice of procurement method can ensure that risk is allocated to whichever party is best placed to deal with it.

Procurement methods are constantly under review and, while there has been a significant trend towards design and build, other methods of procurement, such as construction management, are also becoming increasingly important.

Alternatively, some large clients such as BAA, Boots and McDonald's enter into partnering arrangements with preferred contractors (see 1.7.4).

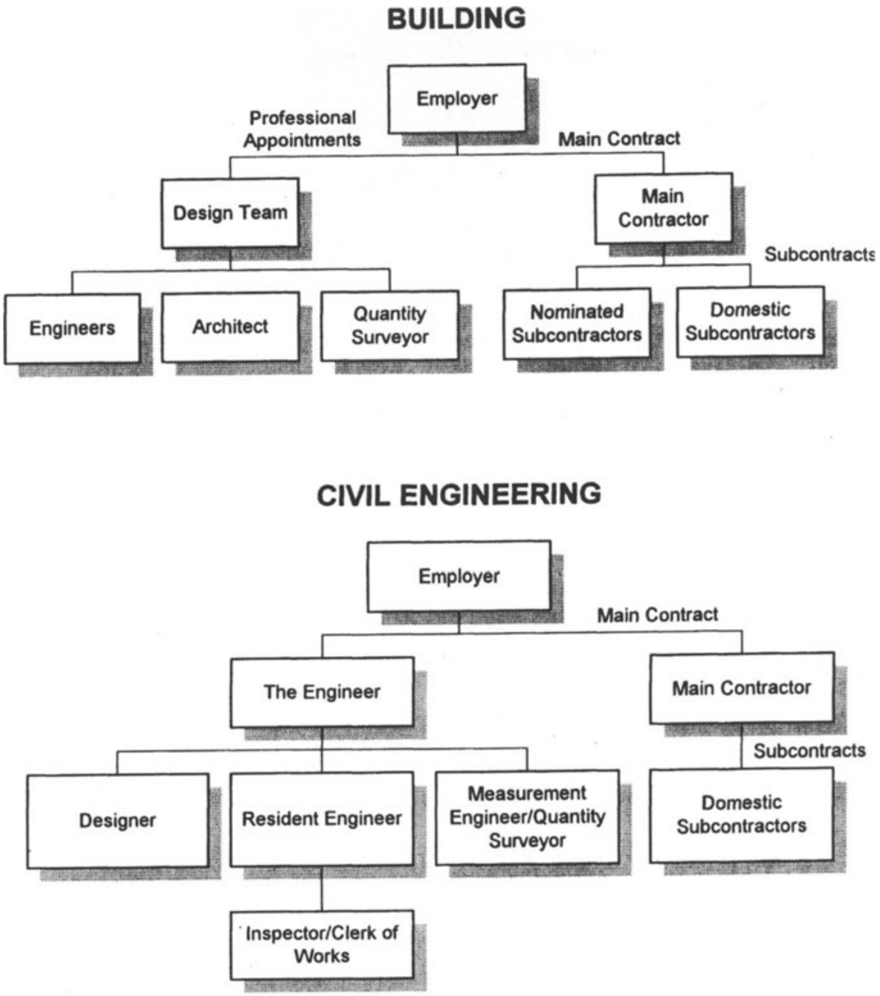
The principal procurement methods are:

- traditional
- design and build
- management contracting
- construction management
- partnering

Suggested approaches to the procurement of a variety of 'case study' projects are illustrated in Figure 10.54 in Chapter 10, which also identifies suitable standard forms of contract to use.

1.7.1 Traditional Procurement

A traditional procurement route may be adopted where the client's design team is appointed to prepare a design before the choice of contractor is considered. This can be considered to be a sequential or 'end-on' process where design and construction is separated by an intervening tendering period. Figure 1.5 depicts the contractual and administrative relationships which result from this method of procurement in 'traditional' building and civil engineering projects.



TRADITIONAL PROCUREMENT RELATIONSHIPS

Figure 1.5

Traditional procurement has the advantage of price competition and ideally the procedure should work, provided that:

- the design is complete before the tender stage (ensuring price certainty for the client)
- the designer understands how the construction will be undertaken (ensuring buildability)
- the design does not change substantially during construction (avoiding delay and disruption)

Figure 1.6 illustrates this idealised scenario. The reality is somewhat different, however, as shown in Figure 1.7, and designs are rarely complete before construction starts. With little or no contractor involvement in the design process, buildability may suffer, leading to inefficiencies on site and delay and disruption when the design is changed or details are awaited by the contractor.

Contractors frequently have to make allowances in their planning for variations and extra work which can cause enormous disruption to the efficient execution of work on site. Under SMM7 for instance, the contractor's programme has to allow for 'defined' provisional work. However, in practice, these items are often so poorly described that the contractor needs his 'crystal ball' to plan for them properly. 'Undefined' provisional items do not have to be allowed for in the programme, but very often the contractor will 'fit them in' without any extension of time.

Standard contracts, of course, do have clauses which cater for variations and extensions of time, but it is arguable whether contractors actually recover the true costs of delay and disruption to their work.

These difficulties are usually handled by most contractors with good humour and a ready acceptance of reasonable reimbursement, but frustration sets in when there is no budget to pay the contractor or the project administrator is compromised by divided loyalties or fear of retribution by the client.

At its best traditional procurement is ideal for many clients, but all too frequently the end product is:

- time overrun
- budget overspend
- disputes
- arbitration or litigation
- a 'lose–lose' situation

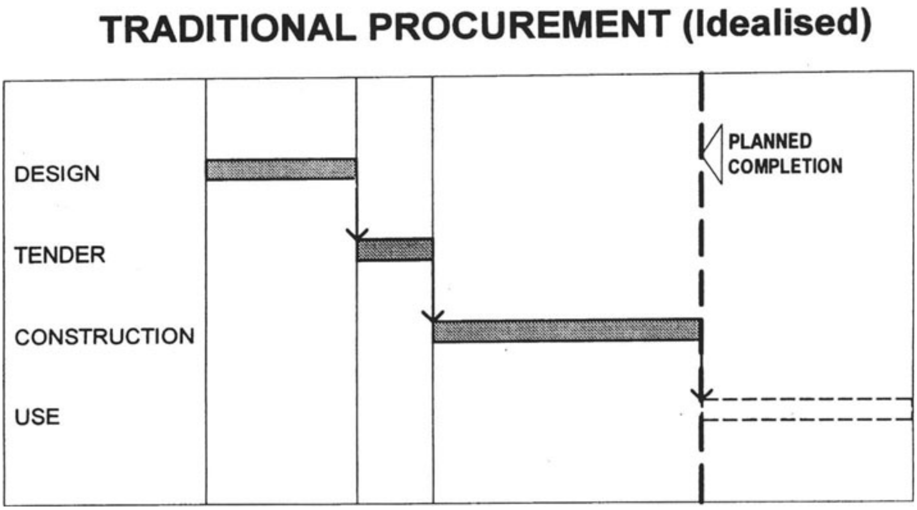


Figure 1.6

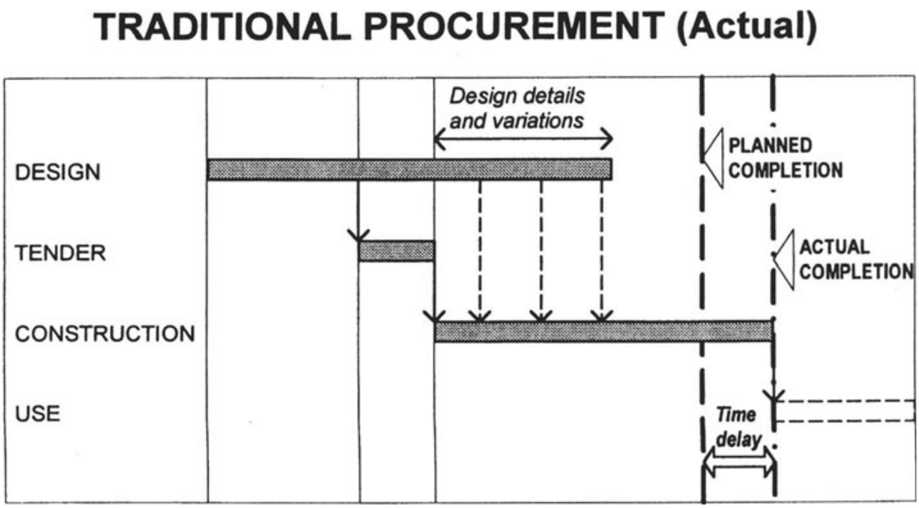


Figure 1.7

1.7.2 Management Contracting and Construction Management Arrangements

As an alternative to the traditional approach, the contractor may be chosen earlier so as to be involved in the early design stages as well as construction, in which case a management contract or construction management might be chosen. Figure 1.8 shows the relationships between the participants in these types of contractual arrangement.

Under both of these arrangements a fee is paid for the contractor's management services which will include the normal 'preliminaries' items of site staff and supervision, site hutting, scaffolding and temporary works as well as health and safety management for the project. In both cases, the works will be carried out by 'works package contractors'. These contractors may undertake substantial parts of the project and may also have design liability for their input. The main difference between the two methods is that a management contractor will be in direct contract with the works or package contractors, whereas under construction management these contracts will be direct with the construction client.

In both methods it is usual to engage the 'fee' contractor and then to place contracts for the packages as the design develops. These packages will usually be tendered competitively to pre-qualified or preferred bidders but this will be after the client has committed himself to the project. In this sense, management methods are more risky for the client because there is less price certainty, but there are benefits from efficiencies in buildability and time owing to the overlap between design and construction.

Figure 1.9 illustrates the time savings which can result from a management approach compared with traditional procurement. The features and benefits of management contracting and construction management are discussed in detail by Sidwell (1983)[9] and Murdoch and Hughes (1996).[10]

1.7.3 Design and Build

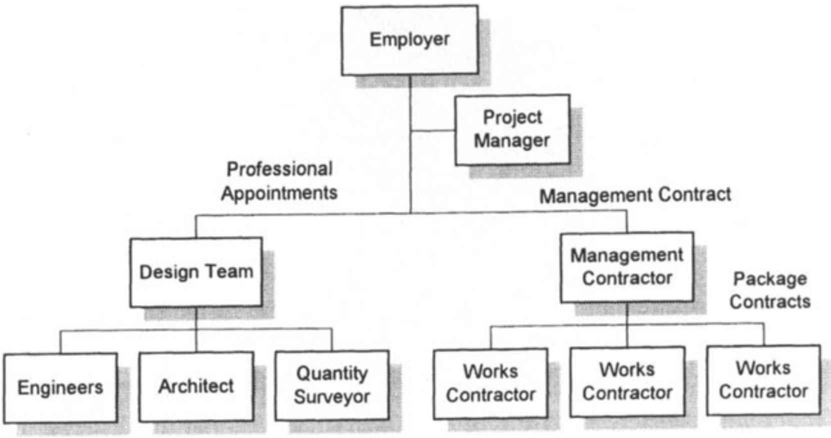
Design and build arrangements, on the other hand, normally involve the contractor taking complete responsibility for the design and delivery of the completed project in accordance with the client's requirements. Design and build relationships for client-led and contractor-led design are shown in Figure 1.10.

This method of procurement has become popular in recent years both in building and civil engineering although the idea is not new. Package deals were common in the 1960s but the modern approach is more sophisticated.

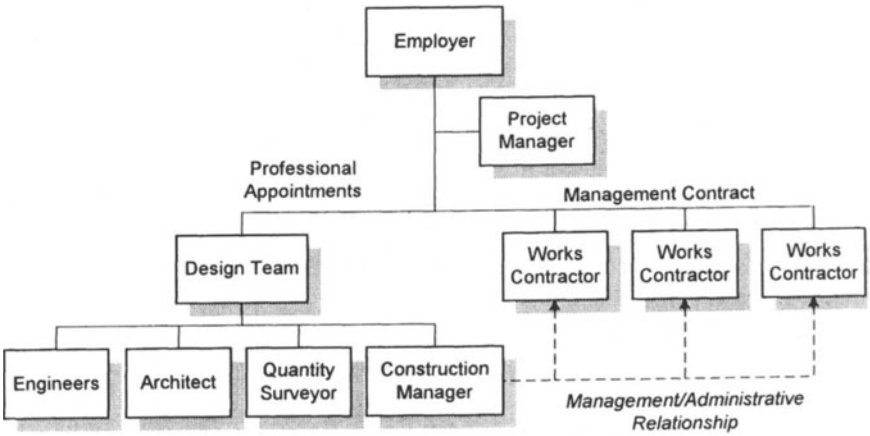
There are several variants of design and build primarily categorised by 'client-led' and 'contractor-led' methods with varying involvement of the client's consultants in the design process. These methods are authoritatively discussed at length by Janssens (1991).[11]

Savings in time and costs are the main benefits of design and build, but inferior design quality may be the penalty. See Figure 1.11 for a comparison.

MANAGEMENT CONTRACTING



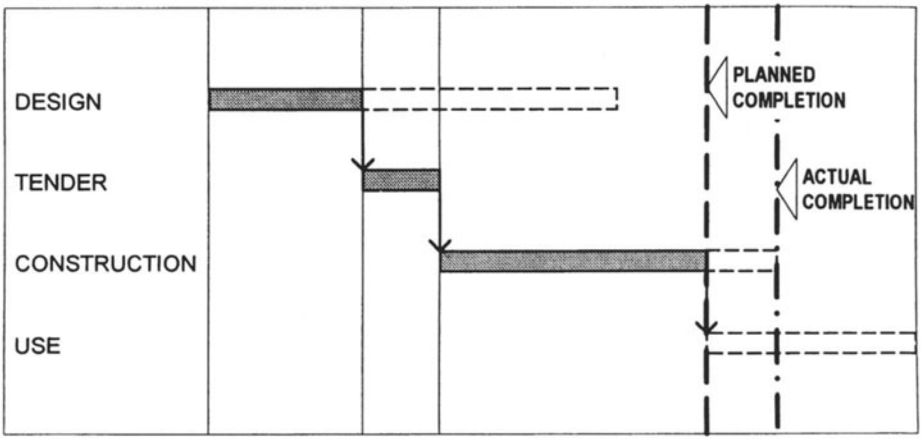
CONSTRUCTION MANAGEMENT



MANAGEMENT CONTRACTING/CONSTRUCTION MANAGEMENT RELATIONSHIPS

Figure 1.8

TRADITIONAL PROCUREMENT



MANAGEMENT PROCUREMENT

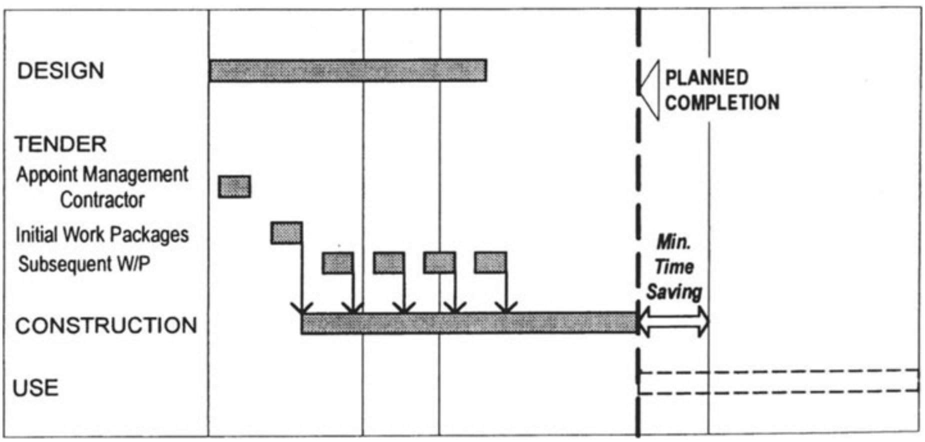


Figure 1.9

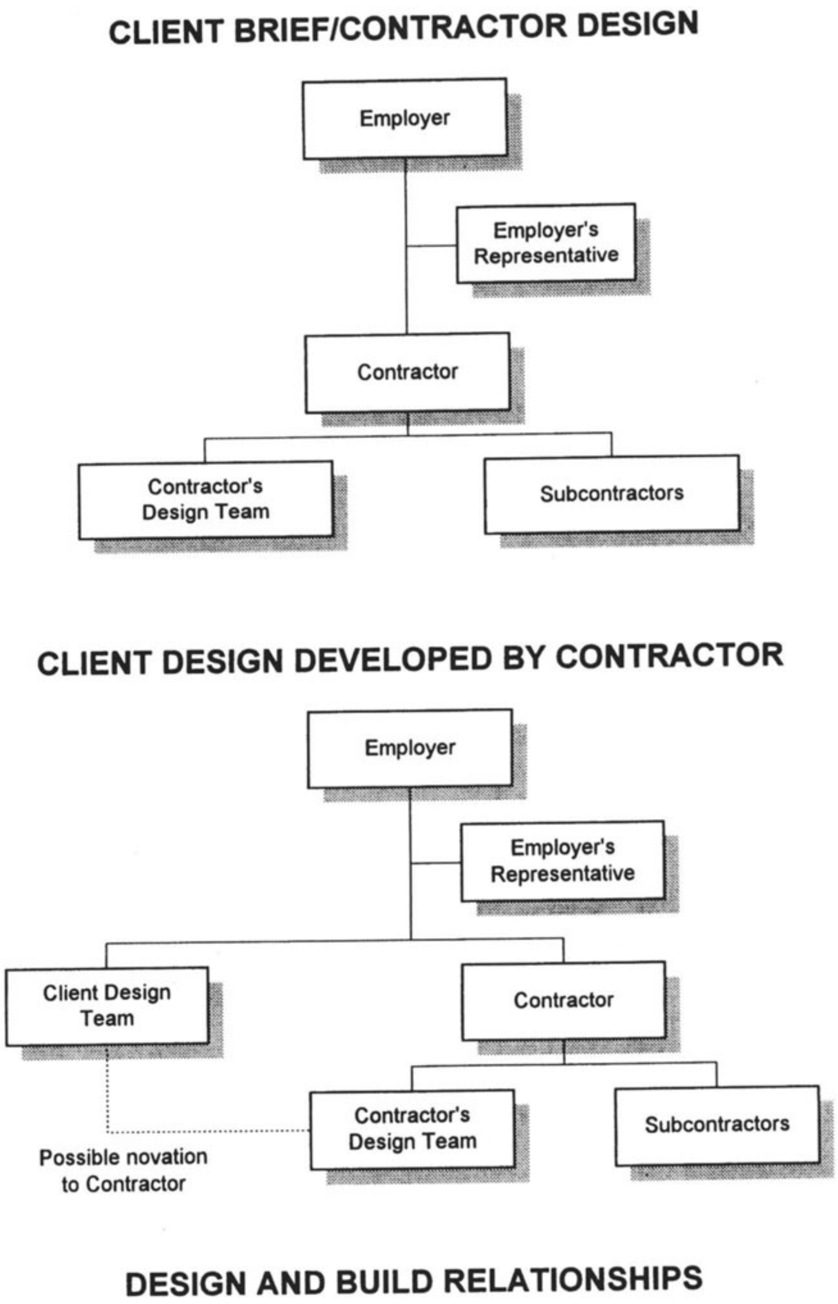
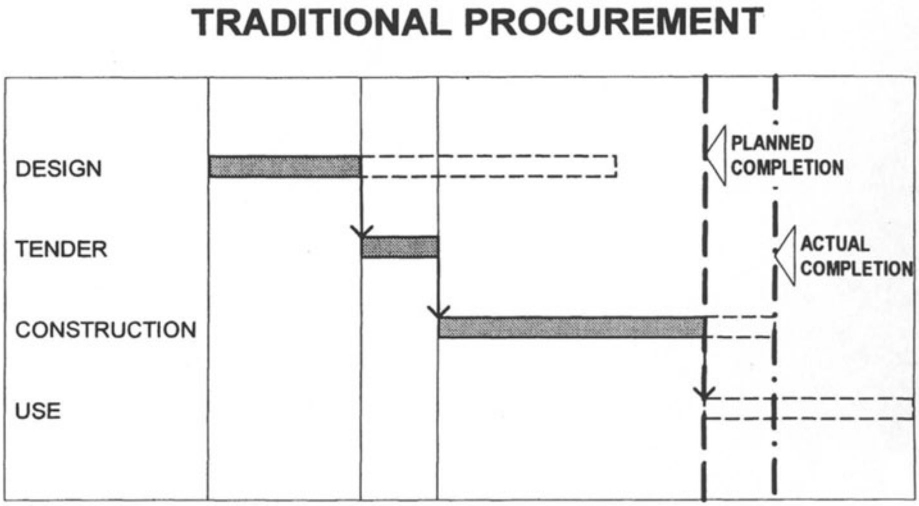

CLIENT BRIEF/CONTRACTOR DESIGN
Employer
Employer's Representative
Contractor
Contractor's Design Team
Subcontractors
CLIENT DESIGN DEVELOPED BY CONTRACTOR
Employer
Employer's Representative
Client Design Team
Contractor
Contractor's Design Team
Subcontractors
Possible novation to Contractor
DESIGN AND BUILD RELATIONSHIPS

Figure 1.10


TRADITIONAL PROCUREMENT
DESIGN
TENDER
CONSTRUCTION
USE
PLANNED COMPLETION
ACTUAL COMPLETION

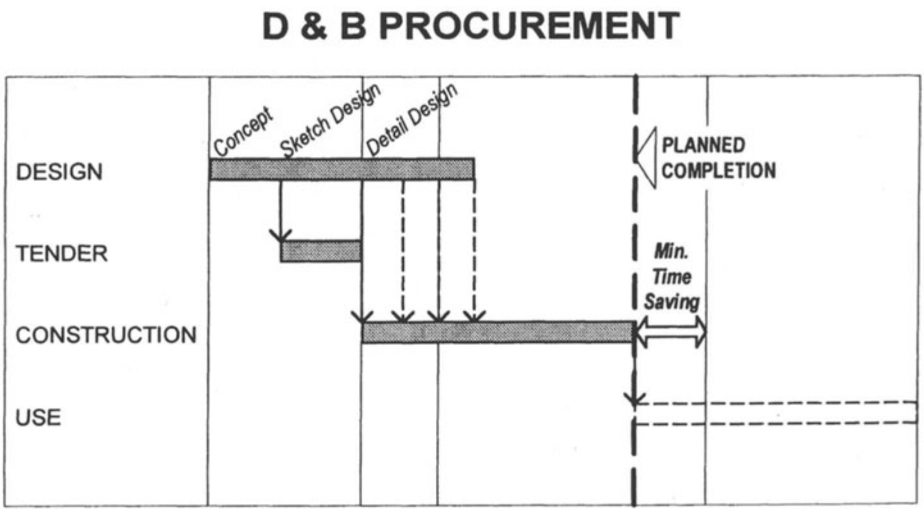

D & B PROCUREMENT
DESIGN
TENDER
CONSTRUCTION
USE
Concept
Sketch Design
Detail Design
PLANNED COMPLETION
Min. Time Saving

Figure 1.11

1.7.4 Partnering

'The Banwell Report indicated that there was scope for awarding contracts in certain circumstances without competition to contractors who had shown particularly good performance on behalf of clients. Such 'serial contracting' or 'negotiation' is especially suitable where it represents a follow on stage to a previous contract, either on an adjoining site or as a logical consequence to it.' (Latham paragraph 6.42)

This type of arrangement is quite normal in construction and a number of close client/contractor relationships have developed over the years. One of the best known 'alliances' is between Marks and Spencer and Bovis, although this has never developed into true or exclusive 'partnering' and other contractors also tender and work for this particular client.

'It is possible to go further, and for the client and contractor to enter into a specific and formal partnering agreement..' (Latham paragraph 6.43)

A number of major clients have moved towards partnering in a big way and these include British Airports Authority, Railtrack and Shell. Also *'some main contractors have developed long-term relationships with subcontractors'* (Latham paragraph 6.46).

There are two types of partnering arrangement:

- strategic partnering
- project partnering

The United States Construction Industry Institute defines partnering as 'a long-term commitment between two or more organisations for the purpose of achieving specific business objectives by maximising the effectiveness of each participant's resources'. In the UK this would be understood as 'strategic partnering', where the relationship would be for an indefinite period and where there is a long-term commitment to the partnering approach.

However, partnering may for a particular project or length of time, such as for an individual contract or for a 3-year maintenance contract. This would be a 'project partnering' approach.

The arrangement may be based on a formal contractual arrangement between the partners or there can be a non-legally binding relationship based on a charter with a mission statement and set of common objectives. In either case there would need to be *'a basis for agreeing prices and conditions of contract that are fair to both parties.'*[12]

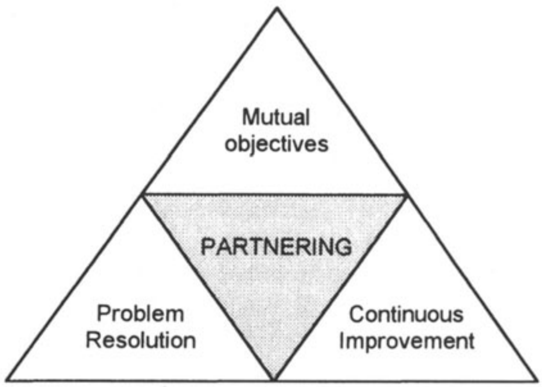
Project partnering is most common in the UK, but both strategic and project specific relationships need to be based on trust, dedication to common goals and an understanding of each other's individual expectations and values. Expected benefits include improved efficiency and cost-effectiveness, increased opportunity for innovation, and the continuous improvement of quality products and services, wherein:

- all seek 'win–win' solutions
- value is placed on a long-term relationship
- trust and openness are norms
- an environment for long-term profitability exists
- all are encouraged to openly address any problems
- all understand that neither benefits from exploitation of the others
- innovation is encouraged
- each partner is aware of the other's needs, concerns, objectives and is interested in helping their partner achieve this
- overall performance is improved[13]

Partnering arrangements may be preferred where the client has repeat business for the industry or perhaps wishes to adopt a 'Latham' or team building approach to a specific project.

This can be achieved by entering into a relationship for a specified period, or for a longer period, where both parties agree to work together to achieve particular goals, for mutual benefit. However, any arrangement that does not have the triangle of features in Figure 1.12 is an 'alliance' and not true partnering.

PARTNERING



Source: The Reading Construction Forum - 'Trusting the Team'

Figure 1.12

Figure 1.13 illustrates the partnering process using a traditional procurement route but the principles of open discussion and consensus using workshops or 'shirt-sleeved' meetings are common whatever the preferred procurement arrangements.

The benefits of building up long term relationships are recognised in the Latham Report, paragraph 6.45, in terms of *'improving quality and timeliness of completion whilst reducing costs'*.

However, Latham also recognises that the benefits need to be mutual for the system to work and, while contractors may be assured of continuity of work, clients must be assured that prices remain competitive within a relationship of trust.

The benefits of partnering or 'alliancing' may be summarised as:

- efficiency and less bureaucracy
- cost certainty
- faster construction
- timely completion
- better quality and safety standards
- reasonable profits

1.8 Public Sector Procurement Legislation

An important influence on construction procurement has been the impact of the Single European Act of 1987 which introduced certain changes to the articles of the original European treaties, including the Treaty of Rome, and set a target date for the single European market of 31 December 1992.

In order to comply with Article 59 of the Treaty of Rome the free movement of goods between member states must not be prevented and discrimination on the grounds of nationality is prohibited by Article 7. Decisions have been upheld in the European Court of Justice to give effect to this.

European Law prevails over national law and as such national laws must be amended to be compatible with European Treaties and Directives. Failure to comply with European Law may lead to actions for damages from offended parties.

For example, the European Communities Works Directive (93/37/EEC) provides for competitive selective tendering. These requirements are enacted in the UK by the Public Works Contract Regulations 1991 which also imposes additional national criteria on tendering procedures.

Public procurement systems therefore have to be designed so that they are clear and open to member states and the use of documents, such as construction specifications, which prescribe the use of materials from a particular nation or specify a particular trade name or product, constitute a barrier to trade and are illegal.

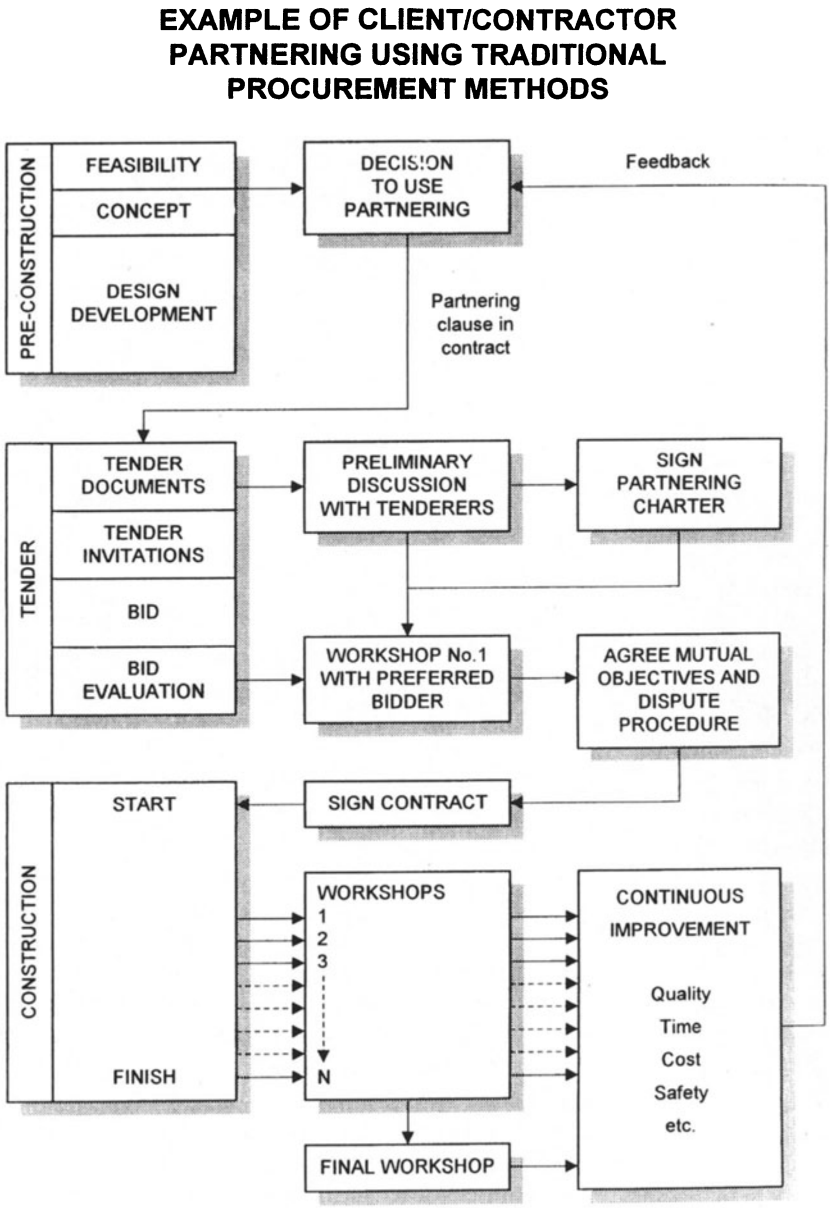

EXAMPLE OF CLIENT/CONTRACTOR PARTNERING USING TRADITIONAL PROCUREMENT METHODS
PRE-CONSTRUCTION
FEASIBILITY
CONCEPT
DESIGN DEVELOPMENT
DECISION TO USE PARTNERING
Feedback
Partnering clause in contract
TENDER
TENDER DOCUMENTS
TENDER INVITATIONS
BID
BID EVALUATION
PRELIMINARY DISCUSSION WITH TENDERERS
SIGN PARTNERING CHARTER
WORKSHOP No.1 WITH PREFERRED BIDDER
AGREE MUTUAL OBJECTIVES AND DISPUTE PROCEDURE
CONSTRUCTION
START
FINISH
SIGN CONTRACT
WORKSHOPS
1
2
3
N
CONTINUOUS IMPROVEMENT
Quality
Time
Cost
Safety
etc.
FINAL WORKSHOP

Figure 1.13

Also, under EU competition law, Article 85 of the Treaty of Rome prohibits any arrangements which seek to limit or prevent trade between member states and this includes price fixing or co-ordination of competition arrangements.

Therefore EU regulations require that contracts for works and supplies over certain value thresholds have to be advertised in the Official Journal of the European Communities. This information is also available on a computer data base called TED (Tenders Electronic Daily). Of course, many public sector bodies in the UK already have rigorous procedures to prevent collusive tendering and cartels and including the requirement for tenderers to sign a collusive tendering declaration.

Where contracts are required to be advertised, contracting authorities not only have to provide tender notices in the EU Journal but are also obliged to publish information on proposed procurement programmes and contract awards.

This is so that firms can identify tendering opportunities and find out how the contract was actually awarded. For works and services contracts awards have to be publicised within 48 days and unsuccessful tenderers are entitled to be informed of the reasons why their tender was not chosen within 15 days if they make such a request.

The effect of these requirements is to impose time constraints on the contracting authority which may be different to the tendering periods that might be expected in the UK. For instance, prescribed 'lead' times have to be allowed for receiving requests to tender (minimum 36 days) and for receipt of tenders (up to 40 days minimum) which have to be taken into account when deciding on the overall timescale for public sector projects.

In order to achieve transparency and fairness in public sector tendering the following directives have been adopted in connection with public works and supply contracts which have particular relevance to the construction industry:

- 93/37/EEC – The Works Directive which deals with public works contracts

- 93/36/EEC – The Supplies Directive which is concerned with public supply/ product contracts

- 92/50/EEC – The Services Directive which includes maintenance and repair services and architecture.

- 93/38/EEC – The Utilities Directive dealing with works and supply contracts in the water, energy, transportation and telecom sectors (WETT)

These directives are only concerned with issues such as the advertising of tendering opportunities, contractor selection, the award of contracts and notification procedures, etc. and do not set out to create common public procurement procedures in member states. The intention is to merely establish a basic set of common rules for tendering for projects above a particular value.

The EU Directives provide for 'Open', 'Restricted' and 'Negotiated' tendering arrangements, but the use of the restricted or negotiated procedures for supply contracts must be justified in writing and there are other rules concerning the award of supplies, works and services contracts.

For instance, for works and services contracts full information has to be prepared in writing setting out details of the contract, names of tenderers, reasons for selection and rejection, the name of the successful tenderer and the reasons why that tender was selected, etc.

Competitive tendering is a fundamental principle of the European Union but the EU Directive on Public Works Contracts Regulations allows contracts to be placed either on the basis of the lowest bid or that which offers the most economical solution.

Therefore the 'whole life' costing of tenders or considerations of cost, time and quality may be applicable for adoption into public sector tendering arrangements. Some public sector authorities are moving in this direction with their procurement arrangements in order to seek better 'value for money' and they apply a weighting factor to cost, time and quality in order to arrive at the most attractive tender.

1.9 The Role of Planning in Construction Contracts

1.9.1 The Importance of Planning

Despite all the change in the construction industry, or perhaps because of it, planning is still an important part of the construction process without which it is difficult to envisage the successful conclusion of any project.

Without planning, effective control of time and money is impossible and this is true throughout all stages of the process from inception through the design, tendering, construction and commissioning stages of a project.

This is especially true during the construction stage and is emphasised by some of the main standard forms of contract which require the submission of a programme as a specific contractual requirement.

However, many standard forms of contract do not require a programme but they nevertheless require the architect, engineer or contract administrator to arrive at a judgement as to whether or not the contractor is proceeding 'regularly and diligently with the works'.

This judgement may form the basis of a default notice to the contractor which may lead to an instruction to accelerate progress or even to determination of the contractor's employment under the contract when the failure is persistent.

It is questionable as to how this judgement can be made without comparing actual progress with a plan and it would therefore be prudent on any project to ask for a programme even though there may be no contractual requirement to do so.

Such a requirement could be provided for in the project documentation:

- instructions to tenderers
- the contract bills

- the specification
- the preliminaries or preambles

1.9.2 Stages of Planning

Planning usually starts with the client team or organisation and can be considered to develop through four distinct though interrelated stages. These stages are:

- Project planning } Client

- Pre-tender planning }
- Pre-contract planning } Contractor
- Contract planning }

Project planning is normally carried out by the construction client's agent, representative or project manager and this sets out the broad framework for the project timescale including:

- overall project duration
- design and tendering periods
- key dates for commencement and completion of construction
- stage or phased handover dates

Detailed aspects of the planning of a project by the contractor, both at tender stage and prior to and during construction, will take place within the parameters set by the client and/or his advisers.

In order to make planning more effective, it is usual to prepare a programme with which to compare actual progress. Several methods of presenting programmes have been developed over the years and these techniques, together with their relationships with progress and financial control, are explored and explained later in this book.

1.9.3 Financial Control

The Design Phase

Control of the financial aspects of a project depends on sensible planning. For example, during the design stages an overall budget is usually established with the aim of ensuring that the client's eventual expenditure is not more than can be afforded.

From the budget a 'cost plan' is then developed by the quantity surveyor which identifies how the budget will be spent. For instance, on a building project, the cost plan is based on the main elements of the building, such as:

- substructure
- superstructure
- finishes
- fittings and furnishings
- services
- external works
- preliminaries

The design team will then decide how to spend the budget according to these elements and the design will be developed accordingly. As more design detail emerges, the budgets for each element are split up into sub-elements so as to keep control of the design as it develops. A detailed account of design cost control procedures and their application is given by Seeley (1996).[14]

One of the benefits of involving a contractor in the early stages of a project is to make use of his accurate and up-to-date cost data for cost planning. This is because professional quantity surveyors normally have placed more reliance on their skills to produce cost plans coupled with less reliable historical cost data such as the RICS Building Cost Information Service (BCIS) and their own internal cost data bases. Some design and build contractors use the technique of design cost planning but by no means all of them do.

The Construction Phase

When it comes to the construction phase of a project, financial planning is geared to ensuring the profitability of the contract and managing the project cash flows.

Most construction contracts are won in competition and a bill of quantities is normally employed for pricing by the tenderers. The successful tenderer will analyse the priced bill and establish budgets or 'spend targets' for each of the main construction activities, such as:

- preliminaries
  - staff and supervision
  - site accommodation
  - site access
  - scaffolding
- groundworks
  - excavation and concreting
  - formwork
  - rebar
- drainage
- brickwork and blockwork
- joinery
- plastering, etc.

These budgets will then be monitored against the actual expenditure and any variance, especially overspend, will be dealt with by management. This action may result in changes to the programming, resourcing or management of the project.

The contractor's budgetary control of a project may be complicated by:

- uneven allocation of overheads and profit to the bill rates
- tactical pricing of items in anticipation of variations or claims
- front loading of bill items to improve cash flow
- lump sum additions to the tender for risk (e.g. ground conditions)
- lump sum deductions from the tender when bidding competitively.

1.9.4 The Contractor's Programme

The contractor's programme will either based on:

- possession and completion dates specified in the appendix to the contract
- a specific period for completion which is stated in the contract appendix
- the contractor's own period which will usually be stipulated in his tender

The contractór may prefer a programme based on his own assessment of the construction period for several reasons:

- the stipulated period is unrealistic
- a longer period may be acceptable to the client which then reduces the risk of liquidated and ascertained damages
- a shorter period is possible and will save money on preliminaries
- a compressed programme has claims potential

The form that the contractor's programme should take is not prescribed in any of the standard forms of contract albeit that this could be set down elsewhere in the contract documents.

The programme is not usually a contract document but is nevertheless an important tool in the management of the project. In this respect, the most appropriate format for Planning may not be the best for Control and therefore it may be advisable to ask the contractor for a bar chart or similar presentation rather than a logic-based format such as a precedence diagram.

The architect or engineer will monitor actual progress against the programme and take action where it is felt that the completion date will not be achieved.

This action may take the form of asking the contractor to expedite or accelerate the programme or granting an extension of time where the nature of the delay warrants it.

1.9.5 Contractual Issues

Standard construction contracts provide that the contractor shall complete within the prescribed contract completion time, which can be extended in certain circumstances. For instance, variations may be ordered which may cause delay or the contractor may be held up waiting for drawings, details or instructions.

Consequently, in order to preserve the employer's right to deduct liquidated damages, standard forms of contract contain a clause allowing the contractor extensions of time for completion. JCT80 clause 25 and ICE6 clause 44 are examples of this.

Nevertheless, it is common practice for contractors to submit programmes showing an earlier completion than that stipulated in the contract, although certain employing authorities do not allow this.

This ploy is often a tactic in anticipation of claims for delay in the mistaken belief that any delay caused by the employer will validly entitle the contractor to claim for delay.

The theory is that a shorter programme, annotated with information deadlines, will put pressure on the architect or engineer to produce drawings etc. to a tight timescale and any failure to provide the information will cause delay to the contractor with a resultant extension of time and costs.

However, in *Glenlion Construction* v *The Guinness Trust (1987),* a JCT building contract, it was held that the contractor will only have a valid claim if the contract is delayed beyond the contractual completion date and that, further, the architect is only obliged to furnish drawings and instructions 'within a reasonable time of the conclusion of the contract'.

Keating (1991) takes the view that the employer is thus not under an implied obligation 'to enable the contractor to complete by the earlier date'.[15]

The consequence is thus that 'provided that the contractor can still complete within the contract period, he cannot recover prolongation expenses' and 'the employer ... is under no ... obligation to ... pay compensation if the contractor is unable to achieve an accelerated programme'.[16] Claims conscious contractors take note!

1.9.6 The Standard Form of Building Contract JCT80

There is no contractual requirement for a programme under JCT80. Therefore, where the contractor is required to produce a programme for the project, perhaps in a specified format, this should be stated in the bill of quantities, specification or preambles.

If the contractor produces a master programme for his own use, then he is obliged, under Clause 5.3.1.2, to supply the architect with two copies of it following the signing of the contract. This is an optional clause which can be deleted by the employer if a programme is not required.

Clause 5.3.2 emphasises that the provision of the programme does not impose any additional obligations on the contractor other than those determined by the contract documents.

The programme is not a contract document and failure to observe the programme is not a breach of contract.

However, when the contractor is given possession of the site as prescribed by clause 23.1.1, he shall commence the works and 'regularly and diligently proceed with the same and shall complete ... on or before the Completion Date'.

In this respect, failure to progress with the works in accordance with the intended programme may provide some evidence of the contractor's failure to proceed regularly and diligently. In extreme cases this could lead to the drastic step of determination of the contract by the employer which, while terminating the contractor's employment under the contract, does not relieve him of his contractual obligations.

Obviously, even the best laid plans rarely work out exactly, but the only obligation to submit a revised programme under JCT80 is where an extension of time is granted under the contract.

The architect/contract administrator has no powers to require the contractor to accelerate the works, but he may issue a notice of determination under clause 27.1 if the contractor persistently fails to progress satisfactorily.

1.9.7 The Standard Form of Building Contract with Contractor's Design JCT81

Unlike JCT80, the design and build form contains no provision for a master programme.

However, clause 27.1 provides for determination of the contractor's employment under the contract for failure to proceed 'regularly and diligently' with the works. It would therefore be prudent for the client's advisers to have a copy of the contractor's up to date programme so as to monitor performance.

This could be provided for in the contract preliminaries or in the instructions to tenderers. Alternatively, a requirement for a programme could be included in the Employer's Requirements which are incorporated in Article 4 of Appendix 3 to the Conditions of Contract.

The contractor's programme may well be an important document, as payment in design and build is usually in stages which may be linked either to construction stages or to activities on the programme.

1.9.8 The Standard Form of Management Contract JCT87

Under these conditions, the contractor tenders on the basis of a management fee and works contracts are placed later on for various 'packages' as and when the design is sufficiently developed.

The intention of this method of procurement is for the client to appoint professional advisers for the architectural and engineering design and quantity surveying ('the Professional Team') and to engage a contractor in a 'professional' capacity to advise on design, technical and buildability issues.

In Article 1, JCT87 requires the management contractor to 'cooperate with the Professional Team during the design stages and in the planning, programming and cost estimating ... for the Project.'

This involves the contractor in preparing the 'Project programme' which has to be agreed by the client's Professional Team.

Additionally, the management contractor is required to 'prepare all necessary programmes for the execution of the Project' (clause 1.5.1) which includes the preparation of a 'detailed construction programme'.

These obligations are emphasised in the Third Schedule of 'The Services to be provided by the Management Contractor' whose duties include 'Maintaining and regularly updating the detailed construction programme'.

1.9.9 The ICE Conditions of Contract 6th Edition

Under this form of contract, the contractor is required to submit his programme for the approval of the engineer showing the order in which he intends to proceed with the works. This programme is commonly referred to as the 'Clause 14 Programme' as it is required under clause 14(1) of the contract.

In addition to this obligation, the contractor is required to submit a written description of his proposed arrangements and methods for the project and, if requested by the engineer, detailed information on construction methods, temporary works and contractor's equipment. Additionally, the contractor is required to explain about his intended methods of working and resourcing of the works to the reasonable satisfaction of the engineer through clauses 13 and 14.

Submission of this information puts the engineer under an obligation to respond within a limited time by either accepting or rejecting the contractor's proposals or requesting him to submit further details. The contractor's programme is not usually a contract document in civil engineering, but far greater emphasis is placed on the programme than in building works.

While not a contract document in its own right, the submission of a programme is a contractual requirement under clause 14. The engineer plays a significant role in its final production and he has the power to reject the proposed programme until such time that he is satisfied with the contractor's order of working.

Under ICE6, an up-to-date programme is a contractual requirement and clause 14(4) entitles the engineer to ask the contractor to submit a revised programme where actual progress is not as intended. Under clause 46(1), if the engineer considers that the contractor is not progressing in accordance with the programme, he is entitled to ask the contractor 'expedite' or speed up his work so as to complete the works on time. This does not, however, give the engineer the power to ask the contractor to accelerate the works so as to finish earlier than the contract completion date.

The provision for 'acceleration' in clause 46(3) does not have the same meaning as 'expedite'. Acceleration provides a means for the client (employer) to ask the contractor to finish the job before the contract completion date (or the extended date) where perhaps an opening or commissioning deadline is important. In such circumstances the parties can agree special arrangements for earlier completion where mutually acceptable but such an agreement will be outside the original contract.

1.9.10 The Engineering and Construction Contract (NEC)

The New Engineering Contract (NEC) was first published in 1991 and is now in its second edition following amendments recommended by the Latham Review. The NEC was considered by Latham to be 'capable of being a common contract for the whole industry' both in the public and private sectors.[17]

The main form of contract has now been renamed 'The Engineering and Construction Contract' within the NEC family of documents which also includes standard forms of subcontract and professional services contracts, etc.

These changes, however, have not altered the fundamental concept of the NEC which was designed to be flexible in its use and applicable to a variety of types of construction work including:

- building
- civil engineering
- process and other engineering
- refurbishment work
- maintenance work

The contract can be used for both major and minor works alike and its flexibility extends to employing a variety of contractual arrangements with different types of project documentation.

A project can be set up on the basis of the following main options:

Option

- A a priced contract using an activity schedule (a list of activities linked to the programme)
- B a priced contract using bills of quantities (e.g. SMM7 or CESMM)
- C a target contract using an activity schedule
- D a target contract using a bill of quantities
- E a cost reimbursable contract using schedules of actual cost (similar in principle to daywork)
- F a management contract (with works package contractors engaged directly by the management contractor)

There is no architect or engineer under the NEC. Instead these traditional appointments are separated into the functional roles of 'project manager', 'supervisor' and 'adjudicator' although, of course, they could be undertaken by one individual if preferred.

The flexibility of this approach is illustrated, for example, where a construction management approach is required. Here, the client would enter into direct contracts with each of the works contractors using the main ECC form and appoint the management contractor as 'project manager' under this form of contract.

One of the basic concepts of the NEC is that any contract requires certain fundamental clauses, such as provision for time, quality, payment and dispute resolution. Other clauses, on the other hand, can be considered as 'optional extras'. These might deal with liquidated damages, bonds and guarantees, retentions, early completion bonuses, etc. Consequently, the NEC has nine 'core clauses', which would be in every contract, and fifteen 'secondary option clauses' from which to choose so as to tailor the contract to the client's requirements.

The flexible approach offered by the NEC facilitates consultant or contractor design and also contracts based on conventional lump sum, remeasurement, management arrangements, target cost or other reimbursable contracts.

The programme is an important document under this form of contract and there are contractual obligations placed on the contractor under clause 30 prescribing information to be shown on the programme and to make sure that it is kept up to date.

The programme must show:

- critical dates
- operations by the contractor and others
- equipment and resources for each operation
- order and timing of the works
- float and time risk allowances
- health and safety requirements
- other general information and dates

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2 Construction Management and Organisation

2.1 The Size of Construction Firms

The Construction Industry is characterised by a large number of small contractors and a relatively small number of large contractors that carry out most of the industry's workload. To illustrate the point, a total of just over 200 000 firms were operating in the industry in 1992 producing a turnover of approximately £45 billion, 70% of which was produced by only 5000 firms.

UK government statistics group companies by the number of direct employees. For instance, the statistics for 1992 were:

Category	Total No. in Employment	Number of firms	Total No of firms
'Small Firm'	1	94 452	
	2-3	68 486	
	4-7	30 395	
	8-13	5 240	
	14-24	3 574	202 147
'Medium Firm'	25-34	1 146	
	35-59	1 148	
	60-79	361	
	80-114	317	
	115-299	387	3 359
'Large Firm'	300-599	103	
	600-1199	59	162
'Big Firm'	1200 and over		36
			Total = 205 704

The top ten companies in the UK (1996) in the 'Big Firm' category are listed below together with their turnover, profit and number of employees.
(Profit figures in brackets are what the Americans call 'negative profits' which in the UK represent losses!)

Rank	Company	Turnover (£m)	Profit (£M)	No. of Employees
1	Trafalgar House	3721	(320.8)	34302
2	Tarmac	2482	20.3	19981
3	AMEC	2451	15.9	21644*
4	Bovis	1641	30.4	5200*
5	Balfour Beatty	1730	(56.3)	16507*
6	Wimpey	1569	15.6	11521
7	Mowlem	1457	(30.0)	12184
8	Laing	1206	20.1	8425
9	Taylor Woodrow	1154	46	9568
10	Costain	842	(142.6)	9707 *

* Not all directly related to construction activity

Details of current annual figures may be obtained from such publications as the *Contract Journal*, *Building* and the individual company financial accounts. It is interesting to match the size of companies in the UK with those of the major construction companies in the European Union. The top ten companies listed in Europe are as follows :

Rank	Company	Country	Turnover (£m)	Profit (£m)	No. of Employees
1	Bouygues	France	9379	(369.9)	91 894
2	Holzmann	Germany	6234	(204.9)	47 400
3	SGE	France	5748	(118.5)	60 898
4	GTM-Entrepose	France	5442	25.1	68 387
5	Hochtief	Germany	4896	60.5	40 300
6	Eiffage	France	4142	26.1	46 253
7	Bilfinger-Berger	Germany	3792	46.2	49 700
8	Trafalgar House	UK	3721	(320.8)	34 302
9	Skanska	Sweden	3374	167.0	32 278
10	Dumez-GTM	France	3158	0.2	34 569

It is noticeable that firms in Europe appear to be content with smaller profit margins than those in the UK.

2.2 The Small, Medium and Large Firm Scenario

It is interesting to compare the changes in the organisational structure of companies as company expansion takes place. In many construction situations the management are frequently unable to cope with the management of changing size.

Drucker (1989)[1] states that the biggest problem in business is growth, i.e. the problem of changing from one size to another. Many principals or owners of construction firms face this problem as business expansion takes place. Often they cannot cope with the new situation they are faced with. This is often due to their lack of vision and competence to manage people around them. Many directors cannot delegate responsibility to subordinates due to a lack of trust. Drucker indicates that a change in behaviour, attitude, competence and vision is needed by people at the top. Success in business often results from a company providing a good service to clients and doing a good job. The business can only service its customers by becoming bigger.

An interesting approach is taken by Drucker in defining the four stages of business growth. These may be summarised as follows.

The 'small' business is distinguished from the one-man proprietorship by requiring a level of management between the man at the top and the workers. Also, small businesses tend to be organised functionally.

In the 'fair sized' business (later referred to as medium sized), the role of the managing director has become a full-time position. He is required to concentrate his efforts on guiding and managing the affairs of the business. The company needs some formal organisation structure preferably based on the federal principle, which focuses the vision and efforts of managers directly on business performance and results.

In the majority of construction firms in this category, the tendency is to develop a departmental approach to the various sections of the organisation, i.e. Construction, Surveying, Estimating, Plant, and Administration.

Once a business reaches the 'large' category, the setting of overall objectives becomes far too big for one person. Responsibility for setting objectives becomes a shared duty of the management team. A large construction organisation may be managed by a main board of directors, supported by departmental directors and regional and technical directors.

The 'very large' business is characterised by the fact that both the action and the overall business objective setting must be organised on a team basis. Each position in the organisation requires the full-time services of several people.

2.3 Structure of the 'Small Firm'

The small firm has been categorised as a business employing between one and twenty-four directly employed staff (or staff and operatives). According to the statistics presented earlier in the chapter, this represents some 92% of companies in the UK construction industry. The number of construction firms in the European Union is in the order of 1 100 000, with 91% of these companies employing less than 10 people.

2.3.1 Business Profile of 'Small' Company A

Company Background

The business enterprise is managed by the principal or owner. Sixty per cent of their work is obtained by negotiation, the rest being from competitive tenders.

Quotations are based mainly on a drawings and specification basis, which places extensive risk on the business enterprise. Turnover after two years of trading is in the order of £800 000. The largest project undertaken to date was in the £250 000 range. The policy of the company is to use labour only and directly employed subcontractors. The number of directly employed staff is three. Figure 2.1 indicates the organisational structure of the company, if a structure can be said to exist.

Figure 2.2 indicates the management approach to the control of projects.

Business Control Procedures

Control is maintained by constant visits to projects by the principal in order to coordinate materials, plant and subcontractors. The principal's major concern is providing a personal service to clients and ensuring that projects are completed on time at a reasonable profit. A non-confrontational approach is adopted in the settlement of contract final accounts. The business relies extensively on negotiating further contracts with satisfied clients. Maintaining client contact during a project is considered essential to the success of the business.

Management checks are made on project profitability at interim valuation stages on a somewhat *ad hoc* basis. Monthly site meetings on all projects are attended by the principal. The majority of the principal's time is spent on preparing tenders for new work and chasing round his existing projects.

Commentary on the Role of the Principal

This is the typical 'small' company approach to managing a construction enterprise. The principal tends to make all decisions, and tends to do everything himself. He does not appear to be able to delegate responsibility to people around him. With further business expansion the principal considers that he will lose control. Unless the principal overcomes this problem, the business will fail to expand and the principal will finish up having an heart attack.

An extensive number of 'small' companies in this situation may however be contented with the profit returns they are achieving and may not wish to become any 'bigger'. Perhaps the approach of working hard for nine months and spending three months lying in the sun is too much to give up for the sake of success!

CASE STUDY - 'SMALL' COMPANY A

ORGANISATION STRUCTURE

PRINCIPAL OWNER

RESPONSIBLE FOR :

- Contact with clients / architects etc.
- Preparation of tenders / obtaining work
- Submission and adjudication decisions
- Pre-contract arrangements
- Letting of subcontracts
- Planning - programming of work
- Interim certificates / final accounts
- Payment to subcontractors / suppliers
- Establishing policy
- All decision making

Figure 2.1

PROJECT ORGANISATION

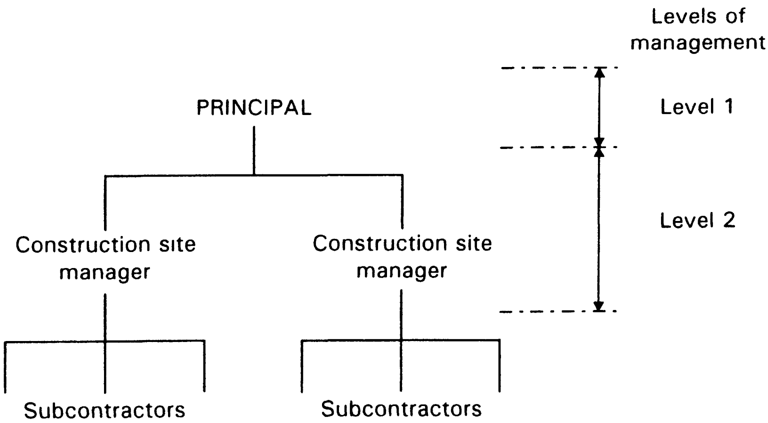


Figure 2.2

2.4 Leadership Styles in Business Organisations

As the business expands the leadership style of the principal or managing director becomes clearly apparent. The various leadership styles are summarised in Figure 2.3 as being autocratic or democratic. Traditionally, leadership has tended to be associated with autocratic command, especially within the small-sized organisation. Many still see leadership mainly in terms of issuing orders which are obeyed by subordinates without question. Drucker (1989)[1] asserts that leadership is the lifting of man's vision to higher sights and the raising of man's performance to a higher standard. Management can only create the leadership under which potential leader-ship qualities become effective.

Clutterbuck (1984)[2] indicates that to be effective 'leaders must be seen'. Perhaps the question should be posed 'How many times in the last twelve months have you had personal contact with your company chairman or chief executive?' Perhaps not at all.

Dixon (1991)[3] defines leadership as the process of directing and influencing the work of team members. Leadership is concerned with guiding and directing others. The style adopted depends in part on the manager's view of human nature in general, and the ability of his/her subordinates in particular. The manager's attitude to his subordinates may be depicted with respect to McGregor's Theory X and Theory Y as outlined in Figure 2.4. The Theory X manager favours the autocratic approach, while the Theory Y manager favours democracy.

Likert's system of management which identifies leadership traits is an interesting approach that is worth considering. Likert studied the pattern and style of leaders and managers for three decades in order to develop an approach to understanding leadership behaviour. He sees the effective manager as being strongly oriented towards subordinates, relying on efficient communications in order to keep all parties working as a unit. All members of the group, including the leader, adopt a supporting relationship in which they feel a genuine common interest in terms of needs, values, aspirations, goals and expectations. Likert sees this approach as the most effective way to lead a group.

Hodgetts (1982)[4] presented a summary of the 'Likert System' as illustrated in Figure 2.5 Aspects in relation to confidence and trust in subordinates, and the process of decision making have been expressed here. Likert found that those managers who applied the System 4 approach to their operations had the greatest success as leaders.

LEADERSHIP STYLES

AUTOCRATIC

- One who commands
- Expects everyone to comply
- Dogmatic - arrogant, assertive
- Positive - clear cut, decisive
- Often rules by threat or reward

DEMOCRATIC

- Manages by consultation with subordinates
- Encourages participation
- Develops a team approach
- Sees the good in people around him

Figure 2.3

THE PRINCIPAL / MANAGER MUST BE CONSIDERATE TOWARDS HIS SUBORDINATES. ONE MAY CONSIDER M^C GREGOR'S THEORY X AND THEORY Y

THEORY X

- People do not like work and therefore coercion, or punishment may be applied to get them to work
- Bring back the "birch"

THEORY Y

- People do not dislike work and therefore work should be a pleasure
- Create interest, encourage responsibility
- Get people involved in participation in the management of the business
- Develop a team approach to problem solving

Figure 2.4

LIKERT'S MANAGEMENT SYSTEM - Approach to Leadership				
	SYSTEM 1	**SYSTEM 2**	**SYSTEM 3**	**SYSTEM 4**
Organisational variable	Explosive Authoritative	Benevolent Authoritative	Consultative Democratic	Participative Democratic
Leadership processes used	Have no confidence and trust in subordinates	Have condescending confidence and trust, such as master has to servant	Substantial but not complete confidence and trust, still wishes to keep control of decisions	Complete confidence and trust in all matters
Character of decision making process	Bulk of decisions at top of organisation	Policy at top, many decisions within prescribed framework made at lower levels but usually checked with top before action is taken	Broad policy decisions at top, more specific decisions at lower levels	Decision making widely done throughout organisation although well integrated through linking process provided by overlapping groups
Leadership style	**AUTOCRATIC**	**AUTOCRATIC**	**DEMOCRATIC**	**DEMOCRATIC**

Figure 2.5

2.5 Structure of the 'Medium Sized Firm'

The medium sized firm has developed from expansion of the small business. This has been brought about by the increase in workload, turnover and business diversification – possibly away from the core business. This may have developed from a need for the company to consider broadening its work base. The core business may have been refurbishment work, but the company may now be offering a design and build or a work package service to clients. Alternatively, the business may have moved into their own speculative refurbishment projects. Many such options are available as a business expands.

A team approach to the management of the company has to be established by the appointment of directors responsible for contracts, surveying, estimating, office organisation and financial aspects of the business. As Drucker states, 'the role of the managing director now becomes a full-time position'. A strategic plan and clear policy objectives must be established. Policy decisions must be communicated throughout the organisation, and the development of teamwork is necessary at all levels of management.

Policy must be clarified in such areas as:

- Safety, health and welfare
- Training and recruitment
- Company control and reporting procedures
- Planning procedures to be utilised on projects

Delegation of responsibility at all levels of management must be introduced. Control and reporting procedures must be established for reporting on contract performance during the progress of construction projects. Communication channels must be set up throughout the company in order that staff know the person to whom they report.

2.5.1 Business Profile of 'Medium' Company B

Background Information to Company

The company was established in the early 1980s as a two-partner business undertaking public house and club refurbishment work. The company has now expanded into a major specialist contractor servicing the leisure and hotel industry. In 1995 the company turnover was approximately £20 million. The company has recently expanded in order to offer a specialist design and build service to the leisure and hotel industry. The policy of the company is to use labour only and established domestic subcontractors. The company at the present time employs between 35 and 40 permanent office and site staff.

CASE STUDY - 'MEDIUM' COMPANY B

ORGANISATION STRUCTURE

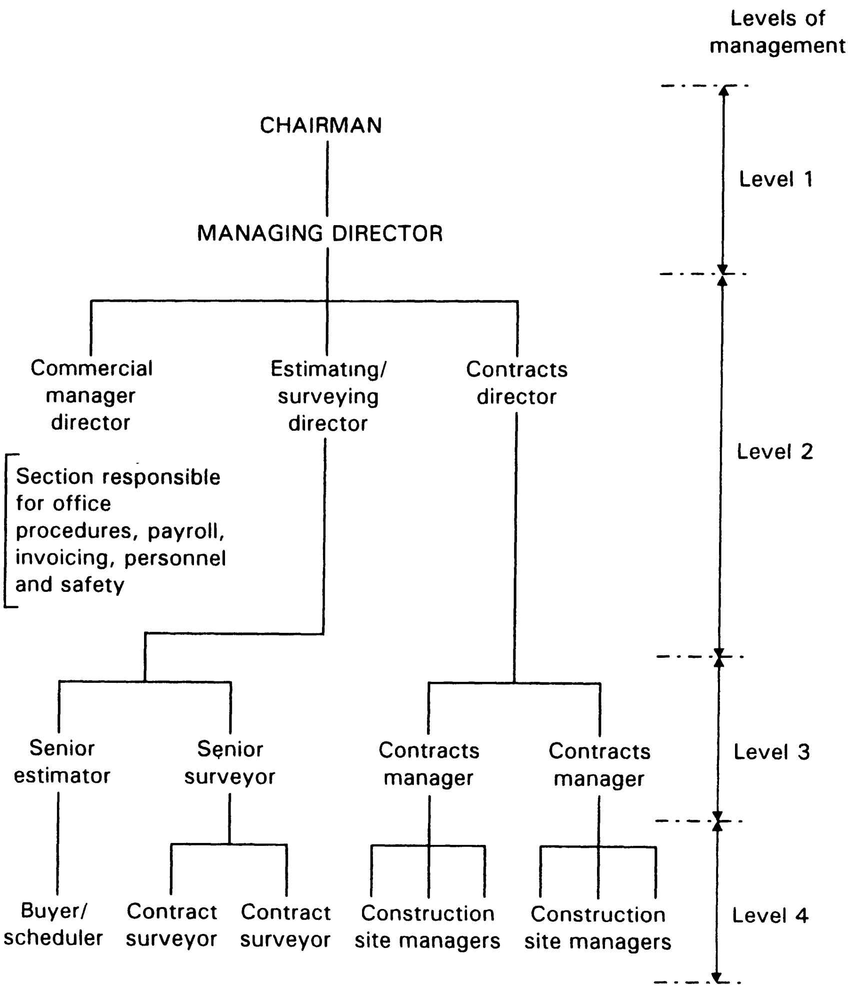


Figure 2.6

CASE STUDY - 'MEDIUM' COMPANY B

PROJECT ORGANISATION

RESPONSIBILITY LIES WITH CONTRACTS DIVISION

SITES ARE SERVICED BY HEAD OFFICE - BUYING / SURVEYING

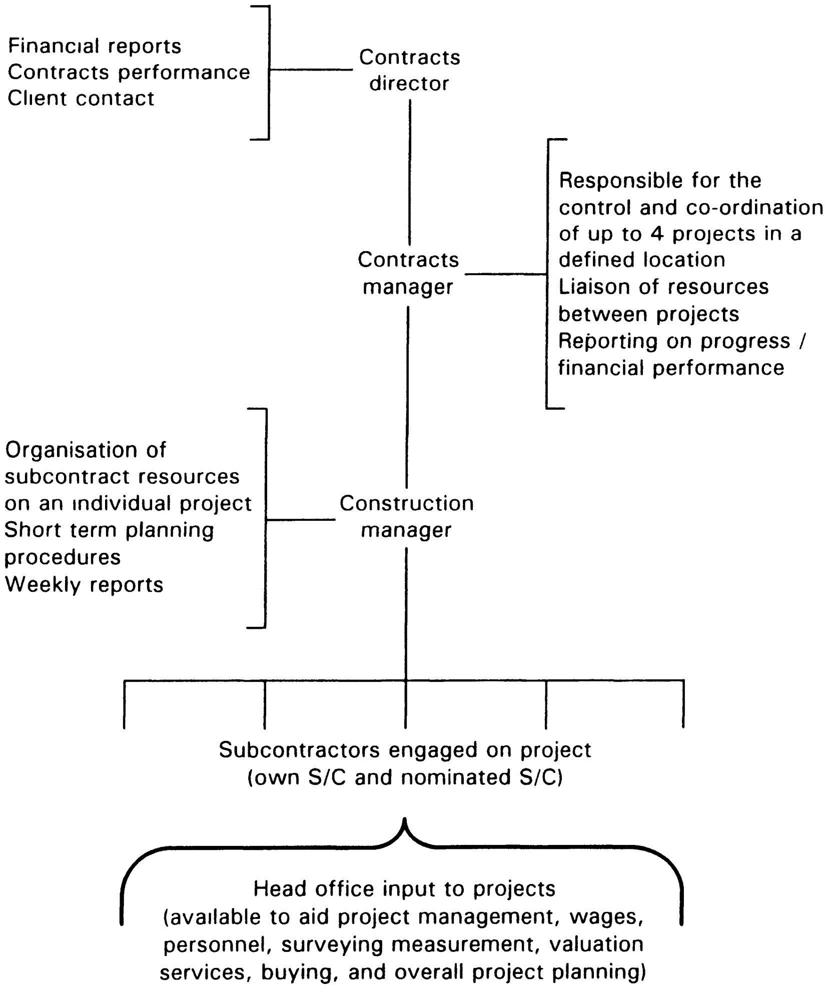


Figure 2.7

Figure 2.6 illustrates the current organisational structure with the business divided into three functional areas: estimating/surveying, contracts and office/ commercial management. Figure 2.7 indicates the approach taken to the organisation of a major project. This simply consists of a construction manager who manages subcontractors. Head office support services are provided as indicated.

The company is in a very competitive market and pricing risks are taken owing to the nature of their enquiries. In order to reduce the risk, the company is moving towards offering a design and build service based on the client's scheme drawings or in-house design services. The largest single project undertaken to date was valued at £2 to £2.5 million.

Business Control Procedures

Control of the various functions of the business is delegated to a team of directors who cover construction management, estimating and surveying. The company is very 'surveying' orientated due to the extensive amount of sub-contract work involved in the contracts. Cash flow is considered to be the life blood of the company. Emphasis is on the control of time and money. Strict guide rules have been established for reporting on the cost and value situation at monthly intervals on all projects and an effective cost/value reconciliation system has been established. This provides data on the performance of each contract in the short term and provides the degree of control and reporting for overview by the directors.

Programming and progress reviewing are the responsibility of the contracts manager. Short term planning and the co-ordination of sub-contractors are the responsibility of the construction manager. Strict control of subcontract orders is maintained by the link between the buyer and surveyors. Extensive pressure is applied to subcontractors in order to perform to programme. The success of projects relies largely upon sub-contractor coordination and control.

Good client contractor relationships are established early in the project by the appointment of a project director. This allows links between the client and contractor to be maintained at the top of the organisation and often leads to further negotiated contracts.

2.6 Control Procedures within Organisations

As companies change size there is a need to review control procedures. In the business context control procedures may be defined as the setting up of standards and then making regular comparisons of actual events with those standards and taking corrective action where necessary. Figure 2.8 illustrates these principles diagrammatically in the form of a control cycle. The application of the control process to progress reporting during a contract is illustrated in Figure 2.9. This illustrates the need for communication channels to be established between all levels of management.

Control mechanisms which may be considered in a construction situation include:

Visual and personal checks – undertaken by a supervisor or site manager. The regular visits to a project by the principal of a small organisation is a means of applying control to a project. The principal gets the 'feel' that all is right, or it quickly becomes apparent that all is not well – call it management intuition, if you like.

Reporting procedures – the submission of regular reports during a project provides control information to management. This applies to weekly site reports on progress and monthly cost/value reports on the profitability position. Monthly reports on progress and cash funding also aid management decision making . As companies change size there is a need to consider the value of internal reporting procedures.

Control by exception – this is a well established management principle. It enables management to consider only reporting on serious deviations otherwise, it is assumed that performance is up to standard. Management by exception saves management time in analysing irrelevant reports and unnecessary data.

Control policy and the establishment of the necessary information in order to control the business must be established by senior management. The management must lay down policy statements in order to establish standards for controlling finance, time and quality. Control systems may be established for reporting on project performance and profitability. These will require strict monitoring and enforcement in order to succeed.

Figure 2.10 illustrates the principles of control applied to cost value reconciliation procedures applicable in a construction situation. This is held to be an essential control procedure in both the medium and large contracting organisation. The application of project control procedures is dealt with in Chapter 7.

CONTROL PRINCIPLES

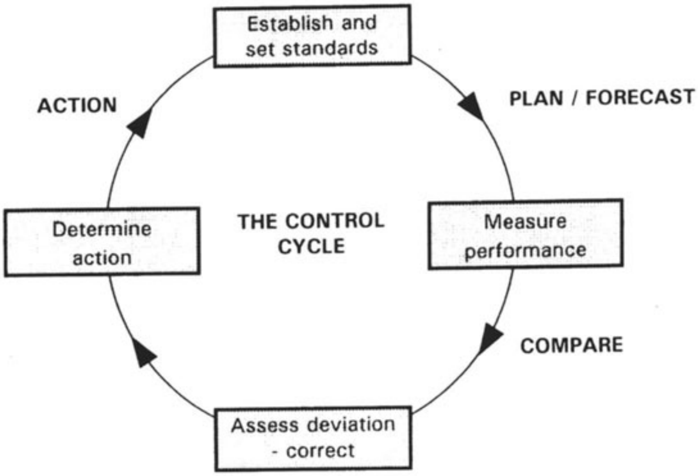


Figure 2.8

CONTROL APPLIED TO CHECKING DEVIATION FROM PROGRAMME

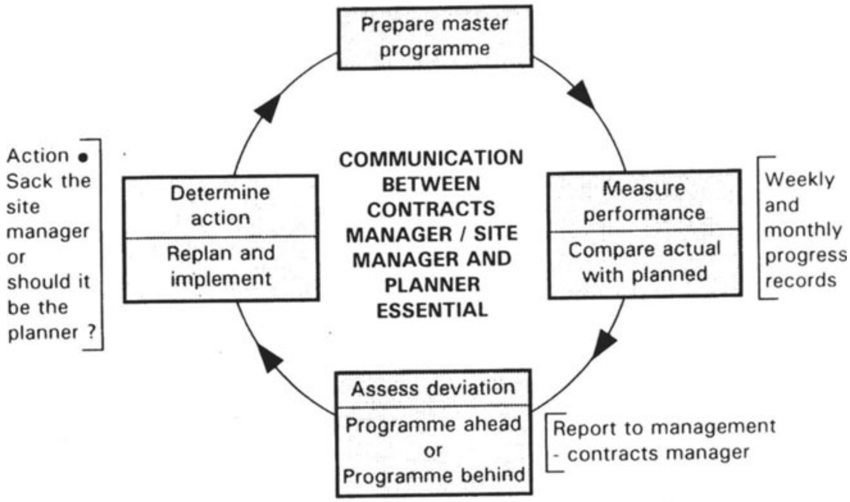


Figure 2.9

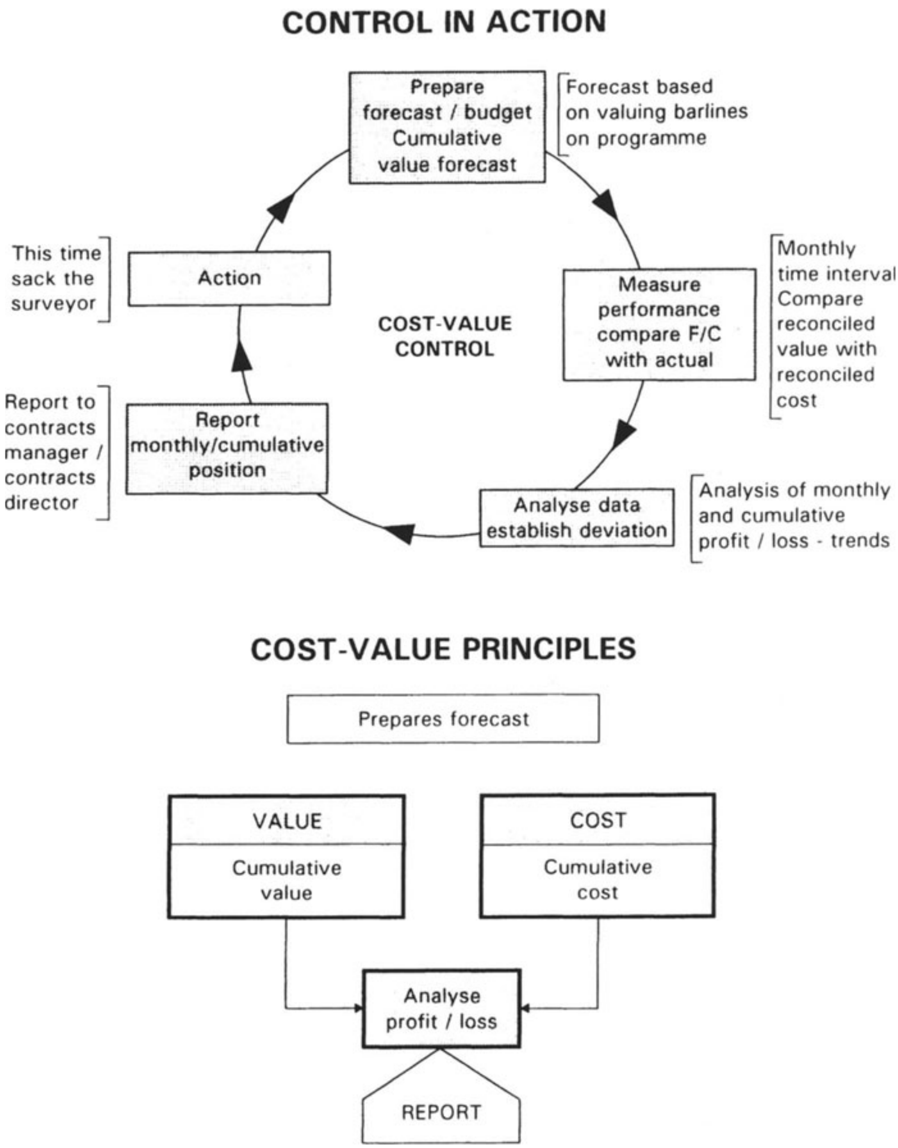

CONTROL IN ACTION
Prepare forecast / budget Cumulative value forecast
Forecast based on valuing barlines on programme
Measure performance compare F/C with actual
Monthly time interval Compare reconciled value with reconciled cost
COST-VALUE CONTROL
Analyse data establish deviation
Analysis of monthly and cumulative profit / loss - trends
Report monthly/cumulative position
Report to contracts manager / contracts director
Action
This time sack the surveyor
COST-VALUE PRINCIPLES
Prepares forecast
VALUE
Cumulative value
COST
Cumulative cost
Analyse profit / loss
REPORT

Figure 2.10

2.7 Structure of the 'Large' Firm

The large contracting organisation has developed from expansion of the medium sized firm. The business may be managed from a single head office or may be regionalised in order to serve better its customers' needs. The functional approach to the management of the business will now have been expanded to form service departments, or divisions, i.e.

Estimating	Surveying	Planning	Contracts
Plant	Personnel	Administration	

Each division may be managed by a director or, if regional, by a regional director. Figure 2.11 illustrates a large company divided into four company divisions responsible for construction activity. Figure 2.12 indicates the approach taken in the management of construction projects within the division. Head office is responsible for providing services to all projects in the form of office administration, estimating, surveying, project planning, safety and marketing.

Figure 2.13 indicates an arrangement for the management of a regional office for a major contractor. There may however appear to be 'too many more chiefs than indians' in this situation, but decisions have to be made on how the region is to be best managed.

Figure 2.14 illustrates the overall site management structure for a £9.2 million management contract during the refurbishment of an inner city department store. The project involves both new work and refurbishment work while the store remains open for business. Figure 2.15 illustrates the organisation of the construction activity during the undertaking of the works on site.

LARGE COMPANY - CONSTRUCTION DIVISIONS

ORGANISATION STRUCTURE

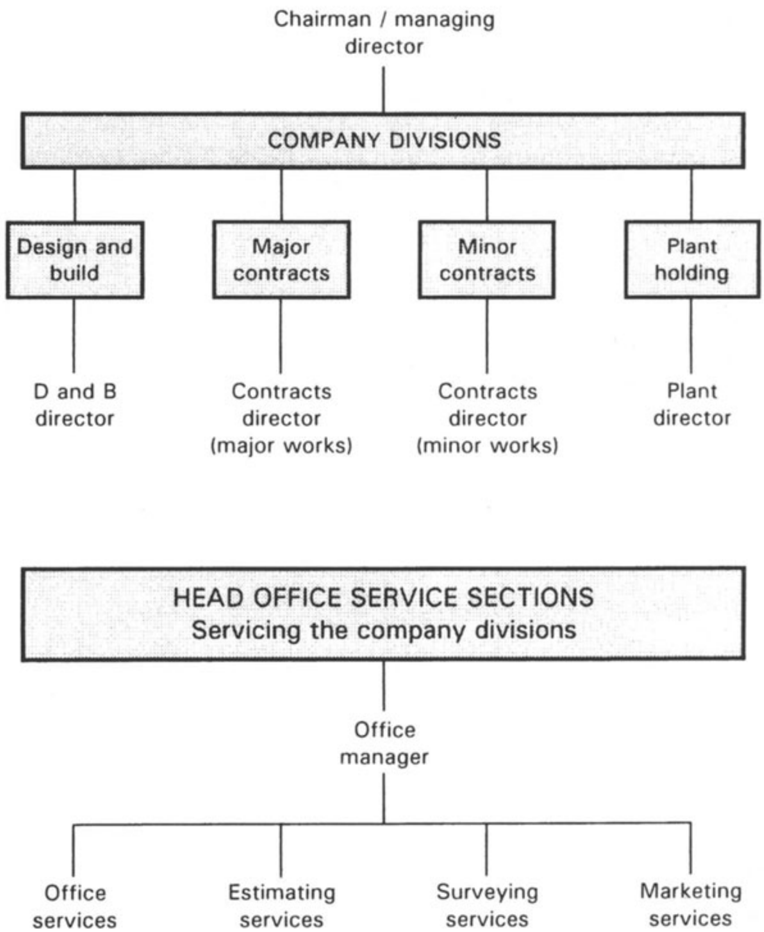
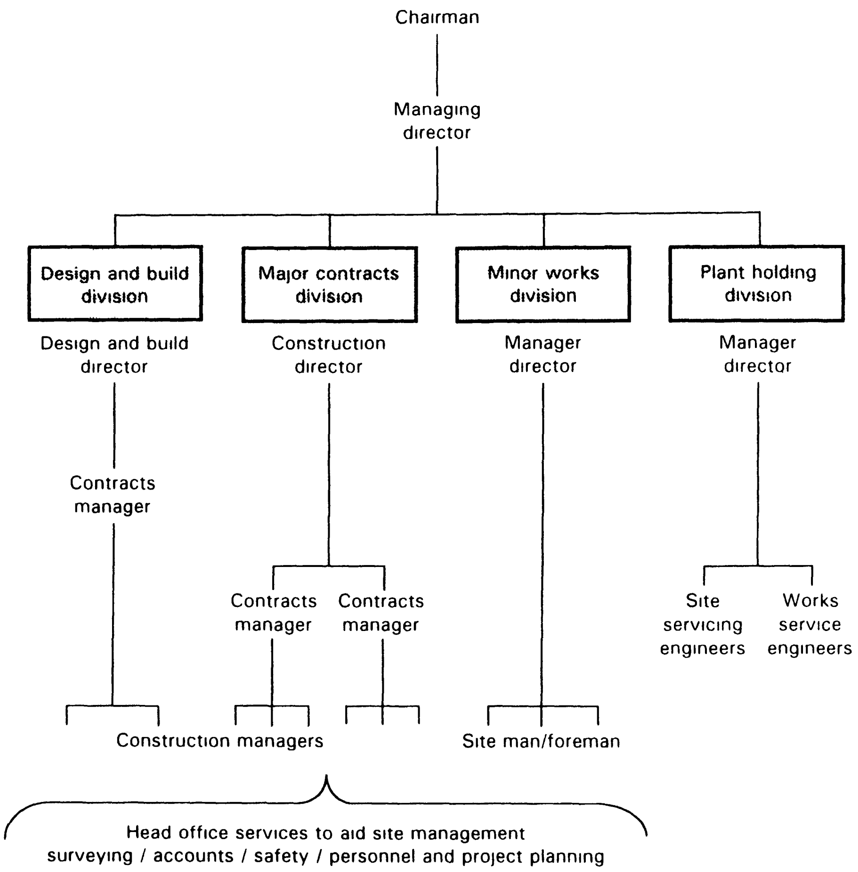


Figure 2.11



ORGANISATION OF CONSTRUCTION ACTIVITIES IN A LARGE COMPANY

Figure 2 12

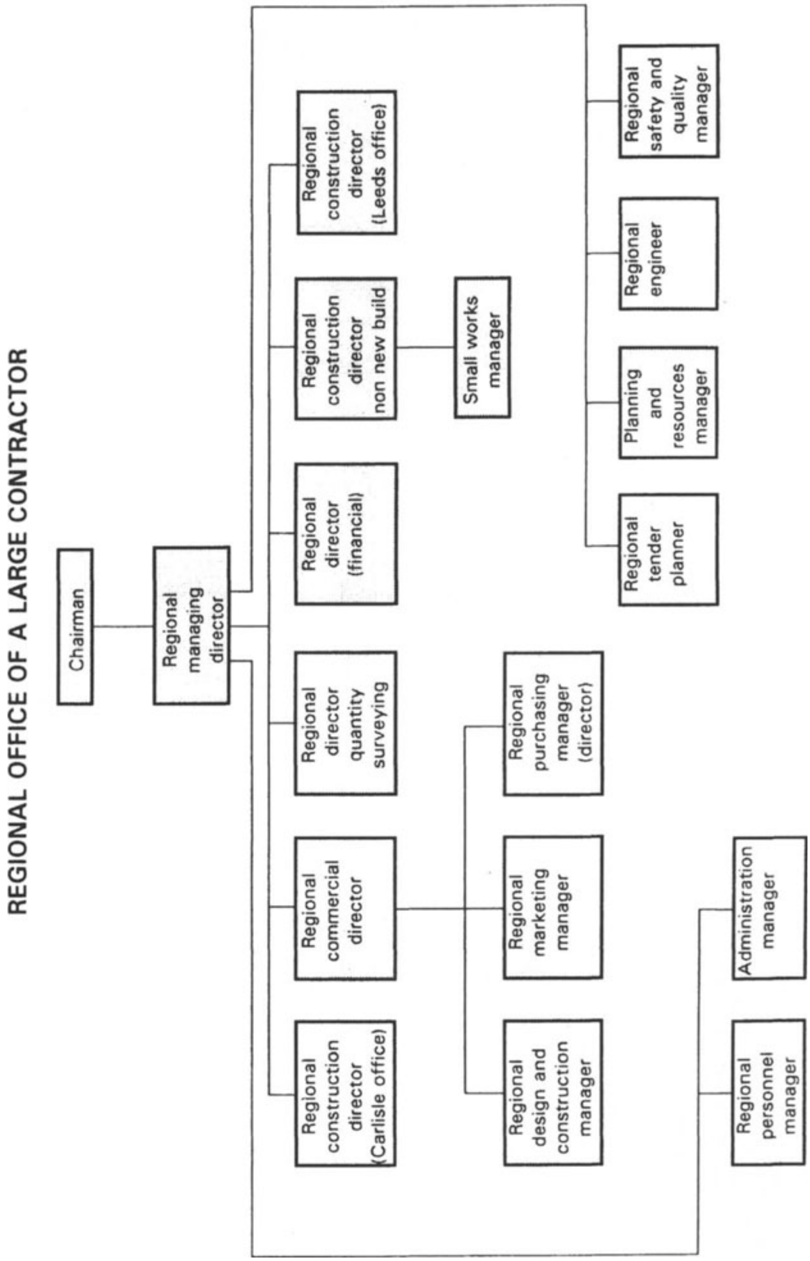
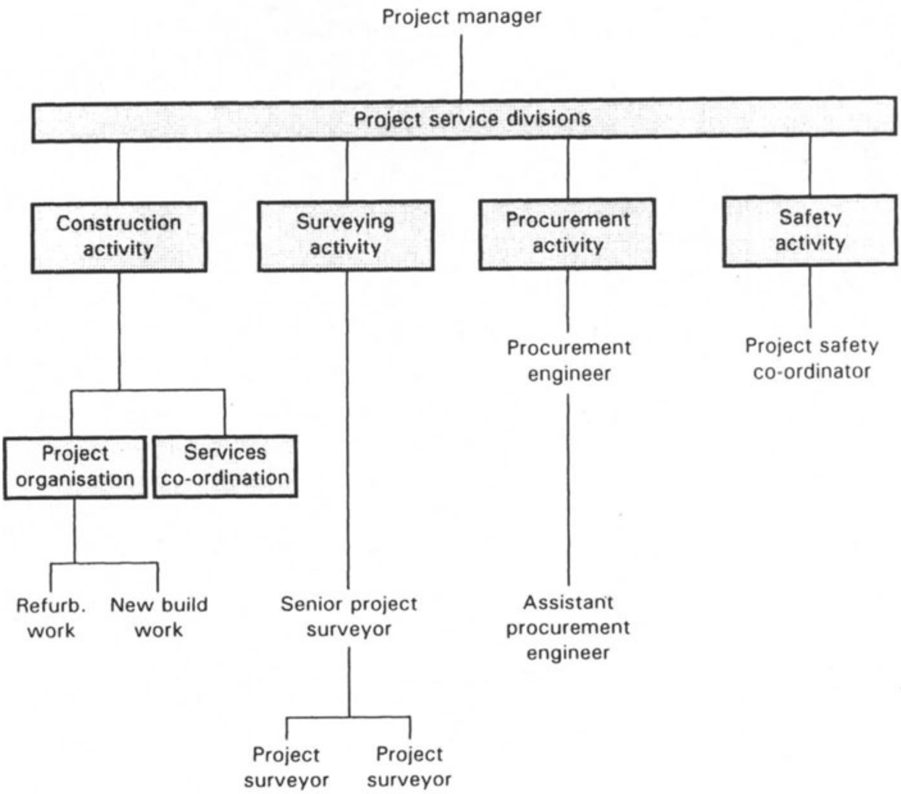

REGIONAL OFFICE OF A LARGE CONTRACTOR
Chairman
Regional managing director
Regional construction director (Carlisle office)
Regional commercial director
Regional director quantity surveying
Regional director (financial)
Regional construction director non new build
Regional construction director (Leeds office)
Small works manager
Regional design and construction manager
Regional marketing manager
Regional purchasing manager (director)
Regional tender planner
Planning and resources manager
Regional engineer
Regional safety and quality manager
Regional personnel manager
Administration manager

Figure 2 13

SITE ORGANISATION - MAJOR PROJECT

OVERALL SITE MANAGEMENT STRUCTURE (management project) - £9.2m Value



OVERALL ORGANISATION STRUCTURE

Figure 2.14

SITE ORGANISATION STRUCTURE FOR A REFURBISHMENT CONTRACT (Value £9.2m)

MANAGEMENT CONTRACT ARRANGEMENT

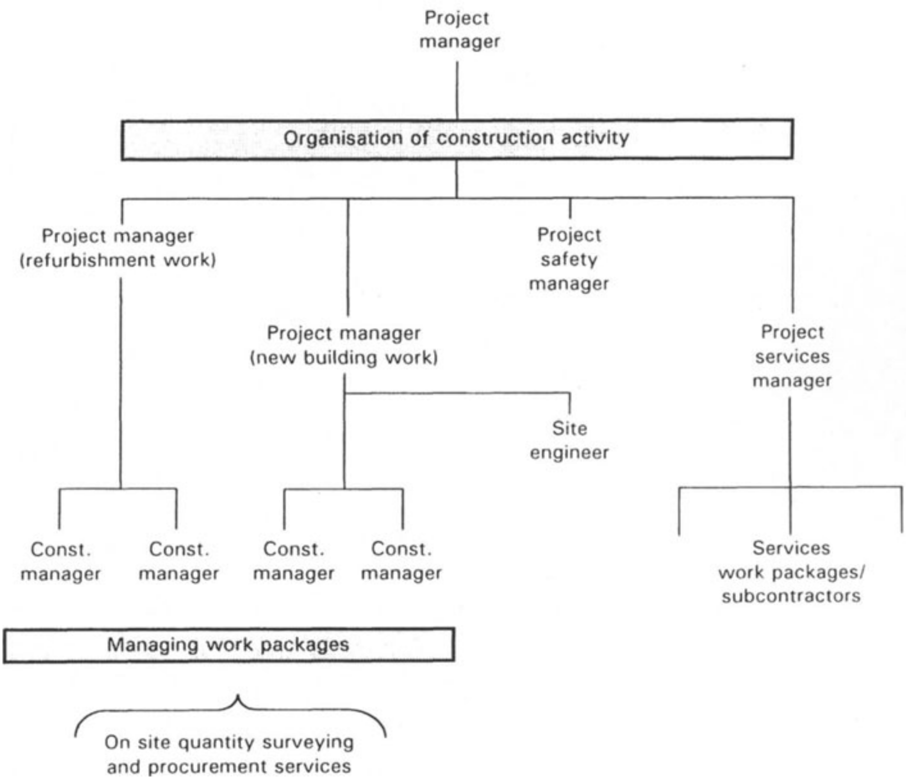


Figure 2.15

2.7.1 Business Profile of 'Large' Company C

Background Information to Company

The company was started in the early 1960s by the current chairman. In the early years, the objective was to develop a reputation as a quality housebuilder within the North West region. By the mid 1970s this goal had been achieved, and in 1974 the company was incorporated as a private limited company. The business then diversified into small commercial office developments in order to provide a sound financial base for the future. At this stage a group holding company was established. Decisions regarding business diversification have led to further business success.

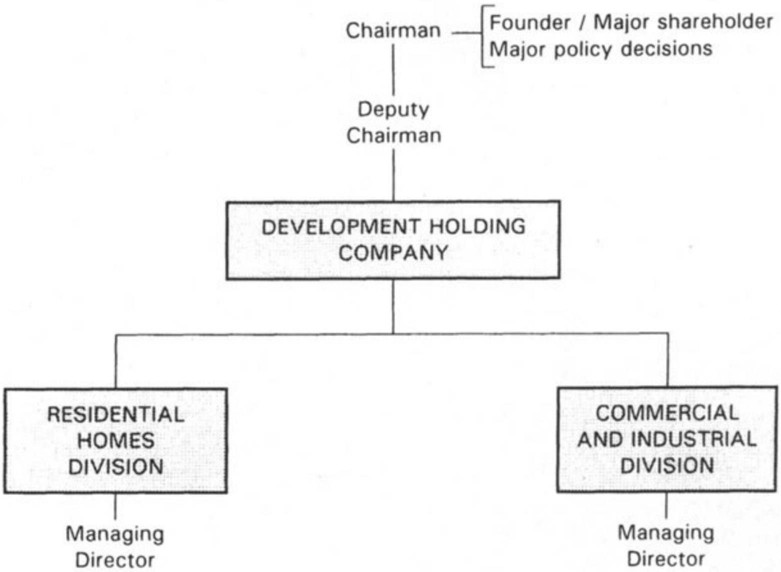
As further expansion took place, more ambitious commercial develop-ments were taken on board. Development work now included shopping precincts, science parks and up-market commercial office projects. In the 1980s a range of villa developments were undertaken overseas in Spain, Portugal and the USA and the company currently (1995) has a turnover of some £3 million from these projects. Further diversification has also been made into the retirement homes market. Figure 2.16 illustrates the overall company structure and key information from the 1995 accounts.

In 1995 the group turnover approximated to some £56 million, with profits in the region of £5 million. Development work is equally divided between its residential and commercial divisions. In the 1995 accounts the company had fixed assets of £229 million, and net assets of some £98 million. The founder's family currently holds 99% of the share issue.

The group employs about 385 staff (including approximately 40 construction managers). The policy is to employ labour only and domestic subcontractors, some of which have been with the company since the mid 1970s. As the group has grown, so have the subcontractors. Figure 2.17 illustrates the organisation structure of the residential homes division of the company's activities.

The homes division is currently undertaking a refurbishment project on a disused Victorian hospital. This involves refurbishing existing three and four storey blocks into luxury flats. Many Victorian features are being retained, including coved plasterwork to ceilings, shuttered windows and the recovery of pine doors and floors. The project value is approximately £10 million over a three-year period. It is a credit to such companies to take an interest in restoring part of our Victorian heritage by bringing such building back into use for many people to enjoy.

CASE STUDY - 'LARGE' COMPANY C



OVERALL COMPANY STRUCTURE

COMPANY PROFILE 1995

Group Turnover	£56M	Homes Division	£ 27M
Home (UK)	£53M	Commercial Division	£ 26M
Europe	£ 1M	Others	£ 3M
USA	£ 3M		
Profit (after tax)	£ 5M	Fixed Assets	£229M
		Net Assets	£ 98M

Shares Issued 24,000
99% Held by family

Figure 2.16

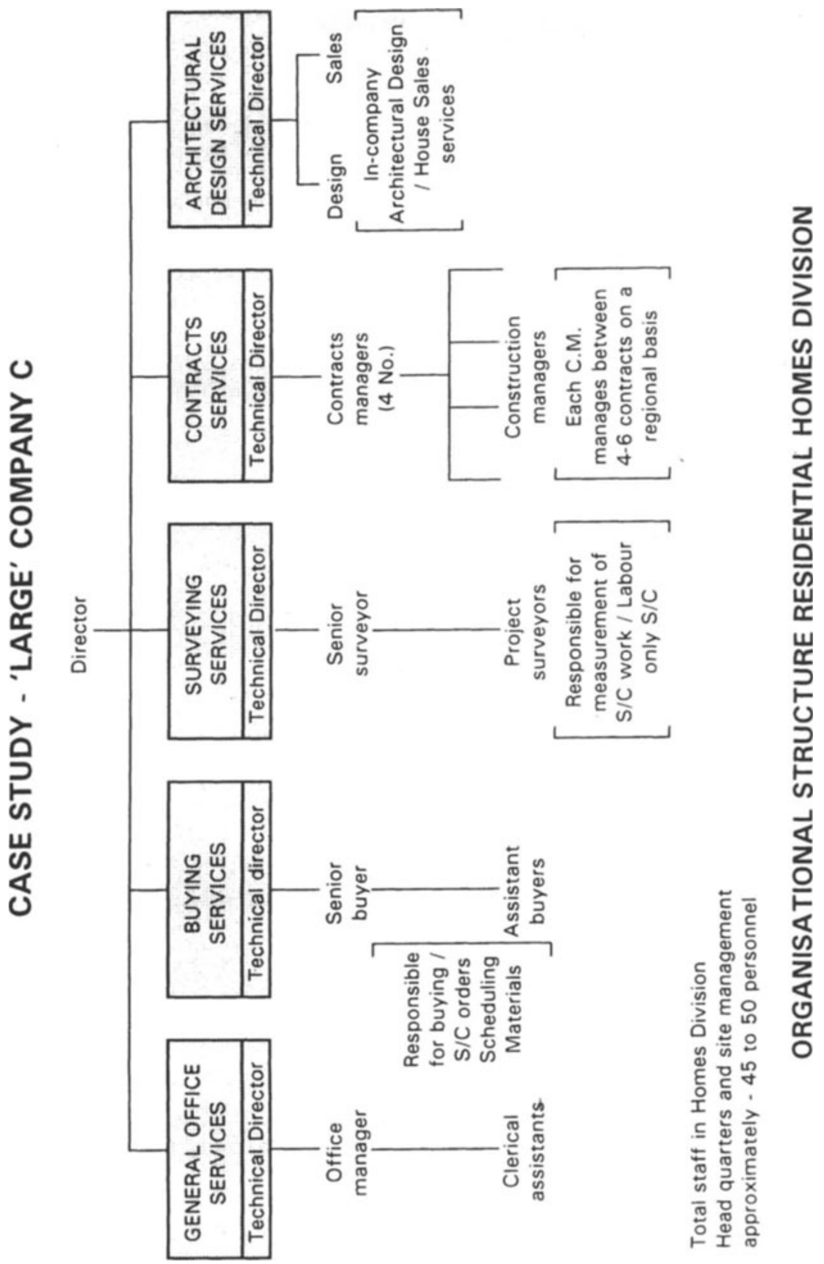

CASE STUDY - 'LARGE' COMPANY C
Director
GENERAL OFFICE SERVICES
Technical Director
BUYING SERVICES
Technical director
SURVEYING SERVICES
Technical Director
CONTRACTS SERVICES
Technical Director
ARCHITECTURAL DESIGN SERVICES
Technical Director
Office manager
Clerical assistants
Senior buyer
Assistant buyers
Responsible for buying / S/C orders Scheduling Materials
Senior surveyor
Project surveyors
Responsible for measurement of S/C work / Labour only S/C
Contracts managers (4 No.)
Construction managers
Each C.M. manages between 4-6 contracts on a regional basis
Design
Sales
In-company Architectural Design / House Sales services
Total staff in Homes Division
Head quarters and site management
approximately - 45 to 50 personnel
ORGANISATIONAL STRUCTURE RESIDENTIAL HOMES DIVISION

Figure 2.17

Comments on Business Strategy and Decision Making

Decisions taken to diversify the range of business activities in the 1980s has certainly brought long term financial returns. Diversification into markets closely linked to the core business have proved successful. This has included such markets as retirement homes, commercial and industrial business parks, as well as overseas residential and villa development projects. The company also support a travel company to service their own holiday developments. Future proposals include establishing a joint venture project with a major tour operator to build a villa holiday complex in the USA.

References

1. Drucker P F, *The Practice of Management*, Butterworth-Heinemann, 1989
2. Clutterbuck D and Goldsmith W, *The Winning Streak*, Weidenfeld & Nicholson, London, 1984
3. Dixon R, *Management Theory & Practice*, Management Made Simple Series, Butterworth-Heinemann, 1991
4. Hodgetts R M, *Management: Theory, Process and Practice*, 3rd Edition, Holt-Saunders International Editions, 1982

3 The Planning Process

3.1 Overview

Directors and managers of all construction organisations, whether large, medium and small, are faced with the same problems and decisions at the tender stage, pre-contract stage and contract stage, whatever they are building. Consequently, the planning process follows a similar pattern within each size of company. Procedures however tend to be more formal within the larger organisations as there is a greater need to record decisions.

No two companies undertake exactly the same procedures but the various stages of planning will be much the same whatever the size of business. For convenience, the planning process may be thought of as three distinct stages:

- Pre-tender planning The planning considerations during the preparation of an estimate and its conversion into a commercial bid.

- Pre-contract planning What happens now that we have been awarded the project? It is essential that planning takes place prior to commencing work on the site.

- Contract planning The planning which is required to be implemented in order to maintain control and ensure that the project is completed on time and within the cost limits established at the tender stage.

Figure 3.1 indicates the relationships between these stages and a checklist approach is suggested for each stage to illustrate what needs to be considered. The considerations suggested in Figure 3.1 are those generally undertaken by both medium and large contractors but are equally valid for small contractors as well.

3.1.1 The Reasons for Planning

- To aid **contract control**
- To establish realistic **standards**
- To monitor **performance** in terms of output, time and money
- To keep the plan under **constant review** and take **action** when necessary to correct the situation.

Consideration of the **control cycle** as outlined in Figure 2.9 is an essential requirement of a good planning strategy.

PRE-TENDER PLANNING

- Decision to tender
- Pre-tender arrangements
- Site visit report
- Enq. to subcontractors and suppliers
- Tender method statement
- Build up estimate
- Pre-tender programme
- Build up preliminaries
- Response to pre-tender Health and Safety Plan
- Management adjudication
- Analysis of tender performance

PRE-CONTRACT PLANNING

- Pre-contract meeting and arrangements for commencing work
- Place subcontractor orders
- Site layout planning
- Construction method statement
- Master programme
- Requirement schedules
- Contract budget forecasts
- Preparation and approval of Construction and Health and Safety Plan

CONTRACT PLANNING

- Monthly planning (long term)
- Weekly planning short term
- Progress reporting
- Report to management
- Review/updating of Health and Safety Plan

OVERVIEW OF PLANNING PROCESS

Figure 3.1

3.1.2 Reasons for Pre-tender Planning

- To establish a realistic **contract period** on which the tender may be based
- To identify **construction methods**
- To access **method related** items which affect the bid price
- To aid the build up of **contract preliminaries** and **plant** expenditure
- To aid the **tendering process**

3.1.3 Reasons for Pre-contract Planning

- To provide a broad **outline plan** or **strategy** for the project
- To comply with **contract conditions**
- To establish a **construction sequence** on which the Master Programme may be based
- To identify **key project dates**
- To highlight **key information requirements**
- To enable the assessment of **constract budgets** and **cumulative value** forecasts
- To schedule **key dates** with respect to key material and subcontractor requirements

3.1.4 Reasons for Contract Planning

- To monitor the Master Programme – monthly , weekly and daily
- To **optimise** and review **resources**
- To keep the project under **review** and report on **variances**

3.2 Establishing Contract Leads

3.2.1 A Marketing Approach

All construction firms need to develop contacts in order to secure opportunities to tender for work or to be 'in the right place at the right time' when the chance to negotiate contracts presents itself.

It is a fact of life that the opportunity to tender for a factory extension for Acme Widgets is more likely to arise in the private boxes at Old Trafford or the Cheltenham Festival than in a back street public house bar!

Within the medium and large size companies however, a formalised 'marketing' approach is common so that contract 'leads' can be developed strategically at as early a stage as possible so as not to miss potential opportunities to be considered for inclusion on the final tender list.

Tendering costs money, perhaps 0.5-1% of turnover; therefore contractors cannot afford to tender for contracts 'willy-nilly' without any thought as to the risk and profit potential involved or whether the type of work or contractual arrangements are suitable.

It is clearly important then for the contractor to be on the tender lists for jobs that he is keen to win and not to waste time and money tendering or taking 'cover prices' for unattractive contracts. Indeed, a more selective tendering strategy may increase the contractor's tender success rate from say 1 in 8 bids to 1 in 6 or better.

3.2.2 Public Sector Projects

In the public sector, major construction works or supply contracts are advertised in the *Official Journal of the European Communities*. This publication covers tendering opportunities over £300 000 in the public and government sectors for projects such as motorways, hospitals, community buildings and projects involving European funding.

These advertisements follow a standard procedure and public works projects and supply contracts are notified in the local language under standard headings. A typical tender opportunity for a hospital project in Sunderland would include the following list of information:

- Awarding authority
- Award procedure and contract type
- Site location and design information available
- Completion deadline
- Legal arrangements for joint venture or consortia bidders
- Deadline, address and language for submitting tender list applications
- Final date for dispatch of tender invitations
- Deposits, bonds or guarantees required
- Financing and payment (e.g. monthly payment against invoice)
- Qualifications such as past experience, technical expertise and financial stability
- Award criteria (e.g. price, technical merit, quality, value for money)
- Variants, which would include permissibility of tender qualifications or alternative bids
- Other information about the project in hand
- Various official dates and notices

Owing to the extensive numbers of advertisements and the language difficulty, most contractors use the services of the local Euro Information Centre or perhaps a firm of contract leads consultants in order to find out what is happening in the market place.

A selective approach to following up potential leads can be undertaken through these sources based on searches using say five preferred criteria.

For example:

- project type
- project size
- contractual arrangements
- form of contract and contract terms
- location

3.2.3 Private Sector Projects

Contract leads may also be obtained from other sources:

- local authority planning applications
- planning committee meetings
- minutes of local authority meetings
- public press announcements
- trade journals and magazines
- trades representatives (they are often 'in-the-know')
- keeping your eyes and ears open

Whatever the source, a lead can take a considerable time to come to fruition. For instance, an average contract lead can take 10 months to track from an initial planning application to inclusion on the tender list.

3.3 Tender Pre-qualifications

More often than not these days, contractors are required to undergo some form of pre-qualification in order to be selected for inclusion on a tender list.

Traditionally this has taken the form of a questionnaire asking for details about:

- the company
- completed contract record
- technical expertise
- plant and labour resources
- financial accounts
- references from previous clients, bankers and the trade, e.g. suppliers and merchants.

Pre-qualification procedures, however, tend to be more sophisticated nowadays and much more emphasis is placed on quality, health and safety and the company's attitude to claims. As well as the general information above, pre-qualification may also involve submitting a company video, attending for interview or making a formal presentation.

Many companies produce formal pre-qualification documents or brochures, the typical contents of which might be:

- company organisation and structure
- regional/national/international offices
- key statistics e.g. registered office, bankers, capital structure, annual turnover, profit progression, 5-year summary of accounts
- the past 3-years audited annual accounts
- current projects
- relevant completed projects
- special expertise or experience
- résumé's of key personnel
- project organisation structures and management approach
- typical outline method statement
- typical outline programme
- cost planning approach for management or target contracts
- details of insurances
- evidence of quality assurance certification
- health and safety policy and safety record statistics

Company brochures can be produced impressively and professionally 'in-house' by making use of modern computer software such as desk-top publishing packages and photo-image software for presenting completed projects in colour. Project management software such as Power Project can be used to present typical contract programmes in colour format.

An average cost in the order of £500 per brochure is a relatively small investment for the opportunity to be included on a tender list for a £8 million warehouse project.

3.4 Pre-tender Planning

3.4.1 Procedures

The procedures outlined are those which are undertaken within the larger type construction organisation and those companies who have developed a structured approach to the tendering process.

The contractor will have to consider the following stages during the preparation of his estimate and the assessment of a commercial competitive bid.

- Decision to tender
- Pre-tender arrangements
- Site visit report
- Enquiries to subcontractors and suppliers

- Tender method statement
- Build up of the estimate
- Assessment of the pre-tender programme
- Build up of contract preliminaries
  Response to the pre-tender health and safety plan
- Management adjudication of the estimate
- Analysis of the tender performance

The Chartered Institute of Building, Code of Estimating Practice (1996)[1] provides an authoritative guide to good practice in estimating for building works from prediction to the acceptance of a successful tender. The Code distinguishes between estimating and tendering. It indicates that estimating is the process of predicting the costs of construction, while tendering is a separate commercial function based on the conversion of the net cost estimate into a competitive bid based on management decisions at the adjudication stage.

The Code of Practice contains many interesting and practice-based proformas which the contractor may consider using at the various stages of the estimate preparation. A series of flow charts is used to illustrate clearly the various stages of the estimating process.

A range of informative references is available, which will be of interest to estimators, including those by Brooke (1993)[2], Smith (1995)[3], Bentley (1987)[4] and those published in CIOB Construction Papers (various dates)[5].

3.4.2 The Decision to Tender

The decision to tender needs to be carefully considered by the contractor as 'tendering costs money'. Tendering costs can be in excess of 0.5% of turnover and therefore an enquiry for a £500 000 contract may cost the contractor in the order of £2 500. Contractors' head office overheads vary of course, but can be as low as 3-5% in a large company and thus tendering costs represent a considerable proportion of the total. However, without this overhead expense the contractor cannot win any work.

Tendering for design and build projects will cost the contractor rather more, generally in the order of 2-3%. For this reason contractors normally take a more selective approach for this type of project, but usually the tender list is shorter than for traditional contracts. The theory works when work is plentiful but when work is scarce the theory goes out of the window.

Checklist relating to the 'decision to tender'

The following factors will influence tendering policy in general as well as specific factors which may be due to market conditions:

1) General tendering policy
   Is it our kind of work – does it fit into our strategic plan?
   Current workload in both the contracts division and estimating section.
   Do we have the resources in both financial and management terms to undertake the work?

2) Working capital available to fund the project – effect on company financial resources.
   To fund a £ 500 000 project will need approximately 15-20% of the monetary value at the peak funding month (say £100 000-£150 000).

3) Availability of resources in respect of management personnel, labour, plant, and subcontractor resources. The resources of individual sub-contractors will also require consideration.

4) Contract location – Is it within the working radius of our trading operations?
   A contract located some miles from head office will often create management and control problems.

5) The size, type of work and monetary value of the project will need consideration.
   Contractors often take on contracts which are too big for them. This can result in placing years of planning and sustained growth at risk. The inherent risk in the contract failing to make adequate returns and the consequential risk and effect on the viability of the business needs consideration.
   A contractor with an annual turnover of £10 million may make a decision to undertake a £4 million contract. If the project fails to meet its projected returns or runs into a loss situation, then this one contract may place the whole business at risk.
   How many times has this factor resulted in the liquidation of a vibrant businesses?
   The contractor should consider his company's performance on similar types of work undertaken in the past.

6) Extent or value of the contractor's work in relation to that of the subcontract element of the project.
   The main contractor may simply find himself managing subcontractors. There may be very little profit in the subcontractor element and hence more risk is placed upon the main contractor.

7) Degree of competition – The number of other contractors invited to tender. It is in the contractor's interest to establish who he is tendering against. This may be considered an essential part of the contractor's marketing strategy, although some may consider this rather dubious. Why does he need this information? Perhaps he wishes to 'take a cover'.A cover price is a tender offer based on a price received from a competing contractor – ensuring that while submitting a bone fide tender, this will not be successful. This practice contravenes collusive tendering restrictions. The contractor may readily obtain details of his competitors by making contact with material suppliers or specialist subcontractors listed in the contract documents. Surely these procedures are frowned upon, or perhaps all is fair in love and contracting!

8) Consideration of the tendering period – Recommendations are indicated in the NJCC Code of Procedure for Selective Tendering, which indicates a period of between four to six weeks for contracts of £500 000 value.

9) Terms and conditions of contract. Consideration should be given to:
The form of contract to be used.
Any amendments to the standard form.
The contract period stated in the documents.
Extent of liquidated and ascertained damages.
Retention applicable.
Defects liability period.
Extent and provision of any bonds or specific insurance requirements.
Payment conditions and terms.
The quality and accuracy of tender documentation will reflect the degree of contractual risk evident in the contract. Poor tender documentation is often a sign of impending problems and potential claims. In many drawings and specification projects, responsibility is placed on the contractor to assess quantities and undertake some design input which may ultimately be reflected in higher prices.

10) The contractor's previous experience of working with the client, architect and other members of the design team. The financial standing of the client may need to be established. The contractor tendering may previously have had difficult experiences with one of the client's design team and may wish to allow for this contingency.

11) Market factors - these include consideration of:
General market conditions in relation to the availability of work.
Bank interest rates and borrowing facility.
Government policy and its effect on the construction sector.

'Feelgood factor' in the business economy.

The decision to tender is the responsibility of senior management. In order to aid this decision, project particulars may be set out on a Preliminary/Tender Enquiry Form as illustrated in the Code of Estimating Practice (1996).

3.4.3 Pre-tender Arrangements

When the contractor has decided to submit a tender, the estimating, buying and construction team will need to be motivated into action. A number of head office personnel will be involved in assisting with the tendering process in order to ensure that the bid is submitted on time. Figure 3.2 illustrates a programme of tender activities highlighting key dates when sections of the estimate must be complete. This may be presented as a pre-tender check list or in bar chart format. Figure 3.3 illustrates the organisation structure of a typical medium sized contracting organisation with responsibilities allocated to those involved in the tender preparation. As previously indicated, no two companies adopt the same procedures at tender stage. Tendering procedures are very much *ad hoc* in order to meet the companies' needs.

Delegation of responsibility for the estimate and tender preparation:

Estimator
- to deal with the management and pricing of the bills of quantities
- to deal with subcontract and material price enquiries when there is no company buyer available

Contracts Manager
- to arrange to visit the site with the Estimator
- to prepare the site visit report
- to prepare the Method Statement and discuss it with the Estimator
- to prepare an assessment of the project plant requirements
- to advise the Estimator on the requirements of the contract preliminaries
- to prepare an assessment of the pre-tender programme – this would be undertaken in conjunction with the company planning engineer
- preparing an assessment of the project safety requirements in response to the Construction Design and Management Regulations
- to arrange to view the project drawings, if not included with the tender documentation

Company Planning Engineer
- preparation of an assessment of the pre-tender programme
- assistance in the assessment of the construction method statement

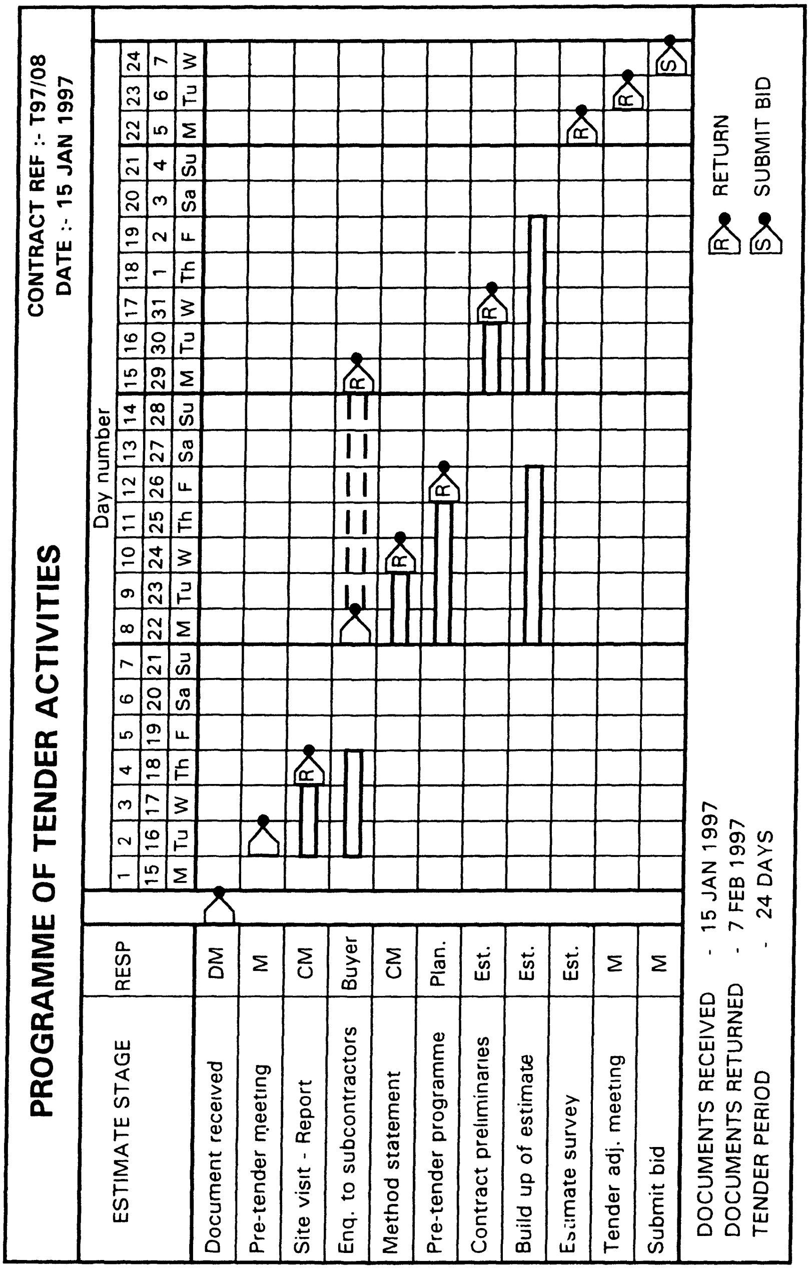
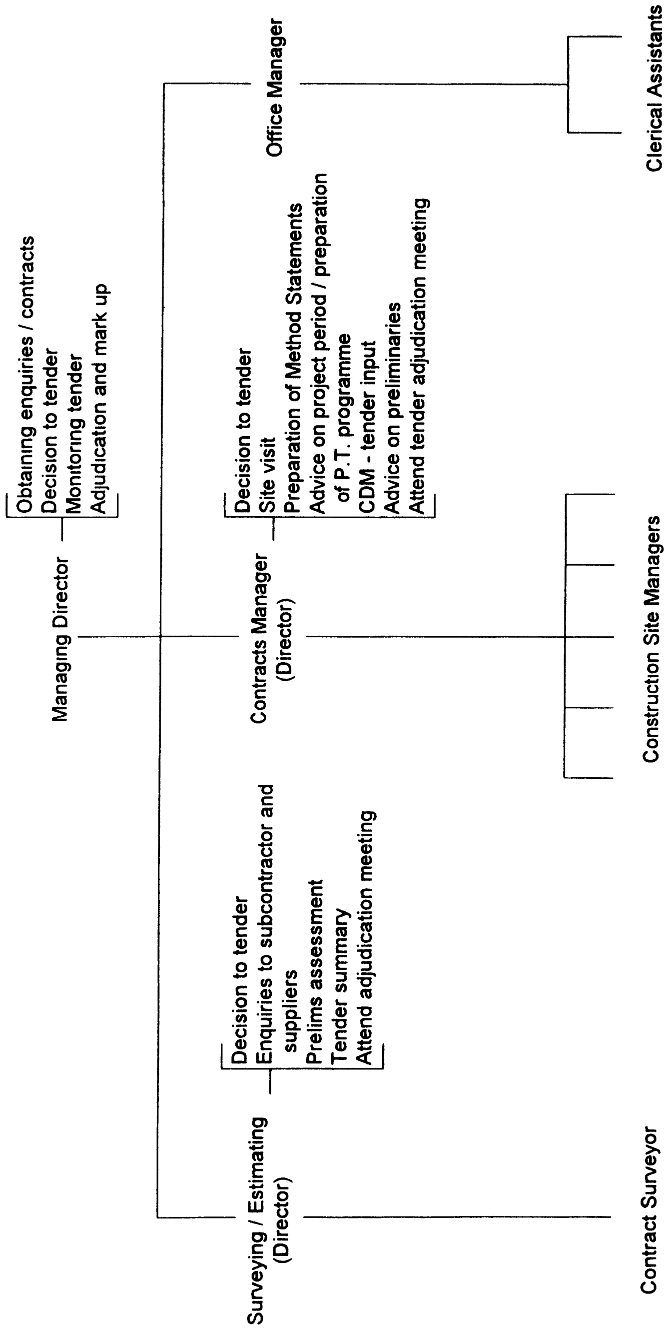

PROGRAMME OF TENDER ACTIVITIES
CONTRACT REF :- T97/08
DATE :- 15 JAN 1997
Day number
ESTIMATE STAGE
RESP
Document received DM
Pre-tender meeting M
Site visit - Report CM
Enq. to subcontractors Buyer
Method statement CM
Pre-tender programme Plan.
Contract preliminaries Est.
Build up of estimate Est.
Estimate survey Est.
Tender adj. meeting M
Submit bid M
DOCUMENTS RECEIVED - 15 JAN 1997
DOCUMENTS RETURNED - 7 FEB 1997
TENDER PERIOD - 24 DAYS
R RETURN
S SUBMIT BID

Figure 3.2



RESPONSIBILITIES FOR ESTIMATE / TENDER PREPARATION IN A MEDIUM SIZED CONTRACTING ORGANISATION

Figure 3.3

Senior Management

- responsible for overseeing all stages of the estimate
- liaison with the Contracts Manager with regard to major decisions
- chairing the tender adjudication meeting and taking all necessary decisions on mark up and profit additions

3.4.4 The Site Visit Report

It is usually a requirement of the contract preliminaries that the contractor must visit the site a tender stage and take account of the conditions thereon.

Site conditions will directly influence his bid price in respect of:

- Access to the works – effect on construction methods
- Site ground conditions and groundwater levels
- Access restrictions affecting the utilisation of plant
- Distance to local tips for the disposal of material
- Provision of site security
- Restrictions imposed by adjacent buildings and services

Many of the large construction firms make use of a standard site visit report pro forma, which acts as a checklist during the site visit, and ensures that essential data are not overlooked. A model site visit report is indicated in the Code of Estimating Practice (1996).

Checklist relating to the site visit report

Points to be noted when preparing a site visit report include:

1) Names of parties involved in the contract.

2) Particulars of local authorities and statutory undertakings – planning, building regulations and existing services locations, etc.

3) Nature of site/topography – flat/sloping/extent of bushes and trees, etc. Site location relative to adjacent roads, other contracts in the immediate area.

4) Extent of buildings to be demolished – site photographs assist in proving useful information when pricing.
   Consider recording the condition of buildings to be demolished on a digital camera.
   Location of and dangers from buildings adjacent to the works – this may influence the costs of temporary works and excavation methods.
   Details of any fly-tipped materials on site will need to be noted.

5) General ground conditions – site surface conditions, any adjacent excavations which may provide evidence of ground conditions and water table levels. Details of any watercourses crossing the site should be noted.

6) Facilities in area for the disposal of tipped material – distance to local tips and tipping charges. Identify the types of materials to be removed from the site, as these may influence disposal costs.

7) Evidence of existing services – water, electricity, drains, manholes, telegraph poles and overhead cables.

8) Possible site security requirements – provision of hoardings, site compounds and the need for the provision of containered materials on inner city sites.

9) Assessment of the labour situation in the area – availability of subcontractors. Telephone number and address of local Job Centre.

10) Availability of materials suppliers – local builders merchants, plant hire firms.

11) Site space requirements for the location of cranes, hard standings, materials storage and site parking for staff and operatives.

12) General site access conditions – low bridges affecting the movement of plant and equipment to site.

13) Specific site requirements for temporary works – access roads.

Site ground conditions and the effect on pricing temporary earth support needs careful consideration. This particular item may be treated as an item of contractual risk within the tender. Many a contractor has lost a project because of his inability to assess contractual risk carefully. Tenders are won on the items that the contractor does not price and simply puts down to contractor risk.

3.4.5 Enquiries to Subcontractors and Suppliers

Chapter 8 is specifically concerned with procedures for dealing with subcontractors at the tender stage on both traditional and design and build contracts. The Code of Estimating Practice (1996) indicates the information to be included in quotations to material suppliers.

3.4.6 The Tender Method Statement

The preparation of method statements now forms an essential requirement of the contractors procedures – especially since the introduction of the Construction Design and Management Regulations in 1994. Hazard and risk assessment at the tender stage forms an essential part of the tender scene.

Method statements may simply be categorised into three distinct formats:

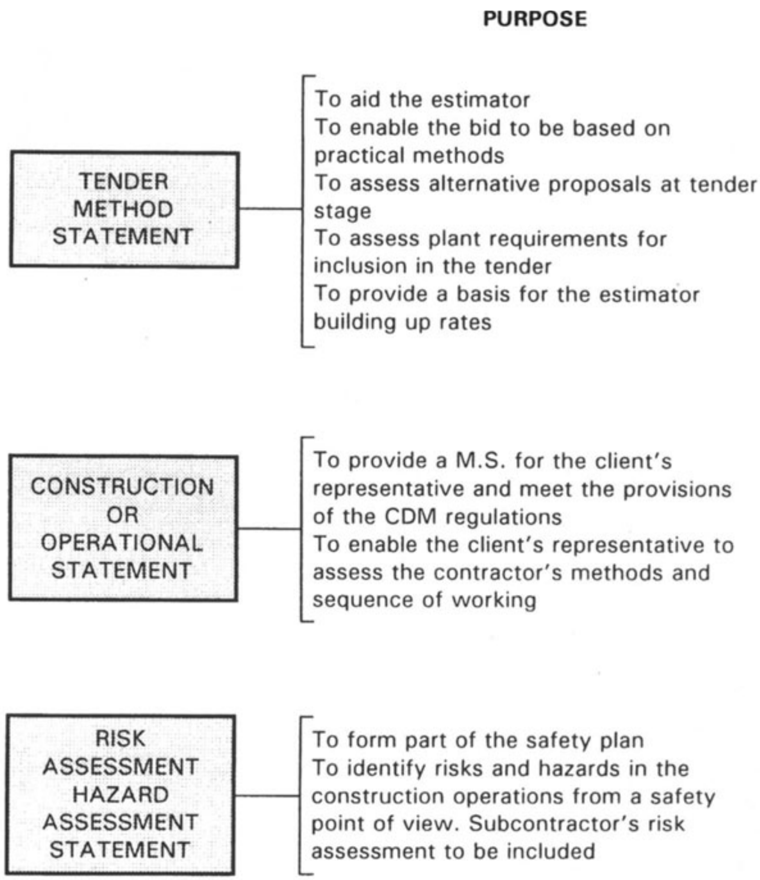
1) The Tender Method Statement
2) The Construction or Operational Method Statement
3) The Safety Method Statement which will include a Hazard Assessment Statement

Figure 3.4 indicates a summary of the objectives of each format. The method statement may be presented as a written statement or in tabular form. Illingworth (1993)[6] illustrates examples of the format used in the practice. It is essential that the purposes of method statements at the various stages of the planning process are understood. Method statements convey different meanings to clients, consultants, subcontractors and main contractors alike. A method statement is not simply a list of construction operations with notes written alongside.

3.4.7 The Purpose of the Tender Method Statement

The pre-tender method statement will outline the sequence and method of construction upon which the estimate is to be based. It should indicate how it is intended to deal with the major elements of work and highlight areas where new or alternative methods are being considered. The method statement should be supported by details of gang sizes, plant and supervision requirements as well as outputs data. Provision should also be made for temporary works requirements. The estimator or planner may be required to assess the costs of any alternative proposals. The main purpose of the pre-tender method statement is to allow ideas developed by those ultimately responsible for undertaking the work to have some practical input at the estimate stage

The pre-tender method statement is usually prepared by the contracts manager in the medium sized contracting. Within the large company however input is also available from the planning section.



OVERVIEW OF METHOD STATEMENT FORMATS

Figure 3.4

3.4.8 Tender Method Statement for Concrete Floors

Factory Refurbishment Project - Project Brief

A subcontractor has received an enquiry to undertake the concreting operations to six floors of a Victorian factory building. Concrete is to be laid 100 mm in thickness and each floor is 500 m^2 in area. Access to each floor is to be via a central goods lift. Alternative proposals for placing the concrete may be considered.

The contracts manager for the subcontract firm prepares the method statement in order to advise the estimator of proposed methods for inclusion in the estimate.

The following points should be considered when preparing the tender method statement:

- a list of operations to be included in the statement
- consideration of available resources – labour gang size, plant and supervision
- approximate quantities, output rates- per gang, per day, etc.
- bay or pour sizes
- any reasoned alternatives

Tender Method Statement – Written Format

Operation Handle and place concrete in floor bays.

Option One Place concrete using Dumpers

Ready-mixed concrete supply to rear entrance of factory at ground floor level.
Discharge concrete into front discharge dumpers and transport to appropriate floor level via central goods lift.
Discharge concrete into floor bays and place by hand.
Tamp floor slab with timber tamping board and float off with patent steel levelling screeder to obtain required tolerances.
Concrete to be placed in 5 metre wide bays running full length of building. Alternate bay construction to be used. Floor surface to be covered with polythene to aid curing for a one day period.
Two bays per day to be poured.

Resources

Plant
3 Nr 1 cubic metre capacity dumpers
1 Nr 5 metre timber screed board
1 Nr steel levelling screed
1 Nr petrol vibrator

Labour
3 Nr dumper drivers
3 Nr labourers placing concrete
2 Nr labourers levelling and finishing
1 Nr foreman supervisor

Output and Quantities
Quantity: 50 m^3 Class C Concrete per floor
Quantity poured per day: 25 m^3
One floor to be placed in 2 days

Option Two Place concrete using Mobile Concrete Pump

Mobile concrete pump to be located in rear access yard. Direct discharge of ready mixed concrete into pump. Concrete to be pumped through existing window openings to floor bay location.
Place concrete and tamp into position. Additional cost of using 'flowable' concrete to be considered. Concrete to be placed in one continuous bay per floor using temporary screeds between bays.
Level off each bay using vibrating screed board and steel levelling screed. Protect as before.

Resources

Plant
1 Nr hired concrete pump
1 Nr vibrating screed board
1 Nr steel levelling screed
1 Nr petrol vibrator

Labour
1 Nr labourer with concrete pump
4 Nr labourers placing concrete
2 Nr labourers levelling and finishing
1 Nr foreman supervisor

Output and Quantities
Quantity 50 m^3 per floor
One floor is to be poured per day

Figure 3.5 illustrates the tender method statement presented in a tabular format. This has the advantages of showing the operational resource requirements in a somewhat clearer format.

The estimator or planning engineer would be responsible for assessing the costs of the alternative proposals and reporting his findings to the contracts

FACTORY REFURBISHMENT			TENDER METHOD STATEMENT			
OP. No.	OPERATION	QUANTITY	METHOD	RESOURCES		NOTES
				PLANT	LABOUR	
			OPTION 1			
1	Concreting to factory floors (floors 1 - 6)	50 m^3 / floor	Place concrete using front discharge dumper trucks. Goods lift to be used as access from ground floor level. Place concrete in 5 m wide bays and tamp level. Steel levelling screed finish.	3-Dumpers 1-5 m Tamp 1-Steel screed 1-Vibrator RMC Supply	3 Drivers 5 Labourers 1 Supervisor	Output per day 25 m^3
			OPTION 2			
2	Concreting to factory floor	50 m^3 / floor	Place concrete using mobile concrete pump located in rear yard area. Pump concrete through window openings at each floor level Continuous bay pour - 1 pour per floor.	1-Vibrating screed 1-Steel screed 1-Vibrator RMC Supply	6 Labourers 1 Labourer at pump 1 Supervisor	Output per day 50 m^3

Figure 3.5

manager. From a planning and speed of construction point of view, Option Two will evidently prove to be the more desirable method for inclusion in the tender. Smith (1995) illustrates an example build up of alternative method proposals when using operational estimating techniques based on method statements. Operational estimating techniques are also shown in the Code of Estimating Practice (1996).

3.4.9 Build up of the Estimate

This is the sole responsibility of the estimator. Assistance may also be available from the company buyer, if the company posseses such expertise. Within the medium sized organisation it is usual for the estimator to be responsible for sending enquiries to subcontractors and suppliers.

Once the estimator has split the bill of quantities up and circulated it for quotations, it is hoped that not much remains to be priced! The various sources of data available to the estimator are summarised in Figure 3.6. The build up of the estimate will involve the estimator in the following processes:

1) Preparing a build up of the 'all-in rates' for craft operatives and labourers. The 'all-in rate' varies from contract to contract due to varying conditions on site and the degree of supervision allowed in the build up. The Code of Estimating Practice (1996) illustrates a typical build up.

2) Pricing the bill trade sections using net unit rates. These may be built up in analytical form – a separate labour, material and plant inclusion for each bill item. Rates are established in 'net' form, with the percentage for overheads and profit being added at the adjudication stage. Alternatively, the estimator may use his own particular method of building up rates, very much based on his experience and knowledge of labour only rates currently applicable.

3) Preparing an analysis of the quotations received from the subcontractors and material suppliers.

4) Preparing a build up of the contract preliminaries, assisted by the contracts manager and advice from management.

5) Collating the estimate, analysing the overall price into labour, materials, plant and subcontractor elements.

6) Attending the tender adjudication meeting and presenting an estimator's report to management.

The estimator is usually the one who 'gets the blame' for winning tenders which ultimately finish up losing money. It is so easy for site management to blame their own inefficiencies on 'bad estimating'. The estimator is always in a 'no-win' situation.

3.4.10 Preparation of the Pre-tender Programme

This is an essential component of the estimating process. In certain tender documentation the contract period may be stated, while in others, the contractor may be required to insert his own assessment of the contract period.

Where the contract period is specified, it is necessary for the contractor to assess whether this period is realistic or not. It is no use tendering for a contract on the basis of a 30 week programme, if the contractor considers that he needs 38 weeks to construct the project. Likewise, if he considers that he can build the project in 24 weeks, then he should base the tender on this period.

Reducing the project period at tender stage will result in a more competitive tender because the time related elements of the contract preliminaries will be related to the shorter period.

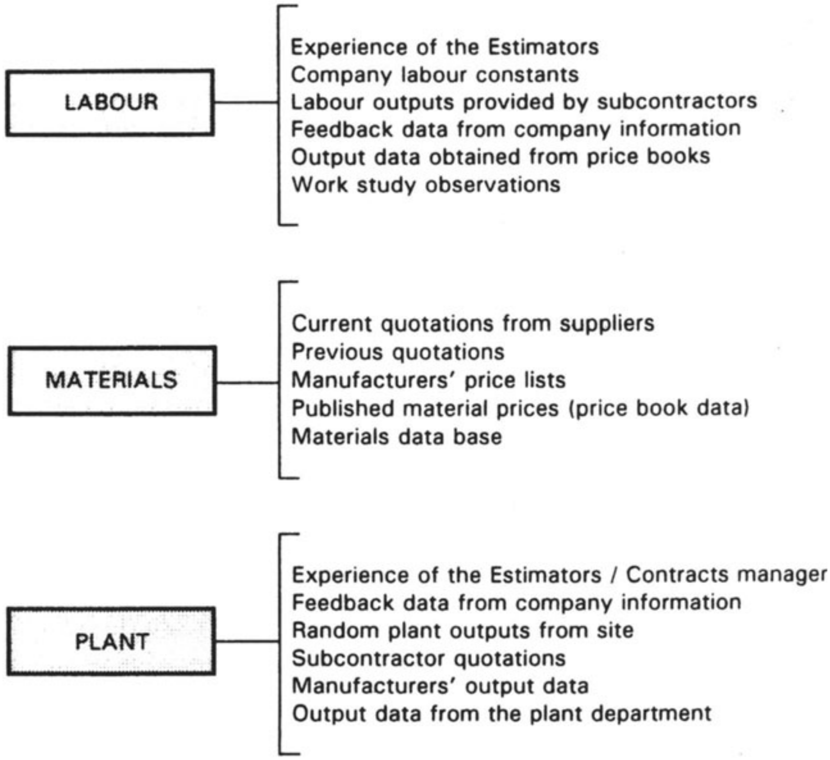
At the tender stage the pre-tender programme is normally presented in bar chart format. The programme will cover the major stages of the work to be undertaken based on the information available from the tender drawings. The utilisation of linked bar chart techniques based on project management software will enhance the programme presentation at this stage. It is now becoming normal practice for the pre-tender programme and method statements to be submitted with the priced bid.

Where a project is being negotiated, it may be the practice of the contractor to present the pre-tender programme in network or precedence format. This however depends on the complexity of the project and information available.

3.4.11 Build up of the Contract Preliminaries

The purpose of the contract preliminaries is to include for the pricing of items which cannot be reasonably included in the measured work. Contract preliminaries are priced on a fixed and time related basis. Certain preliminary items relate to a one-off or fixed charge to the project, e.g. the erection of cabins and site accommodation. Other items are directly related to the contract duration, e.g. the utilisation and weekly hire cost of using a tower crane. The division of the preliminaries costs into fixed and time related elements is directly reflected in additional charges to the client in relation to extensions of time and claims for loss and expense. It has been shown that the tender success rates improve where management involvement is evident in the build up of the contract preliminaries.

The Code of Estimating Practice (1996) indicates an extensive projects overhead schedule to assist in the build up of preliminaries costs. This ensures a logical approach to the assessment of project overheads.



SOURCES OF ESTIMATING DATA

Figure 3.6

Checklist of items for pricing project overheads

1) Employer's Requirements
Time Related Costs include allowances for site accommodation and telephone facilities for the use of the Architect and other consultants. Hire costs of a computer facility if specified in the documents.

Fixed Costs include for the erection and dismantling of accommodation, fitting out and decorating, furniture and fittings, technical and surveying equipment, telephone installation and site notice boards.

2) Contractor's Management and Site Staffing
Time related costs include site staff allocated to the project including site manager, trades supervision, site engineering staff, site support staff. In certain organisations it may be policy to treat staff servicing the site as part of the head office overheads, i.e. contracts managers, surveying and planning personnel, etc.

This is dependent upon the policy within the organisation and their approach to the pricing of project overheads.

3) Site Accommodation costs
Time related costs include hire charges for all required site accommodation including the servicing of such facilities.

Fixed related costs include the delivery to site, erection, fitting out and the dismantling and removal on completion.

4) Attendance on Domestic and Nominated Subcontractors
Time related costs including unloading and distribution of materials, attendance on domestic subcontractors and progressive cleaning of building.

Fixed related costs include for the cleaning out of the building on completion of the works.

5) Facilities and Services associated with the Works
Time related costs include weekly costs of telephones, office equipment and stationery, safety health and welfare provision, power and lighting for offices and site security costs per week. This may also include for such items as the removal of site rubbish, drying out buildings and office cleaning services.

Fixed related costs include installation and connection charges relating to the above. The majority of the costs will be involved in temporary service connections.

6) Temporary Works Costs
Time related costs include maintaining, cleaning and servicing of access roads, hard standings, compounds and hoardings. Moneys may also be included for complying with traffic regulations and work in connection with attendance on pumping and de-watering.

Fixed related costs include the initial installation and removal of items such as access roads, hard standings, compounds, and hoardings. Items in relation to pumping and de-watering may be included separately.

7) Mechanical Plant
The selection of plant for a project will have a direct effect on preliminaries costs and ultimately on the competitiveness of the tender. The pre-tender method statement requires careful review in the light of proposed alternatives and cost exercises may need to be undertaken. The costs of installing a track or a tower crane may prove an expensive exercise to undertake and must not be considered lightly at estimate stage. Consideration must also be given to the provision of power supplies to large items of plant. All these factors may force the contractor into taking more risk at the tender stage.

Time related costs include the hire charge per week of cranes, hoists, mixers, vibrators, compactors, dumpers, fork lift trucks and site vehicles for the collection of goods. Plant items such as excavators may be included in the built up rates. The contractor's approach to the inclusion of mobile concrete pumps is debatable, as this may be treated as a preliminary cost in the mechanical plant section, or included in the unit rate for concrete work.

Fixed related costs include the transport of the plant to the site, cost of receiving and installing and removal on completion. This should include for any additional costs in providing temporary works such as the track or base for tower cranes.

8) Non-mechanical Plant (or Small Tools and Equipment)
This includes for such plant items as bar-bending machines, provision of saw benches, ladders, wheelbarrows, road barriers and lamps, slings and chains, skips and surveying equipment.

The main item included here is scaffolding, which will carry the bulk of the cost in this section. Quotations will normally be obtained for scaffolding, as part of the subcontract enquiry process. The contractor may also include as a fixed cost, items such as power tools, including the transportation to and from site.

Many contractors tend to price non-mechanical plant as a 1% addition on the labour cost.

Preliminaries costs in general may make up to 5% to 15% of the overall contract sum. If the contractor included for every conceivable item in the contract preliminaries section then he would never win a competitive tender. Contractual risk must however come into the equation somewhere. As previously stated, the contractor tends to win the tender on items he has not included, rather than on those he has.

3.4.12 Response to Pre-tender Health and Safety Plan

In view of the statutory requirements as regards health and safety management in construction, it is clearly important for tendering contractors to address the health and safety aspects of projects at tender stage.

The CDM Regulations Approved Code of Practice requires the pre-tender health and safety plan to be sufficiently developed so as to be included with the tender documentation.[7] This will enable the principal contractor to take account of the health and safety plan in his tender and to plan and programme the works accordingly.

For instance the contractor may have to allow in his pricing for dealing with hazards identified in the health and safety plan or the planning supervisor may have imposed requirements or restrictions which may have a cost implication.

Clearly, to expect a contractor's fully developed health and safety proposals to be submitted with tenders would not be realistic both in terms of the effort needed and the time constraints of the tender period.

However, asking for a response to the pre-tender health and safety plan with tenders is a good way to confirm the competence of contractors with regard to the health and safety management for a specific project and whether sufficient resources for health and safety have been allocated in the tender.

For instance, an abnormally low price may indicate lack of adequate health and safety provision in the tender, while an over-optimistic programme may mean that insufficient time has been allocated to the proper planning and implementation of health and safety management provision on the site.

Although this is not a requirement of CDM, it is becoming common good practice in the industry to ask for this response in the tender enquiry documents.

The contractor's tender stage response should cover such issues as:

- health and safety policy
- evidence of adequate health and safety provision for the project
- resources available to control and manage the major health and safety risks
- evidence of competence to comply with health and safety legislation[8]

Tender enquiries from contractors to potential subcontractors should also include the pre-tender health and safety plan, or at least relevant extracts thereof so that any pricing implications in the health and safety plan can be included in subcontract quotations.

It should be noted, however, that the contractor's tender stage response to the pre-tender health and safety plan will probably be insufficient to satisfy fully the requirements of the CDM Regulations such as to allow work to start on site.

3.4.13 Management Adjudication of the Estimate

The Code of Estimating Practice (1996) indicates a suitable form for the Estimate Summary, Analysis and Report. One must pose the question 'Who attends the adjudication meeting and what are they supposed to contribute?' Maybe the management wish to take all the decisions and simply obtain approval of their intentions. At the end of the day it is the management who must assess the risk inherent in the tender and decide upon a competitive bid price. It is now too late to blame anybody else!

Checklist of items to be considered at the adjudication stage

1) Supporting documentation produced during the estimate build up including:

Tender enquiry form	Pre-tender method statements
Site visit report	Schedule of project overheads
Schedule of pre-contract sums	Tender summary
Pre-tender programme	Cash funding requirements (if required)

2) The estimator's project reports, produced during the estimate build up.

3) Details of current and future contractual commitments.

4) Details of parties involved in the contract (see tender enquiry forms).

5) Overview of construction methods allowed in estimate, planning report and pre-tender programme. (Comments on feasibility of programme from the planner/contracts manager; management may consider reducing the contract period.)

6) Contract conditions: amendments to the standard form, including an overview of the damages for non-completion, and situation regarding insurances and bonds.

7) Working capital implications.

8) Summary of the net cost analysis: amount of work to be sublet. Risk inherent in the subcontract prices.

9) Knowledge of competitors: the management hope at this stage that all known competitors have taken a 'cover price'. We can but live in hopes!

The practice of cover pricing is frowned upon by architects and clients alike. They should, however, clearly understand that if the tender enquiry is circulated to some six contractors, they are unlikely to receive six bona fide bids.

10) Consideration of mark up in respect of the quality of tender information, contractual risk in both the construction time and methods allowed.

Assessment of head office overheads (% addition), discounts and addition for profit.

Profit percentages may be in the range of 1% to 20%, especially if you do not wish to win the tender. At this stage it may be better to hire a crystal ball or buy gold earrings and headscarves for the management team.

Once decisions have been made on the adjudication, the revisions will have to be expressed in the submission of a priced bill or form of tender. The form of tender will have to be signed by a responsible person and submitted in the appropriate envelope. If alternative proposals have been invited, these should be clearly stated.

3.4.14 Analysis of Tender Performance (or the Application of Bidding Theory)

Many professionals, both academics and directors of construction organisations, consider the practice of analysing tender performance in a statistical and analytical form to be of little benefit.

Many senior managers in medium and large construction firms have very little faith in bidding theories and analysis. It is perhaps only for academics. Bidding theory is only relevant in stable market conditions, where the contractor is bidding against known competition in the market place. In the current construction climate, this is rarely the norm. Changes in procurement procedures have led contractors to enter into partnering arrangements, with more emphasis on negotiated contracts and hence less emphasis on bidding strategies.

Once a bid has been submitted and the contractor has committed himself to a contract price, it is no good reviewing what he should have done in the light of other competitors' bid prices. (If only we had 'done this or adjusted that'.) Perhaps one should consider sacking the estimator, because surely it is now all his fault? Management rarely takes the blame for adjudication decisions.

On acceptance of the contractor's bid price, procedures will be implemented in order to check the priced bill, agree any bills of reduction and arrange for contracts to be signed. Letters of intent may be issued in order that the contractor may prepare to commence work on site, and set off the pre-contract stage of the planning process.

3.5 Pre-Contract Planning

3.5.1 The Pre-Contract Planning Process

On award of the contract the pre-contract planning process commences. The contractor may have up to six weeks in order to plan the commencement of works on site, or he may simply have six days. The commencement date will normally have to be negotiated with the client's representative or may be specified in the tender documents. On a major contract of say £3 000 000 in value the following stages will be involved in the pre-contract planning:

- The pre-contract meeting and arrangements for commencing work
- Placing orders for subcontractors and suppliers
- Site layout planning
- Construction method statement
- Master programme preparation
- Preparation of requirement schedules
- Preparation of contract budgets
- Preparation and approval of the construction health and safety plan

It must again be pointed out that no two companies undertake exactly the same procedures at the pre-contract stage. Procedures are dependent upon the policy of the company and the need for establishing standard routines which may be followed on every new contract. The procedures to be outlined normally apply to the larger company or the more organised medium sized organisation. Within the larger organisation a more formal approach will be taken to the arrangements for commencing work.

3.5.2 The Pre-contract Meeting and Arrangements for Commencing Work

The purpose of the pre-contract meeting is to hand over the tender documentation. It is also to delegate responsibility to the those responsible for arranging the commencement of the project. Prior to the commencement of the project, a pre-contract meeting will also be called by the client's representative in order to coordinate the start of works on site. The pre-contract arrangements outlined here will relate to those undertaken by the contractor on a traditional contract.

The pre-contract arrangements will require consideration of the following:

- the pre-contract planning meeting
- the registration of drawings and distribution of information
- preparation of the project health and safety plan (compliance with CDM)
- arrangements for commencing work

3.5.3 The Pre-contract Meeting – Contractor's Team

A meeting will be held to announce the award of the contract and allocate responsibility to the construction team responsible for undertaking the work. All documentation produced at the tender stage will now become available to the construction section. The following personnel will normally attend the meeting which will be chaired by the Chief Estimator or the Contracts Manager:

Chief Estimator

To act as meeting chairman, as he is fully aware of all decisions taken at the tender stage. He will be responsible for handing over all the estimating data to the contracts section including:

- Estimate summary and analysis
- Build up of the 'all-in rates' and net bill rates
- Summary of subcontractors and suppliers quotations
- Pre-tender method statements
- Preliminaries build up
- Pre-tender safety assessment
- Tender adjudication report

Contracts Manager

Responsible for organising the commencement of work. At this stage, it is not usual for the construction manager to be appointed or available. On the larger multi-million pound projects it would prove advantageous however to have him allocated to the project team at the pre-contract stage. The contracts manager is therefore responsible for all pre-contract activities within the medium and smaller sized organisation. He would be responsible for finalising the operational method statement and assisting with preparing the master programme. Since 1994 it is now a legal requirement to prepare a Safety Plan and obtain approval of the plan by the client, prior to the commencement of work on site (Construction Design and Management Regulations, 1994). The contracts manager's responsibilities will also include arrangements for the transfer of key staff to the project or the recruitment of additional staff to manage the project.

Arrangements will have to be made for the delivery of site accommodation and the mobilisation of plant and equipment for the initial site operations.

Company Buyer or Quantity Surveyor (in the medium sized organisation)

Responsible for placing orders for subcontractors and suppliers based on the information received at the tender stage. It may be the policy of the company to ask subcontractors and suppliers to requote for the work. Smith (1995) makes an interesting reference to the practice of 'bid peddling' once the contractor has been awarded a contract. This practice is often frowned upon by the sub-contractor fraternity – and rightly so.

In many of the medium sized construction firms, the contract quantity surveyor undertakes the responsibility for placing subcontract orders and preparing contracts. This practice enables the surveyor to become familiar with the project from the outset. The placing of subcontract orders will however continue throughout the project period. The scheduling of key subcontract dates will need to be tied in with the master programme and related to the project requirement schedules.

Chief Quantity Surveyor or Surveying Manager

Responsible for allocating surveying personnel to the project and arranging for the checking and signing of the contract. The surveyor will also be responsible for preparing the contract cumulative value forecast based on an analysis of the contract bills and master programme (see Chapter 5, section 5.2.5).

Office Manager

It will be necessary to establish communication channels for the distribution of project information as it is received from the architect. This will involve establishing procedures for the circulation of drawings and correspondence. The office manager will also be responsible for allocating office staff to deal with wages and material invoicing. Notices to the factory inspectorate will have to be issued together with applications for hoarding licences, footpath crossings and the provision of temporary service connections. The necessary insurance requirements for the contract will also need to be organised.

3.5.4 The Pre-start Meeting

A client's pre-contract meeting is usually held by the architect/engineer, design team, client's representative and the contractor in order to establish initial contact between the parties. This enables channels of communication to be set up for the issue and distribution of project information. At the pre-contract meeting the contractor may be required to present his outline programme. This may indicate the requirements for key nominated subcontract dates, in order that realistic information requirements may be assessed. Outstanding matters in relation to the contract commencement dates may be discussed, together with arrangements for the signing of the contract.

A typical agenda for such a meeting might contain some or all of the following items:

1. Introductions
2. Apologies for absence
3. Employer's organisation and delegated powers
4. Contractor's organisation
5. Tax exemption matters
6. Insurances
7. Notices
8. Commencement date
9. Programme and method
10. Site boundaries and access

11. Setting out arrangements
12. Working hours
13. Contractor's tip and cleaning roads
14. Safety management arrangements
15. Communications and correspondence
16. Progress meetings
17. Valuations and payment
18. Emergency procedures
19. Any other business
20. Date of next meeting

3.5.5 Placing Orders for Subcontractors and Suppliers

As indicated above, it will be necessary to consider the company policy with regard to the procedures to be adopted for the placing of orders for subcontractors and suppliers. The practice of offering work on the basis of a 'Dutch Auction' should not be encouraged. Chapter 8 deals with subcontractor selection and control criteria. Within the larger organisations procedures are implemented to award subcontracts on the basis of standard forms of subcontract (Domestic Form of Subcontract – DOM 1).

Within the small and medium sized organisations, subcontracts may simply be awarded on the basis of a letter of appointment with no formal written contract being entered into. Nominated subcontracts are let on the Nominated Subcontract Form (NSC/C).

3.5.6 Site Layout Planning

Site layout planning is an essential part of pre-contract planning. The contractor is often required to submit his proposals for approval by the client's representative prior to commencing work on the project. It is important to consider the allocation of preliminaries facilities allowed in the original estimate, as this establishes the basis of the preliminaries budget. Overspending on the preliminaries is a common problem on contracts and one must learn to work within the moneys allocated at the tender stage – no matter how inadequate.

Where 'pencil sharpening' cutbacks have occurred at the tender adjudication stage, there will no doubt have been some reductions in the site overhead allowances.

Checklist for preparing a Site Layout Plan

1) Location of offices and site accommodation
This is directly related to the space available on site, and the 'open' or 'restricted' site situation may apply.

On open sites, the site accommodation should be located close to the entrance in order that vehicles and personnel may be readily observed entering the site.

Site notices, instructing personnel entering the site to report to the office, should be displayed. Site compound areas should be adequately stoned up or tarmaced and consideration should be given to the site parking of vehicles for staff and operatives. The site office area may be fenced and provided with secure gates.

On restricted sites, similar to the one shown in Figure 3.7, consideration may be given to locating the offices on a gantry over the pavement or alternatively renting some space adjacent to the site. The contractor may also consider locating his offices in the building being refurbished, if this ties in with the sequence of work. Consideration may also be given to moving the accommodation into completed parts of the building as it is being constructed. On restricted sites problems are also relevant to the storage of materials and the location of plant and equipment.

The location of offices and accommodation will also be influenced by the location of access roads and site services. Careful consideration is required with regard to site security. Arrangements should be made to have the site well illuminated at night. Powerful security lighting may be used for this purpose in order to deter theft and break-ins. On a site in the Hulme district of Manchester, the police recommended using powerful security lights to deter theft, but during the first week of the project the security lighting was stolen. Consideration will have to be given to the siting and location of the site signboards and any site component sample panel areas.

Figure 3.8 indicates the proposed site plan for the construction of a three storey office block. The frame consists of a reinforced concrete frame which is externally finished in quality brickwork. Figure 3.9 illustrates a proposed site layout plan for the project.

2) Location of site services

Consideration will have to be given to the location of existing and new site services. This is in respect of existing water, drainage connections, electricity and telephone services serving and crossing the site. The statutory authorities will need to be contacted in order to establish existing locations and entry points for new services. The contractor will be required to establish the proposed location of temporary standpipes for site mortar mixing or facilities for the washing down of site vehicles. On open, greenfield sites, permanent services may require to be laid early in the project in order to provide temporary service connections.

Power supplies to major items of plant such as tower cranes will need consideration together with the provision of electrical service connections for site power tools and site temporary lighting.

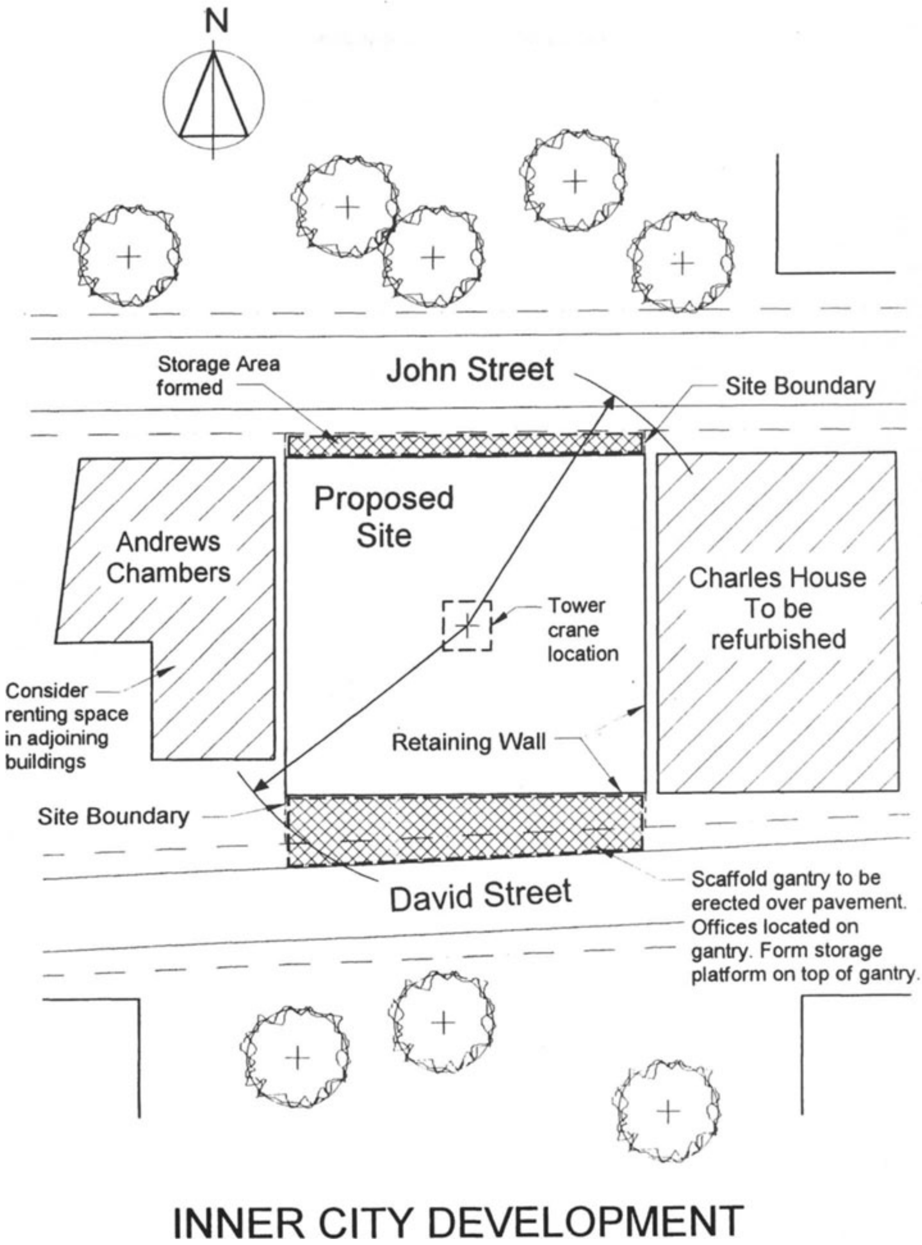
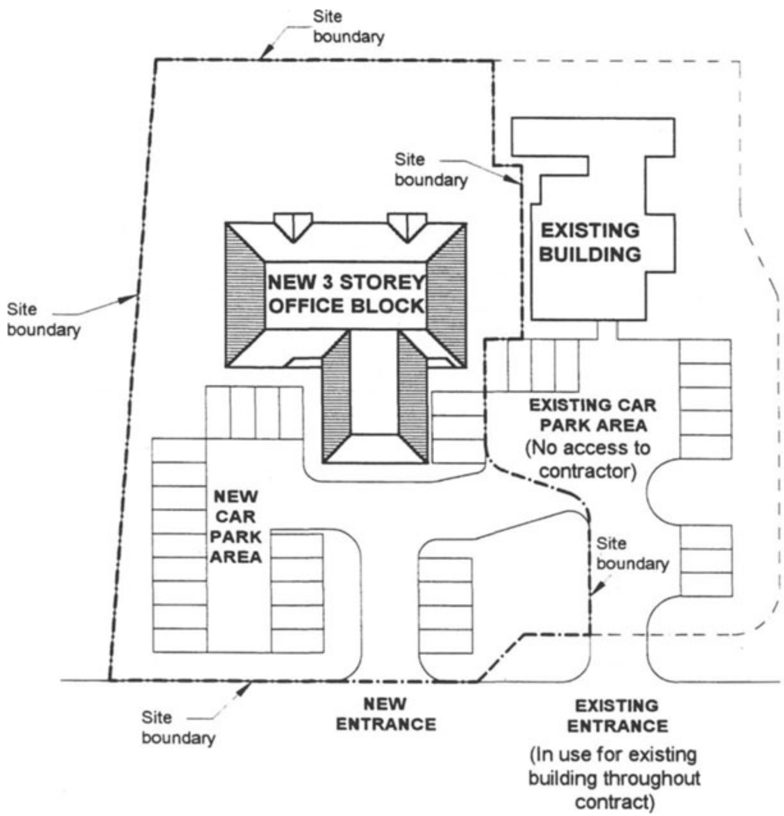

N
Storage Area formed
John Street
Site Boundary
Proposed Site
Andrews Chambers
Charles House To be refurbished
Tower crane location
Consider renting space in adjoining buildings
Retaining Wall
Site Boundary
David Street
Scaffold gantry to be erected over pavement. Offices located on gantry. Form storage platform on top of gantry.
INNER CITY DEVELOPMENT

Figure 3.7

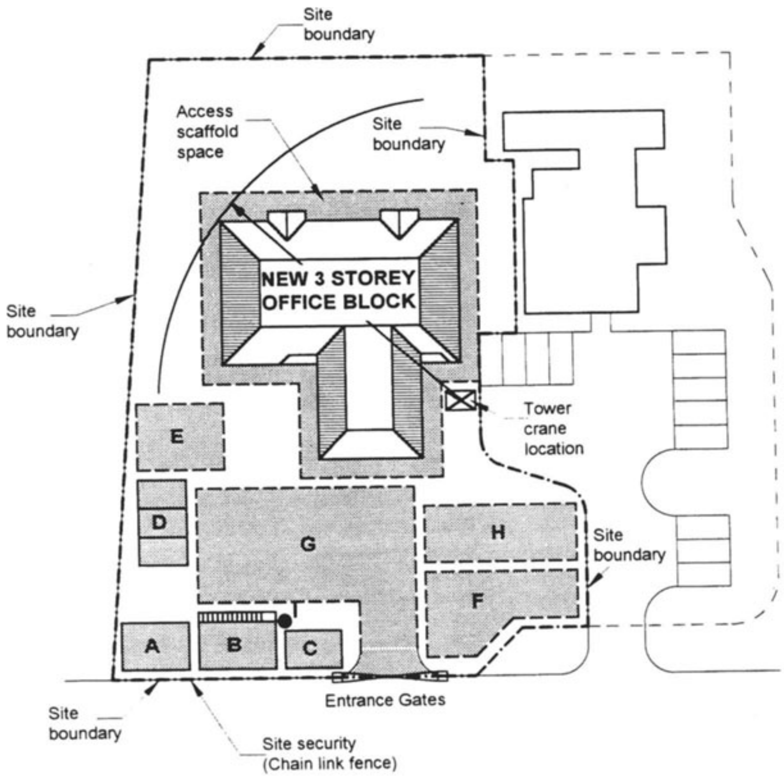


Description of Construction Method

Three storey R.C. frame brick and block external walls.
P.C. floors (wide slab).
Steel Mansard roof structure.
Timber rafters / Timber roof.
Ready mixed concrete supply.
Timber stud walls internally.
Plasterboard finish.
Suspended Ceilings.
Tower crane allocated for frame erection.

SITE PLAN
3 STOREY OFFICE BLOCK
(Not to scale)

Figure 3.8



ITEMS included on LAYOUT PLAN

Site security fencing.
Entrance gates.
A - Mess accommodation.
B - Tiered office accommodation.
C - Stores - lock up
D - Storage racking for finishing materials.
E - Brick storage area on hardstanding.
F - Formwork / reinforcement fabrication areas.
G - General hardstanding area for movement corridor - formed up on car park area at commencement of contract.
H - Area for subcontractors accommodation and storage.
I - Site floodlight at high level.

SITE LAYOUT PLAN
3 STOREY OFFICE BLOCK
(Not to scale)

Figure 3.9

3) Temporary roads, hard standings and access to the works

Reference will again have to be made to moneys allocated in the contract preliminaries. Temporary hard standings may be required for the location of cranes, piling rigs or for the unloading of materials such as ready mixed concrete. On a factory project it may be necessary to provide a temporary access road around part of the building for mobile lifters during the cladding stage of the works.

It may prove opportune to lay hardcore to car park areas at a lower level early in the contract, in order to use them as temporary hard standings for the works. Foundations for tower crane bases or tracks will require preparing early in the contract prior to the erection of the cranes.

4) Location of plant and equipment

The contractor will have to consider the storage and security of plant during evenings and weekend periods. A locked compound may be provided. The location and working radius of cranes will require to be marked on the site layout plan in order to establish the best location for delivery points.

Consideration will have to be given to the rights of adjoining owners with regard to the swinging of tower crane jibs and booms over land adjacent to the site. The contractor has no rights to enter the air space of an adjacent site without permission from the owner, and may be sued in trespass if he does so. Likewise the contractor has a duty of care to persons using footpaths, streets and highways adjacent to the works. With respect to an adjacent highway, the main contractor is responsible for the deeds of his subcontractors when working in the vicinity of an adjacent highway. The contractor may be sued for negligence in the case of an accident involving the public.

Consideration will also have to be given to site space requirements around the building for the provision of scaffolding.

5) Materials storage areas on site

One of the major considerations is the safe and secure storage of materials and components. This is in order to reduce waste and ensure safe working procedures. Materials are an expensive commodity and care must be taken in their handling, storage, protection and placing in position. Recommendations for materials storage areas should be shown on the site layout plan.

Bricks and blocks

These should be stored on a firm clean surface or on pallets suitable for handling with a fork lift truck. Blocks should not be stacked too high. Bricks should be stored in locations which do not become waterlogged or where the brick stockpiles may become contaminated by mud.

Structural timber
To be ordered in cut or stock lengths to avoid cutting waste. May be banded for ease of handling. Must be stored clear of the ground and protected with polythene or tarpaulin sheets to avoid changes in moisture content.

Finishing timbers (architraves and skirtings)
Architraves and door linings to be ordered in door sets. Skirtings and timber mouldings to be stored on horizontal racking internally. Where it is possible, garages should be erected early in the project and used for storage purposes.

Roof trusses
May be stored on purpose-built, timber or steel storage racks, which support the trusses clear of the ground. It is preferable to deliver the trusses to site in phased deliveries in order that they may be lifted directly into position.

Scaffolding and props
May be stored on horizontal racking with the fittings stored in drums or bins. These are expensive components to lose as the contractor will be charged for material losses.

Drainage goods
A material which is brittle and easily damaged if mishandled. Drainage fittings may be delivered to site in a crated form. Pipes may be banded and stored on timber separators. Materials may be stored adjacent to the works in a small compound.

3.5.7 Construction Method Statements

These may be presented as a written statement or in tabular form. It will be necessary to incorporate method statements into the project Health and Safety Plan together with those of any subcontractors. Safety hazard assessments may also be included in order to cover the main stages of the works. Approval of construction methods may be a requirement of the client prior to commencing any operations on site. Reference will have to be made to any pre-tender method statements prepared.

Figure 3.10 indicates the plan and section of a reinforced concrete basement to be constructed as part of a multi-storey office development project on an open site. Figures 3.11, 3.11a and 3.12 indicate an operational method statement and hazard assessment statement for the initial stages of the works.

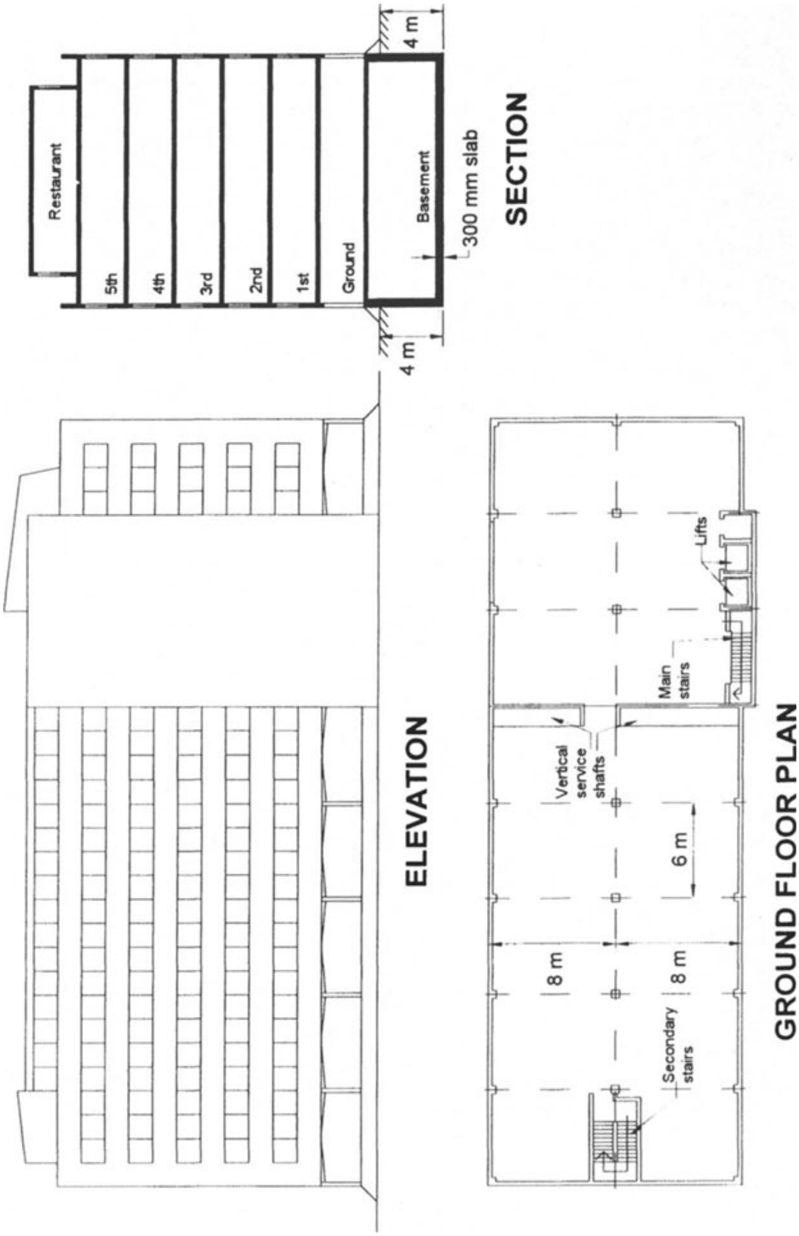

Restaurant
5th
4th
3rd
2nd
1st
Ground
Basement
300 mm slab
4 m
4 m
SECTION
ELEVATION
Lifts
Main stairs
Vertical service shafts
6 m
8 m
8 m
Secondary stairs
GROUND FLOOR PLAN

Figure 3.10

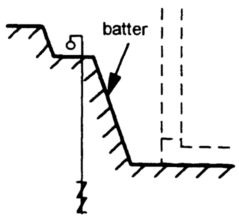
BASEMENT TO MULTI STOREY BUILDING		CONSTRUCTION METHOD STATEMENT		OPERATIONAL STATEMENT		Page 1/2
OP No.	OPERATION	QUANTITY	METHOD	RESOURCES		NOTES
				PLANT	LABOUR	
1	Reduced level excavation. (0.5m deep)	500 m^3	Excavate to reduced level using hydraulic backactor (JCB 6C). Load 10 m^3 wagons and remove to tip off site.	Hydraulic Excavator 4 -10 m^3 lorries	1 - Banksman	Duration 2 days
2	Earth to support basement excavation.	Free draining sand / gravel W.T. 1.5m	Battered excavation. Wellpointing to perimeter of basement. 150 dia. header - 2 Wellpoint pumps. 50 mm pvc. risers - 80 to 100 points. Wellpoints to be in operation three days prior to commencement of excavation work.	Hired wellpoint equipment	3 - Labourers	Installation period 2 weeks (10 days)
3	Excavation to basement (including batter)	4500 m^3	 **Excavate using large hydraulic backactor loading wagons. Part deposit on site, majority cart away to tip off site.**	Hydaulic Excavator 4 - 10 m^3 wagons	1 - Banksman **$\frac{4500}{40}$ =120 mhrs** **$\frac{120}{8}$ = 15 days** **15 days = 1 machine** **8 days = 2 machines**	Output 40 m^3 / hr

Figure 3.11

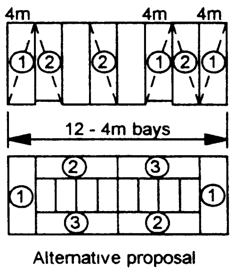
BASEMENT TO MULTI STOREY BUILDING		CONSTRUCTION METHOD STATEMENT		OPERATIONAL STATEMENT		Page 2/2
OP No.	**OPERATION**	**QUANTITY**	**METHOD**	**RESOURCES**		**NOTES**
				PLANT	**LABOUR**	
4	Basement floor (300mm thick)	250 m^3	<u>Formwork</u> Plywood panel shutters to edge of floor formed with 150mm high upstand kicker.		2 - Joiners	
			<u>Reinforcement</u> Steel to be delivered to site cut and bent. Lift reinforcement into basement area using crane.	Low pivot jib crane	4 - Steel fixers	
	Bay layout 		<u>Concrete</u> - Ready mixed supply. Divide basement area into 4m wide bays. Pour in sequence shown on bay layout. (Alternative proposal shown) Place concrete using concrete pump, pouring 3 bays per day (20 m^3 per bay). End bays to be poured in first sequence in order to release work on wall reinforcement and formwork.	Concrete pump (hired) 2 - Poker vibrators	6 - Labourers	Pour 3 floor bays per day

Figure 3.11A

BASEMENT WORK — **HAZARD ASSESSMENT STATEMENT** — Page 1/1

OP No.	OPERATION	CONSTRUCTION HAZARD LIKELY TO BE ENCOUNTERED	PERSONNEL AFFECTED	DEGREE OF RISK	PROPOSED STEPS TO REDUCE HAZARD
1	Reduced level excavation	Access to site for vehicles	Own labour	Low	Provide adequate directory signs.
		Access to workplace	Own labour	Low	Hardstanding for loading vehicles
		Moving plant	Own labour	Medium	Banksman to control movement of vehicles and to provide adequate stop barriers at edge of excavation.
		Plant security	Public	Low	Plant to be disabled during evening / night. Site security services provided.
2	Excavate to basement	Provision of adequate earth support	Subcontract labour	Medium	Provision of wellpoint system. Care in use of jetting and wellpoint installation system. Operatives to be trained by specialist plant installer. Batter to be formed to correct slopes.
		Persons falling into excavation	Own labour	Medium	Excavation to be adequately fenced off. Timber stop barrier around top of excavation.
		Moving plant during excavation works	Own labour	Medium	Provision of banksman to direct lorries into position for loading by excavator. Provision of adequate hardstanding for plant and vehicles.
		Public gaining access to basement area	Public	Low	Site to be fully fenced, security provision during evening periods.

Figure 3.12

3.5.8 The Master Programme Preparation

The contract master programme is an important management tool. It is an essential requirement in the coordination of the many integrated tasks to be undertaken during the project. On a major project, many different programmes are required to cover each stage of the work in order to ensure the smooth flow of information during the project. This includes consideration of:

- A contract master programme covering the major phases or sections of work and clearly indicating the planned sequence of construction.

- A programme indicating the key dates for the release of design team information in order to meet the requirements of the contract master programme.

- A programme to coordinate the requirements of subcontractors, material supplies and the resources of the main contractor.

- Separate detailed programmes relating to the various project phases or stages, highlighting the links between each work stage.

The master programme forms the basis of the contractor's budgetary control and financial forecasting procedures and aids the client in assessing his cash funding requirements at the monthly payment stages. It is also important in relation to the contract.

Firstly, the contract programme is not usually part of the contract documents as, under the JCT form for instance, these normally consist of the Articles of Agreement, the project drawings, the Bills of Quantities or Specification. However, the provision of a 'master programme' is a condition of contract in the JCT form under the optional Clause 5.3.1.2. This clause states that 'the contractor without charge, is to provide the employer with two copies of the master programme for the execution of the works'. Also, 'within 14 days of any decision by the architect in relation to an extension of time, he must provide two copies of any amended programme'. However, this clause only applies where the contractor has actually prepared a programme which, unlike ICE Clause 14, he is not obliged to do.

If the master programme was included as a contract document it would somewhat impair its flexibility and usefulness. This would involve both parties having to strictly adhere to the programme and the contractor would be required to start and finish each operation by the programmed dates and in the programmed sequence. In this respect the programme would lose its purpose as a flexible contract tool and become unworkable.

Consideration should also be given as to whether or not the master programme constitutes notice of the contractor's information requirements to the architect. In the case of *Merton* v *Stanley Leach* for instance, the judge held that the programme, if it gave sufficient detail, would be a notice of the contractor's requirement for further information. It follows that a post-contract programme is a unilateral declaration of the intention by the contractor, and notice of when he requires information.

It is good practice for the contractor and design team to agree amicably a realistic contract programme prior to the commencement of the project. This will avoid recourse to legal threats which only tend to lead to strained relationships which everybody can do without.

The master programme may be presented in bar chart, network or precedence format depending upon the programming techniques adopted by the contractor. Contractors tend to use the programming technique which best suits their mode of operations and works for them. The master programme indicates the sequence of operations and relationships may be shown between related operations by introducing links in the form of a linked bar chart. This is illustrated in the programme displays in Figures 4.2 to 4.5 of Chapter 4.

Copies of the master programme should be circulated to the architect for courtesy approval and to the major subcontractors in order to indicate their approximate commencement dates and periods on site.

The programme is used to record progress weekly and monthly throughout the contract period in order to achieve the planned completion date.

3.5.9 Preparation of Requirement Schedules

Many contractors may consider that 'the claims start here'. This should not be the reason behind requesting information requirements at this stage of the contract. The purpose of requirement schedules is to aid the smooth running of the project. The release of information to the contractor continues throughout the contract; it is no use asking for information relative to painting schedules at week one on a seventy week project, and then expecting to formulate a claim at week twenty, simply because you have not received the information. Surveyors will still however remain mesmerised by information requirement schedules for evermore.

The following requirements schedules may be used by contractors when requesting information from the client's representative. Certain schedules relate to the contractor's internal requirements whilst others concern key dates for the release of information from the client or client's representative.

- Contractor's internal schedules:
  - Key materials schedule
  - Plant schedule
  - Domestic subcontractor requirements

- Client based information requirements:
  - Subcontract schedule (Nominated subcontractors and suppliers)
  - Drawings and information requirements schedule

Illustrations of the above schedules are shown in Figures 3.13, 3.14, 3.15 and 3.16.

Key information requirements may also be highlighted in the form of milestone events on the master programme. Alternatively the 'early warning system' developed by a major contractor in the early 1970s is still a valid method of highlighting project requirements today.

Key Materials Schedule

Figure 3.13 illustrates this schedule which is prepared in conjunction with the contractor's planning or buying section and shows the key materials scheduled to meet key operational programme dates.

The materials requirements are assessed from the contract drawings, with the quantities in the bills being used as a check. Phased deliveries may be arranged for materials such as bricks and precast floor units. On sites with restricted space, or inner city refurbishment projects, phased deliveries to suit the contract programme may again be the norm.

It is important that the material schedule contains full information with regard to the supplier. Site management personnel must be encouraged to use the schedules presented to them. It is important that material suppliers are kept informed of the contract's progress position with regard to any amendment to planned delivery schedules.

Plant Schedule

This schedule indicates key dates for the major items of plant allocated to the contract (see Figure 3.14). The schedule may be presented in tabular format or as a bar chart programme. The plant schedule enables the plant department to plan its resources between projects. It enables a balance to be obtained between owned plant utilisation and hired plant suppliers.

Reference must be made to the allowances for plant within the contract preliminaries because overspending on plant is a common source of loss at site level.

Sub-contract Schedule

The co-ordination of subcontractors and suppliers is an essential part of project control. The schedule illustrated in Figure 3.15 enables the site manager to overview key contract dates with respect to contract progress. Details are also shown relating to details of the subcontract order, contact address and notification dates. Reference should be made to the sub-contractor's programme prepared at the contract stage. The release of key information relative to nominated subcontractors and suppliers may lead to an extension of time when the delay is caused by the architect.

Drawings and Information Requirement Schedule

It is essential to monitor and record the issue of contract drawings and contract information from the architect. It is the contractor's responsibility to give adequate notice relative to key information requirements. Typical requests may include:

- Setting out dimensions – measurements to site boundaries.
- Reinforcement details for pile caps, foundation beams, etc.
- Details of ground floor services and pockets/fixing bolts.
- Fixing details for cladding panels.
- Colour schedules for internal decoration.
- Service layout details.

Where information is delayed by the architect, the contractor may apply for an extension of time. The schedule shown in Figure 3.16 allows the contractor to record the date of the information request, and compare this with the information release date.

3.5.10 The Preparation of Contract Budgets

The essential budgets which are prepared by the contractor at the pre-contract stage include:

- The cumulative value forecast - based on the master programme
- The preliminaries budget
- The labour expenditure budget - based on the master programme
- The plant expenditure budget

These and other budgets prepared in a contracting organisation are explained in Chapter 5 but, as a matter of principle, it must be pointed out that it is no use preparing forecasts unless they are monitored and reported upon as part of the company's control procedures.

Examples of how contract budgets are monitored and reported throughout the contract period can be found in Chapters 5 and 7.

MATERIALS SCHEDULE									
CONTRACT :-		PREPARED BY -				SHEET No. :-	Date issued :-		
CONTRACT No. :-		PROGRAMME REF :-				SUPPLIER DETAILS			
Material	B of Q Ref.	Latest Req. Date	Latest Order Date	Delivery Period	Required on site Date	Supplier	Tel. No.	Order No.	Comments/ Remarks

Figure 3.13

PLANT SCHEDULE

CONTRACT :-	PREPARED BY :-	SHEET No :-
CONTRACT No. :-	PROGRAMME REF. :-	DATE PREPARED :-

Ref.	Operation	Plant Item	Date Requested	Date required on site	Duration on site	Plant Release Date	Actual Release Date	Notes/ Comments

Figure 3.14

SUB-CONTRACT SCHEDULE									
CONTRACT :-		PREPARED BY :-				SHEET No. :-	Date Prepared :-		
CONTRACT No. :-		PROGRAMME REF. :-				SUBCONTRACTOR DETAILS			
Trade	Nom. or Dom.	Latest Inquiry Date	Latest Order Date	Period of S/C notice	Comm. date on site	Subcontractor	Tel. No.	Order No.	Notes

Figure 3.15

DRAWING AND INFORMATION REQUIREMENTS SCHEDULE

CONTRACT :-		PREPARED BY :-			SHEET No :-	
CONTRACT No. :-		PROGRAMME REF. :-			DATE PREPARED :-	
Ref.	Information Request	Date Requested	Date Required	Date received on site	Receipt of Final Details	Comments / remarks

Figure 3.16

3.5.11 Preparation and approval of the Construction Phase Health and Safety Plan

'The health and safety plan is the foundation upon which the health and safety management of the construction phase needs to be based'.[9] This has to be developed from its pre-tender form by the principal contractor in accordance with CDM Regulation 15(4).

The client has a statutory obligation[10] to ensure that construction work is not started before a satisfactory health and safety plan has been prepared.

The plan must basically consist of the principal contractor's arrangements to ensure:

- the health, safety and welfare of persons at work
- the health and safety of those affected by persons at work
- construction risks are accounted for

It is important that the client allows sufficient time between tender submission and starting on site for the principal contractor to fully develop his proposals for a health and safety management system for the project.

The principal contractor's management system will include:

- management organisation structure
- communications
- monitoring procedures
- welfare arrangements
- site rules
- emergency procedures
- site induction procedures
- safe working procedures for early construction activities

With regard to specific operations on the contractor's programme, however, it is probable that design information may not available at the start of the project and it may be that the health and safety plan cannot be fully complete before work starts.

In such circumstances, therefore, it may be that only preliminary activities covering the first few weeks can be planned in any detail with appropriate risk assessments and method statements. Examples of such activities may include site clearance, demolition and groundworks, etc.

Later on in the project, detailed risk assessments and method statements can be developed for specific activities and included in the health and safety plan when sufficient design information is available or when specialist subcontract packages have been awarded.

The CDM Approved Code of Practice recognises this possibility and that the health and safety plan will be developed over time as the job proceeds.[11]

Under the requirements of the CDM Regulations the client is required to approve the project health and safety plan before work can be allowed to commence. It is probable that the planning supervisor will advise the client as to the suitability of the plan and have meetings with the principal contractor to discuss his health and safety management system for the project.

When the health and safety plan has been agreed, it is good practice for the client to sign his approval so that the principal contractor can confidently commence work on site without being in fear of breaching statute.

The role of the planning supervisor effectively ends when the design phase is complete but in practice this will overlap considerably with the construction phase. For instance, there will undoubtedly be design changes with a health and safety significance which the planning supervisor will have to coordinate and there may be temporary works designs from the contractor which will require input from the planning supervisor.

Therefore, the construction phase health and safety plan will be continuously evolving and the site manager will have to ensure that risk assessments and, where appropriate, method statements are prepared. This will include sub-contractors activities especially where there is a specialist design input.

As a consequence, site safety inductions will have to be updated and regular toolbox talks will be needed to communicate and discuss the plan with the workforce.

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4 Programming Techniques

4.1 Planning a Project

The contractor is involved in programming at all stages of the planning process. At the tender stage, the pre-tender programme is prepared as the basis of the contractor's bid. At the pre-contract stage the tender programme is developed into the contract master programme as more information becomes available. During the contract stage, short term monthly and weekly programming procedures are implemented in order to keep the master programme under constant review.

When preparing a programme for a project it is essential to follow a logical thought process in order to develop a realistic and workable programme. The following points are intended to cover the basic thought process when preparing a programme using any of the recognised techniques such as bar charts, network analysis or precedence diagrams, etc.

4.1.1 Developing a Project Strategy

The planner/manager must develop a logical approach to the planning of a project which involves various steps or thought processes as follows:

Getting a 'feel' for the project

- Study the drawings and project documentation
- Assess the scale and scope of the project
- Think about approximate value in relation to project time
- Consider the cash funding profile – value/time relationship

Assessing key project dates

- Start flags/finish flags
- Holiday periods
- Key project stages – building watertight, etc.
- Sectional or phase completion dates
- Contract completion and handover date

Establishing the construction sequence

- Prepare a list of operations/activities which must be of significance to the construction sequence and which must have a duration and resource implication

- Assess the construction sequence by:
    - listing operations/activities
    - assessing operational durations in days or weeks
    - considering the order of work and overlap between related operations
    - considering 'start to start' or 'finish to start' relationships
- Try at this stage to present the logic of the construction sequence in the form of a bar chart or linked bar chart, or preferably in the form of a simple arrow diagram, or as a series of precedence relationships. A 'doodle diagram' for the whole project can be useful and this is illustrated in Figure 4.7. The project logic is important and it can be established by taking each activity in turn and by asking:
    - what must precede this activity
    - what must follow this activity
    - what can happen at the same time (concurrency)

- Consider sub-activities as each main activity may have a sequence of its own. For example, an operation/activity such as 'Construct Pile Caps' may have sub-activities such as:
    - Excavate pile cap
    - Cut off and trim piles
    - Blind base of pile cap
    - Fix formwork to base
    - Fix steel reinforcement
    - Set bolts in base
    - Place concrete
    - Strip form work
    - Backfill working space

Decide which programming technique to use

A variety of techniques are available for programming the project and these need to be considered in the light of the type of project in hand, the contractor's preferences and any stipulations in the contract documentation. The history, development, application and use of these techniques is now discussed.

4.2 Bar Charts and Linked Bar Charts

4.2.1 History and Development of Bar Charts

Kempner (1980)[1] and other management writers recognise that Henry Gantt first introduced bar charts in the early 1900s by popularising the graphical presentation of work versus time. Each operation is represented by a block or bar drawn to a time scale. These 'Gantt Charts' were the first scientific considerations of work scheduling and they have now become the basis of the modern bar chart, developed as a graphical representation of construction sequences.

In th preparation of bar charts the planner/manager is influenced first by the overall construction period – and often works backwards from this to establish the overall programme format. The resulting bar chart is often no more than wishful thinking. It has been said that the bar chart often suffers from a 'morning glory complex' – it blooms early in the project and is nowhere to be seen later on!

Bar charts are well suited to depicting construction sequences, and are readily understood at all levels of management. They can be used to link the programme prepared at the tender stage with the master programme and likewise with the short term planning throughout the contract period. Bar charts are easily and readily updated at weekly and monthly time intervals. A colour coding system may be introduced for progress recording which provides an accurate record of the contract's progress for future reference purposes.

Where network analysis has been requested as the project planning technique, bar chart representations of the construction sequence are often required to aid clarity and understanding. Architects and site managers tend to have problems in understanding anything other than bar chart displays.

Developments in project management computer software has led to a resurgence in the use of bar charts – especially linked bar chart relationships. The software enables the user to present bar charts in a professional manner for the pre-tender and master programmes which can be readily updated on site with the aid of a notebook computer. Figure 4.1 illustrates the relationships used on linked bar charts. These include:

- Finish to start relationships
- Start to start relationships (overlaps)
- Finish to finish relationships

Contractors are now beginning to realise the importance of presentation techniques at the tender negotiation stage. A variety of bar chart displays are shown for a range of project situations:

- Figure 4.2 illustrates a pre-tender programme for a factory project using linked bar chart principles. This enables the critical sequence of work to be highlighted.

- Figure 4.3 indicates the procedures adopted for recording progress at weekly time intervals using a colour coding system. This is achieved by allocating a colour to show the actual work undertaken during each week of the contract.

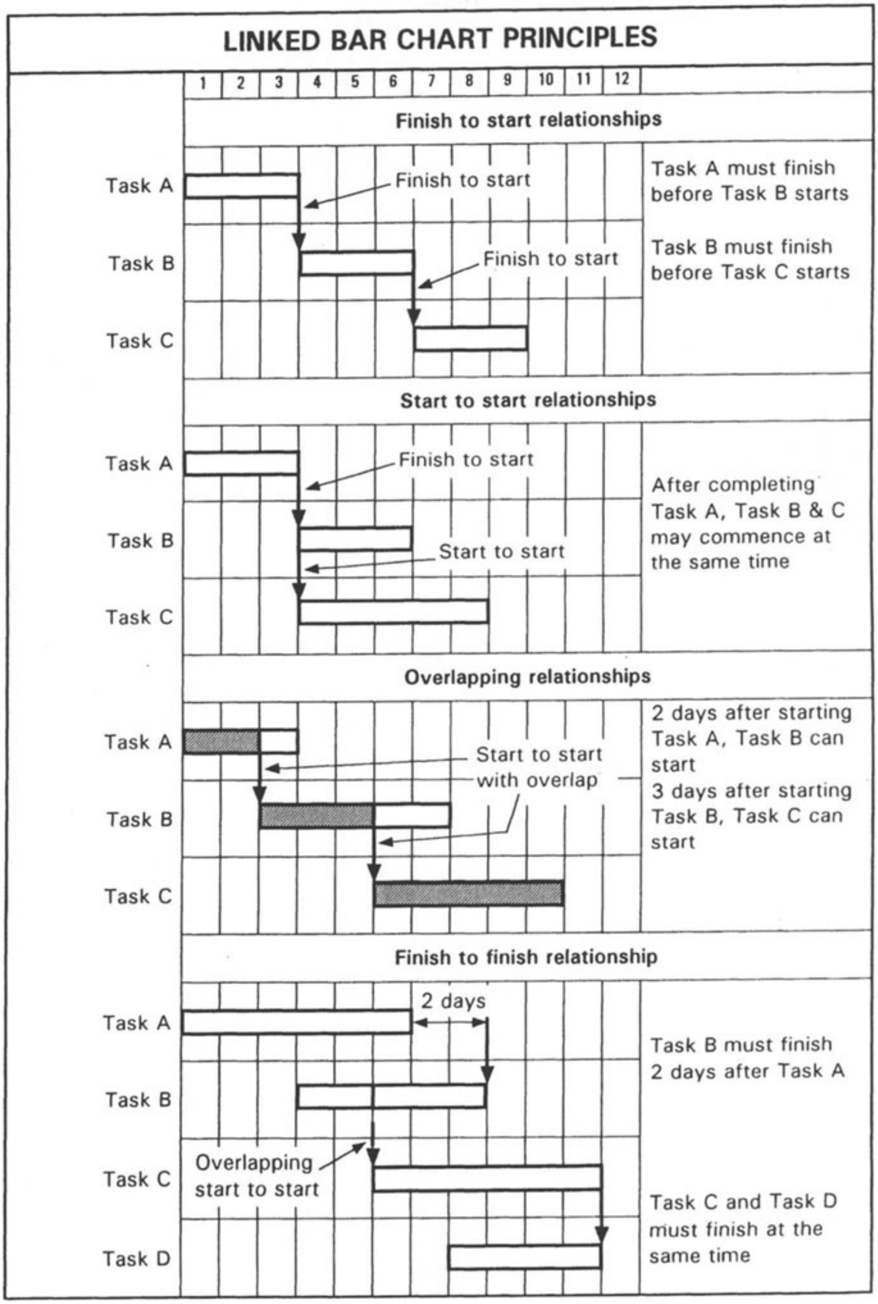

LINKED BAR CHART PRINCIPLES
1 2 3 4 5 6 7 8 9 10 11 12
Finish to start relationships
Task A
Task B
Task C
Finish to start
Finish to start
Task A must finish before Task B starts
Task B must finish before Task C starts
Start to start relationships
Task A
Task B
Task C
Finish to start
Start to start
After completing Task A, Task B & C may commence at the same time
Overlapping relationships
Task A
Task B
Task C
Start to start with overlap
2 days after starting Task A, Task B can start
3 days after starting Task B, Task C can start
Finish to finish relationship
Task A
Task B
Task C
Task D
2 days
Overlapping start to start
Task B must finish 2 days after Task A
Task C and Task D must finish at the same time

Figure 4.1

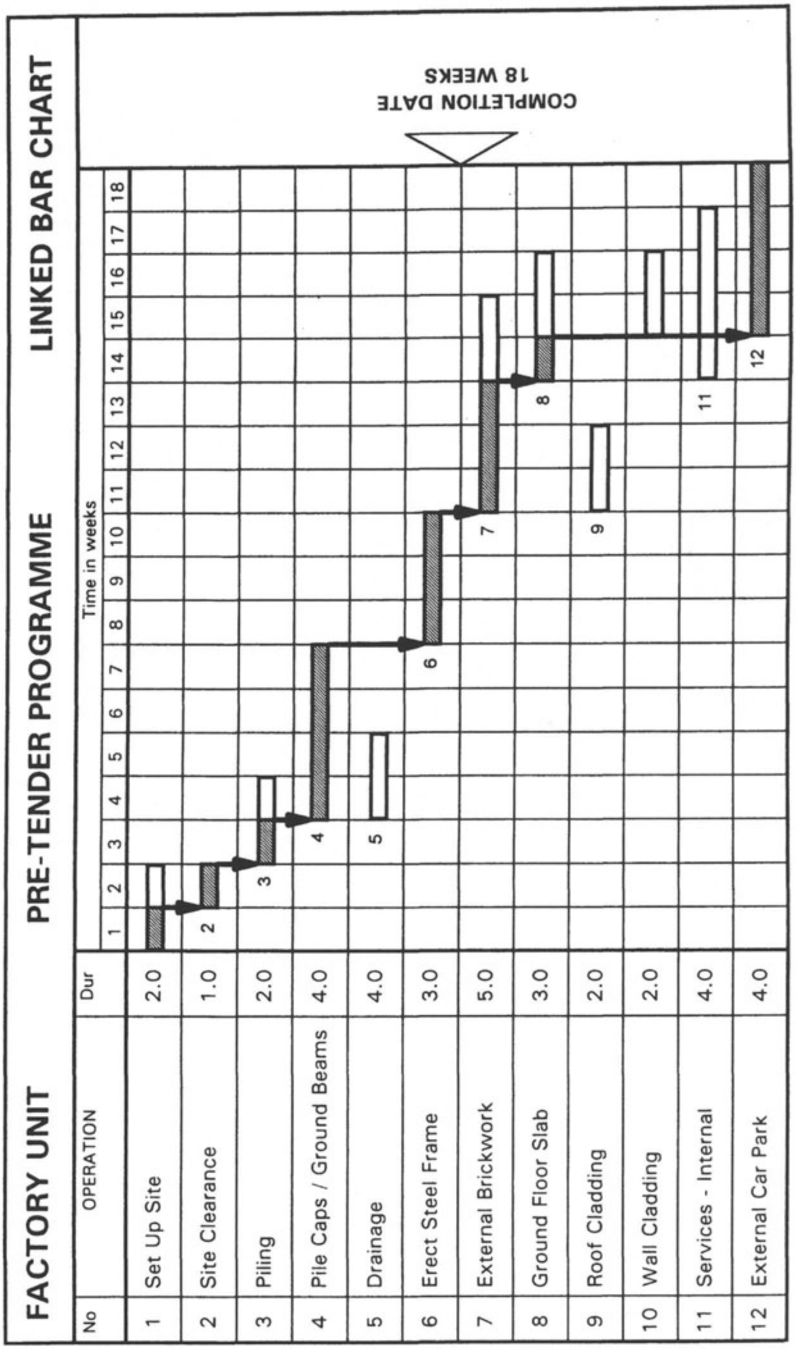

FACTORY UNIT
PRE-TENDER PROGRAMME
LINKED BAR CHART
No
OPERATION
Dur
Time in weeks
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
1 Set Up Site 2.0
2 Site Clearance 1.0
3 Piling 2.0
4 Pile Caps / Ground Beams 4.0
5 Drainage 4.0
6 Erect Steel Frame 3.0
7 External Brickwork 5.0
8 Ground Floor Slab 3.0
9 Roof Cladding 2.0
10 Wall Cladding 2.0
11 Services - Internal 4.0
12 External Car Park 4.0
COMPLETION DATE
18 WEEKS

Figure 4.2

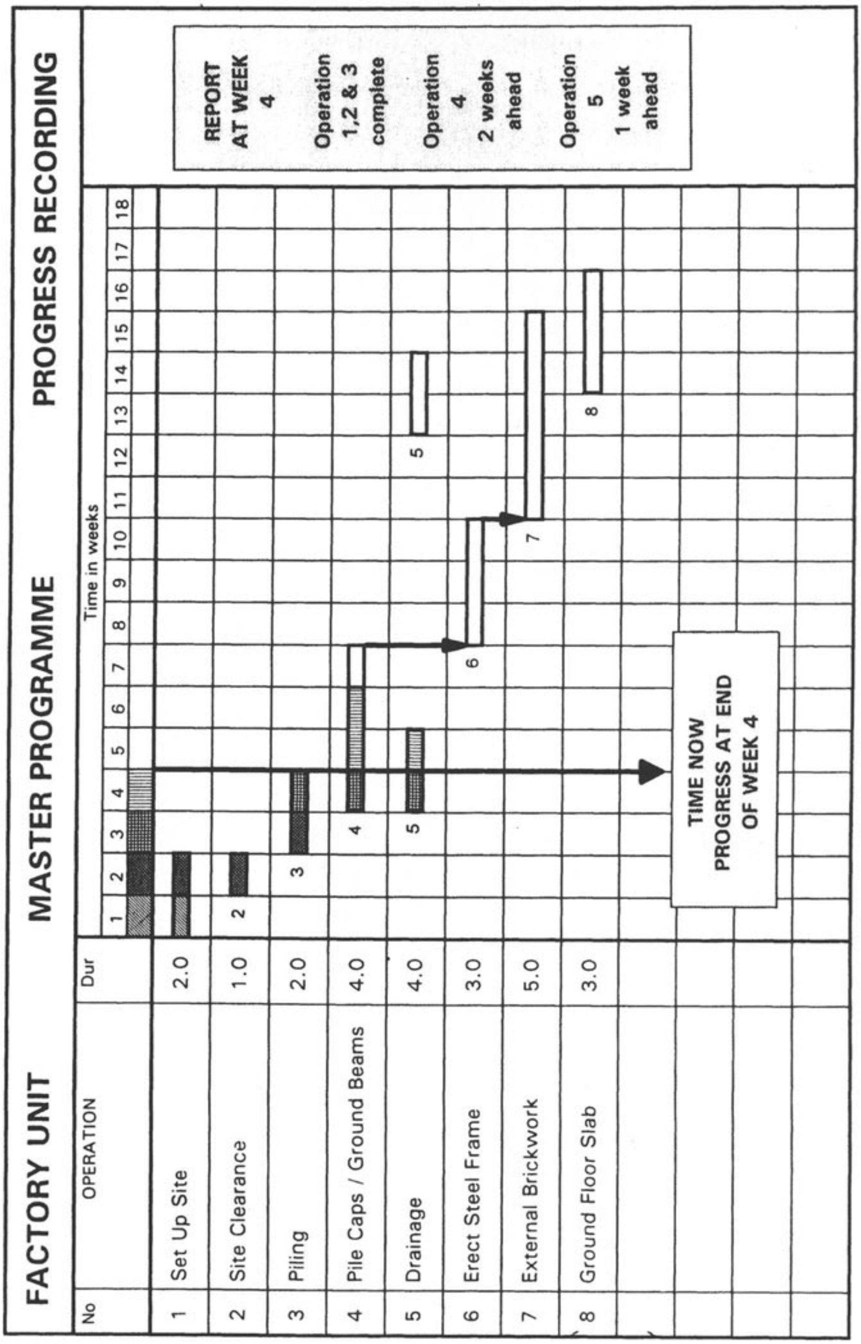

FACTORY UNIT
MASTER PROGRAMME
PROGRESS RECORDING
No
OPERATION
Dur
Time in weeks
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
1 Set Up Site 2.0
2 Site Clearance 1.0
3 Piling 2.0
4 Pile Caps / Ground Beams 4.0
5 Drainage 4.0
6 Erect Steel Frame 3.0
7 External Brickwork 5.0
8 Ground Floor Slab 3.0
TIME NOW
PROGRESS AT END
OF WEEK 4
REPORT
AT WEEK
4
Operation
1,2 & 3
complete
Operation
4
2 weeks
ahead
Operation
5
1 week
ahead

Figure 4.3

- Figure 4.4 illustrates a bar chart depicting the design process operations for a social housing project highlighting the available lead in time prior to the project's commencement.

- Figure 4.5 indicates a programme for the construction stage of the same project. Milestone symbols have been introduced relating to key dates in the procurement process. Symbols of this type may simply be introduced by the planner to relate to any specific event in the procurement cycle.

4.2.2 Application of Bar Charts and Linked Bar Charts

Advantages

- Simple format readily understood at all levels of management.

- Relates clearly to all stages of the planning process: pre-tender/pre-contract and contract planning. Assists in showing the relationship between the pre-tender programme, master programme and short term programmes.

- Clearly relates to the construction sequence - the use of linking on bar charts aids the overlapping of related operations.

- Easily updated at weekly and monthly time intervals for review purposes and progress reports.

- Key milestone symbols may be introduced to highlight critical dates with regard to key contract stages and information requirements.

- Resources may be readily related to the rate of working – labour histograms, value forecasts (value/time), cumulative labour and plant forecasts in the form of project budgets.

- Requirement under the contract – the contractor is usually required to submit a programme prior to commencing work on the project. The programme must be realistic and achievable.

- The 'as built' programme may prove an asset to the contractor in the formulation of contractual claims. The effect of the receipt of late information on programmed operations can be monitered and reported upon. Copies of the contract position at the date of a specific occurrence may provide evidence of the resulting delay.

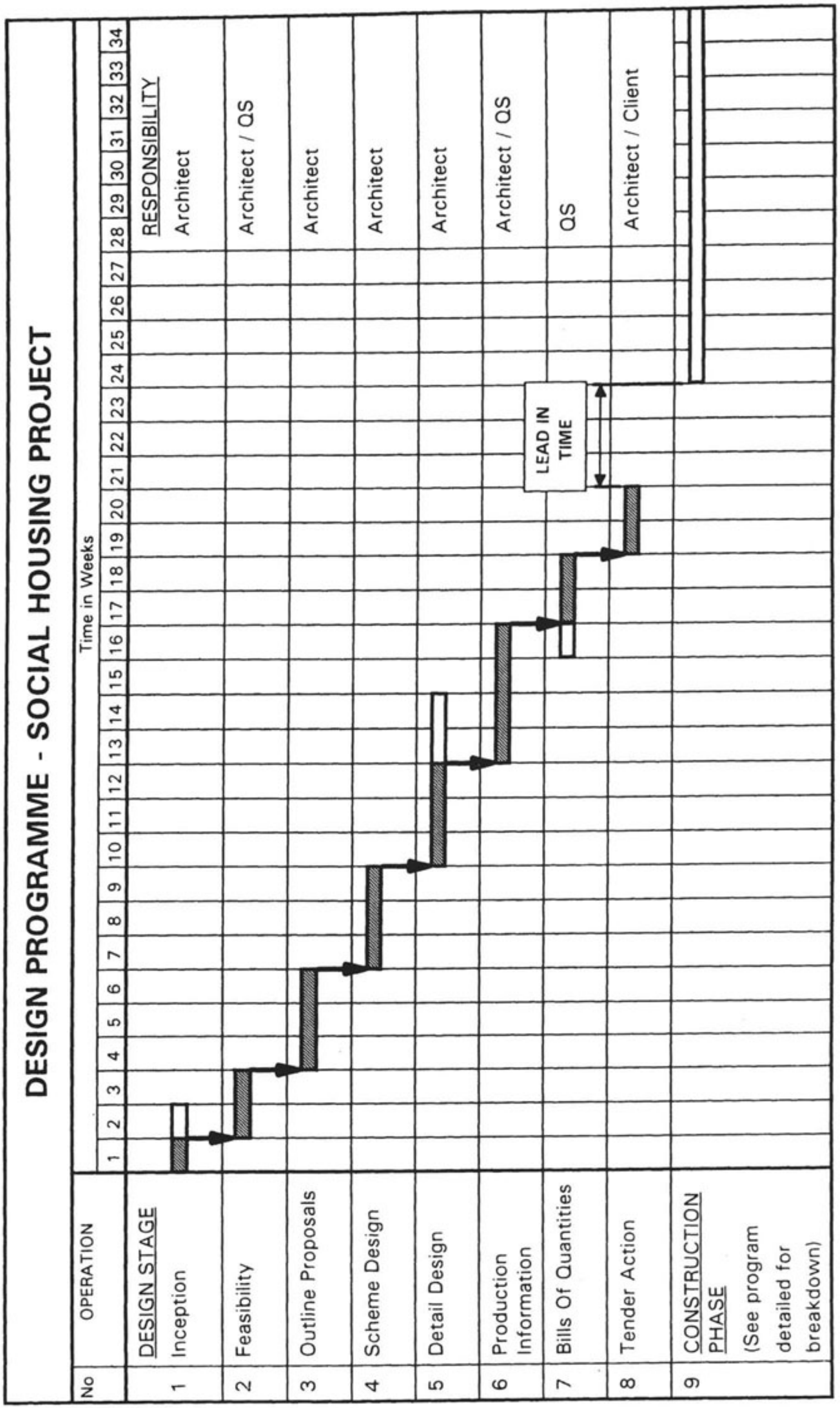

DESIGN PROGRAMME - SOCIAL HOUSING PROJECT
No
OPERATION
Time in Weeks
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
DESIGN STAGE
RESPONSIBILITY
1 Inception
Architect
2 Feasibility
Architect / QS
3 Outline Proposals
Architect
4 Scheme Design
Architect
5 Detail Design
Architect
6 Production Information
Architect / QS
7 Bills Of Quantities
QS
8 Tender Action
Architect / Client
LEAD IN TIME
9 CONSTRUCTION PHASE
(See program detailed for breakdown)

Figure 4.4

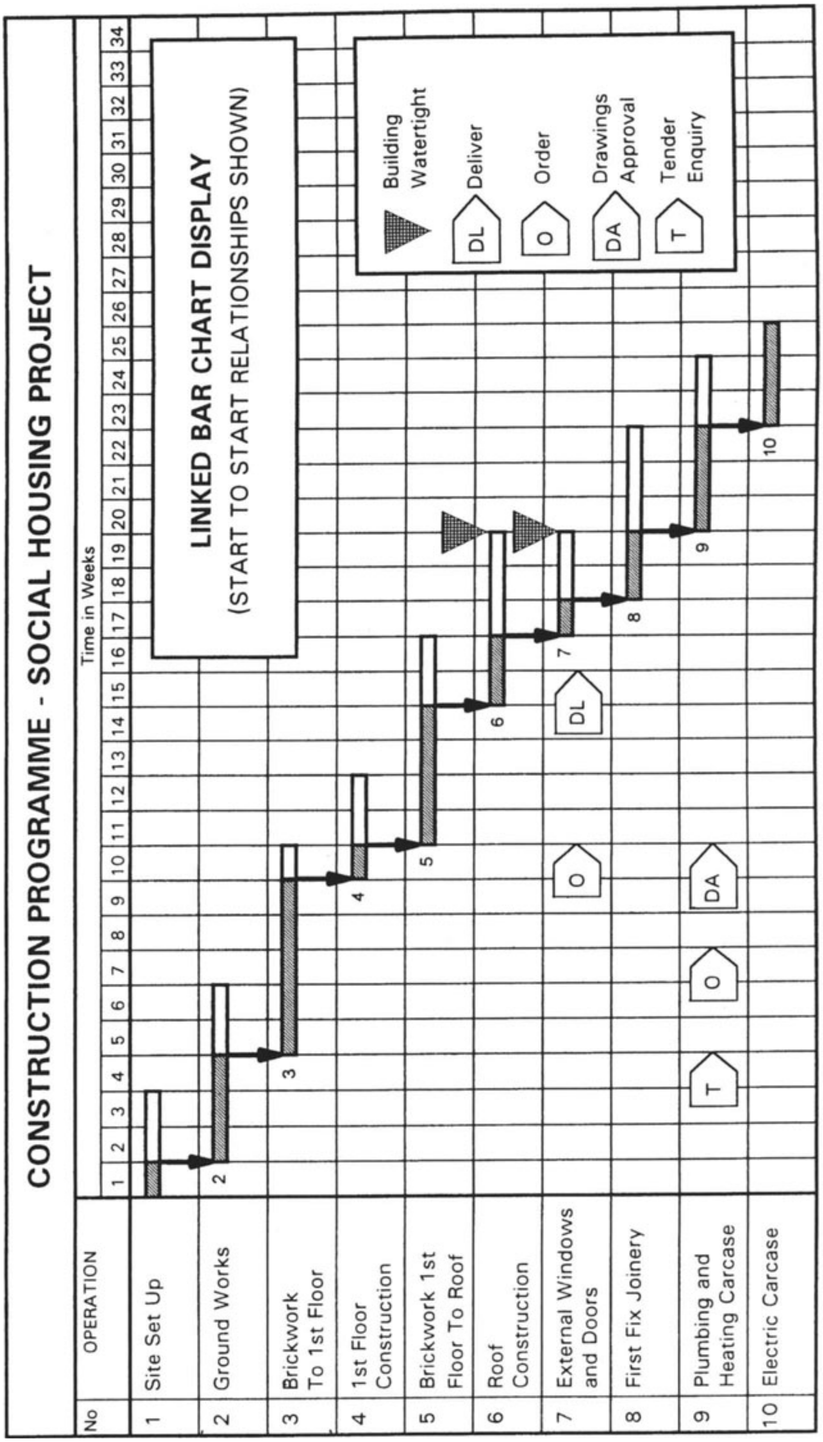

CONSTRUCTION PROGRAMME - SOCIAL HOUSING PROJECT
No
OPERATION
Time in Weeks
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
1 Site Set Up
2 Ground Works
3 Brickwork To 1st Floor
4 1st Floor Construction
5 Brickwork 1st Floor To Roof
6 Roof Construction
7 External Windows and Doors
8 First Fix Joinery
9 Plumbing and Heating Carcase
10 Electric Carcase
2
3
4
5
6
7
8
9
10
T
O
DA
O
DL
LINKED BAR CHART DISPLAY
(START TO START RELATIONSHIPS SHOWN)
Building Watertight
DL Deliver
O Order
DA Drawings Approval
T Tender Enquiry

Figure 4.5

- The programme forms the basis of financial forecasting for both the client and the contractor.

- Symbols and signs may be introduced to aid subcontractor and materials procurement.

Disadvantages

- Does not clearly indicate which operations directly relate to the successful completion of the project. Management by exception therefore cannot be applied to the construction sequence.

- Complex interrelationships cannot be clearly shown.

4.2.3 Use of Bar Charts in Construction Practice

Bar charts are the most commonly used method of depicting relationships between construction operations. They are widely used in small and medium sized construction organisations where company policies dictate the programming techniques to be used. Companies of this size, tend to use the programming method which works for them in practice, and which provides them with a sufficient degree of control. Medium sized companies do not often employ management personnel who sufficiently understand network analysis or precedence formats in order to apply the techniques in practice. Perhaps over the next five to ten years this situation will change, with the growing number of building graduates being produced by universities.

The use of computer software such as Power Project, and other similar drag out bar charts, enables bar chart relationships to be readily developed on the computer screen. Major projects within the larger construction organisations are currently being managed with the aid of such software. The software allows the master programme, stage programmes and short term planning procedures to be linked together to form a comprehensive planning and reporting tool.

4.3 Network Analysis – The Critical Path Method

4.3.1 History and Development of Critical Path Analysis

In 1956, the E.I. du Pont de Nemours Company established a team to study new management techniques relating to the company's engineering functions. One of the first areas to be considered was the planning and scheduling of construction work.

Data was input into a UNIVAC I computer in the form of construction sequences and activity durations in order to generate a schedule of work.

In early 1957, J.W. Mauchley, J.E. Kelley Jr and M. Walker developed the basic principles of CPM (Critical Path Method). A test group was set up to apply the new technique to a chemical plant project in Kentucky. In 1958, Mauchly Associates developed a series of training programmes to spread knowledge and use of the method throughout industry. The development of PERT (Program Evaluation and Review Technique) was originated by the Special Projects Office for the Polaris missile programme.

In the United Kingdom, development work on CPM was undertaken by the Building Research Establishment and a number of papers were published by Nuttall and Jeans in 1960.[2]

The initial applications developed were only suitable for the large complex project, and required the assistance of a mainframe computer to analyse the data. Data input and output data retrieval was slow and difficult to interpret – in fact often the progress situation on the project had often changed by the time the data was analysed and reported upon. Reece[3] in his article on the future of project planning overviews the rise and fall of CPM. The resurgence in the use of CPM in the late 1980s is mainly due to the introduction of the Personal Computer and developments in user friendly project planning software. At the current time the resurgence is continuing with the introduction of Microsoft Windows based software and lower hardware prices. The computer has now become an everyday site tool for both the construction manager and planner alike.

Project management based software is regularly reviewed in the CIOB Construction Computing Journal and some of the software presently available includes:

- C.S Project Professional — Leach Management
- Hornet — Claremont Controls
- Micro-planner Expert — Microplanner International
- Plantrac — Computerline Ltd
- Power Project Professional — Asta Developments
- Primevera — Forgetrack Ltd
- Superproject — Computer Associates

The project management software carries out the time analysis for the programme sequence developed by the planner. This allows the operations to be sorted into priority, thereby enabling the longest duration to be calculated and highlighted as the critical path. The critical path defines the sequence of operations which must be undertaken in order to complete the project in the shortest possible duration.

4.3.2 Application of Critical Path Analysis

Advantages

- Through the discipline of CPM, the user can achieve better planning due to the logical approach undertaken during the development of the construction sequence.
- Identification of critical operations on which effort and resources can be applied aids the contractor's management. This enables 'management by exception' to be applied to critical activities.
- CPM allows the planner to express his ideas in graphical form. Recent developments in project management software allow networking on the screen to be carried out.
- The planner has the facility to assign priorities to labour, plant, material and subcontractor resources to each operation on the network.
- Bar chart analysis aids understanding at site management level for both the contractor and client.
- The effect of changes and variations can be evaluated and time cost optimisation analysis undertaken.
- Cash flow assessments and valuation forecasting information may be output in graphical format and readily updated during the project.
- Using notebook and site-based computers, the progress situation may be speedily analysed, and a variety of management reports made available.

Disadvantages

- The development of a network sequence is mainly based on 'finish to start' relationships and this often does not represent the situation on the project. The relationships which can be developed on precedence diagrams aids the overlapping of related operations.
- After all the man-hours spent on company management training programmes learning to appreciate networks, they have never captivated managers in small and medium sized companies

4.3.3 Use of Networks in Construction Practice

Networks are here to stay, albeit that developments in project management software using precedence presentation formats are slowly taking over from arrow diagram techniques. As construction projects become larger and more complex to plan and manage, project managers and the larger contractors will become increasingly reliant on the computer to undertake project planning tasks and the use of project management software will become the norm.

Computer software programs such as Power Project, CS Project and Project Scheduler, allow precedence and linked bar charts to be developed on the screen.

Powerful notebook computers enable the planner to update site programmes on a Monday morning and have progress reports on the Contract Manager's desk by lunch time.

4.4 Developing an Arrow Diagram

Example Setting up a site compound area

Figure 4.6 indicates the plan of a site compound which is to be set up at the commencement of a project. A schedule of operations has been abstracted from the drawing and listed in the table. The operations or activities have not be listed in any specified order. A practical assessment of the duration of each activity has been made in days.

The basic thought process undertaken in developing a network diagram for the project is as follows:

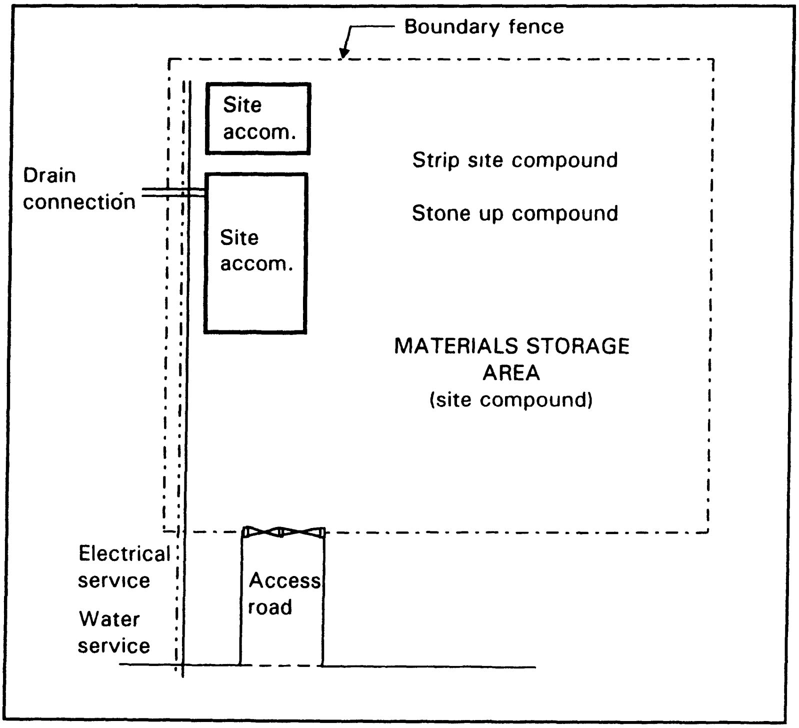
- Stage 1 Preparation of an assessment of the overall construction period.

  This involves a study of the project drawings in order to 'get a feel for the project'. This should include an initial assessment of the overall time period. Ask the question 'Is the overall duration likely to be 3 weeks, 5 weeks or 100 weeks?' If the manager/planner has no experience on which to base his assessment, then he should consult somebody in the organisation who does know.

  Stage 2 Assessment of the construction operations, durations and sequence of work.

  A list or schedule of operations will be drawn up from the project drawings. This should cover in sufficient detail the building sequence appropriate to the stage of planning being carried out. For example a pre-tender programme may only relate to the major operations or work stages, whereas a short term programme will cover more detailed operations or sub-operations.

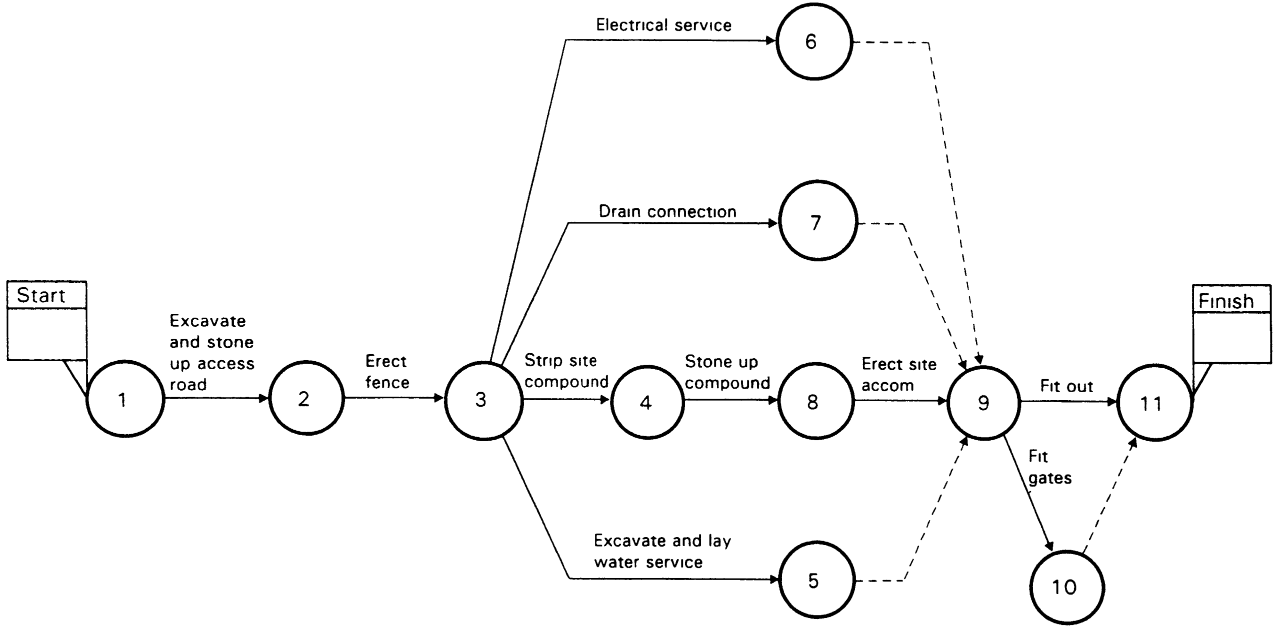
SITE LAYOUT PLAN - ESTABLISHING THE SITE



Operation	Duration (days)
Excavate and stone up access road	3
Erect fence	4
Strip site compound	4
Stone up the compound	2
Erect site accommodation	5
Fit out	5
Electrical service	1
Temporary drain connection	3
Excavate and lay water service	3
Fit gates	1

Figure 4.6

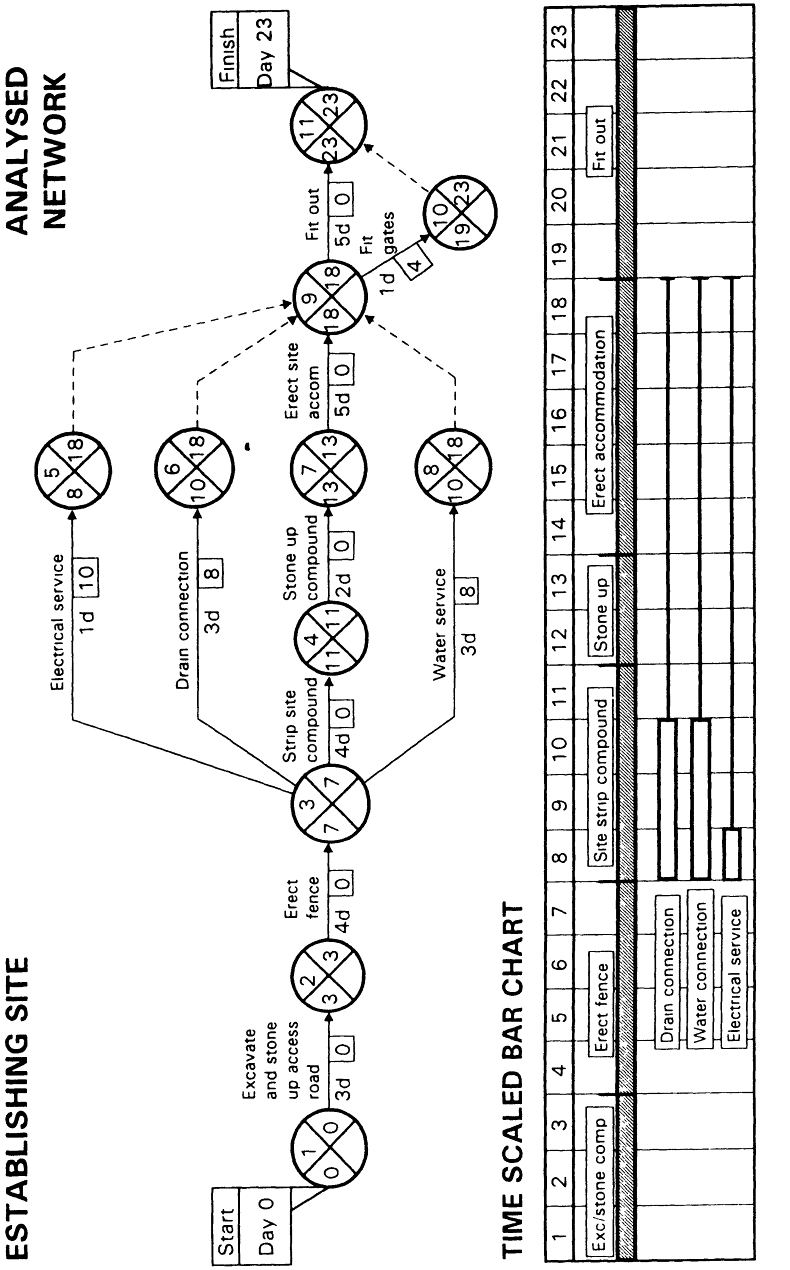
ESTABLISHING SITE



INITIAL NETWORK DIAGRAM
(Doodle diagram)

Procedure - Establish logic
Draft arrow diagram
Enter event numbers

Figure 4.7



ESTABLISHING SITE
ANALYSED NETWORK
Start
Day 0
Excavate and stone up access road
3d 0
Erect fence
4d 0
Strip site compound
4d 0
Stone up compound
2d 0
Erect site accom
5d 0
Fit out
5d 0
Fit gates
1d 4
Electrical service
1d 10
Drain connection
3d 8
Water service
3d 8
Finish
Day 23
TIME SCALED BAR CHART
Exc/stone comp
Erect fence
Site strip compound
Stone up
Erect accommodation
Fit out
Drain connection
Water connection
Electrical service

Figure 4.8

For each operation an assessment should be made of its appropriate duration (in days or weeks). Durations may be based on the experience of the manager/planner or on an analysis of the man-hour allocation in the estimate.

An attempt should now be made to express the operations/activities in the form of an initial arrow diagram (or doodle diagram) in order to commit pen to paper. Figure 4.7 indicates the initial network sequence.

When developing an initial arrow diagram the planner should pose the following questions concerning related operations/activities:

- Which is the first activity in the sequence?
- Which activities must be completed before the next one starts? (finish to start relationship)
- Which activities can be undertaken at the same time?
- Which is the last activity in the sequence?

It is important at this stage that the arrow diagram is based on finish to start relationships and it is important to check the operational logic to ensure that the sequence of construction is correct. It is no good planning to put the roof on a building until all the columns supporting the roof have been erected. Figure 4.8 indicates a redrafted arrow diagram containing all the relevant data:

- event numbers
- earliest event times
- latest event times
- floats
- the identification of the critical path

Below the arrow diagram, a time scaled bar chart has been developed from the analysed data. The presentation of the bar chart in this form allows the critical operations to be presented in a single horizontal bar line, with the non-critical activities grouped together. This approach simplifies the presentation for the understanding of site management personnel.

4.5 Precedence Diagrams

4.5.1 History and Development of Precedence Techniques

Precedence diagrams consist of a series of operational boxes representing a construction sequence, which are linked together by a series of lines which represent the relationships between the operations. They were developed in the early 1970s by the Cementation Company as an alternative approach to network analysis which could more readily be applied to works of a civil engineering nature.

The finish to start limitations of arrow diagrams causes difficulties when, for instance, one activity is required to start before the preceding activity is completed. This either means dividing the preceding activity into smaller parts or introducing a dummy with a time value. This difficulty resulted in the precedence approach being developed which introduced activity boxes rather than activity arrows. The boxes permit a number of different relationships to be expressed between activities which relates more to the real situation on a construction project. These relationships include:

- Finish to Start Relationships
- Start to Start Relationships
- Finish to Finish Relationships
- Start to Finish Relationships

4.5.2 Application of Precedence Diagrams

Figure 4.9 indicates the notation used in the precedence format together with an example illustrating the basic principles of analysing a precedence sequence.

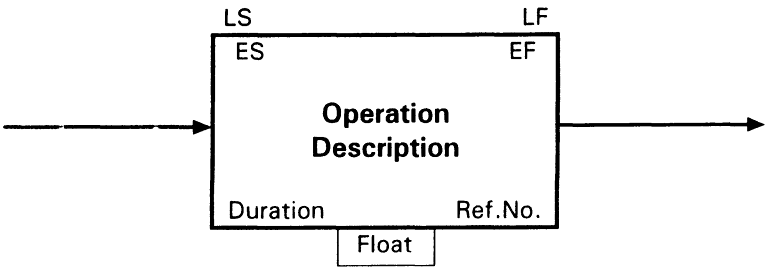
Relationships used when developing a precedence diagram are illustrated in Figures 4.10 to 4.14. These have been illustrated in network, precedence, and bar chart format in order to develop familiarity with the presentation. Similar relationships have also been applied to the principles of linked bar charts as previously shown in Figure 4.1.

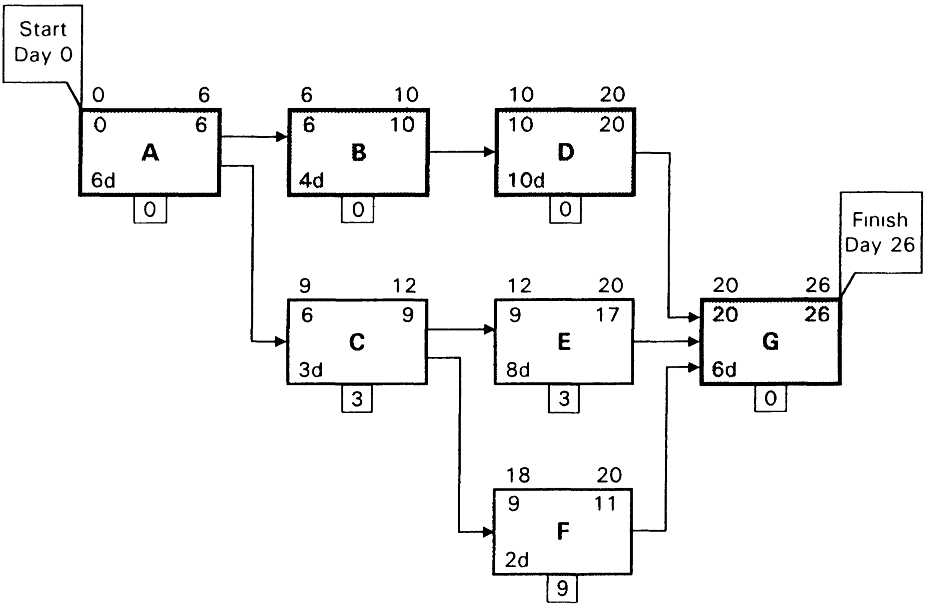
It is important that students clearly understand the relationships between arrow diagrams, precedence diagrams and bar charts so that they can readily be related to the construction process at site level. Using precedence diagrams, dummies are eliminated and the resulting 'number crunching' analysis becomes somewhat simplified. The assessment of the total float for each activity can be readily observed on the diagram by simply deducting the numbers in the corner of the activity box. How simple?

Figure 4.15 illustrates a precedence sequence for the early stages of a factory project. This shows clearly the overlapping of operations such as establishing the site, clearance, piling and the pile cap construction. The example has been used to illustrate start to start, and lag start relationships. The principles used for the analysis of the earliest and latest activity times is calculated when applying the 'forward and backward pass' to the precedence routine.

Various applications of precedence techniques are illustrated in relation to a range of civil engineering projects by Cormican (1985).[4]

PRINCIPLES OF PRECEDENCE DIAGRAMS

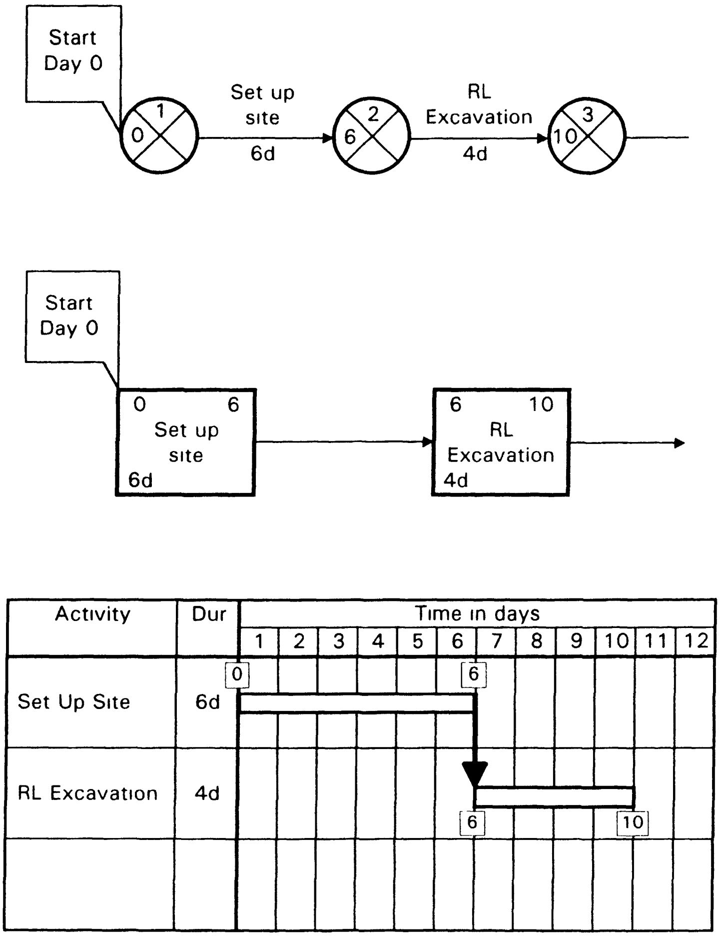




PRECEDENCE NOTATION

Figure 4.9

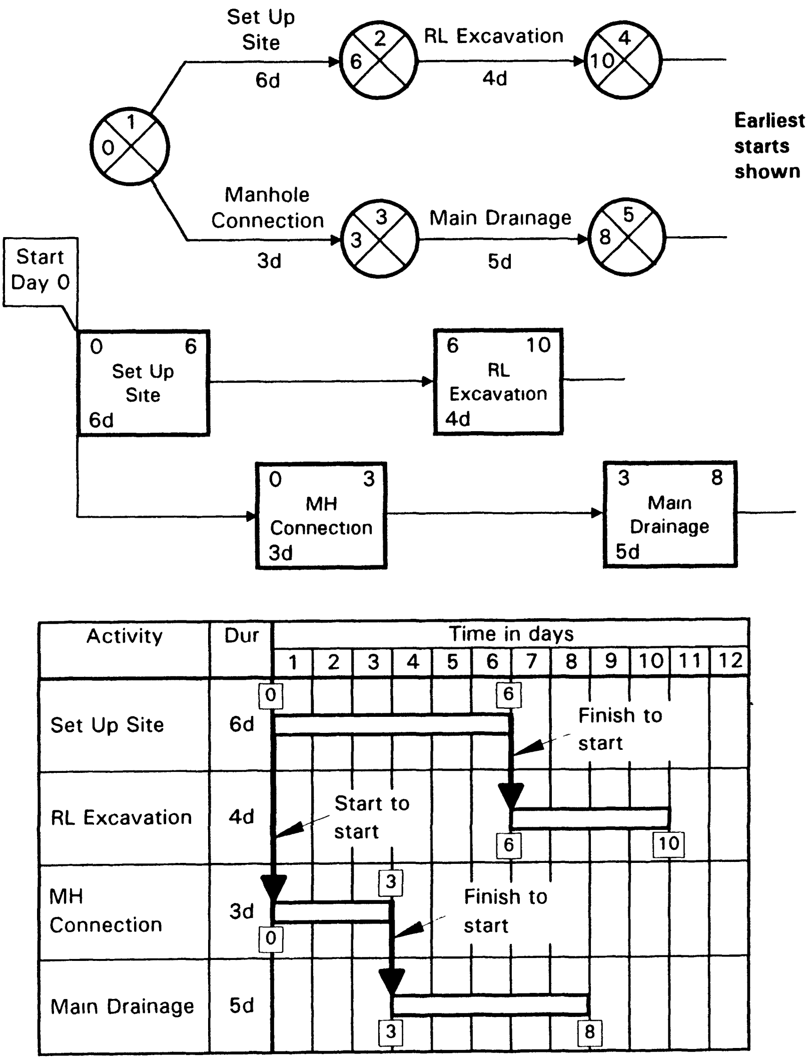
PRINCIPLES OF PRECEDENCE DIAGRAMS
(applied to Factory Project)



FINISH TO START RELATIONSHIPS

Figure 4.10

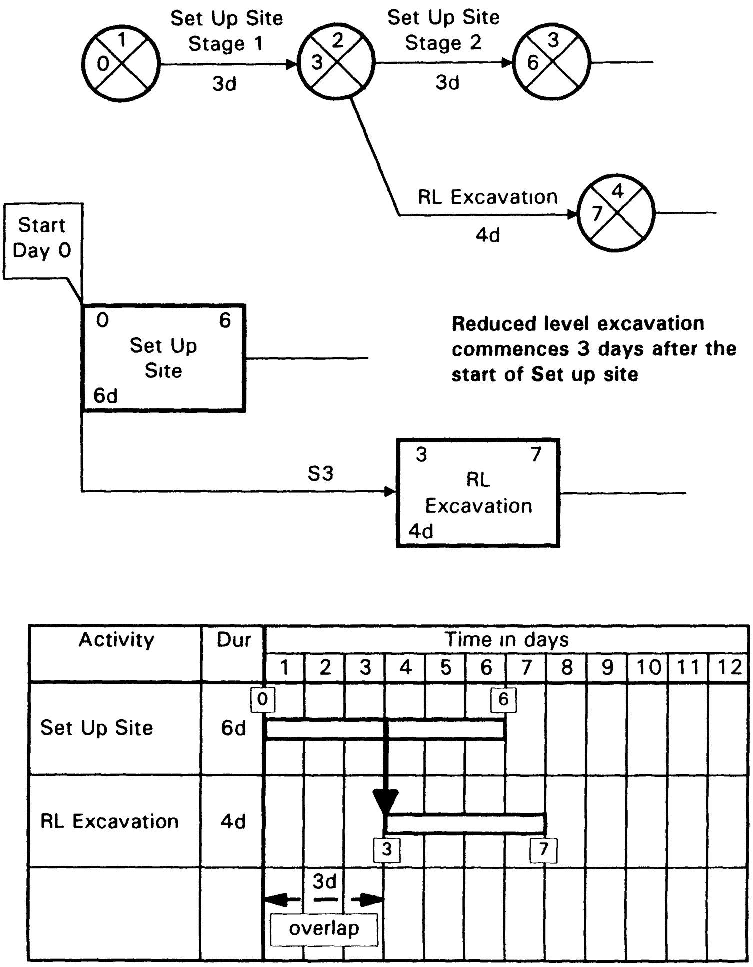
PRINCIPLES OF PRECEDENCE DIAGRAMS
(applied to Factory Project)



START TO START RELATIONSHIPS

Figure 4.11

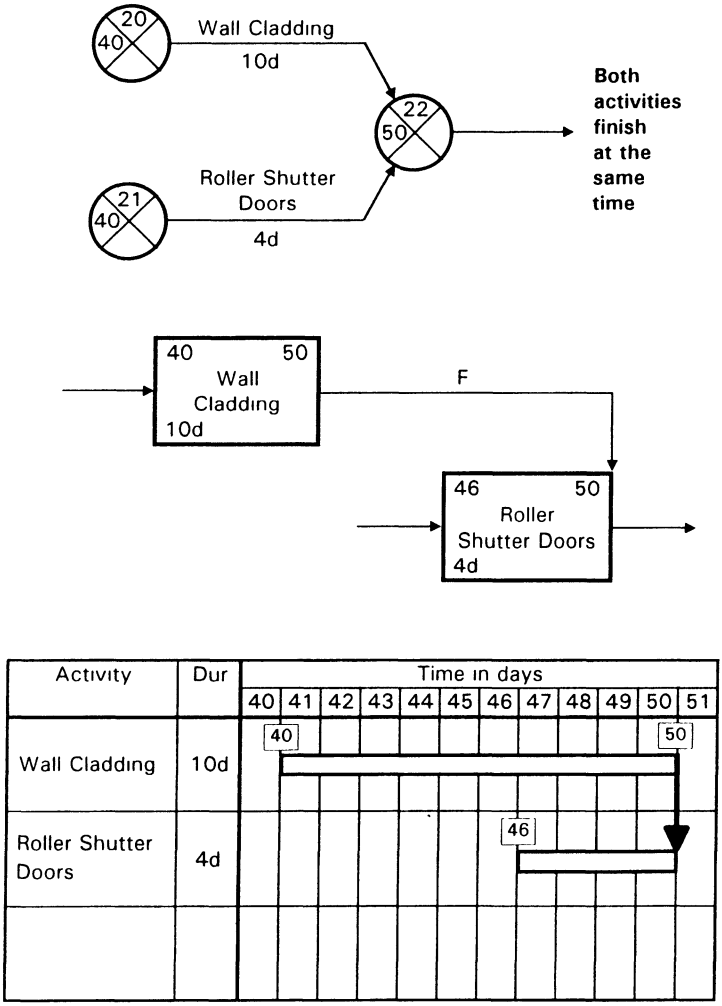
PRINCIPLES OF PRECEDENCE DIAGRAMS
(applied to Factory Project)



START TO START RELATIONSHIPS
(Overlapping Activities)

Figure 4.12

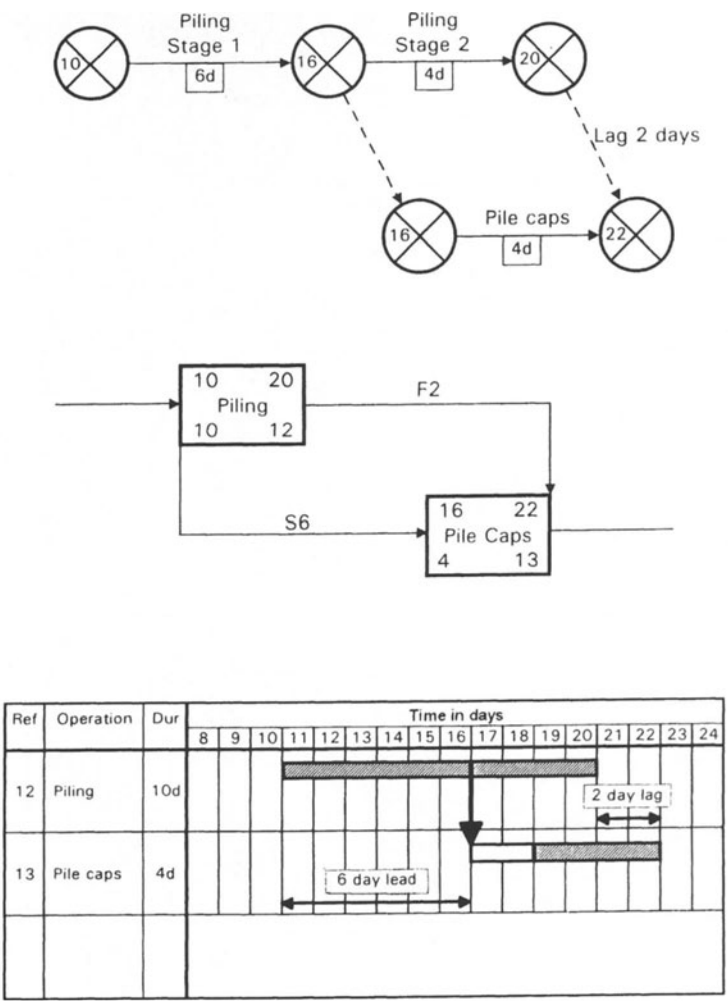
PRINCIPLES OF PRECEDENCE DIAGRAMS
(applied to Factory Project)



FINISH TO FINISH RELATIONSHIPS

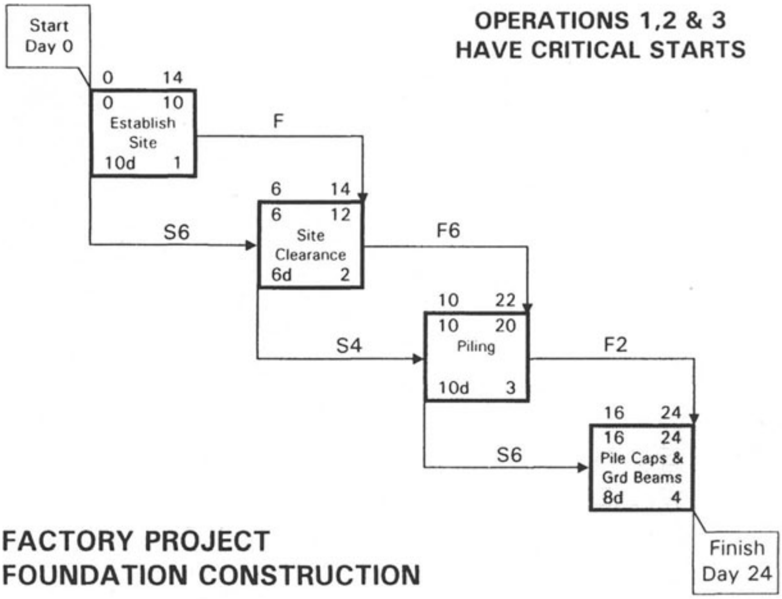
Figure 4.13

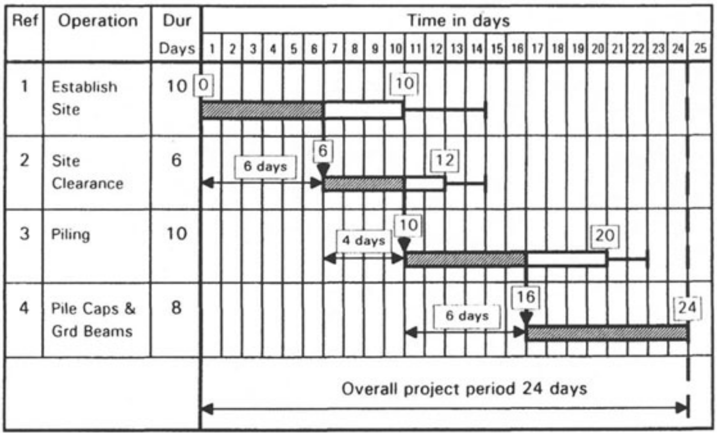
PRINCIPLES OF PRECEDENCE DIAGRAMS



START TO FINISH RELATIONSHIPS

Figure 4.14





BAR CHART DISPLAY

Figure 4.15

4.5.3 *Use of Precedence Diagrams in Construction Practice*

The use of precedence diagrams as a means of expressing construction relationships has now largely replaced arrow diagrams. This is mainly due to the simplicity of linking operations to each other in various ways and the ability to introduce time restraints realistically, conveniently and without over complicating the diagram.

Project management software packages, such as Microplanner Expert, enable a variety of links to be drawn between precedence boxes directly on the computer screen by using the 'drag and drop' technique.

Software is also available which allows the planner/project manager to switch between precedence diagrams and linked bar chart displays in order to see how the overall programme is developing.

Developments in computer software have had a significant impact on the development and understanding of the precedence diagram as a management tool.

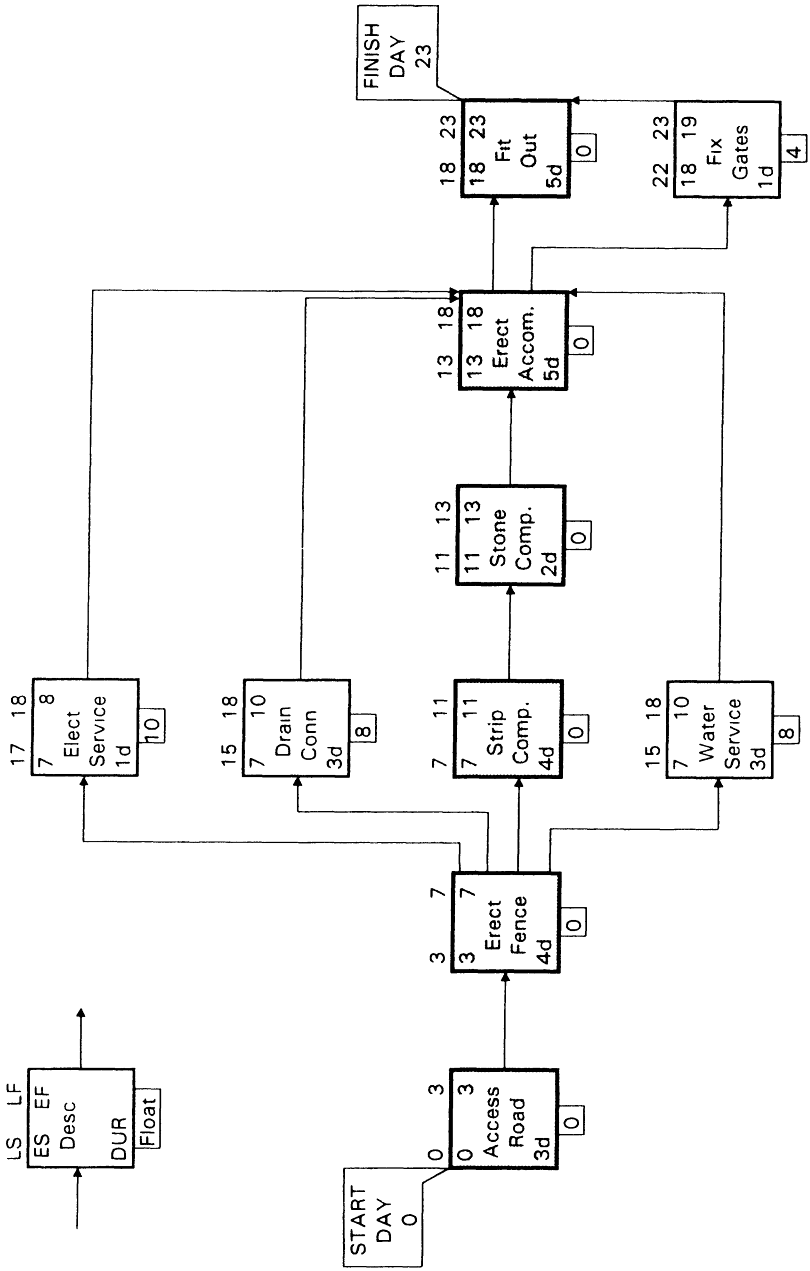
4.5.4 *Developing a Precedence Diagram*

Example **Setting up a site compound area**

Figure 4.16 shows a precedence diagram for establishing the site compound where all the relationships are 'finish to start'.

Start and finish flags have been entered on the diagram and the critical operations have been highlighted. The sequence has been presented in bar chart format in Figure 4.17. Compare this to the 'arrow diagram' approach in Figure 4.8.

Fully worked examples for developing precedence sequences are given in Chapter 10.



PRECEDENCE DIAGRAM - ESTABLISHING SITE

Figure 4 16

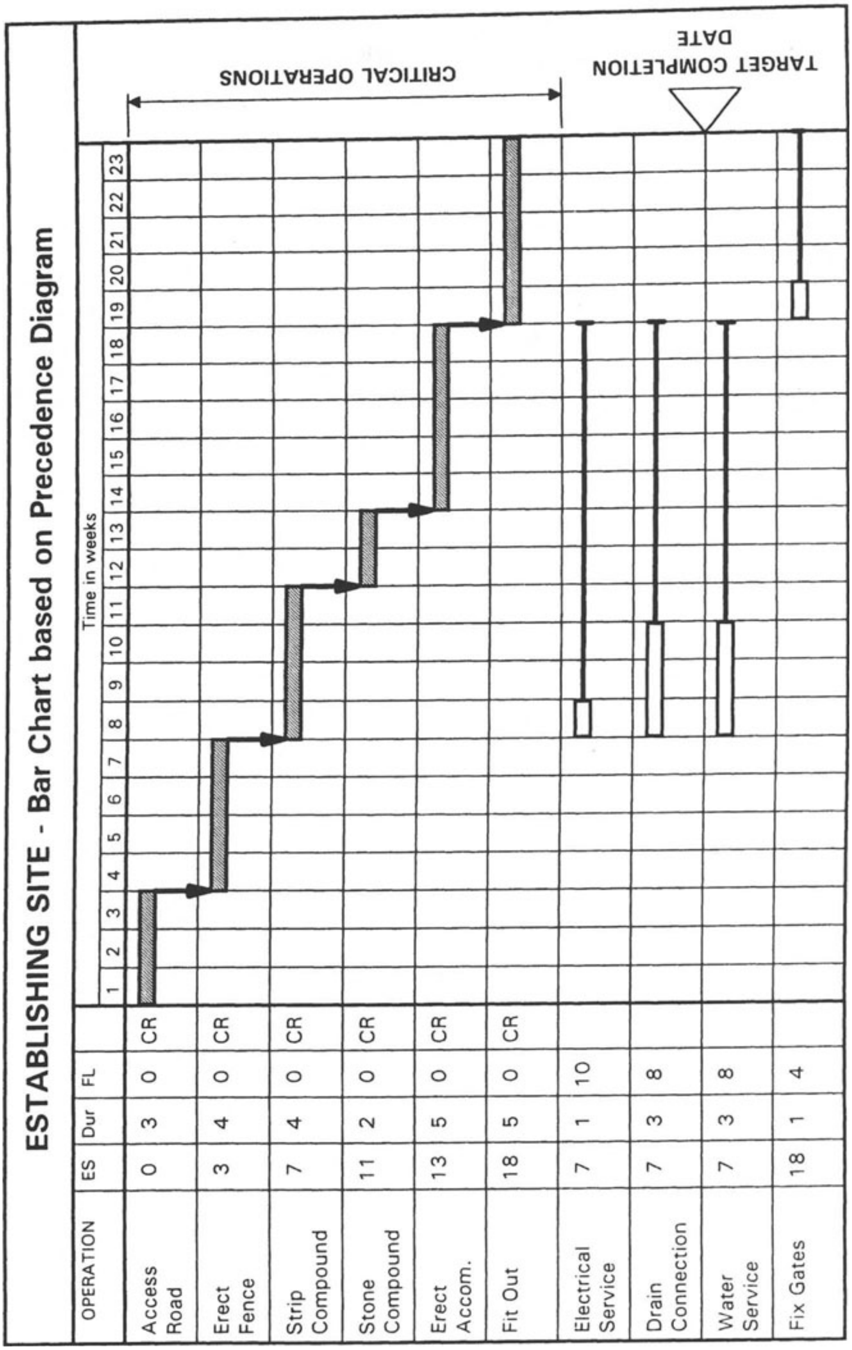

ESTABLISHING SITE - Bar Chart based on Precedence Diagram
OPERATION
ES
Dur
FL
Time in weeks
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Access Road 0 3 0 CR
Erect Fence 3 4 0 CR
Strip Compound 7 4 0 CR
Stone Compound 11 2 0 CR
Erect Accom. 13 5 0 CR
Fit Out 18 5 0 CR
Electrical Service 7 1 10
Drain Connection 7 3 8
Water Service 7 3 8
Fix Gates 18 1 4
CRITICAL OPERATIONS
TARGET COMPLETION DATE

Figure 4.17

4.6 Line of Balance (Elemental Trend Analysis)

4.6.1 History and Development of Line of Balance

A line of balance diagram comprises a series of inclined lines which represent the rate of working between repetitive operations in a construction sequence. This approach was developed by the National Building Agency.

The application of line of balance to construction was pioneered by Lumsden (1965)[5] and became recognised as being the best planning method for repetitive work such as housing.

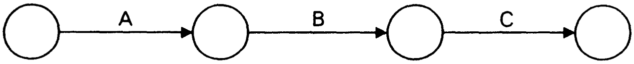
The technique has been widely used for the planning of refurbishment works, new build housing and flats and in recent years the technique has also been applied to civil engineering works as illustrated by Harris and McCaffer (1989)[6] and Cormican (1985).[4] It is not unusual to see bar chart displays incorporating a line of balance diagram to illustrate the programming of any repetitive sections of the works.

Line of balance is a visual display of the rate of working from one operation to another. The ideal line of balance display shows all balance lines running parallel to each other; in practice this is often difficult to achieve.

4.6.2 Application of Line of Balance

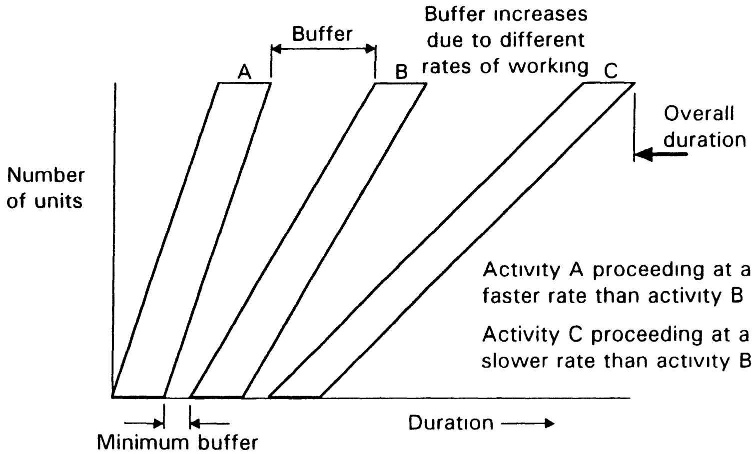
Figure 4.18 illustrates the logic diagram for three operations A, B, and C in a construction sequence. Figure 4.19 indicates the line of balance diagram for different rates of working from one operation to the other. As can be observed from the diagram, operations B and C are out of balance with operation A. By increasing the number of gangs employed on operations B and C the line of balance diagram as shown in Figure 4.20 can be achieved.This results in a considerable saving in the overall project period. Buffers have been introduced at the start or finish of an operation in order to build some degree of flexibility into the programme. This also allows the preceding operation to move clear of the unit before the next operation commences.

Figure 4.21 indicates a logic diagram for a construction sequence where operations B and C may start or finish together, prior to the commencement of operation D. Figures 4.22 and 4.23 illustrate the balance diagrams for these two situations, depending on whether operation B is working at a slower or faster rate than operation C. The principles of calculating the slope of the balance lines will be covered in the worked examples contained in Chapter 10.



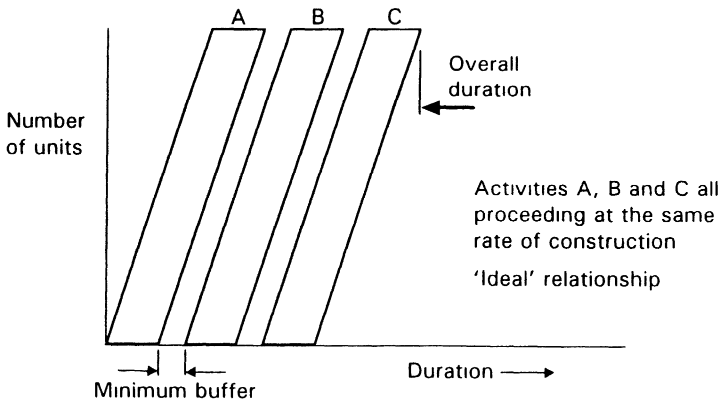
LOGIC DIAGRAM FOR SEQUENCE

Figure 4.18



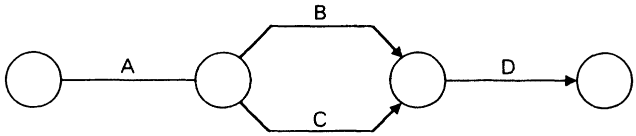
LINE OF BALANCE DIAGRAM - NON PARALLEL WORKING

Figure 4.19



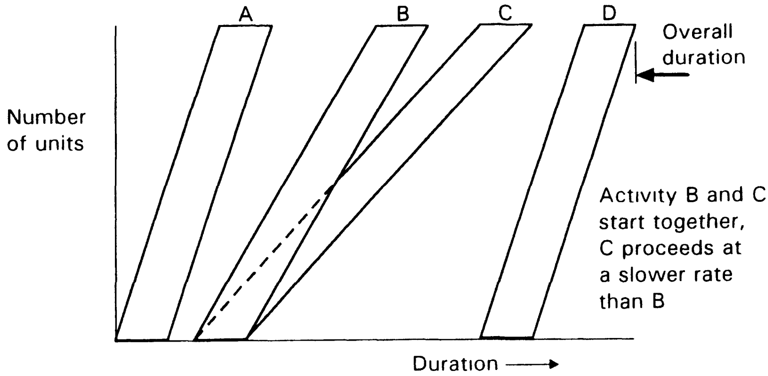
LINE OF BALANCE DIAGRAM - IDEAL RELATIONSHIP

Figure 4.20



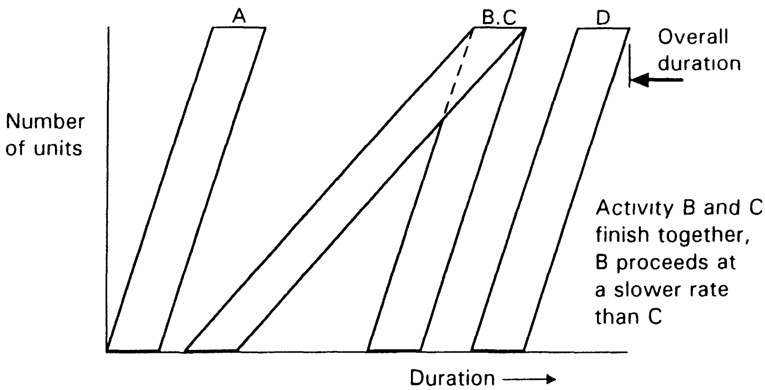
LOGIC DIAGRAM FOR SEQUENCE

Figure 4.21



LINE OF BALANCE DIAGRAM - OPERATIONS B AND C COMMENCING TOGETHER

Figure 4.22



LINE OF BALANCE DIAGRAM - OPERATIONS B AND C FINISHING TOGETHER

Figure 4.23

4.6.3 Use of Line of Balance in Construction Practice

Line of balance principles are rarely understood by construction managers and planners alike. Where it is company policy to use line of balance, then it will be used - but this is only in a small number of companies. Line of balance is only really applicable to repetitive operations on refurbishment and housing projects, and therefore has not the same application range as bar charts or networks.

Line of balance has gained a foothold in a number of the large house building firms where the repetitive part of a construction sequence can readily be integrated into a bar chart programme.

4.6.4 Developing a Line of Balance Diagram

Example **Construction of a reinforced concrete platform**

Figure 4.24 illustrates the plan and section of an elevated access platform. The work involves the construction of six bays of elevated deck together with the associated pile supports and capping beams. The operations are shown in the logic diagram in Figure 4.25.

Operation 1 Install piles
Operation 2 In situ beams
Operation 3 Precast concrete deck

Based on utilising one gang of men on each operation, the line of balance diagram as shown in Figure 4.26 has been developed. The planner/manager is required to consider the most economical proposal for speeding up the project.

From the line of balance diagram it can be observed that operation 2 is out of balance with operations 1 and 3. By increasing the number of gangs on operation 2 (from one gang to two gangs) the balance lines will move into a better overall parallel position.

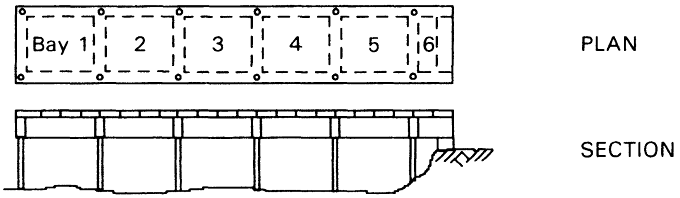
Figure 4.27 indicates the procedure for producing a histogram of labour resources from a line of balance diagram.This is achieved by considering the start and finish date of each of the labour gangs engaged on each operation.

Figure 4.28 indicates the redrawn line of balance diagram using two labour gangs on operation 2. This results in an overall time reduction of some 10 days. The revised labour resources are shown below the line of balance diagram.

Line of balance planning provides a visual display of the rate of working across the whole project and enables decisions to be made in relation to the use of labour. It enables the planner to start with a forecast handover rate per week and then to produce a forecast of the labour resources to achieve it.

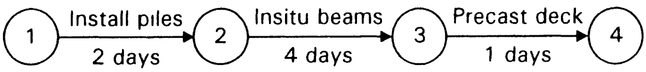
Line of balance programming techniques are still very much underused in the construction industry and only tend to be favoured by those who have a thorough grasp of the principles and application based on experience.

ACCESS DECK PROJECT



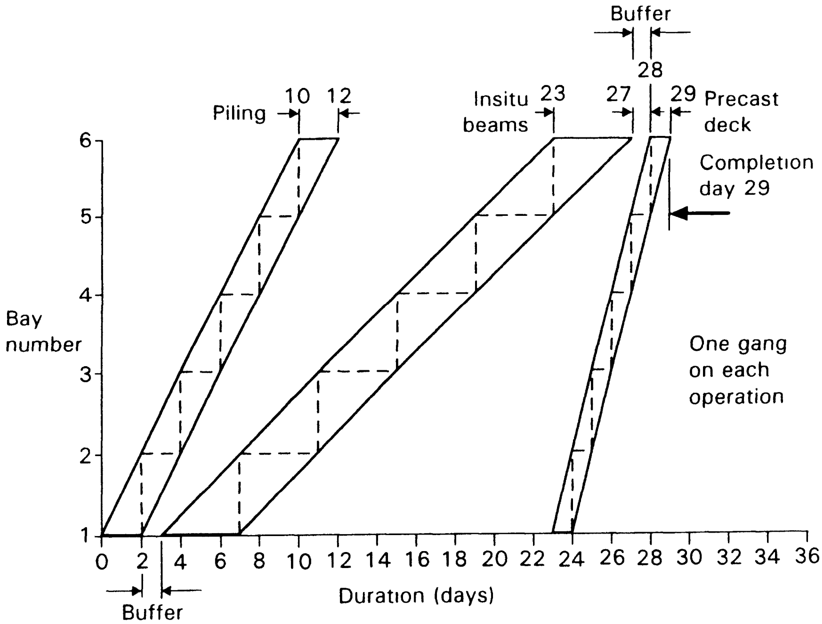
PLAN AND SECTION - REINFORCED CONCRETE PLATFORM

Figure 4.24



LOGIC DIAGRAM

Figure 4.25

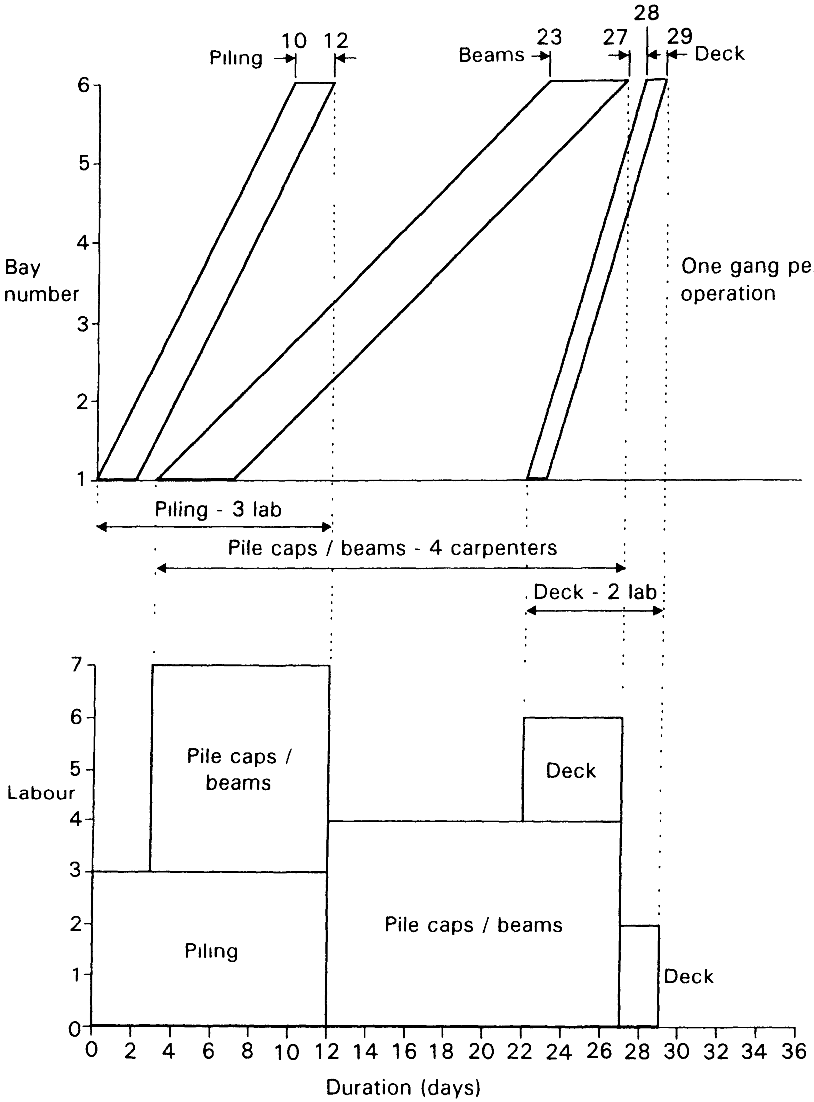


LINE OF BALANCE CHART

LINE OF BALANCE SCHEDULE - REINFORCED CONCRETE PLATFORM

Figure 4.26

ACCESS DECK PROJECT

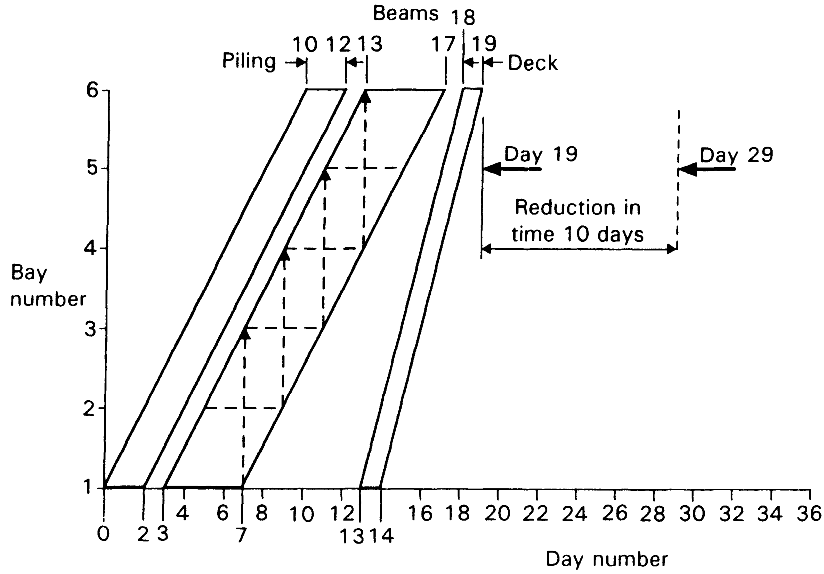


LABOUR RESOURCES - REINFORCED CONCRETE PLATFORM

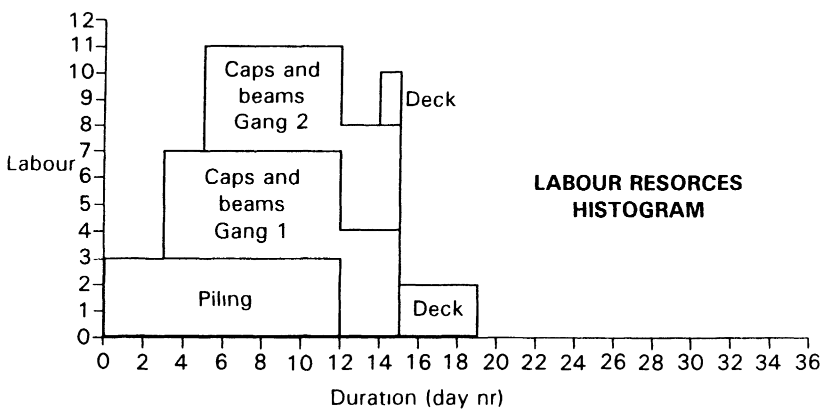
Figure 4.27

ACCESS DECK PROJECT

LINE OF BALANCE CHART BASED ON TWO GANGS WORKING ON BEAMS AND CAPS



REVISED LINE OF BALANCE SCHEDULE



REVISED LABOUR RESOURCES

Figure 4.28

4.7 Time-Chainage Diagrams

4.7.1 History and Development of Time-Chainage Diagrams

In simple terms, the 'time-chainage' diagram, or 'location-time' chart referred to by Cormican (1985), is a combination of the bar chart and line of balance scheduling formats and it is from these programming techniques that time-chainage principles have been developed.

The time-chainage form of presentation enables the time dependencies between activities to be shown together with their order and direction of progress along the job. These diagrams are most usefully employed as a planning tool on projects such as motorways and major highway works, pipelines, railway track work, tunnelling, etc.

Projects of this nature can be viewed as mainly 'linear' in nature. In other words, construction starts at one point and proceeds in an orderly fashion towards another location. This would be typified on a highway project by activities such as fencing, drainage, road surfacing and road markings.

To some extent this type of work calls for a different planning technique because bar charts would not be useful in giving locational information and precedence/arrow diagrams would not reflect the time/location relationship which clearly exists on such projects.

In this respect, most operations take place on a 'forward travel' basis with the gang starting at one point or chainage and moving along the job. As one activity leaves a particular location then other activities can take their place. This ensures the correct construction sequence and avoids over-intensive activity in one location.

4.7.2 Application of Time-chainage Diagrams

Most of the lines on the time-chainage diagram have no appreciable thickness. This is because the time spent by each gang at a particular location is relatively small and the gang moves along the site quite quickly. Examples of this are drainage, road surfacing and safety barrier erection on a motorway.

Retaining walls would also constitute a 'linear' activity but would tend to occupy any particular location (or chainage) for a more appreciable time due to the nature and duration of the construction operations involved.

With earthworks cut and fill operations, the situation is different in that earthworks plant will occupy a particular cut or fill zone for some time before moving to another location.

Bridges, culverts and underpasses, on the other hand, are 'static' operations and can be viewed as individual 'sites' in their own right. Such activities act as restrictions and 'forward travel' activities may have to be programmed around them. For instance on a highway project drainage work may be interrupted by a bridge site and consequently the contractor will have to return later on to finish the drainage once the bridge nears completion.

Various types of time-chainage representations are possible but, basically, the diagram comprises two axes, time and distance with the various activities shown as lines or bars on the chart.

Linear activities are represented with a line or bar which is positioned on the chart to show its commencement and completion chainages and is inclined in the direction of progress at an angle consistent with the anticipated duration of the operation.

A static activity, such as a bridge on a motorway, is represented by a line or thin bar positioned at a particular location or chainage with the duration of the activity expressed by the length of the line or bar.

Activity labels are annotated on the respective line or bar to distinguish one operation from another.

Figures 4.29 and 4.30 illustrate two methods of presentation of time-chainage diagrams. Chainages can either be located on the vertical or horizontal axes with time (usually in weeks) shown on the other axis.

4.7.3 Use of Time-chainage Diagrams in Construction Practice

Time-chainage diagrams have been widely applied on major roadworks projects and in the development of the motorway system in the UK for many years.

The technique was also used for the planning of tunnelling and fixed equipment installation on the Channel Tunnel project and its application is discussed in Proceedings of the Institution of Civil Engineers: The Channel Tunnel (1992).[7]

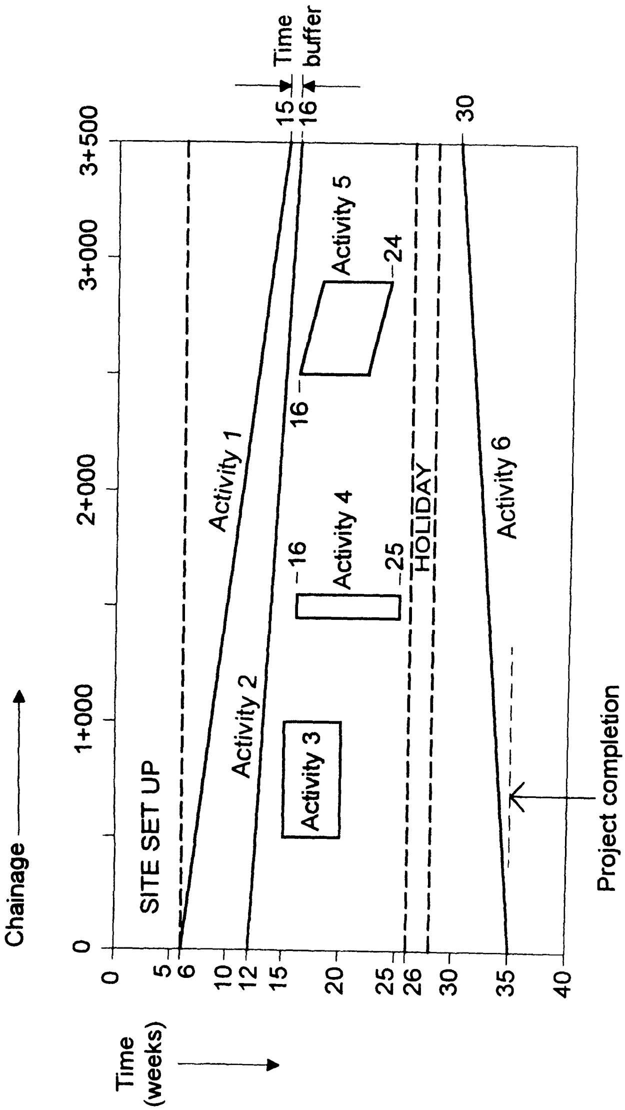
Time-chainage diagrams, like their close cousin, the line of balance, are only applicable for limited types of project and therefore are not as widely appreciated in the industry as bar charts and network techniques. Nevertheless, the technique has distinct attributes and advantages on projects where it is important to depict:

- the order of activities or operations
- where activities are happening locationally
- how activities must progress in relation to direction and distance
- time, key dates and holidays, etc.

4.7.4 Developing a Time-chainage Diagram

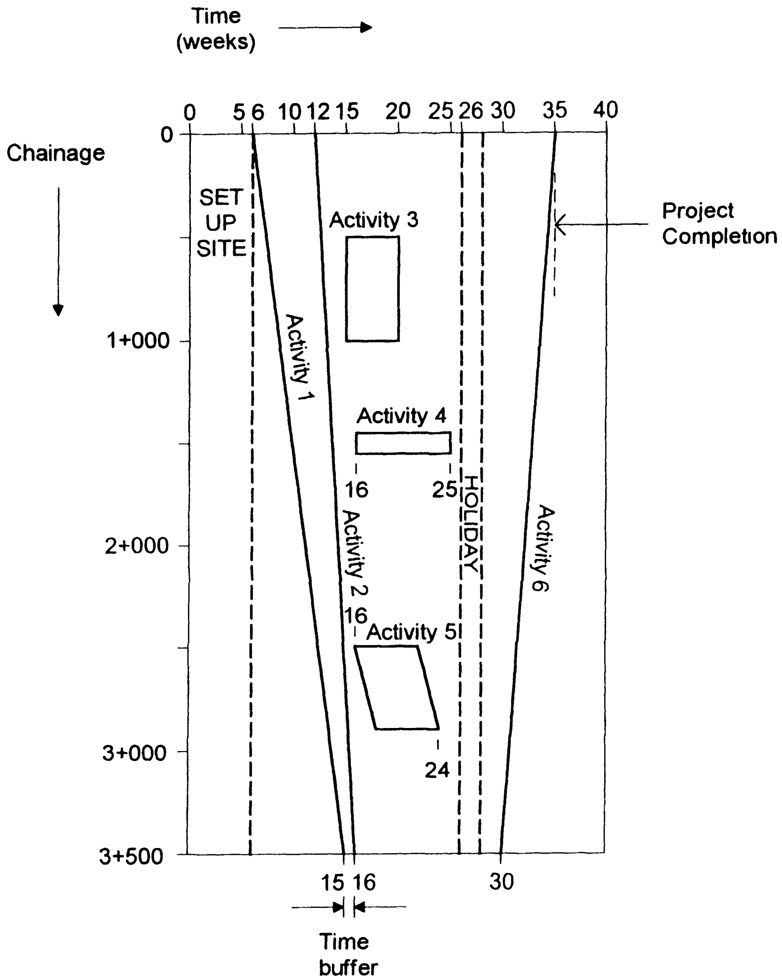
Take, for example, a project to carry out improvements to an existing highway 3.5 km long comprising the following activities:

- Activity 1 Fencing
- Activity 2 Drainage
- Activity 3 Bulk Earthworks
- Activity 4 Footbridge
- Activity 5 Retaining Wall
- Activity 6 Road Surfacing



TIME - CHAINAGE DIAGRAM
Horizontal Format

Figure 4.29



TIME - CHAINAGE DIAGRAM
Vertical Format

Figure 4.30

OPERATION	TIME / LOCATION	EXAMPLE
Set up site	Starts at time 0 Duration 6 weeks	Offices for Contractor and Engineer
Activity 1	Starts at week 6 Duration 9 weeks Finishes week 15 Forward travel up chainage	Fencing
Activity 2	Starts week 12 Duration 4 weeks Finishes week 16 Forward travel up chainage	Drainage
Activity 3	Starts week 15 Duration 5 weeks Finishes week 20 Occupies zone between chainage 0+500 and 1+000 for 5 weeks	Bulk earthworks
Activity 4	Starts week 16 Duration 9 weeks Finishes week 25 Takes place at chainage 1+500	Footbridge
Activity 5	Starts week 16 Duration 8 weeks Finishes week 24 Takes place between chainage 2+500 and 2+900 Forward travel up chainage at the rate of 50 metres per week	Retaining wall
Activity 6	Starts week 30 Duration 5 weeks Finishes week 35 Forward travel down chainage	Road surfacing
Holiday	Starts week 26 Duration 2 weeks Finishes week 28	Christmas shut down

TIME - CHAINAGE DIAGRAMS
Explanation

Figure 4.31

The start of the job is at chainage 0+000 and the project finishes at chainage 3+500. A footbridge is required to cross the highway at chainage 1+500 which would be 1500 metres up chainage from the beginning of the job Distances or locations can be conveniently determined by these 'chainages'.

This 'chainage' referencing system is also useful on site where the contractor will usually position chainage boards along the job and thereby enable anyone to quickly identify exactly where they are on the site.

The advantage of showing chainage along the horizontal axis is that this more readily resembles the way the drawings are laid out and the programme can therefore be more easily related to what has to be constructed. On the other hand, time-chainage diagrams showing time on the horixontal axis may be easier to read by those familiar with bar charts. The choice is a matter of personal preference.

Figure 4.31 explains how the different activities are plotted on the time-chainage diagrams which appeared earlier in Figures 4.29 and 4.30

Close inspection of Figures 4.29 and 4.30 will reveal 'time buffers' between activities similar to those used in line of balance/elemental trend analysis.

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7. The Channel Tunnel Part 1: Tunnels, Proceedings of the Institution of Civil Engineers, Thomas Telford, 1992

5 Establishing Contract Budgets

5.1 Contract Budgetary Control

5.1.1 Definitions

It is an essential function of management to prepare forecasts in order to establish a plan for the future of the business. Without a plan against which to monitor performance, management has no control.

Budgetary control is an important management technique used for the purpose of controlling income and expenditure. Control is achieved by preparing budgets relating to the various activities of the business, and these provide a basis for comparison with actual performance.

A budget may be defined as a monetary cost plan relating to a period of time. It may also be considered as a financial plan for the contract as a whole and presented as a financial version of the programme.

The budget may be expressed in tabular or graphical format such as 'S' curves, line graphs or histogram displays, although in practice managers tend to favour graphical trends as a way of expressing data.

5.1.2 Types of Budget

Harris and McCaffer (1995)[1] identify the various types of budgets which are applicable to a contracting organisations. These include:

- Forecast of company borrowings (working capital requirements)
- Operating budget (staffing, overheads, labour, materials, subcontractors)
- Capital expenditure budgets (plant and equipment, development land)
- Cash flow forecast (movement of moneys in and out of the business)
- Annual sales budget
- Overall master budget

A contractor or developer needs to prepare various budgets relating to his business while a developer/client may prepare a budget relating to future borrowings on a single contract or a number of contracts running concurrently. This may cover an annual period of from one to five years.

A housing developer will prepare an annual sales budget in order to monitor actual sales against a predetermined plan, but a general building contractor on the other hand may be more concerned about forecasting his cash flow. In this case, cash flow budgets would directly help with cash control and also identify working capital requirements. Budgets may also relate to turnover forecasts or the value of cumulative tender enquiries received. Capital budgets lay down the planned requirements for the long term survival of the business.

At 'project' level, contractors need to forecast the amount of work they expect to carry out each month (the value) and what the expenditure on wages, materials and plant, etc. is likely to be (the cost). This facilitates control over payments made by the client under the contract and enables the contractor to assess how the contract is performing financially.

5.1.3 Preparing Budgets

The procedures involved in the preparation of a budget may be divided into five stages:

1. Prepare the forecast
2. Consider the company policy
3. Compute the budget by expressing resources, quantities or values in monetary terms to form the initial budget
4. Review the forecast, policies and the initial budget until an acceptable budget emerges
5. Accept the budget at all levels of management. Ensure that it has the company's backing from the top down.

The budget is now established.

Figure 5.1 indicates the above stages diagrammatically, together with the principles of budgetary control applied to the control cycle for a sales, cumulative value forecast or cash flow budget.

Control procedures must now be established in order to monitor the budget at clearly defined time intervals. This may be daily, weekly, monthly, quarterly or annually.

Management must then take corrective action where variances from the budget occur. Management must act where variances are apparent at each review date, whether they are positive or negative. Any director can shout loud when it is obvious that things have gone wrong. The astute manager is the one who analyses variance trends and applies decisive action at the appropriate moment in time.

The application of variance analysis forms part of the budgetary control process and examples of the analysis of contract variances are illustrated in Chapter 7.

BUDGETARY CONTROL PRINCIPLES

STAGES IN PREPARING A BUDGET

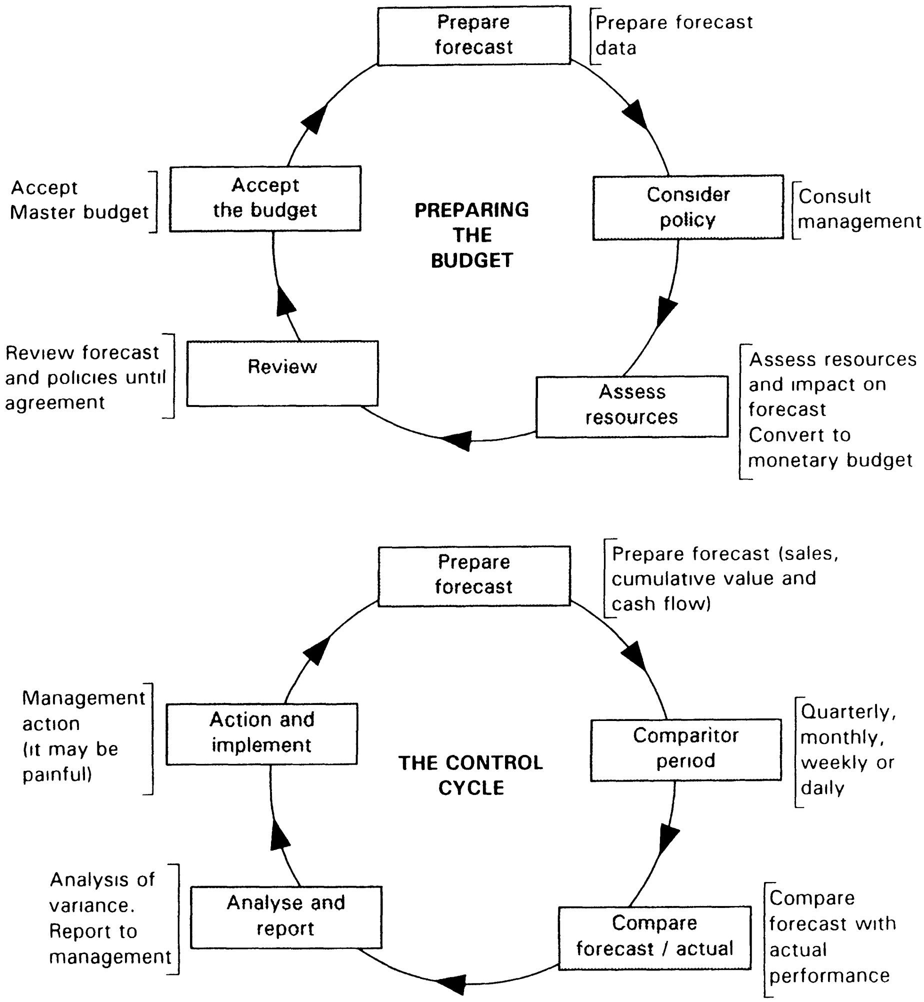


Figure 5.1

Variance analysis is the matching of actual performance with the forecast in order to assess the 'difference', whether it be positive or negative. It is the responsibility of management to highlight variances, report on the findings and implement action, the effect of which may often prove to be painful to subordinates. Failure to meet targets may have a damaging effect on morale within the organisation and clearly questions will be asked about the initial forecasting approach and methodology.

An easy way out at this stage is for management to simply admit that the forecast was wrong and to discharge the person responsible for preparing it! This is the usual escape route and gives everyone the impression that decisive action has been taken.

For budgetary control to be an effective tool in the management of the business, forecasting must be realistic and achievable.

5.2 Forecasting Contract Value

When assessing the financial requirements of a project, or a number of projects to be undertaken over an annual period, the contractor must ask the following questions:

- What is the basis of the forecast?
- What is the basic information required?
- How does timing affect the monetary requirements?
- How accurate does the forecast need to be?
- How does the contractor monitor the cash requirements during the project?
- Will the budget information will help to convince lenders that the cash funding requirements have been realistically thought through? (A slick presentation at this stage may help, but this is doubtful!)

Various techniques are available to help but their usefulness depends upon what stage has been reached and the information available. An overview of these methods of forecasting funding requirements will now be outlined.

5.2.1 The 'Good Guess' Method

This method is often used as a last resort when all else has failed to produce a satisfactory forecast. With practice and experience, preparing forecasts based on intuition may produce acceptable results.

All too often though, 'Well I guessed it' is the excuse given by the surveyor who is unable to substantiate his forecast.

5.2.3 'S' Curves

Various types of 'S' curves are available upon which to base a cumulative value forecast. The quarter third approximation is a geometric curve which has been found to give a reasonable assessment of value, while other approximations, based on the 'ogee' curve give a similar range of cumulative values.

The 'S' curve is best applied to projects where the provisional sums are evenly spread though the contract, as the technique does not allow for high expenditure provisional items early in the project period.

Figure 5.2 illustrates the basic principles of the quarter third approximation and Figure 5.3 indicates the cumulative values forecast using this method for a contract of 6 months duration and a value of £160 000.

5.2.4 Cumulative Percentage Value

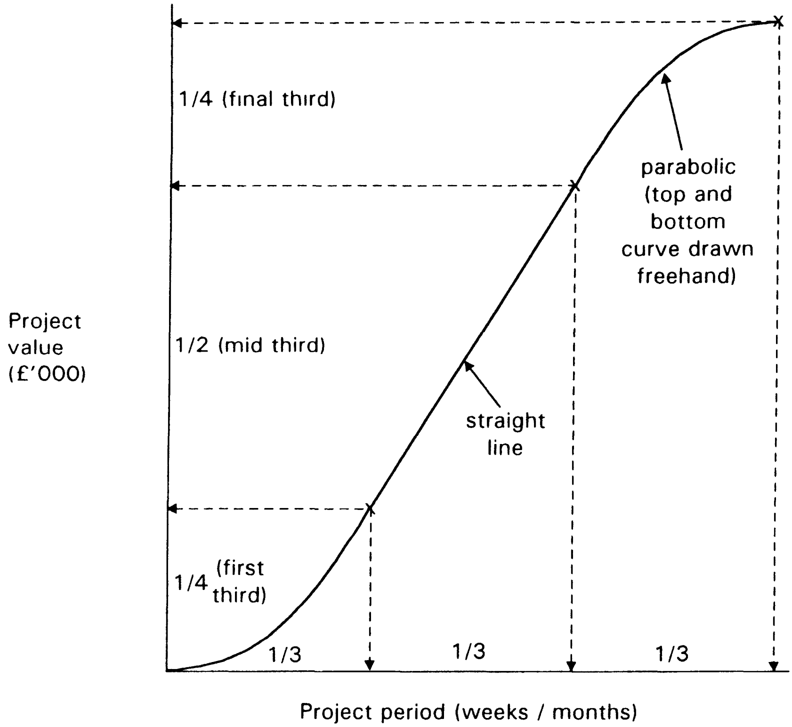
This method involves preparing a forecast of the cumulative percentage value per month based on data analysed from similar types of project. The purpose is to produce a reasonable 'S' curve approximation at the feasibility or tender stage of the project.

The method is illustrated in Figure 5.4 which indicates a tabular display of the cumulative percentage value forecasts for projects up to 12 months in duration. Data is abstracted for a contract of £160 000 in value and of six months duration by choosing the project duration along the top scale and reading off the estimated percentages vertically (see Figure 5.5).

This approximation gives a slightly lower cumulative value forecast than the quarter third method as has been shown by comparing values and curve profiles in Figure 5.5. The tabular display in Figure 5.4 is ideal for displaying as a spreadsheet model, as this allows the analysis to be speedily undertaken and displayed in line graph form.

The idea of percentage value analysis relative to time may be developed by collecting empirical data for different types of projects, e.g. schools, housing, factory and office type developments. In this way a series of different 'S' curve profiles may be developed for forecasting the cumulative project values at feasibility and tender stages.

S CURVE APPROXIMATION
1/4 - 1/3 RULE



PRINCIPLES

1/4 Value expended in first 1/3rd of project period

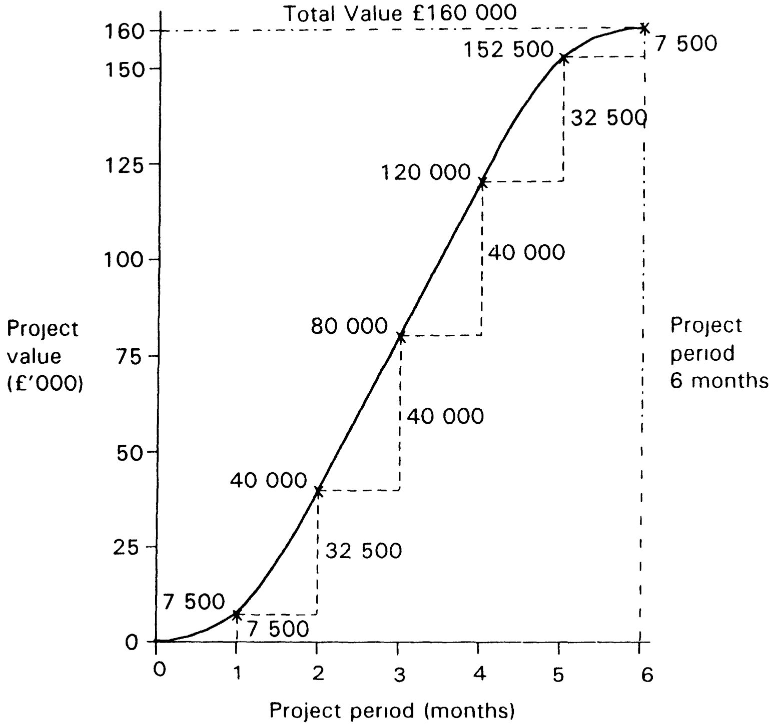
1/2 Value expended in middle third

1/4 Value expended in final 1/3rd of project period

Figure 5.2

S CURVE PRESENTATION

Project Value £160 000
Contract period 6 months



VALUE FORECAST (Cumulative)			
Month	Cumulative value	Month	Cumulative Value
1	7 500	4	120 000
2	40 000	5	152 500
3	80 000	6	160 000

Figure 5.3

PROJECT PERIOD (months)

MONTH	1	2	3	4	5	6	7	8	9	10	11	12
0	0	0	0	0	0	0	0	0	0	0	0	0
1	100	45	24	18	12	9	7	6	5	5	4	3
2		100	76	45	30	24	18	14	12	11	9	7
3			100	79	60	45	35	27	23	20	1‾	13
4				100	82	67	55	45	37	31	27	22
5					100	85	72	63	53	45	38	33
6						100	88	77	67	59	51	45
7							100	90	80	72	64	56
8								100	92	83	75	66
9									100	92	85	76
10										100	93	85
11											100	93
12												100

Cumulative % value complete forecast

HOW TO USE

Read off cumulative % value relative to contract duration

ie 6 month contract

CUMULATIVE VALUE

Month	Cumulative %
1	9
2	24
3	45
4	67
5	85
6	100

Figure 5.4

CUMULATIVE VALUE FORECAST

Contract Value £160 000
Contract Period 6 months

Cumulative Value Forecast (from % graph)

Month	Cumulative %	Cumulative Value	Compared with 1/4 - 1/3rd
1	9	14 400	7 500
2	24	38 400	40 000
3	45	72 000	80 000
4	67	107 200	120 000
5	85	136 000	152 500
6	100	160 000	160 000

COMPARISON OF 1/4 - 1/3rd WITH % VALUE FORECAST

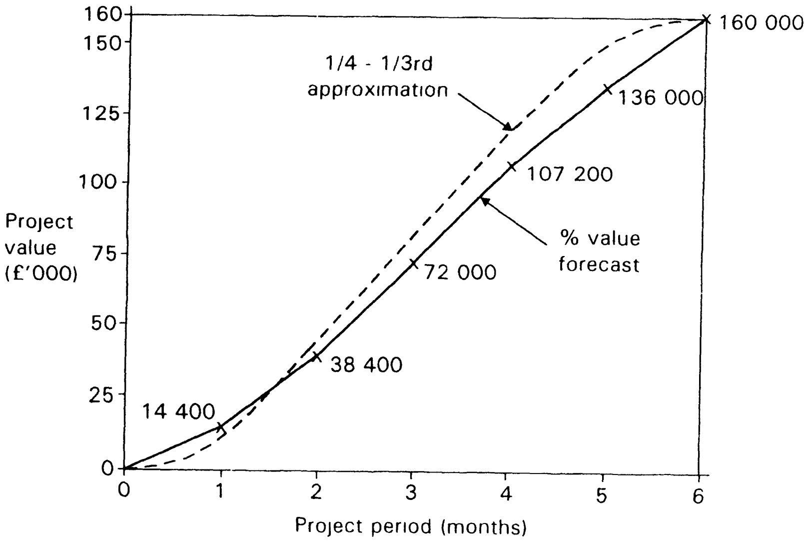


Figure 5.5

5.2.5 Using the Bar Chart Programme

The bar chart programme may be used as the vehicle for expressing the rate of value accumulation during the project. This may be achieved by analysing the contract estimate into an operational format in order to allocate the moneys to a linear time scale on the bar chart.

As the project develops and further information becomes available, a more realistic cumulative value forecast may be prepared from the pre-tender programme or master programme. This enables the value forecast to be directly linked to the sequence of construction operations. The cumulative value forecast is therefore better prepared at this stage of the project as it provides a tool for controlling the project. At monthly time intervals, the actual cumulative and forecast values may be matched as part of the company's monthly cost reporting procedures. The cumulative value forecast may also be used for assessing the client and contractor's cash funding requirements. It is often a requirement of the tender submission that a cumulative value forecast is provided at the tender stage of the project in order to assist the client's assessment of his funding requirements.

Figure 5.6 illustrates a bar chart for a factory development project showing the weekly and cumulative forecast values at each of the planned valuation dates. A cumulative value/time forecast based on the programme is shown in Figure 5.7 If the relationship between value and time is represented by a nearly straight line, as in this case, then so be it. The cumulative value forecast normally follows the basic S curve, except where high values are expended on such items as erecting steelwork early in the project period.

It must be pointed out at this stage that the cumulative value forecast is only as good as the accuracy of the planning forecast. If the planning is too ambitious, then so will the resulting value forecast. It is the responsibility of management to overview the budget forecasts and ensure that they are attainable. All levels of management thrive on achieving success and meeting targets. The achievement of budget forecasts during a project helps in establishing a team approach to ensuring a successful project.

5.3 Forecasting the Contractor's Income

Figure 5. 8 indicates the principles of assessing the payments to be made to the contractor at the end of each payment period. The final payment is released to the contractor at the end of the defects period. The histogram display included below the line graph allows the monthly payment sums to be more cleary presented

The forecast of income from the contract valuations and the release of the interim payment certificate to the contractor are dependent upon the payment terms contained in the various forms of contract.

FACTORY PROJECT - BAR CHART PROGRAMME - CUMULATIVE VALUE FORECAST

OPERATION	BUDGET	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		Time in weeks																			
Establish	5 000	5																			
Piling	10 000		10																		
Caps & G.Beams	21 000			7	7	7															
Drainage	6 000		2	2	2																
Erect frame	20 000						10	10													
Roof cladding	14 000								7	7											
Ext. brickwork	30 000									6	6	6	6	6							
Floor slab	12 000													4	4	4					
Internal services	20 000															5	5	5	5		
External works	16 000																	4	4	4	4
Preliminaries	10 000	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Weekly value (£'000)		5.5	12.5	9.5	9.5	7.5	10.5	10.5	7.5	13.5	6.5	6.5	6.5	10.5	4.5	9.5	5.5	9.5	9.5	4.5	4.5
Cumulative weekly value		5.5	18.0	27.5	37.0	44.5	55.0	65.5	73.0	86.5	93.0	99.5	106.0	116.5	121.0	130.5	136.0	145.5	155.0	159.5	164.0
Monthly value					37.0				73.0				106.0				136.0				164.0
Valuation periods					1 →				2 →				3 →				4 →				5 →

20 week Project period

Project value £164000

Figure 5.6

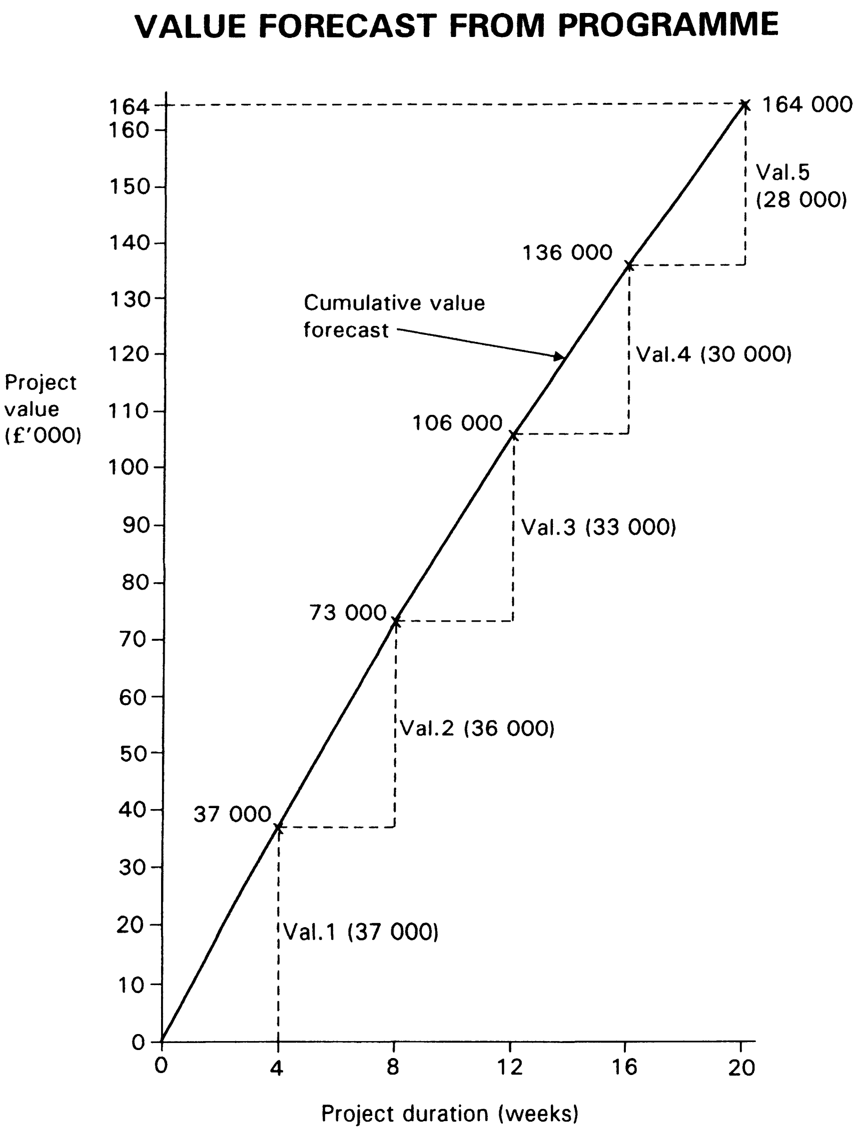
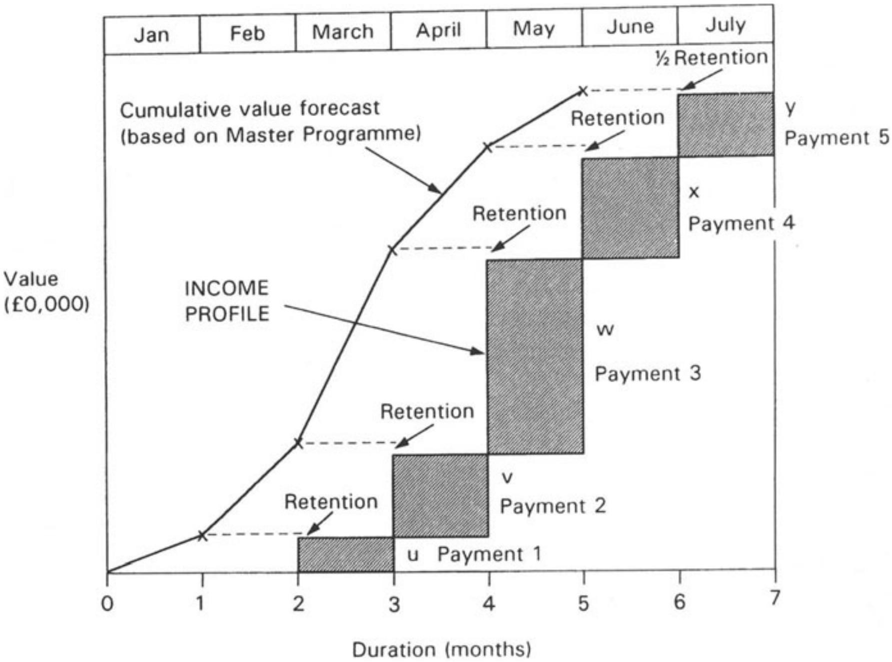

VALUE FORECAST FROM PROGRAMME
164
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Project
value
(£'000)
164 000
Val.5
(28 000)
136 000
Cumulative value
forecast
Val.4 (30 000)
106 000
Val.3 (33 000)
73 000
Val.2 (36 000)
37 000
Val.1 (37 000)
0
4
8
12
16
20
Project duration (weeks)

Figure 5.7

PRINCIPLES OF FORECASTING MONTHLY PAYMENTS DUE TO CONTRACTOR



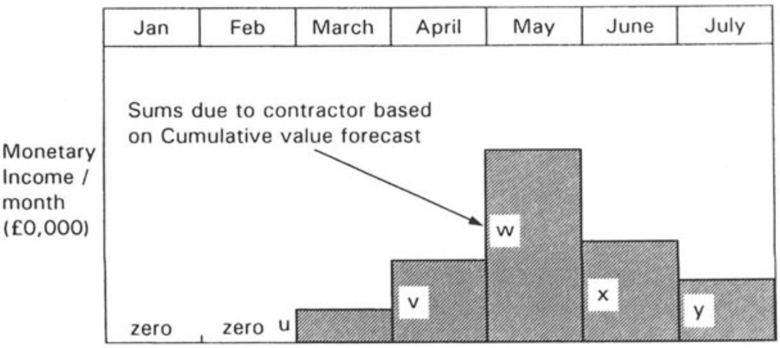


Figure 5.8

JCT 80 contract terms

Under JCT 80 conditions, the payment terms are stated as being 14 days from the date of issue of the interim certificate. However, the overall time period between the date of the interim valuation and the payment of the money into the contractor's bank account may cover a period of some 28 days (see Figure 1.2). This time delay is made up of:

- 7 days between the valuation date and the issue of the interim certificate
- 14 days payment period
- 7 days to receive and clear the payment

The interim payment is subject to retention, as stated in the contract Appendix which may be 3% or 5% depending upon the overall value of the project. The retention is reduced by one-half on issue of the Practical Completion Certificate and the balance of the retention fund is released on issue of the Contract Completion Certificate (at the end of the Defects Liability Period). The defects liability period is normally 6 months for building work and 12 months for mechanical engineering installations.

JCT 81 With Contractor's Design contract terms

Under the JCT 81 'design and build' conditions, the payment terms may be based on periodic payments (normally monthly) or based on agreed stage payments or 'milestones'. The payment period from the payment request date is specified in the contract as being 15 days. Similar terms to JCT80 apply to the issues of retention and defects liability.

ICE Conditions of Contract (6th Edition)

For civil engineering contracts, where the 6th edition is used, valuations are agreed between the Engineer and the Contractor and payment becomes due within 28 days of the issue of the certificate.

5.3.1 Worked Example

The following cumulative value forecast has been obtained from a master programme.

Month	Cumulative Value Forecast (£)	
1	45 000	
2	124 000	Payments = Monthly
3	198 000	Retention = 3%
4	265 000	
5	320 000	
6	380 000	

Figure 5.9 shows the cumulative value forecast presented graphically, together with the forecast cumulative and monthly income profile.

5.4 Labour, Plant and Preliminaries Budgets

Budget forecasts may be developed for labour, plant and preliminaries expenditure based on an analysis of the contractor's net estimate, in other words excluding profit and overheads.

Moneys may be allocated to time on a bar chart and extended into a graphical display in the form of a value/time curve forecast. During the project the contractor may then monitor actual expenditure and use the analysis as part of his monthly cost control and reporting procedures.

5.4.1 Labour Budget

Figure 5.10 indicates a bar chart display for labour expenditure. The graphical display in Figure 5.11 has been presented as a cumulative forecast of man-weeks expenditure plotted against time. This allows the actual man-weeks expended on the project to be matched with the forecast as the project proceeds.

This simple approach is highly effective as a cost control aid, but needs to be reconciled with the contracts progress position in order be an effective management tool. The reason for the variance of two man-weeks could be due to the contract being behind programme. This could have resulted from insufficient labour being available to the contractor

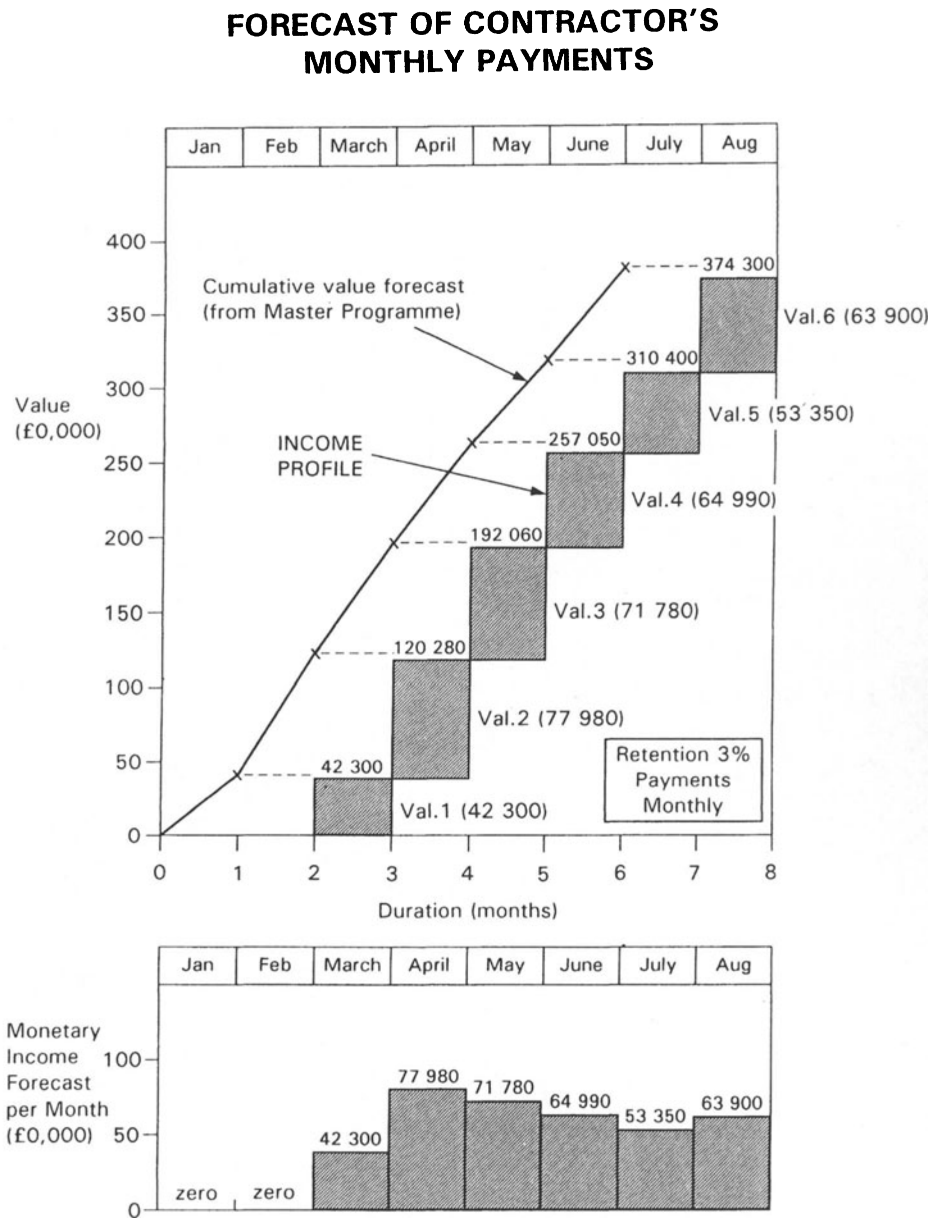

FORECAST OF CONTRACTOR'S
MONTHLY PAYMENTS
Jan
Feb
March
April
May
June
July
Aug
Value
(£0,000)
400
350
300
250
200
150
100
50
0
Cumulative value forecast
(from Master Programme)
INCOME
PROFILE
374 300
310 400
257 050
192 060
120 280
42 300
Val.6 (63 900)
Val.5 (53 350)
Val.4 (64 990)
Val.3 (71 780)
Val.2 (77 980)
Val.1 (42 300)
Retention 3%
Payments
Monthly
0
1
2
3
4
5
6
7
8
Duration (months)
Jan
Feb
March
April
May
June
July
Aug
Monetary
Income
Forecast
per Month
(£0,000)
100
50
0
zero
zero
42 300
77 980
71 780
64 990
53 350
63 900

Figure 5.9

LABOUR EXPENDITURE BUDGET

OPERATION	Labour Budget Man Hours	Man Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Foundations	800	20	4	4	4	4	4												
Brickwork to DPC	360	9					4	5											
Ground Floor Slab	200	5							5										
External Brickwork	960	24							2	6	6	6	4						
Roof		S/C																	
1st. fix	240	6													2	2	2		
Plaster		S/C																	
Weekly Man Weeks			4	4	4	4	8	5	7	6	6	6	4	0	2	2	2	0	0
Cumulative Man Weeks			4	8	12	16	24	29	36	42	48	54	58	58	60	62	64	64	64

☐ Man weeks

Figure 5.10

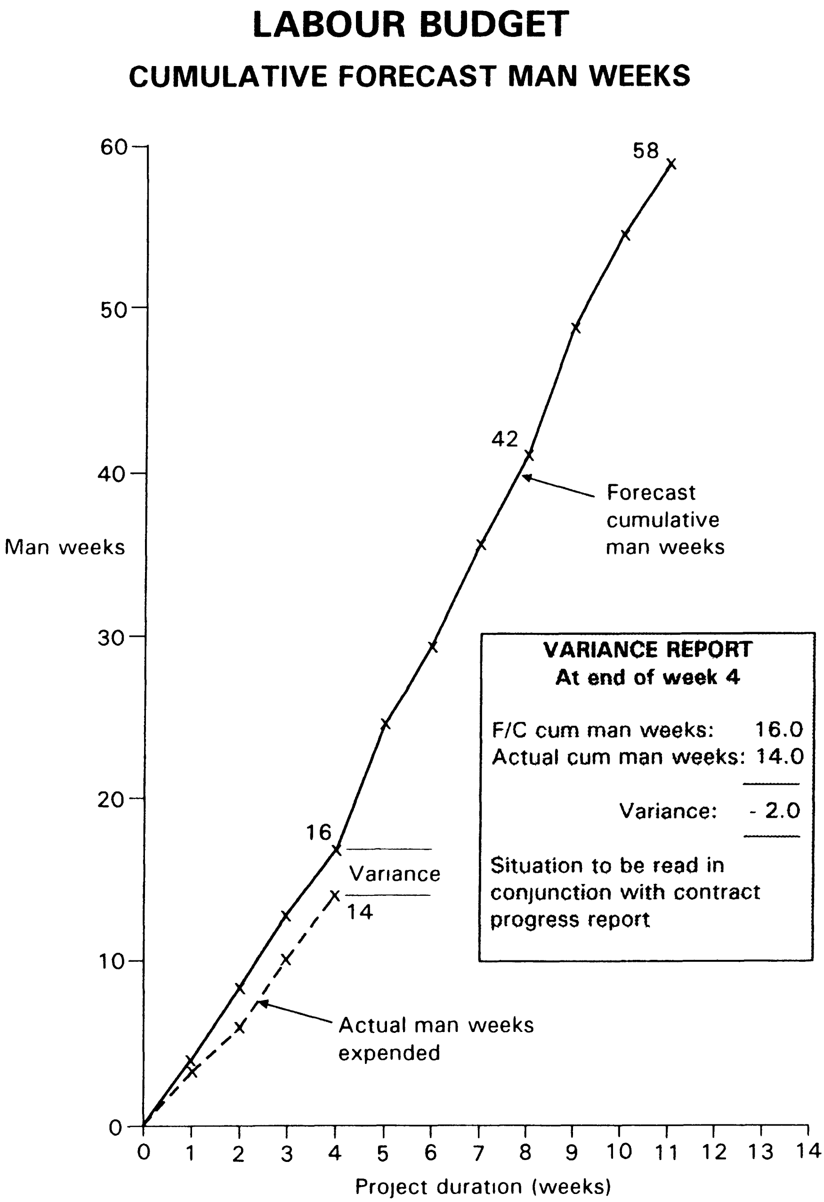

LABOUR BUDGET
CUMULATIVE FORECAST MAN WEEKS
60
50
40
30
20
10
0
Man weeks
58
42
16
14
Variance
Forecast cumulative man weeks
Actual man weeks expended
VARIANCE REPORT
At end of week 4
F/C cum man weeks: 16.0
Actual cum man weeks: 14.0
Variance: - 2.0
Situation to be read in conjunction with contract progress report
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Project duration (weeks)

Figure 5.11

5.4.2 Plant Budget

Figure 5.12 illustrates a plant budget for a project, presented in bar chart form and Figure 5.13 represents the graphical display of the forecast cumulative plant expenditure.

Plant costs on site frequently exceed expenditure allowances in the tender and site managers are notorious for keeping plant on site for too long just 'for convenience'. Whether plant is hired or owned by the contractor, strict control over budget variances needs to be excercised and plant and equipment must be 'off-hired' as soon as it is not required.

Similar principles may be applied to the preparation of a contract preliminaries budget by analysing the preliminaries allowances in the estimate, preparing a bar chart, and allocating moneys to time.

The application of cost reporting at monthly time intervals forms part of the discussion in Chapter 7.

5.4.3 Preliminaries Budget

One of the most common areas of overspending on a project is on contract preliminaries. This may be due to management failing to allow sufficient moneys to cover this section of the tender or over-elaborate site organisation. It is also the area which is most subject to adjustment at the tender adjudication stage, either to make the tender more competitive or because the contractor decides to tender on a shorter programme period. The total of preliminaries typically represents between 6% and 15% of the contract sum but, on small contracts, the percentage could be a lot higher.

Figure 5.14 indicates a tabular display for a preliminaries budget. This has been prepared in bar chart format with the preliminaries expenditure forecast presented to a timescale. Fixed costs relating to the establishment of the site and its consequent dismantling are also indicated. Figure 5.15 shows the cumulative expenditure forecast presented graphically as a line graph.

Actual preliminaries costs may be matched with the forecast expenditure in tabular and graphical form as the contract proceeds and in this way the preliminaries variance may be monitored continuously during the project.

The preliminaries budget is an ideal application for a spreadsheet display.

PLANT EXPENDITURE BUDGET

OPERATION	Plant Allocated	Budget £	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Site Clearance	P.Shovel 4 Lorries	2000	400	800	800													
Excavate Foundations	Hyd. B/A. 2 Lorries	5000			1000	1000	1000	1000	1000									
Concrete Foundations	Concrete Pump	1000								1000								
Brickwork DPC	Mixer	200									100	100						
Ground Floor Slab	Concrete Pump	1000											1000					
External Walls	Scaffold Mixer	4000												1000	1000	1000	1000	
1st Fix	Crane	1000																1000
Weekly Expenditure Forecast			400	800	1800	1000	1000	1000	1000	1000	100	100	1000	1000	1000	1000	1000	1000
Cumulative Expenditure Forecast			400	1200	3000	4000	5000	6000	7000	8000	8100	8200	9200	10200	11200	12200	13200	14200

Figure 5.12

PLANT BUDGET
CUMULATIVE EXPENDITURE FORECAST

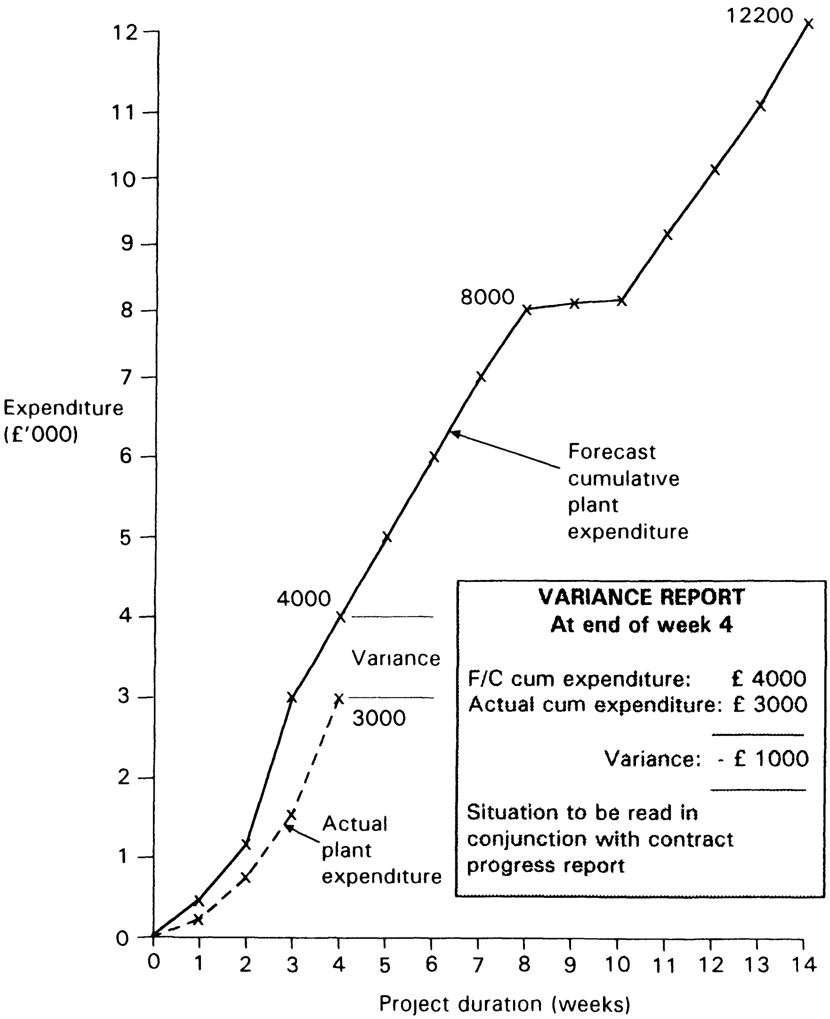


Figure 5.13

CONTRACT - BOLTON FACTORY CONTRACT VALUE - £600 000		**PRELIMINARIES BUDGET**																				BUDGET FIGURES ARE NET PRELIMINARIES SUMS IN THE BILL
OPERATION	BUDGET £	Time in weeks 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Establish Site	8 000	4	4																			
Site Accommodation																						
Establish	1 000		1																			
Hire	200 / w			0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2		
Dismantle	1 000																				1	
Site Management																						
Site Manager	1 000 / w	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
General Foreman	500 / w								0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5						
Site Engineer	500 / w	0.5	0.5												0.5	0.5						
Temporary Roads	2 000	0.5	0.5					0.5	0.5													
Hardstandings	2 000			1	1																	Total Prelims £48 400
Site Hoarding																						
Erect / Dismantle				1	1															1	1	
Weekly Expenditure Forecast		6	7	3.2	3.2	1.2	1.2	1.7	2.2	1.7	1.7	1.7	1.7	1.7	2.2	2.2	1.2	1.2	1.2	2.2	3	
Cumulative Expenditure Forecast		6	13	16.2	19.4	20.6	21.8	23.5	25.7	27.4	29.1	30.8	32.5	35.2	37.4	39.6	40.8	42	43.2	45.4	48.4	
Actual Weekly Cost		5	5	2	2	2	2	2	2													
Cumulative Weekly Cost		5	10	12	14	16	18	20	22													

Figure 5.14

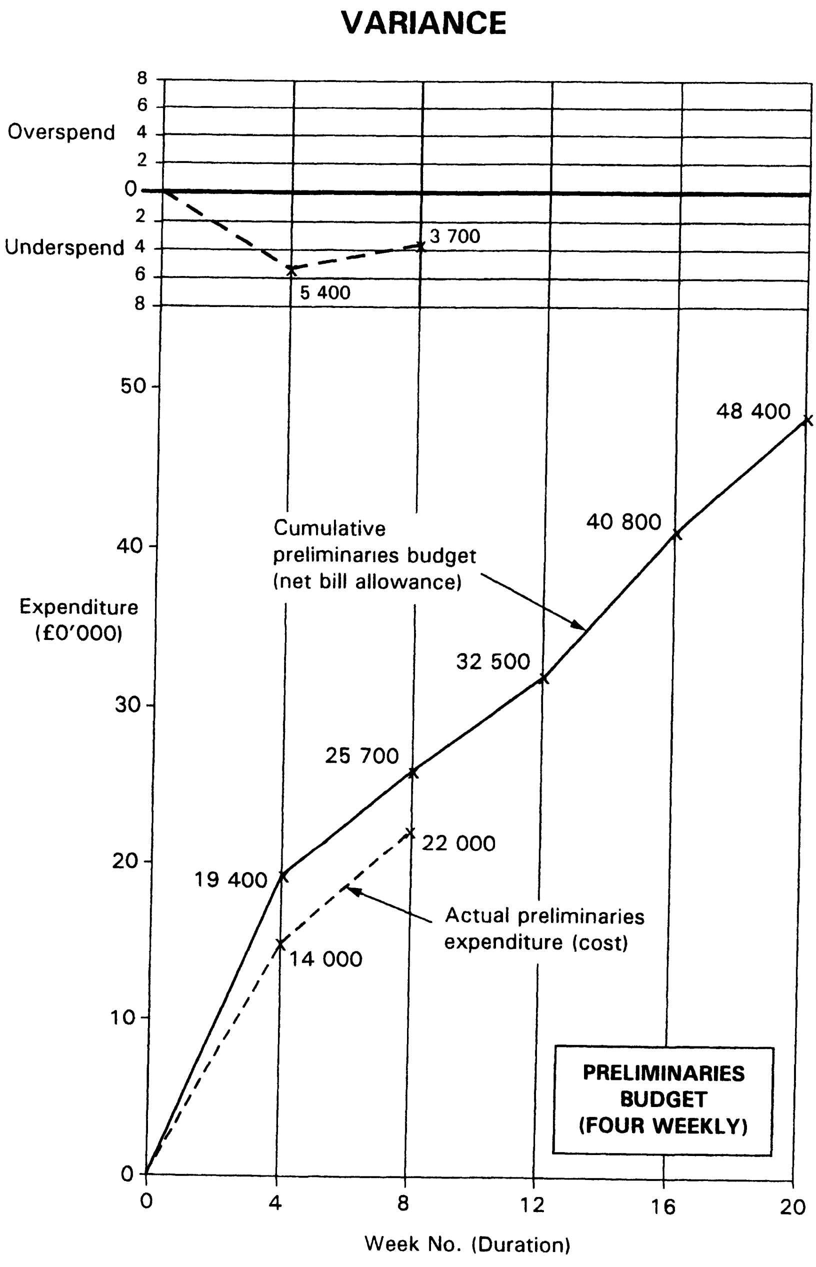

VARIANCE
8
6
Overspend 4
2
0
2
Underspend 4
6
8
3 700
5 400
50
40
30
20
10
0
Expenditure
(£0'000)
48 400
40 800
32 500
25 700
22 000
19 400
14 000
Cumulative
preliminaries budget
(net bill allowance)
Actual preliminaries
expenditure (cost)
PRELIMINARIES
BUDGET
(FOUR WEEKLY)
0
4
8
12
16
20
Week No. (Duration)

Figure 5.15

5.5 Forecast Value and Cash Funding – Worked Example

Project Brief

A contractor has obtained a contract for a project to be undertaken in 3 phases. Details of the phases with approximate durations and monetary values are shown below. The overall project duration is 24 months.

Tender Analysis

Phase 1	Two storey extension		
	Value = £1 500 000		
	Duration = 10 months		
	Operations		
		Substructure	£150 000
		Superstructure	£600 000
		Finishings and services	£750 000
Phase 2	Refurbished canteen		
	Value = £750 000		
	Duration = 8 months		
	Operations		
		Demolitions	£38 000
		Superstructure	£225 000
		Finishings and services	£487 000
Phase 3	Office refurbishment		
	Value = £1 500 000		
	Duration = 10 months		
	Operations		
		Demolitions	£75 000
		Superstructure	£450 000
		Finishings and services	£975 000
Contract Preliminaries			£250 000
Total Project Value			£4 000 000

Project Task

Produce a cumulative value forecast for the complete project and an assessment of the contractor's working capital requirements for the first 6 months of the project period. This is to be based on the following:

- The above values include a 5% contribution to profit and overheads
- 5% retention is to be applied to the payments
- Costs are to be paid at the end of the month in which they are incurred (i e. no delay in meeting the cost situation)
- Interim payments are to be made monthly, payable one month after the valuation date (JCT 80 contract)

Worked Solution

The approach to the assessment of the cumulative value forecast and the working capital requirements involves the following stages.

1 Assess the cumulative value forecast for the three phases of the project by allocating project values to a bar chart programme

2. Establish the graphical relationship between value/time, cost/time and income/time
3. Calculate the maximum and minimum working capital requirements

4 Display the working capital requirements in the form of a 'saw-tooth' diagram for the first six months of the project and comment on the analysis

Figure 5.16 shows a bar chart display for the three phases of the project with moneys allocated to project operations. The value for contract preliminaries has been allocated separately throughout the contract period with an extra sum of £10 000 for establishing the site at week 1 of the project. The cumulative value forecast is presented along the bottom of the bar chart and displayed as a value/time graph in Figure 5.17.

Figure 5.18 indicates the relationship between value/time, cost/time, and income/time for the first six months of the project period. The cash funding profile is shown in the form of a saw-tooth diagram under the graphical display. This is based on the 'no delay situation' in meeting the cost as stipulated in the project brief.

The cash funding profile indicates that during the first six months of the project period, cash requirements peak at the end of months 3 and 6 respectively. The working capital requirements at the end of months one to six are as follows :

Month	Max. cash requirement (£)
1	90 400
2	226 600
3	281 200
4	210 200
5	210 400
6	353 300

CASH FUNDING FOR THREE PHASE PROJECT

OPERATION		VALUE (£'000)	Time in months																								
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
			PHASE I																								
													PHASE II														
																	PHASE III										
Subst.	PH.I	150	75	75																							
Superst.		600		100	100	100	100	100	100																		
Finishings		750						150	150	150	150	150															Phase I must be complete before Phase II and Phase III start
Demolition	PH.II	38											38														
Superst.		225												45	45	45	45	45									
Finishings		487															122	122	122	122							
Demolition	PH.III	75															75										
Superst.		450																90	90	90	90	90					
Finishings		975																			162	162	162	162	162	162	
Prelims	ALL	250	20	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
Monthly value			95	185	110	110	110	260	260	160	160	160	48	55	55	55	252	267	222	222	262	262	172	172	173	173	
Cumulative monthly value			95	280	390	500	610	870	1130	1290	1450	1610	1658	1713	1768	1823	2075	2342	2564	2786	3048	3310	3482	3654	3829	4000	

Figure 5.16

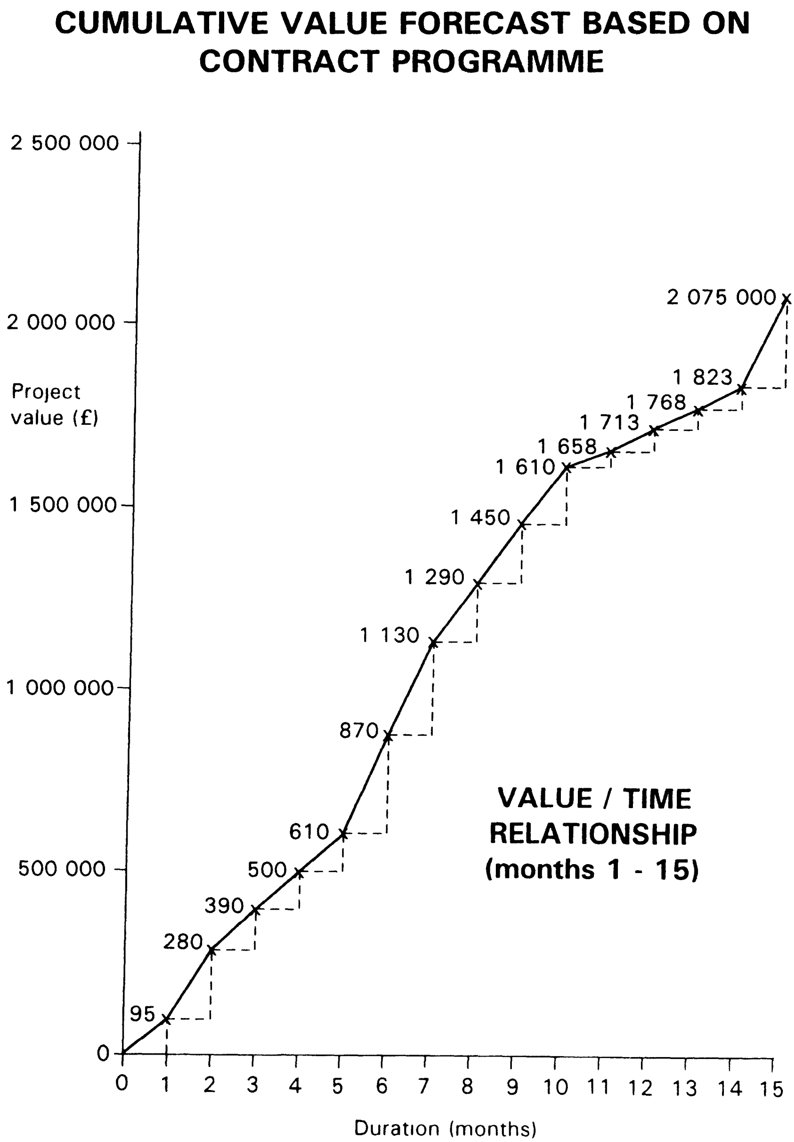

CUMULATIVE VALUE FORECAST BASED ON CONTRACT PROGRAMME
2 500 000
2 000 000
Project value (£)
1 500 000
1 000 000
500 000
0
2 075 000
1 823
1 768
1 713
1 658
1 610
1 450
1 290
1 130
870
610
500
390
280
95
VALUE / TIME RELATIONSHIP (months 1 - 15)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Duration (months)

Figure 5 17

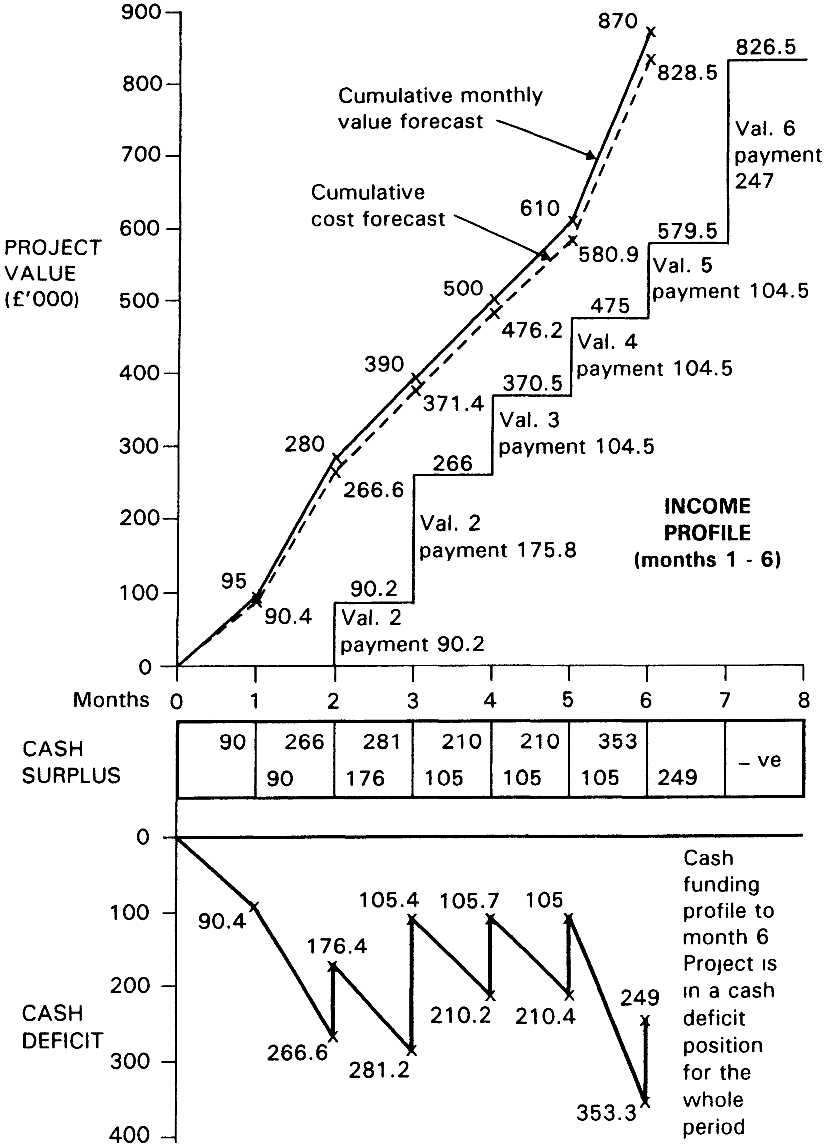


Figure 5.18

Reference

1. Harris F and McCaffer R, *Modern Construction Management*, 4th Edition, Blackwell Science (UK), 1995

6 Planning During Construction

6.1 Planning Procedures within a Large Construction Organisation

The reasons for undertaking planning have been outlined in Chapter 4. During a major construction project, the contractor will need to implement appropriate procedures in order to keep the master programme under constant review. Figure 6.1 indicates the relationships between the master programme, stage programmes, 4-6 weekly programmes and the weekly programming at site level.

Support will be required at site level to monitor the planning in the form of site-based planning engineers or head office based planners visiting the site. Monthly and weekly site meetings will assist in standardising the reporting procedures at site management and senior management levels. Figure 6.2 indicates the relationship between the various programmes produced and the reporting and control meetings taking place at site level.

The organisation structure of the planning department within a large organisation is illustrated in Figure 6.3. This shows the relationship between the pre-tender planning and the contract planning functions. The contract planning staff may be site based on the larger projects; smaller projects may be serviced by planning staff from an adjacent major site.

6.2 Meetings as Part of the Control Process

Meetings are an essential component of the control process on any construction project. They are part of the control cycle and their purpose is to:

- Collect and distribute project information
- Review the current situation
- Consider ideas for resolving bottlenecks
- Consider the opinion of other parties
- Develop a team approach to problem solving
- Discuss problem areas and suggest alternative solutions
- Decide on appropriate action

Various meetings are held in relation to the construction process in order to develop communication links between the parties, i.e. the client, architect, design team, contractor and his subcontractors. Meetings help in building a team approach to decision making and problem solving. The various meetings that may take place during the construction process include:

RELATIONSHIP BETWEEN PLANNING UNDERTAKEN DURING THE CONSTRUCTION STAGE

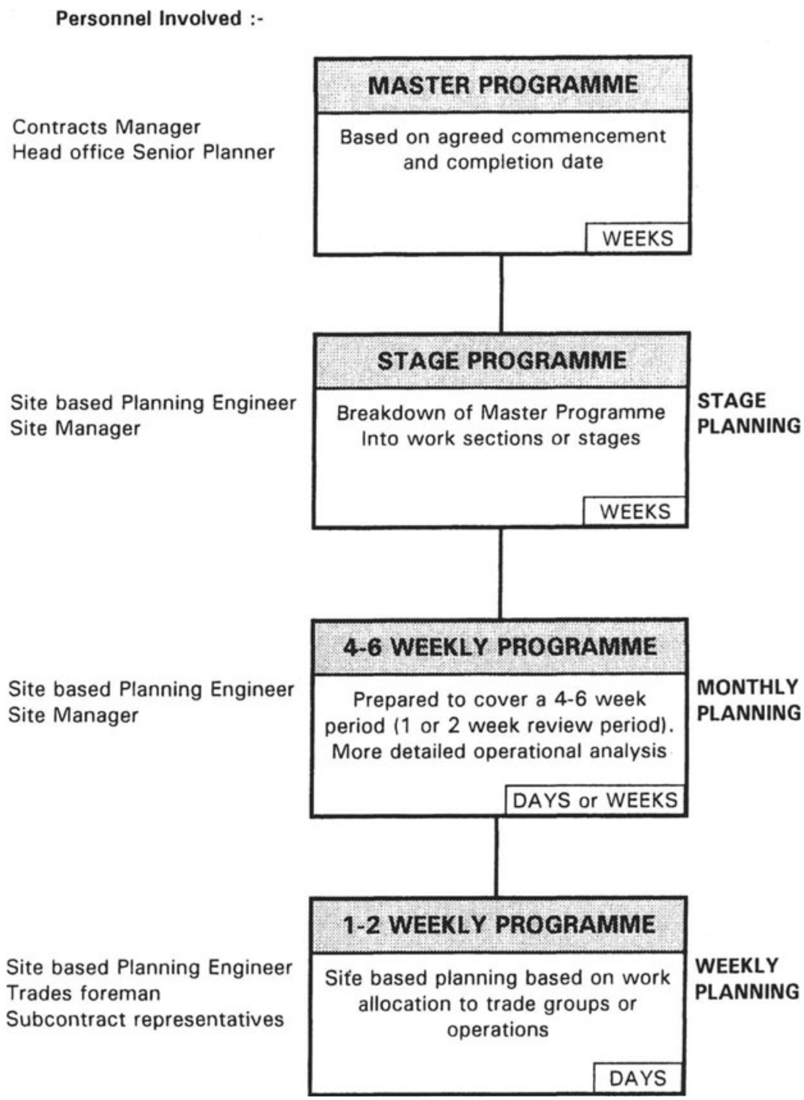


Figure 6.1

RELATIONSHIP BETWEEN PROGRAMMING AND REPORTING AND CONTROL MEETINGS

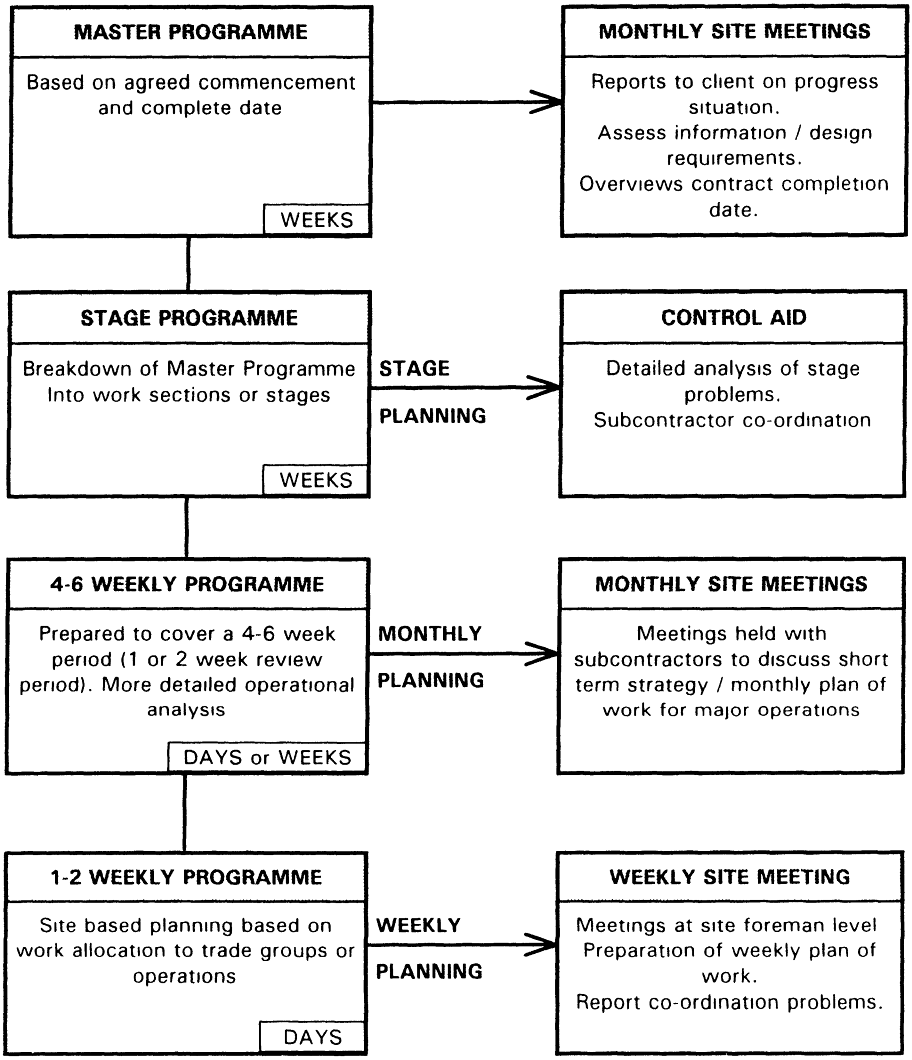


Figure 6.2

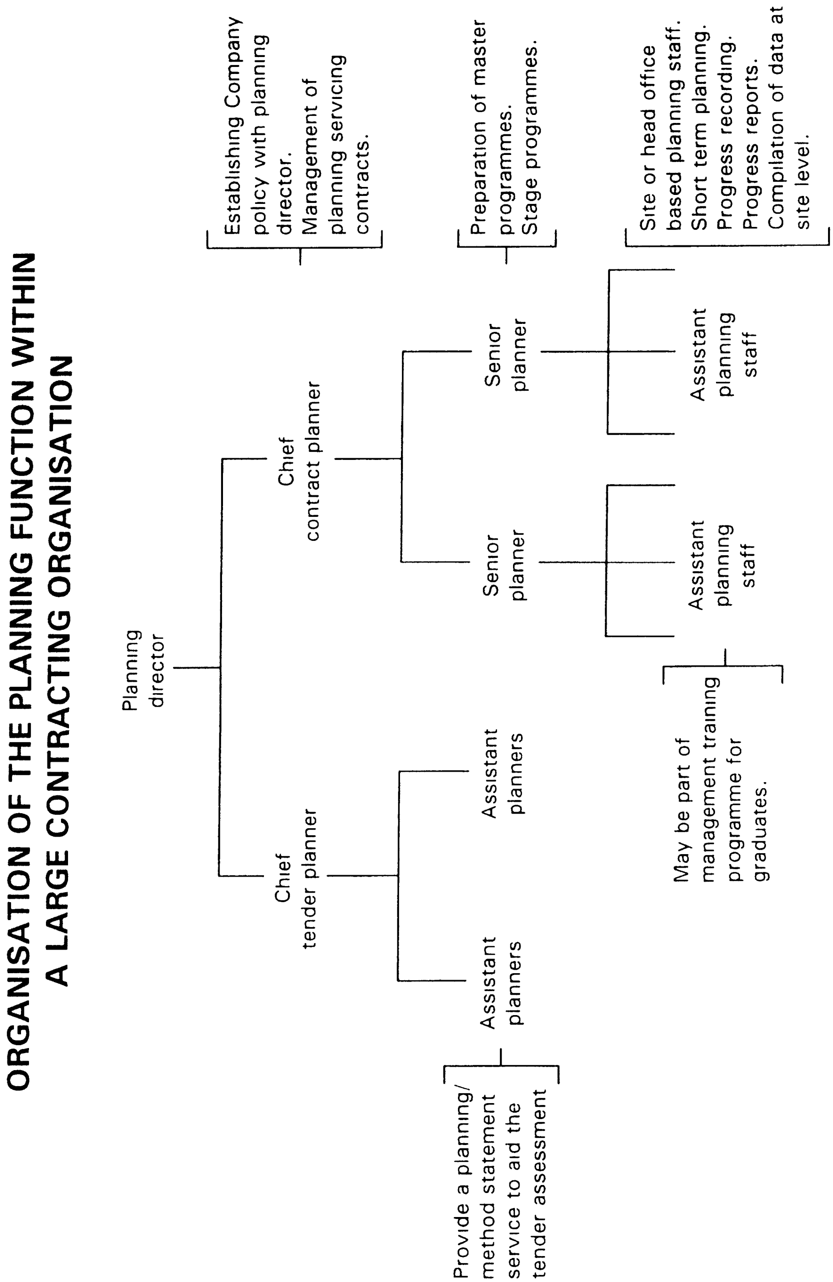

ORGANISATION OF THE PLANNING FUNCTION WITHIN
A LARGE CONTRACTING ORGANISATION
Planning director
Chief tender planner
Chief contract planner
Assistant planners
Assistant planners
Senior planner
Senior planner
Assistant planning staff
Assistant planning staff
Provide a planning/ method statement service to aid the tender assessment
May be part of management training programme for graduates.
Establishing Company policy with planning director. Management of planning servicing contracts.
Preparation of master programmes. Stage programmes.
Site or head office based planning staff. Short term planning. Progress recording. Progress reports. Compilation of data at site level.

Figure 6.3

- Tender Stage
  - Pre-qualification meeting (Client/Architect – Contractors)
  - Pre-tender meeting (Contractor)
  - Tender coordination meetings (Contractor)
  - Tender adjudication meeting (Contractor)

- Pre-Contract Stage
  - Pre-contract meeting (Contractor's personnel)
  - Pre-contract meeting (Client/Architect, etc. – Contractor)
  - Pre-start meeting (Client/Architect, etc. – Contractor)
  - Pre-contract meeting (Contractor – Subcontractors)

- Contract Stage
  - Monthly site meetings (Architect/Contractor)
  - Meetings to discuss defects issues (Architect – Contractor)
  - Meetings to progress the final account (Quantity Surveyor – Contractor)
  - Monthly site meetings (Contractor – Subcontractors)
  - Weekly or fortnightly progress meetings (Contractor)
  - Weekly meetings to problem solve contract emergencies (Contractor)

A lot of managers are of the opinion that 'One cannot meet ***and*** work'. Too many meetings may impede or disrupt the working sequence on a project It is therefore important to obtain the correct balance between working and meeting.

Meetings may be held on a formal or informal basis. Formal meetings such as the client's pre-contract meeting and monthly site meetings have procedures and rules. Informal meetings such as tender co-ordination meeting and weekly site meetings with the trades foreman may be of a more casual and relaxed nature. However, all meetings should have an agenda and minutes should be recorded and circulated.

6.2.1 Monthly Site Meetings

The meeting agenda is the responsibility of the meeting chairman and it should be circulated before the meeting in order that the personnel attending are fully aware of the items to be discussed. Minutes of previous meeting should also be circulated in order that they can be formally accepted as a true record.

A typical agenda for a monthly site meeting to be chaired by the project architect is indicated below:

Minute Ref.*	Headings for the order of the meeting
1.1	Personnel attending and apologies for absence
1.2	Confirmation of minutes of previous meeting
1.3	Matters arising from minutes
1.4	Confirmation of matters raised at intermediate site visits by architect
1.5	Weather report – record of inclement weather to date
1.6	Progress review – normally given by the Contractor or Clerk of Works
1.7	Drawings and information requirements
1.8	Construction queries – relating to materials or design
1.9	Design issues – anticipated future requirements
1.10	Nominated Subcontractor and Nominated Supplier information requirements
1.11	Liaison with statutory undertakings/utilities
1.12	Health and safety matters
1.13	Variation orders – review of outstanding architect's instructions and instructions requiring confirmation
1.14	Dayworks – overview of outstanding dayworks
1.15	Financial review – quantity surveying matters for discussion
1.16	Project completion date – review of projected completion
1.17	Any other business
1.18	Date and time of next meeting

* to be referred to in all site minutes

6.2.2 Weekly Progress Meetings

Weekly progress meetings are held at site management level in order to review the programme in the short term and to coordinate the activities of subcontractors and the contractor's own trade gangs. Coordination is essential for the success of the contract and the weekly site meetings are used to discuss the short term programme and interfaces for the following one or two week period. On the larger projects the meeting will be chaired by the assistant project manager assisted by the site based planning engineer. A meeting agenda will be prepared and minutes recorded.

Headings for the order of the meeting:

1.1 Personnel attending
1.2 Overview of progress to date
1.3 Overview of the programme requirements for the next period
1.4 Reasons for the delays - critical review
1.5 Resources to meet proposed short term programme

Labour review
Plant review
Subcontractor resources
Key material requirements

1.6 Architect's instructions/information requirements
1.7 Interface between proposed operations - coordination of operations
1.8 Date of next meeting

On large projects involving the integration of a number of specialist sub-contractors, separate weekly site meetings may be held between the sub-contractors. An example of this is mechanical and electrical engineering services and it is now becoming common for contractors to employ a services coordinator to deal with specialist work of this type.

6.3 Case Study – Major Project

Project Brief

The project involves the construction of a £300 million shopping complex on the outskirts of Manchester. The contract has been awarded on the basis of a management contract arrangement. The management contractor was appointed to assist at the project feasibility study and to provide advice on buildability at the design stage.

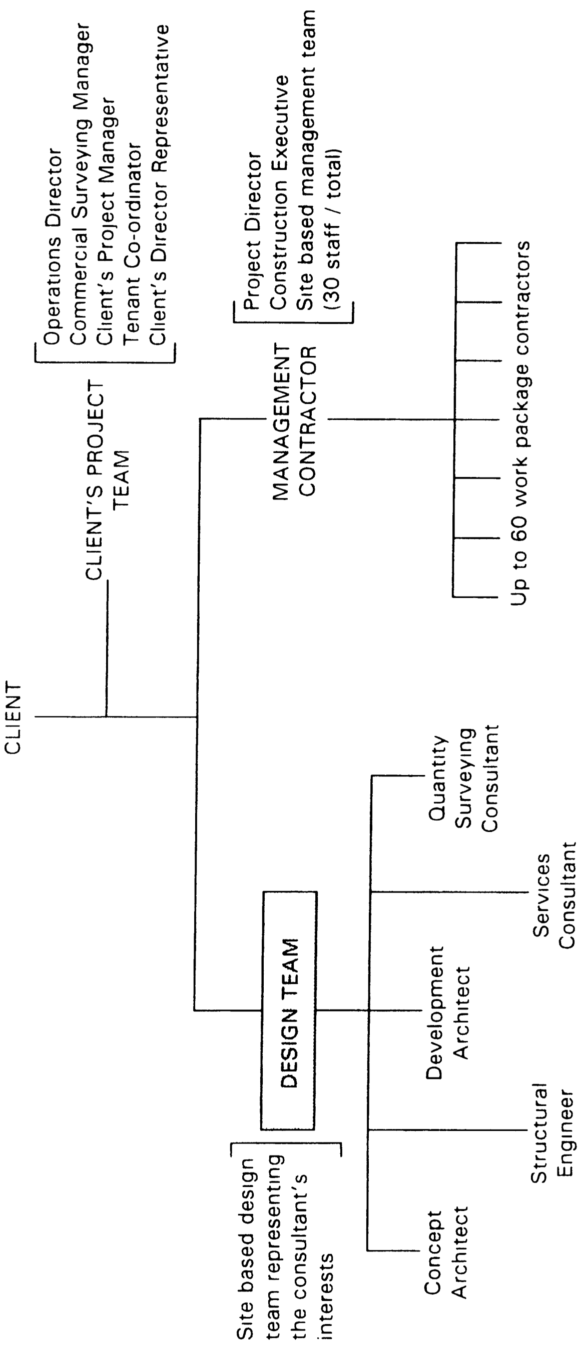
The value of the building shell and core is approximately £160 million and this forms the bulk of the work contained in the management contract. The shell and core involves the coordination of some 60 work packages.

The overall contract period, including the client's fitting out, has been assessed at 32 months. The value of the fitting out work is in the order of £100 million

Relationships between the Client and the Project Team

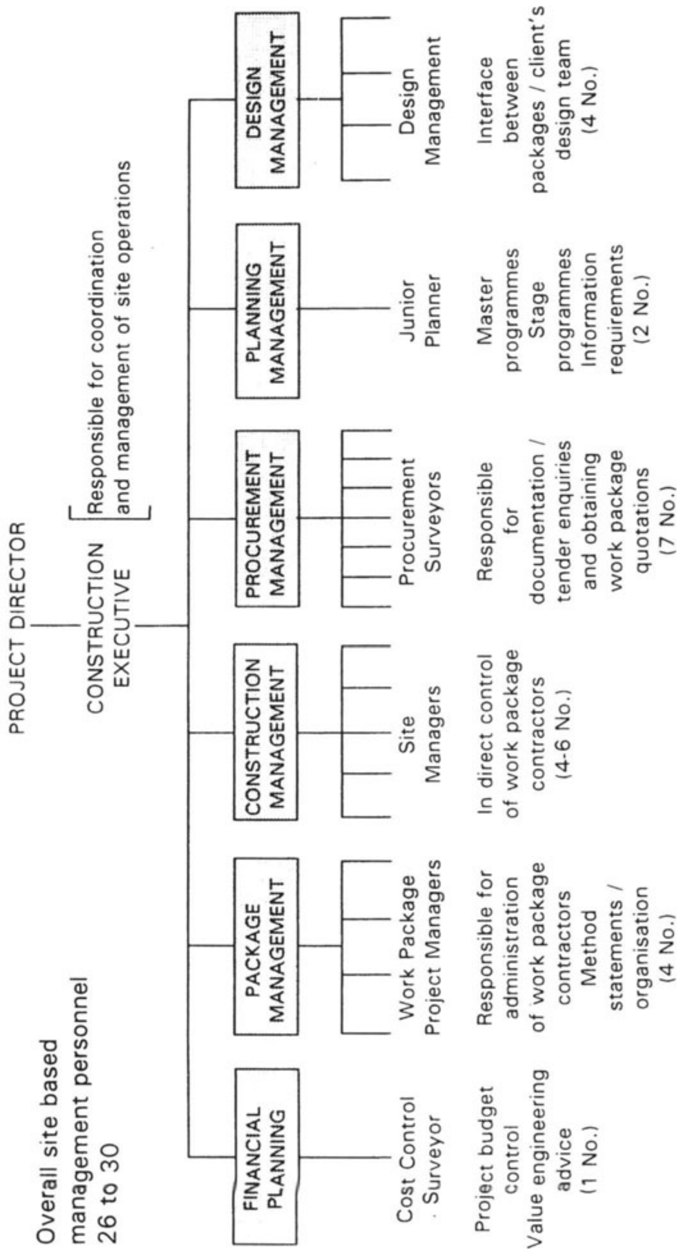
Figure 6.4 indicates the relationship between the client/client's project team/the design team and the management contractor. The client's project team consists of eight members of the client's commercial team who will be ultimately responsible for taking over the complex on completion. A team of representatives from the design team is based on site in order to coordinate information requirements.

Figure 6.5 indicates the management contractor's site team established to manage the project. The site management staff approximates to some 30 clerical and management personnel. The team is under the control of a site based project director assisted by a construction executive responsible for the management of site activities. The management of the project is split up into six areas (see Figure 6.5). These are:



RELATIONSHIP BETWEEN CLIENT / DESIGN TEAM AND MANAGEMENT CONTRACTOR

Figure 6.4



MANAGEMENT CONTRACTOR'S SITE BASED TEAM

Figure 6.5

- financial planning
- package management
- construction management
- procurement
- planning and
- design

A consulting land survey company has also been engaged to provide the main grid references for setting out the foundation works and car park areas. Figure 6.6 illustrates a plan of the project indicating the proposed nine work zones This relates to the sequence of work for the piling, substructure, frame erection and suspended floors. Joint consultations between the design team and management contractor have resulted in the development of the construction sequence A to J.

Planning and Control of the Project

Figure 6.7 indicates an overview of the master programme with the monetary values of the main work areas allocated to time. The cumulative value forecast has been plotted across the bar chart. This indicates valuations in the order of some £9 million per month during peak contract activity.

Computers are used extensively on the project in order to handle the vast amount of information passing between the design team and management contractor. Power Project (Asta Developments) is being used for the coordination of the work package programmes. Programmes submitted by the work package subcontractors are transferred to Open Plan (Project Management Software) in order to link them into the main contract network programme.

The responsibility for planning the project lies with a senior planner and an assistant The senior planner's responsibilities include.

- Preparation of the master programme
- Coordination of the work package master programme
- Preparation of the stage programme for each work package indicating key dates for the start and finish of each of the nine work zones
- Coordination of design team information requirements
- Monitoring contract progress with the package managers
- Attending project co-ordination meetings with the project team and client's representatives
- Attending work package contractor interviews at the package negotiation stage

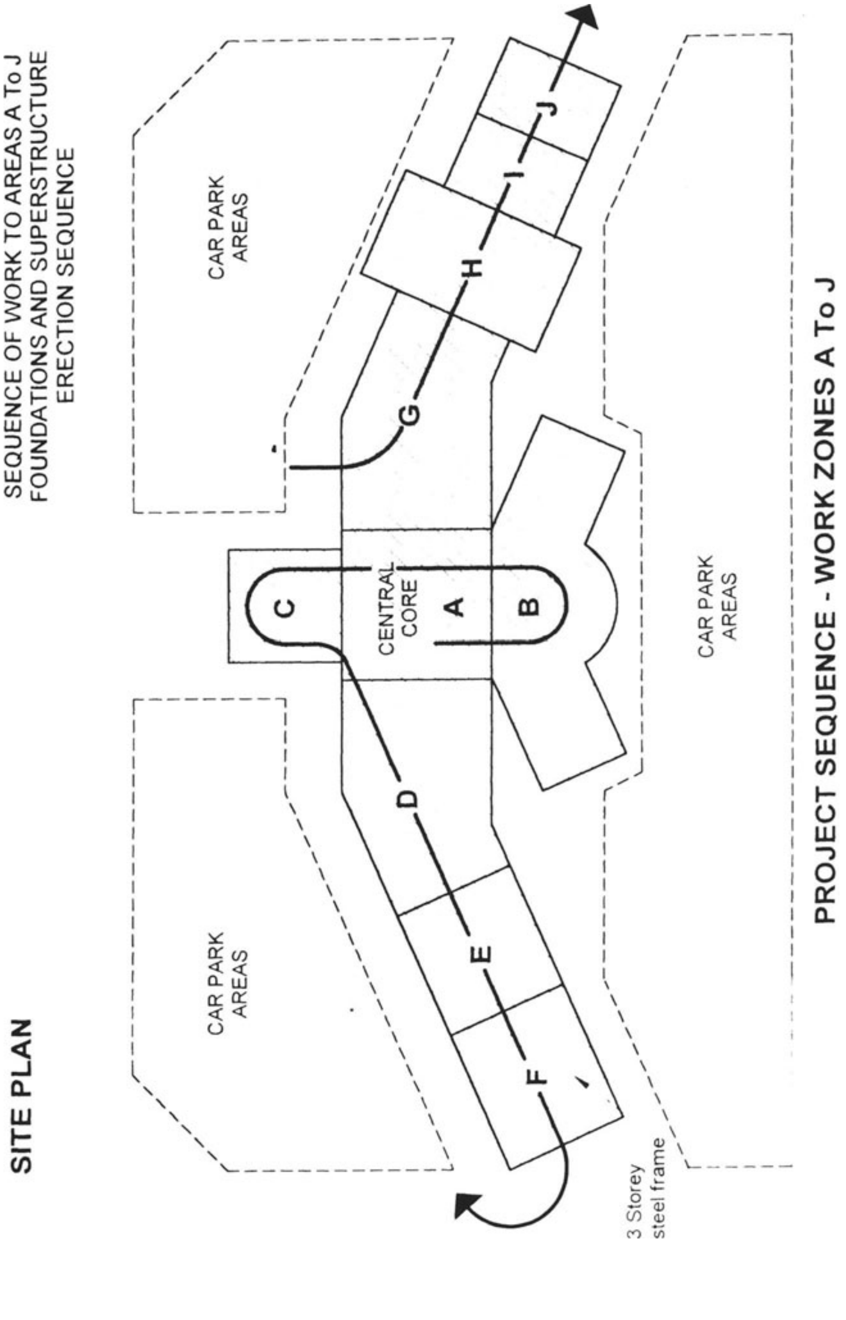

SITE PLAN
SEQUENCE OF WORK TO AREAS A To J
FOUNDATIONS AND SUPERSTRUCTURE
ERECTION SEQUENCE
CAR PARK
AREAS
CAR PARK
AREAS
CAR PARK
AREAS
CENTRAL
CORE
A
B
C
D
E
F
G
H
I
J
3 Storey
steel frame
PROJECT SEQUENCE - WORK ZONES A To J

Figure 6.6

Duration - 32 months
Project value - £160M

MASTER PROGRAMME

SHOPPING PRECINCT

WORK AREAS	Dur	Val	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Enabling Work	4	2	0.5	0.5	0.5	0.5																												
Sub-structure	8	4					0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5																				
Structural Frame	8	16							2	2	2	2	2	2	2	2																		
Fire Protection	10	5									0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5														
External Envelope	12	25											2	2	2	2	3	2	2	2	2	2	2	2										
Mec./Elec. Services	18	54							3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3								
Mall Finishes	12	24																			2	2	2	2	2	2	2	2	2	2	2	2		
Ext. Works Per Road	6	6					1	1	1																							1	1	1
Ext. Car Parks	24	24									1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Total Value		160																																
Value / month			0.5	0.5	0.5	0.5	1.5	1.5	6.5	5.5	7	7	9	9	8.5	8.5	7.5	6.5	6.5	6.5	8	8	8	8	6	6	3	3	3	3	3	4	2	2
Cumulative Value			0.5	1	1.5	2	3.5	5	11.5	17	24	31	40	49	57.5	66	73.5	80	86.5	93	101	109	117	125	131	137	140	143	146	149	152	156	158	160

Cumulative value curve

Figure 6.7

PROGRAMMING STAGES DURING CONSTRUCTION

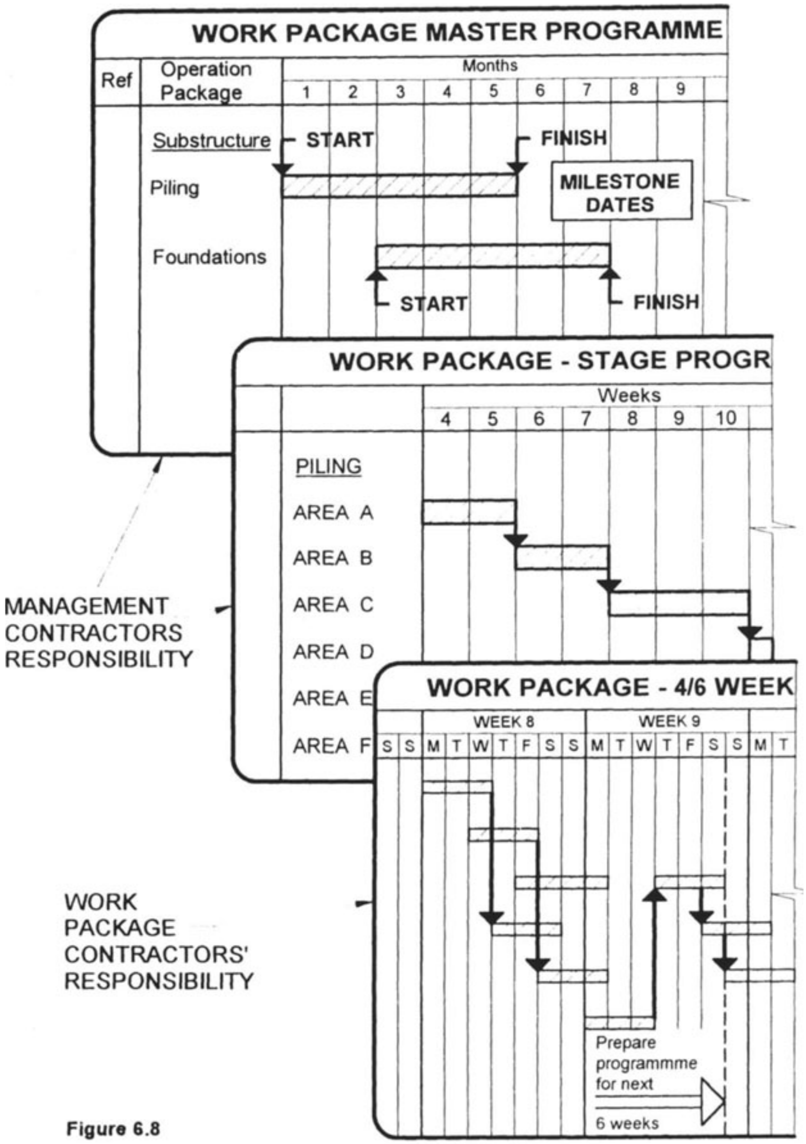


Figure 6.8

Each of the work package contractors is responsible for short term planning within each of their work zones. This is based on four to six weekly short term planning programmes to be agreed with the package managers.

Figure 6.8 indicates the relationships between the work package master programme, stage programme and six weekly short term programme as applied to the piling and substructure work package. It is becoming the norm on major projects for subcontractors to be responsible for the planning of their own work, and they must be willing to include for this risk at the tender stage.

During the project a series of project site meetings are held in order to report on the project progress position both weekly and monthly. Meetings are essential in order to review information requirements between the client's project team, the design team and the management contractor.

7 Project Control Procedures

All contractors have different ideas on the degree of control necessary for the projects that they undertake. Many factors need to be considered including the size and organisation of the firm and the scale and complexity of the projects in hand.

In order to monitor a contract's performance, information needs to be collected within a structured reporting system so that appropriate action can be taken if and when things start to go wrong.

Control areas which may be considered essential are:

- the control of ***money***
- the control of ***time***
- the control of ***resources***

7.1 Reporting Procedures on the Project Value, Cost and Profit

The control of money depends on procedures for reporting on the financial position of the contract with respect to three main issues:

1. Cash flow
2. Cost
3. Value

In order to provide a yardstick for comparison during the project, it is essential that realistic budgets are prepared at the pre-contract stage and that they are monitored during the progress of the contract. Monitoring the forecast during the project is an essential part of the project control process. The procedure for preparing cumulative value forecasts, based on the master programme are outlined in Chapter 5 and illustrated in Figure 5.9.

Within the 'small' contracting organisation little is done regarding cost and value reporting during the project. The principal is more concerned about his cash flow position and keeping his bank at bay. Cash flow is the life blood of the firm and he must keep the money flowing in whatever crisis he may have on the project. Comparison of value with cost is only really made at defined stages of the contract if at all! This may be undertaken at the completion of the substructure, thesuperstructure work, or when the building is finished.

The majority of 'small' contractors do not operate any form of cost control system whatsoever. They may simply look at the actual cost and value situation, perhaps at the final account settlement stage, or they may be perfectly content to have their overdraft under control. This rather *ad hoc* approach to the management of cost information may be satisfactory for the small contractor, but as the business expands there is a greater need to report in a more formal manner.

Within the 'medium' sized organisation which may be undertaking contracts in the order of £500 000 in value the reporting of financial information takes on more importance. Projects of this size cannot be allowed to drift along with management unaware of the financial position and procedures must be implemented for reporting on contract profitability as the work proceeds. The majority of medium sized contractors undertake some degree of cost reporting during the progress of work. They also have cost/value reconciliation procedures as an integral part of the monthly valuation process which are conducted as one of the surveyor's normal monthly responsibilities. Whether or not senior management seriously consider the information to be reliable is another matter. A detailed account of the principles and practice of cost/value reconciliation procedures is given by Barrett (1981).[1]

As a company expands further, emphasis on the analysis of project performance becomes more important and consideration has to be given to more reliable methods of reporting. Within the 'large' organisations there is also a legal requirement for formal reporting procedures.

In the 1970s, a number of the large construction firms operated reporting systems which collected data on every single site operation in progress. This practice appears to be out of favour in the 1990s and a more global approach is taken to the collection and analysis of data. Companies have at last begun to realise that collecting data for data's sake is an expensive luxury that they simply cannot afford.

As a general rule, 80% of the value of a contract is contained within 20% of the items in the bills of quantities. This is known as the 'Pareto Principle'. It is therefore worth considering setting up a control system to deal with the 20% of bill items which ultimately affects the contract's profitability.

Changes in the industry resulting from the introduction of information technology, the greater use of subcontractors and the use of work packages has resulted in the collection and analysis of more selective data. Reductions in profit margins and staffing levels have led to a serious review of existing control systems in order to make the business a little leaner and to gain a more competitive edge. Old outdated systems have been abandoned as a result of changes in the nature of construction work practices.

7.2 Monthly Cost/Value Reporting

Cost/value reconciliation (CVR) is the comparison of the project value with the project cost at predetermined intervals during the progress of a project. This interval is normally monthly and tends to tie in with the company's valuation and accounting procedures. The purpose of CVR is to allow management and statutory accounts to be prepared on a more meaningful basis. The basic principles of cost/value reconciliation are illustrated in Figure 7.1.

PRINCIPLES OF COST VALUE REPORTING

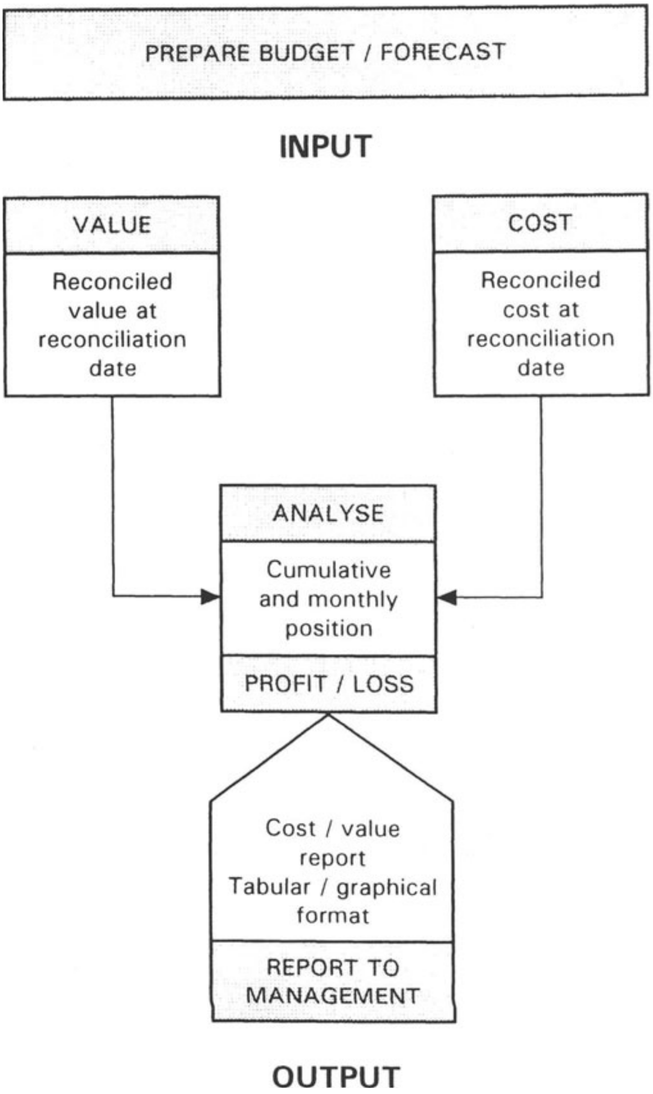
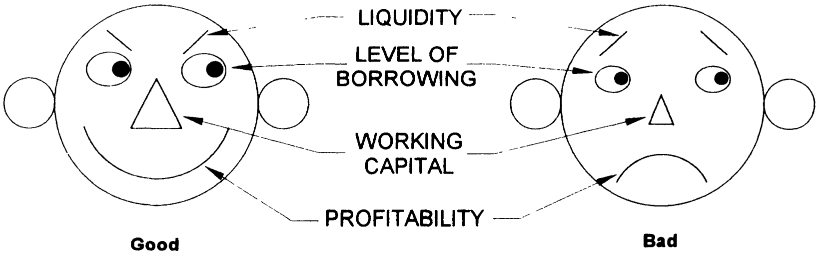
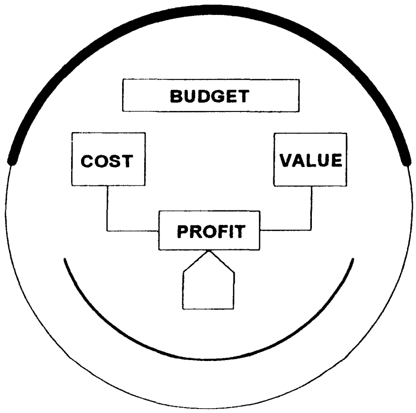


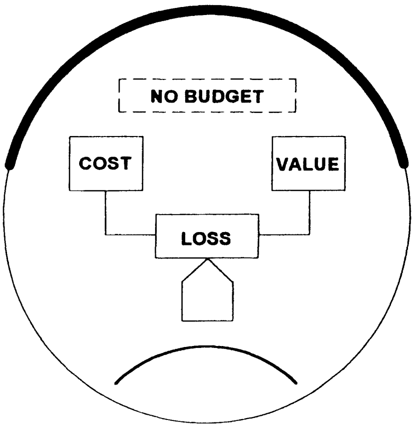
Figure 7.1



EXPRESSION MANAGEMENT



PROPOSALS FOR A WAY OF ASSESSING A (PROJECTS) HEALTH BY USING CARTOON FACES



Applied to COST / VALUE REPORTING (Monthly Cost Reports)

Figure 7.2

It is worth noting that a new approach to understanding accounts has been proposed. This has been suggested by a number of Manchester academics as part of a new accounting system which attempts to put a 'brave face' on company figures. It has been devised as a way of assessing a company's health by using cartoon faces. This approach should appeal to those responsible for interpreting cost/value reports in construction and assist in providing instant feedback to senior management. Figure 7.2 illustrates the possible application of 'Expression Management' to cost/value reporting.

7.2.1 CVR Terminology

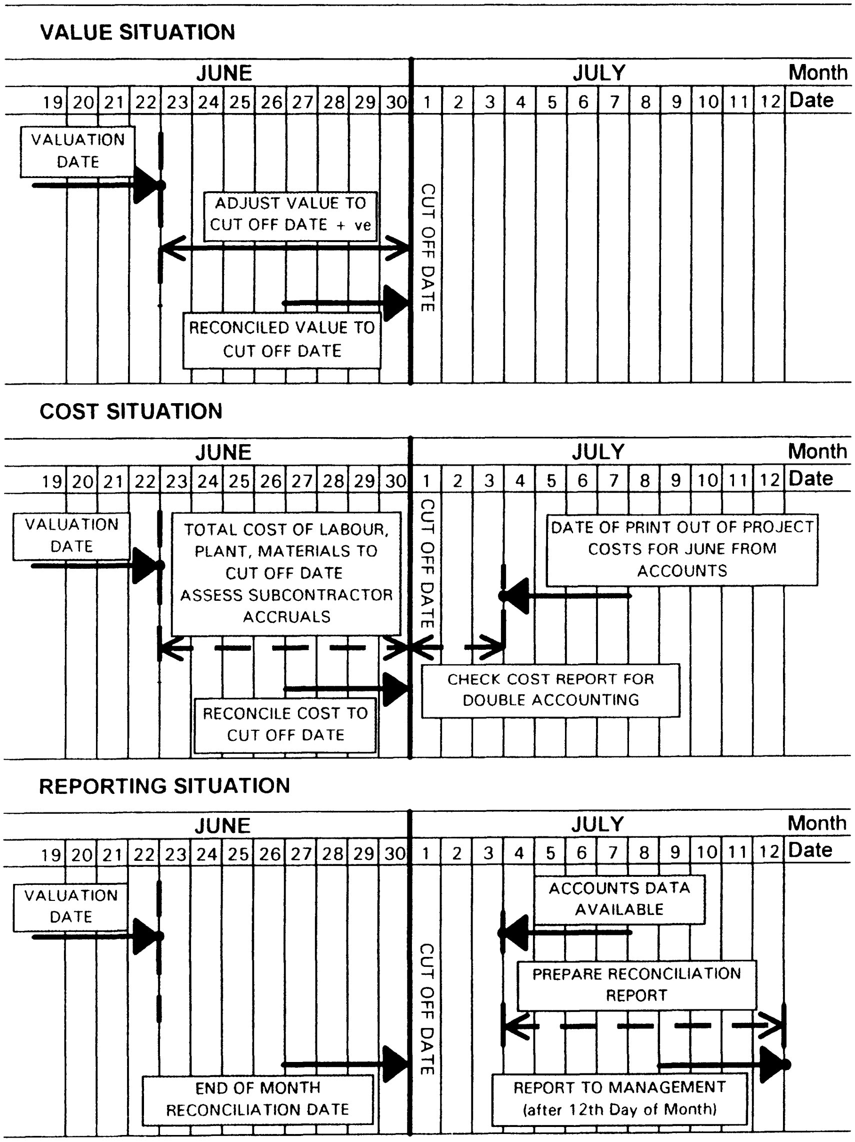
The procedure for reconciling cost and value at a cut-off date at the end of each month during a project is outlined in Figure 7.3 and this should be read in conjunction with the following definitions:

Forecast Value (Cumulative)

This is a forecast of the cumulative value based on the contract master programme. It is obtained by allocating money to the bar chart or schedule of operations and presenting the monetary figures in the form of a cumulative line graph or cumulative value forecast. It must, however, be based on a realistic assessment of the sequence of work or contract programme (refer to Chapter 5, Figure 5.6). The forecast may be presented in tabular or graphical format.

Reconciled Value (Cumulative)

This is the project value assessed at the cut-off date. It is often referred to as the contract cost/value reconciliation date. This may be somewhat different to the value agreed at the monthly valuation date with the professional quantity surveyor and the contractor. The value, for the purposes of comparison with the project costs, must be the reconciled value adjusted for the time variance between the valuation date and the reconciliation date. The may involve assessing the value of the work undertaken in the intervening period between the actual valuation date and the cut-off date. Depending on valuation date, the adjustment may be positive or negative. Figure 7.4 indicates a typical format for presenting the assessment of the reconciled value.



RECONCILIATION PROCEDURE

Figure 7.3

ASSESSMENT OF RECONCILED VALUE

GROSS VALUE — VAL. DATE 23/5/96			
Gross Value Certified by the Professional Quantity Surveyor			176 000
	ADD	OMIT	
ADJUSTMENTS TO RECONCILIATION DATE 31/5/96			
PLUS or MINUS			
Under Valuation +ve			
Over Valuation -ve		5 000	
Adjusted value to date of reconciliation +ve	15 000		
Variations issued (not yet included in Valuation)	2 000		
Dayworks - ditto.	1 000		
Remeasured work sections	3 000		
Preliminaries adjustments - under valuation +ve or - over valuation -ve		2 000	
Materials on site adjustments	1 000		
	22 000	7 000	15 000
RECONCILED VALUE			**£191 000**

Figure 7.4

Reconciled Cost (Cumulative)

This is the cost expended at the date of reconciliation. It is the cost in the contractor's cost ledger, adjusted to the cut-off date or reconciliation date. The cost assessment must include for all accruals for materials and subcontractors which have not been included in the cost ledger at the date on which it was closed. Assessment of the reconciled cost is one of the major areas of error in the reconciliation process, especially in the assessment of the subcontractor accruals. Similar errors also occur in the assessment of the material costs. Materials accruals represent the cost of materials delivered to site but which are not yet included in the cost ledger. For this purpose it may be necessary to put a value to goods received records and material delivery notes

Reconciliation Date (or Cost/Value Cut-off Date)

This is the date agreed by management when the comparison or reconciliation of cost and value is to take place It is usually the date when the monthly accounting period is closed and is frequently referred to as the 'cut-off date'. This may be the last Friday in each month, the 30th of each month or simply the last day in the month.

Date of Report to Management

The report date in principle should be as close to the cut-off date as possible, but will depend on when the project cost figures are available. Figure 7.3 illustrates this as being achieved by the end of the 12th day of the month.

7.2.2 CVR Reports

Figure 7.5 illustrates a typical format for a cost/value reconciliation report in a large contracting organisation. Various adjustments to the cost are indicated in order to match cost with the adjusted value. 'Accruals' are costs which have been incurred but not received by the accounts department and 'provisions' recognise future costs which have to be assessed in order report 'true' value.

The comparison of the cumulative value with the cumulative cost is often referred to as the 'Monthly Cost Report' and a suitable form for this comparison is displayed in Figure 7.6. The comparison may be presented in such a table or alternatively in graphical format. Figure 7.7 indicates the principles of the relationship between the cumulative value forecast, actual reconciled value and reconciled cost presented in graph form. The value variance and time variance have been highlighted. Variance analysis which highlights the difference between actual and expected figures forms an essential part of the cost/value reporting procedure.

COST / VALUE RECONCILIATION REPORT		
Contract ____________	Valuation No ____________	
Contract No ____________	Date of Valuation ____________	
Contract Duration ____________	Month ____________	
VALUATION ASSESSMENT	**CUMULATIVE**	**THIS MONTH**
Value of certificate to / /		
ADJUSTMENTS		
Adjustment to Valuation Date		
Preliminaries Adjustment		
Over Valuation		
Variations		
ADJUSTED VALUATION TOTAL		
CONTRACT COST ASSESSMENT	**CUMULATIVE**	**THIS MONTH**
Contract Costs to / /		
ADJUSTMENTS TO COST (ACCRUALS)		
Plant		
Materials		
Subcontractors		
Inter-Site costs		
PROVISIONS		
Subcontractor Liabilities		
Future Losses		
Maintenance / Defects Costs		
Cost of Delays		
Liquidated Damages		
ADJUSTED COST TOTAL		
PROFIT (LOSS) As a Value		
Percentage		
Date of Reconciliation / /	Prepared by	

Figure 7.5

MONTHLY COST REPORT
COST / VALUE RECONCILIATION

Date	Val No.	Certified Value	Recon Value	Cum. Cost	Cumulative		Monthly			
					Profit	%	Value	Cost	Profit	%
30/5	1	27 000	29 000	25 000	4 000	16.0	29 000	25 000	4 000	16 0
30/6	2	64 000	67 000	59 000	8 000	13 5	38 000	34 000	4 000	11 7
28/7	3	110 000	112 000	102 000	10 000	9.8	45 000	43 000	2 000	4 6
26/8	4	170 000	175 000	163 000	12 000	7.4	63 000	61 000	2 000	3.3
25/9	5	270 000	280 000	265 000	15 000	5 6	105 000	102 000	3 000	2 9

Forecast Cumulative Value
(based on programme)

Val. No	Forecast Cumulative Value	Val. No.	Forecast Cumulative Value
1	30 000	5	310 000
2	70 000	6	410 000
3	130 000	7	480 000
4	200 000	8	560 000

Figure 7.6

PRINCIPLES OF C.V.R. ANALYSIS PRESENTED GRAPHICALLY

Value Time / Cost Time Relationship

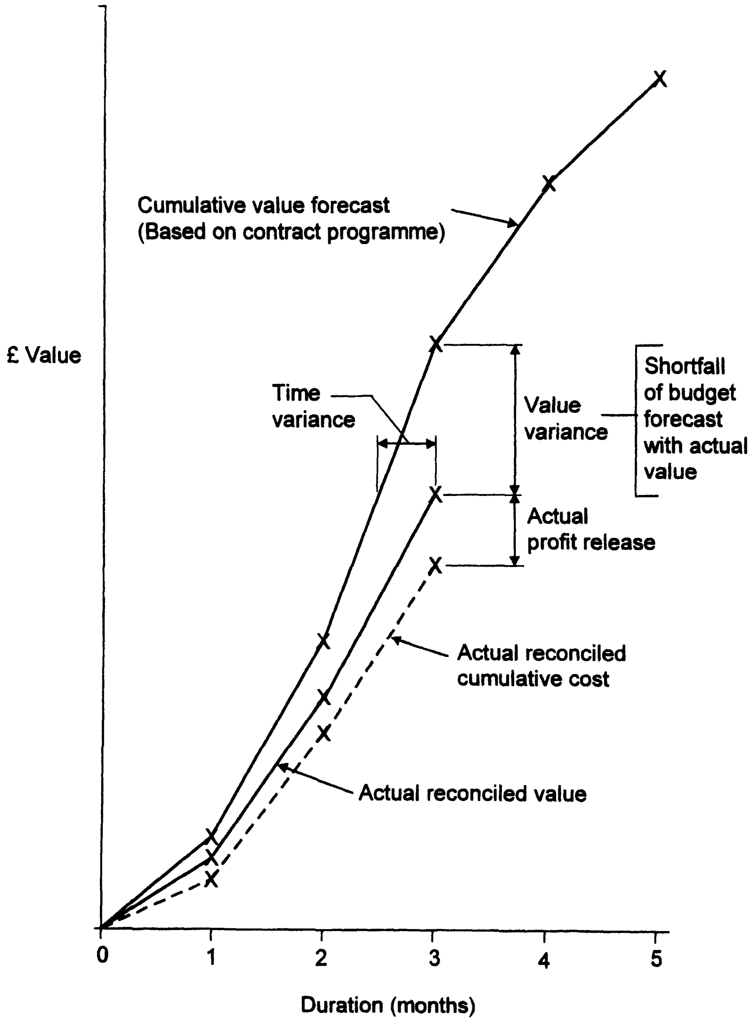


Figure 7.7

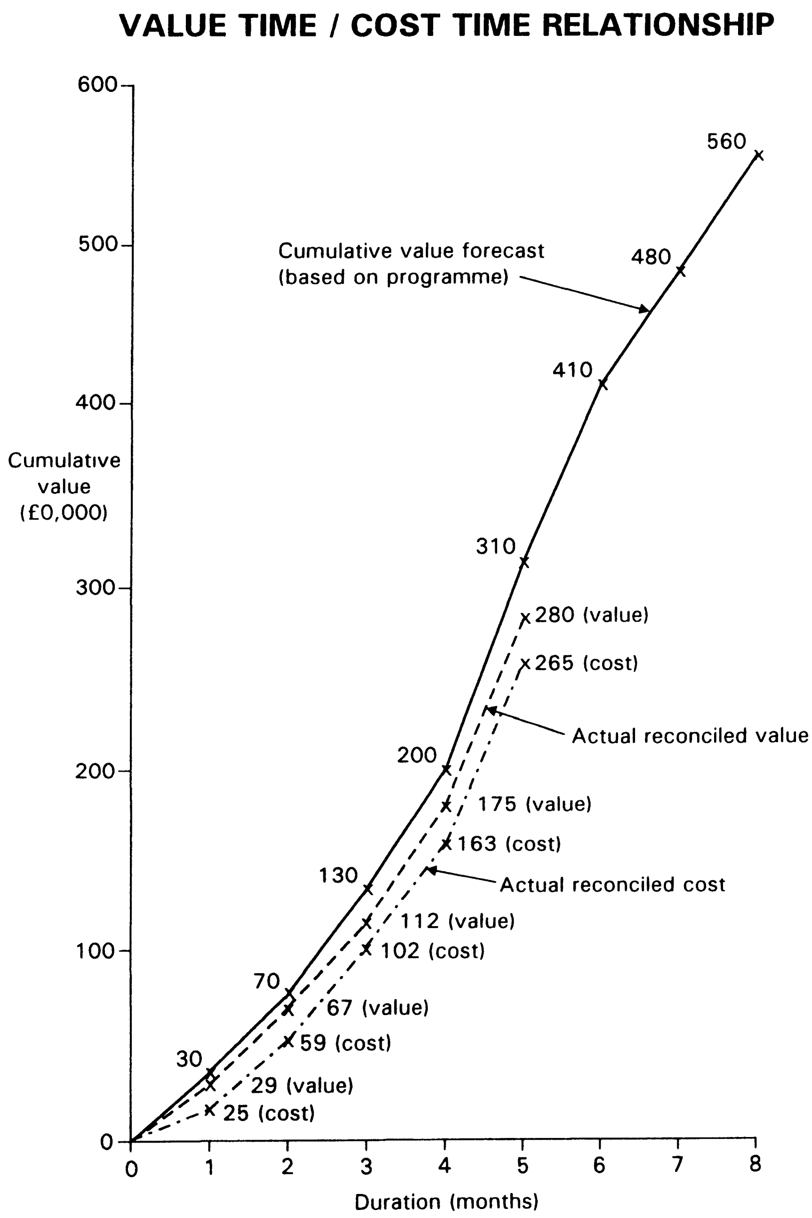

VALUE TIME / COST TIME RELATIONSHIP
600
500
400
300
200
100
0
Cumulative
value
(£0,000)
Cumulative value forecast
(based on programme)
560
480
410
310
280 (value)
265 (cost)
Actual reconciled value
200
175 (value)
163 (cost)
130
Actual reconciled cost
112 (value)
102 (cost)
70
67 (value)
59 (cost)
30
29 (value)
25 (cost)
0
1
2
3
4
5
6
7
8
Duration (months)

Figure 7.8

PERCENTAGE PROFIT RELEASE

Date	Validation No.	CUMULATIVE		MONTHLY	
		PROFIT	%	PROFIT	%
30/5	1	4 000	16	4 000	16
30/6	2	8 000	13.5	4 000	11.7
28/7	3	10 000	9.8	2 000	4.6
26/8	4	12 000	7.4	2 000	3.3
25/9	5	15 000	5.6	3 000	2.9

Profit forecast at tender stage 10%

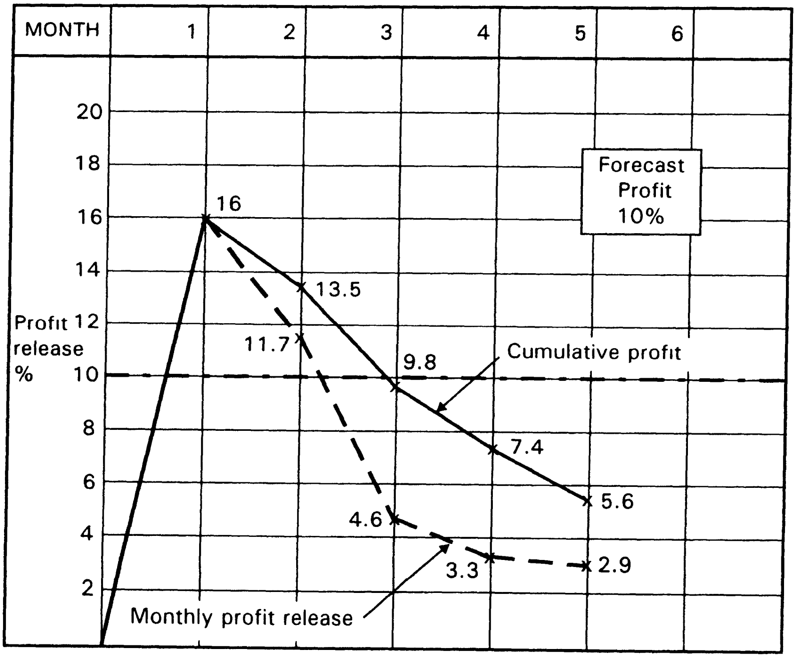


Figure 7.9

As previously outlined in Chapter 5, it is essential to review the contract's progress when considering variances as there must be reasons for any shortfall in the project value.

Data relating to a project has been indicated on the Monthly Cost Report in Figure 7.6, together with the forecast cumulative value for the project. The relationship between forecast value, actual value and cost has been presented in graphical form in Figure 7.8. The percentage profit release situation has been displayed in both cumulative and monthly terms in Figure 7.9.

Management tends to react more to graphically presented data which clearly indicates the relationship between forecast, actual value and cost.

Commentary on Figure 7.9

The cumulative profit release has been slowly declining each month of the project. In five months profit has fallen from 16% to 5.6%. During this period, the monthly profit has declined from 16% to 2.9%. During months 3, 4 and 5 the average monthly profit release has been some 3.5%. At month 5 of the 8 month contract, the cumulative profit release of 5.6% is well below the forecast profit of 10%. It is doubtful that the contract will achieve its forecast margin without some drastic action by senior management.

Part of the cost/value reporting procedures within the larger contracting organisations include preparing a forecast of the project's cost and profitability to completion. This will involve consideration of the profit level capable of being achieved on the remaining operations to be completed (between month 5 and the end of the contract).

7.2.3 CVR Case Study

Contract Brief

The following data indicates the contract value and cost position at the end of month three of a four month project:

Month	Cumulative Value forecast	Actual Cumulative value	Actual Cumulative cost
1	£30 000	£22 000	£20 000
2	£90 000	£65 000	£60 000
3	£140 000	£100 000	£92 000
4	£180 000		

The forecast project profit margin is 10%.

Analysis of the Variance at the End of Each Month

An analysis of the variance at the end of months 1 to 3 has been outlined in the form of a report to senior management:

Contract variance analysis at the end of month 1

Forecast value	£30 000	Actual value	£22 000
Actual value	£22 000	Actual cost	£20 000
Value variance	£8 000	Profit variance	£2 000

The value variance of £8 000 represents a time variance of approximately one week delay in the progress of the works. This position must be verified by means of contract progress reports and the reasons for the one week delay at this stage of the project must be established. Is the delay due to the contractor, his subcontractors or delay in the receipt of information from the architect? All these questions must be answered.

The actual profit release to date is 10% and the contract is therefore within the forecast margin.

Contract variance analysis at the end of month 2

Forecast value	£90 000	Actual value	£65 000
Actual value	£65 000	Actual cost	£60 000
Value variance	£25 000	Profit variance	£5 000

The value variance of £25 000 represents a time variance of approximately two weeks delay in the progress of the works. The reasons for the two week delay must again be investigated and actual progress checked against the master programme. The effect on the project completion date must also be assessed and, if appropriate, requests for an extension of time should be considered.

The cumulative profit release to the end of month two is 8.3% and the monthly profit release is 7.5%. Both of these figures indicate a need for concern at this stage of the project.

It is recommended that the work rate be increased during the next eight weeks in order to bring the contract back on programme. Intensive short term planning procedures should be implemented at site level.

Contract variance at the end of month 3

Forecast value	£140 000	Actual value	£100 000
Actual value	£100 000	Actual Cost	£92 000
Value variance	£40 000	Profit variance	£8 000

The value variance of £40 000 is now giving rise for concern as the project is now some three weeks behind programme. In order to complete the programme on time some £80 000 value of work will require to be completed next month. Realistically this is not possible considering the project's past performance.

The action recommended at the end of month 2 has not been fully implemented. A serious overview of the reason for the delays to date must be undertaken. A realistic project completion date must now be assessed and the client informed of any delay to the project completion date.

The cumulative profit achieved to date is 8.7% and the monthly profit release is 9.4%. Possible liquidated damages to be levied at contract completion will affect the final profit release. A cost and value forecast to the completion of the project should be prepared.

Figure 7.10 indicates the relationship between forecast, actual value and actual cost presented graphically. At the end of month 3 the total value variance is £40 000 (–ve) and the time variance shows that the project is approximately 3 weeks behind programme.

7.3 The Control of Resources

The control of project resources requires consideration of:

- Labour
  - Directly employed labour
  - Subcontract labour
- Materials
  - Control of waste at site level
- Plant
- Preliminaries

Labour and materials control in particular are discussed below, while procedures for forecasting and monitoring of labour and plant are dealt with in Chapter 5. The control of subcontractors is discussed separately in Chapter 8.

7.3.1 Labour

The widespread use of subcontractors in construction in recent years has shifted the emphasis away from the need for contractors to employ sophisticated labour control procedures as was the case in the days of the 'general contractor' who directly employed his own workforce.

VARIANCE ANALYSIS

MONTHLY AND CUMULATIVE REPORT

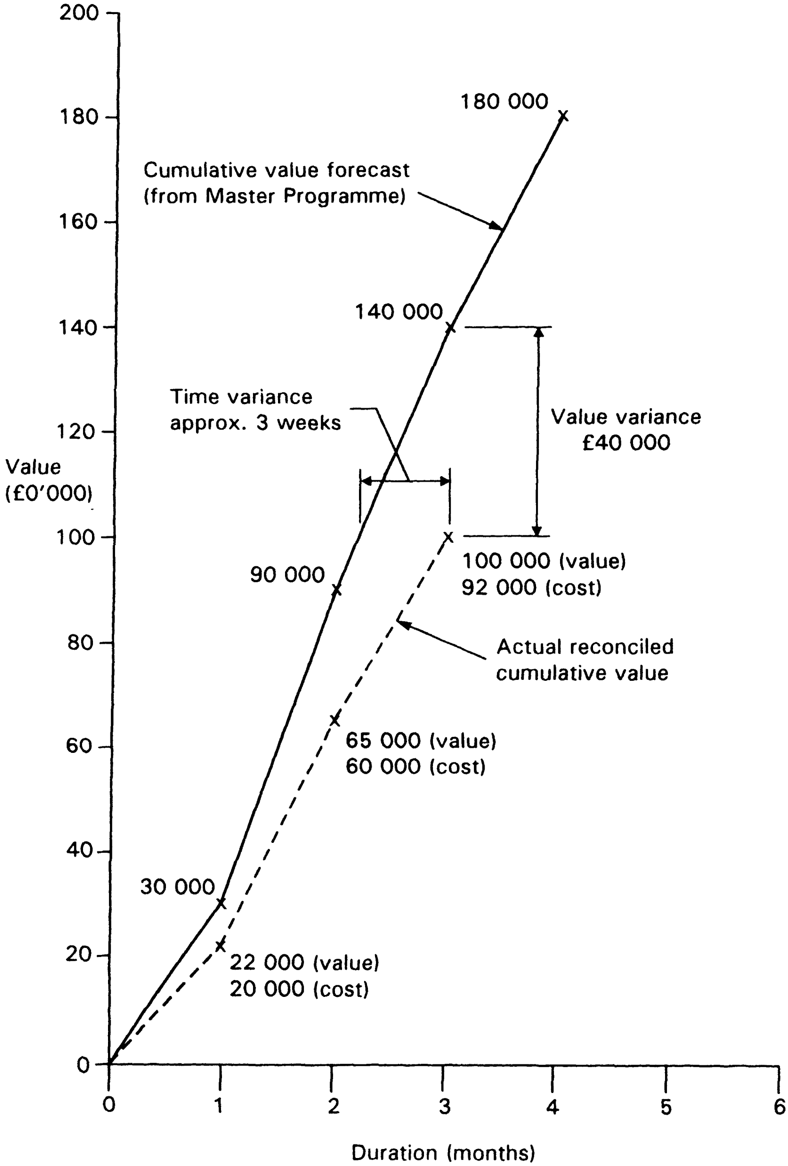


Figure 7.10

On large projects, the contractor is more concerned with keeping the overall labour expenditure within the estimated allowance. For example, Figure 5.10 indicates a labour expenditure budget forecast based on the number of man-weeks allocated in the estimate. The forecast is based on the operations on the master programme. The monitoring of actual labour expenditure involves recording the actual man-weeks expended each week on the project and matching this with the forecast. It is important to relate the analysis to the actual contract progress situation, as the reason for an apparent overspend can simply be due to the project being ahead of programme.

7.3.2 Materials

Materials expenditure represents a major proportion of contract value. Therefore, the control of purchasing, scheduling, delivery and handling of materials on site is an essential part of the control process.

Within small organisations, the responsibility for all aspects of material control lies with the principal. He is the estimator, buyer, surveyor and contracts manager all rolled into one.

In medium sized companies, responsibility for the purchase of materials may rest with the estimator/buyer or may be part of the surveying function. However, once materials have been delivered to site, they become the sole responsibility of the construction site manager.

Large companies, on the other hand, usually have departments responsible for buying and procurement, estimating, surveying, contracts and administration all operating within their own 'little empires'. Within such organisational structures, these separate functions operate more formally and therefore a formalised approach to the procurement and management of materials is necessary. In the worst possible scenario, communication problems between departments may arise where, for instance, the chief buyer is not talking to the chief estimator for some reason or other. Perhaps the contracts director thinks the chief surveyor is an idiot – and on it goes!

Good communications are important and the buying and contracts sections need to liaise closely in order to ensure that materials arrive on site on time. Contact needs to be established between the contract buyer and the site manager in order to ensure that the material call-off schedules clearly tie in with the programme of work.

Responsibilities also have to be clearly defined. The responsibility for buying materials within the estimate allowances lies with the buyer and any resulting savings created by efficient buying contribute to the profitability of the contract. The responsibility for handling materials, distribution around the site and fixing them in position is the site manager's domain; he is also responsible for material loss and accounting for excessive waste. Procedures for reducing loss and waste on site will be reviewed later in this chapter.

7.3.3 *A Materials Management System for Speculative Housing*

Principles of the System

For a materials management system, the objective is to produce material schedules which will be of benefit to the site manager. The system should combine the material scheduling with the planning and control of the project. Material schedules have to be synchronised to the sequence of work (or elements of construction) on each phase of a project and also be directly related to the requirements of the contract programme. The site manager is responsible for 'calling-off' or requesting delivery of materials to the site and for keeping suppliers informed of revised delivery dates in situations where work on site is behind or ahead of schedule.

Stage 1 -- Establishing the Construction Elements

The stages of construction should be divided into elements, such as:

1. Foundations
2. Ground floor slab
3. Internal and external walls
4. Intermediate floors
5. Roof construction
6. First fix
7. Second fix
8. Final fix
9. Sanitary appliances
10. Drainage
11. Paving and landscape
12. Roadworks and main sewer work

Certain of these elements may not be applicable in cases where the work is to be sublet to a subcontractor who supplies materials. The elemental list may be extended to suit the requirements of individual projects.

Stage 2 – Establishing the Materials Schedule

For each of the elements indicated it is necessary to identify a schedule of materials. This will only relate to the materials to be scheduled and ordered by the buying department. Figures 7.11 and 7.12 show a 'Materials Summary' sheet for the Foundations and External walls element.

MATERIAL SUMMARY

ELEMENT - 1	FOUNDATIONS		Contract :- Date :-	
REF.	MATERIAL	SUPPLIER	ORDER NUMBER	SCHEDULE REFERENCE
1/1	Ready mixed concrete			C1
1/2	Hardcore - brick			C2
1/3	Hardcore - stone			C3
1/4	Visqueen DPM			C4
1/5	Reinforcement fabric			M1
1/6	Reinforcement bar			M2
1/7	Common bricks			B1
1/8	Sand lime bricks			B2
1/9	Engineering bricks			B3
1/10	Facing bricks			B4
1/11	Trench blocks			B5
1/12	Blockwork			B6
1/13	Wall ties			B7
1/14	Air vents			B8
1/15				
1/16				
1/17				

Figure 7.11

MATERIAL SUMMARY

ELEMENT - 3	EXTERNAL WALLS		Contract :- Date :-	
REF.	MATERIAL	SUPPLIER	ORDER NUMBER	SCHEDULE REFERENCE
3/1	Facing bricks			B9
3/2	Facing bricks			B9A
3/3	Facing bricks			B9B
3/4	Common bricks			B10
3/5	Blockwork			B11
3/6	Blockwork			B12
3/7	Flue blocks			B13
3/8	Metal lintols			B14
3/9	Timber lintols			B15
3/10	PC. lintols			PC1
3/11	Ext. door frames			J1
3/12	Ext. windows			J2
3/13	Ext. windows			J2A
3/14	Special frames			J2B
3/15	Garage door frames			J2C
3/16	Steel beams			S1
3/17	PC thresholds			PC2
3/18				
3/19				
3/20				

Note :- The External Wall Element covers all items in the Superstructure Shell (ie. external / internal walls)

Figure 7.12

ELEMENT 1 - FOUNDATIONS
MATERIAL - COMMON BRICKS

MATERIALS SCHEDULE

SCHEDULE REF. B
Ref. B1. B3. B5.

Supplier	Address	Telephone Number	Order Number	Date order placed	Material Description	Total Quantity	CALL OFF DATES		Notes
							Date	Quantity	
Armstrong	84, Lord St	0151-702	73496	12/2/97	Common	15,000	13/6/97	8,000	
Bricks	Southport	3849			Bricks		20/7/97	7,000	
	SK7 4RL								
Armstrong	Ditto	Ditto	73497	12/2/97	Engineering	5,000	13/6/97	5,000	
Bricks					Bricks				
Tarmac	97, Albert Rd	0161-798	75001	15/3/97	Trench	15,000	2/6/97	5,000	
	Manchester	3026			Blocks		20/7/97	5,000	
	M21 3RU						15/8/97	5,000	

Note :- Separate schedules may be provided for each material or similar material may be combined on a single schedule

Figure 7 13

The materials scheduler (working within the buying department) is responsible for taking off quantities from the drawings and setting up the materials schedules for each element. Minor materials which are to be purchased at the local builders' merchants will not be included on the schedule. The key material delivery dates will be established from the contract programme after consultation with the site manager and contracts manager. Figure 7.13 indicates the layout of the Materials Schedule.

The material control system outlined above is ideal when the contractor is building standard house types on different development projects. Where this is the case, the materials scheduler has only to prepare material requirements for each house type and then apply the schedules to the phasing of the project.

7.4 Materials Wastage on Construction Sites

A report published by the Institution of Civil Engineers (1996) indicates that over 500 million tonnes of construction waste is generated each year. Landfill space is becoming scarce and the cost of tipping materials is very high and rising. The introduction of the Landfill Tax in 1996 has trebled the cost of disposing of hired skips and the cost of this will ultimately be passed on to the client in the form of increased tender prices.

For all these reasons, therefore, waste management on constuction sites should be taking on more importance.

Over the years much research has been undertaken into the subject of material waste on construction sites (1974)[2] and numerous papers[3] have been published on the topic.

However, many of these references are now years old and therefore in order to establish some evidence of current practice in materials management for this book, a small survey was undertaken. Eight housing construction sites were visited in the Manchester region, all of which were being developed by established housing contractors.

Although this evidence is anecdotal, and the sample was small, it is probably a fair reflection of the standards of materials management generally. Quite frankly, the standards were shocking. It appears from these observations that little has been learnt from the lessons of the past and that the site managers concerned were unaware of any materials policy within their organisation. Any regard at all for materials waste appeared to be entirely discretionary, and on six of the eight projects materials were appallingly mismanaged.

Illingworth (1993)[4] makes similar observations based on personal experience of waste management.

Observations relating to the mismanagement of materials included:

- Excessive waste left under scaffolds including bricks, blocks, skirting boards, facia boards, drainage fittings, etc.

- Expensive facings and engineering bricks being bulldozed into the ground and then covered over with topsoil to provide 'instant brick gardens'.
- Materials being stored on uneven ground, adjacent to unprepared access roads, allowing the material to become contaminated with mud and water.
- Pallets of bricks and blocks unloaded directly on to unprepared ground, away from the workplace.
- Damage to materials while unbanding the packs.
- Roof trusses being stacked on unprepared areas allowing them to distort and twist.
- Lack of covering and protection to internal timber floor joists, door frames and finishing joinery items. Structural timbers left unprotected in the rain.
- Excessive thickness of ready-mixed concrete to in situ concrete kerb beds.
- Out of sequence working, resulting in the excessive waste of stone filling materials, bricks and blocks, etc.
- Commencing foundation work with no provision for adequate access to the works. This resulted in chaos with respect to the storage of materials around the work area.

Only two of the companies had a materials management policy. On a number of projects, the site manager placed the blame for materials mismanagement on the extensive use of subcontract labour. Site managers also stated that they had far too much to do to worry about materials waste and were unaware of wastage allowances in the estimate.

7.4.1 Wastage Allowances in the Contractor's Estimate

The contractor's estimator allows for wastage when building up the unit rates for materials at the estimate stage. Each estimator has a different perspective on waste allowances but Skoyles and Hussey (1974) found that the percentage allowances compared to actual waste for a variety of materials were:

	Normal estimator's % allowance	Typical % loss in practice
Ready-mixed Concrete		
in foundations	2.5	10
in formwork	2.5	6-10
Bricks and blocks		
Commons	4	8
Facings	5	12
Engineering	2.5	10
Lightweight blocks	5	10
Concrete blocks	5	7

Roofing		
Tiles	2.5	10
Felt	2.5	8
Lead flashings	2.5	7
Joinery items		
First fix timbers	5	10
Boarding	5	15

It is considered that a comparison of current estimator's allowances with actual losses in practice would produce similar figures today.

7.4.2 Recommendations for Reducing Waste

BRE Digest 247 (1981) divides waste into four distinct categories. These are defined as:

- design waste
- take off/specification waste
- delivery waste and
- site waste.

Delivery and site waste can be reduced by considering the following:

- Allow adequate moneys in the estimate for the provision of temporary access roads and hardstanding areas for plant and equipment. Allow for providing material storage areas and facilities to store materials clear of the ground (storage racks).

- Ensure good site layout planning at the pre-contract stage. Allow the site manager to become involved in the decision making at this stage of the project.

- Encourage the site manager to manage his materials properly – he can be assisted by establishing in-company courses on materials management. The company may offer some degree of incentive to managers who achieve the minimum waste targets on their projects.

- Ensure that the staff are aware of the company materials management policy and of the allowances built into the estimate.

- Make senior managers responsible for the losses occurring on their projects as well. It is no use blaming the site manager, when his superior is oblivious to the losses when he visits the site.

- Ensure adequate control procedures for receiving materials on site including checking of delivery notes, correct handling and protection of materials on site. Ensure the use of correct lifting equipment which does not damage the goods. Provide adequate facilities for the unbanding of material packs.

- Provide adequate site security facilities and materials storage compounds.

- Provide simple procedures and checks for reconciling materials utilisation during the project. This could form part of the surveyor's role at the valuation stages.

- Make subcontractors aware of the company's materials wastage policy. Establish procedures for contra charging subcontractors for the excessive waste that they create.

The company may consider producing a simple site guide on its waste management policy. Recommendations may be included on good practice regarding materials handling and control. This could be issued to subcontractors and the company's directly employed labour. Also, poor control of materials wastage can create health and safety problems. Procedures should be included in the contractor's safety management system to eliminate this potential hazard.

References

1. Barrett F R, *Cost Value Reconciliation*, Chartered Institute of Building, 1981
2. Skoyles E R and Hussey H J, 'Wastage of Materials', article in *Building*, February 1974
3. Various papers on Loss and Waste published by The Chartered Institute of Building, Technical Papers 1, 15, 60, 87, 92
4. Illingworth J, *Construction Methods and Planning*, E & F Spon, 1993
5. *Managing and Minimising Construction Waste*, Institution of Civil Engineers Publication, 1996

8 The Control and Coordination of Subcontractors

The planning stages involved in the control and coordination of subcontractors follows similar stages to those that the main contractor goes through, i.e. pre-tender, pre-contract and contract planning. The decision making process in respect to subcontractors and their involvement in the project will therefore be dealt with under these headings. Subcontractors' input into the various planning stages is illustrated in Figures 8.1 and 8.2.

8.1 The Pre-tender Planning Stage

Assuming a traditional JCT80 main contract, the subcontractor selection process follows the following steps:

- Stage A Compiling the shortlist
- Stage B Criteria for subcontractor selection
- Stage C Information for subcontract tender enquiries
- Stage D Comparison of quotations
- Stage E Management adjudication of the bid

Each of the above stages will be dealt with in the form of a checklist, as outlined in the Code of Practice issued by the Building Employers Confederation (BEC) (1975)[1] and recommendations contained in the CIOB Code of Estimating Practice (1983).[2]

8.1.1 Stage A Compiling the Short List

As soon as it has been decided to select a subcontractor by competitive tender, a shortlist of those considered suitable to be invited to tender should be compiled. It is often the case that the main contractor has a list of subcontractors of established skill, integrity, responsibility and proven competence. This should be considered as a matter of policy within the contractor's organisation.

Main contractors should review their lists periodically so as to exclude firms whose performance has been unsatisfactory and to allow the introduction of new subcontract firms.

In some cases, the main contractor may find difficulty in compiling a short list owing to the shabby way he has treated his subcontractors in the past. In this case he may have to revert to the 'pin-sticking approach' using the building section in Yellow Pages in order to obtain quotations. There are dangers in this practice and it is much more preferable to cultivate good subcontractor relationships as recommended in the Latham Report. Many contractors are now benefiting from the wisdom of this approach.

The cost of preparing tenders is a significant element of the overheads both of the main contractor and his subcontractors. Tender lists therefore should be kept as short as practicable. Enquiries should be kept to between three and six, depending upon the type of subcontract work and size of project.

Perhaps the main contractor should consider adopting a policy of creating good relationships with a small group of reliable subcontractors whose businesses can expand as the main contractor becomes more established. Often the main contractor's reputation may rely solely on the excellence of his sub-contractors' performance.

The use of a register of subcontractors at the selection stage is recommended by Canter (1993).[3] This may lead to establishing subcontractor record cards relating to subcontractor performance criteria on previous contracts. It is important that such records are regularly updated and consideration given to adding new subcontractors to the register. It may be advisable at this stage to consider using a computer database, such as Microsoft Cardfile, for compiling the subcontract register. This may prove advantageous to a medium sized contracting organisation in order to speedily access subcontract information.

It is important that close relationships are encouraged between the main contractor and his subcontractors for the survival of both parties in the long term.

8.1.2 Stage B Criteria for Subcontractor Selection

Checklist for subcontractor selection

- Previous experience with the subcontractor.
- The subcontractor's ability to manage his resources and liaise with the main contractor's staff. Good relationships between parties are an essential requirement to developing a team approach to a successful project.
- Financial standing of the subcontractor. His ability to 'wait to be paid'.
- The subcontractor's expertise which he can bring to the project.
- The subcontractor's reputation and his standing with the client.
- The current commitment of the subcontract organisation. Their current work-load with other contractors should be determined and serious consideration given to their ability to cope with the increased work. A large number of subcontractors just cannot say 'No' when it comes to taking on more work. They often pull and push their limited labour force between sites hoping the main contractor will not notice that they are stretched to the limit.
- The acceptability of the subcontractor to the client. On many contracts the contractor is required to name his subcontractors at the tender stage.

SUBCONTRACTOR INPUT INTO THE PLANNING PROCESS

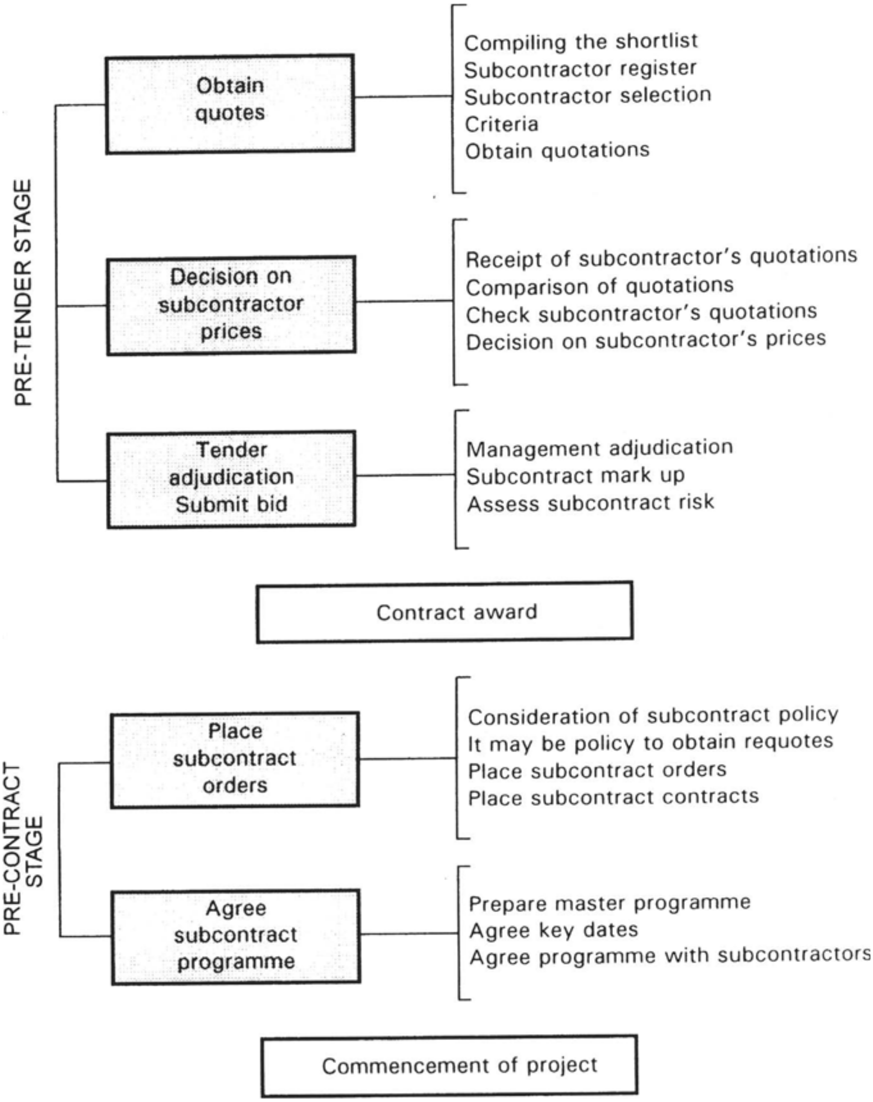


Figure 8.1

SUBCONTRACTOR INPUT INTO THE PLANNING PROCESS

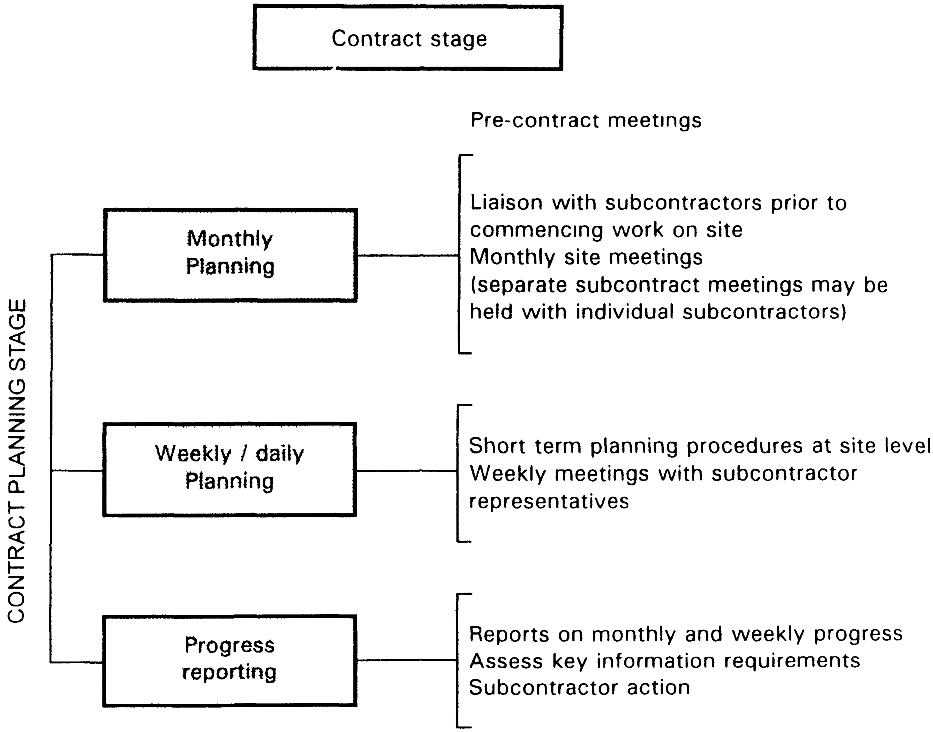


Figure 8.2

- The competitiveness of the subcontractor's price. The price must be right otherwise the subcontractor will never win any work. Price discounts which may be applicable and the subcontractor's response to negotiation may be an important factor.
- The contractual risk which the main contractor takes on the subcontract item. Subcontract operations of a 'low risk' category may be let to the more 'risky subcontractor' and hence the main contractor may include a lower subcontract price in his estimate. For example a 'high risk' subcontract operation could be external brickwork while site demolition work could be 'low risk'. Subcontract operations which are 'critical' to the success of the contract require careful consideration.
- The ability of the subcontract organisation to meet 'quality assurance criteria' as laid down by the main contractor or as specified by the client.
- References available from the subcontractor. These include trade and bank references. The willingness of the subcontractor to allow previous contract work to be inspected.

It is important that good relationships are established between the main contractor and subcontractor as early in the planning process as possible. This is especially important where the main contractor intends to sublet all the work on a particular project.

A survey of thirty-three refurbishment contractors undertaken by Okoroh and Torrence (1992)[4] indicated that most contractors did use some form of criteria when selecting subcontractors.The table below indicates the responses to a questionnaire relating to the frequency with which certain selection and appointment criteria are applied:

Criteria	**Never**	**Rarely**	**Sometimes**	**Always**
Financial strength	6	8	12	7
Previous experience	0	0	8	25
Ability to submit a bona fide bid	1	4	16	12
Labour resources	0	2	14	17
Management capability	0	30	2	0
Current and anticipated workload	1	1	23	8
Quality of workmanship	0	2	12	19
Transportation/ project location	27	4	0	2
Safety records/ working practices	0	11	7	15
Reliability and trustworthiness	0	0	8	25

Previous experience and reliability ranked first with regard to subcontractor selection, closely followed by quality of workmanship and labour resource availability.

In the process of choosing a subcontractor, it was found to be very important to select a firm that could liaise amicably with both the contractor's head office and site staff and satisfy different interests. A further significant consideration was the acceptability of subcontractors to clients and their consultants.

8.1.3 Stage C Information for Subcontract Tender Enquiries

Both the BEC Code of Practice (1975) and CIOB Code of Estimating Practice (1983) identify what information should be contained in the contractor's enquiry to a subcontractor. The BEC Code also proposes a useful checklist which is summarised as follows:

Checklist for subcontract invitation to tender

- Details of Main Contract works
    - Job title and location of site
    - Name of employer
    - Names of architect, supervising officer, quantity surveyor and other consultants including the planning supervisor
    - General description of the works

- Subcontract works
    - Relevant extracts from bills of quantities and specification
    - Extracts from the contract Preliminaries section
    - Copies of relevant drawings
    - Details of where original documents may be inspected
    - Time period for completion of subcontract work (if known)
    - Approximate dates when subcontract work will be undertaken
    - Names of adjudicator (in case of dispute)

- Subcontractor's responsibility for site arrangements and facilities:
    - Watching and lighting
    - Storage facilities
    - Unloading, hoisting and getting in materials
    - Scaffolding
    - Water and temporary electrical supplies
    - Safety, health and welfare provisions
    - Licences and permits
    - Any additional facilities

- Conditions of subcontract
  - Form of subcontract agreement
  - Period of interim payments and payment terms, including whether 'pay when paid' will apply
  - Discount applicable to the payments
  - Fluctuations or fixed price tender
  - Other special conditions

- Particulars of the main contract conditions
  - An extract from the Appendix to the form of contract will assist in providing a summary of the contract particulars. This should contain the following information:
    - Form of contract
    - Fluctuations provisions
    - Method of measurement
    - Main contract period and completion date
    - Defects liability period
    - Liquidated and ascertained damages
    - Period of interim certificates
    - Basis of dayworks
    - Insurance provisions
    - Deletions or amendments to standard contract clauses

- Type of quotation required from the subcontractor
  - Lump sum quotation
  - Schedule of rates

- Other information
  - Date for the return of the tender
  - Person in the contractor's organisation to contact
  - Period for which the tender is to remain open for acceptance
  - Extent of the phasing of the works and number of anticipated visits to undertake the works
  - Reference to any relevant attendances likely to affect the subcontractor

Similar checklist points can also be found in Canter (1993)[3] and Brook (1993).[5]

8.1.4 Stage D Comparison of Quotations

The CIOB Code of Estimating Practice (1983) section 6.03 includes recommendations for analysing subcontractor quotations in the form of a domestic subcontractor register. Subcontractors' quotations are not straightforward to compare. Some do not price all the items in the enquiry; often there are mistakes and some subcontractors price net while others offer discounts, typically 2.5%. Therefore, a register or 'spreadsheet' is a useful device to enable quotations to be matched, discrepancies identified and discounts adjusted.

A typical checking procedure when comparing subcontractors' quotations should include consideration of the following:

- Does the work described in the quotation comply with the specification?
- Have all items have been priced and if not are they included in other rates?
- Are unit rates consistent throughout the quotation?
- Check that the quotation does not form a counter-offer and that the subcontractor has accepted the terms and conditions of the enquiry.

8.1.5 Stage E Management Adjudication of the Bid

Adjudication of the main contractor's estimate and its conversion into a tender requires management decision making whatever the size of firm. Where the tender includes a large proportion of subcontract work then it is critical to carefully decide on the mark up on the subcontractor's quotations selected for inclusion. It will also be necessary to carefully scrutinise the estimator's allowances for attendance on the subcontract works at the adjudication stage.

Consideration needs to be given to any late quotations received which will directly affect the competitiveness of the overall bid and this is where the subcontract comparison sheet or register facilitates last minute lump sum adjustments to be made to the tender.

The percentage mark-ups on subcontractors' quotations often vary widely according to the contractor's desire to win the contract. Percentages will probably be in the range of 2.5% to 15%, depending on the contractor's view of the risk attached to the subcontract element of the contract.

Despite all the foregoing considerations, there often appears to be no rhyme or reason as to how contractors arrive at their tender adjustments. Mystic Meg or a crystal ball are just two suggestions!

8.2 Works Package Procurement in Management Contracting and Construction Management

The procurement of subcontract work packages is somewhat different under management contracts compared with the arrangements and negotiations on a traditional JCT 80 contract. For instance, the management contractor or construction manager has to work in conjunction with the design team's quantity surveyor in order to produce a workable budget. This may take the form of an overall budget developed from an assessment of the budget figures for individual work packages.

Deciding how to 'package' the project is another principal difference compared to conventional contracts. Sidwell (1983)[6] suggests a flow chart approach to the process of establishing work packages and this concept is illustrated in Figure 8.3. However, the packages cannot be thought of as 'subcontract enquiries' in the normal sense and careful thought is needed so as to avoid too many 'interface' problems on site. These interfaces could lead to the situation where none of the package contractors has included for a particular item of work or duplication may occur where several firms are responsible for the same item. Either way, extra cost or disputes could result. Also, procurement of the work packages requires special negotiating skills and package contracts have to be carefully set up in order to reduce the risk of disputes.

The process involves close liaison between the design team and the appointed management contractor or construction manager in order to establish procedures for securing the 'best buy'.

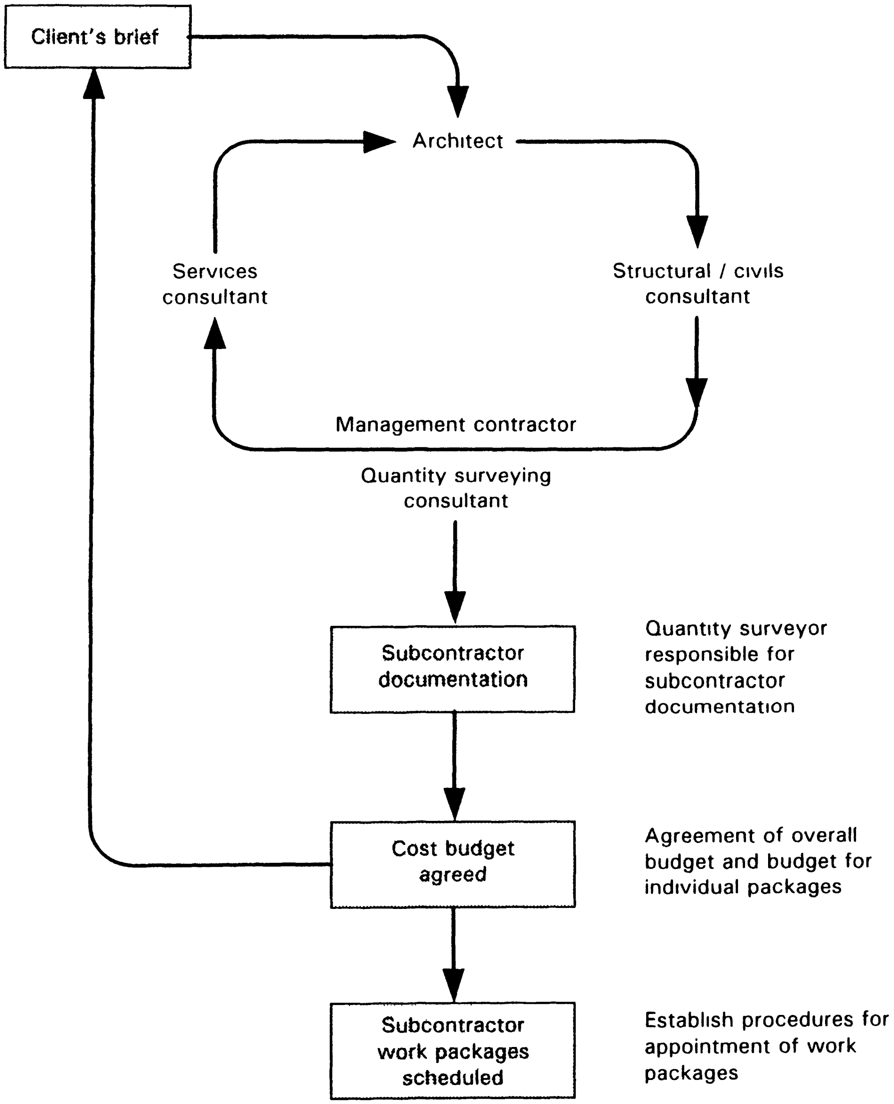
Figure 8.4 illustrates a typical 'Work Package Budget' for a science park project involving the construction of an office block of some 3000 m^2 in floor area. The work packages are established at the design stage and budget figures have been produced from the scheme drawings based on approximate quantities and current rates.

Provision has been made on the Work Package Budget form for entering actual work package tender prices in order to identify variances in the budget and to update the budget as the project develops. Of course, the individual budgets may not always be achieved in practice and therefore a 'swings and roundabouts' approach may have to be taken, while at the same time making sure that the overall budget is maintained.

Many experienced management contractors and construction managers adopt standard procedures for the selection and appointment of work package contractors and examples of these are outlined below.

8.2.1 Establishing Work Package Information Requirements

When the scope of the various packages has been established, it is then necessary to assess lead in times for each of them prior to commencing the procurement process. Additionally, information requirements relative to each of the work packages have to be assessed and this will require the design team to work closely with each other and the management contractor/construction manager as they will have to produce the information by agreed dates prior to sending out work package enquiries.



DETERMINATION OF WORK PACKAGES

Figure 8.3

WORK PACKAGE BUDGET

PROJECT - UNIT ONE - WARRINGTON SCIENCE PARK				
PACKAGE REF.	WORK PACKAGE	BUDGET	ACTUAL	SAVING/ INCREASE
SUBSTRUCTURE				
100	FOUNDATIONS	110,000	100,000	-10,000
101	DRAINAGE	25,000	18,000	-7,000
102	CAR PARKS	90,000	95,000	+5,000
103	LANDSCAPING	30,000		
STRUCTURE				
200	STEEL FRAME	250,000	245,000	-5,000
201	FLOOR/ROOF DECKS	40,000		
202	ROOF FINISHES	20,000		
203	EXTERNAL ENVELOPE	220,000		
204	EXT. WINDOWS/DOORS	60,000		
FINISHES				
300	INTERNAL PARTITIONS	40,000		
301	FLOOR FINISHES	35,000		
302	CEILING FINISHES	25,000		
SERVICES				
400	HEATING	150,000		
401	ELECTRICAL	100,000		
402	AIR CONDITIONING	70,000		
403	LIFTS	80,000		
404	FIRE AND ALARM	20,000		
CONTINGENCY		50,000		
TOTALS		**1,415,000**		
INITIAL BUDGET ASSESSMENT		**1,500,000**		
FINAL BUDGET ASSESSMENT				

Figure 8.4

A typical set of 'Key Dates' is given below which could be used for each of the work packages in a procurement schedule:

- Agree work package list
- Design information complete - architect/engineer/services
- Design packages to the quantity surveyor
- Schedules and quantities complete
- Tender package issued
- Enquiries sent to work package subcontractors
- Tenders returned
- Technical checks complete
- Work package negotiations complete
- Appoint work package subcontractor - letter of intent
- Arrange work package contract to be signed
- Working drawings issued
- Lead time required
- Commencement date on site planned

The establishment of key dates for each of the above items places extensive responsibility on the management contractor/construction manager. Above all, he has to motivate the design team to produce the information on time and to clearly point out the consequences of failing to meet the programmed dates. Just one uncooperative member of the design team can cause the best planned project to fall apart.

The key date requirements relative to each of the work packages may be linked to the project planning software being used for the project. Many of these packages produce key date schedules relative to pre-contract activities developed from the project network diagram.

Figure 8.5 illustrates a Work Package Procurement Schedule for a major project. This enables planned, current and actual dates for each work package to be monitored as the packages are awarded.

8.2.2 Arrangements for Procuring the Work Packages

Selection of the individual work packages often follows a standard procedure which may also be part of a quality system. It should be noted that the extent to which selection procedures are strictly adhered to may depend upon the degree of risk allocated to the work package contractor.

For each of the work packages the following selection routine may be followed:

- Select eight potential work package contractors
- Shortlist to six work package contractors
- Send questionnaire to each

- Financial checks
- Visit current contracts
- Reduce shortlist and interview four contractors
- Tender documents to four contractors
- Tenders received and checked
- Interview lowest two tenderers
- Appoint work package contractor in agreement with the design team

This procedure is illustrated in Figure 8.6.

8.3 Pre-contract Liaison

Following the selection process, prospective subcontractors or works package contractors should be informed that their tenders have been accepted and that a contract will follow. However, before contracts are signed several matters need to be clarified so that disputes do not arise during the works. At this stage, it is useful to follow a checklist approach to ensure that all the pre-construction issues are covered. These will include:

- Confirm order or issue letter of intent
- Prepare contracts for signing
- Agree key dates, sequence of works and programme including integration with the project programme
- Agree timing for issue of drawings or approval of design information
- Confirm requirements for insurances
- Agree or obtain client/client representative approval of subcontracts or packages where there is a contractual requirement to do so
- Agree the provision of samples, sample panels and mock ups to be submitted for client approval
- Agree the facilities to be provided by the subcontractor/package contractor, for example, cabins, stores, offloading, scaffolding, removing rubbish, etc
- Agree dates for interim certificates and procedure for requesting payment
- Agree notification requirements for instructions, variations, dayworks, etc
- Sign contract

Before any work commences on site, it is vital that the main contractor or the management contractor/construction manager maintains contact with the works contractor in order to keep him fully informed of the contract progress position. For instance, where there is the likelihood of the commencement of the work being delayed, then as much notice as possible should be given.

It is essential to maintain this contact and to ensure that notification procedures agreed at the pre-contract stage are observed by all parties.

PACKAGE		Issue tender documents	Collate tender documents	Out to tender	Return tender	Tender appraisal	Client review	Place order	Lead-in time (weeks)	Start date on site
100/1	Planned	29/03/96	01/04/96	09/04/96	03/05/96	07/05/96	28/05/96	31/05/96	13	27/08/96
Brickwork and Blockwork	Current	29/03/96	01/04/96	09/04/96	03/05/96	07/05/96	28/05/96	31/05/96	13	27/08/96
	Actual									
200/1	Planned	12/04/96	15/04/96	19/04/96	17/05/96	20/05/96	03/06/96	07/06/96	17	30/09/96
Wall cladding Excl glazing	Current	12/04/96	15/04/96	19/04/96	17/05/96	20/05/96	03/06/96	07/06/96	17	30/09/96
	Actual									
200/2	Planned	16/02/96	19/02/96	01/03/96	29/03/96	01/04/96	15/04/96	19/04/96	16	05/08/96
Rooflights	Current									
	Actual									
200/3	Planned	26/01/96	29/01/96	09/02/96	22/03/96	25/03/96	15/04/96	19/04/96	24	30/09/96
External glazing panels	Current	26/01/96	29/01/96	09/02/96	22/03/96	25/03/96	15/04/96	19/04/96	24	30/09/96
	Actual									
300/1	Planned	04/04/96	09/04/96	12/04/96	10/05/96	13/05/96	24/05/96	31/05/96	15	09/09/96
Roofing and Northlights	Current	04/04/96	09/04/96	12/04/96	10/05/96	13/05/96	24/05/96	31/05/96	15	09/09/96
	Actual									
400/1	Planned	16/08/96	19/08/96	30/08/96	27/09/96	30/09/96	14/10/96	18/10/96	5	18/11/96
Plaster / screeds	Current	16/08/96	19/08/96	30/08/96	27/09/96	30/09/96	14/10/96	18/10/96	5	18/11/96
	Actual									

WORK PACKAGE SCHEDULE

Figure 8.5

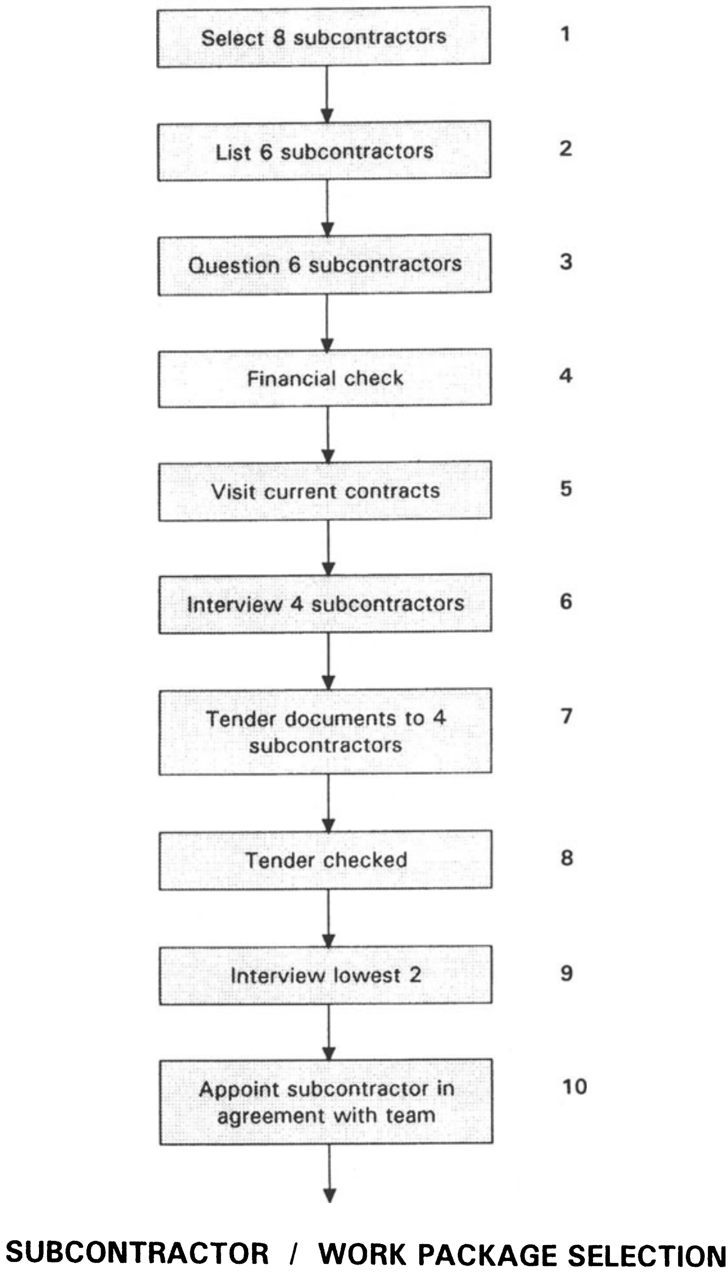

Select 8 subcontractors
1
List 6 subcontractors
2
Question 6 subcontractors
3
Financial check
4
Visit current contracts
5
Interview 4 subcontractors
6
Tender documents to 4 subcontractors
7
Tender checked
8
Interview lowest 2
9
Appoint subcontractor in agreement with team
10
SUBCONTRACTOR / WORK PACKAGE SELECTION

Figure 8.6

8.4 Liaison during the Contract Period

The coordination and control of subcontractors and package contractors is crucial to the success of the project and this lends itself to a standardised approach. Many of the large contracting organisations and construction managers have developed their own procedures for this. What is the secret to success? Well, by 'Meetings, bloody meetings', as the John Cleese Management video recommends!

Many major contractors adopt a policy of ruling works contractors with a rod of iron, but this is not the way to ensure cooperation and team working on site. The success of a project depends on the performance and quality of those who carry out the work on site and such a short-sighted policy will ultimately fail.

Good liaison and mutual respect must be established as early in the contract period as possible and maintaining contact with subcontractors or works package contractors during the pre-contract period helps to build up an early working relationship. During the project, this theme is developed by regular contact at weekly and monthly progress and coordination meetings.

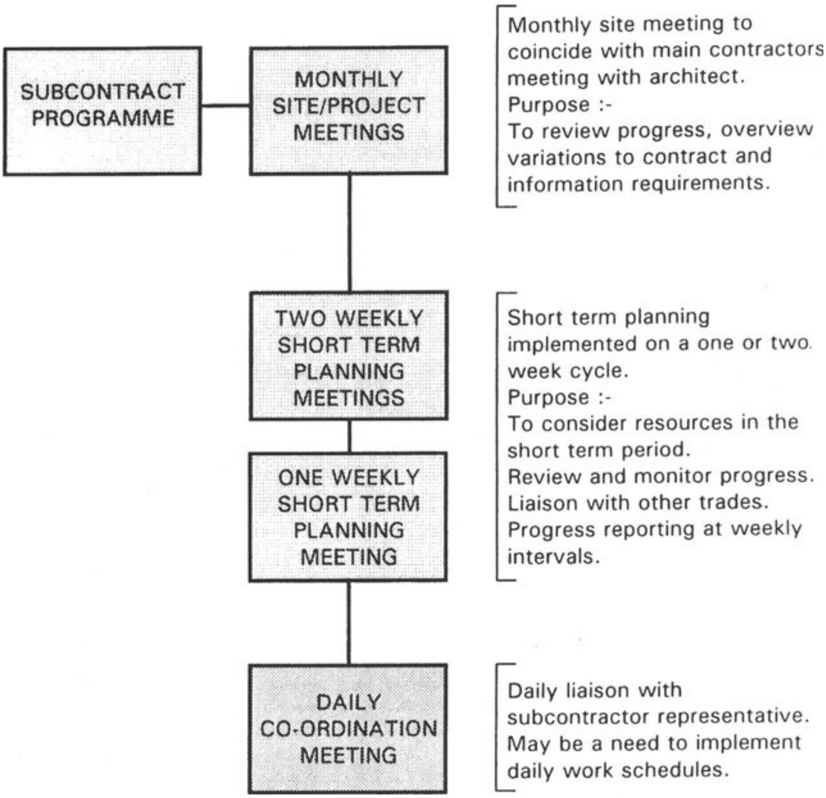
Figure 8.7 illustrates the meetings likely to be held during the contract stage where the works contractors will discuss problems and information requirements and iron out any difficulties which may be affecting the progress of operations on site.

A checklist of points to be considered at such meetings will include:

- Review progress and quality of work
- Review of the programme including relationships between the main programme operations and those of other works activities
- Action to maintain progress
- Investigate site problems and hold-ups
- Review labour situation
- Review of the plant and material supply situation
- Overview of site organisation and supervision requirements
- Consideration of the health, safety and welfare situation
- Confirmation of the situation regarding the issue of site instructions and variations to contract
- Review of the valuation and payment situation to date

A system of short term planning may be implemented in order to keep works contract progress under constant review. This will involve preparing weekly or two weekly programmes which will be discussed at the progress meetings and the preparation of work plans for the next short term period. Figure 8.8 illustrates the principles of a two weekly short term planning system.

It is important that the works contractors' site representatives participate in the short term planning procedures and a good working relationship is established at site level.



SUBCONTRACTOR LIAISON MEETINGS

Figure 8.7

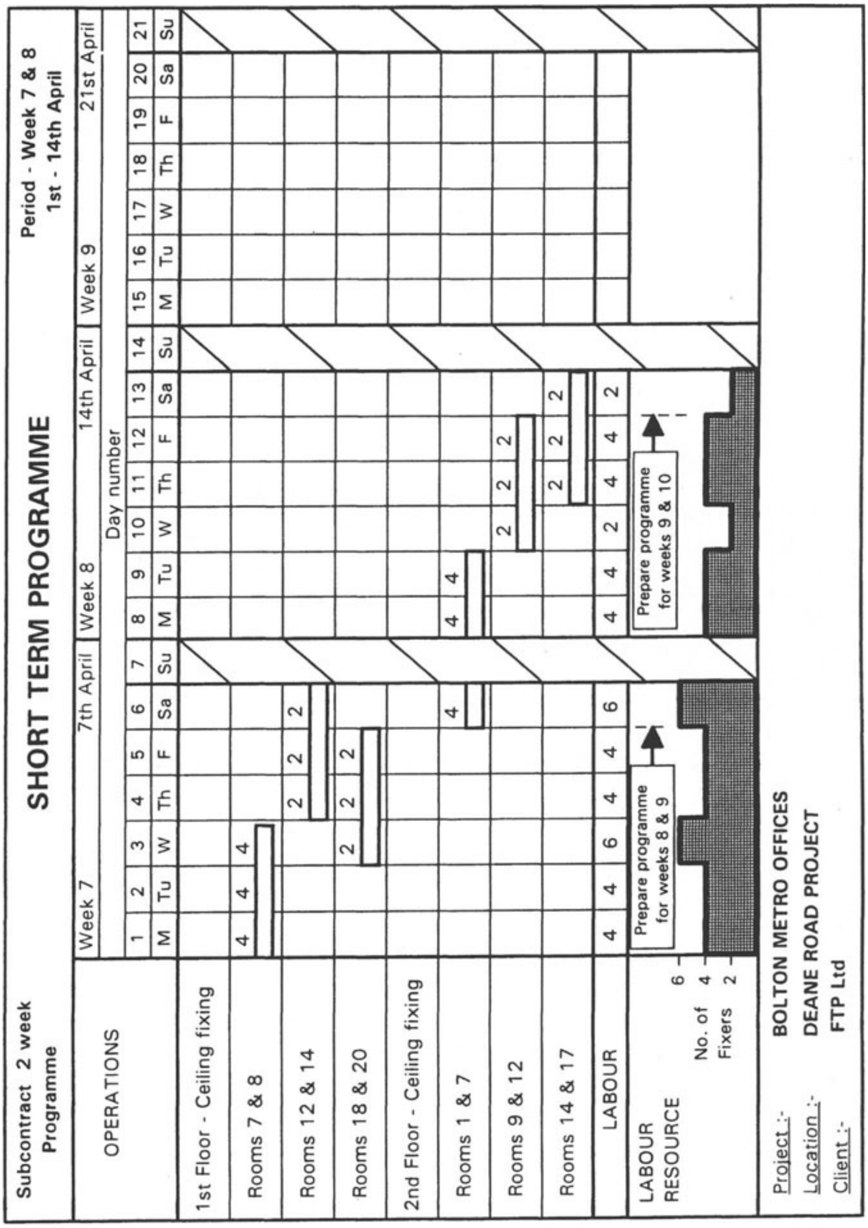

Subcontract 2 week Programme
SHORT TERM PROGRAMME
Period - Week 7 & 8
1st - 14th April
OPERATIONS
Week 7
7th April
Week 8
14th April
Week 9
21st April
Day number
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
M Tu W Th F Sa Su M Tu W Th F Sa Su M Tu W Th F Sa Su
1st Floor - Ceiling fixing
Rooms 7 & 8
Rooms 12 & 14
Rooms 18 & 20
2nd Floor - Ceiling fixing
Rooms 1 & 7
Rooms 9 & 12
Rooms 14 & 17
LABOUR
4 4 6 4 4 6
4 4 2 4 4 2
LABOUR RESOURCE
No. of Fixers
6
4
2
Prepare programme for weeks 8 & 9
Prepare programme for weeks 9 & 10
Project :- BOLTON METRO OFFICES
Location :- DEANE ROAD PROJECT
Client :- FTP Ltd

Figure 8.8

With future projects in mind, it is a good idea to record the performance of the works contractors on site. This will provide useful feedback for reviewing tender lists to ensure that works contractors are competent and adequately resourced and that there is an up-to-date database for new projects. One possible approach is to list the key performance criteria and to rate each one on a scale of 1 to 5. The performance criteria might be:

- price
- quality and workmanship
- health and safety
- standard of cooperation
- time/programme performance

The maximum score would be 25, but a rating of say less than 10 might lead to exclusion from the tender list. Certain criteria, such as health and safety for instance, could be weighted for importance where appropriate.

References

1. *Subcontractor Code of Practice*, Building Employers Confederation Publication, 1975
2. *Code of Estimating Practice*, Chartered Institute of Building, 3rd Edition 1983
3. Canter M R, *Resource Management for Construction*, Chapter 6, Macmillan Press 1993
4. Okoroh M and Torrence V., Technical paper based on PhD Thesis, 'Knowledge based decision support systems in the selection and appointment of Subcontractors in Building Refurbishment', University of Loughborough, 1992
5. Brook M, *Estimating and Tendering for Construction Work*, Butterworth-Heinemann, 1993
6. Sidwell A C, *An Evaluation of Management Contracting*, Construction Management and Economics Volume 1, E & F Spon, 1983

9 Accelerating the Project

9.1 Project Acceleration and Time Cost Optimisation

There are many circumstances in which the contractor may wish to speed up work on a contract. This may be due to the contractor being behind programme, and having to increase production in order to minimise extensive liquidated damages. Alternatively, the client may have requested the contractor to indicate the additional costs of completing the project earlier than the contract completion date.

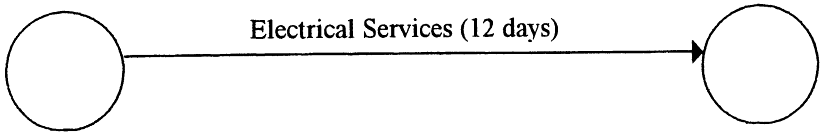
In practice, a department store client, for instance, may request an earlier occupation date for the building in order to take advantage of the winter or summer sales. The additional profit created by the earlier opening might well exceed the contractor's additional costs.

In order to balance the time savings against the costs of speeding up the work, optimisation studies are undertaken in order to consider the various options available. These studies allow the client and/or contractor to assess the effect on the direct and indirect costs of reducing the overall project period which can then be compared with the potential profits or savings in liquidated damages due to earlier completion.

Many writers refer to this method of analysis as 'Time Cost Optimisation', 'Least Cost Optimisation' or 'Crash Costing', but perhaps a more appropriate term would be 'Project Acceleration' as this is really what it is all about. Whatever you decide to call it, however, the first step is to understand the terminology used and then the principles of the process which will be illustrated below by way of two worked examples.

9.2 Project Acceleration Terminology

Consider the network arrow for the activity 'Electrical Services':



Normal Time, Normal Cost

This is the usual time that would be needed to carry out the electrical services work under normal circumstances which is estimated at 12 days with a cost of £10 000.

Crash Time, Crash Cost

The crash time is the maximum time by which the operation can be compressed by increasing the resources. This reduction in time leads to an increase in the direct cost. The revised cost is called the 'crash cost'. In this example, the accelerated time or crash time is to be 8 days at a total cost or crash cost of £18 000.

Cost Slope

The cost slope represents the cost of accelerating any of the project activities by one unit of time (in the above case, 1 day).

In order to achieve a reduction in the overall project duration at the least possible cost, the activities on the critical path of the programme must be compressed as much as is physically possible. This is done by first considering the activities with the least cost slope.

The cost slope of the Electrical Services activity is expressed as:

$$\frac{\text{Increase in Cost}}{\text{Reduction in Time}} \quad \text{or} \quad \frac{\text{Crash Cost less Normal Cost}}{\text{Normal Time less Crash Time}}$$

$$= \frac{£18\ 000 - £10\ 000}{12 \text{ days} - 8 \text{ days}} = \frac{£8\ 000}{4 \text{ days}}$$

$$= \underline{£2\ 000 \text{ Cost Slope}}$$

Activity Ranking

Once the arrow or precedence relationship has been analysed and the critical activities identified, all the activities on the critical path are ranked in order of their cost slopes starting with the least expensive.

It is obviously more economical to apply reductions in the project time to the less expensive activities first in order to achieve the required reduction in the overall project period. As the ranking is applied to the network sequence, the float times and cost slopes of non-critical activities must be considered, for at some moment in time these may become critical.

Direct Costs

These are the costs associated with carrying out activities on the programme including:

- Labour
- Plant
- Materials
- Subcontractors (if applicable)
- Overheads and profit

When an activity is accelerated, the corresponding direct costs will increase. This may be due to the need to supply additional resources in the form of increased labour, plant and materials requirements. Accelerating an operation may also involve working overtime or weekend working. Also, incentives, in the form of bonus payments may have to be made in order to ensure that the task is completed on time. Other direct costs may be incurred such as additional formwork. This will reduce the number of uses originally envisaged by the estimator and thus add to the direct cost of acceleration.

Acceleration may require extra direct supervision, such as foremen and gangers, to cover weekend working and the supervision of additional labour gangs.

Indirect Costs

These are the time related costs of the project which change as the project duration changes. They are normally included in the contract preliminaries and will include:

- project supervision
- site hutting and accommodation
- site office telephones, heating and lighting
- vans and site transport

When an activity is accelerated, the corresponding indirect costs will decrease. This is due to the reduction in project duration which directly affects the contract preliminaries. The contractor will, in principle, be on site for a shorter period and therefore the client will expect some reduction in the site administration costs or preliminaries.

Total Project Cost

This is the summation of the direct and indirect costs. The total cost is usually expressed at the normal time and at the optimum project duration.

Optimum Project Duration

The optimum project duration occurs at the point where the most beneficial least cost situation occurs, taking into account both direct and indirect costs. In order to establish the least cost situation the cost increase for each unit of time reduction must be considered.

Figure 9.1 illustrates the relationship between direct cost, indirect cost and project duration. The summation of the direct and indirect costs (i.e. the total project cost) is also indicated. The optimum duration is shown on the total cost graph which is the date at which the costs rise most significantly.

9.3 Project Acceleration Applications

9.3.1 Application 1 Based on a Network Arrow Diagram

Project Details

Figure 9.2 shows a construction sequence involving activities A to I in arrow diagram format. The tabular data indicates the normal times, normal costs, crash times and crash costs. The indirect costs (or time related preliminary costs) of the project amount to £2 000 per week.

Figure 9.3 illustrates the analysed arrow diagram based on the normal time situation which gives an overall project duration of 28 weeks. The total project cost, based on normal time, has been calculated at £254 000, which is made up of direct costs of £198 000, plus £56 000 (28 weeks × £2 000) of indirect cost.

The following two scenarios will now be considered:

Scenario 1 A reduction of 5 weeks in the project duration in order to complete the project by week 23.
The effect on the direct and indirect costs will be considered in order to achieve this reduction in time.

Scenario 2 The effect on the project cost for each weeks reduction in time in order to assess the least cost situation.

RELATION BETWEEN INDIRECT COST, DIRECT COST AND TOTAL PROJECT COST

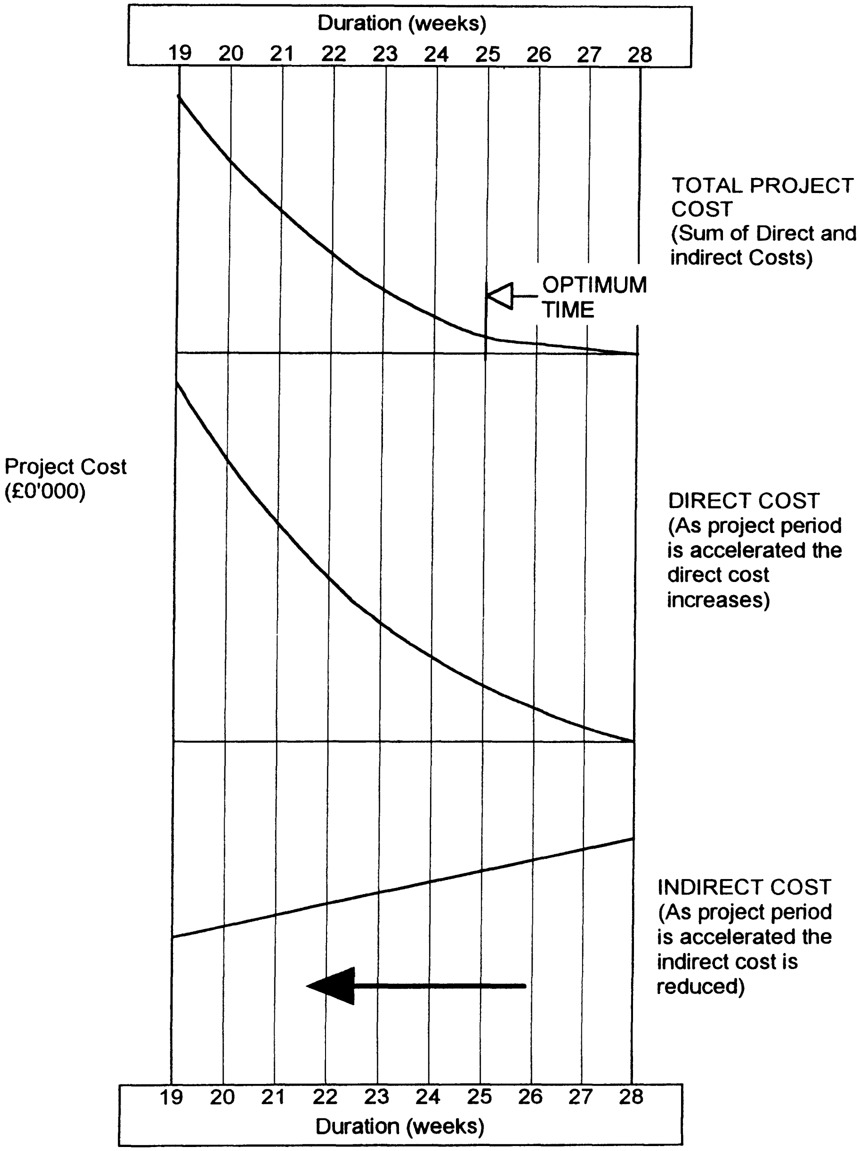
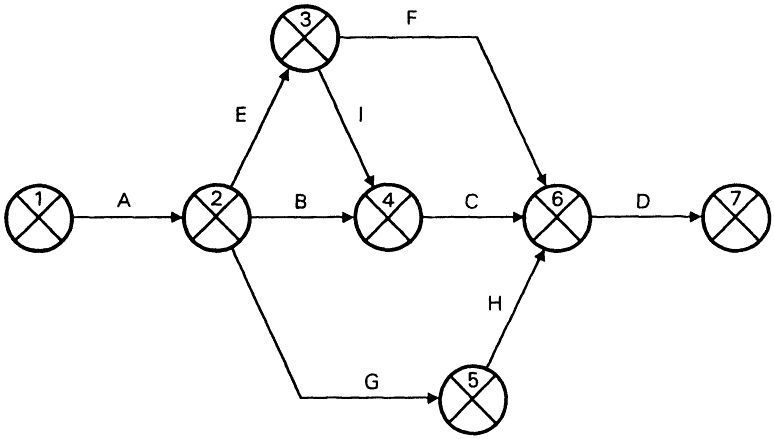


Figure 9.1

INITIAL ARROW DIAGRAM

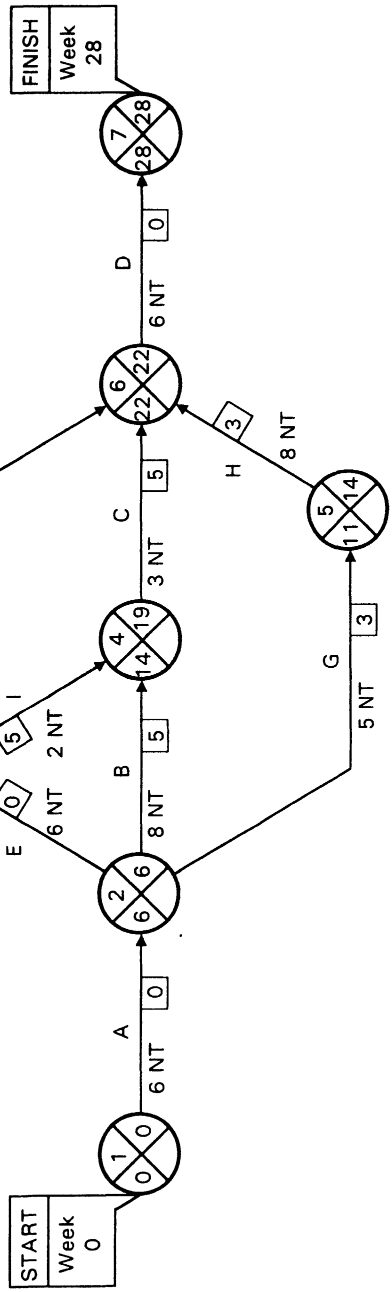


PROJECT DATA				
Activity	Normal Time	Normal Cost	Crash Time	Crash Cost
A	6	12 000	4	20 000
B	8	24 000	4	48 000
C	3	18 000	2	20 000
D	6	18 000	4	24 000
E	6	36 000	4	54 000
F	10	10 000	6	50 000
G	5	20 000	3	30 000
H	8	40 000	6	50 000
I	2	20 000	2	20 000
	Summation	£198 000		
Indirect costs £2 000 per week				

Figure 9.2

Normal Time = 28 weeks
Normal Cost = Direct Cost plus Indirect Cost
= £198 000 + 28(£2 000)
= £254 000

Total Project Cost at Normal Time £254 000



Duration in Weeks

NORMAL TIME / NORMAL COST ANALYSIS

Figure 9.3

Scenario 1 Analysis

In order to reduce the project duration by 5 weeks, it will be necessary to consider the cost slopes of all activities. The assessment of the cost slopes and their appropriate ranking are indicated in Figure 9.4.

With reference to Figures 9.3 and 9.4, it can be seen that in order to reduce the project duration by 5 weeks it will be necessary to reduce the durations in rank order on the critical path (from the least expensive to the more expensive cost slopes). In Figure 9.4 the critical path follows activities D, A and E in rank order. By using the crash durations for these activities, a 5 week reduction in the overall project period can be achieved.

Activity	**Normal time (weeks)**	**Crash time (weeks)**	**Reduction in time (weeks)**	**Cost slope (£)**	**Increase in direct cost (£)**
D	6	4	2	3 000	6 000
A	6	4	2	4 000	8 000
E	6	5	1	9 000	9 000

Reduction in overall time	=	5 weeks
Increase in direct cost due to this reduction in time	=	£23 000

Total project costs at week 23

Direct costs	=	£198 000 + £23 000	=	£222 000
Indirect costs	=	23 weeks @ £2 000	=	£46 000
Total project cost			=	£268 000

Therefore, in order to achieve an acceleration of 5 weeks, the project cost will be increased by £14 000, i.e.:

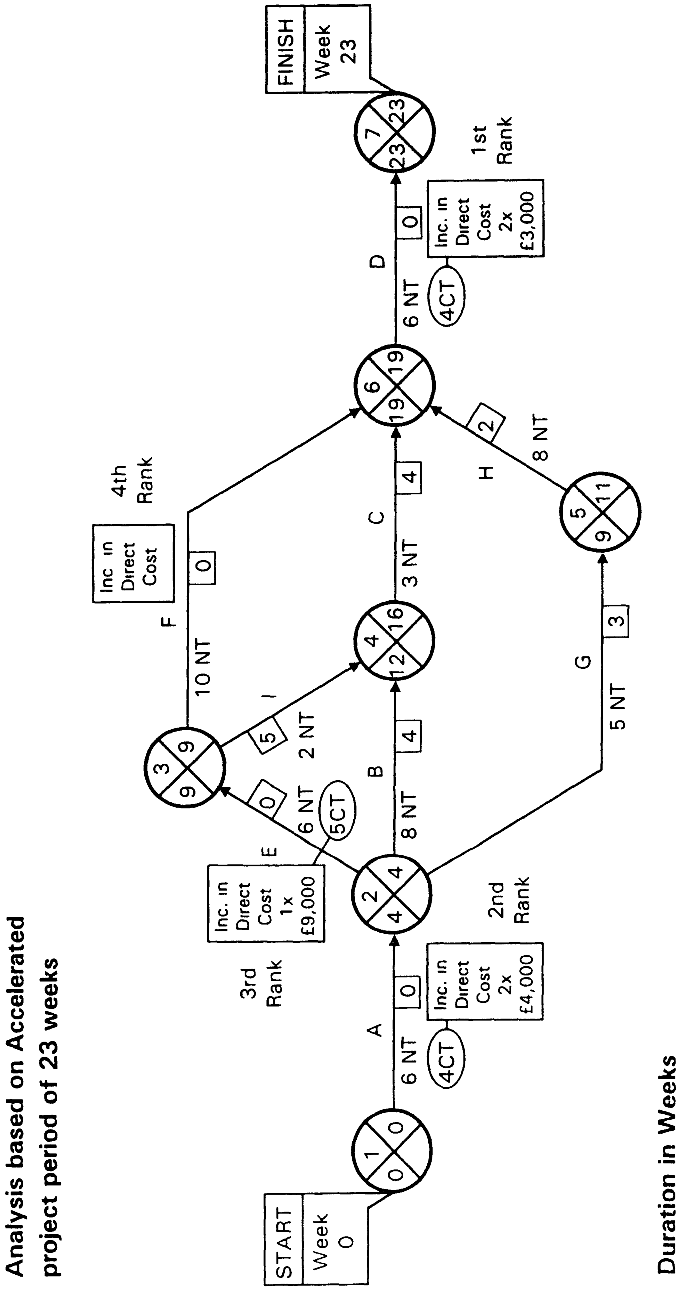
Crash cost	=	£268 000
less normal cost	=	£254 000
Acceleration cost	=	£14 000

Figure 9.5 shows the revised arrow diagram analysis using the crash times on activities A, E and D. This analysis also indicates the revised float times on the non-critical activities.

COST SLOPE ASSESSMENT

Activity	Normal time	Crash time	Saving in time	Normal cost (£'000)	Crash cost (£'000)	Increase in cost (£'000)	Cost slope	Float	Order / Ranking
A	6	4	2	12	20	8	4000	Zero	2nd
E	6	4	2	36	54	18	9000	Zero	3rd
F	10	6	4	10	50	40	10000	Zero	4th
D	6	4	2	18	24	6	3000	Zero	1st
B	8	4	4	24	48	24	6000	5	Non critical operations
G	5	3	2	20	30	10	5000	3	
H	8	6	2	40	50	10	5000	3	
I	2	2	0	20	20	0	0	5	
C	3	2	1	18	20	2	2000	5	

Figure 9.4



REVISED ARROW DIAGRAM

Figure 9.5

Scenario 2 Analysis

The change in the direct and indirect costs due to each week's reduction in the project time is indicated in Figure 9.6. This relationship is presented in graphical form in Figure 9.7.

The relationship between the indirect and direct costs for each week of the project from weeks 28 to 18 can be observed in Figure 9.7. The summation of the direct and indirect costs is displayed and the point on the graph where the cost suddenly increases is the position of the optimum time and least cost situation. This occurs at the end of week 24. At week 25 the change in cost per week changes from £2 000 to £7 000 per week.

The project costs have been analysed back to week 18 in order to provide an overall assessment of the project cost situation.

9.3.2 Application 2 Based on a Precedence Network

Project Details

Figure 9.8 indicates a precedence diagram for activities A to J during a construction sequence. Details of the normal time, normal cost, crash time and crash cost is presented below:

Activity	Normal time (days)	Normal cost (£)	Crash time (days)	Crash cost (£)
A	6	18 000	3	21 000
B	5	14 000	3	18 000
C	5	16 000	4	18 000
D	4	8 000	4	8 000
E	3	10 000	3	10 000
F	7	22 000	5	28 000
G	5	4 000	4	5 000
H	3	12 000	2	13 000
J	3	10 000	2	15 000

Total normal cost = £114 000

Indirect cost (Preliminaries) = £1000 per week

Week No. Start	Direct cost		Indirect cost		Aggregate	Total project cost (£0'000)	Activity ranking
		+ve		-ve			
28	198		56			254	
27		+3		-2	+1	255	Activity D
26		+3		-2	+1	256	
25		+4		-2	+2	258	Activity A
24		+4		-2	+2	260	
23		+9		-2	+7	267	Activity E
22		+9		-2	+7	274	
21		+10		-2	+8	282	Activity F
20		+10		-2	+8	290	
19		+10		-2	+8	298	
18		+10		-2	+8	306	

CALCULATION OF CHANGE IN DIRECT AND INDIRECT COST PER WEEK AFTER APPLYING RANKING

Figure 9.6

INDIRECT COST, DIRECT COST AND TOTAL PROJECT COST RELATIONSHIP

GRAPHICAL PRESENTATION

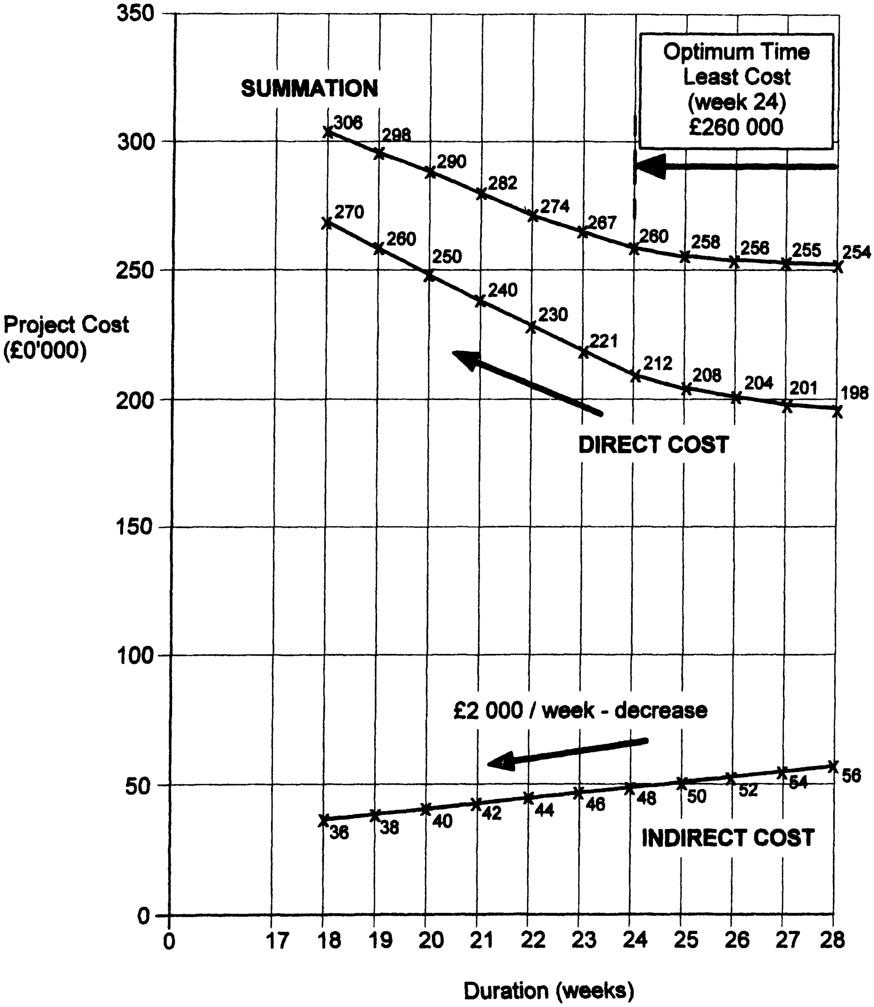
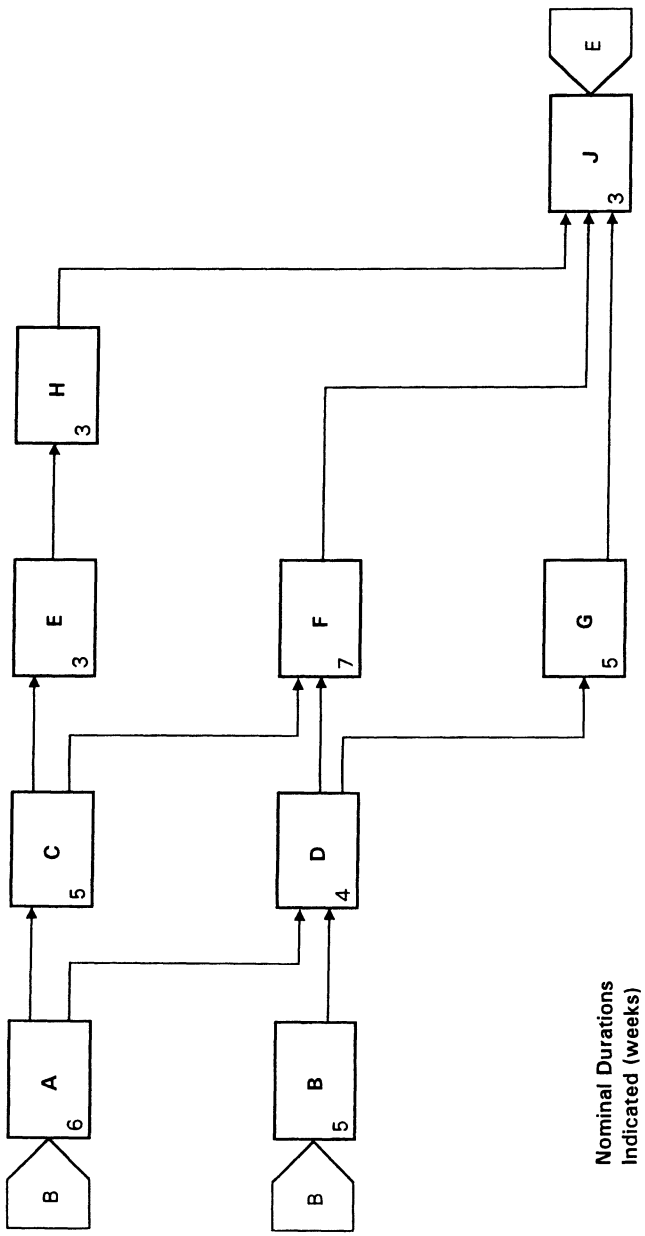


Figure 9.7



INITIAL PRECEDENCE DIAGRAM

Figure 9.8

Project Scenario

An assessment of the optimum time and optimum cost solution for the project is required in order to complete the construction sequence as economically as possible.

Assessment of the Normal Time Situation

Figure 9.9 indicates the analysis of the precedence diagram based on normal time. The overall project period is 21 weeks and the critical path follows the activities A, C, F and J.

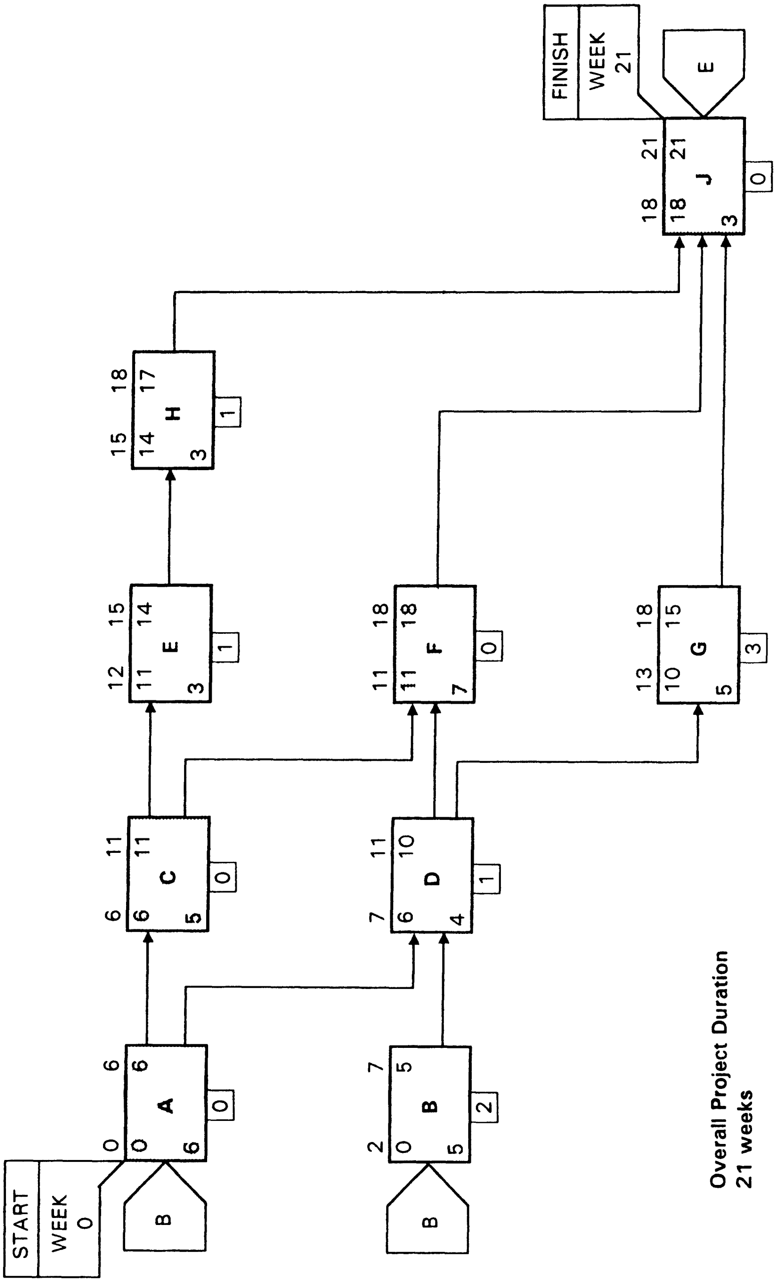
Assessment of the Cost Slopes

The cost slope for each activity may be assessed in tabular form in order to simplify the analysis. The activities are listed below in critical order, followed by non-critical activities in earliest start order.

Activity	Time (wks) normal	Crash	Saving	Cost (£000) normal	Crash	Increase	Cost slope £000	Float	Rank
A	6	3	3	18	21	3	1	Crit	1
C	5	4	1	16	18	2	2	Crit	2
F	7	5	2	22	28	6	3	Crit	3
J	3	2	1	10	15	5	5	Crit	4
B	5	3	2	14	18	4	2	2	
D	4	4	-	8	8	-	-	1	
G	5	4	1	4	5	1	1	3	
E	3	3	-	10	10	-	-	1	
H	3	2	1	12	13	1	1	1	

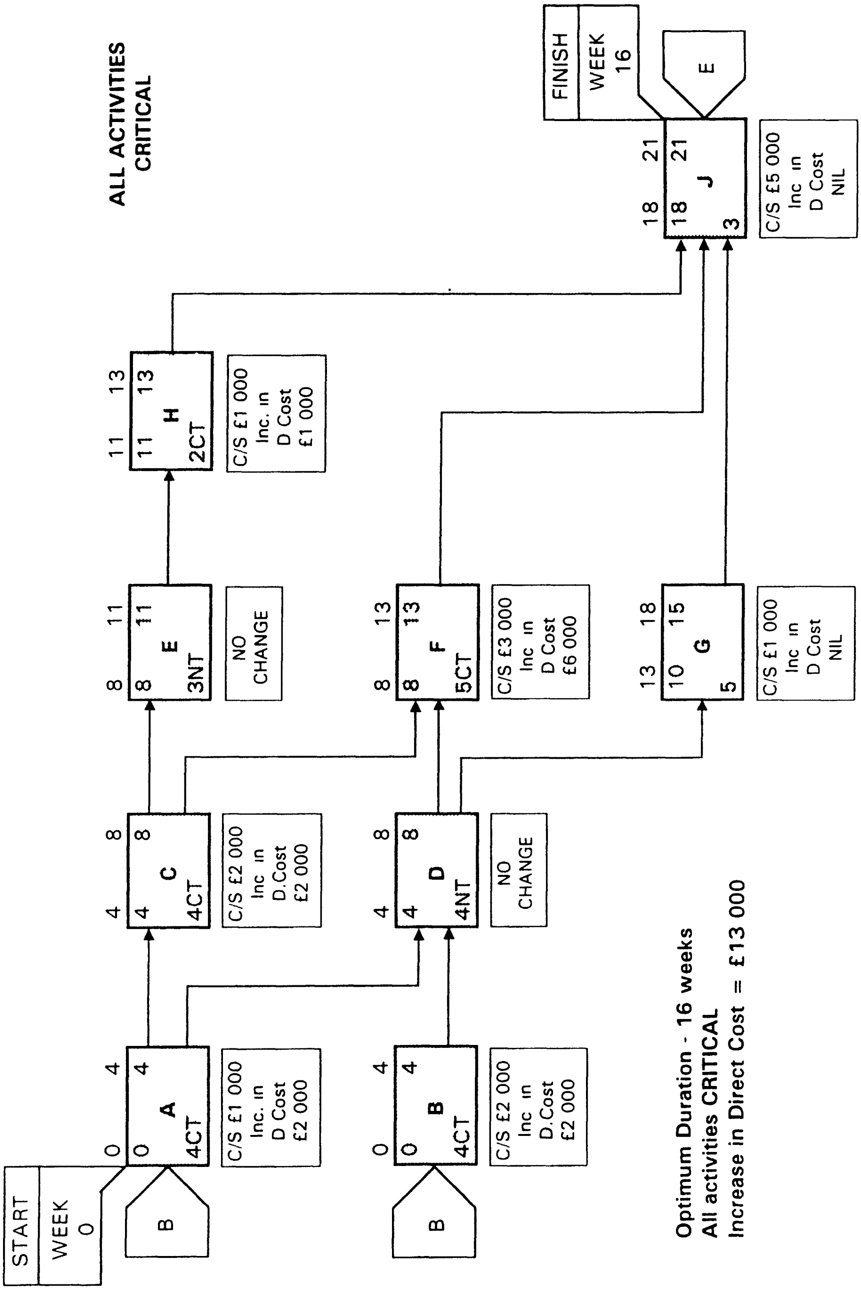
The purpose of the analysis is to consider the effect on direct cost of reducing the overall duration one week at a time. The activities should be considered in the order of their cost slope values and ranking. Figure 9.10 indicates the revised precedence diagram analysis using the new durations which enable the overall project period to be reduced to 16 weeks. Notes have been included in Figure 9.10 relating to the increase in direct cost attributed to each activity.

The analysis has resulted in all the activities becoming critical. This is a common situation which occurs when using Project Acceleration or Time/Cost Optimisation techniques. A summary of the effect on the direct cost of using the revised durations is indicated below.



ANALYSIS OF NORMAL TIME

Figure 9.9



RE-ANALYSIS TO OBTAIN OPTIMUM DURATION

Figure 9.10

Change in Direct Costs

Activity	Reduction in time (weeks)	Cost slope	Critical or non-critical	Rank	Increase in direct cost
A	2*	£1 000	C	1	£2 000
B	1	£2 000	NC		£2 000
C	1*	£2 000	C	2	£2 000
D	no change	-	-		-
E	no change	-	-		-
F	2*	£3 000	C	3	£6 000
G	no change	-	-		-
H	1	£1 000	NC		£1 000
J	no change	-	-		-

* = 5 days reduction in project duration

Total increase in direct cost = £13 000

The total project costs at week 16 is therefore as follows:

Direct cost at week 21	=	£114 000
Additional direct cost	=	£13 000
Total direct cost	=	£127 000
Indirect cost =		
16 weeks @ £1000	=	£16 000
Total project cost at week 16	=	£143 000

10 Planning and Programming Case Studies

The objective of this chapter is to demonstrate the application and versatility of the various programming techniques referred to in this book. This is done using a series of practical examples relating to a variety of different construction situations. The case studies referred to are also used at the end of this chapter to illustrate various approaches to procurement methods and forms of contract which might be employed in practice.

The Case Studies are examined under the following headings:

10.1 Bar charts

- Example 10.1.1 Pre-tender programme and method statement for two multi-storey tower blocks and eight blocks of low rise housing units.
  (See procurement case study 1 – Figure 10.56.)

- Example 10.1.2 Contract reporting – Monthly progress and cost reports.
  (See procurement case study 2 – Figure 10.56.)

- Example 10.1.3 Canal project – Method statement, Clause 14 programme, risk assessment and safety method statement.
  (See procurement case study 3 – Figure 10.56.)

10.2 Networks

- Example 10.2.1 Cumulative value forecast based on earliest and latest start dates.
  (See procurement case study 4 – Figure 10.56.)

- Example 10.2.2 Labour resource allocation example.
  (See procurement case study 5 – Figure 10.57.)

- Example 10.2.3 Comparison of arrow diagram and precedenceformat for a garage project.
  (See procurement case study 6 – Figure 10.57.)

10.3 Precedence Diagrams

- Example 10.3.1 Labour resource application.

- Example 10.3.2 Labour resource application and labour smoothing.

- Example 10.3.3 Precedence for factory project based on a more complex relationship
  (See procurement case study 7 – Figure 10.57.)

10.4 Line of Balance

- Example 10.4.1 Valuation forecast based on line of balance diagram. (See procurement case study 8 – Figure 10.57.)

- Example 10.4.2 Application of line of balance to a housing project.

- Example 10.4.3 Line of balance programme based on man-hour allocation to site operations.

10.5 Time-chainage Diagrams

- Example 10.5.1 Major Highway Project application – Development of Clause 14 Programme. (See procurement case study 9 – Figure 10.57.)

10.6 Procurement Case Studies

A number of the preceding case studies have been used to illustrate procurement methods referred to in Chapter 1. These illustrations also include recommendations for which standard forms of contract might be applicable in each case, together with alternatives, where appropriate.

The procurement case studies can be found in Figures 10.56 and 10.57.

10.1 Bar Charts

10.1.1 Pre-tender Programme and Method Statement

Project Brief

The project consists of the construction of two eight-storey reinforced concrete framed buildings, which are to be externally clad in brickwork, and twenty-eight low rise housing units. The foundations to each block are to be piled and incorporate a raft foundation. The balance of the development consists of the erection of twenty-eight low rise units contained in six terraced blocks as shown on the site plan in Figure 10.1. The adjacent site roadway and site service connections have been completed as part of a separate contract.

The project is £3.5 million in value and the buildings are to be handed over in phases to an agreed schedule.

Project Tasks

(1) Prepare a pre-tender method statement, outlining the contractor's strategic approach to undertaking the project.

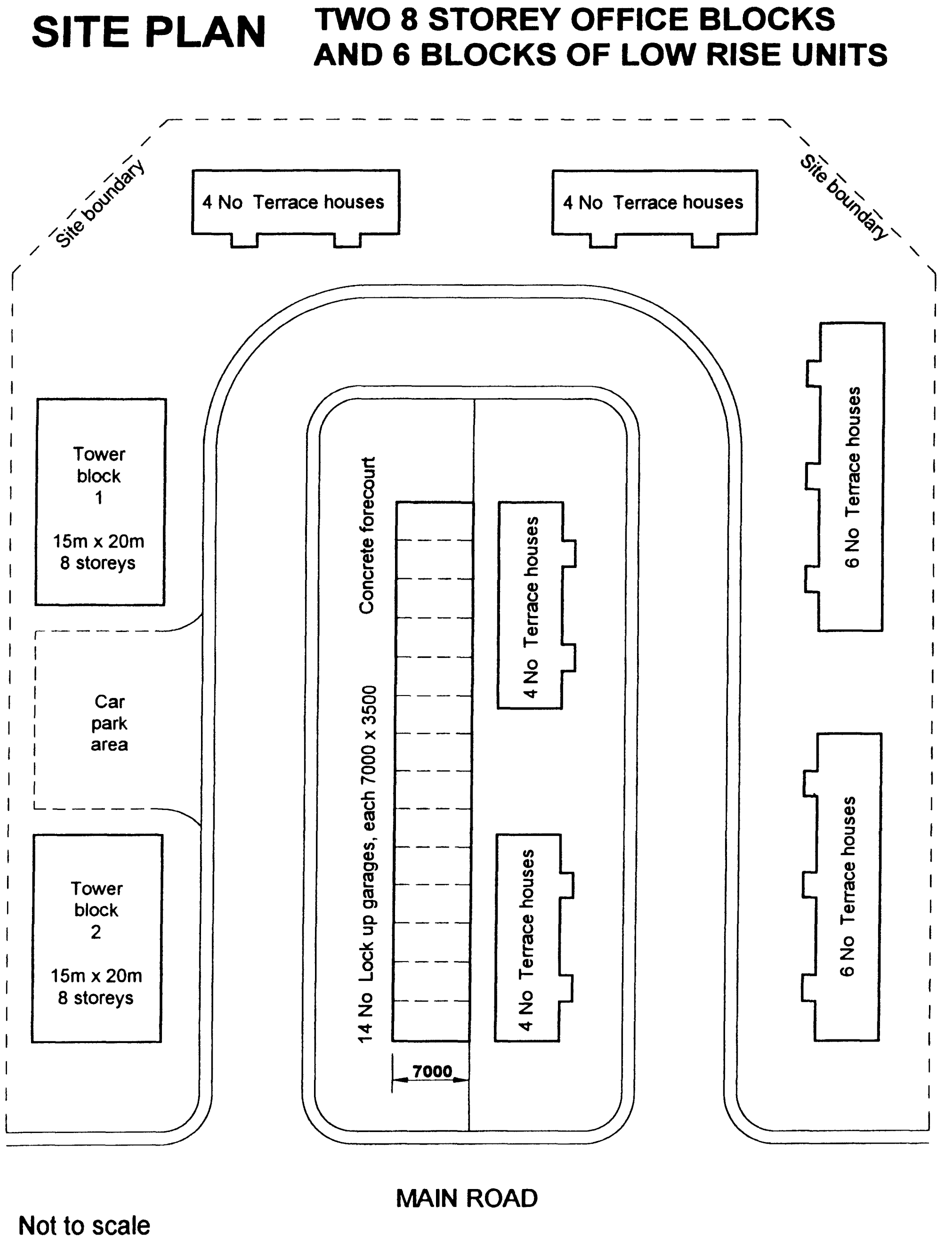

SITE PLAN
TWO 8 STOREY OFFICE BLOCKS
AND 6 BLOCKS OF LOW RISE UNITS
Site boundary
Site boundary
4 No Terrace houses
4 No Terrace houses
Tower block 1
15m x 20m
8 storeys
Car park area
Tower block 2
15m x 20m
8 storeys
Concrete forecourt
14 No Lock up garages, each 7000 x 3500
7000
4 No Terrace houses
4 No Terrace houses
6 No Terrace houses
6 No Terrace houses
MAIN ROAD
Not to scale

Figure 10.1

(2) Present a pre-tender programme based on the strategic approach. All assumptions are to be stated to qualify the overall contract period.

(1) Assessment of strategic approach to the project.

Sequence of undertaking the work (overall project strategy and initial thoughts).

Consideration may be given to dividing the site into two distinct sections and managing the project as two contracts (albeit under one project manager). This would involve one section being the construction of the two tower blocks and the other being the construction of the low rise dwelling units.In this way both project sections could be started at the same timer; alternatively, the construction of the tower blocks could start prior to the low rise units. A fast track approach could be considered on the project.

Sequence of work on the tower blocks

It is necessary to consider the utilisation of labour and plant and the movement of resources between the two tower blocks.

Plant Utilisation: Use of tower crane

Option 1: The contractor is to consider constructing tower block A and then moving the tower crane to construct tower block B. The labour gangs would likewise move from block to block as the work progressed.

Option 2: Tower blocks A and B are to be constructed simultaneously. This will involve erecting a separate tower crane on each of the blocks. Likewise in this situation, separate labour gangs would be required for each block.

The work in connection with the piling of both tower blocks would be undertaken during one visit to the site.

A senior management decision will be necessary in order to agree the strategic approach to the project at this stage, as this will directly affect the contractor's bid in respect of the overall project period.

Figures 10.2A and 10.2B indicate a pre-tender method statement based on the decision to undertake a 'fast track' approach as outlined in Option 2. Figure 10.3 indicates the sequence of work illustrated on the layout plan.

MULTI-STOREY FLATS AND LOW RISE UNITS	Sheet 1
TENDER METHOD STATEMENT	
1 - SITE ESTABLISHMENT	
Loop access road constructed prior to commencement of work. Site compound to be located in area of block 6, with entry and exits to adjacent road. Fully serviced compound to be maintained throughout the contract period until commencement of work to block 6. At this stage the compound may be reduced in size to accommodate the rear garage area. Garages at the rear of block 5 to be constructed at early stage in project as they are to be used as covered storage.	
2 - TOWER BLOCKS 1 AND 2	SUBSTRUCTURE WORK
Piling to blocks 1 and 2 to be completed in single visit to site. Tower blocks to be constructed using separate gangs on sub-structure and superstructure work. Concrete pumping to be utilised for foundation beams and ground floor slab construction.	
3 - TOWER BLOCKS 1 AND 2	SUPERSTRUCTURE WORK
Fast track approach using a separate tower crane located in front of each block. Construction sequence of 2 weeks per floor to be achieved with aid of patent formwork system and complete set of formwork soffits for two floors of the building. Floor pours to be concrete pumped.	

Figure 10.2A

MULTI-STOREY FLATS AND LOW RISE UNITS	Sheet 2
TENDER METHOD STATEMENT	
4 - LOW RISE UNITS	SUBSTRUCTURE WORK
Substructure works to low rise units to commence at week 1 of contract. Low rise units to be managed by separate construction manager. Foundation gangs to be moved from block to block in sequence shown on layout drawing. Four week construction cycle per block to be developed for foundations and services to ground floor level.	
5 - LOW RISE UNITS	SUPERSTRUCTURE WORK
A sixteen and twenty week construction cycle per block to be developed with phased handover as illustrated on pre-tender programme.	
6 - LOW RISE UNITS	BUILDING SERVICES
Full continuity of specialist services work to be achieved for subcontract service trades (electrical, heating and plumbing services).	
7 - PROJECT PROGRAMME	
A fast track approach to the project has been taken with an overall completion date of 10 months. Phased handover programme to be prepared and submitted for clients approval.	

Figure 10.2B

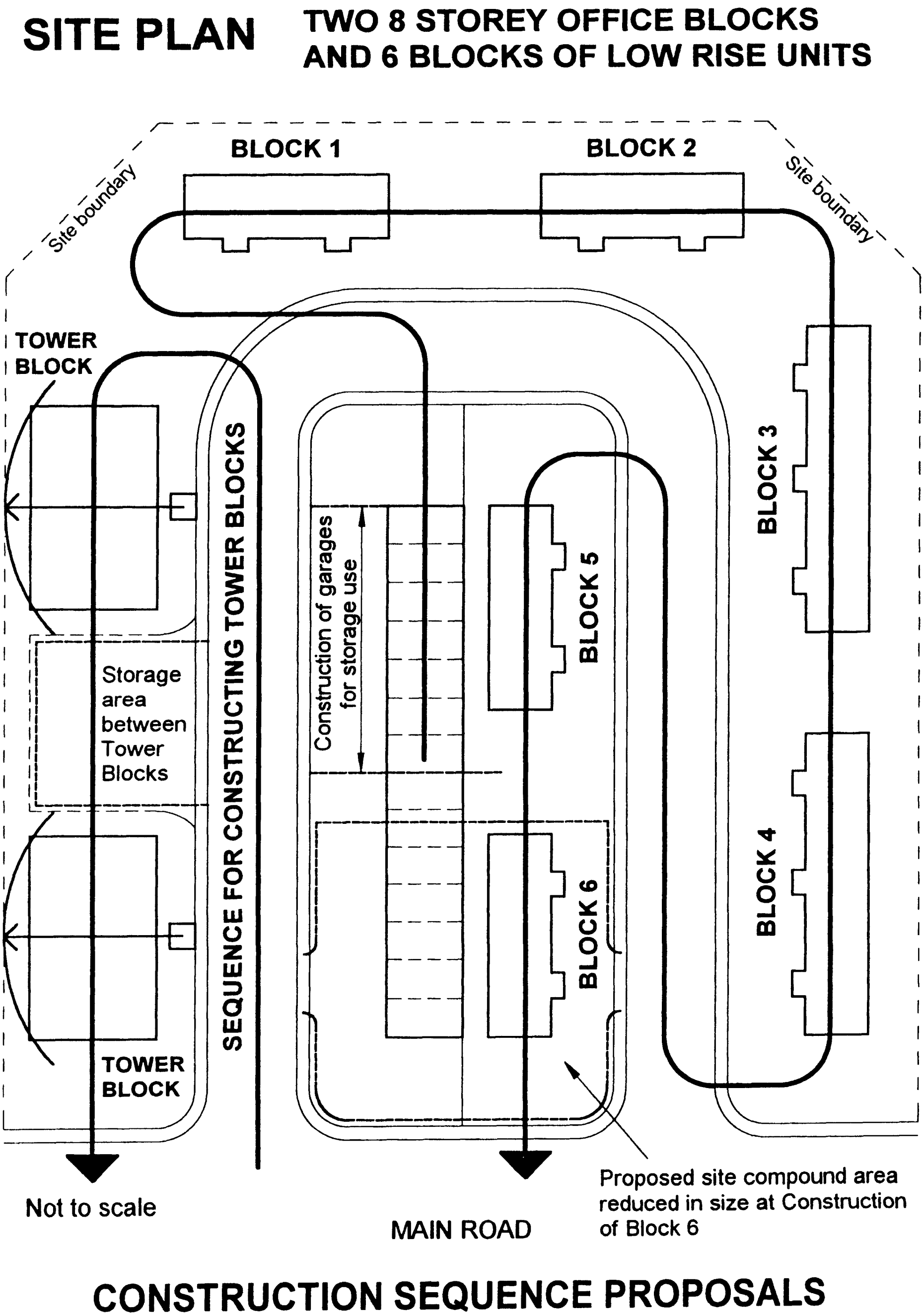

SITE PLAN
TWO 8 STOREY OFFICE BLOCKS
AND 6 BLOCKS OF LOW RISE UNITS
BLOCK 1
BLOCK 2
Site boundary
Site boundary
TOWER BLOCK
SEQUENCE FOR CONSTRUCTING TOWER BLOCKS
Construction of garages for storage use
BLOCK 3
BLOCK 5
Storage area between Tower Blocks
BLOCK 4
BLOCK 6
TOWER BLOCK
Not to scale
MAIN ROAD
Proposed site compound area reduced in size at Construction of Block 6
CONSTRUCTION SEQUENCE PROPOSALS

Figure 10.3

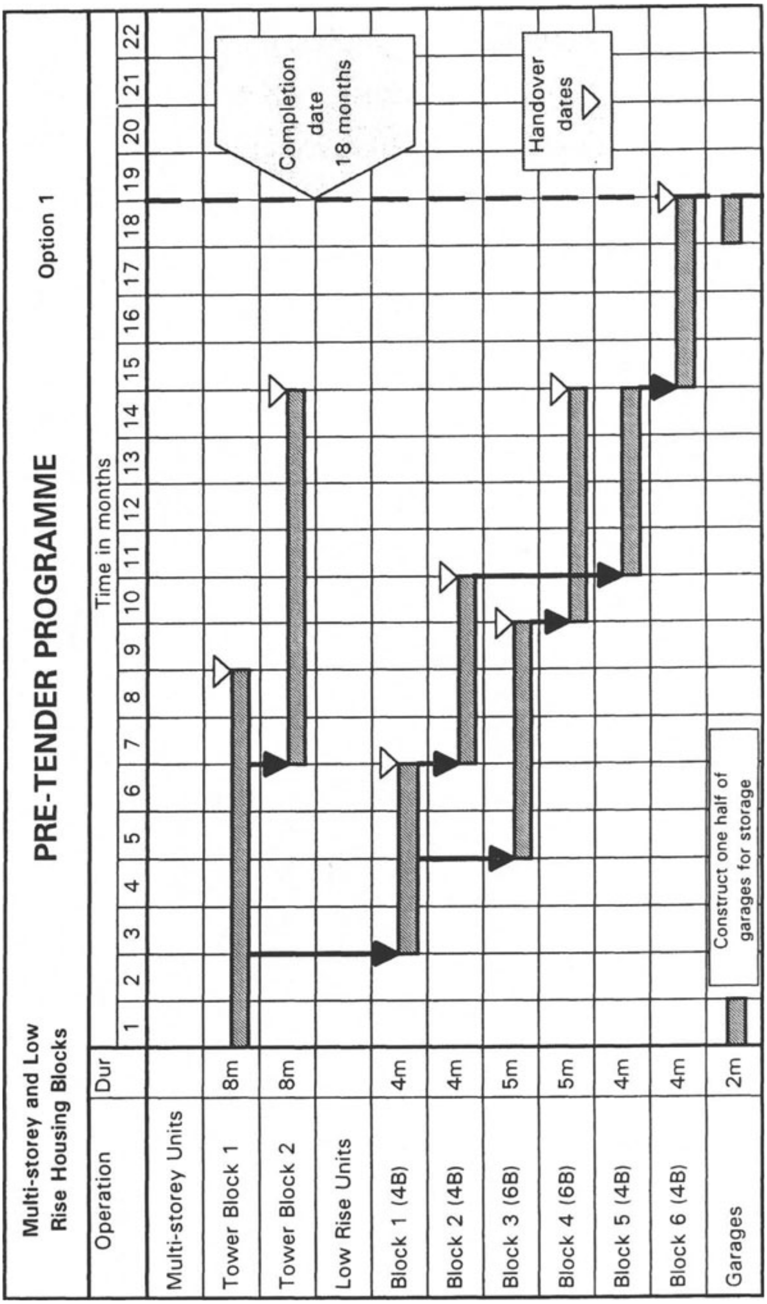

Multi-storey and Low Rise Housing Blocks
PRE-TENDER PROGRAMME
Option 1
Operation
Dur
Time in months
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Multi-storey Units
Tower Block 1
8m
Tower Block 2
8m
Low Rise Units
Block 1 (4B)
4m
Block 2 (4B)
4m
Block 3 (6B)
5m
Block 4 (6B)
5m
Block 5 (4B)
4m
Block 6 (4B)
4m
Garages
2m
Completion date 18 months
Handover dates
Construct one half of garages for storage

Figure 10.4

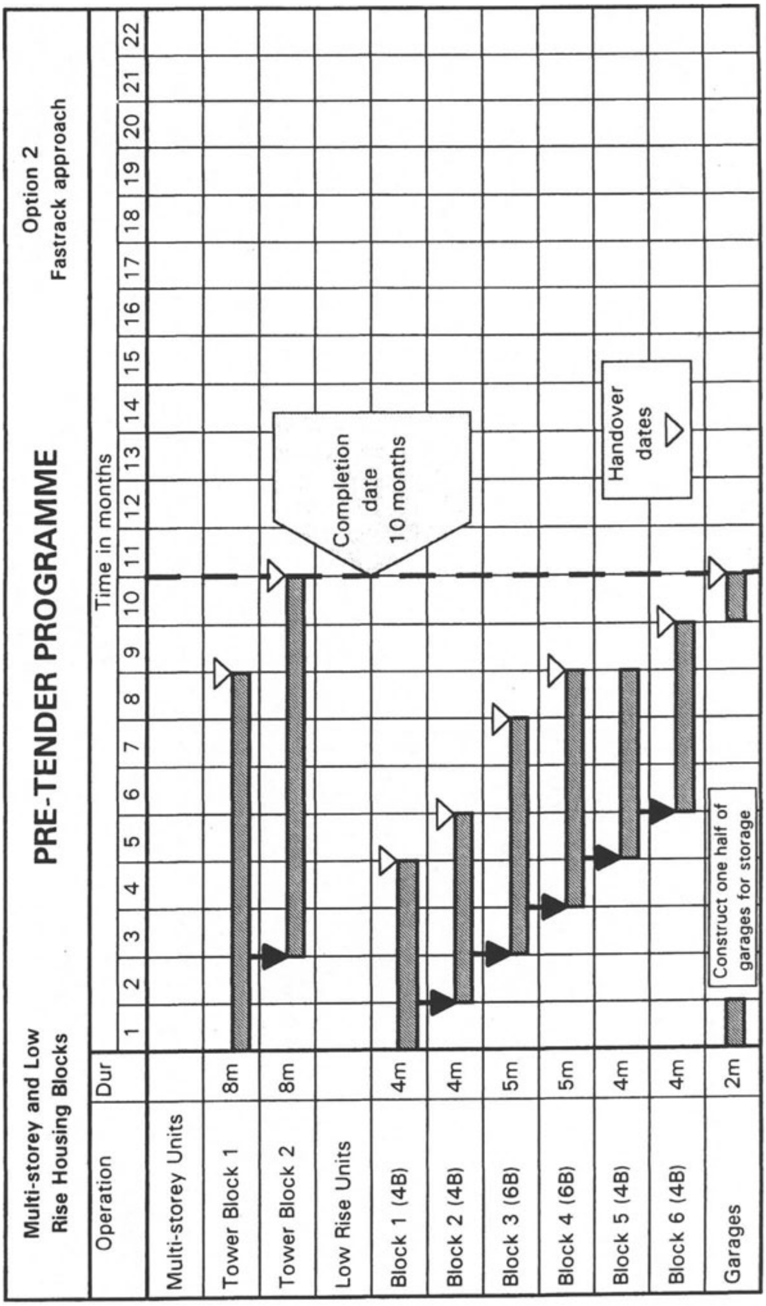

Multi-storey and Low Rise Housing Blocks
PRE-TENDER PROGRAMME
Option 2
Fastrack approach
Operation
Dur
Time in months
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Multi-storey Units
Tower Block 1
8m
Tower Block 2
8m
Low Rise Units
Block 1 (4B)
4m
Block 2 (4B)
4m
Block 3 (6B)
5m
Block 4 (6B)
5m
Block 5 (4B)
4m
Block 6 (4B)
4m
Garages
2m
Completion date 10 months
Handover dates
Construct one half of garages for storage

Figure 10.5

(2) Pre-tender programme – based on alternative approaches

Assessment of the contract duration for the completion of one tower block.

Foundations and piling work	6 weeks
Reinforced concrete frame : allow a two week cycle per floor	
8 floors at 2 weeks per floor	16 weeks
External brickwork cladding	6 weeks
Internal finishes	10 weeks
Overall duration for one tower block	32 weeks (8 months)

Assessment of duration for low rise blocks

Four unit block	16 weeks (4 months) per block
Six unit block	20 weeks (5 months) per block

Figure 10.4 illustrates a pre-tender programme based on constructing the tower blocks A and B separately.

Figure 10.5 illustrates a 'fast track' approach to the project based on the pre-tender method statement for constructing the tower blocks simultaneously.

10.1.2 Monthly Progress and Cost Reports

The contract reporting scenario consists of monthly reports on the progress and operational cost situation based on a project bar chart.

Project Brief

Figure 10.6 indicates a programme covering a 10 week period of a contract. As part of the contractor's control procedures, a monthly report is to be prepared by the construction manager for submission to the contracts manager.

Project Tasks

(1) Prepare a report at the end of month two summarising the progress and operational cost position on the contract.

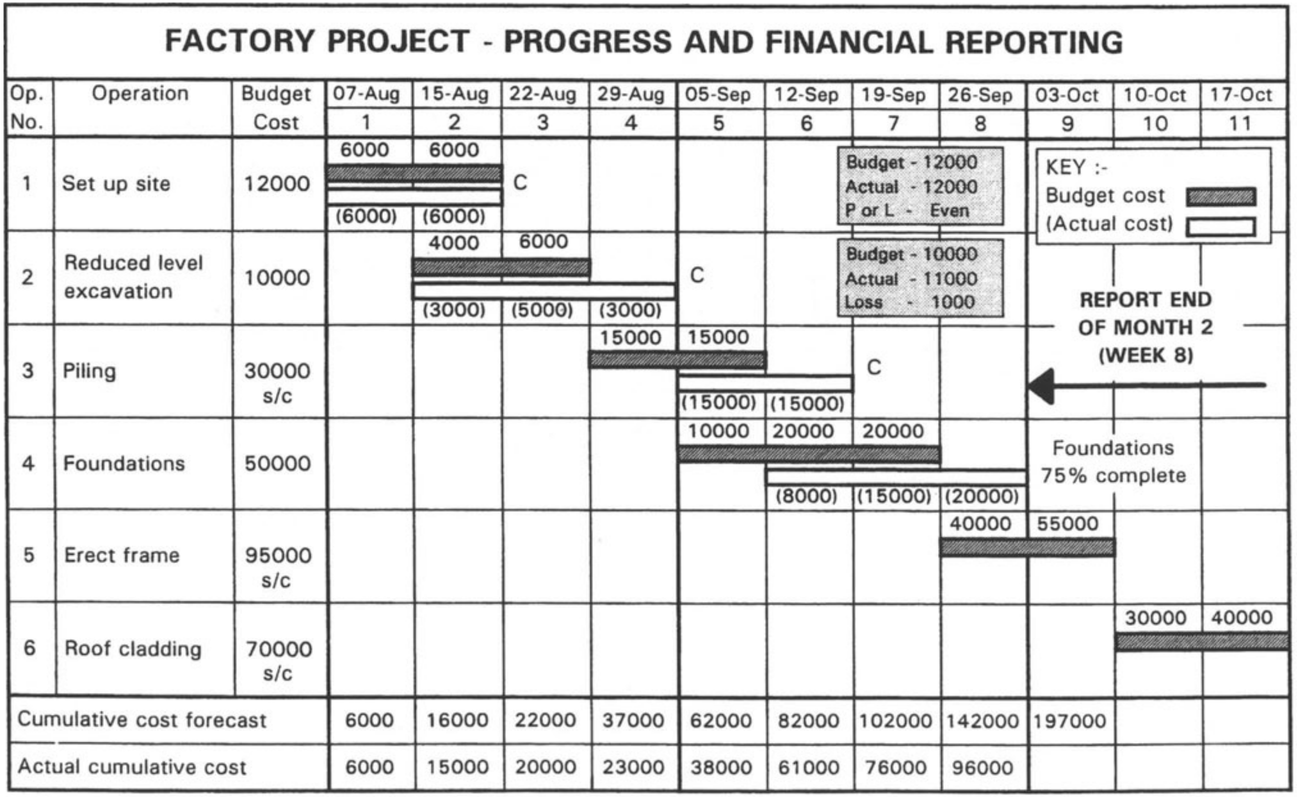

FACTORY PROJECT - PROGRESS AND FINANCIAL REPORTING
Op. No.
Operation
Budget Cost
07-Aug 15-Aug 22-Aug 29-Aug 05-Sep 12-Sep 19-Sep 26-Sep 03-Oct 10-Oct 17-Oct
1 2 3 4 5 6 7 8 9 10 11
1 Set up site 12000
6000 6000 (6000) (6000) C
2 Reduced level excavation 10000
4000 6000 (3000) (5000) (3000) C
3 Piling 30000 s/c
15000 15000 (15000) (15000) C
4 Foundations 50000
10000 20000 20000 (8000) (15000) (20000)
5 Erect frame 95000 s/c
40000 55000
6 Roof cladding 70000 s/c
30000 40000
Budget - 12000
Actual - 12000
P or L - Even
Budget - 10000
Actual - 11000
Loss - 1000
KEY :-
Budget cost
(Actual cost)
REPORT END OF MONTH 2 (WEEK 8)
Foundations 75% complete
Cumulative cost forecast 6000 16000 22000 37000 62000 82000 102000 142000 197000
Actual cumulative cost 6000 15000 20000 23000 38000 61000 76000 96000

Figure 10.6

Report

Subject: Report on contract progress and cost situation at the end of Month 2

To: Mr B. James Contracts manager (North West Region)
From: Mr D Stott Construction Manager West Heath Project
Date: !st March 1997

Contract: West Heath Office Development

Operational Report
Operation 1 Set up site

Commenced on programme and finished on schedule

Budget allowance in the Estimate	£12 000 (net cost)
Actual expenditure	£12 000
Variance:	Zero

Operation completed within the allocated cost allowance.

Operation 2 Reduced level excavation

Commenced on programme at the beginning of week 2
Operation completed one week late due to inclement weather

Budget allowance in the Estimate	£10 000 (net cost)
Actual expenditure	£11 000
Variance: Operational loss	£1000

Operation completed at a loss of £1000

Operation 3 Piling (Subcontract operation)

Commenced one week late due to delays with reduced level excavation
Operation completed in planned time but finished one week late

Budget allowance in the estimate	£30 000
Actual subcontract costs	£30 000
Variance:	Zero

Operation completed within the allocated cost allowance

Operation 4 Foundations

Commenced one week late owing to delays to reduced level excavation works
The operation is currently in progress and is 75% complete

Budget allowance in estimate (100%)	£50 000
Value of work completed to date (75%)	£37 500
Actual expenditure to date	£43 000
Variance: Operational loss to date	£5 500
Projected final cost to completion	£53 000
Forecast operational loss	£3 000
The operation is forecast to make a loss of	£3 000

Operation 5 Erect frame

Operation not yet started
Operation one week behind programme

Overall Contract Progress Situation

The project is currently one week behind programme due to the initial one week delay to the reduced level excavation work. The foundations work is anticipated to be completed one week late and work on the erection of the frame will also commence one week later than programmed.

To date it has not been possible to recover the one week delayed period.

Project overall cost situation:	Total project value	£89 500
	Total project cost	£96 000
	Project loss to date	£6 500

Figure 10.7 indicates the cumulative cost forecast presented graphically. The actual cumulative cost and value release has also been shown up to the end of week 8. It is important that any cost reports are read in conjunction with the contract progress position This may be presented diagrammatically at the head of the display as illustrated.

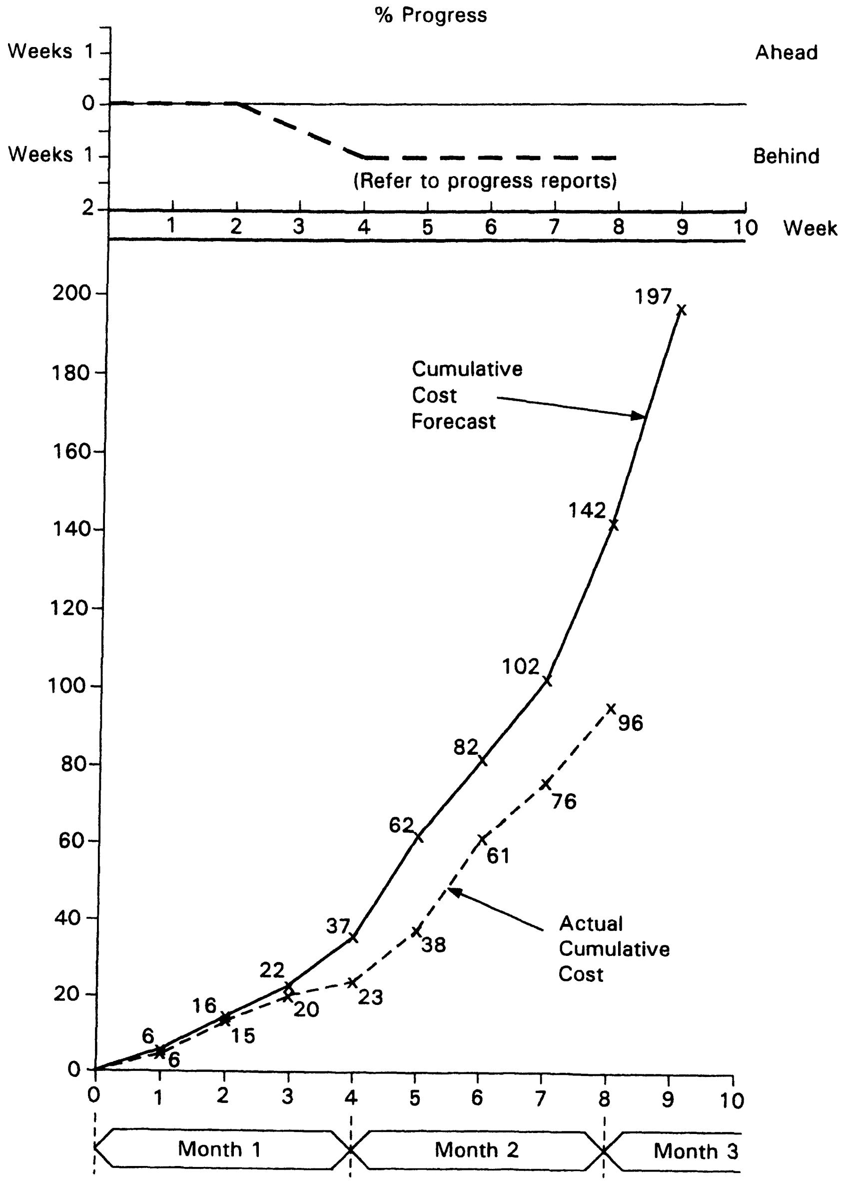

% Progress
Weeks 1
0
Weeks 1
2
Ahead
Behind
(Refer to progress reports)
1 2 3 4 5 6 7 8 9 10 Week
200
180
160
140
120
100
80
60
40
20
0
Cumulative
Cost
Forecast
Actual
Cumulative
Cost
6
16
22
37
62
82
102
142
197
6
15
20
23
38
61
76
96
0 1 2 3 4 5 6 7 8 9 10
Month 1
Month 2
Month 3

Figure 10.7

10.1.3 Canal Project
Development of Project Method Statement, Clause 14 Programme, Risk Assessment and Safety Method Statement

The project consists of the refurbishment of a disused canal and lock as part of a project to create a marina facility for pleasure boats and yachts.

The employer's budget for the refurbishment works is in the order of £1 million and the conditions of contract will be the ICE Conditions.

General arrangement drawings of the existing site and details of the proposed works are given in Figures 10.8 and 10.9.

General Description

The work involves cleaning out of the existing canal and lock together with new work comprising:

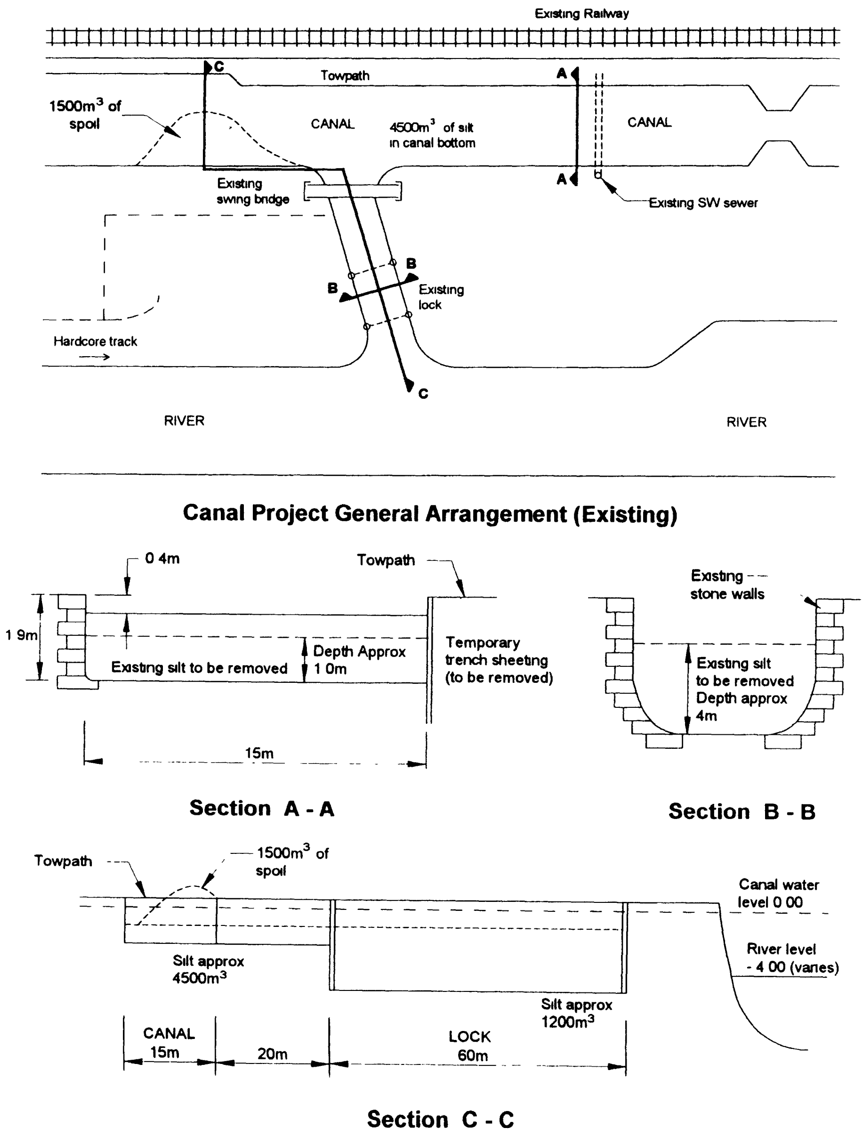
- a precast concrete retaining wall with insitu concrete capping
- an in situ concrete retaining wall with gabion wall behind
- guniting to the existing lock walls
- drainage works
- a small pumphouse comprising loadbearing brickwork and a concrete flat roof
- foundations for a new swingbridge
- refurbishment of two pairs of existing lock gates
- associated earthworks and temporary works

The existing lock connects to an adjacent tidal river and is to be emptied of silt which is approximately 4 metres deep. The silt is to be retained on site for landscape mounding. The canal basin is silted to a depth of 1 metre which is to be removed to a tip off site along with a spoil heap of 1 500 m^3 which is located at one end of the site.

A new in situ retaining wall is to be constructed to one side of the lock. The remaining walls are to be protected with a layer of sprayed concrete (gunite).

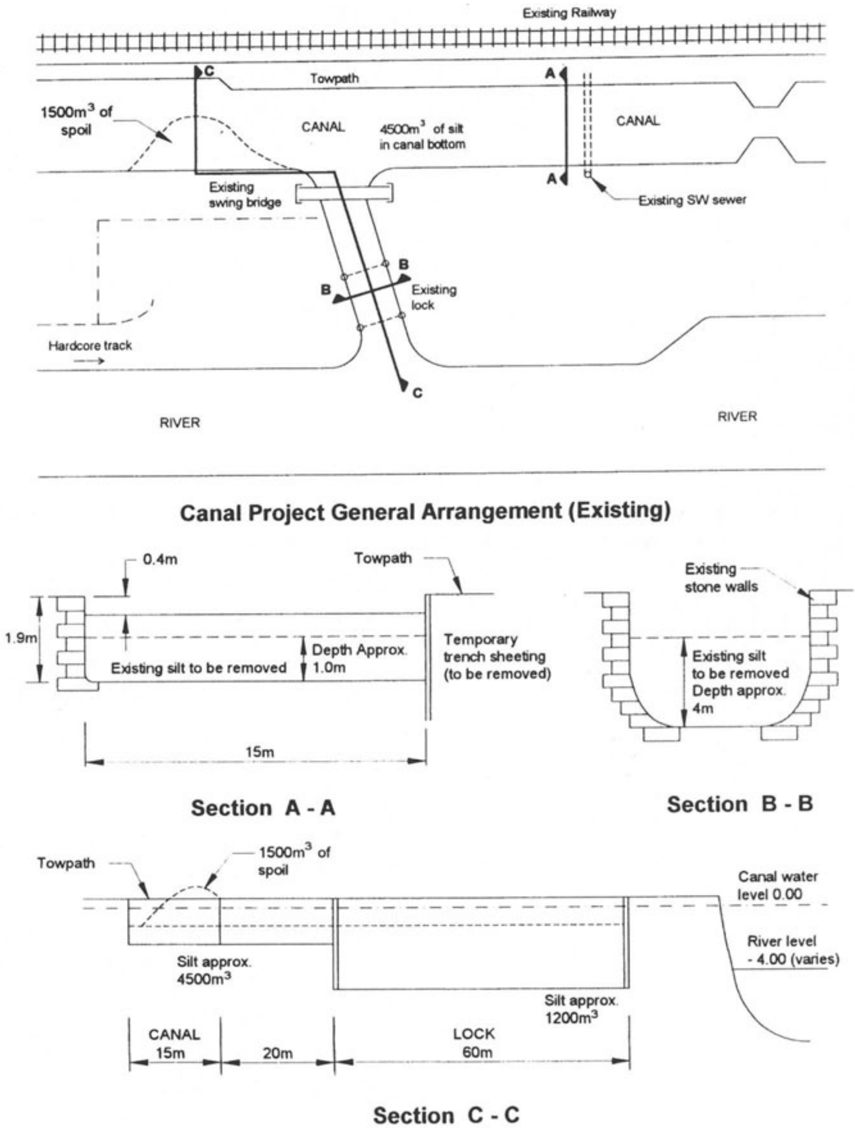
The existing canal is located adjacent to a 'live' railway line and silt is to be cleaned out of the canal basin to a depth of approximately 1.5 metres. This material is to be removed off site to the contractor's tip.

A precast concrete retaining wall approximately 300 metres long is to be constructed along the towpath next to the railway line. The wall is to be finished with an in situ concrete capping and a new concrete towpath laid alongside.



CANAL REFURBISHMENT PROJECT

Figure 10.8



CANAL REFURBISHMENT PROJECT

Figure 10.9

Construction methodology

Access and temporary works are considered to be of primary importance to the success of the project both constructionally and in terms of health and safety.

In order to carry out work in the existing canal and lock the basins will have to be pumped dry and water excluded both from the remainder of the canal and the river. This will involve the construction of a sheet piled cofferdam at the lockmouth and both ends of the canal basin will have to be blocked or 'stanked-off' with sandbags or earth bunding.

Access to the site is along an existing hardcore track but temporary access to the canal basin and the pumphouse side of the lock will be required. Additionally, access for a piling rig will be needed in order to construct a cofferdam to the lockmouth.

Consequently, a quantity of imported hardcore will be placed in the canal at the entrance to the lock and also in the main canal basin so as to form a ramp down to the bottom of the basin. This will be placed after cleaning out the silt and removed prior to removing the cofferdam.

Another temporary hardstanding will be constructed in the lockmouth for the piling rig to stand on. Pollution of the river may be a problem and the contractor would need to take appropriate advice before tendering and possibly consider driving the sheet piles from a pontoon located in the river. This option would add to the cost of the project and consequently would affect the tender price.

Programme and Method

In civil engineering work, the submission of a tender programme and method statement is often a condition of tendering. The tendering contractors may also be asked to submit their preliminary response to the pre-tender health and safety plan.

For the construction phase, however, these submissions would be unlikely to be sufficiently detailed to satisfy the requirements of either the conditions of contract or the CDM Regulations. The ICE Conditions require:

- a programme for acceptance by the Engineer showing the contractor's proposed order of construction
- a general description of arrangements and methods of construction
- further detailed information from time to time regarding proposed methods of construction, temporary works and plant

The clause 14 programme has to be submitted for the engineer's consideration within 21 days of the award of the contract together with details of the contractor's proposed method of working. Figures 10.10A and 10.10B show a construction method statement for the main work stages.

The clause 14 programme in linked bar chart format is shown in Figure 10.11 which illustrates the contractor's approach to the overall planning of the project.

Prior to commencing work on site, the client has to be satisfied with the principal contractor's proposals for the management of health and safety in accordance with the CDM Regulations. This takes the form of a health and safety plan which the principal contractor has to develop from the pre-tender health and safety plan sent with the tender documents.

The construction health and safety plan contains details of the principal contractor's health and safety arrangements which at least must cover the safety management system for the project and sufficient detail about how he intends to manage specific initial activities on the clause 14 programme. The health and safety plan will then be developed for other activities as the project progresses.

There are several methods of presenting the construction phase health and safety plan which might include safety method statements for key activities on the contractor's programme or those which pose potentially significant risks.

A suggested safety management approach for the construction of the sheet piled cofferdam is shown in Figure 10.13 which has been based on an initial contractor's risk assessment of this activity, as illustrated in Figure 10.12.

METHOD STATEMENT

Operation	Quantity	Output	Duration	Method	Resources			Temp Works	Remarks
					Plant	Labour	S/C		
Construct cofferdam	$350m^2$	$45m^2$ per day	Allow 2 weeks in total	Install sheet piles from temporary hardstanding using crawler crane and pile hammer Pump out lock and fill to provide working area to install bracings Remove hardstanding and install bottom walings and struts.	22RB BSP 900 Pile hammer Cat 325 excavator 2 No 30T Waggons	Piling Foreman Banksman 4 Labourers		Frodingham 3N sheet piles Steel I-Section bracing Quarry waste fill	
Clean out canal	$600m^3$	$30m^3$ /hr	5 weeks	Excavate silt Load waggons and cart spoil to tip 8km from site Provide dozer for levelling spoil at tip	Komatsu 380 excavator 4 No 30T waggons Cat D4 dozer	Ganger Banksman 2 Labourers			
Clean out lockmouth	$1200m^3$ of silt	$12m^3$ /hr	Say 3 weeks	Excavate silt from lockmouth Load dumpers and cart to *pumphouse area* Dozer to spread and level spoil in landscape mound		Ganger Banksman 2 Labourers			

Figure 10.10A

METHOD STATEMENT

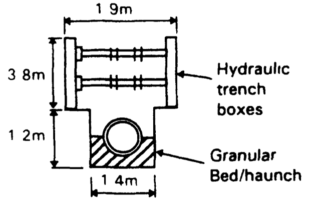
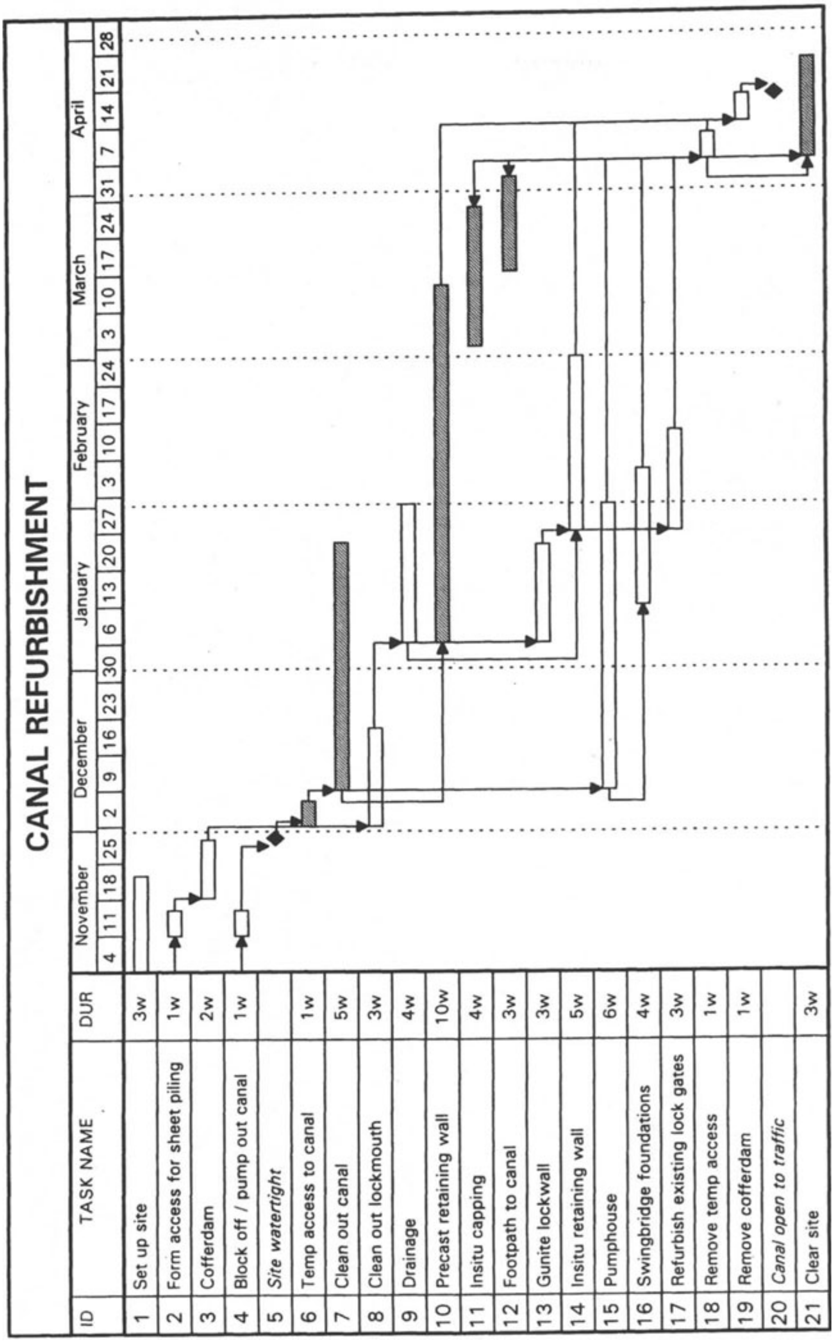
Operation	Quantity	Output	Duration	Method	Resources			Temp Works	Remarks
					Plant	Labour	S/C		
Drainage 	90m	Allow forward travel at 0.6m/hr	4 weeks	Excavate preliminary trench and install trench boxes Excavate trench for pipe Level bedding and lay and joint pipe. Backfill with suitable material and withdraw trench boxes in stages. Concrete bottom of M/H and lay bottom ring. Build up M/H and surround with concrete using proprietory circular forms Fix precast concrete 'biscuit' and heavy duty C.I. cover and frame.	Cat 325 Moxy dumper JCB 3CX Trench roller 4" pump Poker vibrator	Ganger 4 labourers Bricklayers		4 No. Hydraulic trench boxes 1 No. Hydraulic M/H box	900mm dia sewer with 1No manhole approx depth 5m. Outfall at lockmouth
Precast retaining wall				Work sequence to be in 30m long bays comprising 10 No. precast concrete units per bay. Remove temporary trench sheeting and batter back excavation. Excavate foundations with back acter and pump mass concrete in foundation. Bed precast concrete units on foundation and backfill behind wall.	Mobile crane Poclain 75 excavator Poker vibrator Roller Concrete pump 30T waggon	Foreman Joiner Bricklayer Banksman 2 Labourers			
Insitu retaining wall			Allow 5 weeks	Break out exising stone walls to lockmouth Excavate for wall with battered dig. Fill and place gabion baskets behind wall Shutter and fix, rebar in foundation, set ties in kicker and concrete Fix rebar and shutter 1st wall lift with RMD formwork and ties, concrete and strip. Repeat sequence for 2nd lift	Mobile crane Concrete pump Komatsu 380 Hydraulic breaker	Foreman 2 Joiners 2 Steel fixers 3 Labourers			

Fig 10.10B



CLAUSE 14 PROGRAMME

Figure 10.11

CONTRACTOR'S RISK ASSESSMENT

Contract	Contract No	Prepared by	Date of Assessment
Canal Renovation	*C2314*	*GHM*	*23 May*

Operation	Potential Hazards	Risk Assessment H	Risk Assessment M	Risk Assessment L	Control Measures
Construct sheet piled cofferdam	*Trapping and crushing by moving plant*		*M*		*Warning device / Banksman*
	Falls from height	*H*			*Guard rails along lock*
	Falls of materials	*H*			*Leave piles proud for edge protection*
	Confined space working			*L*	
	Working over water	*H*			*Safety harness and life jacket to be worn*

Programmed for	Training / Certification	Action	PPE Required (specify)
16 June	*All operatives to undergo one-day safety awareness course* *Plant operators to be CITB certified*	**Method statement** ☑ **Work permit** ☑ **Assessment :** COSHH ☐ Noise ☑	*Safety harnesses* *Hard hats* *Gloves* *Welding goggles* *HV vests* *Life jackets* *Ear defenders*

Figure 10.12

SAFETY METHOD STATEMENT

Contract	Contract No	Prepared By	Date	Checked By	Date
Canal Renovation	*C2314*	*GHM*	*26 May*	*APH*	*27 May*

Operation	Plant
Construct sheet piled cofferdam	*22 RB Crane* *BSP 900 Pile Hammer* *Komatsu 380 Excavator* *2 No. 30T Wagons* *150mm Diesel Pump*

Work sequence	Supervision and monitoring
Construct hardstanding for piling rig in lock mouth using imported quarry waste *Erect guide frame and install Frodingham 3N piles* *Pump out water between hardstanding and piles* *Fill behind piles for access* *Remove piling frame* *Construct top bracing with steel wallings and struts* *Remove hardstanding and install bottom bracing* *Erect secure ladder access to bottom of cofferdam*	*Site Engineer* *Piling Foreman* *Operation to be monitored daily by the site agent* *Banksman to work with mobile plant* *Daily check on crane equipment, load indicators and operation* **Controls** *Authorised personnel area only* *When working over water to remove piling frame, life jackets and safety harness must be worn* *Area to be fenced off at night with chestnut paled fence* *Warning notices to be displayed either side of cofferdam 'Danger deep excavation' and 'Danger deep water'*

Emergency procedures	First Aid	PPE schedules
Send for site first aider and/or call emergency services where necessary *Rescuers must not put themselves in danger* *Follow first aid drill if appropriate* *Do not remove evidence* *Notify site agent*	*Dinghy to be moored adjacent to cofferdam* *2 No. Life buoys in wooden locker* *First aid box in site office* *2 way radios*	*Safety harnesses* *Hard hats* *Gloves* *Welding goggles* *High visibility vests* *Life jackets* *Ear defenders*

Figure 10.13

10.2 Network Arrow Diagrams

10.2.1 Cumulative Value Forecast

This application illustrates the analysis of an arrow diagram in order to prepare an assessment of the project cumulative valuation forecast at the earliest and latest start dates. The application illustrates the steps involved in preparing this assessment.

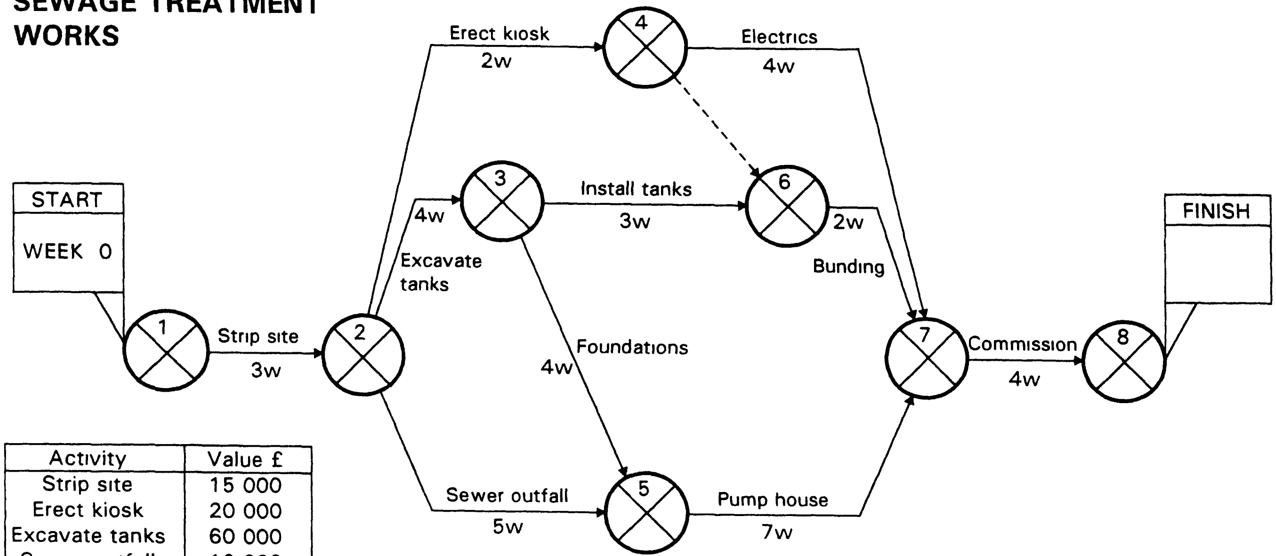
Figure 10.14 indicates the initial arrow diagram for the project together with the monetary value of each of the activities. Figure 10.15 indicates an analysed arrow diagram indicating an overall project duration of 22 weeks.

Figures 10.16 and 10.17 indicate the earliest and latest start bar chart programme displays for the project. The valuation periods and cumulative value forecast for each situation have been shown.

Figures 10.18 and 10.19 illustrate the value time line graph based on the earliest and latest start situations.

The cumulative valuation forecast may be used to monitor the contract's actual value release. This may form part of the contractor's budgetary control procedures at monthly time intervals.

SEWAGE TREATMENT WORKS



Activity	Value £
Strip site	15 000
Erect kiosk	20 000
Excavate tanks	60 000
Sewer outfall	10 000
Install tanks	15 000
Electrics	20 000
Bunding	12 000
Foundations	12 000
Pump house	28 000
Commission	40 000
Total	232 000

VALUATION FORECAST BASED ON A NETWORK DIAGRAM

Figure 10.14

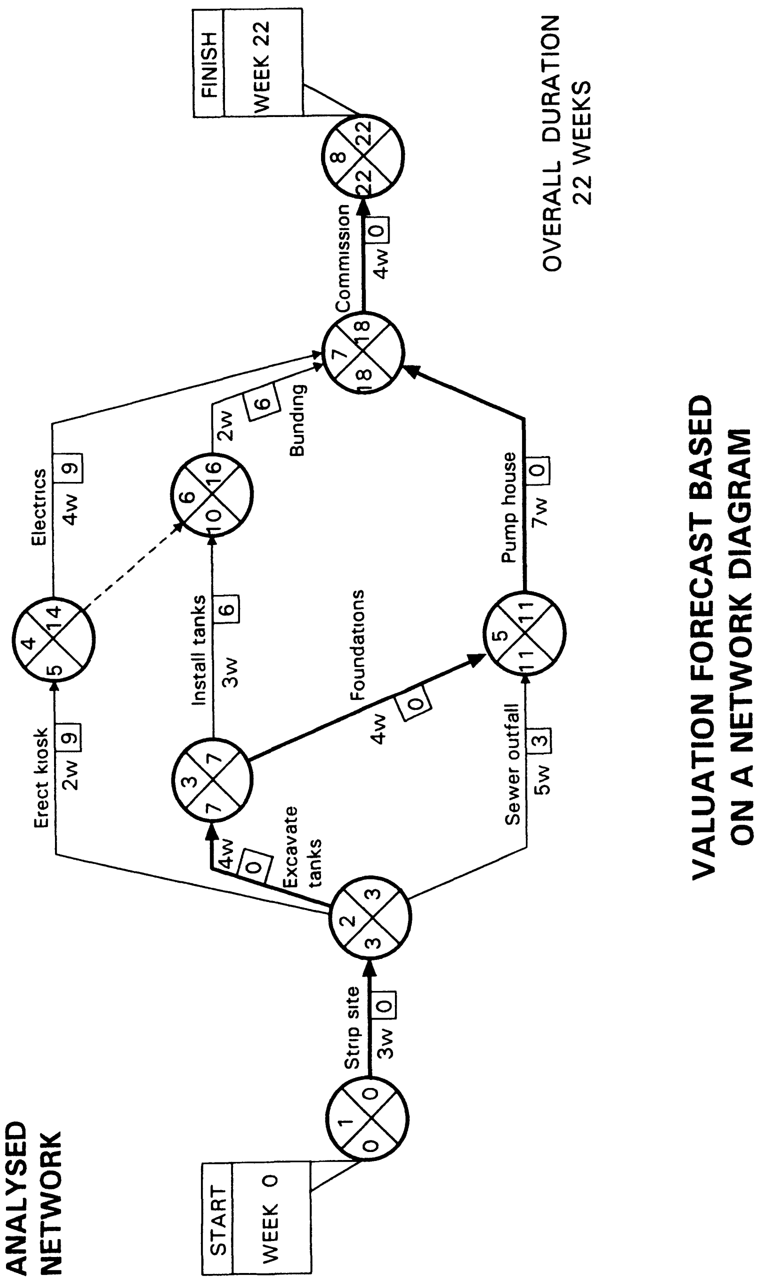

ANALYSED NETWORK
START
WEEK 0
FINISH
WEEK 22
Strip site
3w 0
Erect kiosk
2w 9
Excavate tanks
4w 0
Install tanks
3w 6
Foundations
4w 0
Sewer outfall
5w 3
Electrics
4w 9
Bunding
2w 6
Pump house
7w 0
Commission
4w 0
OVERALL DURATION 22 WEEKS
VALUATION FORECAST BASED ON A NETWORK DIAGRAM

Figure 10.15

EARLIEST START - BAR CHART PROGRAMME

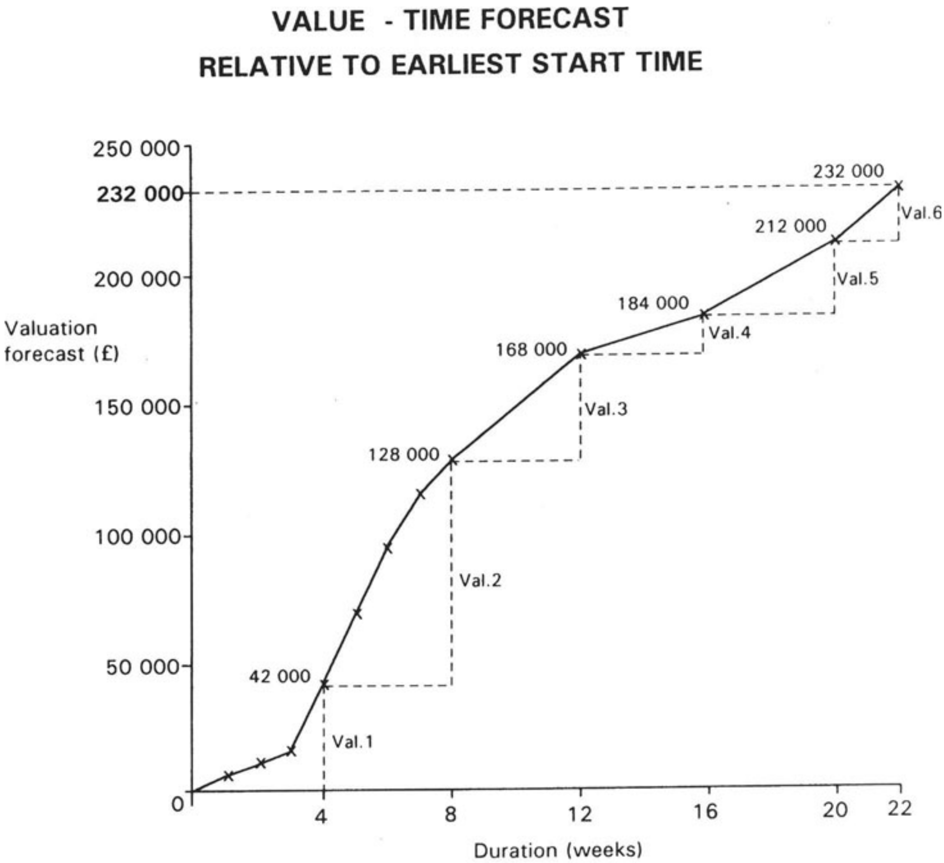
OPERATION	ES	Dur	FL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	VALUE
Strip site	0	3	0	5	5	5																				15000
Excavate tanks	3	4	0				15	15	15	15																60000
Foundations	7	4	0								3	3	3	3												12000
Pump house	11	7	0												4	4	4	4	4	4	4					28000
Commission	18	4	0																			10	10	10	10	40000
Erect kiosk	3	2	9				10	10																		20000
Electrics	5	4	9						5	5	5	5														20000
Sewer outfall	3	5	3				2	2	2	2	2															10000
Install tanks	7	3	6								5	5	5													15000
Bunding	10	2	6											6	6											12000
Weekly value				5	5	5	27	27	22	22	15	13	8	9	10	4	4	4	4	4	4	10	10	10	10	232000
Cumulative value				5	10	15	42	69	91	113	128	141	149	158	168	172	176	180	184	188	192	202	212	222	232	
Monthly value							42				128				168				184				212		232	
Valuation dates							1 →				2 →				3 →				4 →				5 →		6 →	

Figure 10.16

LATEST START - BAR CHART PROGRAMME

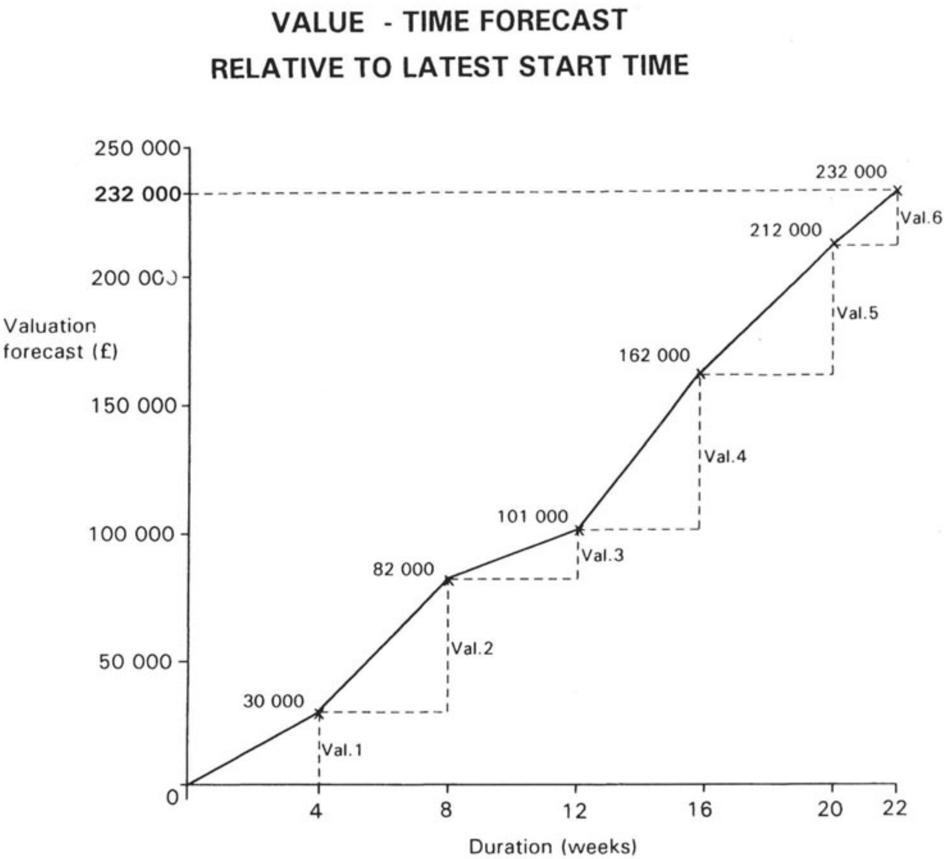
OPERATION	LS	Dur	FL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	VALUE
Strip site	0	3	0	5	5	5																				15000
Excavate tanks	3	4	0				15	15	15	15																60000
Foundations	7	4	0								3	3	3	3												12000
Pump house	11	7	0												4	4	4	4	4	4	4					28000
Commission	18	4	0																			10	10	10	10	40000
Erect kiosk	12	2	9													10	10									20000
Electrics	14	4	9															5	5	5	5					20000
Sewer outfall	6	5	3							2	2	2	2	2												10000
Install tanks	13	3	6														5	5	5							15000
Bunding	16	2	6																	6	6					12000
Weekly value				5	5	5	15	15	15	17	5	5	5	5	4	14	19	14	14	15	15	10	10	10	10	232000
Cumulative value				5	10	15	30	45	60	77	82	87	92	97	101	115	134	148	162	177	192	202	212	222	232	
Monthly value							30				82				101				162				212		232	
Valuation dates							1				2				3				4				5		6	

Figure 10.17



EARLIEST START VALUE FORECAST	
Week	Cumulative value
4	42 000
8	128 000
12	168 000
16	184 000
20	212 000
22	232 000

Figure 10.18



LATEST START VALUE FORECAST	
Week	Cumulative value
4	30 000
8	82 000
12	101 000
16	162 000
20	212 000
22	232 000

Figure 10.19

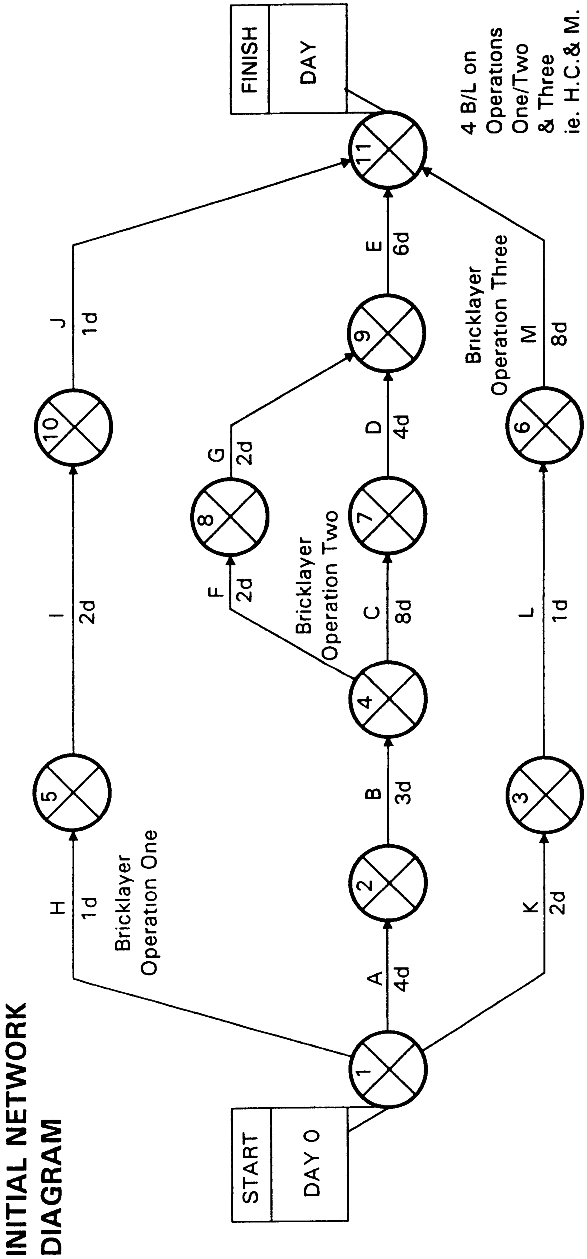
10.2.2 Labour Resource Allocation

This application illustrates the principles of labour resource allocation applied to an arrow diagram sequence. It relates to the labour resourcing of the bricklayer operations in order to achieve continuity of work. This clearly illustrates the utilisation of float times on non critical activities in order to gain continuity of work for an individual trade.

Figure 10.20 indicates the initial arrow diagram together with the activities relating to the brickwork operations. Figure 10.21 shows the analysed network indicating an overall project period of 25 days.

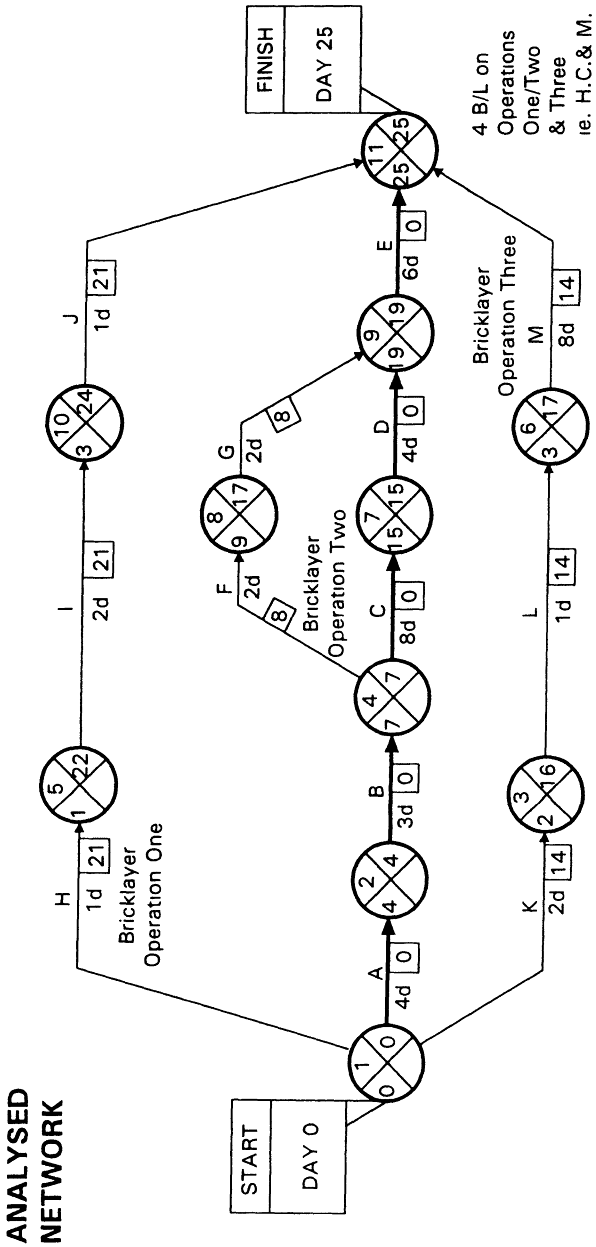
Figure 10.22 indicates the earliest start bar chart highlighting the bricklayer operations. An earliest start labour histogram is illustrated with the critical labour requirements shown shaded. In order to obtain continuity of work for the bricklayers it will be necessary to consider the available float on non critical brickwork operations (operations H and M).

Figure 10.23 indicates the resourced labour situation together with the resourced labour histogram.



RESOURCING BRICKLAYING OPERATIONS TO ACHIEVE CONTINUITY OF WORK

Figure 10.20



RESOURCING BRICKLAYING OPERATIONS TO ACHIEVE CONTINUITY OF WORK

Figure 10.21

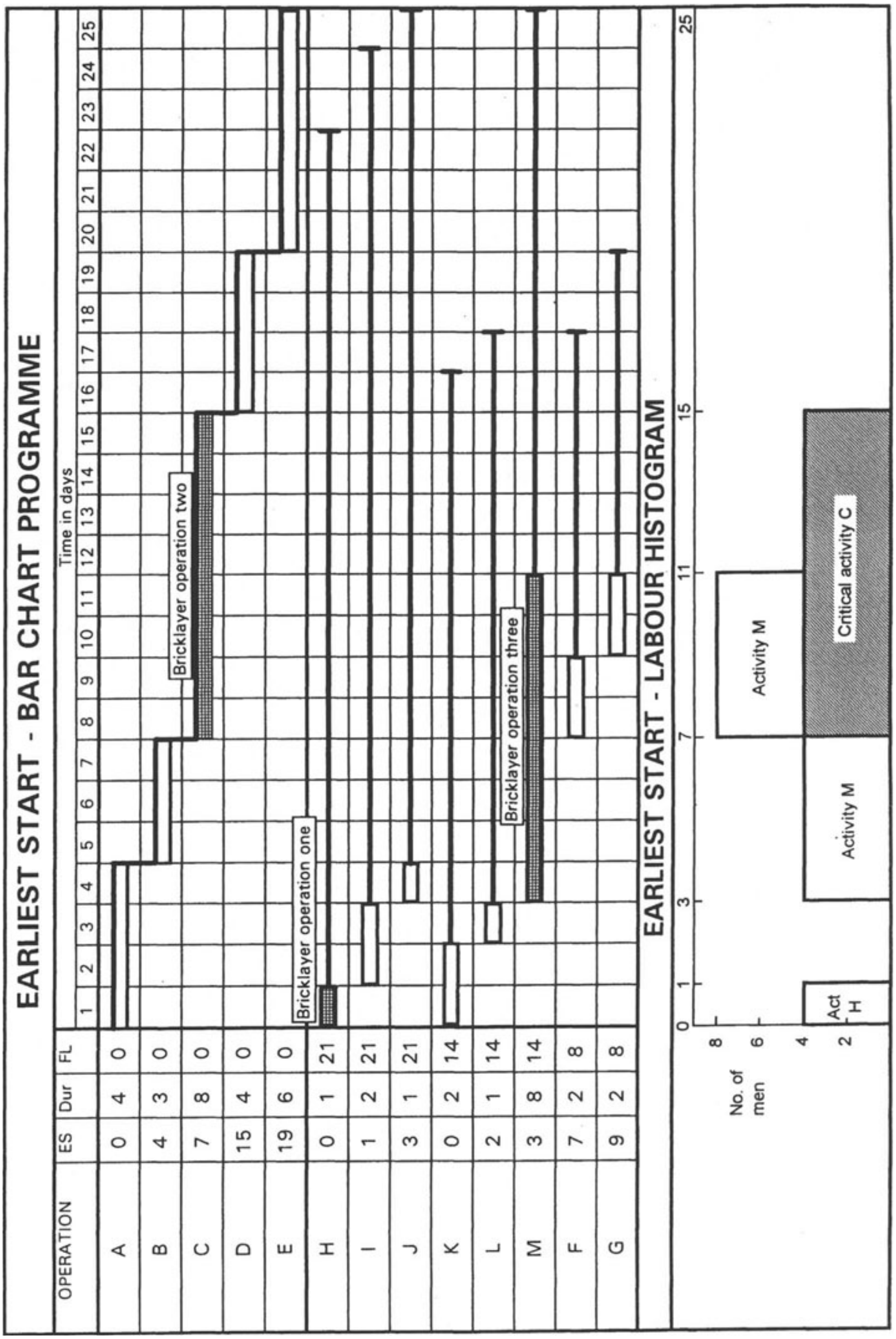

EARLIEST START - BAR CHART PROGRAMME
Time in days
OPERATION ES Dur FL
A 0 4 0
B 4 3 0
C 7 8 0
D 15 4 0
E 19 6 0
H 0 1 21
I 1 2 21
J 3 1 21
K 0 2 14
L 2 1 14
M 3 8 14
F 7 2 8
G 9 2 8
Bricklayer operation one
Bricklayer operation two
Bricklayer operation three
EARLIEST START - LABOUR HISTOGRAM
No. of men
Act H
Activity M
Activity M
Critical activity C

Figure 10.22

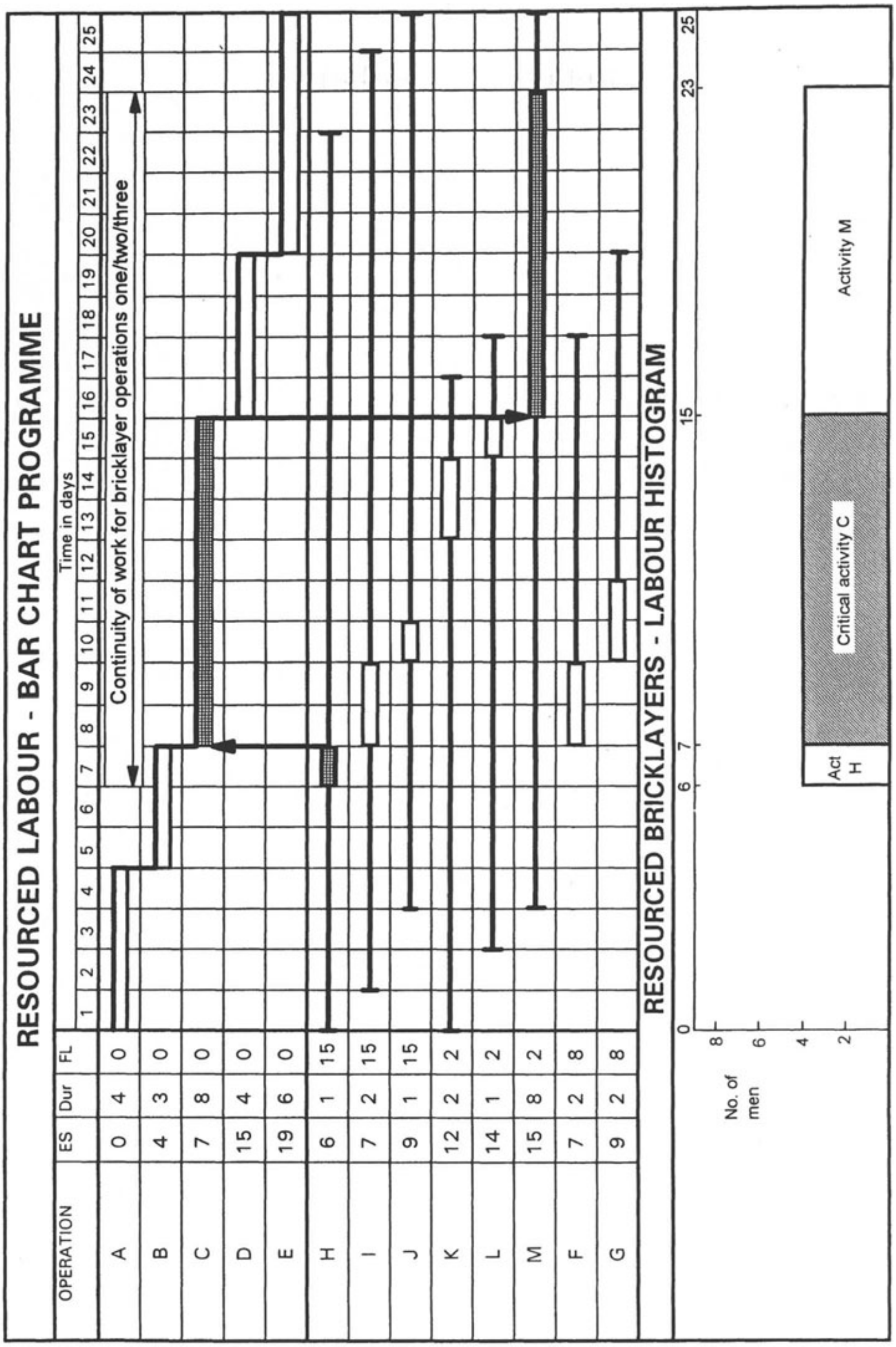

RESOURCED LABOUR - BAR CHART PROGRAMME
OPERATION
ES
Dur
FL
Time in days
A 0 4 0
B 4 3 0
C 7 8 0
D 15 4 0
E 19 6 0
H 6 1 15
I 7 2 15
J 9 1 15
K 12 2 2
L 14 1 2
M 15 8 2
F 7 2 8
G 9 2 8
Continuity of work for bricklayer operations one/two/three
RESOURCED BRICKLAYERS - LABOUR HISTOGRAM
No. of men
Act H
Critical activity C
Activity M

Figure 10.23

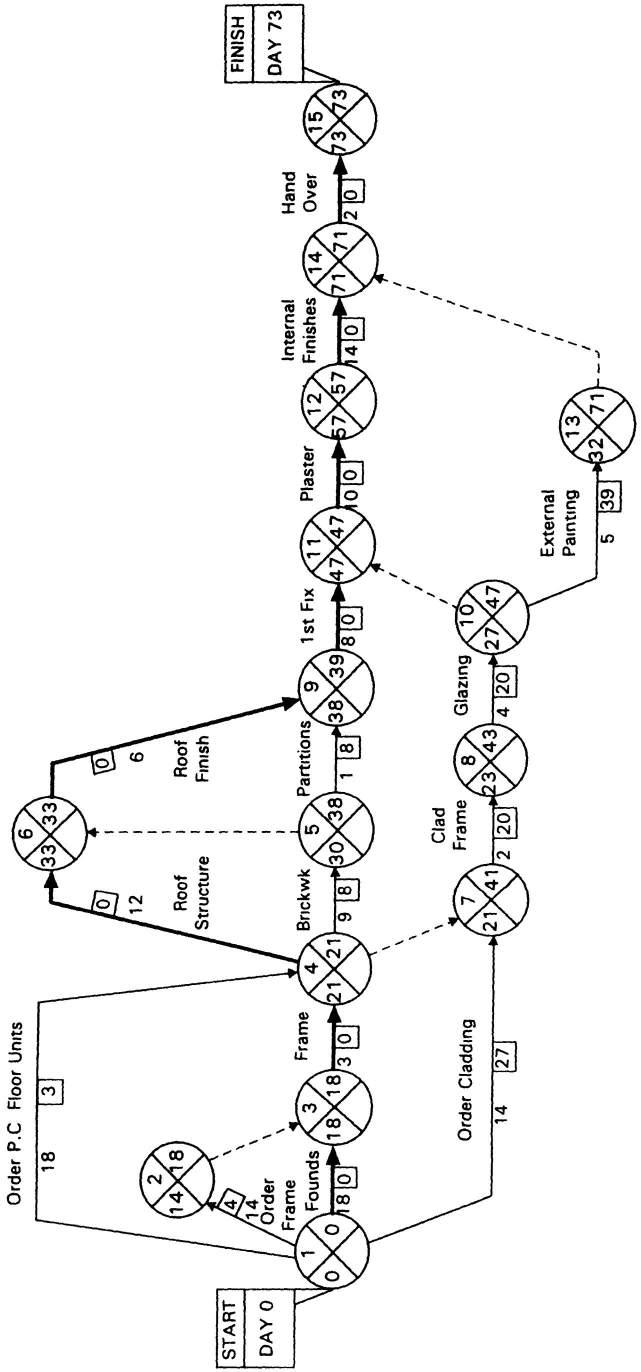
10.2.3 Comparison of Arrow and Precedence Format

This application allows the reader to compare a project analysed using the arrow diagram technique with the precedence diagram. This is order that the format of the displays may be compared and the ease of analysis matched.

Figure 10.24 illustrates an analysed arrow diagram highlighting the floats and critical path. Figure 10.25 indicates a precedence diagram for the same sequence of operations with the critical precedence operations highlighted. Operation flags have been shown relating to the latest dates for ordering key materials.

Figure 10.26 indicates an earliest start bar chart based on the precedence analysis. The critical path has been highlighted on the bar chart by shading and linking the critical operations.

CASE STUDY - GARAGE PROJECT



ANALYSED ARROW DIAGRAM

Figure 10.24

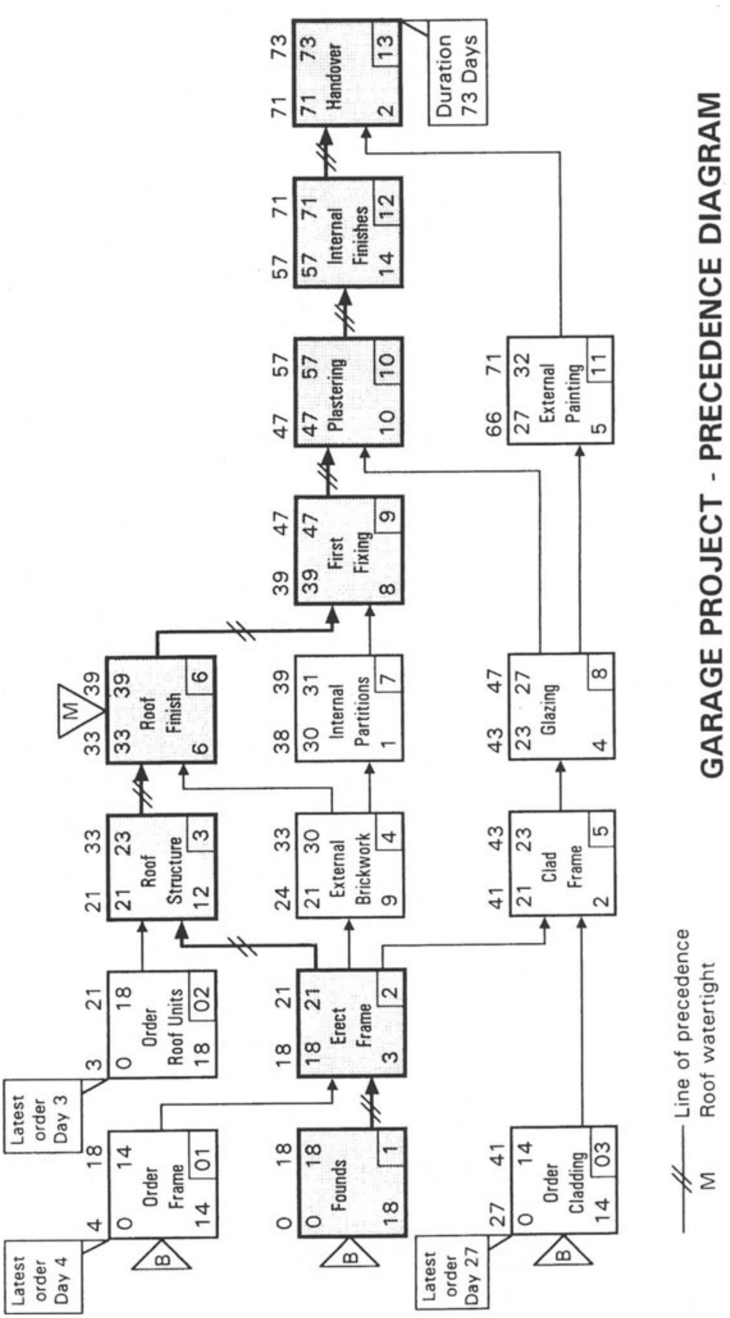

Latest order Day 4
Latest order Day 3
Latest order Day 27
Order Frame
Order Roof Units
Order Cladding
Founds
Erect Frame
Roof Structure
External Brickwork
Clad Frame
Roof Finish
Internal Partitions
Glazing
First Fixing
Plastering
External Painting
Internal Finishes
Handover
Duration 73 Days
Line of precedence
M Roof watertight
GARAGE PROJECT - PRECEDENCE DIAGRAM

Figure 10.25

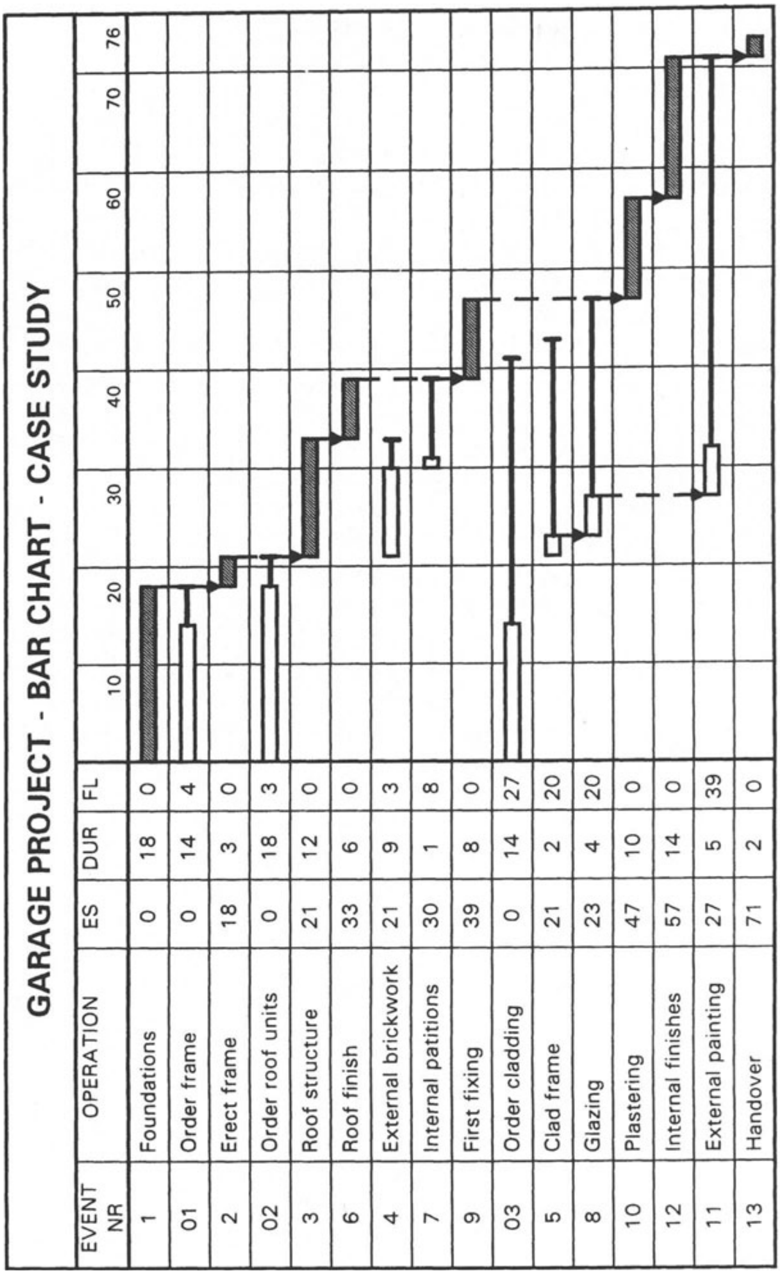

GARAGE PROJECT - BAR CHART - CASE STUDY
EVENT NR
OPERATION
ES
DUR
FL
10
20
30
40
50
60
70
76
1 Foundations 0 18 0
01 Order frame 0 14 4
2 Erect frame 18 3 0
02 Order roof units 0 18 3
3 Roof structure 21 12 0
6 Roof finish 33 6 0
4 External brickwork 21 9 3
7 Internal patitions 30 1 8
9 First fixing 39 8 0
03 Order cladding 0 14 27
5 Clad frame 21 2 20
8 Glazing 23 4 20
10 Plastering 47 10 0
12 Internal finishes 57 14 0
11 External painting 27 5 39
13 Handover 71 2 0

Figure 10.26

10.3 Precedence Diagrams

10.3.1 Labour Resource Application

The application illustrates the analysis of a precedence diagram based on finish to start relationships. The objective is to produce a forecast of the labour resources at the earliest start situation, presented in both bar chart and histogram format.

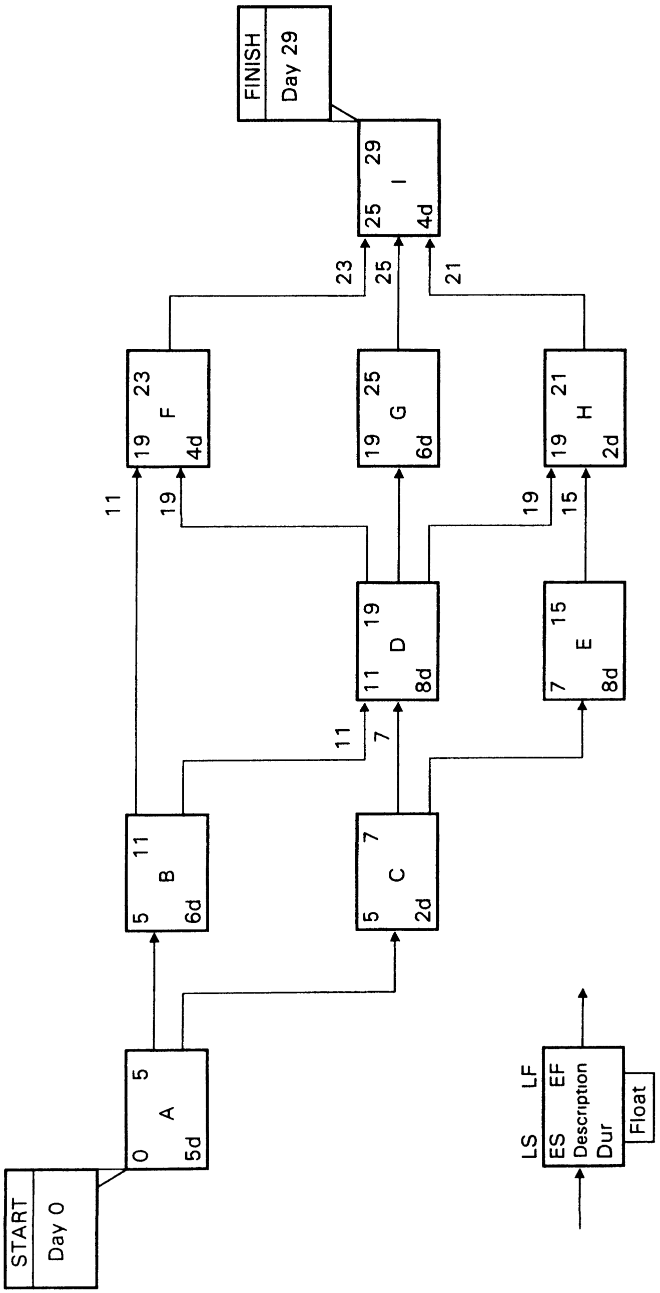
Figure 10.27 indicates the details of activities A to I together with activity durations and labour allocation. Figure 10.28 indicates the precedence diagram for the sequence displaying the earliest start and latest start dates after completing the foreword pass. This indicates an overall project duration of 29 days. Figure 10.29 indicates the analysed precedence diagram showing each activities total float, and the highlighted critical path.

The assessment of the labour resource histogram may be produced from a bar chart display or directly from the precedence diagram. Figure 10.30 illustrates a bar chart display produced from the precedence sequence with the labour resource allocated to each of the bar lines. The bar chart has been presented showing the critical operations first in the programmed sequence. Below the bar chart, the earliest start labour histogram has been shown. When presenting the labour histogram, the critical labour requirements may be 'fixed' along the base of the histogram with the non-critical labour simply stacked on top.

The labour histogram may be presented directly from the precedence diagram. This is achieved by developing the histogram from the earliest start dates, durations and labour allocation per operation. Why not have a go and prove how easy it really is?

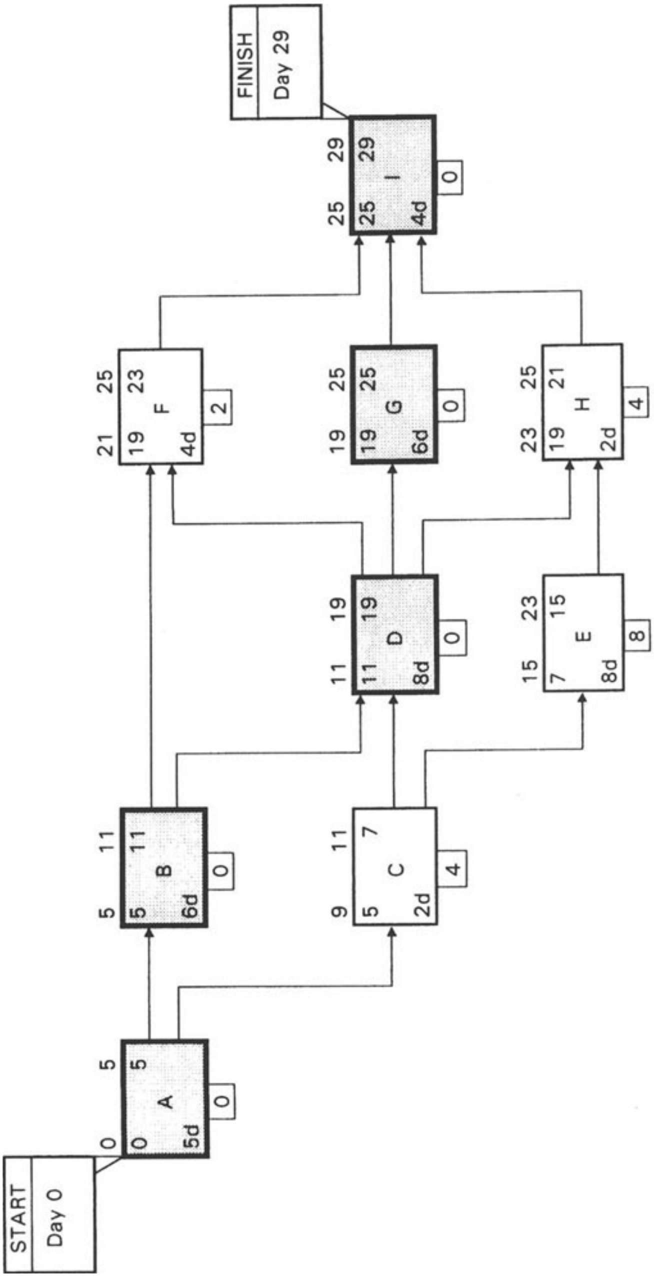
PRECEDENCE DIAGRAM ASSESSMENT OF EARLIEST START LABOUR			
Activity	Duration (Days)	Labour	
A	5	4L	Prepare an assessment
B	6	6L	of the labour
C	2	2L	requirements based
D	8	4L	on an earliest start
E	8	4L	situation
F	4	2L	
G	6	6L	
H	2	4L	
I	4	2L	

Figure 10.27



PRECEDENCE DIAGRAM SHOWING EARLIEST START & EARLIEST FINISH DATES

Figure 10.28



PRECEDENCE DIAGRAM SHOWING
FULL ANALYSIS - CRITICAL ACTIVITIES HIGHLIGHTED

Figure 10.29

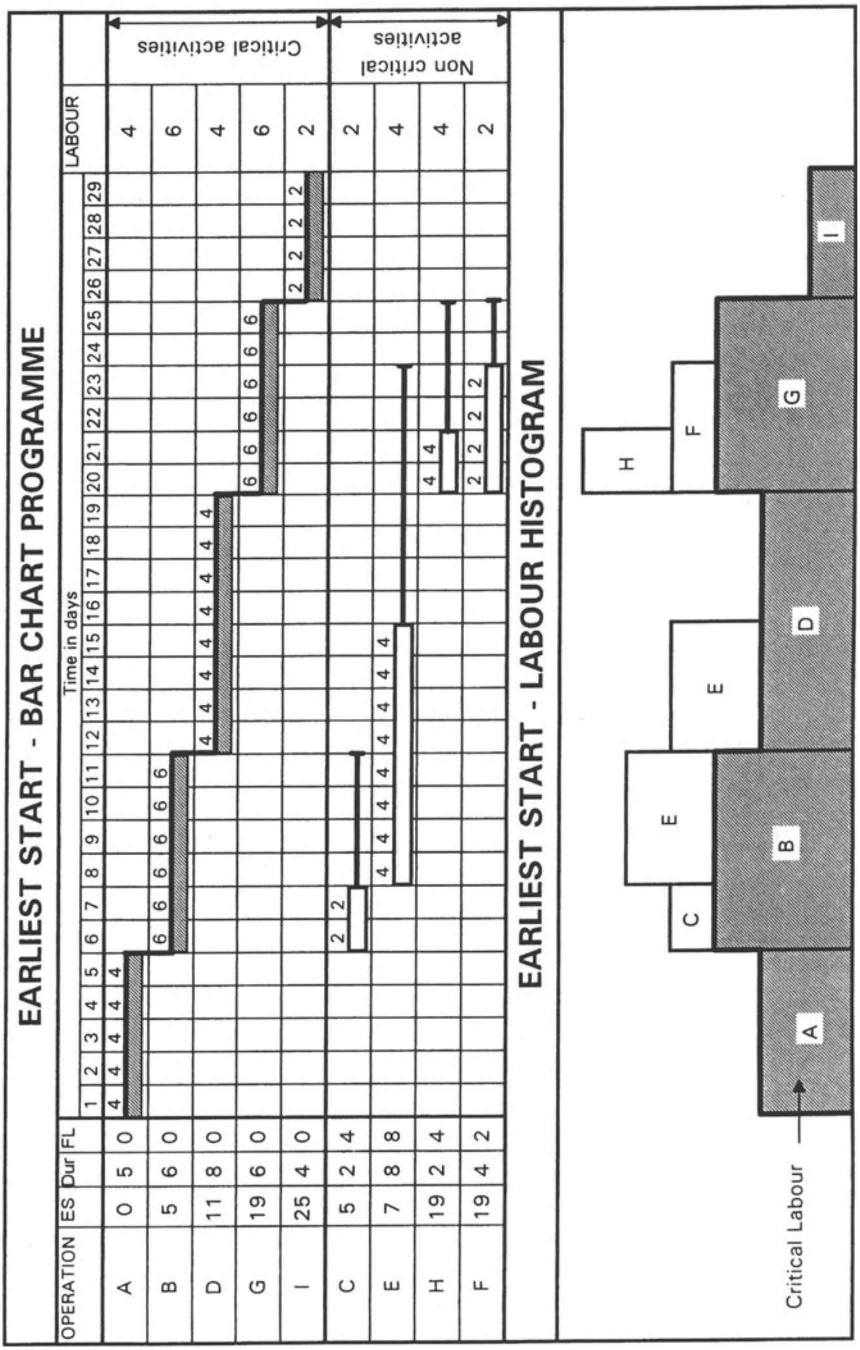

EARLIEST START - BAR CHART PROGRAMME
OPERATION
ES
Dur
FL
Time in days
LABOUR
A 0 5 0
B 5 6 0
D 11 8 0
G 19 6 0
I 25 4 0
C 5 2 4
E 7 8 8
H 19 2 4
F 19 4 2
Critical activities
Non critical activities
EARLIEST START - LABOUR HISTOGRAM
Critical Labour
A
B
C
D
E
F
G
H
I

Figure 10.30

10.3.2 Labour Resource Allocation or Labour Smoothing

The application illustrates the procedure to be adopted in order to use activity float times to smooth or level out labour resources. The example uses a precedence relationship in order to establish the most economic way of resourcing 6 joiners during the refurbishment of a canteen project

Figure 10.31 indicates the precedence relationship for activities A to I during the refurbishment work. Activity descriptions, durations and the required labour requirements are indicated. A maximum of 6 joiners are available to undertake the work. The objective is to establish the most economic way of using the labour

The procedure to be adopted in analysing the situation is as follows:

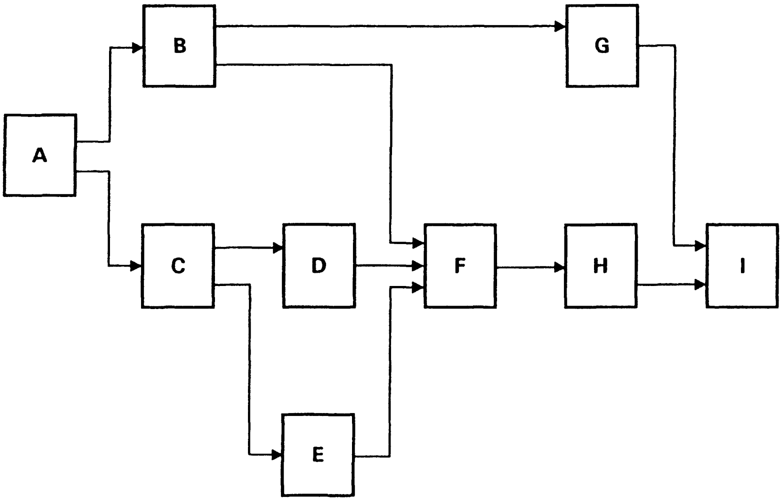
1. Analyse the precedence sequence in order to establish critical activities
2. Present the analysed precedence sequence in the form of an earliest start bar chart
3. Indicate the labour resources on the bar chart by allocating labour resources to the various bar lines
4. Establish the total labour resource for each day of the programme
5. Prepare an earliest start labour histogram: first fix the critical labour requirements along the base of the histogram and stack the non-critical labour on top
6. Now consider how the non-critical labour may be moved in its float times to 'smooth out' the peaks and troughs on the labour histogram.

Figure 10.32 illustrates the analysed precedence diagram highlighting the critical sequence and the total float times on non critical activities

Figure 10.33 indicates the earliest start bar chart produced from the analysed precedence sequence. The critical activities in the sequence have been shown first. The total labour requirements for each day of the project have been indicated along the base of the bar chart. Figure 10.34 illustrates the earliest start labour resources indicating a maximum labour requirement of 10 joiners early in the project. The critical labour activities have been highlighted along the base of the histogram.

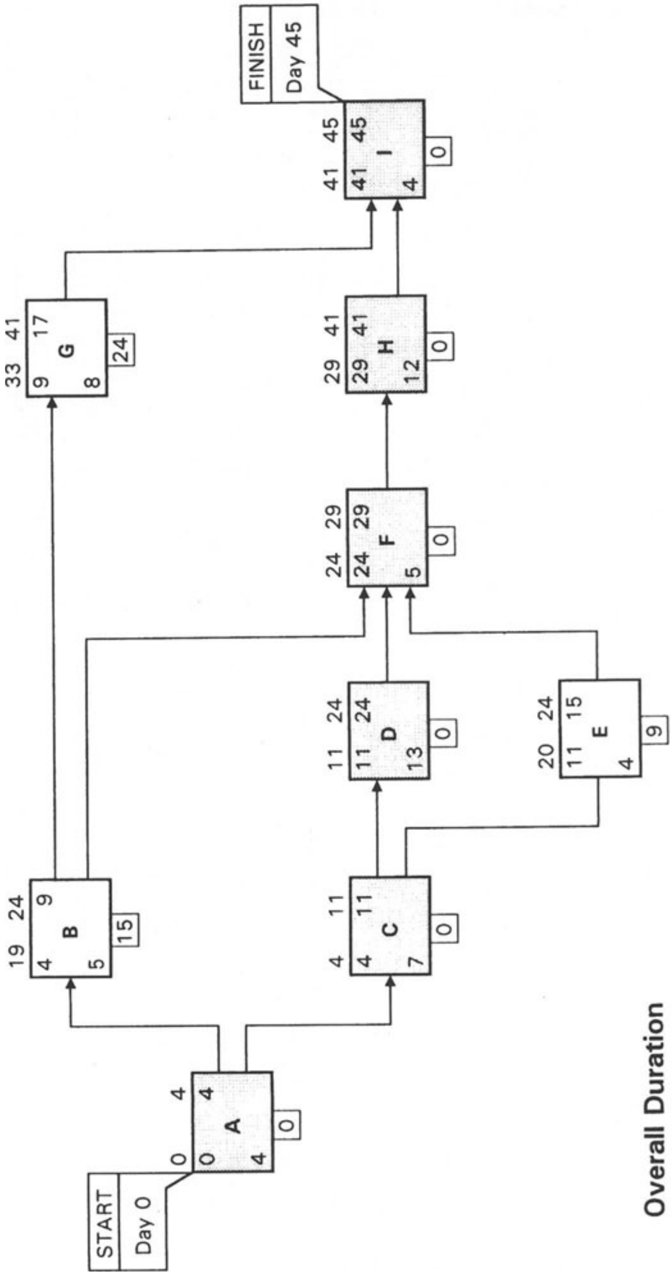
By moving the labour allocated to non critical activities, as shown dotted in Figure 10.34, the resourced histogram in Figure 10.35 may be produced. The analysis indicates the maximum utilisation of the 6 joiners allocated to the project.

PRECEDENCE RELATIONSHIP



ACTIVITY REF.	ACTIVITY DESCRIPTION	DURATION (DAYS)	REQUIRED JOINERY RESOURCE
A	Remove existing units	4	2
B	Construct plinths	5	4
C	Wall battering	7	6
D	Wall cabinets	13	2
E	Display units	4	3
F	Wall panelling	5	6
G	Counter units	8	4
H	Internal fittings	12	2
I	Internal tiling	4	2

Figure 10.31



ANALYSED PRECEDENCE DIAGRAM

Figure 10.32

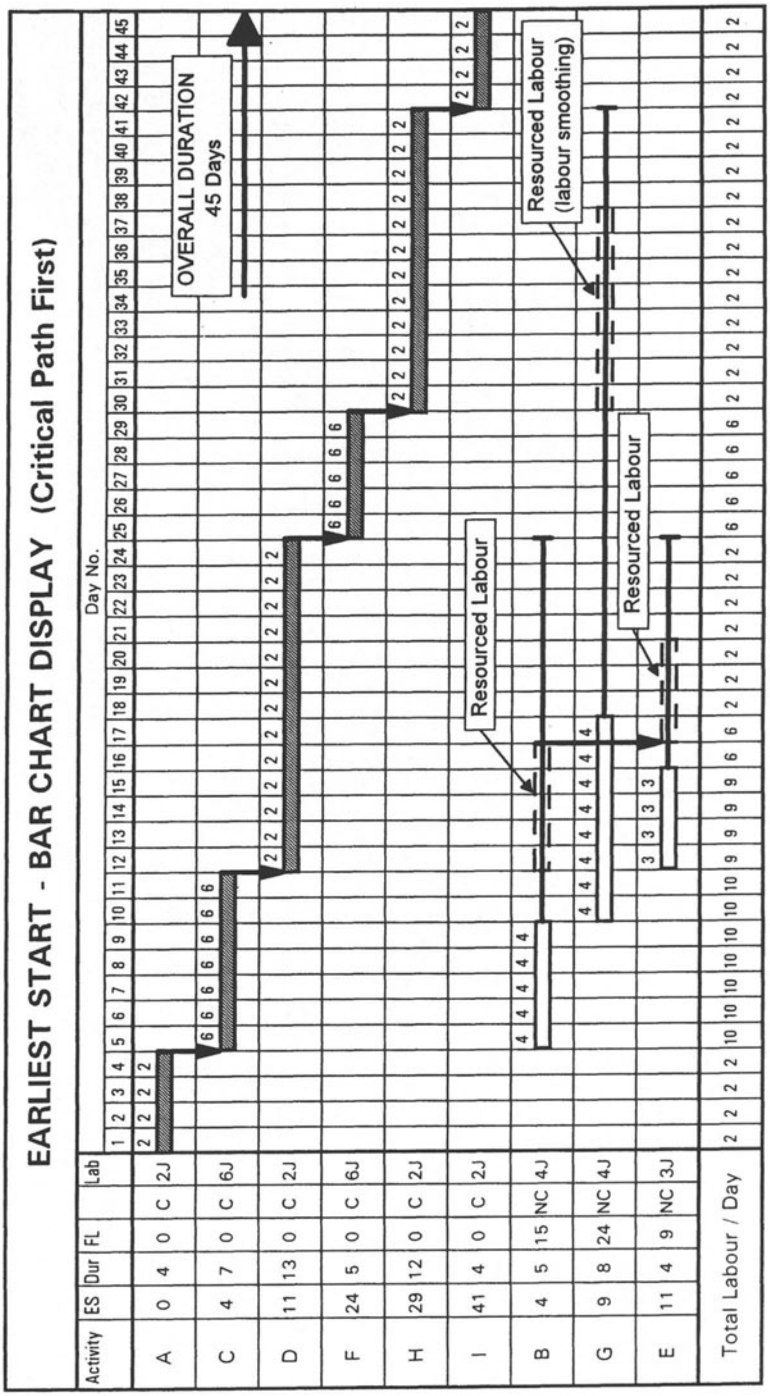

EARLIEST START - BAR CHART DISPLAY (Critical Path First)
Activity ES Dur FL Lab
Day No.
A 0 4 0 C 2J
C 4 7 0 C 6J
D 11 13 0 C 2J
F 24 5 0 C 6J
H 29 12 0 C 2J
I 41 4 0 C 2J
B 4 5 15 NC 4J
G 9 8 24 NC 4J
E 11 4 9 NC 3J
OVERALL DURATION
45 Days
Resourced Labour
Resourced Labour
Resourced Labour
(labour smoothing)
Total Labour / Day
2 2 2 2 10 10 10 10 10 10 10 9 9 9 9 6 6 2 2 2 2 2 2 2 6 6 6 6 6 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2

Figure 10.33

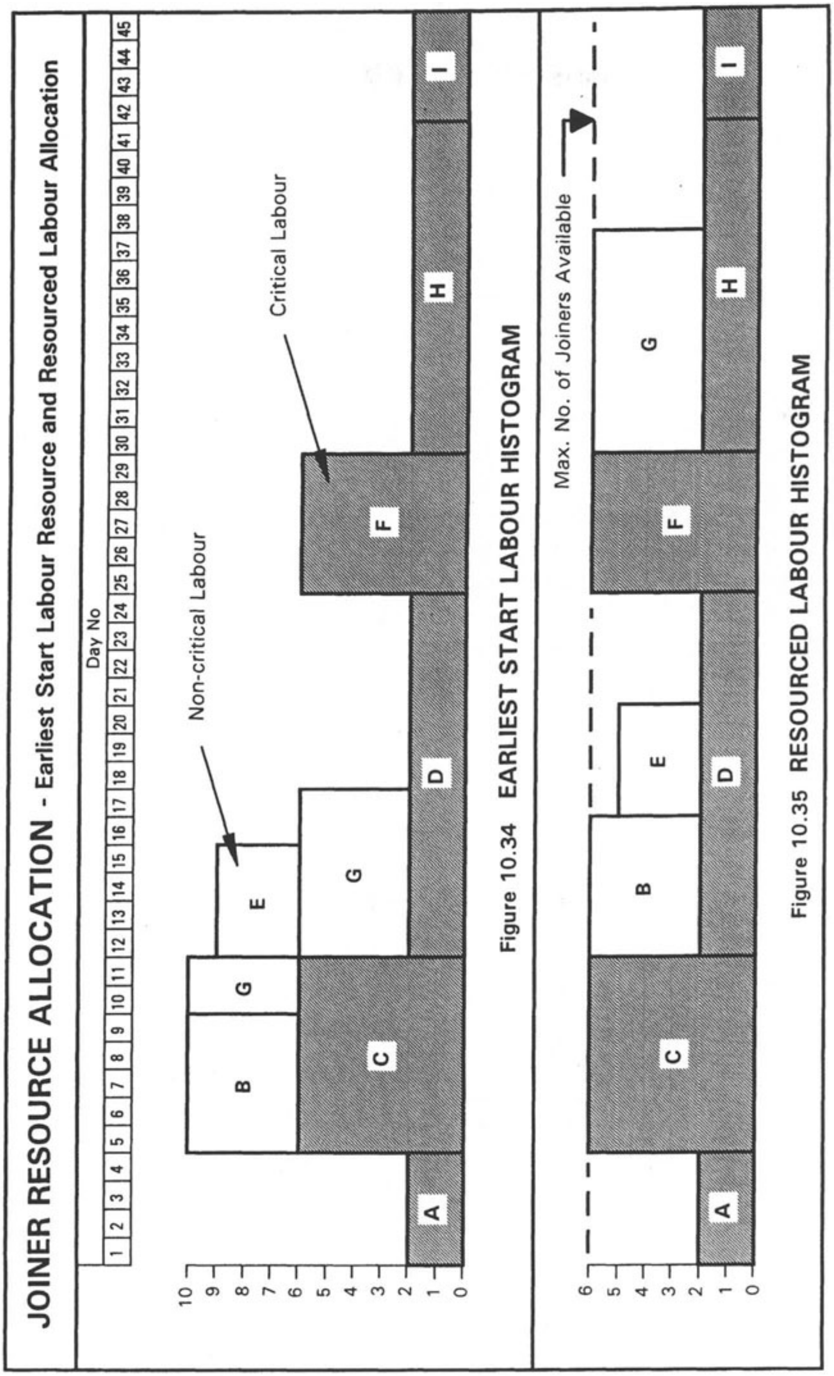


Figure 10.34 EARLIEST START LABOUR HISTOGRAM

Figure 10.35 RESOURCED LABOUR HISTOGRAM

10.3.3 Cumulative Value Forecast

This application illustrates the analysis of a precedence diagram based on a variety of start to start, finish to start and finish to finish relationships. The sequence relates to the foundations, frame and ground floor slab operations during the construction of a factory building. Figure 10.36 indicates the initial network precedence diagram. Figure 10.37 illustrates the analysed precedence diagram indicating floats, and critical operations in order to achieve an overall completion date of 34 days. The objective of the exercise is to produce a cumulative project value forecast based on the earliest start situation.

Figure 10.38 illustrates an earliest start bar chart showing the critical operations listed first in the sequence.The analysis indicates that the start to start periods (overlaps) on the first three site operations are critical to achieving the overall completion date of 34 days.This has been highlighted on the bar chart by linking the critical operations. The bar chart in Figure 10.39 has enabled monetary values to be allocated to the bar lines in order to produce the cumulative weekly value forecast. Figure 10.40 indicates the value time forecast presented both graphically and in tabular format.

The cumulative value forecast, based on a realistic and achievable programme, enables the planning process to be integrated with the project monthly cost/value reporting procedures. Examples of analysing cost and value variances are covered in the examples in Chapter 7.

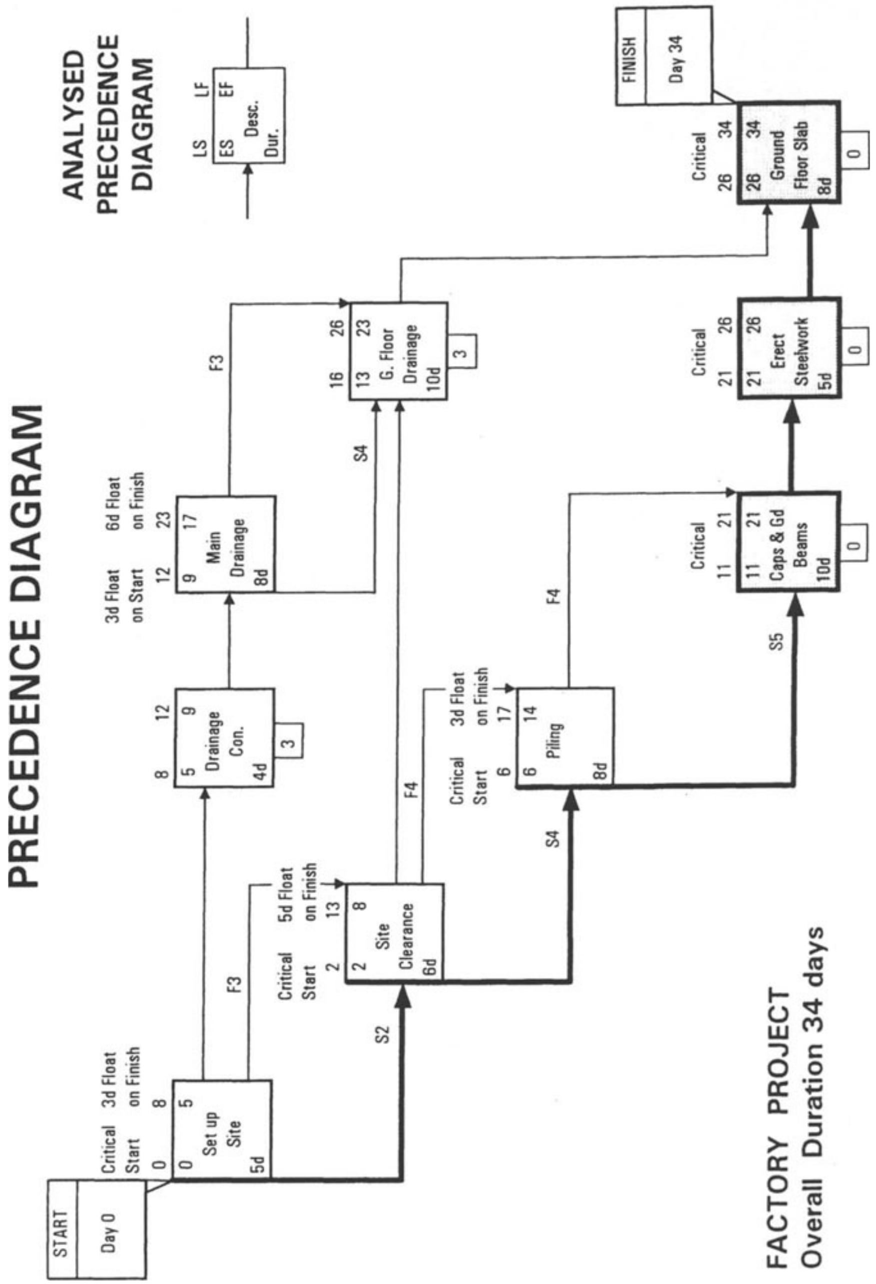

PRECEDENCE DIAGRAM
ANALYSED PRECEDENCE DIAGRAM
LS LF
ES EF
Desc.
Dur.
START
Day 0
Critical Start 3d Float on Finish
0 8
0 5
Set up Site
5d
S2
F3
Critical Start 5d Float on Finish
2 13
2 8
Site Clearance
6d
8 12
5 9
Drainage Con.
4d
3
3d Float on Start 6d Float on Finish
12 23
9 17
Main Drainage
8d
F3
S4
16 26
13 23
G. Floor Drainage
10d
3
F4
Critical Start 3d Float on Finish
6 17
6 14
Piling
8d
S4
S5
F4
Critical
11 21
11 21
Caps & Gd Beams
10d
0
Critical
21 26
21 26
Erect Steelwork
5d
0
Critical
26 34
26 34
Ground Floor Slab
8d
0
FINISH
Day 34
FACTORY PROJECT
Overall Duration 34 days

Figure 10.36

PRECEDENCE DIAGRAM

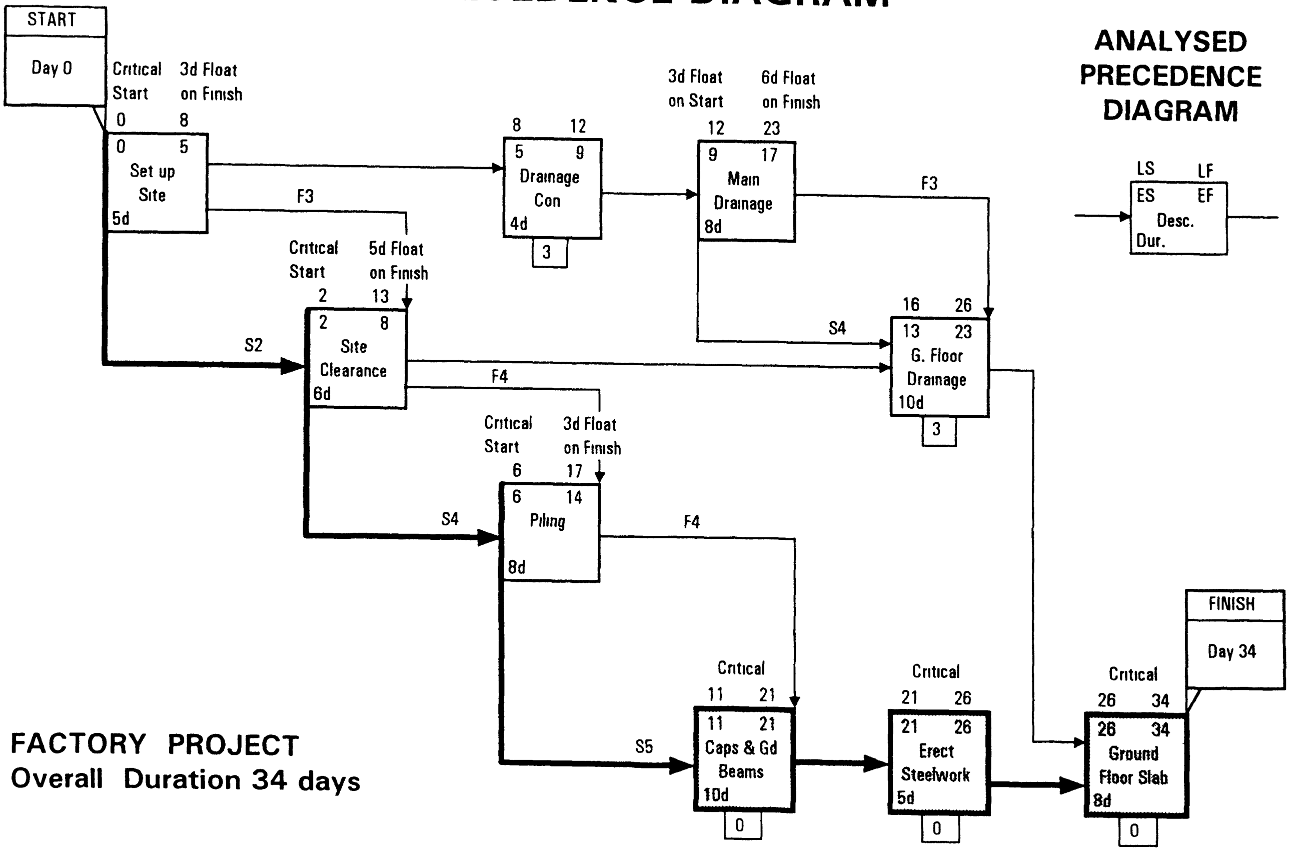


Figure 10.37

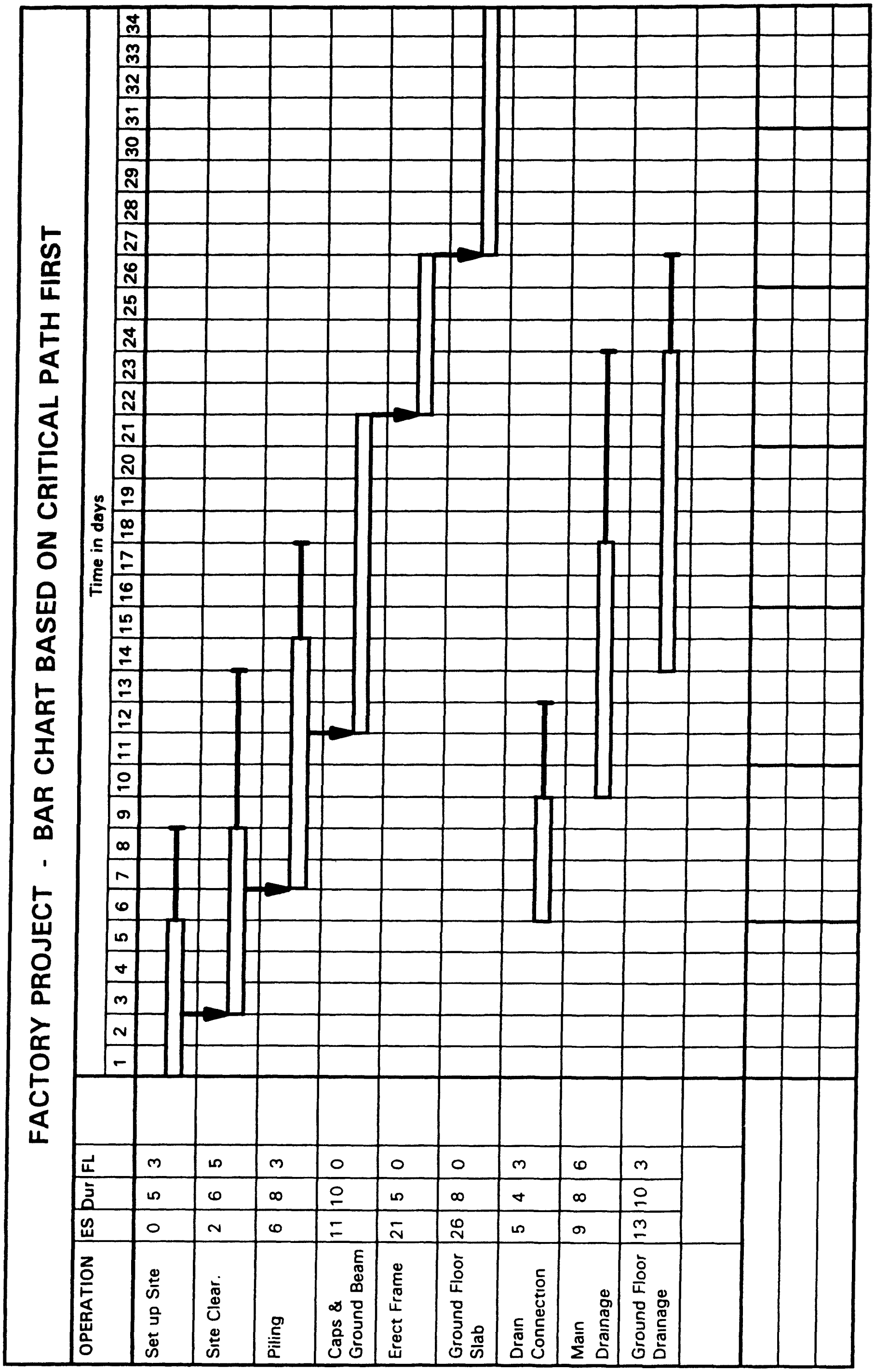

FACTORY PROJECT - BAR CHART BASED ON CRITICAL PATH FIRST
OPERATION
ES
Dur
FL
Time in days
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
Set up Site 0 5 3
Site Clear. 2 6 5
Piling 6 8 3
Caps & Ground Beam 11 10 0
Erect Frame 21 5 0
Ground Floor Slab 26 8 0
Drain Connection 5 4 3
Main Drainage 9 8 6
Ground Floor Drainage 13 10 3

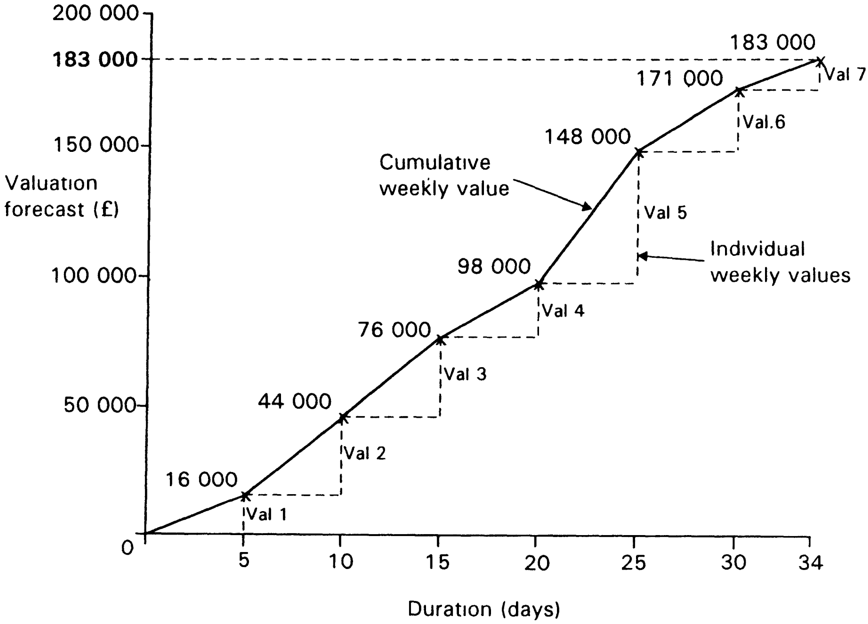
Figure 10.38

FACTORY PROJECT - BAR CHART (from Prec. Diagram)

OPERATION	ES	DV	FL	VALUE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Set up Site	0	5	3	5000	1	1	1	1	1																													
Site Clear.	2	6	8	12000			2	2	2	2	2	2																										
Piling	6	8	7	24000							3	3	3	3	3	3	3	3																				
Caps & Ground Beam	11	10	0	20000												2	2	2	2	2	2	2	2	2	2													
Erect Frame	21	5	0	50000																						10	10	10	10	10								
Ground Floor Slab	28	8	0	16000																											2	2	2	2	2	2	2	2
Drain Connection	5	4	3	4000						1	1	1	1																									
Main Drainage	9	8	9	8000										1	1	1	1	1	1	1	1																	
Ground Floor Drainage	13	10	3	10000														1	1	1	1	1	1	1	1	1	1											
Prelims	£1000 per day			34000	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Daily Value					2	2	4	4	4	4	7	7	5	5	5	7	7	8	5	5	5	4	4	4	4	12	12	11	11	11	3	3	3	3	3	3	3	3
Cumulative Value					2	4	8	12	16	20	27	34	39	44	49	56	63	71	76	81	86	90	94	98	102	114	126	137	148	159	162	165	168	171	174	177	180	183
Weekly Value									16					28					32					22					50					23				12

Figure 10.39

VALUE - TIME FORECAST
FACTORY PROJECT



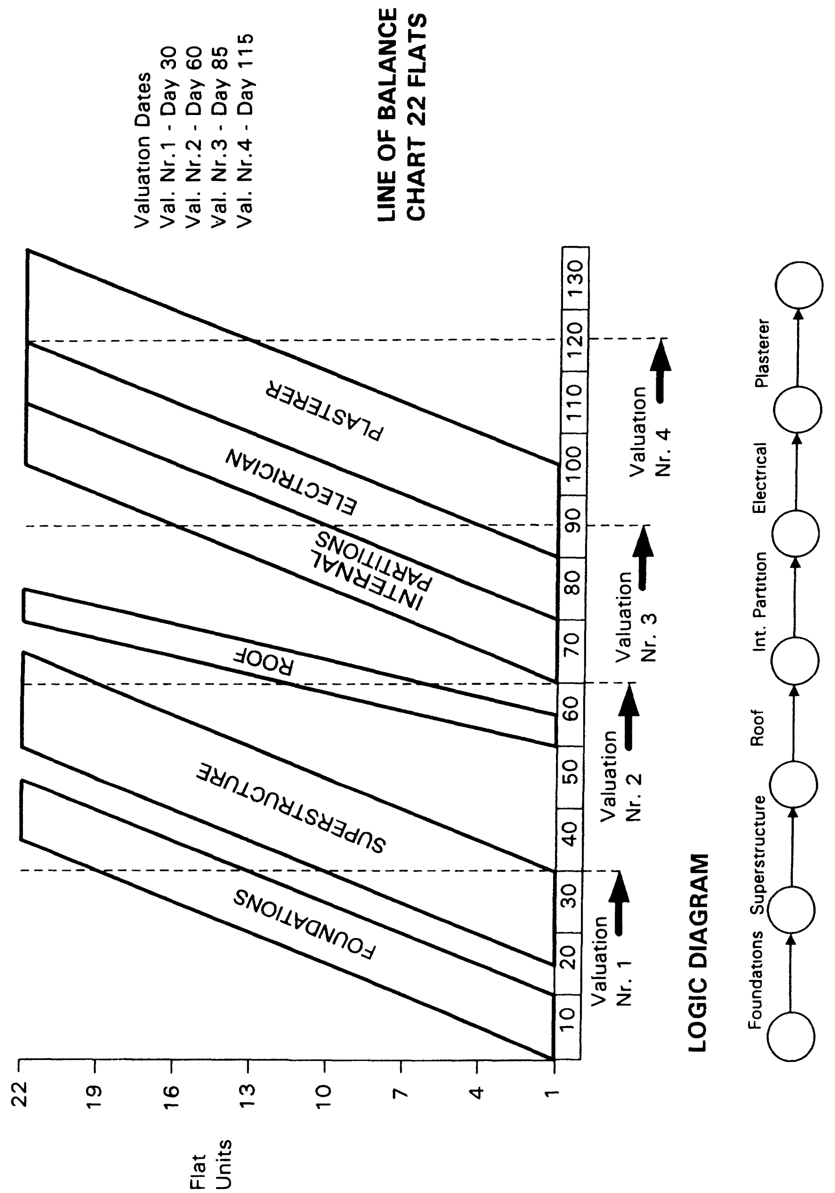
TABULAR CUMULATIVE WEEKLY VALUE FORECAST			
Week	Day	Cumulative value	Weekly value
1	5	16 000	16 000
2	10	44 000	28 000
3	25	76 000	32 000
4	20	98 000	22 000
5	25	148 000	50 000
6	30	171 000	23 000
7	34	183 000	12 000

Figure 10.40

10.4 Line of Balance

10.4.1 Monthly Valuation Forecast

The example is intended to demonstrate how a monthly value forecast may be assessed from a line of balance chart. Figure 10.41 illustrates a line of balance diagram for the construction of twenty-two flats. Interim valuation dates have been indicated along the base of the diagram and extended vertically to cut the balance lines. By reading off the number of units completed at each of the valuation cut off lines, the display shown in Figure 10.42 may be developed. The number of units completed at each of the valuation dates has been summarised to indicate the valuation forecast for months one to four.

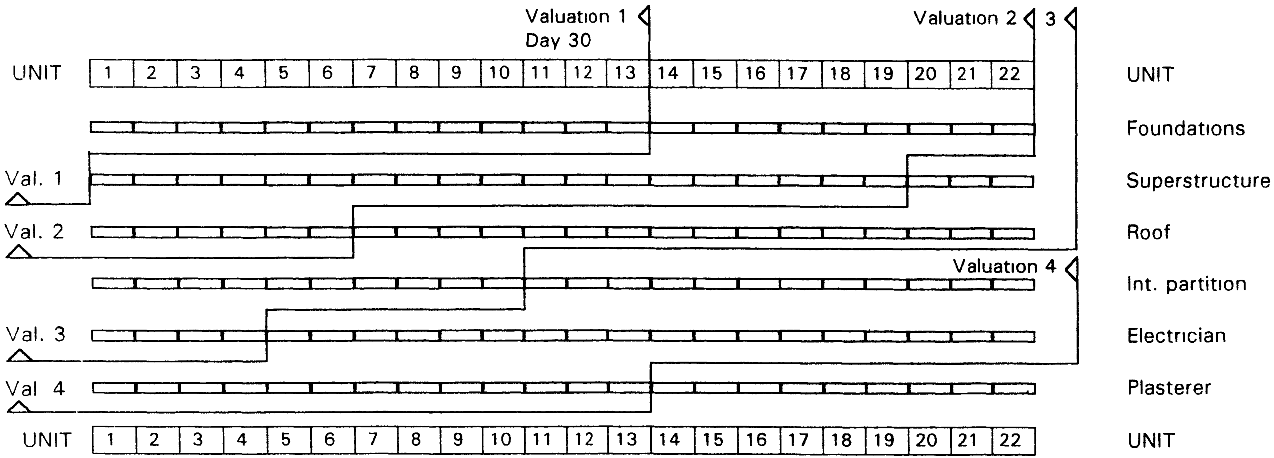


LINE OF BALANCE SCHEDULE - VALUATION STAGES

Figure 10.41

HOUSING PROJECT

VALUATION FORECAST BASED ON LINE OF BALANCE (Total value £121000)



Val Nr	Foundations	Superstructure	Roof	Int.Ptns	Electrician	Plasterer	Total Value	Day Nr
1	13-£800						£10 400	30
2	22-£800	19-£1200	6-£600				£44 000	60
3	22-£800	22-£1200	22-£600	10-£800	4-£600		£67 600	85
4	22-£800	22-£1200	22-£600	22-£800	22-£600	13-£1500	£107 500	115

Figure 10.42

10.4.2 Application of Line of Balance to a Housing Project

A contractor requires a programme prepared in Line of Balance format for the construction of 10 house units. The following five operations occur in the construction sequence:

Operation	Duration Weeks	Number of gangs
Foundations	2	2
External walls	4	3
Roof construction	1	1
Internal finishes	4	3
External works	2	2

A minimum of 1 weeks buffer is to be allowed between the start or finish of any operation.

Figure 10.43 indicates the sequence logic for the five operations.

Procedure to be adopted when preparing the programme:

1. For each operation assess the start and finish date for the first and last unit in the sequence. Use the following formulae in each case:

$$\frac{(\text{Nr. of Units} - 1) \times \text{Operational duration}}{\text{Number of gangs used}}$$

Consider the rate of construction between related operations. Plot each pair of balance lines as the calculations are developed.

Operation 1 Foundations

Start of unit 1 Week 0
Finish of unit 1 Week 2 (the operation's duration)

$$\text{Start of unit 10} = 0 + \frac{(10 - 1) \times 2}{2 \text{ gangs}} = \frac{18}{2} = \text{Week 9}$$

Start of unit 10 Week 9
Finish of unit 10 Week 9 + 2 weeks = Week 11

$$\text{Slope of balance line} = \frac{\text{duration}}{\text{Nr of gangs}} = \frac{2.0}{2.0} = 1.00$$

Figure 10.44 indicates the balance line drawn for the foundations operation 1.

Operation 2 External walls

$$\text{Slope of balance line} = \frac{4}{3} = 1.33$$

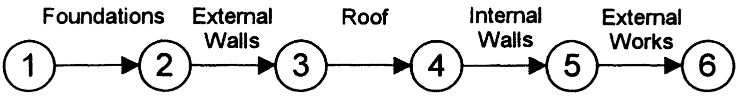
Because operation 1 is progressing at a faster rate than operation 2, the relationship between the balance lines is therefore at the finish of house unit 1.

Start of unit 1 Week 2 + 1 weeks buffer = Week 3
Finish of unit 1 Week 3 + duration of 4 weeks = Week 7

$$\text{Start of unit 10} = \text{Week } 3 + \frac{(10-1)\times 4}{3 \text{ gangs}} = 3 + \frac{36}{3} = \text{Week } 15$$

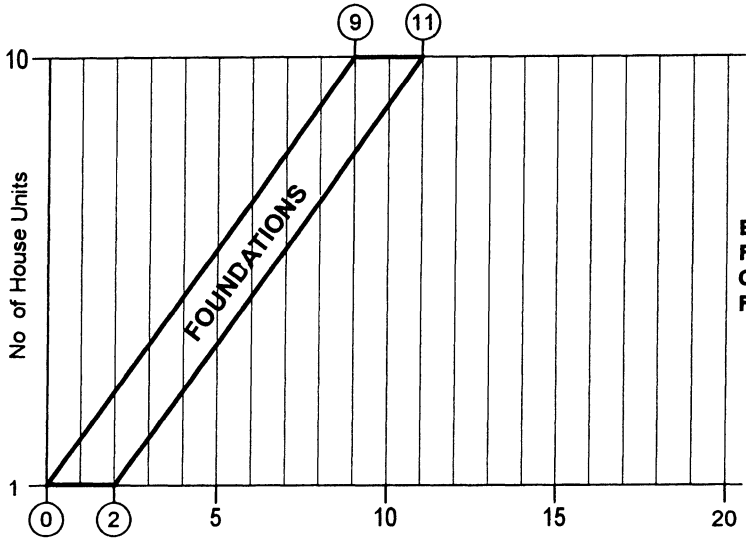
Finish of unit 10 Week 15 + 4 weeks duration = Week 19

Figure 10 45 illustrates the relationship between balance line 1 and balance line 2.



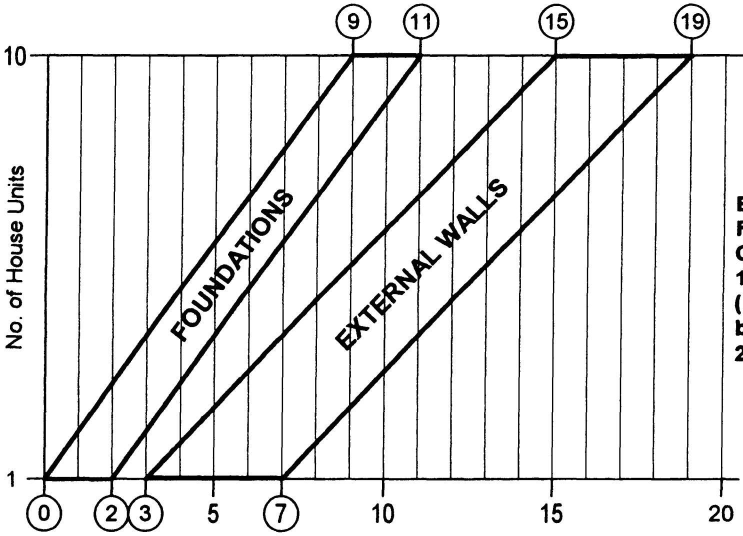
SEQUENCE LOGIC FOR OPERATIONS

Figure 10.43



BALANCE LINE FOR OPERATION 1 FOUNDATIONS

Figure 10.44



BALANCE LINES FOR OPERATIONS 1 and 2 (1 day buffer between day 2 and 3)

Figure 10.45

Operation 3 Roof construction

$$\text{Slope of balance line} = \frac{1}{1} = 1$$

As the roof operation is progressing at a faster rate than the external walls, the relationship between the balance lines will be at the finish of house unit 10 of the external walls.

Start of house unit 10	Week 19 + 1 week buffer	= Week 20
Finish of house unit 10	Week 20 + 1 week duration	= Week 21

$$\text{Start of unit 1} = \text{Week } 20 - \frac{(10-1) \times 1}{1 \text{ gang}} = 20 - 9 = \text{Week } 11$$

Finish of unit 1 = Week 11 + 1 week duration = Week 12

Figure 10.46 illustrates the line of balance diagram for the first three operations in the construction sequence. The balance of the operations has been added to the diagram in order to indicate an overall completion date of day 32.

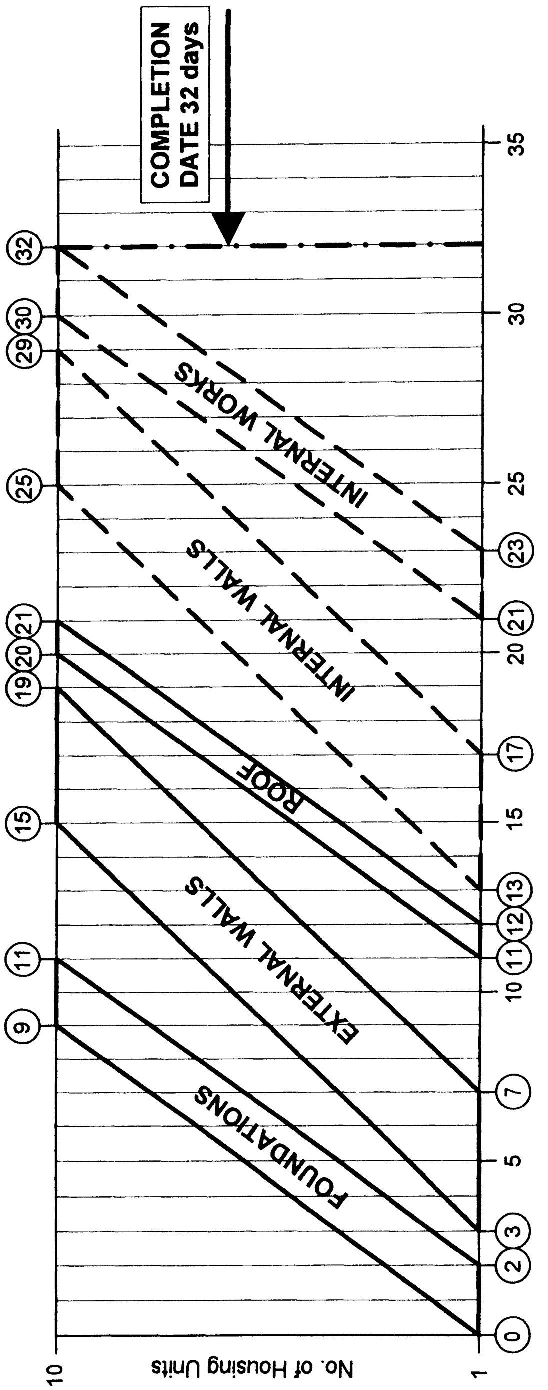

COMPLETION DATE 32 days
FOUNDATIONS
EXTERNAL WALLS
ROOF
INTERNAL WALLS
INTERNAL WORKS
No. of Housing Units
10
1
0
2
3
7
11
12
13
17
21
23
9
11
15
19
20
21
25
29
30
32
5
10
15
20
25
30
35

Figure 10.46

10.4.3 Short Term Planning Sequence

This example is intended to illustrate the assessment of a line of balance diagram, based on the manhours allocated to the various operations, during the fitting out of fourteen laboratory units. The objective is to indicate the approach to preparing a line of balance diagram based on achieving a handover rate of one unit every 5 days.

The following operations and man-hour allocation have been allocated to the construction sequence.

Reference	**Operation**	**Man-hour allocation per laboratory unit**
1	Floor finishes	60
2	Wall plastering	64
3	Wall tiling	60
4	Furniture	160
5	Services connections	120
6	Suspended ceilings	120

Required handover rate: One laboratory unit every 5 days

Figure 10.47 indicates the rate of construction to be achieved, i.e. one unit every 5 days. This relates to the slope to be aimed at in order to achieve the planned rate of construction.

Figure 10.48 indicates an overview of the line of balance diagram for the complete sequence showing the relationships between all operations.

Assessment of balance line for Operation 1 Floor finishes

Man-hours allocated for one unit 60
Nr of man-hours to complete 1 uni $1 \times 60 = 60$ m-hr
Number of operatives required to complete one unit every 5 days

= 60 m-hr / 5 days $\times$ 8 hr per day = 60 / 40 = 1.5 men
Therefore use 2 men in gang

Actual output / handover rate per week

$= 1.0 \times 2.0 / 1.5 = 1.33$ units per week

Operation Duration = 60 m-h / 2 men $\times$ 8 hr per day = 3.75 days

Start of first unit Day 0
Finish of first unit Day 3.75

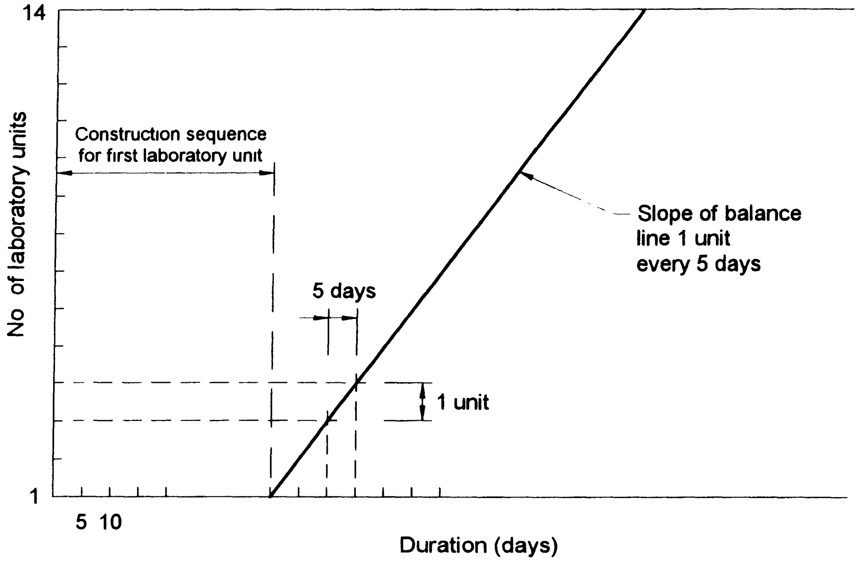


Figure 10.47

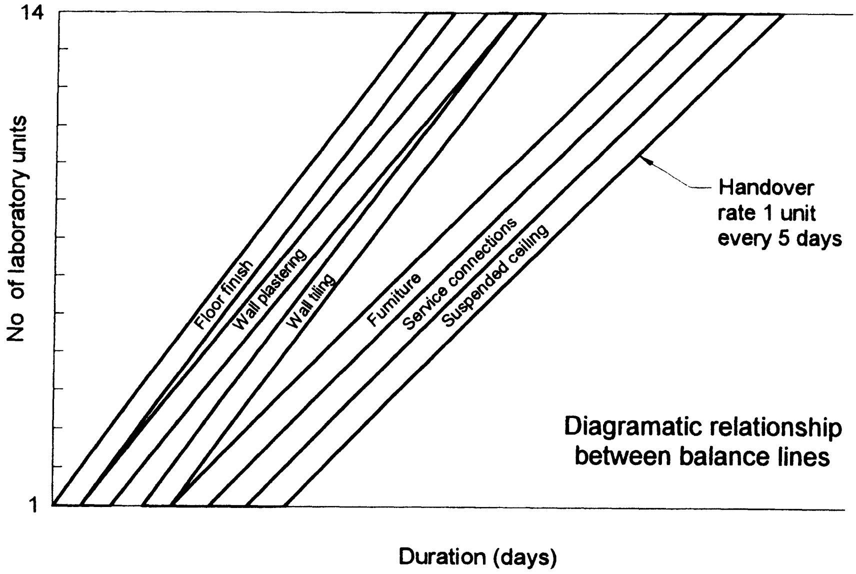


Figure 10.48

To calculate the start date of the last unit, the following formula has been used:

$$\frac{(\text{Nr of units} - 1) \times \text{Duration}}{\text{Number of gangs used}}$$

$$\text{Start of lab. unit } 14 \quad \frac{(14 - 1) \times 3.75 \text{ days}}{1 \text{ gang}} = \text{Day } 48.75$$

Finish of laboratory unit 14 = Day 48.75 + 3.75 days duration = Day 52.5

The balance line for the floor finish operation is illustrated in Figure 10.49.

Assessment of balance line for Operation 2 Wall plastering

Manhours allocated for one unit 64 m-hr
Nr of man-hours to complete one unit 1 × 64 = 64 m-hr
Number of operatives required to complete one unit every 5 days

= 64 m-hr / 5 days × 8 hr per day = 64 /40 = 1.6 men
Therefore use 2 men in gang

Actual output / handover rate per week

= 1 × 2.0 / 1.6 = 1.25 units per week

Operation 2 is progressing at a slower rate of construction than operation 1. Therefore the relationship between the balance lines commences at the completion of unit 1 of the previous operation (floor finishes).

Operation Duration = 64 m-hr / 2 men × 8 hr per day = 4 days

Start of first unit Day 3.75
Finish of first unit Day 3.75 + 4.0 = Day 7.75

Start date of last unit (unit 14)

$$= 3.75 + \frac{(14 - 1) \times 4.0}{1}$$

$$= 3.75 + 52 = \text{Day } 55.75$$

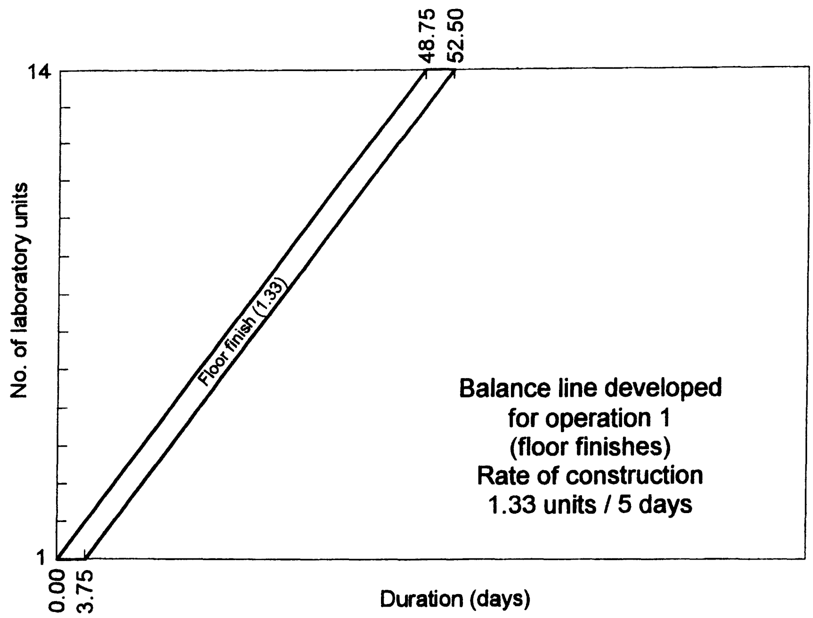


Figure 10.49

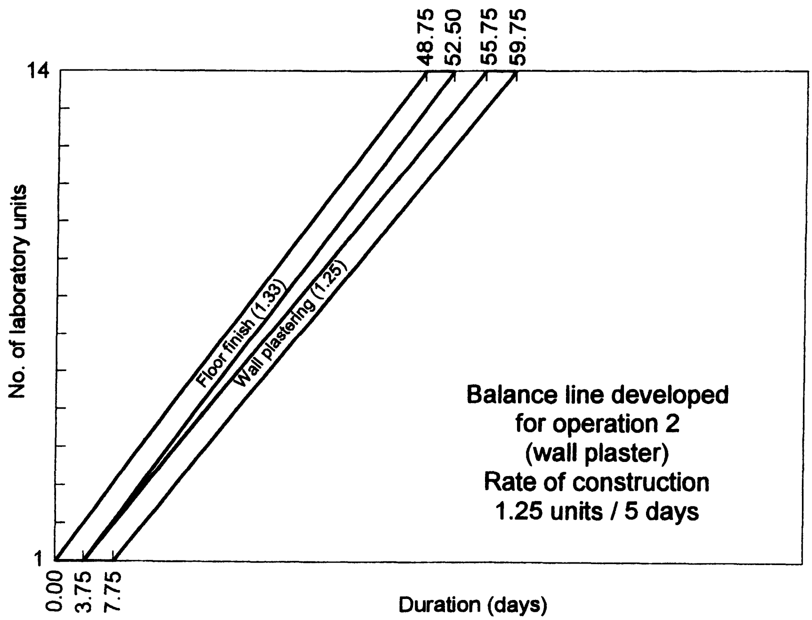


Figure 10.50

Finish of last unit = Day 55.75 + 4.0 days duration = Day 59.75

The relationship between the balance lines for the floor finishes operation and the wall plastering is shown in Figure 10.50. It is convenient to write the rate of construction across the balance lines in order to understand their relationships and relative slopes.

Assessment of balance line for Operation 3 Wall tiling

Man-hours allocated to one unit 60 m-hr (similar duration to Operation 1)

Actual output/ handover rate per week: 1.33 units
Operation duration: 3.75 days

Operation 3 is progressing at a faster rate than Operation 2. Therefore the relationship between the balance lines commences on completion of the wall plastering to unit 14.

Start of unit 14 Day 59.75
Finish of unit 14 Day 59.75 + 3.75 = Day 63.5

Start of unit 1 of the wall tiling operation will therefore be:

$$\text{Day } 59.75 \text{ minus } \frac{(\text{Nr. of units} - 1) \times \text{Duration}}{\text{Nr of gangs}}$$

$$59.75 - \frac{(14 - 1) \times 3.75}{1}$$

$$59.75 - \frac{13 \times 3.75}{1}$$

$$59.75 - 48.75 = \text{Day } 11$$

Start of wall tiling = Day 11
Finish of wall tiling to unit 1 = Day 11 + 3.75 = Day 14.75

The relationship between the balance lines for the first three operations is shown in Figure 10.51. The balance lines for the three remaining operations have also been added in order to illustrate the complete sequence.

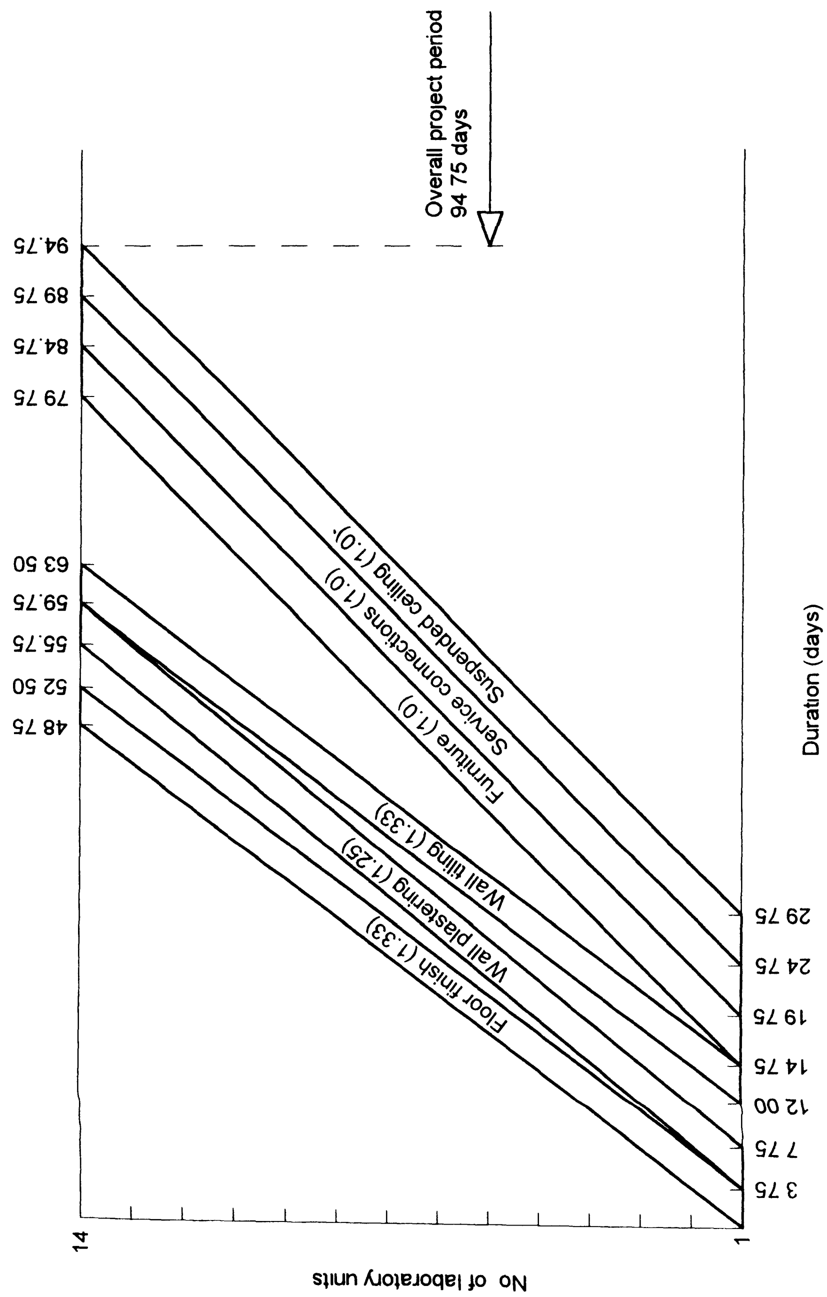

Overall project period
94 75 days
94.75
89 75
84.75
79 75
63 50
59.75
55.75
52 50
48 75
Suspended ceiling (1.0)
Service connections (1.0)
Furniture (1.0)
Wall tiling (1.33)
Wall plastering (1.25)
Floor finish (1.33)
29 75
24 75
19 75
14 75
12 00
7 75
3 75
14
1
No of laboratory units
Duration (days)

Figure 10.51

10.5 Time-chainage Diagrams

10.5.1 Major Highway Project Application Development of Clause 14 Programme

Figure 10 52 shows a proposed dual carriageway trunk road which is to be built to motorway standards under the Department of Transport Specification for Highway Works.

Under the ICE conditions of contract, the contractor is required to submit a 'clause 14 programme' to the engineer within 21 days of the award of the contract. A time-chainage diagram would be an appropriate display on this type of project.

A typical cross section through the road is given in Figure 10.53. This shows the permanent fencing and fenceline drainage which both have to be completed in advance of bulk earthworks operations. At chainage 3+600 there is a proposed box culvert which would also have to be completed in advance of filling to the embankment.

The main activities for the project and estimated durations are given in Figure 10.54.

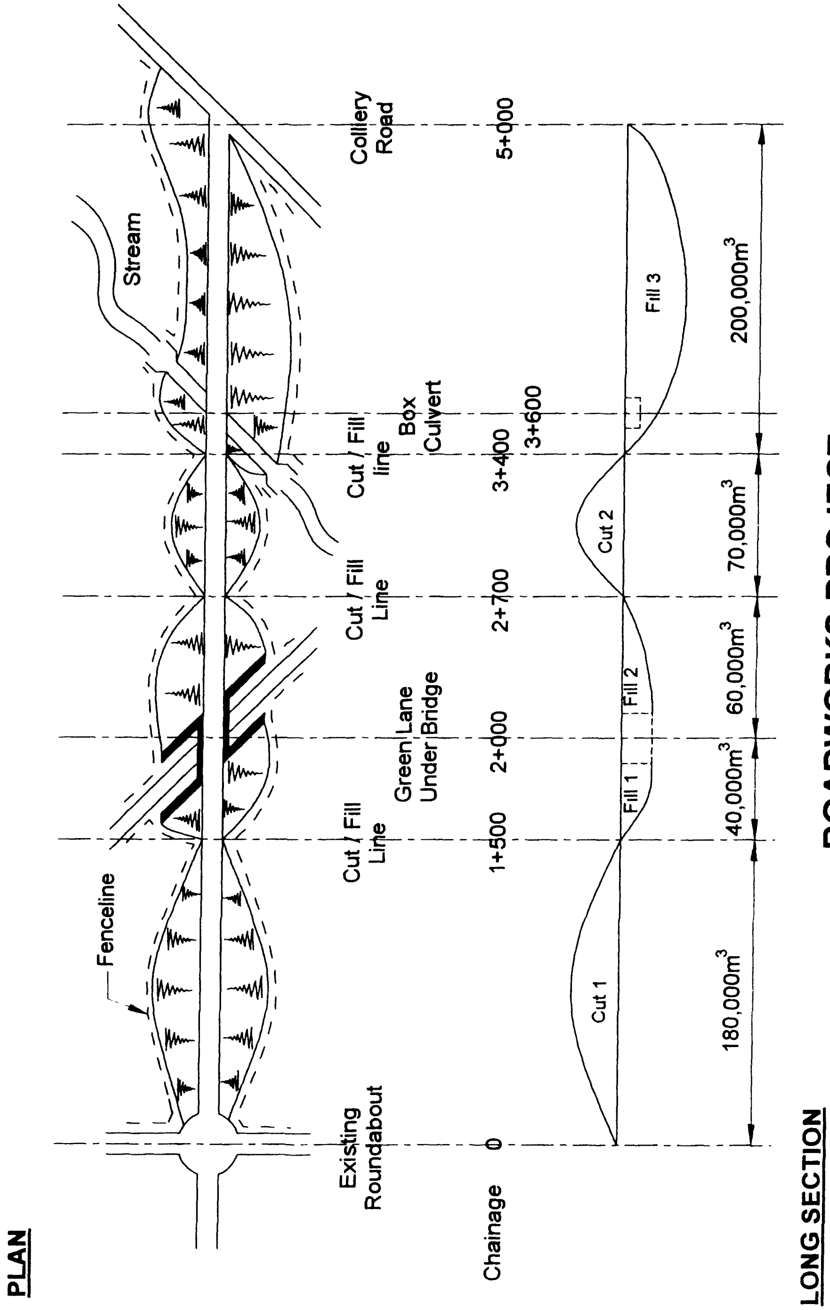
There are three access points available on to the site, one at the existing roundabout, one at Colliery Road and the other via Green Lane.

Earthworks

The project is significantly influenced by the earthworks in that the sequencing of cut and fill operations largely controls the sequencing of the entire project. However, no activity can be considered mutually exclusive as the sequencing of the earthworks is itself affected by the construction of the bridge and box culvert.

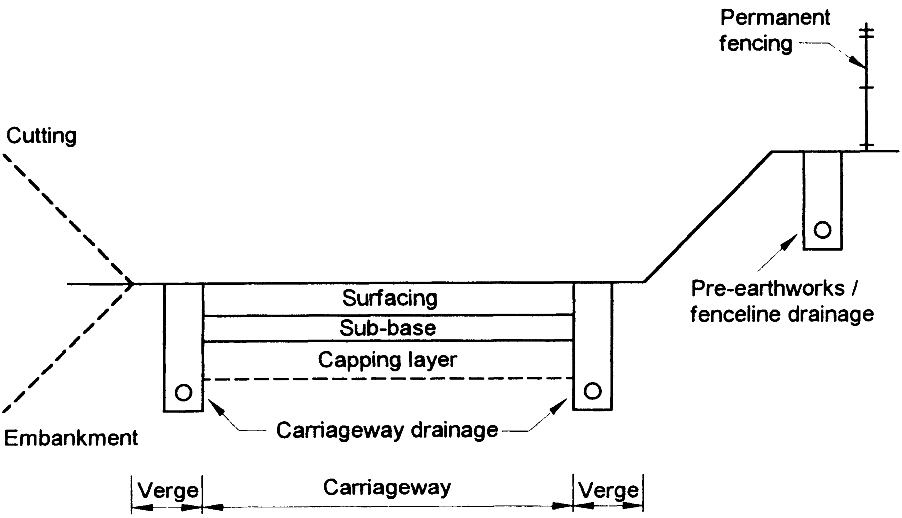
On major road projects, the quantities of earth to be shifted are often very large and two or three million cubic metres is not unusual. The quantities for this case study are therefore relatively small but there are a number of problems which face the earthworks contractor:

- the major cut and fill zones are at opposite ends of the site and the average haul distance on the project is approximately 2 km each way
- the second fill zone is bisected by a proposed bridge site
- a box culvert is required at chainage 3+600 which must precede filling to the embankment
- there is a shortfall of acceptable fill material and therefore 50 000 m^3 will have to be imported
- the existing road at Green Lane must be kept open to traffic during construction of the new bridge



ROADWORKS PROJECT

Figure 10.52



TYPICAL CROSS-SECTION

Figure 10.53

ACTIVITY	DURATION (weeks)
Set up site	6
Fencing and site clearance	10
Topsoil strip	4
Fenceline drainage	14
Excavation and filling	20
Capping layer	10
Carriageway drainage	12
Sub-base	10
Surfacing	12
Box culvert	8
Bridge	26
Finishes	18
Tie-ins to existing roads	6

SCHEDULE OF ACTIVITIES

Figure 10.54

Earthworks plant for a project of this nature has changed over the last 30 years or so. Conventionally, major earthworks were carried out using rope operated scraper boxes towed by caterpillar-type tractors but motorised scrapers, which were faster and with larger capacity, became popular. Scrapers often need dozers pushing to help loading especially in heavy ground conditions.

Nowadays, it is also popular to use large tracked back actors with articulated dump trucks (ADTs) carrying excavated materials to fill zones. Modern excavators are fast and powerful and the new breed of dumpers carry large volumes of spoil. However, where the haul distances are long this either means the excavators being kept waiting or employing a large fleet of dumpers. A contractor may well use a combination of scrapers and excavators/dumpers, the main considerations being:

- volume of earthmoving
- nature of materials to be removed
- whether material is to be used for fill or carted off site
- cost of delivering plant to site
- cost and availability of plant
- use of own or hired plant
- haul distances
- time constraints
- access
- restrictions (e.g. bridges)

Example (simplified)

Bulk excavation to Cut 1 assuming all material is acceptable as fill. Part of Cut 1 is used for embankment construction at Fill 3 and the remainder for bringing up embankment construction either side of Green Lane Bridge.

Quantity = 180 000 m^3 of excavation

Method

Cutting to be taken out using a combination of motor scrapers push-loaded with a tracked dozer and 40 tonne 360° tracked excavators loading into articulated dump trucks. Average haul distance = approx 2.25 km. Filling and compaction is a separate activity.

Outputs

The average haul distance is relatively long and the scrapers will do well to achieve 3 cycles per hour. The scraper crews usually work a long day in the order of 10 working hours over 6 or 7 days per week in the earthworks season. A large scraper will move an average of 450 m^3 each per day over the haul distances on this project. The output of the back actors is usually governed by the haul times of the dumpers unless the digging is hard. Therefore the output is decided on how many trips/cycles can be achieved. Again, because of the average haul distance, this will be no more than three per hour giving around 300 m^3 per dumper per day. Using 3 dumpers this equates to 90 m^3 per hour for the excavators which is no problem for two large machines. The gang therefore has capacity for trimming operations and dealing with obstructions, etc.

Gang

Foreman
3 No Terex TS24 motor scrapers
1 No Cat D7 dozer (pushing)
1 No Akerman H10 excavator
1 No Komatsu PC380 excavator
3 No Cat D400 Dumpers
Banksman

Activity Duration

$$= \frac{180\,000 \text{ m}^3}{[(3 \text{ scrapers} \times 450 \text{ m}^3) + (3 \text{ dumpers} \times 300 \text{ m}^3)] \times 6 \text{ days}}$$

$$= \underline{14 \text{ weeks}}$$

The earthworks activity will therefore occupy Cut 1 for 14 weeks between chainages 0+000 and 1+500 and this is shown plotted on Figure 10.55.

Drainage

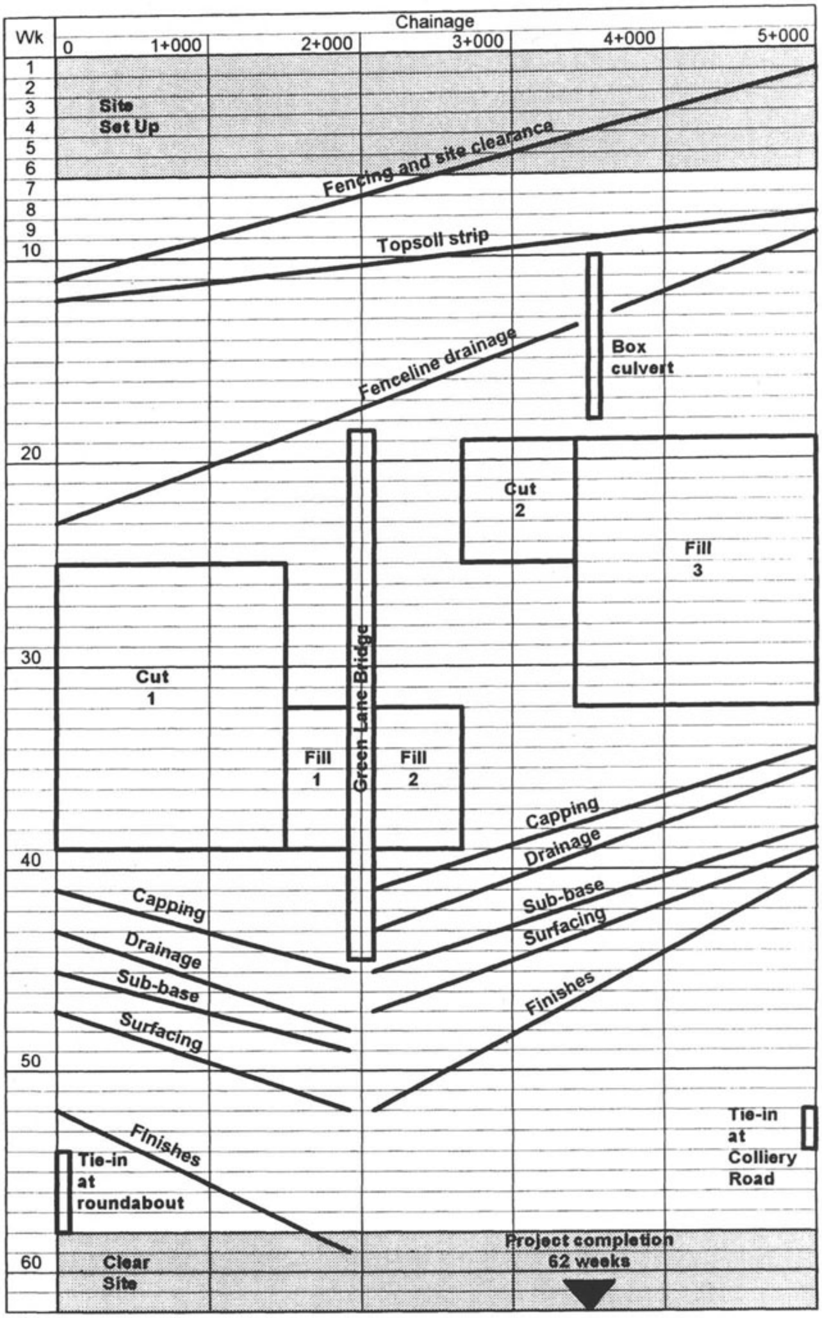
The drainage works comprise:

- Pre-earthworks or fenceline drainage mainly consisting of porous rubble-filled 'french' drains with associated catchpits and connections to surface water ('carrier') drains, culverts and lined and unlined ditches.

- Carriageway drainage comprising both 'carrier' drains, manholes and gullies and 'french' drains and catchpits.

The pre-earthworks drainage normally commences early in the project and follows on behind erection of the permanent fenceline and the topsoil strip over the site.

TIME - CHAINAGE DIAGRAM Roadworks Project



NB: Holidays and other activities omitted for clarity

Figure 10.55

When the pre-earthworks drainage is reasonably advanced, bulk earthworks can follow on behind. Earthworks may be interrupted by culverts crossing the carriageway which will affect muckshift sequencing and may involve temporary diversions around the culverts 'site'.

Pre-earthworks drainage poses problems for the contractor such as:

- Access – there may be no haul roads in and plant may have to 'track' along from the main access points eg access for the box culvert would have to be from Colliery Road.
- Materials – without proper access for road vehicles, site conditions and the weather will very much dictate whether access will be possible along the 'spread' of the job. Drainage materials such as pipes, manhole/catchpit components, bricks and ironwork etc may have to be delivered to the main compound and then double-handled by site transport such as tractor and trailer to the various locations along the job. Drain fills are delivered from the quarry by road transport and may have to be tipped at access points and reloaded onto site dumpers. Ready mixed concrete may similarly be a problem.
- Drainage arisings – a major proportion of the spoil from drainage excavations will not be required for filling trenches but may not be suitable for filling elsewhere on the site. The suitability of fills is the responsibility of the main contractor/ earthworks subcontractor and therefore the drainage subcontractor will have to be instructed as to what is required of him. Part of the contractor's thinking could be either for the drainage sub-contractor to load the arisings into waggons/dumpers or, perhaps more cost effectively, left to one side to be removed by the earthworks sub-contractor. This is an interface which would require managing by the main contractor and the respective responsibilities would have to be written into each of the sub-contract packages.
- Resources – the main contractor will have to carefully manage the drainage subcontractor to make sure sufficient gangs are available so as not to slow the earthworks down. This is important because the earthworks 'season' is relatively short. Often on large projects the drainage is split into two or more 'packages' and different subcontractors are employed on each. Again there will be interface problems here particularly with regard to the control of materials which the main contractor has to think about.

Calculating the slope of 'linear' activities requires consideration of:

- the quantity of work
- method of working
- gang size/make up
- estimated gang output (rate of forward travel)

Example (simplified)

Assume that the carriageway drainage from chainage 0+000 to 2+000 varies from 150-300 mm in diameter at an average depth of 1.50 m with 1 No catchpit at approximately 100 m intervals.

Quantity = 4500 metres of pipework including crossings and connections
40 Nr catchpits

Method

1 Nr drainlaying gang either side of the carriageway excavating trenches, laying and jointing pipes and backfilling. 1 No catchpit gang following up concreting catchpit bases and placing bottom chamber ring and then next day completing remaining rings, precast slab and temporary cover. Gullies, gully connections and brickwork and ironwork to gullies and catchpits to follow on later during roadworks.

Gangs

Drainlaying:	Ganger Komatsu PC180 tracked excavator Banksman Komatsu WA470 Wheeled Loader 3 Labourers	} 2 Nr Gangs
Catchpits:	Ganger JCB 3CX Banksman Bricklayer 2 Labourers	} 1 Nr Gang

Outputs

Drainlaying: 90 m/gang/day working a 5 day week
Catchpits: Average 2 Nr per day

Activity duration

Drainlaying:

$$= \frac{4500 \text{ m}}{90 \text{ m/day} \times 5 \text{ days} \times 2 \text{ gangs}} = 5 \text{ weeks}$$

Catchpits:

$$= \frac{40 \text{ No}}{\text{Ave 2 Nr per day} \times 5 \text{ days}} = 4 \text{ weeks}$$

The two operations run concurrently and therefore the activity duration is 5 weeks overall.

The drainage activity would then be plotted between chainage 0+000 commencing at week 43 and chainage 2+000 finishing at week 48.

Structures

One of the problems facing the contractor is the construction of structures across the carriageway, such as bridges and culverts, especially in fill areas. In this example there is a bridge at chainage 2+000 and a box culvert at chainage 3+600 both of which would have to be constructed in advance of embankment construction. Fill can then be brought up to and behind each structure so as to bring levels up to the correct height for road construction to follow.

With regard to the bridge at chainage 2+000, abutment walls and foundations will have to be constructed parallel to Green Lane. This may require traffic management arrangements or possibly a temporary diversion of traffic around the bridge site. Alternatively, it may be possible to close the road during construction.

In order that bridge construction can proceed without impeding earthworks operations, a temporary haul road will be constructed around the bridge site. This will involve traffic control measures on Green Lane as heavy plant will be crossing frequently. This will also complicate the time-chainage programme as drainage works and other activities will have to be left incomplete at this location until later. This has not been shown on Figure 10.55 for simplicity.

Example (simplified)

3000 mm × 2500 mm precast concrete box culvert at chainage 3+600 comprising 1200 mm long units laid in trench on gravel bed jointed with compressible neoprene and polysulphide sealant and backfilled with free draining material.

Quantity = 80 linear metres
1 No headwall at each end

Method

Excavate trench with battered sides using tracked excavator and remove material to spoil with articulated dump trucks. Lay bed of gravel and lay and joint precast concrete units to line and level. Backfill working space on completion. Headwalls to be constructed at each end of the culvert comprising gabion baskets filled with stone. The excavator will be used for diverting the stream and for all excavation, backfilling and handling bedding materials. A rough terrain mobile crane will be needed for offloading and handling the precast concrete culvert sections and for lifting and placing the gabions.

Gang

Foreman
Cat 320 tracked excavator
40T mobile telescopic crane
Banksman
Volvo A25 Dumper
3 Labourers

Output

Allow forward travel of 3 complete precast sectional units per day

Activity Duration

= Diversion of stream = 1 week
Culverting:

$$\frac{80\text{ m}}{3\text{ units per day} \times 5\text{ days}} = 5\text{ weeks}$$

Headwalls = 2 weeks
Total = 8 weeks

The culvert is a 'static' activity and is therefore plotted at chainage 3+600 with a duration of 8 weeks which is shown on the vertical axis of the time-chainage diagram.

Other activities

Depending upon the design of the roadworks, a layer of fill may be required preparatory to road construction. This is known as 'capping layer' and this operation follows on from bulk earthworks.

Owing to the earthworks sequencing, the capping layer, drainage and road construction would start at chainage 5+000 and progress towards chainage 2+000.

This would be more efficient than starting from chainage 0+000 as capping etc could follow filling to zone 3. A two week lead time has been allowed after completion of filling in order to give a time buffer between capping and filling to zone 2 at chainage 3+400.

At week 41, capping layer, drainage etc is programmed to commence at chainage 0+000 working towards Green Lane bridge. Note that continuity of working is preserved by using time buffers of different durations between activities.

10.6 Procurement Case Studies

Figures 10.56 and 10.57 illustrate a number of case study situations for both building and civil engineering work together with a suggested procurement route for each. Of course, there is always more than one procurement approach to any particular project and many considerations have to be made in choosing the right solution for each set of circumstances.

The case studies are intended to show procurement methodologies for different types and sizes of project and to illustrate appropriate forms of contract which could be employed in each particular case.

Reference should be made to Chapter 1 for a brief account of the various procurement methods and forms of contract referred to in Figures 10.56 and 10.57.

Project	Value	Type of Work	Procurement Method	Appropriate Forms of Contract	Commentary
Procurement Case Study - 1			**High Rise Blocks and Low Rise Units**		**Planning Case Study 10.1.1**
2 No 8-storey office blocks with 6 blocks of terraced houses	£3 5 M	Building	Traditional lump sum with bill of quantities	JCT80 or NEC with Option B	With SMM7 With SMM7 Nominated subcontractors not permitted under NEC forms
Procurement Case Study - 2			**Factory Project**		**Planning Case Study 10.1.2**
Steel framed factory building on piled foundations	£197 K	Building	Traditional lump sum with bill of quantities	IFC84 or NEC with Option B	Preferred subcontractors may be 'named' under either of these forms of contract
Procurement Case Study - 3			**Canal Project**		**Planning Case Study 10.1.3**
Refurbishment of existing canal and lock as enabling works for boating marina	£1 M	Civils	Traditional remeasure with bill of quantities	ICE5 or 6 or NEC with Option B	The method of measurement would be the CESMM in all cases
Procurement Case Study - 4			**Sewerage Tanks and Pump House Building**		**Planning Case Study 10.2.1**
Installation of new concrete settlement and filtration tanks with pumphouse building in existing sewage works	£100 K	Civils	Traditional lump sum based on drawings and spec	ICE Minor Works form or NEC with Option B	
Procurement Case Study - 5			**Refurbished Office Block**		**Planning Case Study 10.2.2**
Bricklaying package as part of a fast track management contract to refurbish an existing office block	£300 K	Building	Management contracting with works package contracts direct with management contractor	JCT87 Works Contract/1 and /2 or NEC Subcontract	with JCT87 as the main management contract using NEC Option F for the main management contract

PROCUREMENT CASE STUDIES

Figure 10.56

Project	Value	Type of Work	Procurement Method	Appropriate Forms of Contract	Commentary
Procurement Case Study - 6			**Garage Project**		**Planning Case Study 10.2.3**
New prestige car showroom and workshop	£900 K	Building	Design and Build with stage (or milestone) Payments	JCT81 with Alternative 'A' method of payment or NEC with Option A	using activity schedule for payment
Procurement Case Study - 7			**Piling To Factory Unit**		**Planning Case Study 10.3.3**
Piling subcontract as part of new factory building	Main works £2 M Subcon £150 K	Building	Traditional lump sum with piling works nominated by client	JCT80 main contract with NSC/C subcontract conditions or NEC with Option B and piling contract direct with the client also using NEC with Option B	NSC/W form of warranty to client Nomination to main contractor not permitted under NEC arrangements
Procurement Case Study - 8			**Sheltered Housing Project**		**Planning Case Study 10.4.1**
22 No warden assisted sheltered flats for a local housing association client	£1 2 M	Building	Contractor led design and build with guaranteed maximum price (GMP)	JCT81 with amendment for GMP or NEC with Option D	Target contract with bill of quantities
Procurement Case Study - 9			**Highway Project**		**Planning Case Study 10.5.1**
Major highway project comprising 5km of dual carriageway and two main structures	£15 M	Civils	Lump sum client led design and construct	ICE Design and Construct conditions or NEC with Option A	with activity schedule

PROCUREMENT CASE STUDIES

Figure 10.57

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