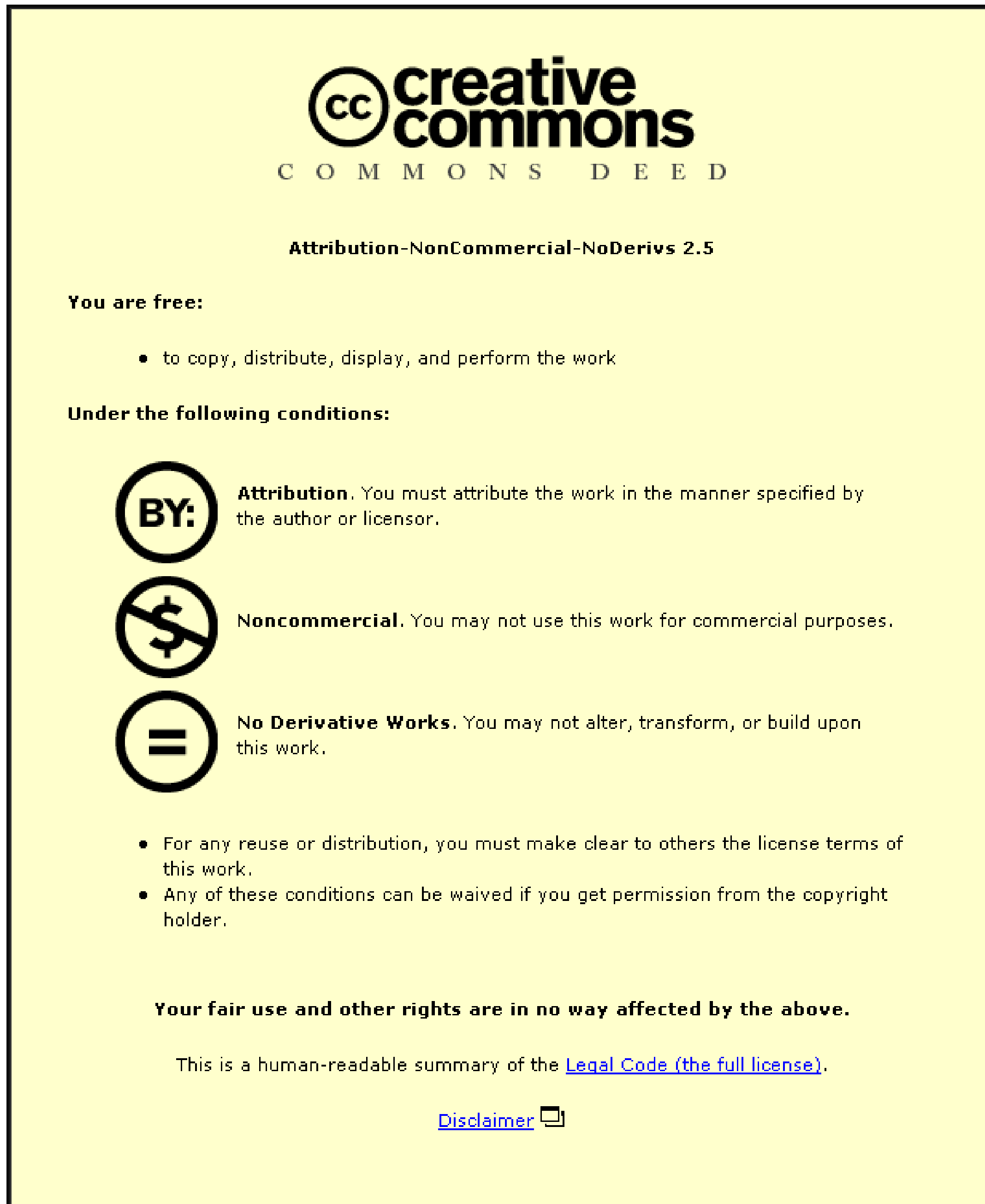


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An Integrated Information System for Hong Kong Construction Contractors

by

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Summary

In the 1990s the capital investment, the standards of technology involved, the complexity of co-ordination, the quality requirements and the speed of construction projects in the world, have been substantially increased in both public and private sectors. These changes have forced contractors to increase their efficiency of management, not only to satisfy their business and commercial requirements but also for their survival in the industry due to the highly competitive environment. The continuing development of information technology has a great impact on all disciplines including construction management, and good information is increasingly important to construction managers.

The research described in the thesis is based on the construction industry of Hong Kong, which is a magnet for all the best construction contractors and professionals in the world, due to the sale of the projects involved and the commercial systems provided. However, the principles generated by this research are of more general application in the management of construction projects.

The main outcomes of the research are as follows:

- a) The existing practices and the impacts of the new developments in the construction projects of Hong Kong have been examined.
- b) A model of construction management practice in Hong Kong has been developed by taking into consideration previous researches, published literatures, current practices and new impacts.
- c) A comprehensive computer system using a fourth-generation language has been developed. The system involves two levels of operation including the management practices of head office and construction sites. The functions provided by the

system include estimation and quality assurance at head office level. The site level systems provide the functions of information control, cost control, materials control and progress control. The integration of information flow among these functions is the main consideration in the development of the system.

- d) The system has been put into field tested using the construction projects of Hong Kong as described in the thesis, and has been found to be effective.

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1 Introduction

1.1 Research Background

This thesis describes research into integrated management information systems for Hong Kong contractors. In this first section, the background leading to the formation of the research is explained.

This Chapter starts with a global view of the changes in construction projects in terms of commercial, technical and management demands. Following on from this a specific emphasis is then put on the Hong Kong construction industry which forms the basis of this research. In a separate sub-section, an important requirement of management information, due to the requirement of quality assurance is introduced. Finally, the impact of computers upon construction management is discussed.

1.1.1 Global Changes in Construction Projects

During the 1990s with the pace of the development of industrialized civilisation, capital investment, standards of technology involved, complexity of co-ordination, quality requirements and speed of construction projects world-wide, have been substantially increased in both the public and private sectors of the construction industry. The participation of major international contractors in world-wide markets not only generates higher competition but also introduces interchanges of advanced technologies in both their technical and managerial aspects. From the viewpoint of contractors, to maximise profit and to increase competitive ability, it is necessary for them to have greatly enhanced management control over construction activities in terms of time, cost and quality. The success of construction projects is largely determined by the management control in achieving acceptable project performance through tight co-ordination and co-operation with all parties involved.

The intense competition for construction work has forced contractors to accept contractual liabilities and rights which give more flexibility and authority to clients enabling them to initiate variations, to assess more vigorously contractors' performance, and to put more risks on the contractors. Higher demands of construction project performance in all aspects including time, cost and quality, through the contractual arrangements, have forced contractors to concentrate upon better management in order to meet the needs of contract administration in such matters as, for example, the timing of notifications and quality of submissions. These changes are reflected in most Standard

Conditions of Contract. The purpose of these arrangements is to enable clients, or their agents, during the work progress to have a clear view of the current status of time, cost and quality implications of the project. Consequently, it is important to get the contractor's prompt response to the variations in order to avoid future disputes.

This change of contractual climate undoubtedly has compelled contractors to elevate their performance, and to improve their standard of construction management, not only to satisfy their immediate business and commercial requirements but also for their long term survival in the industry.

1.1.2 The Hong Kong Construction Industry

Hong Kong is one of the foremost economic and commercial centres in the world and has enjoyed economic growth in pace with the commercial developments of the Pacific Rim and the "open-door" policy of Peoples' Republic of China (PRC). The construction industry of Hong Kong will be one of its most important industries for the coming ten years because of the huge infrastructure developments in Hong Kong. These developments are closely monitored by the governments of Britain and PRC. In addition, these developments are known to be one of the crucial issues in maintaining the prosperity of Hong Kong and help to safeguard a smooth transfer of the Hong Kong sovereignty to PRC on 1st July 1997.

Since early 1991, Hong Kong has embarked upon a programme of infrastructure development called The Port and Airport Development Strategy (PADS) that will enable the territory to achieve continued economic growth and maintain its important role as a centre of world trade, commerce and communications well into the next century. The Memorandum of Understanding signed by Britain and China in September 1991 means that Hong Kong can move forward with confidence to the next stage of the Airport Core Programme Projects. The scale of the PADS is around HK\$ 170 billions total investment, to be completed within 6 years. For the implementation of the PADS, a new set of Procedures and Conditions of Contract was introduced in order to achieve better planning and control and to satisfy public concern regarding value for money reflected by the considerations of time, cost and quality of the projects.

In addition, there is a unusual blend of the commercial practices of international investors, and the mentality of Chinese culture in commercial management, which traditionally depended upon gentle and mutual negotiations over contractual matters rather than the "hard", definitive, conditions of western business management. The procurement systems of the construction industry in Hong Kong as a whole, have been greatly biased by the practices of the United Kingdom, through the influence of Hong Kong being a Crown Colony of Britain for over 100 years. However, other practices introduced by overseas investors have also had a substantial influence on the procurement systems of Hong Kong.

These factors give the construction industry of Hong Kong its own unique characteristics, and the management requirements are consequently different from the practices of other countries.

1.1.3 Quality Assurance Requirement in the Construction Industry

In line with higher quality requirements demanded by society and the demands of higher living standards of people, quality assurance is a trend in all disciplines throughout the world. In addition to the classical objectives of time, cost and quality of a construction project, nowadays clients require contractors to have systematic approaches in their own management functions to ensure that required quality standards can be achieved in the work thoughtfully conceived and implement, rather than just relying on the supervision by the client's agent in a "police against thrive" mode.

Clause 45 of the Airport Core Programme Conditions of Contract of Hong Kong Government, states the need of a quality assurance system for the contractors to proceed with the construction projects.

In April 1990, the Hong Kong Housing Authority published the 'Rule for the Administration of the List' for the 'Housing Authority List of Building Contractors'. Under Rule No 13 it states that all contractors employed on Housing Authority Contracts will be required by 31st March 1993 to have in operation approved Quality Management and Quality Assurance Systems conforming generally to ISO Guides 9000 to 9004 and accredited by the Hong Kong Quality Assurance Agency.

The basic concept of quality assurance systems involves the procedures and records to ensure and show that all the planned and systematic actions necessary to provide adequate confidence for required quality are satisfied. The requirements on quality issues have made the contractors have to review their own management information systems. In addition to the traditional progress and cost information, performance data in a more comprehensive manner will be required. This enhanced expectation on information is not just used to support the internal needs for decision-making, and the external needs of contract administration from the client, but also the need of the accreditation body for quality standard certification.

1.1.4 Impact of Computers to Construction

In addition to the developments described above, and in common with other industries, one of the most significant influences in construction management is in the use of computers to satisfy the information demands of clients, professionals and contracts for complex and capital intensive projects. The use of computer techniques has much to offer for processing and analyzing large volumes of information quickly, accurately and economically. In a fast-changing environment, the value of management decisions depends firstly on the quality of information available and secondly the ability to gain access to it quickly. The development of computer technology in both hardware and software has been little short of astonishing, and this creates an environment which enables construction computing to exploit the development of computer science.

Although the construction industry has a conservative reputation, it is likely that computers will become increasingly common in assisting construction project management, as well as other technical areas. In addition, an awareness of computing has permeated everyone's daily life, and this has fostered a new climate in the context of management in all fields (CICA 1990).

The impact of information technology on the construction industry has always progressed alongside the development of computer technology.

1.2 Research Hypothesis

The above section has given the background and context for the research described in this thesis. This section develops the hypotheses used as a basis for conducting the research itself.

1.2.1 Hypothesis Statements

The hypothesis of this research is that if construction managers are provided with a comprehensive information system that is easy to use and integrates the major external and internal management functions, better performance in terms of cost, time and quality will be achievable. The research will test this hypothesis by means of the use of a comprehensive computerised system developed by the author to produce information for the management of construction projects. The effectiveness of the information is determined by the quality, timing and cost of acquiring the information. The use of such information aids effective management in terms of fulfilling both aspects of external contractual obligations and internal management objectives.

In considering the provision of management information by computer systems, the systems should be designed to provide functions which will support the practical procedures of construction management, and aid the tasks that would have to be done, even without the use of computers. This approach is considered to be a crucial factor in justifying the effectiveness of the use of computers for construction management.

1.2.2 Development of the Hypotheses

This hypothesis was based on conclusions drawn from a comprehensive study of previous work on the subject of computer systems in construction management. Sources of information included an extensive literature search, conducted both in Hong Kong and at Loughborough, a study of the practices of the construction in Hong Kong. One very important influence was the hypotheses of PhD theses in the Department of Civil Engineering at Loughborough. Staff of the Construction Management Group of this Department have produced a substantial volume of research on the subject of computing support for construction management functions, and the research theses were an important influence on the formulation of the hypothesis for this research. Some examples are given below:

* Baldwin, A.N. in 1982

Title: Computer Aided Estimating for Civil Engineering

System

Developed: INTEREST-C.E.

Hypothesis: An interesting feature of this thesis that there was no formal statement of a hypothesis.

* Ndekugri, I.E. in 1986

Title: Construction Contract Information Management: An Integrated Systems Approach.

System

Developed: PLUS VAL.

Hypothesis: Computer technology and systems concepts can be used to develop the necessary tools that will produce the effective and integrated systems needed.

* Abdullah, R. Z. in 1988

Title: Integrated Systems for Site Management.

System

Developed: PLUS COST.

Hypothesis: There are technical constraints impeding the computing of construction management data. The constraints lie in the management systems and data structures. Thus if it can be demonstrated that these constraints can be solved, then the free flow of information is possible with the resulting benefit to management at all levels in the construction industry.

*** Thorpe, A. in 1992**

Title: Information Flow in House Building Organisations.

**System
Developed:** DEVELOP.

Hypothesis: More efficient management of house builders organisations is achievable by streamlining and integrating the information flows between the various management functions.

These hypotheses give an aggregate concept in construction management that integrated management information is significant to the efficiency of management, the success of which can be achieved through the application of information technology.

1.3 Research Objective and Contributions to Knowledge

The research objectives and the contribution to knowledge expected from their achievement are given into the following sections.

1.3.1 Construction Management Practices in Hong Kong

To identify the construction management practices in Hong Kong in respect of their utility and effectiveness for internal controls and responses to external requirements.

The characteristics of the Hong Kong construction industry are affected intrinsically by the political and economical developments of Hong Kong itself, and extrinsically by global trends of construction projects. Construction management practices in this context are worthy of exploration and comparison with existing published knowledge. Before this thesis, there were no systematic reviews on the topic of construction management practices in Hong Kong at Phd level. The corresponding findings by this research are contained in Chapter 3 and Chapter 4.

1.3.2 Model of Construction Management in Hong Kong

To develop a model of construction management based on a model of business strategy of contractors in Hong Kong and its associated organisation structure. The management functions of the construction model are the main thrust of this study. Accordingly the management tasks and the data flow within the management functions are derived to support the development of a comprehensive management information system. The corresponding findings for the development of the construction model is described in Chapter 6.

1.3.3 Development of a Computer System for Construction Management

To develop a computer system for improving the efficiency of construction management. The system serves existing needs and copes with the trends of future development in the construction industry of Hong Kong. The contribution to knowledge through the development of the system is described in the following sections.

1.3.3.1 The System Design for Computerised Construction Management Systems.

The systems developed for construction management in previous academic research are based on low-level computer languages such as BASIC, FORTRAN, COBOL, Pascal etc. Construction management itself has no need for complicated scientific calculations and therefore speed and accuracy should not be a problem of first priority. Previous relevant research has put more emphasis on system development than practical system applications. The practical system application might involve large amounts of debugging and amendments, which will be difficult and complicated for the systems developed in low level computer languages.

The use of 4th generation language (FoxPro version 2 in this research) makes system development tasks simpler to achieve, and system designs can concentrate more on user friendliness, data security, selective menu design and data input practice. In pace with the development of 4th generation languages, the approach to system design in this research gives an indication of new concepts for future system developments for construction management. The details are contained in Chapter 5 of this thesis.

1.3.3.2 Means of Integration for Computerised Construction Management Systems.

The concept of integration in the system design for construction management, has been dragging on far too long in previous literature and research without achieving tangible objectives. There still are lots of problems in the practical applications of integrated systems. The system developed by this research uses one of the most popular 4th generation languages, enabling data sharing and communication with other commercial software systems. This approach aids the development of specific functions in integrated systems. This kind of 'quasi-integration' provides a high efficiency on the use of computers for construction management, according to the field test and the system evaluation in Chapter 13.

1.3.3.3 Role of Computerised Construction Management Systems for External Submissions.

The information demand from the clients on the performance of a project through the contractual requirements, has created an impact on the contractors in their cost, quality and timing for getting and providing information. This impact has created a burden on the contractor's management practices with substantial influence on the overhead costs and consequently their ability in competition. Therefore, there is a need in the industry to cater for this requirement.

The use of computers is regarded as one of the solutions. Previous research in this field has concentrated more on solving the efficiency of internal management needs, but has seldom been in touch with external needs, especially in application levels. The trend of external needs forms another crucial factor in the contractors' considerations for the use of computers. The relevant study in this research contributes to the knowledge on the new trends of future system development for construction management.

1.3.3.4 Relationship of Quality Assurance and Computerisation.

The introduction of quality assurance into construction contracts makes the contractors pay more attention to the procedures and records for their performance. Such quality assurance systems have a great influence not just on their

current contracts but also their survival in terms of ability to tender in the future. Since computer systems are befitting in setting up pre-defined procedures and with high efficiency in data processing for records, this makes a tremendous motivation for contractors to reconsider their computerization strategy.

There is little and inadequate current literature and previous research in connection with the relationship between quality assurance systems and computerisation. The relevant study by this research is in the forefront of such conceptual application, from which base future research could be developed. The corresponding findings of this research are contained in Chapter 12.

1.3.3.5 Use of Computers in Construction Management

To review the current use of computers in construction management. The study has to consider the parallel developments of computer technology, the mentality of people on computerisation, and the top management demands on the quality of management.

The relevant study in this research has examined and accommodated previous research and should have contributions to the future research in this field. The results of this study are contained in Section 3.6 and Section 13.3.

1.3.4 The Methodology of Field Tests

System field test is a critical step in the development of commercial software. In respect of computer systems developed by academic research, system field test should be regarded a crucial part to scrutinise the knowledge gaps between theory and practice.

There is little existing literature and previous research into field tests of construction management systems through academic research. The steps and practices of the system field tests in this research are introduced in Chapter 13 of this thesis. The experience and methodology used in the field test for this research provides a case reference for system field tests of future research.

1.4 Research Methodology

The work undertaken to carry out this research is described in the following sections.

1.4.1 Literature Review

A literature review of relevant work was undertaken. This information has been put into a computerised database system specially developed for the literature review. The system provides the interaction between glossary and literature for the crucial terms in this research. Figure 1.4.1 (a) shows the main menu of the system:

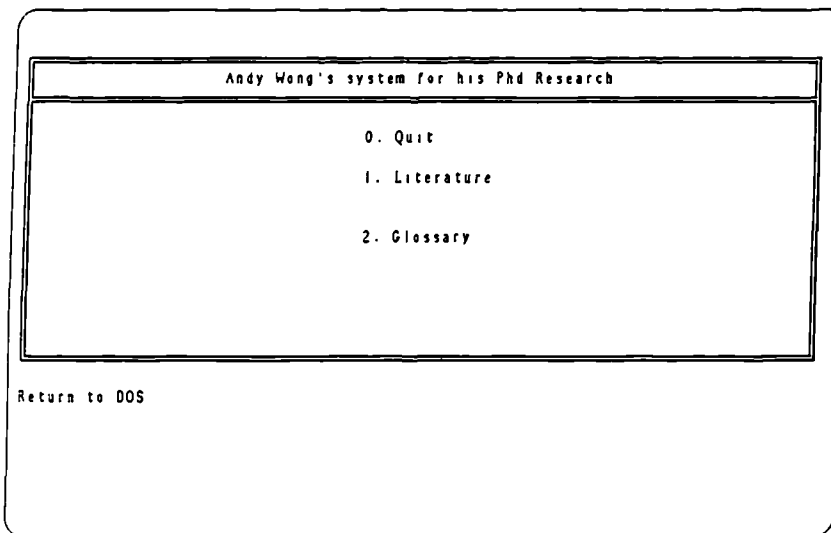


Figure 1.4.1 (a)
Main Menu of the
Literature Review
System.

Each item is kept as a record in the database, consisting of the following structure:

Item	Field Name	Field Length
a)	Type of literature	30 characters
b)	Title of literature	254 characters
c)	Year of issue	10 characters
d)	Topic reference index	30 characters
e)	Author's name	30 characters
f)	Issue institute	40 characters
g)	Further relevant reference	50 characters
h)	Remark	180 characters
i)	Abstracted content	unlimited memo field
j)	Comment on its relevance	unlimited memo field

Table 1.4.1 (a) - Data Structure of Literature Review Records.

Data List						
Tre	Trec	Type	Index	Date	Author	Titl
516	516	Article	Quality Management	1969	Anderson P.D.M & Her	Appli
448	448	Book	Planning and Control	1976	Anthony, R.M. & Dear	Manag
447	447	Research P	Planning and Control	1965	Anthony, Robert M.	Plann
324	324	Phd Thesis	Planning	1991	Aouad G. F.	Integ
582	582	Article	BQ	1970	Architect's Journal	Bill
108	108	Phd Thesis	Network Analysis	1973	Arditi D.	An in
555	555	Article	Network Analysis	1983	Arditi D.	Diffu
499	499		Management Theory	1970	Argyris C	Resis
671	671	Book	Management Technique	1986	Armstrong, Michael	A Han
169	169		Cost Control	1985	Asce	Const
402	402	Article	Quality	1986	Ashford, J.L.	The Q
151	151	Book	Quality Management	1989	Ashford, John L.	The M
79	79	Phd Thesis	Planning and Control	1981	Ashrafi, R.M.	Risk
53	53	Book	Cost Control	1983	Ashworth, A.	Build
141	141	Paper	Estimation	1987	Ashworth, A.	The c
290	290	Article	Telecommunication	1991	Ashworth, Geoffery	EDI :
36	36	Book	Project Management	1984	Asset Mgt Group	Total
[F3] to save; [F4] to function						
FUNCTION: Add E)dit G)oto F)ilter O)rder P)rint M)ake						

Figure 1.4.1 (b)
Shows a list of
literature
records.

Record: 000534		02/28/93	
Type [=] Phd Thesis	YEAR	1990	
Author Kodikara G.W.	Issue	Loughborough University	
Index [=] Data Flow			
Title	Data Flow in Building Contractor Organisations.		
Ref			
Abstract	Revealed that, although contractors widely use the estimate for post-tender work, the full potential is not being		
[File : E)dit, I)mpart, eX)port]			
Comment	Definition of Management Functions; Management Groups; Management Tasks.		
Remark	Oteifa's Thesis		
Sortf	Blank		
EDIT/VIEW: (E)dit (D)efinition (G)oto (L)ocate _			
(N)ext-record (P)rev-record <Return>			

Figure 1.4.1 (c)
Shows an example
of a record.

The use of such a computerised database system enables the topics or any fields to be grouped and sorted in any desirable order and layout. In this research more than 720 literature records have been input into the database, 115 of which comprise the reference section of this thesis.

1.4.2 Glossary Review

During the literature review process, some of the fundamental terms have been examined. The terminology is crucial to any research. The definitions of some of fundamental terms from the leading literature have been put into another database with the following structure:

Item	Field Name	Field Length
a)	Glossary Term	30 characters
b)	Author	30 characters
c)	Source of Reference	unlimited memo type
d)	Year of Reference	10 characters
e)	Issue Source	50 characters
f)	Definition Content	unlimited memo type

Table 1.4.2 (a) - Data Structure of Glossary Review Records.

```

Record: 000258                                02/28/93
TERMS (=) Cost Accounting                      YEAR    1985
Author   Ng T k                               Issue    Loughborough University

Reference Msc Project : Cost Control On Construction Projects; as
           quoted in Raji's thesis.

[File : Import, eXport ]
Content   is generally concerned with accumulating the actual costs of
           construction, both direct and indirect, and allocating the
           direct cost to the operation that incurred them, together
           with a proportion of the indirect cost.

Full Screen Edit [F8]

EDIT/VIEW: (E)dit (F)ind (G)oto (L)ocate <Del> -
           (N)ext-record (P)rev-record <Return>

```

Figure 1.4.2 (a)
Shows an example
of a particular
glossary record.

The use of such a computerised database system enables the terms to be grouped and sorted in any desirable order and layout. In this research more than 200 terms have been input into the database. By the use of this system, the historical development of fundamental definitions affecting the theoretical concepts have been taken into account in this research.

1.4.3 Questionnaire Survey

A field survey has been conducted in the construction industry of Hong Kong in order to evaluate the effectiveness of the current construction management practices of the contractors. The questions were divided into the aspects of: estimate, time control, resource control, cost control, information control, performance feedback, quality assurance, and communications between head office and construction sites.

In the survey, 105 questions were asked by questionnaire together with follow up by personnel interview. During the personnel interviews, further explanation on the parameters of the questions could be discussed face to face.

1.4.4 Study of the New Developments of the Industry

Research interviews regarding new developments in the industry have been taken place through the following Government Departments and consultants:

- a) Hong Kong Housing Authority;
- b) New Airport Projects Co-ordination Office;
- c) Hong Kong Government Secretary of Works;
- d) Teadwood Maunal Consultants; and
- e) Mortiboys Consultants.

The implementation of PASS by Housing Authority, the implementation of ISO 9000 in 1993, the new procedures and contract conditions for the New Airport Core Projects have been studied in this research. Particular emphasis was on the influence of these new developments on the management of contractors and how the problems could be tackled by the application of computers.

1.4.5 Computer System Development

1.4.5.1 System Design

Concurrent with the joint research on site and the survey of current practice, a number of computer systems, known as CCMS, has been completed and installed on a test field site to aid the operations of the site management. FoxPro version 2 has been used as the development tool for the systems instead of Turbo Pascal version 5.0 which was proposed to be used at the initial stage of the research. The reason for the development tool change was that Foxpro is more popular and user-friendly and has a higher potential for further development.

Significant advances in computing application on site have been achieved. The criteria of the design are:

- a) Multi-window handling for concurrent access to different databases. This is in considering of the nature of construction projects, which are normally burdened with intensive co-ordination and communication needs.
- b) On-line update of the database through windows during the data input. It enables the keyword databases to develop as the work progress and avoids users having to remember codes.

- c) Memo fields in the database system enables virtually unlimited characters to be stored in a record. This is a significant facility for background information to be recorded.
- d) A new technique in FoxPro version 2 called "Rushmore" was used in the system design. The Rushmore technology is a data access technique that permits database operation hundreds, or perhaps even thousands of time faster than before.

1.4.5.2 Models of the Systems Completed

CCMS was written by FoxPro version 2 in a micro-computer environment and comprised 6 sub-systems including approximately 25,000 lines of code. Since FoxPro is a DBase compatible 4th generation computer language, programming tasks and future maintenance is much easier than other lower level computer languages such as Pascal, FORTRAN and BASIC etc.

The system models are as follows:

Sub-System Names	Level of Usage
Estimation	Head Office/Site
Quality Assurance	Head Office/Site
Information Control	Site
Material Control	Site
Progress Monitoring	Site
Cost Control	Site

1.4.6 Collaborated Research and Field Test

One of the biggest international contractors in Hong Kong, collaborated in this research. One of their current housing contracts was used as a test site for the proposed systems. The details of the field test are contained in Chapter 13.

The objectives of the collaborated research were:

- a) From the view point of the contractor, a computer work station on site is considered to be technically and economically viable. Through the research, practical problems were able to be fully addressed.
- b) Human behaviour in relation to the use of a computer workstation on site could be examined. The efficiency on the use of computers for the site management could be assessed.
- c) The use of computerised feedback data from site could be proved and justified in line with the process of decision making for the management.
- d) The effectiveness of the use of computers to provide information required by the client can be assessed in comparison with the current manual practices.

1.4.7 System Evaluation

The system development and field testing was a continuous process. By the end of the research, there was a process of system evaluation. In order to explore the comments and opinions of other professional in the industry on the computer models, an extension course was held in the Hong Kong Polytechnic with 20 attendants who are mostly from all classes of contractors. Their comments were gathered by means of a questionnaire after the system demonstration for each sub-system, and were put into a computer database. The system evaluation is described in Chapter 13.

1.5 Research Achievements

The achievements of this research are as follows:

- a) The current construction management practices in Hong Kong have been identified. The practice covers the management activities in the range of estimating to site management and quality assurance. It also emphasises the effects of performance feedback in response to the requirements of external contractual obligations in terms of time, cost and quality, and internally the business and commercial maintenance. (See Section 3.7)

- b) The trend of the new developments of the construction industry in Hong Kong has been examined. The influence of the new developments on construction management by contractors have been identified and accordingly the subsequent effects on construction management have been examined. (See Section 4.6)
- c) The model of construction management and the mapping of data flow within the management functions has been established by taking into account of both the existing management practices and the new developments in the Hong Kong construction industry. (See Chapter 6)
- d) The development, implementation and maintenance of CCMS as a computerised system based on the model of construction management has been completed and documented. (See the final section of each chapter from Chapter 7 to Chapter 12)
- e) New computer technologies have been used in the system development of CCMS. The mode of system operation has demonstrated new ways of system design for construction management software. (See Section 5.5)
- f) The functional sub-systems of the developed system have been field tested in a live construction project. A general model of the methodology and practice of system field test for construction management has been developed. The relationship between system field test, system validation and system evaluation for construction management software has been established. (See Section 13.3)
- g) Human behaviour in the use of computers on site has been examined. The efficiency on the use of computers for site management has been assessed. (See Section 13.4)
- h) The hypothesis stated in Section 1.2 has been proved, tested and analysed as described in Section 14.3 of this thesis.
- i) A set of recommendations has been derived to aid for any future research in this field. (See Section 14.3)

1.6 A Guide to the Thesis

Figure 1.6 (a) gives a schematic guide to this thesis and shows the logical relationship of each chapter. Following

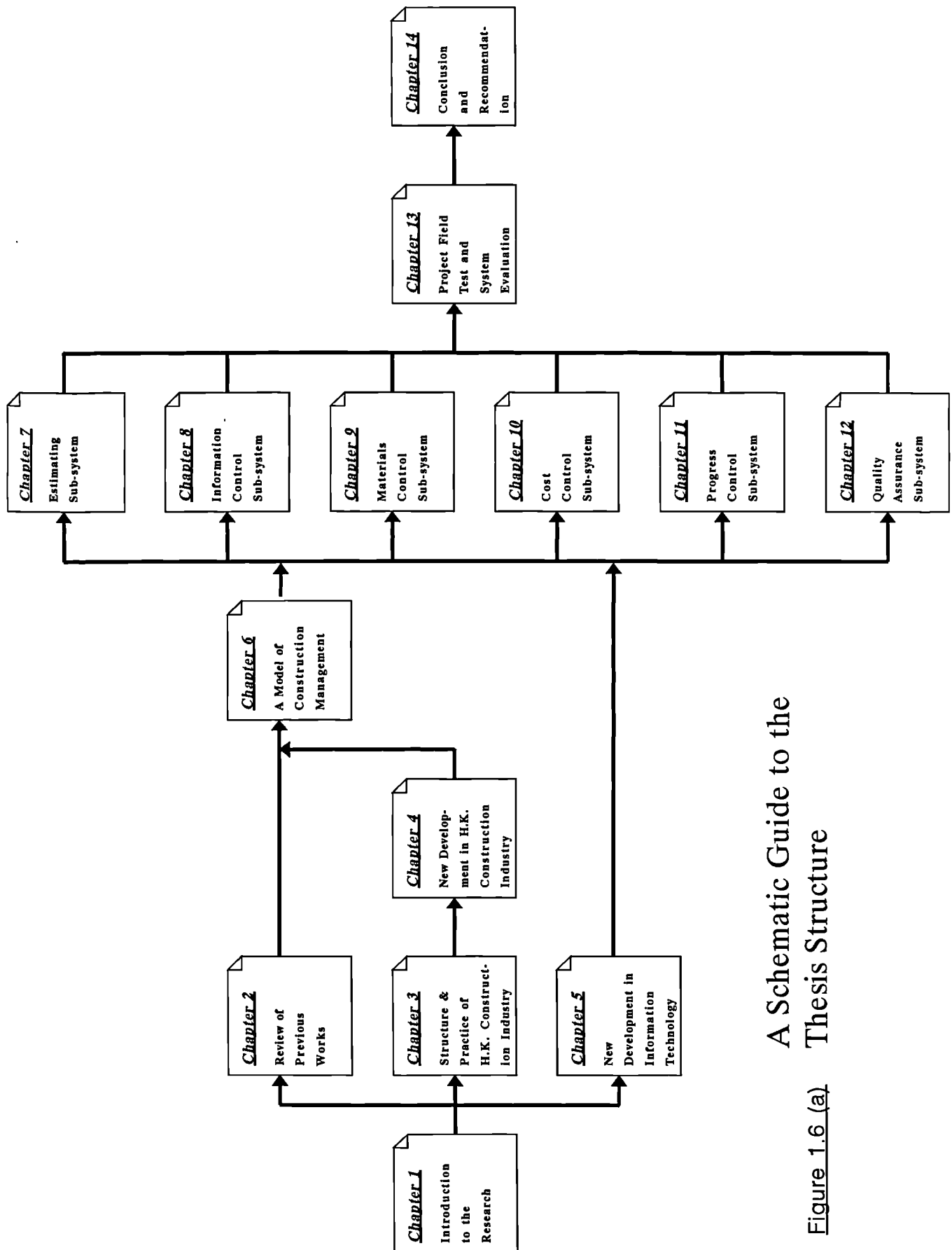
the introduction to this research described in Chapter 1, thirteen chapters from Chapter 2 to Chapter 14 are developed in this thesis and are described in the following sections.

Chapter 2 is a review of the previous work relevant to this research, which includes published papers and articles, higher degree theses, and industrial research. The review describes the previous work in relation to the areas of communication for contract administration, data flow within contracting organisations, computer-aided construction management systems and relevant researches in the Hong Kong Construction Industry. The theoretical context based on the previous work has been used for the establishment of the model of construction management described in Chapter 6.

Chapter 3 starts with an introduction to Hong Kong and the construction industry which is the background of this research. Following that the research target, the public sector contractors, is identified with specific emphasis on the control systems adopted by the Government for the administration of contractors. The core of this Chapter describes the survey of the management practices conducted in this research. The management practices include the classical functions in construction management, which are estimating and tendering, time control, resources control, cost control, material control, quality assurance, information control and communication between head office and sites.

Chapter 4 describes the new developments in the Hong Kong construction industry, which are considered to be crucial to the future management practices of the target contractors and are significant to this research. The study of the new developments includes quality assurance, the Performance Assessment Scoring System (PASS) in housing projects, and the new infrastructure development in Hong Kong. The findings in this research described in both Chapter 3 and Chapter 4 support the development of the model of construction management described in Chapter 6.

Chapter 5 contains a review of the development of information technology specifically related to the areas of the development of computer software in association with this research. The computer system is called 'CCMS' (Computerised Construction Management System) and is written in a 4th Generation Computer Language, the characteristics of which are described in this chapter, with an outline of the special features of the system. The computer techniques detailed in this Chapter, together with the concepts of the model of construction management described in Chapter 6, form the



A Schematic Guide to the
Thesis Structure

basis in the development of CCMS which contains six integrated sub-systems and the details of each system are described in Chapter 7 to Chapter 12 respectively.

Chapter 6 describes the development of a model of construction management based on the theoretical contexts contained in Chapter 2 and the construction management practices identified in Chapter 3 and Chapter 4. The model contains the management functions in construction management outlined by previous studies. Within each of the management functions, the management tasks and the management groups are specified with the details to support the development of CCMS Sub-systems described in Chapter 7 to Chapter 12.

Based on the findings established in Chapter 6 and the Chapter 5, Chapter 7 to Chapter 12 describes the details of each sub-systems of CCMS. The mode of description for each sub-system includes both the details of each operational function and the theoretical context of the design. Chapter 7 to Chapter 12 contains the following sub-systems:

- Chapter 7: Estimating Sub-system.
- Chapter 8: Information Control Sub-system.
- Chapter 9: Materials Control Sub-system.
- Chapter 10: Cost Control Sub-system.
- Chapter 11: Progress Control Sub-system.
- Chapter 12: Quality Assurance Sub-system.

Chapter 13 contains a description of the project field test for the development of CCMS. It is a crucial element in this research, because it applies the system to a live project. The parameters of the project used in the field test and the field test procedures are detailed in this Chapter. Both the system validation and the system evaluation for CCMS are described.

Finally, Chapter 14 summarises the findings and draws the conclusions for this research described in this thesis. The recommendations for future research are identified in this Chapter.

2 Review of Previous Work.

2.1 Introduction

This chapter contains a summary of published literature and previous research relevant to this thesis. The purpose is to establish the theoretical context and the background information for the research described later. It is arranged in the following sections:

- a) communication for contract administration;
- b) data flow within contracting organisations;
- c) quality assurance in contracting organisation;
- d) the use of computers aid management systems; and
- e) relevant researches in the Hong Kong Construction Industry.

The term 'this research' used in this section means the research described in this thesis.

2.2 Communication for Contract Administration

2.2.1 Surveys by Industrial Level

In the 1950s and 1960s, there was a number of studies of communications in the construction industry. The development of techniques to improve the flow of information was co-ordinated by the British Government and much of the work was aimed at producing standardised systems for the transmission of information within the construction industry.

Commissioned by the National Joint Consultative Committee for Architects, Quantity Surveyors and Builders, the Tavistock Institute of Human Relations in the early 1960s undertook a study of the organisational structure and communication processes of the building industry. A report of this study was published in 1965 by Higgin and Jessop entitled "Communications in the Building Industry". The study was concerned with inter-professional level communications in the industry, because the contemporary systems between the members of building team were found unsatisfactory, particularly regarding the appropriateness of the use of bills of quantities as the main medium of contract communication to builders.

This report has over time become the classical work on the subject. Subsequently, further attempts were made to introduce more effective documents such as operational bills (Skoyles 1965; Skoyles 1968; Bishop 1966), Schedule of Activity under BPF system (British Property Federation 1983); Builders' Quantities (Pasquire 1988).

In 1963 the Joint Consultative Committee of Architects, Quantity Surveyors and Builders launched the Building Industry Communication Project. In May 1966, the Ministry of Public Building and Works established a Committee on the Application of Computers in the Construction Industry (CACCI) which in turn commissioned a study of coding and data co-ordination for the Building Research Station. BRS completed the study in 1968 (BRS 1969) and recommended that the work should be continued in this field. In late 1968, the National Consultative Council of the Ministry of Public Building and Works set up the Working Party on Data Co-ordination.

By contrast, there were comparably few studies of the information flow between contractors and the client's contract supervisors. Particularly there was a lack of surveys and studies by industrial level for establishing the prototypes of communication between contractors and the client's contract supervisors for contract administration purposes. The following sections describe more recent work in the study of information flows in the management of projects.

2.2.2 Carter (1987): The use of Structured Information Systems in Building Contract Administration.

Carter studied the information flow from site to supervising officer (architect in his case) on a number of hospital building contracts in northern England. The contracts were all based on the JCT 80 Form of building contract. The study used the techniques of data flow diagrams originally developed by DeMarco(1978) and Gane and Sarson(1979).

The initial study revealed that the actual information flow for each of the case studies was broadly similar. The problem of the existing practice was the considerable duplication of information flow and storage resulting in many physical files and documents which contained information on more than one topic requiring the reader to consult numerous documents to obtain complete information for one topic. Therefore,

relevant information for contract administration decisions from sites in its traditional form was limited by the slowness and difficulty of information retrieval.

The study involved the following stages:

- a) To determine the existing methods of information procurement by the supervising officer by modelling the physical information flow from site to supervising officer using data flow diagram techniques on each of the case studies. The existing physical data flow diagram was then prepared.
- b) To convert the existing physical data flow diagram to its logical equivalent by examining the information which are used by the supervising officer for the various contract administration processes (They called 'Activity Profile') and the information required under the Conditions of Contract for the operation of the Contract. The existing logical data flow diagram was prepared accordingly.
- c) To propose a new system by analysing the contract administration function of the supervising officer and relating it to the essential data flows identified on the existing logical data flow diagram. It was called 'Rationalised system of information flow'.
- d) The proposed system was then developed into a working prototype, based on a micro-computer.
- e) The advantages of the system were claimed as follows:
 - i) staff could collect promptly and use specific items of information;
 - ii) there would be quicker transmission, storage and retrieval of data;
 - iii) controls could be imposed at any level; and
 - iv) intervention of senior staff could be called by the system when required (i.e. in case of disputes or contractual claims involved).

The study by Carter showed that the techniques of data modelling were capable of identifying existing physical data flow on site. It also addressed an important concept that the site information system was not only capable of being used to monitor the performance of work on site but was also adequate to oversee the performance of the supervising officer. Carter's data modelling techniques and the concept of external monitoring have been adopted in this thesis to analyse the data flow on site and the contributions of contractors' site management systems to supervising officers for contract administration. Much of the work in data modelling has been applied in Chapter 6 of this thesis for describing the model of the construction management in Hong Kong. The contributions of information for contract administration from contractors has much been emphasised in the new developments of the Hong Kong construction industry as described in Chapter 4. The details showing how this concept can be achieved are reflected in various sections of Chapter 8 (information control sub-system) and Chapter 11 (progress control sub-system) of this thesis.

2.3 Data Flow within Contractor's Organisations.

2.3.1 Introduction

Apart from the work by Gunning, much of the work described in the following sections was part of a comprehensive programme of research in the Civil Engineering Department of Loughborough University of Technology. This has attracted substantial funds from the United Kingdom Science and Engineering Research Council, and the United Kingdom Construction Industry. Several research projects have resulted in PhDs. It may be assumed, therefore, that the work is academically rigorous, as well as being relevant to the needs of industry, so forming a sound basis for the work described in this thesis.

2.3.2 Gunning (1984) Site Management Information and Control Systems

Gunning made a strong observation by concluding that most construction projects in trouble are due to reasons related to managerial or financial factors rather than practical or technological problems. With the management problems, Gunning believed that classical and modern theories invariably contain some elements of truth and realism among their postulations, but most served to confuse lay readers, such as site management staff, who are preoccupied with the

day-to-day problems faced in managing a construction site. In another words, it means that the more complex management techniques are seldom relevant to the practicalities of site management on all but the largest projects.

In this paper, Gunning examined the role of site management in controlling resources throughout a project and suggested simple control standards and reporting procedures. He emphasised the importance of communicating management information to all levels within and beyond the contractor's organisation. It was stressed in Gunning's paper that the major role of site managers is in making decisions based upon the feedback on of performance, the details of which are classified into tangible and non-tangible items as follows:

Tangible items	a)	men;
	b)	materials;
	c)	machines; and
	d)	subcontractors.
Non-tangible items	a)	progress;
	b)	productivity;
	c)	cost;
	d)	quality;
	e)	safety;
	f)	information; and
	g)	methods.

Gunning stressed that site managers should set up an information system which keeps continuously supplying on-going performance information, for which the quality and timing of information are the keys to a successful system. A model management information system was developed by Gunning as shown in Figure 2.3.2 (a)

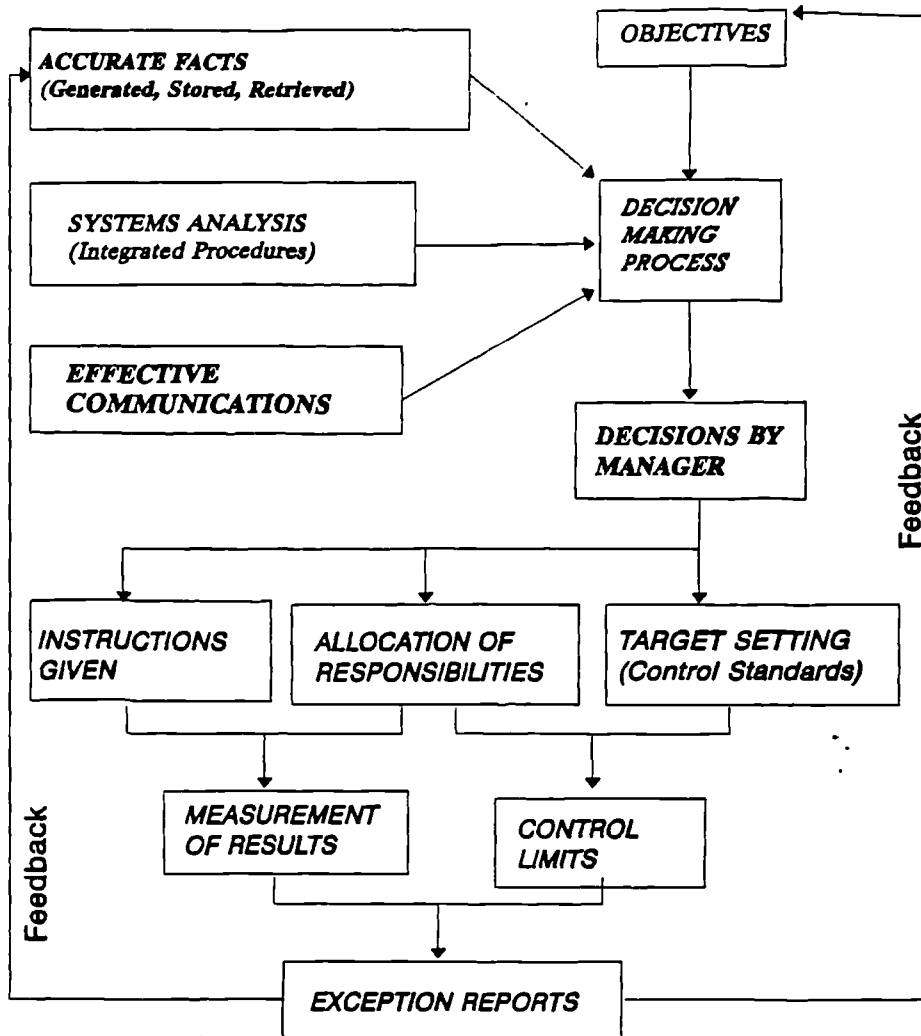


Figure 2.3.2 (a)

MANAGEMENT INFORMATION SYSTEM

With the operation of the management information system mentioned above, the regular information on the following aspects of performance were emphasised by Gunning: **Table 2.3.2 (a)**

Resources	Standards
Labour	Labour schedules, productivity data, training programmes, conditions of employment, disciplinary procedures etc.
Materials	Materials schedules, stock-holding levels, wastage allowances, storage requirements, inspection procedures, delivery programmes etc.
Plant and Equipment	Plant schedules, productivity data, site layout plan, maintenance programmes, company policy, local requirements etc.
Money (Costs)	Bill rates, unit cost estimates, turnover budget, cash flow forecast, financial ratios etc.
Time (Progress)	Programme and productivity data, contract variations and agreements, client requirement etc.
Quality	Specifications, drawings, British Standards, samples, manufacturers' data, building regulations, expectations of supervisors for workmanship etc.
Safety and Security	Legislation on safety, health and welfare, local authority requirements, trade union agreements, company policy, established good practice.
Information	Information schedules, programmes, contract and sub-contract requirements, company policy on record keeping.
Methods	Methods statement, productivity data, work study information, previous experience.
Management	Contract requirements, job descriptions, management development programme.

In addition, Gunning in his paper suggested the items of information that should be included in the following schedules:

- a) labour plant or equipment;
- b) materials;
- c) subcontracts;
- d) contract information; and
- e) methods statement.

The approach to site management in respect of the significance of performance feedback by Gunning, is in line with the direction of this research. The areas of site information quoted by Gunning act as an important reference for the development of the sub-systems in the model of construction management in this thesis. However, the items of information to be controlled are not entirely applicable in this research because of the environmental difference in the construction industry between Hong Kong and UK.

For the presentation of information for site management, Gunning suggested the use of standard reporting forms and checklists which should greatly reduce the physical effort

involved and improve the flow of information. Gunning's approach to information presentation for site management has been adopted in this research.

2.3.3 Ndekugri and McCaffer (1988): Management Information Flow in Construction Companies.

This paper presented an outline analysis of the characteristics of the flow of construction contractors' management information. The study involved literature reviews, consultation with contractors and expert opinion. The following basic management functions of construction contractors were studied in order to identify the information entities:

- a) planning;
- b) estimating;
- c) cost flow forecasting;
- d) valuations;
- e) cost control; and
- f) accounting.

From the findings of the study, systems input-output models of the flow of the above six information entities were constructed. The individual functional models were then compared to determine their interrelationships in their use and production of information. The conclusions were:

- a) the information used or produced was ill-defined in many cases;
- b) some of the entities comprised data which were not in the category of traditional data-processing data;
- c) the production of the data was duplicated in some cases;
- d) there was a high level of use of common data; and
- e) some functions provided data for others.

The study also concluded:

"In the majority of cases the nature of the data as well as the format in which it is to be received is ill-defined. Hardly ever is the data structured with the convenience of the receiving parties in mind.

The obvious result is that a lot of manipulation has to be done with further time-consuming contacts for amplification or explanation. Indeed, some receiving parties find the information of so little use that they either re-extract or make up their own data".

In addition:

"Integration in the sense that any information once stored by any function is available for use by other functions can solve these problem".

Although this paper was relevant to this thesis, Ndekugri and McCaffer's conclusions only give the conceptual meaning of integration. The work described in this thesis has further developed the system integration for construction management into two more levels, namely the operational meaning of integration and technical meaning of integration. This is described in Section 5.3.3 of this thesis.

The format of the flow charts developed by Ndekugri and McCaffer is a good reference for the approach to be adopted and the information to be compared in this research for the study of the Hong Kong construction industry.

2.3.4 Kodikara, G.W. (1990): Data Flow in Building Contractor Organisation (Phd Thesis)

Kodikara's research was based on the Sri Lanka construction industry and U.K. practice, and aimed to propose better formats and presentations for estimating data in order to reduce the repetition and re-work in the post-contract use of estimating data for construction management.

Ten case studies in Sri Lanka established the scale and nature of the problem, based on interviews and discussion with professionals. Proposals were then formulated defining:

- a) an efficient classification and coding system;
- b) a well defined library structure; and
- c) a new format to the contractor's estimate.

The research revealed that, although contractors had widely used the estimate for post-tender work, the full potential was not being achieved. He found that the extent of use of the estimate for post-tender work in the industry averaged 50%. In addition, substantial re-work of the data involved was required for the use in other information systems

throughout the contract. According to the survey conducted, 91% of professionals agreed that the effective use of computers at estimating linked to the site control would reduce the re-work and repetition, and hence should increase the efficiency of contractors' organisations.

The research also pointed out that one of the reasons of poor feedback to estimators, was the mismatch between what the estimator provided for the site staff and what the estimator required from the site. The estimator only provided a unit rate for each bill item, but asked for a full report on usages and rates of resources consumed for the work. If the estimator could provide a breakdown of resource requirements for bill item, then the site staff would have a data structure to provide the actual usages and rates using the same sheet. The data to observe the usages of resources in each bill item could be extracted from normal cost control sheets by using the codes given to resources, build-ups and bill items.

Kodikara also found that the bill of quantities often comprised work descriptions which had been measured according to trades or work sections, whereas the actual work was in fact carried out as complete operations involving several trades. This created incompatibility between the site work and the feedback that required by the estimator. The research advised the use of the existing recommended sheets such as invoices, delivery notes, goods received books and daily labour time allocation sheet as a means of collecting data on actual costs. However, codes given to resources, build-ups and bill items would help the management staff to collect the cost data to required cost centre. Kodikara highly recommended this as future research, to produce better feedback systems and considered that the proposal in his research could then be used to formulate an efficient feedback system.

The findings by Kodikara mentioned above are significant in the formation of the basis for this thesis. His proposed coding system lays a good foundation for the design of a cost code system as an effective way of passing information from estimating to post-contract planning and control. Further details on the use of such coding systems are given in Section 10.2 of this thesis.

2.4 Quality Assurance in Contracting Organisations

2.4.1 Building Research Establishment (1987): Achieving Quality on Building Sites.

A study of quality and quality assurance was undertaken for the United Kingdom National Economic Development Office (NEDO) by the Building Economic Development Committee (Building EDC). A report entitled "Achieving Quality on Building Sites" was published in 1987. The study was carried out by the Building Research Establishment (BRE) to identify the extent of quality failure in the building projects and assessed the significance of specific project aspects including management procedures, information flow, supervision and inspection in the apparent shortfalls in quality.

BRE conducted three surveys focusing upon building site quality control procedures of fifty construction sites in both the public and private sectors of industry. All the projects were single developments using a range of procurement and contractual procedures including traditional, design/build and management contracting approaches. The research was conducted by three surveys. The first survey of 27 construction sites in the public sector, was to highlight how problems could arise on site and how the extent of their occurrence was affected by the nature of deficiencies in design, organisation and workmanship.

The second survey, of 11 building sites in the private sector, was to identify how constraints of time and cost would affect the capability of management on site to resolve problems of quality.

The third survey (of an unspecified number of sites) was to examine how site staff handled problems of quality and to review their roles and responsibilities under different types of contractual arrangement to see if this noticeably affected quality.

Some of the significant findings were as follows:

- a) traditional specifications frequently failed to specify quality requirements for particular contracts ;
- b) although contractual arrangements seemed to have little effect upon the quality achieved, the management structure used was influential ;

- c) inadequate project information was significantly influential upon achieved quality levels ;
- d) where deficiencies in quality occur, it was difficult to identify who was responsible for affecting the remedial action ;
- e) architect's representatives were not always delegated sufficient responsibility to control quality effectively on site ;
- f) contractor's site management spent too little time 'managing' quality on site ;
- g) motivation was essential to the achievement of quality on site ; and
- h) good quality relies upon good site management supervision, training and adequate resources to provide such supervision.

The most significant finding by BRE to this research is that many of quality related events were found to be caused by ambiguous or missing project information, for which there were 125 events out of over 500 events recorded. BRE's research concluded that:

"Inadequacy in the quality of information itself or lack of completeness and availability are highlighted as major influences on the level of quality achieved. On a number of the sites, it was thought that management spent too much time chasing late information and clarifying inadequate information, all of which consumed time which could be better sent by managing quality on site".

The conclusion made by BRE in their research was that an improvement in the efficiency of site management in terms of information control could have a great contribution to quality assurance. This shows a clear direction for the use of computers on site for aiding construction management, and improving information flow between contractors and contract supervisors.

2.4.2 Bhattarai, D.P. (1990): Problems of Quality Control on Construction Sites

In this project a questionnaire survey was conducted to obtain the views and opinion of clients, contractors and engineers in the aspects of quality control. The response rate was 46.67% with 28 replies out of 60 questionnaire dispatched. Four most important causes of poor quality of work according to the survey were:

- a) poor supervision during construction;
- b) poor quality of design/drawing/specification;
- c) low level of skill of the work force; and
- d) lack of finance and low bidding.

Within the recommendations of the study, there was an important point that further detailed research seemed to be very important to develop a computer system for quality control on construction sites.

Further exploration to the existing literatures, showed that there was a study by Anderson (1969) almost 23 years ago called 'Applications of Computers in Quality Control'. It is obvious that a knowledge gap may exist in this area in view of the influence to all disciplines by the development of computer technology.

2.5 Computer-aided Construction Management Systems.

2.5.1 Ndekugri, I.K. (1986): Construction Contract Information Management: An Integrated System Approach. (PhD Thesis)

The hypothesis of Ndekugri's research was that computer technology and systems concepts could be used to develop the necessary tools that would make integration possible and effective. The results of the research showed that the application of computer technology and system concepts could produce effective integrated systems which not only assisted contractors in carrying out their obligation but also provided reliable information for decision making.

The research revealed that the causes of lack of integration in the contemporary computerised construction management systems were:

- a) segregated education, training and working of functional groups;

- b) development of software by people without the relevant expertise; and
- c) inadequate research and failure to apply research findings due to the structure of the construction industry.

The system was named PLUS VAL, comprising of 17,000 lines of ANSI FORTRAN 77 code, and taking up 195 kilobytes of memory in PRIME 750 minicomputer environment. The major features of PLUS VAL were:

- a) to assist in valuations, purchasing management and cost control,
- b) to link estimating, planning and accounting,
- c) quick access to contract information.

Nedekugri listed the advantages of integration as:

- a) reduced data capture costs;
- b) better turn-around times (faster throughput of information);
- c) better management of computer resources;
- d) greater consistency of information; and
- e) greater flexibility.

Nedekugri in the final part of his thesis identified the areas of future research, one of which was the desirability of recording data directly into a computer medium instead of first recording them on paper. This concept has been accommodated in the development of the system as described in Chapter 7 of this thesis.

2.5.2 Abdullah, R.Z. (1988): Integrated Systems for Site Management. (Phd Thesis)

Abdullah in his research took the concepts of integrated systems developed by Nedekugri and applied them to site control systems. The hypothesis was:

"There are technical constraints impeding the computing of construction management data. The constraints lie in the management systems and data structures. Thus if it can be demonstrated that these constraints can be solved, then the free flow of information is possible with the resulting benefit to management at all levels in the construction industry."

The research was divided into 3 sections:

Section 1:

- a) Literature Survey on the existing knowledge of efficient site control systems in order to derive the questionnaire accordingly.
- b) Survey by interviewing 13 construction companies based on the questionnaire developed from a) to identify the following two objectives:
 - i) the existing site control facilities in use; and
 - ii) the companies requirements for an efficient system.
- c) Survey by interviewing 8 computing companies regarding site control software based on the comparison between the survey b) and this survey, in order to establish the objectives of the testable hypothesis of the research

Section 2:

- a) To examine the feasibility of an integrated site control system linking to the available management systems.
- b) To produce the data requirements for the integration.
- c) To develop a software model for collecting, processing and analyzing data from site to produce control data and reports, called "PLUS COST".

Section 3:

- a) To investigate how well the model program has achieved the research objectives based on the demonstration to a number of selected industrialists.

- b) To modify the model program based on the comments received by those industrialists and to make conclusions and recommendations for future research accordingly.

PLUS COST comprised 22,000 lines of ANSI FORTRAN 77 code which took up 430 kilobytes of memory in PRIME 750 minicomputer environment, and provided the following functions:

- a) accepting the estimating and valuation data accessed from the other construction management systems;
- b) contract price adjustment for inflation;
- c) cost accounting of the contract;
- d) costing and performance control of labour and plant on site;
- e) the provision of information for the management of material purchasing, utilisation and usage on site;
- f) preliminary control on site (both, preliminary items and in-rate)
- g) sub-contractor's site costing and control;
- h) value/cost adjustment on site for claims and variation orders;
- i) the provision of information for cost/value reconciliation;
- j) the provision of information for short term planning and control to the section engineer;
- k) the provision of information for cost forecasting;
- l) providing site information on claims and variation orders and their valuation for both main and subcontractors.

Most of the above functions have been included in the system developed by the author in this research but with a wider scope of application. This includes functions catering for quality control and external submissions, which is also capable of running in micro-computer environment instead of minicomputer. Abdullah in his research recommendations pointed out that any attempt to develop a computer-aided construction management system must start by using structural programming principles. This concept has been used in the development of the system described in Chapter 5 of this thesis.

Abdullah's method of model evaluation for his model program was by a demonstration (in slides and on-computer seminars) to the selected industrial personnel, for seeking their personal point of view through the questionnaire. Conclusions drawn from demonstrations and questionnaire surveys may be limited and inadequate for researches in the application of management systems in construction management. This research has adopted an approach of field testing in addition to the system validation and the system evaluation practices.

2.6 Construction Management Research in Hong Kong.

2.6.1 Fox, P.W. (1989): A Study of the Hong Kong Construction Industry using a Systems Approach.

Fox pointed out that there were no major research studies of the Hong Kong construction industry and the aim of the work was to examine the characteristics of the industry and their inter-relationship. By a qualitative analysis, fifty two significant characteristics of the industry were identified and arranged into a causal model. In Fox's thesis the model was drawn in an A2 paper with complicated logic links. The construction of the model was done on the basis of sixteen authoritative sources from the literatures. In this research, Fox's model has been converted into a table (Table 2.6.1 (a)) form including the following columns:

- a) **Code:**
It is an identification for each characteristic from 1 to 52 in ascending order. For those 11 items marked with '()' are the environmental input to these characteristic and are classified as the starter in this table.
- b) **Description:**
The description for each characteristic. For those items marked with '(*)', the source of reference is from logical thinking and the other items are from the literatures.
- c) **Preceding Logics:**
It shows the characteristic references affecting a particular item of characteristic. Borrowing the terms from network analysis, it means 'backward logics'.

d) **Succeeding Logics:**

It shows the characteristic references to be affected by a particular item of characteristic. It is same as 'forward logics'.

Table 2.6.1 (a)

Code	Description for Characteristic	Preceding Logics	Succeeding Logic
(1)	(HIGH) CONCENTRATION OF POPULATION (starter)		7
(2)	(LOW) AVAILABILITY LAND FOR DEVELOPMENT (starter)		7
(3)	(LOW) BASIC PAY (starter)		50; 28; 32
(4)	LOCAL ECONOMIC CONDITION (starter)		24; 51
(5)	(LOW) AVAILABILITY OF LOCAL RAW MATERIALS (starter)		19
(6)	(HIGH) POPULATION GROWTH (starter)		52
(7)	(HIGH) COST OF IMPORTED MACHINERY (starter)		32
(8)	GOVERNMENT POLICY (starter)		2; 34; 4; 6; 20
(9)	BRITISH CULTURE (starter)		4
(10)	(LOW) LEVEL OF EDUCATION OF WORK FORCE (starter)		9; 25; 10
(11)	HONG KONG CHINESE CULTURE (starter)		25; 26; 18; 11
(12)	(HIGH) TOLERANCE OF CORRUPTION IN SOCIETY		37
1	(HIGH) INCIDENCE OF DEMOLITION AND REDEVELOPMENT COMPARED TO REFURBISHMENT	51	8
2	(HIGH) GOVERNMENT COMMITMENT TO IMPROVING STANDARD AND DEVELOPMENT	(8); 24	3; 5; 21; 45; 46; 48
3	(HIGH) PWD/L&W BRANCH WORKLOAD	2; 47	44
4	(HIGH) INFLUENCE OF H.K. PROFESSIONAL SYSTEM	(8); (9)	6; 10; 11; 16; 20; 22; 30; 31; 34; 42
5	(HIGH) USE OF FOREIGN CONTRACTOR	51; 36; 43; 10; 11; 45; 2	31
6	INFLUENCE OF GOVERNMENT STRUCTURE AND PROCESS e.g. manpower planning & department structure	(8); 4; 37	15; 25; 30
7	(HIGH) INCIDENCE OF HIGH RISE BUILDING	(1); (2); 52	11; 17; 39; 49
8	(LOW) COMMITMENT OT MAINTENANCE	49; 1; 50; 35	38
9	(LOW) ADEQUACY OF EDUCATION FOR PRODUCTION MANAGERS	(10); 22	30
10	(LOW) QUALITY OF PRODUCTION MANAGEMENT	30; 47; 37; 35; 4; 31; 40	5; 11; 12; 13; 14; 22; 25; 26; 32; 43; 46
11	(HIGH) USE OF SUBCONTRACTING / MULTI-STOREY SUB-CONTRACTING	(11); 41; 10; 23; 4; 7	5; 18; 25; 26; 32; 36
12	(LOW) LABOUR PRODUCTIVITY e.g. lower at boom time	25; 32; 29; 33; 14; 10	
13	(HIGH) WASTAGE OF MATERIALS	10; 14; 29	
14	(LOW) SOPHISTICATION OF METHODS OF CONSTRUCTION	18; 10	12; 13; 26
15	(MEDIUM) NUMBERS OF DESIGNERS	6	44
16	(VARIABLE) QUALITY OF DESIGNERS	20; 37; 4	38; 46
17	(HIGH) USE OF CIVIL AND STRUCTURAL ENGINEERS FOR BUILDING WORKERS	39; 7; 20	

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18	(HIGH) NUMBERS OF SMALL CONTRACTING FIRMS	(11); 11; 2	14; 25; 31
19	(HIGH) IMPORTATION OF MATERIALS	(5)	33; 47
20	SYSTEM OF AUTHORISED PERSONS	(8); 4	16; 17; 38
21	(LOW) LEVEL OF RESEARCH ON ARCHITECTURE AND BUILDING	2; 46	35
22	(HIGH) STUDENT GRADUATES ATTRACTION TOWARDS DESIGN NOT PRODUCTION	4; 10; 26	9
23	(HIGH) FLUCTUATION IN INDUSTRY WORKLOAD FLEXIBILITY IN RESPONSE	24	11; 25; 32; 33
24	(HIGH) GOVERNMENT INFLUENCE ON TOTAL WORKLOAD	(4); 52	2; 23; 31; 35; 51
25	(LOW) LEVEL OF TRAINING OF OPERATIVE	(10); (11); 23; 11; 10; 36; 18; 6	12; 26; 29
26	(LOW) LEVEL OF SAFETY	(11); 29; 25; 10; 11; 14; 36	22
27	(HIGH) PROJECT PRODUCTION RATE	28; 51	33; 40; 48
28	(HIGH) USE OF OVERTIME WORKING	(3); 30	27
29	(LOW) NUMBERS OF TRAINED WORKFORCE	(10); 25	12; 13; 26
30	(LOW) NUMBERS OF PRODUCTION PERSONNEL	4; 9; 6	10; 28; 48
31	(HIGH) COMPETITION IN PRODUCTION SECTOR	24; 4; 18	10; 43
32	(LOW) LEVEL OF MECHANISATION	(3); (7); 41; 11; 10; 23	12
33	(LOW) RESPONSE IN SUPPLY OF MATERIALS	35; 19; 27; 23	12
34	(LOW) LEVEL OF INTEGRATION OF RESPONSIBILITY FOR MANAGING INDUSTRY	(8); 4	35
35	(LOW) LEVEL OF INFORMATION ABOUT INDUSTRY PERFORMANCE	24; 21; 42; 34	8; 10; 33
36	(LOW) LEVEL OF TRADES UNION RESTRICTIVE PRACTICES	11	5; 25; 26
37	(HIGH) LEVEL OF CORRUPTION IN CONSTRUCTION	(12)	6; 10; 16
38	(LOW) QUALITY OF BUILDING	20; 16; 8; 40	
39	(HIGH) USE OF REINFORCED CONC. IN-SITU	7	17
40	(HIGH) OVERLAP BETWEEN DESIGN AND PRODUCTION PHASE	27	10; 38
41	(HIGH) CONTRACTORS RISK AVOIDANCE	43	11; 32
42	(LOW) LEVEL OF CO-ORDINATION OF THE INDUSTRY	4	35
43	(LOW) LEVEL OF CAPITALISATION OF CONTRACTORS	10; 31	5; 41
44	(HIGH) WORKLOAD OF PRIVATE SECTOR DESIGNERS	3; 47; 51; 15	48
45	(HIGH) OUTPUT OF INDUSTRY	51; 2; 48	5
46	(LOW) DEMAND FOR RESEARCH IN CONSTRUCTION (*)	51; 2; 16; 10	21
47	(HIGH) COMPLEXITY / COMMUNICATION (*)	19	3; 10; 44
48	(HIGH) WORKLOAD OF PRIVATE SECTOR PRODUCERS (*)	44; 30; 27; 2	45
49	(LOW) LEVEL OF COMMUNITY ORGANISATION BETWEEN FLAT OWNER	7	8
50	(HIGH) PERCENTAGE OF OCCUPANT RENTING DWELLING IN COMMUNITY	(3)	8
51	(HIGH) PRIVATE SECTOR DEVELOPMENT OPPORTUNISM	(4); 24; 25	1; 5; 27; 44; 45; 46
52	(HIGH) DEMAND FOR BUILDING AND CIVIL ENGINEERING FACILITIES (*)	(6)	7; 18; 24; 51

Fox identified gaps in published knowledge of the construction industry of Hong Kong, especially in aspects of construction management. The model developed by Fox shows an outline of the characteristics of the Hong Kong construction industry and their interrelationship. Fox's findings form a significant reference in this research for describing the environment and characteristics of the Hong Kong construction industry.

2.6.2 Mortiboys (1991): Quality Management in Public Housing of Hong Kong

In July 1990, the Hong Kong Housing Authority and Hong Kong Construction Association jointly commissioned Mortiboys to undertake a study of quality management practices in public housing construction in Hong Kong. The general objectives of the study were:

- a) to recommend a strategy for upgrading final quality, quality assurance and quality management in the industry as a whole.
- b) to evaluate and recommend ways of making the contractors' improvement of quality assurance achieve maximum effect on final quality.
- c) to identify the issues and problems the contractors will face in implementing ISO 9000; to describe the resources they might use including training and external consultancy; and to outline a programme/list of steps for implementing contractor quality assurance systems.

The study included planning, testing, executing, analysing and writing six specific research studies as follows:

- a) a survey of the main contractors current quality management practices.
- b) a study of the sub-contractors quality management practices and their interfaces with main contractors and Hong Kong Housing Authority.
- c) a survey of housing material suppliers concerning quality problems encountered in supplying to public housing projects.
- d) a survey of housing managers concerning the finished quality of public housing.

- e) a survey of public housing tenants or owners concerning their satisfaction or dissatisfaction with the finished quality of public housing.
- f) in-depth case studies of the current quality management practices on five current housing projects.

The aim of the study is specifically related to quality issues of housing projects. The study for the main contractors mentioned in above a) is particularly relevant to this research. For the survey on the main contractors, it involved a study on 54 contractors comprising of 18 overseas contractors working in Hong Kong and 36 local contractors. The contractors were invited to attend a meeting for completing the structured questionnaire with 51 questions. The majority of the questions were closed-ended but open-ended questions were asked to invite more details from the respondents. Contractors were briefed on the questions and were given the opportunity to seek clarification. Contractors were then asked to complete the questionnaire back in their offices. Questionnaires were then mailed anonymously to the research office. One week was allowed for the contractors to complete the questionnaire. At the end, 36 contractors completed and returned the questionnaire. The following topics were covered in the contractors questionnaire:

- a) responsibility for quality;
- b) communication interfaces;
- c) working relationships;
- d) documentation;
- e) factors affecting quality;
- f) record keeping;
- g) quality planning;
- h) materials;
- i) site quality;
- j) selection and control of sub-contractors; and
- k) training.

The summary of the study specifically relevant to this research are summarised as follows:

- a) Contractors have daily communication with Housing Department site staff and domestic sub-contractors. Communication with the Housing Department Headquarters based project team members is on a weekly basis. No significant communication problems were reported but

minor difficulties were reported with the nominated sub-contractors, sub-sub-contract labour and project resident engineers.

- b) Contractors reported reasonably good working relationships with the Housing Department. However, about half claimed that there was a lack of consistency in the standards of workmanship and quality required from project to project and across project teams. These problems of consistency were perceived as worse by overseas contractors. Some improvement in attitude and co-operation was requested.
- c) The contractors were asked to rate a list of tender and contract documents in respect of accuracy, completeness, timeliness and buildability. Results indicated that improvements can be made in all these areas for drawings, bills of quantity, and site instructions.
- d) The contractors identified the following factors, in descending, order as having an important effect on quality: tender price; skilled labour availability; tender competition system; project team co-operation; time for completion and timely issue of drawings.
- e) Contractors indicated that for most contracts they have formal filing systems for contract management, and that almost all contractors keep an up-to-date list of suppliers and sub-contractors used. Most contractors also keep records of the performance of listed suppliers and subcontractors.
- f) Contract reviews involving site staff take place, but in most cases the procedures for these reviews are not documented. Contractors have procedures to ensure that materials are available when required and mostly keep records of defective materials.
- g) A quality management system appears to be present on most sites. The main features of the system in over 80% of the contractors surveyed were as follows:
 - i) appointment of person responsible for quality on site;
 - ii) maintaining a master catalogue of drawings and documents on site; and
 - iii) maintaining a programme for the site work.

However, from site to site, there may be inconsistencies which were not immediately obvious, as the procedures and systems were not documented to any great extent.

- h) Managing directors and contract managers have more influence over sub-contractor selection than quantity surveyors or site agents, and the principal selection criteria are price and previous track record of quality performance. Regular progress meetings are held with sub-contractors and workmanship performance is addressed. Sub-contract agreements contain minimal information and are usually one page in written Chinese.
- i) Over half of the contractors say that they "always" identify jobs requiring skills and "sometimes" offer training for employees.
- j) Contractors "mostly" have procedures for dealing with complaints from the Housing Department, and complaints from subcontractors. However, these procedures, the nature of the complaints and subsequent actions are generally not documents. Bad handling, inadequate storage, non-optimised cutting and theft were identified as the main causes of wastage.

Mortiboys' study was one the significant and systematic surveys of recent construction practices in Hong Kong. The sample of the survey is the contractors working for the public sector, which is in line with the target of this research. The methodology of the survey is by questionnaire and this approach has also been applied in the study of the management practice of the Hong Kong construction industry as described in Chapter 3 of this thesis. The above mentioned summary is a abstract for the results relevant to this research. The summary together with the findings mentioned in Chapter 3, outline the profile of the management practice of the Hong Kong construction industry.

2.7 Summary.

The publications reviewed in this chapter identified a number of crucial points which set down the theoretical foundations for this research. These are:

- a) In comparison with the industrial studies in the 1960s of communication in the construction industry, there has been insufficient research and studies for information flow between contractors and contract supervisors in

contract administration, especially the use of information from site produced by contractors to contract supervisors. (Carter 1987)

- b) Techniques of data modelling are capable of identifying existing physical data flows on site. The site performance information is not only significant to the contractors for management purpose but also important to the contract supervisors for their contract administration decision-making. This highlights that the performance feedback data from site should serve for both internal management use and external submission. (Carter 1987)

In addition, this has also identified a research potential for direct computer system linking between contractors and contract supervisors for exchanging information. (Carter, 1987)

- c) Site management is an important factor in determining the success of a construction project from the contractors' point of view. Site managers have to make decisions relying on the performance data on various progress areas, for which a management information system, with simple reporting procedures, is essential to ensure the regular supply of relevant information. (Gunning, 1987)
- d) Integrated computer systems for construction management still need considerable development before they can satisfy the needs of the industry. One of the problem areas of site management computerisation is the extra workload caused by the data input and the double-handling of data. (Nedekugi 1986, McCaffer 1988).
- e) Models of integrated system for construction management have been attempted by academic research, but none has yet gone through substantial field tests in live projects under a micro-computer environment. Structured programming in 4th generation languages was highly recommended as a development tool in this area. (Abdullah 1988).
- f) Proper common coding systems are crucial to the efficiency of data flow within contracting organisations, and have a great significance in the use of estimating data for post-contract management. (Kodikara 1990)

- g) The traditional bill of quantities in unit rate format, without further manipulation, will inhibit the feedback of project performance data for supporting future estimation. (Kodikara 1990).
- h) Efficiency of project information flow on site between contractor and contract supervisors should have a significant contribution to the improvement of quality assurance for construction project. (BRE 1987).
- i) Few studies have considered the relationship of the computerisation of construction management and quality assurance information in the construction industry. (Bhattarai 1990)
- j) Recent studies in Hong Kong have outlined the characteristics and the site management practices for the public sector in a rather superficial manner. However, there still has been insufficient research and studies for the construction management of Hong Kong construction industry. (Fox 1989, Mortiboys 1991)

3 Survey of Hong Kong Construction Management Practice

3.1 Introduction

This chapter describes a study of the construction industry and construction management practice in Hong Kong. The results of this study are considered to be a crucial element in this thesis, because they established the context and need of the system developed in this research.

The chapter begins with a brief introduction of the geography, economy and political circumstances of Hong Kong, with especial reference to the future of the colony. The construction industry is then described, and the significant influence of the public sector and government control of contractors. This forms the basis of the marketing environment in which the mode of construction management is developed in Chapter 6 of this thesis.

In order to establish that there was a real need for information systems of the type developed in this thesis, a survey was conducted to review the current practices in the management of construction projects. This was a detailed survey within a number of contractors, and the results and discussion comprise the main part of this chapter.

3.2 The Background of Hong Kong

Hong Kong is one of last British Colonies, for which a Joint Declaration was signed in 1983 between Peoples' Republic of China and British Government, for Hong Kong to revert to Chinese sovereignty after 30th June 1997.

Hong Kong is located in the south coast of China with the total area 1,071 square kilometres including two main islands, one peninsula and 200 small islands of various size. It is well-known that Hong Kong is a small, compact and commercially vigorous community of about 6 million people, and is an international commercial centre for the Asia-Pacific Region. With the continuing adoption of 'open-door' policy in China over the last 12 years and its further encouragement of a free market economic policy, Hong Kong becomes an important gateway to China for trade, investment and tourism.

Hong Kong enjoys a high rate of economic growth and has achieved 6.2% average annual GDP growth in real terms for the past 10 years. Despite recession in many countries, in 1991 the growth of the Hong Kong economy was around a remarkable 4% and the per capital GDP in Hong Kong was over US\$ 14,000. Thus, there

is a strong market for building and infrastructure development. The business and social life in Hong Kong is generally disciplined and efficient, and systems, both human and electronic, are well developed.

3.3 The Construction Industry of Hong Kong

The construction industry in Hong Kong includes both building and civil engineering work. Hills (1991) quoted the information from the Census and Statistics Department of Government that the construction industry employs approximately 5 % of the working population, and contributes between 8-13 % of the gross domestic product (GNP) each year. The construction industry in Hong Kong operates on a massive scale and plays a significant role in the economy. Hills (1991) further pointed out that the construction industry is seen as a barometer of the economy and the Government measures to control the economy usually affect the industry, either directly, by the control of output, by licensing or by reducing the programme of public expenditure, or indirectly by restricting borrowing.

The following table shows the expenditure at contemporary prices of building and construction from 1979 to 1990. (Source: Hong Kong Census and Statistics Department).

Year	Total Value	Public Sector	
	(HK\$M)	(HK\$M)	Share (%)
1979	12,339	5,203	42.2
1980	16,623	6,097	36.7
1981	19,937	7,127	35.7
1982	24,787	10,340	41.7
1983	25,112	10,873	43.3
1984	24,414	10,135	41.5
1985	22,970	7,875	34.3
1986	24,403	7,985	32.7
1987	30,262	10,067	33.3
1988	38,502	12,097	32.4
1989	48,664	15,323	33.6
# 1990	58,573	19,730	36.7
* 1991	63,602	19,313	30.4
+ 1992	74,210	24,142	32.5

Provisional * Preliminary + Forecast (March 1992)

Various crucial planning strategies have been applied to the Hong Kong construction industry, which should have significant influence on the industry. These developments are described in the next chapter of this thesis.

3.4 Approved Contractors for Public Works

In accordance with the Rules for Administration of Approved Contractors for Public Works (published in Hong Kong Government Gazette on 3rd April 1992), which is a key document governing the administration for the classification of contractors undertaking public projects, the contractors for public projects are classified as List I and List II with the following definitions:

- a) List I: Contractors whose main presence and head office is in Hong Kong.
- b) List II: Contractors whose main presence and head office is outside Hong Kong (overseas contractors).

Contractors in List I are further classified according to the value of contracts for which they are normally eligible to tender. The group limits are periodically adjusted and are currently (1992) set as follows:

- Group A - contracts of value up to HK\$ 6 million.
- Group B - contracts of value up to HK\$ 30 million.
- Group C - contracts of any value.

List II contractors are not subdivided into groups, but will normally be eligible to tender only for contracts of value exceeding HK\$ 30 million. Exceptionally, this restriction may be removed when the type of work in a Group A or B contract is specialized and the inclusion of List II contractors is considered desirable and appropriate.

The classification of public projects in terms of the nature of the work is also divided into five categories, which are managed by different managing departments with the following details:

	Category	Managing Department
a)	Buildings	Architectural Services
b)	Port Works	Department
c)	Roads and Drainage	Civil Engineering Department
d)	Site Formation	Highways Department
e)	Waterworks	Territory Development Department
		Water Supplies Department

Each category of projects has its own grouping of contractors. This means that different groupings of contractors should be applied in different categories. The eligibility of contractors in a grouping is dependent on their financial, technical and management capabilities, subject to individual assessment by the corresponding managing department. A mechanism of promotion and down grading is applied in the grouping system, subject to periodical reviews of the performance of the contractors.

The contractors for public works under this grouping system are the subject of the field survey of this research, and subsequently form the basis of the model of construction management described in Chapter 6 of this thesis.

3.5 Overseas Contractors (List II Contractors)

The term "overseas contractors" is defined as those contractors whose main presence and offices are outside Hong Kong, in accordance with the Rules for Administration of Approved Contractors for Public Works mentioned in Section 3.4 above. Overseas contractors have a long history of service in Hong Kong. Unlike many other countries in which the local service industries are protected, for example in Japan and Korea, foreign contractors are not allowed to enter their markets, Hong Kong Government adopts a non-intervention policy towards the local construction industry with no restrictions on the operations of overseas contractors. This long-adopted policy provided opportunities for overseas contractors to establish and expand their business.

In the 1960s and 1970s the overseas contractors concentrated mainly on heavy civil engineering works, particularly port works, site formation and water works. By the end of the 1970s, the construction of the Hong Kong Mass Transit Railway (MTR) was the turning point of the participation of overseas concerns in Hong Kong. Subsequently the expanding local infrastructure developments attracted more overseas contractors, who set up operations in Hong Kong.

The participation of overseas contractors encourages joint ventures between local contractors and overseas contractors. Through joint ventures, commercial risk can be spread and finance, plant and expertise of the overseas contractors can be provided by the overseas partner. The involvement of overseas contractors in the Hong Kong construction industry has substantial impacts on both the technical and management practices of local contractors.

3.6 Survey of Current Practice

3.6.1 Questionnaire Survey

A field survey in a form of a questionnaire, following by personnel interviews was conducted in order to study the practices of construction management adopted by the contractors. The questions were mainly directed towards aspects of estimating, time control, resource control, cost control, information control, performance feedback, quality assurance, and the communications between head office and construction sites.

Murphy et al (1974) conducted a study of 650 projects in USA using an evaluation instrument containing over 190 questions. A condensed version of the evaluation instrument for completed projects was developed and presented in 1979. The format and approach of Murphy's team have been applied in this survey. The questionnaire for this survey comprises 105 questions.

Bryman (1989) recommended that the design of questions in questionnaire surveys should take into account the following considerations:

- a) questions should be clear and unambiguous;
- b) wherever possible simple language should be used so that respondents can comprehend questions;
- c) questions are recommended to be short;
- d) 'double-barelled' questions, in which the respondent is asked about two things in one question, should be avoided, since it can be confusing to both respondent and researcher; and
- e) questions should not contain negatives since they can be readily misinterpreted.

It is obvious that a questionnaire survey with the above criteria is inadequate on its own to cope with a study of those complex issues of construction management. In order to overcome this inadequacy, follow-up interviews were used to ensure the validity of the findings. The survey results of this approach should be more reliable, because the possibility of misunderstandings due to the different interpretation on management terms could be reduced and more background information could be explored. For example, people may have different understanding of integration, performance, feedback and control, etc.

Sudman and Bradburn (1982) defined three types of questions to be used in questionnaire surveys, which are:

- a) open-ended (where respondents answered in their own words in the space provided);
- b) closed with ordered choices (where the respondent close from a list of alternative answers, usually by ticking a box); and
- c) semi-closed (Where the respondent can choose an answer provided or have the option to create his own response).

In this survey, mainly the form of 'closed with ordered choices' was adopted in the questionnaire. Seeking information on existing practices of complicated issues, such as construction management, open-ended questions were considered inappropriate due to the scope of involvements are too wide. Type of information to be sought through 'open-ended' questions such as comments or opinions, were acquired by the follow-up interviews instead of questionnaire.

In addition, a schedule-type question was used to allow greater flexibility for the respondent to present information. This type of question is similar to 'semi-closed' type, but more flexible for investigating complex issues, such as information flow. Therefore it should be classified as 'guided open-ended questions'.

3.6.2 Survey Samples

The survey sample was considered as a representation of the population, which in this case is the construction industry of Hong Kong. It was believed that with proper sampling

methods, the sample results would provide good estimate of the population characteristics. Anderson and Sweeney (1987) proposed six basic sampling techniques:

- a) simple random sampling;
- b) stratified random sampling;
- c) cluster sampling;
- d) systematic sampling;
- e) convenience sampling; and
- f) judgement sampling.

The first four are a form of probability sampling techniques where elements selected from the population have a known probability of being included in the sample. The other two are non-probability techniques, where items are selected without pre-specified or known probabilities of being selected.

The judgement sampling method was adopted, which was considered the easiest way of finding case studies to meet both the research constraints and representativeness. For establishing the samples by judgement, the Author, through his connections and experience, selected the samples that were considered to be most representative.

The survey samples and type of contractors selected were as follows:

Type of Contractor	Number
International Contracting Consortium	3
Local Class 'C' Contractors (large)	5
Local Class 'B' Contractor (medium)	2
Local Class 'A' Contractor (Small)	0

The target contractors were contractors in public sector as described in Section 3.4 and Section 3.5 of this thesis. It was considered that a study of a few contractors in-depth, with interview backup to the questionnaire would be more appropriate for this research than a shallow postal survey of many.

3.6.3 Survey Approach

Having designed the questions, the survey format and the sampling tool, the survey study was implemented. The survey approach is summarised as follows:

- a) The Author contacted the Architectural Service Department of the Hong Kong Government to get an updated list of the contractors in Hong Kong in all classifications, with the identity also the projects currently undertaking. Then the sample was selected according to the principles mentioned in Section 3.6.2 with the consideration also on their competence, management style, project type and potential in further expansion etc.
- b) Through the direct or indirect contacts of the Author, the key persons of those selected contractors were identified, who were considered appropriate to provide the information for this survey.
- c) Telephoned the selected key persons and explained the research to them.
- d) Sent them the questionnaires with a covering letter mentioning the aims and objectives of the research.
- e) Three days later called their secretary or themselves directly to make sure that the letter together with the questionnaire had been received.
- f) About one week later phoned the key persons directly to check for any problems and agreed with them a date for an interview. Also asked them to send back the completed questionnaires before the interview.
- g) Studied those returned questionnaires and accordingly prepared a list of questions for the interview.
- h) With the consent of the interviewee, during the interview used a small recorder to record the conversations. Since the questions in the questionnaire encompassed a wide range of aspects, the interview might involve a number of representatives from different departments or sections.
- i) During or immediately after the interview, arrangements were made to access to the following documents:

- i) Quality assurance documents;
- ii) Master programmes;
- iii) Progress reports from site;
- iv) Short term programmes prepared on site;
- v) Daily reports from site; and
- vi) The forms specified in their answers for the questionnaire.

3.6.4 The Questions and the Answers

This section describes all the questions of the questionnaire survey with the summary of the answers and the comments for each question. The original text is stated in this section for each question and the corresponding comments are the background and supplementary information acquired through the follow up interviews. The questions and the format are exactly as it contained in the original questionnaire, with the following sections:

- a) Estimation and tendering.
- b) Time control.
- c) Resources control.
- d) Cost control.
- e) Material control.
- f) Quality assurance implementation.
- g) Information control and communication between head office and sites.
- h) Other overall comments.

3.6.4.1 Estimation and Tendering

- a) Do you prepare your tendering programme or schedule to monitor tender submissions ?

- * Yes, for all tenders.
- * Yes, but not compulsory for all tenders.
- * No, only for certain large tenders.
- * Others (please specify) _____
- * No

If 'Yes', who is assigned to prepare the tender programme.

Ans: Most respondents selected 'Yes, for all tenders' and commented that for the tendering of small projects a simple schedule form of tender timetable might be used. In most cases, it should be the estimator or the team leader to prepare the tender programmes for the approval of the department head.

b) What are the estimation techniques applied in your estimation ? (Please also specify the percentage of work load distribution in different techniques).

- * Operational cost (____ %).
- * Output rate cost (____ %).
- * Past unit rates (____ %).
- * Subcontract rate (____ %).
- * Others (please specify) _____ (____ %).

Ans Most respondents found difficult to answer this question. After further explanation, they pointed out that it would be difficult to assess the estimation techniques in terms of work load distribution. But it should be possible to express it in terms of bill items. Finally the following responses were acquired:

- * Operational cost (10-15%) (cost significant items)
 - * Output rate cost (15-25%)
 - * Past unit rate (30-40%) (for small items).
 - * Subcontract rate (45%-65%) (main traditional items)
-

c) What are the work load distributions in the preparation of a tender submission ?

- * Reading and analysis tender documents (____ %).
- * Measurement of quantities (____ %).
- * Obtain material quotations (____ %).
- * Obtain subcontract quotations (____ %).
- * Negotiation with subcontractors (____ %).
- * Method analysis and study (____ %).
- * Calculation of tender price (____ %).
- * Documentation and paper works (____ %).
- * Others (please specify) _____ (____ %).

Ans The answers were quite varied, but it showed that negotiations, paper work, routine calculations, procuring information acquisitions were the most effort-consuming jobs.

- d) What are the tasks of estimation that rely on the feedback from previous contracts.

(You can have more than one choice and please specify the percentage of workload that has to rely on the feedback of previous contracts).

- * Preliminary cost (____ %)
- * Overhead cost (____ %)
- * Productivity rate (____ %)
- * Subcontract rate (____ %)
- * Mark up & risk (____ %)
- * Others (please specify) _____ (____ %).

Ans Most respondents failed to answer this question because in practice they seldom used such kind of feedback information for estimation. But they appreciated the significant of the information if it is available.

3.6.4.2 Time Control

3.6.4.2.1 Selection of Planning Techniques:

- a) What are the planning techniques your company currently used for your construction programming ?

(You can have more than one choice)

- * Simple barchart
- * Linked barchart
- * Line of balance
- * Arrow diagram network analysis
- * Precedent diagram network analysis
- * Others (please specify) _____

Ans Most answers especially those from class 'B' contractors were in 'simple barchart and linked barchart'. Some large contractors selected 'precedent diagram network analysis'.

- b) What criteria do you use when you choose a particular planning technique at tender stage for a new project ?

(You can have more than one choice)

- * Requirements of the condition of tender
- * Availability of time
- * Client's wishes
- * Workload in hand
- * Eagerness for the project
- * Complexity of the project
- * Familiarity to planning staff
- * Additional expense required
- * Others (please specific) _____

Ans The first three choices dominated the answers.

c) What criteria do you use when you choose a particular planning techniques at construction stage for a new project ?

(You can have more than one choice)

- * Requirements of the condition of contract
- * Client's requirement
- * Workload in hand
- * Complexity of the project
- * Numbers of activities involved
- * Familiarity to planning staff
- * Familiarity to site staff
- * Additional expense required
- * Others (please specify) _____

Ans Most respondents expressed that all the above factors should influence on the choice of a particular planning technique.

d) Who makes the final decision for the choice of planning techniques at tendering stage. ?

- * Company director
- * Contracts manager
- * Planning engineer
- * Estimator
- * Standard policy of company
- * Others (please specify) _____

Ans For those class 'B' contractors it would be the company top management. For those class 'C' or above it would be the functional top management such as contracts manager or planning engineer.

e) Who makes the final decision for the choice of planning techniques at construction stage. ?

- * Contracts Manager
- * Site Project Manager
- * Planning Engineer
- * Site Engineer
- * Others (please specific) _____

Ans For those class 'B' contractors it would be the head office top management such as contracts manager. For the class 'C' or above and well-organised contractors it would be the functional top management such as site project manager or planning engineer.

3.6.4.2.2 Application of Planning Techniques

- a) What are the factors which determine the number of activities in your master programme.?

(You can have more than one choice)

- * Complexity of Project
- * Type of Planning Technique in Use
- * Contractual Requirements
- * Client's Requirements
- * Ability of Planner
- * Others (please specify) _____

Ans In most responses, the first three choices dominated the answers. But the comments from most class 'C' or above contractors through the interviews showed that all the above should have an influence, especially in the application of network diagram analyses.

- b) Do you have a standard hierarchy in your company for the breakdown of activities when you prepare your master programme ?

- * Yes, for all activities .
- * Yes, but not compulsory for all activities
- * No, only for certain large contracts
- * Others (please specify) _____
- * No

Ans Most small contractors selected 'No, only for certain large contracts'. But most large contractors selected 'Yes, but not compulsory for all activities'.

c) Your hierarchy of activity breakdown is by

- * 1 - Phase of work
- * 2 - Section of work
- * 3 - Location of work
- * 4 - Trade of work
- * 5 - Type of work

Please specify the numbers in hierarchical order
()

Ans In those proper answers, ascending order (1,2,3,4,5) was the main choice.

d) Who makes the final decision for the breakdown of activities in the master programme ?

- * Contracts Manager
* Site Project Manager
* Planning Engineer
* Site Engineer
* Others (Please specify) _____

Ans Most respondents chose 'planning engineer' or 'site project manager'.

f) Who makes the final decision for the logic linking of activities in the master programme ?

- * Contracts Manager
* Site Project Manager
* Planning Engineer
* Site Engineer
* Others (please specify)

Ans Most respondents chose 'planning engineer or site project manager'.

g) For the computerised network analysis, do you request the system to print out network diagram.

- ```
* Yes, in all cases
* Yes, occasionally depends on the situation
* No, we expect the printout just in bar chart form
* Other comments:
```

**Ans** Initially most answers were selected 'Yes, occasionally depends on the situation'. During the interviews, further discussions reviewed that computerised network analysis was useless in practical applications, but linked barcharts should be more appropriate to show the logic linking of network analysis.

---

h) Who is generally involved in the determination of activity durations in the master programme ?

(You can have more than one choice)

- \* Contracts Manager
- \* Site Project Manager
- \* Planning Engineer
- \* Estimator
- \* Site Foremen
- \* Subcontractor
- \* Others (Please Specific) \_\_\_\_\_

**Ans** Most respondents chose 'planning engineer or site project manager'.

---

i) How do you decide on whether the major planning work is to be carried on site or at head office ?

(You can have more than one choice)

- \* Standard company policy
- \* Nature of project
- \* Complexity of project
- \* Geological position of site
- \* Quality of Site Planning Staff
- \* Work Load Distribution
- \* Site Environment
- \* Others (Please Specific) \_\_\_\_\_

**Ans** Most responses selected the first four choices.

---

### 3.6.4.2.3 Progress Reporting and Updating

a) How often would you update your master programme ?

- \*Occasionally, depend on the Architect/Engineer's request
- \*Pursuant to the contract requirements
- \*Monthly
- \*Fortnight
- \*Others (please specify) \_\_\_\_\_

**Ans** Most respondents selected the first two choices. During the subsequent interviews further quantitative information was acquired indicating that the master programme updating was probably at an interval of every three months.

---

b) Is there any difference in respect of the frequency of progress updating between the use of manual planning and computerized planning system ?

\*If yes, please specific the frequency of updating the master programme:

Manual: \_\_\_\_\_ Weeks

Computer: \_\_\_\_\_ Weeks

\* No different. Please explain: \_\_\_\_\_

**Ans** Most answers were 'yes'. In manual practice it might involve 4 to 6 weeks but in case of computerised planning involved the frequency of progress updating could be reduced to every 1 to 2 weeks.

---

c) When you check on the work progress for program updating, which programme do you use ?

- \* Master Programme
- \* Sectional Programme
- \* Trade Programme
- \* Monthly Programme
- \* Weekly Programme
- \* Others (please specify) \_\_\_\_\_

**Ans** Most answers were based on an assumption of using computer planning system. Most respondents selected 'trade programme and monthly programme'.

---

d) *Usually by what means does your head office communicate with the site regarding the progress of the work ?*

*(You can have more than one choice)*

- \* daily report*
- \* progress chart*
- \* progress meeting*
- \* progress check list*
- \* Others (please specify) \_\_\_\_\_*

**Ans** The answers were quite various, but were concentrated in the first three choices.

---

e) *Who is responsible for reporting the progress information from site ?*

- \* Site Project Manager*
- \* Site Engineer*
- \* Site Quantity Surveyor*
- \* Site Foreman*
- \* Others (please specific) \_\_\_\_\_*

**Ans** Most respondents selected 'site engineer'. But in fact most planning jobs were carried out on site. Except in cases of involving the use of a sophisticated computerised planning system which might be located at the head office, the progress information would be reported from site to the head office.

---

f) *Please explain in brief the general procedures for updating the progress information from site.*

---

---

---

**Ans** This question is related to question e) above. In case of using head office facilities, it would use progress charts or pre-defined forms for the site staff to report the progress. In case of site planning involved, the planning engineer would use progress charts, site observations and daily reports.

---

g) Are there any counter-checking procedures to ensure that the progress feedback reported is precise.

\* If no, please state reasons:

---

---

---

\* If yes, please state who is responsible for and how it is done ?

---

---

---

**Ans** Most respondents answered 'yes'. It would be responsible by the site project manager in normal circumstances. For large contracts the contract administration team of supervisor also played an important role for ensuring the precision of progress information.

---

h) Do you request site management to prepare a short term forecasting programme ? If yes, please choose the following details:

\* Frequency of updating:

Two months; One month; Half month; Two week;  
One week;

\* Who is the site management responsible for:

Project Mgr; Planning Eng; Gen Foreman;  
Section Foremen;

\* Format of Programme:

Simple Barchart; Linked Barchart; Network  
Analysis;

\* Other details please specify

---



**Ans** Most answers were 'yes' with the details as follows:

- Frequency of updating: one month to two weeks
  - Responsible person: planning engineer
  - Format of programme: simple barchart.
- 

i) In general, how long does it take to collect sufficient information for progress updating use ?

\* Please specify in working days or hours:

\_\_\_\_\_ days/hours

**Ans** The answers ranged from 1 day to 2 days.

---

j) In general, how long does it take to update your master program after you have received the information ?

\* Please specify approximate working day:

\_\_\_\_\_ days

**Ans** The answers also ranged from 1 day to 2 days.

---

#### 3.6.4.2.4 Use of Programme Reports

a) What kind of programmes you will submit to the Architect/Engineer ?

(You can have more than one choice)

- \* Master Programme
- \* Sectional Programme
- \* Trade Programme
- \* Monthly Programme
- \* Weekly Programme
- \* Others (Please Specific) \_\_\_\_\_

**Ans** The answers were concentrated on 'master programme' and 'monthly programme'.

---

b) Do you prepare separate programmes just for the purpose of submission to the Architect/Engineer ?

- \* ) Yes, for every contract
- \* ) Yes, depends on the situation

Please give a: \_\_\_\_\_  
recent example \_\_\_\_\_

- \* ) No

**Ans** Most answers were 'Yes depends on the situation', of which one of the example given was for the submission of extension of time claim.

---

c) What kind of programmes you will copy to your subcontractors including both nominated and domestic subcontractors ?

(You can have more than one choice)

- \* Master Programme
- \* Sectional Programme
- \* Trade Programme
- \* Monthly Programme
- \* Weekly Programme
- \* Programme specific to this sub-contractor
- \* Others (Please Specific) \_\_\_\_\_

**Ans** The answers indicated that various programmes would be given to subcontractors depending on the situations including master programmes, sectional programmes, trade programmes and monthly programmes etc. It was noted that the type of programme might have been specified in the subcontract conditions.

---

d) What kind of floats in your network analysis you will indicate on your external programmes ?

(Please tick on the table)

| <i>Contractual Parties</i>                         | <i>Total Float</i> | <i>Free Float</i> | <i>Not Indicated</i> |
|----------------------------------------------------|--------------------|-------------------|----------------------|
| * <i>Contract Supervisors (Architect/Engineer)</i> |                    |                   |                      |
| * <i>Nominated Subcontractor</i>                   |                    |                   |                      |
| * <i>Domestic Subcontractor</i>                    |                    |                   |                      |

**Ans** The answers showed that the floats would be indicated on the programmes only if specifically required by the contract supervisor or contract conditions.

e) What kind of floats in your network analysis you will indicate on your internal programmes ?

(Please tick on the table)

| <i>Type of Programmes</i>     | <i>Total Float</i> | <i>Free Float</i> | <i>Not Indicated</i> |
|-------------------------------|--------------------|-------------------|----------------------|
| * <i>Master Programme</i>     |                    |                   |                      |
| * <i>Monthly Programme</i>    |                    |                   |                      |
| * <i>Short Term Programme</i> |                    |                   |                      |

**Ans** The answers showed that in case of programme using computerised critical path analysis only total float would be indicated for internal programmes. Free float would be indicated on specific requests or in order to suit particular purposes.

f) Would you use the feedback of progress data from previously completed projects to help your future planning ?

- \* *In all cases*
- \* *For certain significant contract*
- \* *Just keep up the data.*
- \* *No definitive policy on that*
- \* *Seldom*
- \* *Never*

**Ans** Most answers showed that there was 'no definitive policy' and 'seldom' using the data from the feedback of previously completed projects. During the interviews, the respondents said that the idea of using feedback data from previous projects was good but usually there such data was bad organised or the data just unavailable.

---

g) How you manage the feedback data ?

- \* Store in the computer system
- \* Convert it into the departmental working manual
- \* Group in written index files
- \* Keep in files as their original status
- \* Others (Please Specific) \_\_\_\_\_

**Ans** Most answers showed that the so-called 'feedback data' were often 'kept in files as their original status'.

---

### 3.6.4.3 Resources Control

#### 3.6.4.3.1 Application of Resources Scheduling

a) In your network analysis, do you incorporate resources consideration in your logic linking ?

- \* Yes, for all situations
- \* Yes, just for certain significant resources
- \* No, resources are considered separately

**Ans** Nearly all answers indicated that resources would be considered separately.

---

b) Do you use resources scheduling technique to balance your resources demand ?

- \* Yes, for all contracts
- \* Yes, only for large contracts
- \* Dependent on the situation

Please give a: \_\_\_\_\_  
recent example \_\_\_\_\_

- \* No

**Ans** Most answers were 'No'. Further investigations showed that it was because most construction activities were subcontracted.

---

c) Do you use computer systems to help with resources scheduling ?

- \* Yes, for all cases
- \* Yes, in combination with manual method
- \* No, only use manual method.
- \* Not in both manual and computer method

**Ans** The respondents showed that computerised resources scheduling was seldom applied.

---

d) What kind of resources you will select for going through a scheduling procedure ?

- \* All relevant resources
- \* Only directly employed resources
- \* All Mobile Plant
- \* Only Selected Significant Plant
- \* Others (Please Specific): \_\_\_\_\_

**Ans** The answers showed that for resource scheduling only directly employed resources or only selected significant plants would be involved.

---

e) Do you consider at company level the interrelationship of resources arrangement and balance among your concurrent projects by using multi-project resource scheduling technique ?

- \* Yes, for all contracts
- \* Yes, only for large contracts
- \* Dependent on the situation

Please give a: \_\_\_\_\_  
recent example \_\_\_\_\_

- \* Not

**Ans** Most respondents indicated that it was sound in theory but would be difficult to be implemented.

---

### 3.6.4.3.2 Updating in Resource Scheduling

a) Do you update your resource scheduling after you have changed your master programme ?

- \* Yes, for all case
- \* Dependent on the situation

Please give a: \_\_\_\_\_  
recent example \_\_\_\_\_

- \* Not

**Ans** Most respondents selected the second choice and indicated that it would be the function of most computerised planning system to update the resource scheduling from the change of master programme.

---

b) What are the considerations which will make you decide to update your resource scheduling ?

(You can have more than one choice)

- \* A major change in the master programme.
- \* For the purpose of claim preparation.
- \* It is an automatic by-product from programme updating by computer system.

**Ans** Most answers included the selection of all the above choices.

---

c) In general, how long you have to spend collecting sufficient information for resource scheduling updating use ?

- \* Please specify in working day:

\_\_\_\_\_ days

**Ans** It was indicated that it might involve 2 to 3 days.

---

d) In general, how long would it take to update your resource scheduling report when you have received substantial information ?

- \* Please specify in working days/hours:

\_\_\_\_\_ days/hours

**Ans** It was indicated that it might involve 1 to 2 days.

---

**3.6.4.3.3 The Use of Resource Scheduling**

a) Within your company, who should study the updated resource profiles and makes decision accordingly ?

- \* Contracts Manager
- \* Site Project Manager
- \* Planning Engineer
- \* Site Engineer
- \* Others (Please Specific) \_\_\_\_\_

**Ans** The respondents indicated that it would depend on the purpose of the resource profile updating and then the decision maker would study the profiles accordingly.

---

b) Do you submit the relevant resource profiles to the contract supervisor ?

- \* Yes, in all cases
- \* Yes, depending on the situation

Please give a: \_\_\_\_\_  
recent example \_\_\_\_\_

- \* Yes, only for claim purposes
- \* Never

**Ans** The answers showed that it would depend on the situation, in which one of the examples would be in the submission of acceleration or loss and/or expense claim.

---

#### 3.6.4.4 Cost Control

##### 3.6.4.4.1 Selection of Cost Control Techniques

- a) What cost control techniques is your company currently using for your construction projects ?

(You can have more than one choice)

- \* Compare monthly total between budgetary interim valuation and certified interim valuation.
  - \* Compare monthly total among budgetary interim valuation, certified interim valuation and the actual cost.
  - \* Compare elemental costs between budget and actual
  - \* Compare bill items between budget and actual
  - \* Compare activity cost between budget and actual
  - \* Others (Please Specify)
- 

**Ans** Most answers indicated that the first two choices were the common methods adopted by most contractors. For certain sophisticated class 'C' contractors, elemental cost comparison method was also applied.

---

- b) Do you use different cost control techniques for different projects ?

- \* Yes
- \* No
- \* Dependent on the situation

**Ans** Most selections rested on the last choice. The situations were indicated in the next question c).

---

- c) What criteria do you consider when you choose a particular cost control technique for a new project ?

(You can have more than one choice)

- \* Contract sum of the project.
  - \* Profit margin of the contract.
  - \* Familiarity of staff to a particular technique.
  - \* Demand of management control
  - \* Company organisation structure
  - \* Work loads in hand
  - \* Additional expense generated
  - \* Others (please specific)
-



**Ans** The answers showed the following selections in descending order based on the number of selections:

- Demand of management control.
  - Contract sum of the project.
  - Profit margin of the contract.
- 

d) *Who makes the final decision for the choice of cost control techniques ?*

- \* *Managing Director*
  - \* *Financial Controller*
  - \* *Contracts Manager*
  - \* *Site Project Manager*
  - \* *Others (please specific)*
- 

**Ans** It would be the top management making the decision, such as the managing director or the financial controller.

---

e) *Does your company use computers to help in project cost control ?*

- \* *Yes, for all case.*
- \* *Yes, for certain large contract.*
- \* *No, never.*

**Ans** Most answers were 'yes for all case'.

---

f) *Do you think that any substantial economic savings are made by the use of a computerised cost control system for your projects.*

- \* *Always*
- \* *Often*
- \* *Seldom*
- \* *Never*
- \* *Don't Know*

**Ans** Most answers were positive by a kind of personal impression from the respondents.

---

#### 3.6.4.4.2 Cost Control Techniques

- a) Having got a contract, at the pre-contract stage how do you manipulate the contract bill ?

(You can have more than one choice)

- \* Prepare an elemental bill based on the cost components.
- \* Break down the bill items into its cost elements.
- \* Prepare an operational bill based on the activities of the master programme.
- \* Others (Please Specific) \_\_\_\_\_
- \* Nothing

**Ans** Most respondents selected the third choice, preparation of operational bill. But it was added during the interviews that the itemisation of the operational bill had to agree with the consultant quantity surveyor's bill.

---

- b) Do you have a pre-defined hierarchical coding system to classify the break down of your bill items ?

- \* Yes, in all cases
- \* Yes, just for certain large contract
- \* No

**Ans** Most answers were 'yes, in all cases'.

---

- c) In normal cases how long does it take for the completion of the manipulation of contract bill ?

- \* Minimum: \_\_\_\_\_ Working Mandays
- \* Maximum: \_\_\_\_\_ Working Mandays

**Ans** The working duration ranged from 10 to 20 working mandays.

---

- d) After having got a contract, what kind of information will you ask from your Estimating Department ?

(You can have more than one choice)

- \* Tender analysis
- \* Break down of unit rates
- \* Subcontract list
- \* Quotation list
- \* Others (please specific)

**Ans** The answers covered a wide range, nearly all the above information except the break down of unit rates which were often treated as confidential.

---

e) In normal case how long do you have to wait for the Estimating Department to give you sufficient information for you to complete your budget preparations ?

\* Minimum: \_\_\_\_\_ Working Days  
Maximum: \_\_\_\_\_ Working Days

**Ans** The waiting duration ranged from 7 days to 14 days if they were available. But further comments showed that sometimes the data were fragmentary.

---

f) Do you link the operational bill with the master programme for establishing the budgets ?

- \* Yes, in all case
- \* Yes, depending on the situation
- \* No

(If yes, please answer the next question.)

**Ans** Most answers were 'yes, depending on the situation'.

---

g) What criteria do you consider for deciding to link between operational bill and master programme ?

(You can have more than one choice)

- \* Contract sum of the project.
- \* Function available in the computer system.
- \* Familiarity of staff.
- \* Demand of management control.
- \* Company organisation structure.
- \* Work loads in hand.
- \* Additional expense generated.
- \* Others (please specific).

**Ans** The answers showed the following selections in descending order based on the number of selections:

- Demand of management control.
  - Contract sum of the project
  - Function available in the computer system.
-

h) Normally what kinds of budget would you use for cost control purposes ?

(You can have more than one choice)

- \* Value budget from the contract bill
- \* Elemental cost budgets i.e. labour, plant and materials
- \* Profit margin budget
- \* Site overhead budget
- \* Head office overhead budget
- \* Preliminaries budget
- \* Resource budget in all trades
- \* Resource budget for those significant items
- \* Others (please specify) \_\_\_\_\_

**Ans** The answers showed the following selections in descending order based on the number of selections:

- Value budgets from the contract bill.
  - Preliminary and site overhead budgets.
  - Elemental cost budgets.
- 

i) What criteria do you consider when deciding to prepare a particular type of budget ?

(You can have more than one choice)

- \* Contract sum of the project
- \* Functions available in the computer system
- \* Familiarity to staff
- \* Demand of management control
- \* Company Organisation Structure
- \* Work loads in hand
- \* Additional expense generated
- \* Others (please specify) \_\_\_\_\_

**Ans** The answers showed the following selections in descending order based on the number of selections:

- Demand of management control.
  - Contract sum of the project
  - Work loads in hand.
-

### 3.6.4.4.3 Updating in Cost Control

a) Do you update the budgets and cash flow in response to the changes of the master programme ?

- \* ) Yes, in all cases
- \* ) Yes, depending on the situation  
(Please also answer the following question )
- \* ) Yes, only for claim submission
- \* ) No, never

Ans Most answers selected the second choice.

---

b) What criteria do you consider when deciding to update your budgets and cash flow in response to the changes of the master programme ?

(You can have more than one choice)

- \* Contract sum of the project
- \* Function available in the computer system
- \* Familiarity to staff
- \* Demand of management control
- \* Company organisation structure
- \* Work loads in hand
- \* Claim submission purpose
- \* Additional expense generated
- \* Others (please specify) \_\_\_\_\_

Ans The answers showed the following selections in descending order based on the number of selections:

- Demand of management control.
  - Claim submission purpose.
  - Function available in the computer system.
- 

c) What is the frequency of your cost reconciliation and budget updating ?

- \* Occasionally, depending on the situation  
Please give a: \_\_\_\_\_  
recent example \_\_\_\_\_

- \* Monthly
- \* Fortnight
- \* Weekly
- \* Others (please specify) \_\_\_\_\_

**Ans** Most answers selected 'monthly' but added that the budget updating were different to cost reconciliation. That meant most contractors having their standard policy on cost reconciliation but not for budget updating.

---

d) How do you record your actual costs for a project ?

- \* Summation of daily unit cost of resources engaged
- \* Actual paid from the Account Department
- \* Others (please specify) \_\_\_\_\_

**Ans** Most respondents selected the second choice.

---

e) Who is responsible for reporting the actual costs information for a project ?

- \* Account Department
- \* Quantity Surveyor
- \* Others (Please Specific)

**Ans** The answers varied between account department and quantity surveyor. Further studies during the interviews revealed that the actual cost reporting would be subject to the close liaison between the quantity surveyor and the account department.

---

f) Are there any counter-checking procedures to ensure that the actual cost feedback is precise.

- \* If no, please state reasons:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

- \* If yes, please state who is responsible for and how it is done.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**Ans** Most respondents answered 'no' in this question with the reason saying that most account practices should be able to detect account errors. But they admitted that account information may not be able to reflect the cost performance of a project.

---

g) In general, how long you have to spend collecting sufficient information for cost control updating use ?

\* Please specify in working mandays:

\_\_\_\_\_ mandays

**Ans** The workloads ranged from 4 mandays to 10 mandays depending on the project situation

---

h) In general, how long you could update your cost control report when you have received substantial information ?

\* Please specify in working mandays/hours:

\_\_\_\_\_ mandays/hours

**Ans** The workloads ranged from 2 mandays to 7 mandays depending on the project situation.

---

i) Do you also record resources used by the subcontractors ?

\* Yes, in all cases

\* Yes, depending on the situation

(Please answer the following question)

\* No

**Ans** Most answers were 'Yes, in all cases'.

---

j) What criteria do you consider for deciding whether or not to record the domestic subcontractor's resources ?

(You can have more than one choice)

\* Contract sum of the subcontract

\* Pass performance of the subcontractor

\* Demand of management control

\* Valuation of main contract

\* Valuation of subcontract

\* Confidence to the subcontractor

\* Work loads in hand

\* Additional expense generated

\* Others (please specify)

---

**Ans** The answers showed the following selections in descending order based on the number of selections:

- Demand of contractual requirement (specified by respondents).
  - Demand of management control.
  - Pass performance of the subcontractor.
- 

#### 3.6.4.4.4 Use of the Cost Control Information

a) What cost control reports are you using ?

(You can have more than one choice)

- \* Total Amounts Comparison
- \* Elemental Costs Comparison
- \* Activity Costs Comparison
- \* Others (Please Specific)

**Ans** Most answered the use of the first two choices.

---

b) Who will be responsible for studying the following reports ?

- \* Profit and Loss: \_\_\_\_\_
- \* Elemental Costs: \_\_\_\_\_
- \* Activity Costs: \_\_\_\_\_
- \* Others  
(Please Specify): \_\_\_\_\_

**Ans** The study reflected that in case the reports were available the readers might be as follows:

- Profit and loss - contract manager or contract top management.
  - Elemental cost - site manager or quantity surveyor. or activity cost.
- 

c) Would you use the feedback of the actual costs from previously completed project to help your future estimating ?

- \* In all cases
- \* For certain significant contract
- \* Just keep up the previous data
- \* No definitive policy on that
- \* Seldom
- \* No



**Ans** The answers revealed that the actual costs of all previously completed projects would be recorded in certain formats. In most cases it would be reflected as an overall profit and loss or the loss and loss of certain major trades. But those feedback information might not be detailed enough to be used for future estimates.

---

d) How do you manage the actual cost feedback data ?

- \* Put into Computer
  - \* Put it into the departmental working manual
  - \* Group in written index files
  - \* Keep in files as their original status
  - \* Others (please specify)
- 

**Ans** The study indicated that for those significant profit and loss information would be kept as confidential. Other cost information would be kept as their original status.

---

#### 3.6.4.5 Material Control

a) Do you have a master procurement schedule ?

- \* In all cases
- \* For certain significant contracts
- \* No definitive policy on that
- \* Seldom
- \* No

**Ans** Most answers selected 'in all cases'.

---

b) How often would you update your master material procurement schedule ?

- \* Occasionally, depend on the management requirements
- \* Pursuant to the contract requirements
- \* Monthly
- \* Fortnight
- \* Other (please specify) \_\_\_\_\_

**Ans** The study indicated that contract and management requirements were the main factors in determining the intervals of updating for material procurement schedules.

---

c) *Who is responsible for updating the master material procurement schedule ?*

*(cross out to show whether to be on site or at head office)*

- \* Contract Manager*
- \* Project Manager (On Site/Head Office)*
- \* Planning Engineer (On Site/Head Office)*
- \* Project Quantity Surveyor (On Site/Head Office)*
- \* Other (please specific) \_\_\_\_\_*

**Ans** Responses to this question were various from project manager to project quantity surveyor or site engineer. But it reflected that the job was carried out on site rather than at the head office.

---

d) *Who on site is responsible for the material control ?*

- \* Site Agent*
- \* Site Quantity Surveyor*
- \* Site Engineer*
- \* Site Clerk*
- \* Other (please specific) \_\_\_\_\_*

**Ans** The study revealed that all the site staff mentioned in the question should have certain contributions to site material control.

---

e) *Do you have any procedures on site to check and count the quantity of material delivery by the subcontractors from store to working area ?*

- \* In all cases*
- \* For certain significant contracts*
- \* No definitive policy on that*
- \* Seldom*
- \* No*

**Ans** Most answers indicated that there were no definitive policy on such kind of checking. For some cases of involving certain expensive items or untrusting on the subcontractor, spot checking might be taken.

---

#### 3.6.4.6 Quality Assurance Implementation

a) Does your company intend to implement a quality assurance standard ?

- \* If yes, which standard to be applied \_\_\_\_\_.
- \* If yes, how long does your company plan to successfully get the validation \_\_\_\_\_ months.
- \* To be decided later.
- \* No.

**Ans** Nearly all contractors indicated their positive attitudes toward the implementation of quality assurance standard. The time schedule of implementation was ranged from 12 months to 18 months.

---

b) What are the main difficulties you consider in the implementation of quality assurance system ?

(You could have more than one choice).

- \* Prepare quality documents.
- \* Implement work procedures.
- \* Implement internal audits.
- \* Implement equipment calibrations.
- \* Carry out staff training.
- \* Taking records.
- \* Comply with the documentation works.
- \* Others (please specific) \_\_\_\_\_

**Ans** The study indicated that all the above items were the potential problem areas and it was difficulties to compare from each other. But the most significant hardness would be the implementation of procedures and the recording of such implementations.

---

#### 3.6.4.7 Information Control and Communication between Head Office and Sites.

**Ans** For the sake of simplicity, the mean of each answer if applicable is stated in the schedule directly, but comments will be added at the end of each question if applicable.

Fill in the following schedules regarding the details of information reported from site to head office.

Note: Interval: means how long in days such information would be reported from site.

From: means who is responsible to report such information from site.

To: means who is in the head office to receive such information.

Format: means the format of presentation in reporting such information i.e. chart, pre-defined form and description etc

How Long to Get: means how long to get the information on site in terms of mandays by the site staff.

a) Description of work progress on site.

| <i>Details</i>                                            | <i>Interval<br/>(in days)</i> | <i>From<br/>(Site)</i> | <i>To<br/>(H.O.)</i> | <i>Format</i> | <i>How<br/>Long<br/>to Get</i> |
|-----------------------------------------------------------|-------------------------------|------------------------|----------------------|---------------|--------------------------------|
| Completed Activities                                      |                               |                        |                      |               |                                |
| On-going Activities                                       |                               |                        |                      |               |                                |
| Activities to be done in the near future (i.e. next week) |                               |                        |                      |               |                                |

**Ans** The study showed that in general there was no intention to have any constant communication between the head office and the site for the work description, but the information would be recorded in the daily reports, progress charts or minutes of meetings. In normal practice future activities would not be recorded and reported.

---

b) Does the report from the site for the above information include the time taken by the direct resources in labour and plant for the corresponding activities ?

- i) Yes
- ii) No
- iii) Subject to the requirements: (please specify.)

---

Ans In fact, this information should be included in the daily reports.

---

c) Materials on site with description and quantities:

| Details   | Interval<br>(in days)    | From<br>(Site)    | To<br>(H.O.)   | Format          | How<br>Long<br>to Get |
|-----------|--------------------------|-------------------|----------------|-----------------|-----------------------|
| Ordered   | Depends on the situation | Assigned person   | Purchaser      | Telephone       | 1 to 2 mandays        |
| Delivered | Ditto                    | Store keeper      | Account        | Delivery notes. | 1 manday              |
| Used      | Ditto                    | Quantity Surveyor | Not applicable | Interim payment | 2 to 7 mandays        |
| In Stock  | 3 months to half year.   | Store Keeper      | Not applicable | Forms           | 3 to 10 days          |

d) External information received on Site: (N.A. - not applicable)

| Details             | Interval<br>(in days) | From<br>(Site) | To<br>(H.O.) | Format | How<br>Long to<br>Get |
|---------------------|-----------------------|----------------|--------------|--------|-----------------------|
| Drawings            |                       |                |              | N.A.   | N.A.                  |
| Letters             |                       |                |              | N.A.   | N.A.                  |
| Memos               |                       |                |              | N.A.   | N.A.                  |
| Instructions        |                       |                |              | N.A.   | N.A.                  |
| Verbal Instructions |                       |                |              | N.A.   | N.A.                  |
| Variation Order     |                       |                |              | N.A.   | N.A.                  |

**Ans** The study reflected that most external information were handled on site. But in case of letters involved, they would be posted to the head office since most sites were no postal services at construction stage. But in Hong Kong most sites were equipped with fax for instant communications between the head office and the construction sites.

---

**e) Subcontractors performance:**

| <b>Details</b>                                                        | <b>Interval<br/>(in days)</b> | <b>From<br/>(Site)</b> | <b>To<br/>(H.O.)</b> | <b>Format</b> | <b>How<br/>Long<br/>to Get</b> |
|-----------------------------------------------------------------------|-------------------------------|------------------------|----------------------|---------------|--------------------------------|
| Work done description                                                 |                               |                        |                      |               |                                |
| Resources allocation for the work done                                |                               |                        |                      |               |                                |
| Plants delivered on site.                                             |                               |                        |                      |               |                                |
| Number of resource on site without allocation to the work activities. |                               |                        |                      |               |                                |
| Works to be carried out in the near future (i.e. next week)           |                               |                        |                      |               |                                |

**Ans** According to the study, in most construction contracts all the above information would be recorded in the daily reports. Such information not just have to be submitted to the head office but also to the contract supervisor pursuant to the conditions of contract.

---

**f) Plant Allocation:**

| <i>Details</i>                                              | <i>Interval<br/>(in days)</i> | <i>From<br/>(Site)</i> | <i>To<br/>(H.O.)</i> | <i>Format</i> | <i>How<br/>Long<br/>to Get</i> |
|-------------------------------------------------------------|-------------------------------|------------------------|----------------------|---------------|--------------------------------|
| Plants required.                                            |                               |                        |                      |               |                                |
| Plants arrived.                                             |                               |                        |                      |               |                                |
| Plants Idling.                                              |                               |                        |                      |               |                                |
| Plants allocation<br>to the<br>corresponding<br>activities. |                               |                        |                      |               |                                |

**Ans** Same as item e) the above information should also be recorded in the daily reports. For those projects involving heavy construction plant, communication procedures would be arranged for the plant deployments

---

**g) Direct Labour Allocation:**

| <i>Details</i>                                                     | <i>Interval<br/>(in days)</i> | <i>From<br/>(Site)</i> | <i>To<br/>(H.O.)</i> | <i>Format</i> | <i>How<br/>Long<br/>to Get</i> |
|--------------------------------------------------------------------|-------------------------------|------------------------|----------------------|---------------|--------------------------------|
| Direct labour<br>required.                                         |                               |                        |                      |               |                                |
| Direct labour on<br>site                                           |                               |                        |                      |               |                                |
| Direct labour<br>allocation to the<br>corresponding<br>activities. |                               |                        |                      |               |                                |

**Ans** Similar to item e) and f) the above information should also be stated in the daily reports.

---

*h) List the specific information required from the site at regular intervals for your company accounting purpose.*

| <i>Details</i>                            | <i>Interval<br/>(in days)</i> | <i>From<br/>(Site)</i> | <i>Format</i>      | <i>How Long<br/>to get</i> |
|-------------------------------------------|-------------------------------|------------------------|--------------------|----------------------------|
| Petty Cash                                | 30                            | Q.S.                   | Forms              | N.A.                       |
| Main Contract Interim Payment Certificate | 30                            | Q.S.                   | Forms              | 2-7 mandays                |
| Delivery Notes & Invoices                 | 30                            | Q.S./StoreKeeper       | Original Documents | Depends on Verification    |
| Subcontract Interim Payment Certificate   | 30                            | Q.S.                   | Forms              | 1-5 mandays                |
|                                           |                               |                        |                    |                            |

*i) List the specific information required from the site at regular intervals for your management functions. (Apart from apart from the normal progress and cost reports mentioned in the other sections of this questionnaire).*

| <i>Details</i>                                            | <i>Purposes</i> | <i>Interval<br/>(in days)</i> | <i>From<br/>(Site)</i> | <i>Format</i> | <i>How Long<br/>to Get</i> |
|-----------------------------------------------------------|-----------------|-------------------------------|------------------------|---------------|----------------------------|
| Contingency Dayworks                                      | Performance     | 30                            | Q.S.                   | Form          | Daily routine job          |
| Site Overhead Cost                                        | Cost Control    | 30                            | Q.S.                   | Form          | Daily routine job          |
| Minutes of Meeting for Internal Site Management Meetings. | Performance     | 30                            | Site Manager           | Minutes       | 2 to 5 days.               |
| Minutes of Meeting for External Progress Meetings.        | Performance     | 30                            | Site Manager           | Minutes       | Prepare by external party  |
|                                                           |                 |                               |                        |               |                            |

*j) List the specific information required from the site at regular intervals or at the completion of contract for your estimation department.*

| <i>Details</i> | <i>Purposes</i> | <i>Interval<br/>(in days)</i> | <i>From<br/>(Site)</i> | <i>Format</i> | <i>How<br/>Long<br/>to Get</i> |
|----------------|-----------------|-------------------------------|------------------------|---------------|--------------------------------|
|                |                 |                               |                        |               |                                |
|                |                 |                               |                        |               |                                |
|                |                 |                               |                        |               |                                |
|                |                 |                               |                        |               |                                |
|                |                 |                               |                        |               |                                |
|                |                 |                               |                        |               |                                |
|                |                 |                               |                        |               |                                |



Ans Most respondents reflected that the above information were not required.

---

**k) Details of the monthly valuations**

| Details                                      | Do on Site<br>or<br>by Head Office | Whom is<br>responsible | Manual<br>or<br>Computer | How Long<br>to take<br>(mandays) |
|----------------------------------------------|------------------------------------|------------------------|--------------------------|----------------------------------|
| External<br>Valuation                        | Site                               | Q.S.                   | various                  | 3 to 7 mandays                   |
| Internal<br>Valuation<br>(Subcontracts)      | Site                               | Q.S.                   | various                  | 1 to 5 mandays                   |
| *** Break Down<br>***                        | *****                              | *****                  | ****                     | ****                             |
|                                              |                                    |                        |                          |                                  |
| Preliminaries                                |                                    |                        |                          |                                  |
| Work Done by<br>Direct Resources             |                                    |                        |                          |                                  |
| Work Done by<br>Domestic<br>Subcontractors   |                                    |                        |                          |                                  |
| Work Done by<br>Nominated<br>Subcontractors. |                                    |                        |                          |                                  |
| Claim for<br>Material on Site.               |                                    |                        |                          |                                  |
| Variations.                                  |                                    |                        |                          |                                  |
| Claims.                                      |                                    |                        |                          |                                  |
| Dayworks.                                    |                                    |                        |                          |                                  |

Ans Most of the above valuations were carried out on site and the responsibility of site quantity surveyor. The respondents found it difficult to fill in the break down details. Various standard software were used to assist in valuation exercises.

---

## 1) Details of the master programme updating.

| Details                                                    | Do on Site<br>or<br>by Head Office | Who is responsible              | Manual<br>or<br>Computer | How Long<br>to take     |
|------------------------------------------------------------|------------------------------------|---------------------------------|--------------------------|-------------------------|
| <i>For Submission</i>                                      | Depends on the situation.          | Planning Engineer               | various                  | 5 mandays to 10 mandays |
| <i>For Internal Use</i>                                    | Ditto                              | Ditto                           | Ditto                    | Ditto                   |
|                                                            |                                    |                                 |                          |                         |
| <b>*** Break Down<br/>***</b>                              | <b>*****</b>                       | <b>*****</b>                    | <b>Format</b>            | <b>*****</b>            |
| <b>&lt;Progress&gt;</b>                                    |                                    |                                 |                          |                         |
| <i>Work done by direct resources</i>                       | Site                               | Site Foremen                    | Manual Daily Report      | Routine Daily Job       |
| <i>Work done by domestic subcontractors</i>                | Ditto                              | Ditto                           | Ditto                    | Ditto                   |
| <i>Work done by nominated subcontractors.</i>              | Ditto                              | Ditto                           | Ditto                    | Ditto                   |
| <b>&lt;Plan&gt;</b>                                        |                                    |                                 |                          |                         |
| <i>Works to be carried out by direct resources.</i>        | Site                               | Site Agent or Planning Engineer | Sectional Programme      | 2-4 mandays             |
| <i>Works to be carried out by domestic subcontractors</i>  | Ditto                              | Ditto                           | Trade Programme          | Ditto                   |
| <i>Works to be carried out by nominated subcontractors</i> | Ditto                              | Nominated Subcontractor         | NSC Programme            | Ditto                   |

**Ans** The respondents commented that the workloads of information updating quoted were approximate assessments.

## m) Details of claim initiation.

| Type of Claims                              | Initiated by whom | What substantiations expected from site | Who is responsible to get the information on site | Format of the info. | How Long to Get |
|---------------------------------------------|-------------------|-----------------------------------------|---------------------------------------------------|---------------------|-----------------|
| Extension of Time.                          | Group decisions   | Programme. Daily report                 | See remark                                        | See remark          | See remark      |
| Loss and/or expense.                        | Ditto             | Daily report etc.                       |                                                   |                     |                 |
| Acceleration                                | Ditto             | Daily report etc.                       |                                                   |                     |                 |
| New Rates.                                  | Q.S.              | Quotation                               |                                                   |                     |                 |
|                                             |                   |                                         |                                                   |                     |                 |
| Claims against the nominated subcontractors | Site Manager      | Various                                 |                                                   |                     |                 |
| Claims against the domestic subcontractors  | Site Manager      | Various                                 |                                                   |                     |                 |

**Ans** The respondents found it difficult to present all the information in this schedule. Substantiation of claims had to rely on various types of information with proper records. The contributions to claims should rely on various management parties on site. The workload of getting claim substantiations

n) Follow up works in response to the claims or complains by others.

| Type of Claims or complains            | Responsible by whom in the company | What substantiations expected from site | Who is responsible to get the information on site | Format of the info. | How Long to Get |
|----------------------------------------|------------------------------------|-----------------------------------------|---------------------------------------------------|---------------------|-----------------|
| Liquidated damages.                    |                                    |                                         |                                                   |                     |                 |
| Workmanship.                           |                                    |                                         |                                                   |                     |                 |
| Poor progress.                         |                                    |                                         |                                                   |                     |                 |
| Not enough resources                   |                                    |                                         |                                                   |                     |                 |
|                                        |                                    |                                         |                                                   |                     |                 |
| Claims by the nominated subcontractors |                                    |                                         |                                                   |                     |                 |
| Claims by the domestic subcontractors  |                                    |                                         |                                                   |                     |                 |

**Ans** The respondents expressed that in response to the claims by others it was important for the site management to have proper records to defend, and the timing of response should also be important.

### 3.6.4.8 Overall Comments

a) Generally what is your personal opinion of the effectiveness of your current project time control systems ?

- \* Excellent
- \* Efficiency
- \* Satisfactory
- \* Workable
- \* Generally fair
- \* Still Areas to be improved
- \* Disappointing

( Please also fill in the degree of confidence about your choice by ticking the following space.)

not sure \_\_\_\_\_ sure

**Ans** Most respondents expressed confidently in satisfying with their existing system.

b) Generally what is your personal opinion on the effectiveness of your current project cost control systems ?

- \* Excellent
- \* Efficiency
- \* Satisfactory
- \* Workable
- \* Generally fair
- \* Still Areas to be improved
- \* Disappointing

( Please also fill in the degree of confidence about your choice by ticking the following space.)

| | | | | | | |  
 not sure sure

**Ans** Most respondents considered their existing system workable.

c) Do you have a centralised company policy which has been applying in all your projects for construction management ?

- \* Yes, in all cases
- \* No, it is to be decided individually.

**Ans** Most class 'C' or above contractors indicated that they had a centralised company policy but still flexibilities were allowed for certain situations. It was further revealed that due to the complicated issues involved in construction projects site management quality should be more important than company policy.

d) Do you have a periodical review on your current management policy or system for the evaluation of its effectiveness ? If yes, approximately how often you will do that ?

- \* not applicable  
\*                      month/months  
\* Not fixed. To be done in case of necessary.

**Ans** Most respondents selected the last choice.

e) What is your opinion regarding your current use of computers in construction management ?

- \* Excellent
- \* Efficiency
- \* Satisfactory
- \* Workable
- \* Generally fair
- \* Still Areas to be improved
- \* Disappointing

( Please also fill in the degree of confidence about your choice by ticking the following space.)

| | | | | | |  
 not sure . sure

**Ans** Most respondents certainly considered that there were still areas to be improved.

f) Do you think you have been using the full potential of your existing computer systems for construction management? Please express your assessment by the selection from the following percentages in terms of the available functions:

(Please tick your answer within the following space.)

A horizontal number line representing percentages from 0% to 100%. The line is divided into 10 equal intervals by vertical tick marks. The first tick mark is labeled 0%, the fifth tick mark is labeled 50%, and the tenth tick mark is labeled 100%.

\* Other comments:

**Ans** Most answers showed less than 50%.

g) Do you feel that it is difficult to train your staff to use computer systems for construction management ?

(Please tick your answer within the following space.)

| | | | | | |  
 Very Fair Very  
 Difficult Easy

\* Others comments:

**Ans** Most respondents selected between 'very difficult' and 'fair'.

h) Do you feel that it is difficult to find staff or expertise with satisfactory expertise in computerisation for construction management ?

(Please tick your answer within the following space.)

| | | | | | |  
 Very Fair Very  
 Difficult . Easy

\* No Idea

**Ans** Most respondents selected between 'very difficult' and 'fair'.

i) What is your opinion on the use of daily report as an instrument of project control data feedback ?

The implementation of this idea is in conjunction with the use of micro-computer on site as a work station, which is also connected with the computer system at the head office through the telephone line and modem. Dedicated site staff will input the information as usually stated in the daily report similar to their current practice. The daily report print out from the machine not only acts as the present hand written daily report with one copy forwarding to the Architect/Engineer, but also simultaneously those progress information will send back to the head office through the modem as the direct feedback of project control data which is accessible by the central planning and control system.

The advantage of this system is to enable the management keep tracking the actual time and cost of the project in activity level for directly comparing to the plans. With the feedback in activity level, it could be helpful and significant for future planning and estimating.

- \* Good Idea
- \* Sounds Workable
- \* Very Difficult to Implement
- \* Impossible

(Those who choose the above answers, please also fill in the degree of confidence about your choice by ticking the following space.)

| | | | | | |  
 not sure sure

- \* No Idea  
\* Other comments

**Ans** Most respondents felt that the idea sounds workable.



### 3.7 Summary and Observation

The study described in this chapter reflects the existing practices of construction management of the contractors in Hong Kong. The format of the study includes the questionnaire survey following by the corresponding interviews. The findings through this study in conjunction with the new developments described in the next Chapter 4 of this thesis, have been applied to the development of the model of construction management described in Chapter 6. The existing construction management practices are summarised as follows:

- a) The Hong Kong contractors in the public sector work in a highly competition market, under which a tender administration system is adopted by the Government. The administration system classifies the contractors by limiting their eligibility of tendering according to the budget sum of projects, by which their financial, technical and managerial capacities are taken into account. It is significant that the current performance in a contract does not just affect the contemporary profit and loss of that particular contract but also the potential of future tenders. In addition, the participation of foreign contractors not only uplifts the competition in tender prices but also the challenges of management enhancement.
- b) British procurement systems and contractual arrangements dominate the construction industry of Hong Kong, through the influence of Hong Kong as a colony of British for over 150 years. Most professional and academic training of the industry rely on the British institutes and connections. In pace of the change of Hong Kong to be an international city and the approach towards 1997, more influences from other practices have been penetrating the economic and the investment environment of Hong Kong. However, this research is concentrated on the construction management of contractors in the public sector, where most policies are under the control of Government and British practices are prevailing.
- c) The estimating department of most contractors has to work under comparatively high workloads, in response to an often high volume of tender documents for each tender. Lump sum bills of quantities contractual arrangements are common in public contracts, for which subcontract orientated unit rate estimating is the common practice. The use of previous feedback information from those completed projects is inadequate. Most information handling for estimating is manual, with the assistance of common commercial packages.

- d) The information from estimating department to support the post-contract management is limited and unsystematic. Most information for post-contract management has to be built up from script through the contract documents. The use of information technology to achieve the integration of information in this aspect is extremely inadequate.
- e) The use of computers in planning and control for construction projects has been adopted by the contractors for a long time, but the full functions of those systems are often not being fully used. The motivation and initiation for the use of computerised planning systems always come from the requirements of conditions of contract, rather than a centralised company policy on that. It is common for the system to be used for presentation purpose rather than providing information to support decision makings. In view of the dynamic nature of construction activities and the involvement of other parties, the functions of progress updating and control provided by those computer systems are ill-adapted.
- f) High volume of information handling is expected in most construction projects due to increased heavy co-ordination duties and the paper work burden on the main contractors. Still information control on site relies on manual procedures. High efficiency of communication can be achieved through the telecommunication environment of Hong Kong such as the use of fax, telephone, mobile telephone and pager. But still paper work are used generally on site and this may lead to the difficulties of future retrieval of information, without a proper application of information technology.
- g) Material controls on site are generally inadequate leading to a situation of high wastage in the industry. For expecting a better profit margins, main contractors prefer centralised material purchasing and the corresponding works are carried out by labour-only subcontractors. This arrangement leads to the difficulty of controlling materials distributions on site. Re-measurement from the updated drawings for material procurements is a heavy workload for site quantity surveyors.
- h) Various cost control systems, either by computer or manually, are applied by the contractors in a sort of account-orientated mode. There is a tendency for the cost control activities to be carried out on site, but

the account practices are still controlled by the head office. Most contractors would consider the performance of their cost control systems to be satisfactory. It is due to the heavy subcontract orientated situation for construction works, in which under the accounting principle the main contractor acts as a broker or agent for the subletted works.

- i) The practice of traditional site management dealing with matters among the various parties involved, is usually in a mode of compromise and negotiation in line with the mentality of Chinese culture. But with the participation of more overseas contractors, consultants and investors, more formalised procedures are applied in the management practices. In response to these changes, information management systems with comprehensively integrated functions are preferred by the contractors. The contractors appreciate the contributions of information technology for enhancing management standard and recognize the potential of improvements in their existing practices.
- j) In terms of the implementation of quality assurance, most contractors, except one or two sophisticated corporations, are still in the teething stage. The contractors recognize the significance of quality assurance to their long term establishment in the construction industry. They have to face the challenge between high competition and extra expenditures due to the implementation of quality assurance, balanced with their survival in the industry and the break even of quality and cost. More details in this aspect are explained in Chapter 4 of this thesis.

### 3.8 Conclusions

This chapter has established that the construction industry is a vital element of a vigorous economy. The structure and practices of the industry are in many ways similar to those of the UK, from which they are derived, but in many ways they are unique to Hong Kong.

The study of practices within some of the contractors shows clearly that a very active and progressive industry, surrounded by advanced communications technology, has been slow to adopt modern information technology as a matter of routine. There is much scope for the application of systems such as the one

developed in this thesis, and there is some encouraging indications that they will be considered favourably by the industry. The next chapter describes the relevant developments.

## **4 New Developments in the Hong Kong Construction Industry**

### **4.1 Introduction**

This chapter describes the recent developments in the Hong Kong construction industry which have significant impact on construction management practices. Such new developments are related to the public sector clients of the construction industry. Relating to the scope of this research the study has confined to the following aspects:

- a) Quality assurance;
- b) Performance Assessment Scoring System in housing contract; and
- c) New infrastructure developments.

The details of each issue will be described in the three sections of this chapter. The methodology of the study was through literature reviews and interviews.

With the findings of the existing management practice described in Chapter 3, and the new developments described in this chapter which are used to project the impact of future management practices, the aggregate effects of these perceptions are adopted to develop a model of construction management described in next Chapter 6.

## **4.2 Quality Assurance in Construction**

### **4.2.1 Quality Assurance in Hong Kong**

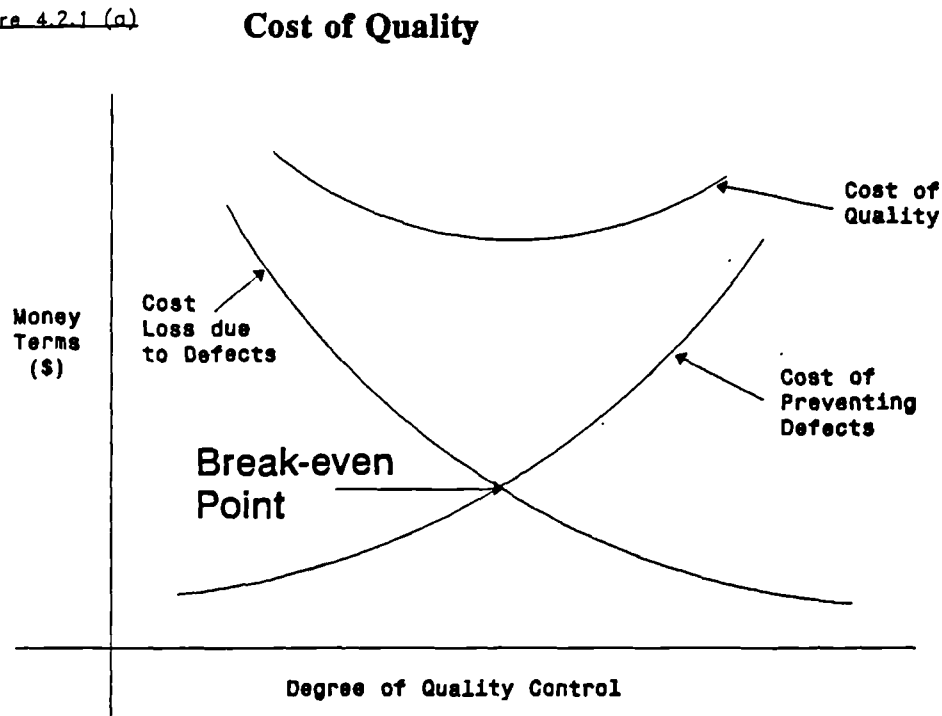
A world-wide change is taking place demanding higher quality products in all industries. This affects all the major developed countries as a result of the influence of the international business environment. Higher quality is not an unreasonable demand but can prevent the society suffering from poor quality. The cost of quality (also termed quality costs) concept has been developed and used in the manufacturing industry (Feigenbaum 1983; Juran 1962; ASQC 1984). Conceptually, quality costs have been defined as "all costs incurred by the business because the product was not designed, produced, or serviced in a perfect manner during the initial cycle" (Simmons 1970). A broader view includes costs to the consumer (Feigenbaum 1983) and even to society (Sullivan 1986).

Gosselin (1991) defined the cost of quality comprises of cost of defects and cost of prevention:

$$\text{Cost of Quality} = \text{Cost of Defects} + \text{Cost of Prevention}$$

The break-even point is the lowest 'cost of quality' which is also defined as 'conformance' according to Gosselin. The following diagram Fig 4.2.1 (a) illustrates this concept.

Figure 4.2.1 (a)



Gosselin further emphasised that the costs of lack of quality included explicit elements and implicit elements. The explicit elements are the visible area, like the top of an ice-berg floating on water. They include accidents, litigations and necessary repair work due to bad quality. The implicit elements such as wasted time in organisation and production, are the invisible area like the bottom of the ice-berg sinking under the water, but it is the major part. This awareness makes more governing bodies and professional institutes pay more attention on quality.

The Hong Kong Government, for influencing and convincing the manufacturers' attitudes towards quality management, launched on 1st March 1990 a Quality Assurance Campaign. The campaign, which lasted for more than three years, emphasized that Hong Kong needs quality to be profitable. It was planned to support the industry and to encourage businesses taking

up the quality challenge. The campaign message was widely publicized by means of quality management seminars, workshops and a wide range of promotional and informative materials. The pursuit of quality in the manufacturing industry might prove to be one of the most important challenges to be faced in the 1990s.

Inevitably such a change also affects the construction industry. Specifically, that change is the introduction of quality assurance concepts to contractors, design consultants, materials suppliers and government departments.

#### **4.2.2 Quality Assurance and Quality Standards**

The U.K. Construction Industry Research and Information Association (CIRIA) Report 109: 1985 defines 'Quality Assurance' as a systematic way of ensuring that organised activities happen in the way they are planned. It is a management discipline concerned with anticipating problems and with creating the attitudes and controls which prevent problems arising.

BS 4778:1987 and ISO 8402: 1986 define 'Quality Assurance' as all those planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality. The implementation of quality assurance should be closely related to the selection of quality standard.

'Quality standards' which are also called 'Quality system standards', identify the elements of quality systems and specify the requirements appropriate to each quality assurance. BS 4778:1987 and ISO 8402: 1986 define 'Quality system' as the organisational structure, responsibilities, procedures, processes and resources for implementing quality management. 'Quality Management' is defined as the aspects of the overall management function that determines and implements the quality policy. 'Quality Policy' is defined as the overall quality intentions and direction of an organisation as regards quality, as formally expressed by top management.

The above definitions give a clear outline for the application of quality assurance, which starts from a 'policy' imposing a 'standard' through the 'system' with the help of 'management'. For the implementation of quality assurance, it is therefore crucial to choose and base the control on a well-recognized quality standard.

BS 5750 is the UK national standard for quality systems, issued in four parts:

- Part 0      Principal concepts and applications.
  - Section 0.1: Guide to selection and use.
  - Section 0.2: Guide to quality management and quality system elements.
- Part 1      Specification for design/development, production, installation and servicing.
- Part 2      Specification for production and installation.
- Part 3      Specification for final inspection and test.

BS 5750 is supported by BS 4778:1987 "Quality Vocabulary" which provides the definitions of the terms commonly use in the quality context. Regarding quality standards in construction industry, BS5750 is an important reference.

#### 4.2.3 Housing Contracts and ISO 9000

Hong Kong Housing Authority (HKHA) was established in 1972, responsible for developing and managing public housing. As part of the Hong Kong Government's Civil Service, HKHA comprises three Branches covering Construction, Housing Management and Administration. The Construction Branch is responsible for managing the construction and maintenance programmes. Bates (1991), in the capacity of Senior Assistant Director of HKHA, disclosed that at any one time there are between 120,000 to 150,000 flats under construction and the annual output is over 40,000 flats with an annual capital expenditure of HK\$ 9,500 million. In 1989 the Authority built a record 53,256 flats and in 1990 construction output of some 53,000 flats remained close to the record level. The construction output of housing projects acts a significant proportion in the overall turnover of construction projects for the public sector. Any policy change on housing contracts should have crucial impacts on the contractors in public sector.

The construction standard of housing projects in 1960s had left a bitter legacy in the form of poorly constructed building, by which the occupants suffered from inconvenience and frustration living. The remedial work was expensive and time-consuming and in some extreme cases defective buildings



had to be demolished. In 1986, 26 public housing blocks with only 20 years building life were re-developed due to the poor quality of concrete structure.

HKHA has realised that production targets in terms of quality should be as important as the quantities. In April 1990, HKHA published the 'Rule for the Administration of the List' for the 'Housing Authority List of Building Contractors'. Rule No. 13 stated that:

"Contractors must initiate and operate quality management systems. All contractors employed on Housing Authority contracts will be required by 31st March 1993 to have in operation approved Quality Management and Quality Assurance Systems conforming generally to ISO Guides 9000 to 9004 and accredited by the Hong Kong Quality Assurance Agency"

This announcement had a great impact to the Hong Kong construction industry because at that time none of the contractors registered in Hong Kong possessed an ISO 9000 certificate. Therefore, ISO 9000 has become the quality system standard in Hong Kong. For housing contracts, Hong Kong is the only place in the world making contractor certification for quality assurance compulsory.

At the same time, April 1990, a HK\$ 2 million consultancy study was initiated by HKHA to assist contractors to introduce a quality management scheme for ensuring the quality of public housing. The programme for improving quality in construction was well supported by Hong Kong Construction Association (HKCA) and the consultancy study jointly funded by the Authority and the HKCA. As a result the Steering Group on External Quality Management has been formed consisting of representatives from the Housing Department, and three members from the HKCA. The consultants organised a major programme to survey the quality management philosophies and methods of the industry, with the objective of developing a strategy for implementing effective quality management. The consultancy study was completed and published in the summer 1991. The recommendations made by the consultants are summarised below: -

#### **Main contractors**

Need for awareness of quality by executives, training at all levels, appointment of a Quality Co-ordinator, setting up proper quality systems procedures, improving site tidiness

and better supervision. Registers to be kept of both approved sub-contractors and suppliers and their performance recorded.

#### **Sub-contractors**

Need for general awareness and improvement in site quality.

#### **Suppliers**

Concrete suppliers need to register under ISO 9000. Material suppliers will have to produce products which meet the specification first time.

#### **4.2.4 ISO 9000 Standards**

With the announcement of the HKHA quality requirement, the ISO 9000 standard became an important reference for quality assurance in the Hong Kong construction industry. Recognized by the United Nations and its member Governments as the specialized agency for international standardisation, the ISO 9000 series of quality system standards were first published by the International Organization for Standardisation (ISO) based in Geneva. The standards were based on the earlier British Standard BS 5750 with input from other countries such as USA. In 1991, an equivalent European Standard EN 29000 was issued and adopted by the EEC countries. In the U.K. the new BS 5750 was completely rewritten to conform to the international standard ISO 9000. The ISO 9000/EN 29000/BS 5750 standards can be seen as the accepted world-wide quality system standards for the construction industry.

ISO 9000 series contain the following fundamental documents:

- ISO 9000:      Quality management and quality assurance standards - Guideline for selection and use.
- ISO 9001:      Quality systems - Model for quality assurance in design, development, production, installation and servicing.
- ISO 9002:      Quality systems - Model for quality assurance in production and installation.
- ISO 9003:      Quality systems - Model for quality assurance in final inspection and test.

ISO 9004:       Quality management and quality system elements  
                  - Guidelines.

ISO 9000 together with ISO 9004 gives guidance to all organizations for quality management purposes, whereas ISO 9001, 9002 & 9003 are quality system models for use by organizations where appropriate.

ISO 9001 would be the standard adopted by architects, engineers and design consultants as it is the only one of the series that includes design. It is the standard that the major concrete producers in Hong Kong will use and be certified against. Nominated sub-contractors with design capability will be certified under ISO 9001 and bear responsibility for designs undertaken. The certified main contractor should be responsible for the quality performance of its sub-contractors and suppliers and in ensuring that they are committed to the standards of quality as contained in the contract specifications.

ISO 9002 is the standard for the majority of major contractors and sub-contractors.

#### **4.2.5 Contractors Views on Quality**

Yeh (1991), an owner of one of the leading local contractors established more than 55 years in Hong Kong, expressed the traditional point of view on quality, based on his more than 35 years experience in the local construction industry, the details of which are summarised as follows:

- a) corporate message;
- b) commitment of staff;
- c) staff stability;
- d) common understanding with the subcontractors;
- e) make the execution job easier for the staff;
- f) co-operation and trust amongst the important players; and
- g) motivate the staff and subcontractors.

Yeh, reflecting the views of a traditional Chinese local contractor, considers that the criticality of achieving quality should be through people. This view is in line with the concept of most quality standards. In addition, procedural approaches with proper records are also emphasised.

Mok (1991), as the contemporary Chairman of the sub-committee called 'Government Buildings Committee' of Hong Kong Construction Association, stated the views of contractors on the impact of quality assurance. The Association comprises over 300 member firms and the membership is considered to be fully representative in terms of the range of sizes of contractors working in the industry. Mok's comments in representing the Association, reflect to a certain extent the concerns by the contractors on the practical issues of quality assurance implementation in Hong Kong construction industry. Mok's comments are summarised as follows:

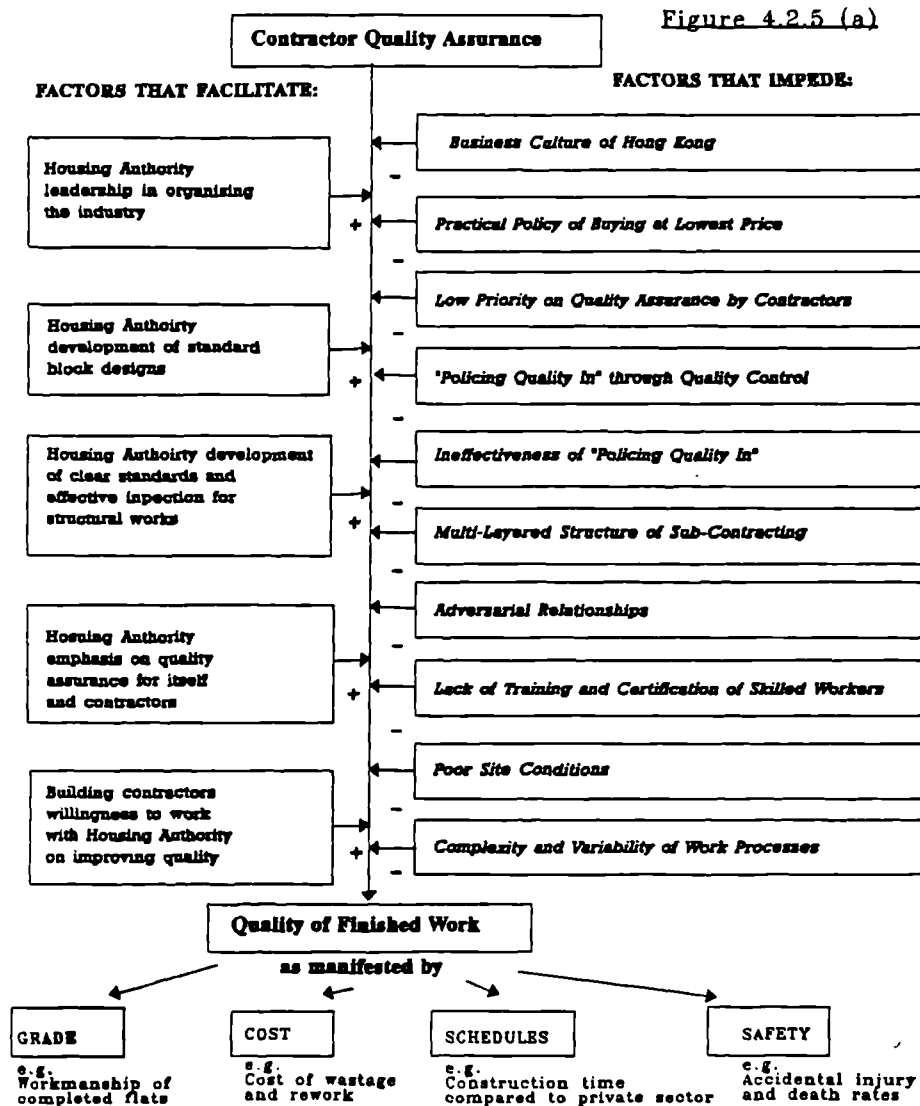
- a) The contractors agree with the need to improve quality in public and private sectors.
- b) Clients should pay the price for quality. The existing tendering practice of awarding contracts to the lowest bidder is in contradiction of this principle. Target price tender system should be applied, where the successful bidder is one who is closest to but not above the target and with satisfactory past performance in quality.
- c) Apart from the contractors, the design consultants including architects and engineers will need to introduce a QA system because many problems with quality arise from poor design. The same principle should be applied to specialist subcontractors and suppliers.
- d) In view of the multi-layer subcontracting practice is involved, it will be difficult for the domestic subcontractors to implement quality systems. Many of the proprietors of these firms are not well educated or not even properly trained as subcontractors. About 50% of them are not even able to read English.
- e) Construction works on site are not in a controlled environment, and is different to manufacturing industry with machines and producing products on a factory flow-line. Site environments increase the difficulties of the implementation of quality assurance in the construction industry.
- f) Due to the vast work-force and the large number of various trades and hired equipments on site, calibration, identification and traceability of all the measuring and testing equipments will be very difficult and tedious.

- g) In order to satisfy the requirements of most quality standards, there will be a lot of documentation, written procedures, checking and control forms and other paper work. Too much paper work may result in the site staff doing it as homework and signing the forms without actually following up the checking procedures.
- h) In terms of quality document control for removing obsolete documents, it will be extremely difficult for the main contractors to comply with the requirement of most quality assurance systems. This is due to the fact that drawings may be issued to subcontractors or sub-subcontractors to the points where replacements for amendment drawings may be unidentifiable. In addition, verbal instructions and variations across multi-drawings also increase the practical difficulties in document control.
- i) The quality requirements for handling, storage, packaging and delivery of materials on site may sometimes turn out to be difficult due to the restricted site conditions.
- j) Some contractors allow about 3% of the contract sum for remedial works during the defects liability period. With the application of quality assurance system it is expected to cut the remedial cost by half. It is generally believed that the additional cost of QA will be balanced the savings on wastage, and later savings on remedial measures for defects.

In view of the above practical problems, the Hong Kong Construction Association considered that a pure and ideal form of ISO 9002 may not work for the construction industry and a Code of Practice for the interpretation of ISO 9002 needs to be established for the Hong Kong construction environment. Hong Kong Construction Association in 1991 commissioned a consultant firm to draft a Code of Practice suitable for the local construction environment. In May 1992, the first issue of the Code of Practice was issued namely the Guidelines for Quality System Implementation and it was quoted as a guidance for contractors implementing of quality assurance system for certification to ISO 9000. The principles of this guide have been used in the design of a quality assurance system in this research and the details are described in Chapter 12.

Romagna (1991), as an important drafter for the Guidelines mentioned above, summarised the factors facilitating and impeding the effectiveness of quality assurance in the Hong Kong contractors as the following Figure 4.2.5 (a).

### Factors that Facilitate and Impede the Effectiveness of Quality Assurance by Building Contractors



### 4.3 PASS in Housing Contracts

In addition to the long term targets of HKHA for achieving quality, as an interim measure the Authority introduced its own independent list of building contractors in April 1990. In managing the contractor list, the Authority has established

an important principle that contractors who perform to the required standard will have more tendering opportunities. Therefore this requires the establishment of an objective means of assessing performance standard. For many years before the implementation of a systematic way of performance assessment, the Authority operated a performance assessment system based on the project staff's rating of the contractor's level of achievement in respect of materials, structure, labour, progress, safety etc. The disadvantage of such practice is its lack of a common scale of preset standards for performance assessments.

The Performance Assessment Scoring System (PASS) was introduced for the Housing Department's new building contracts at the beginning of 1990. The System is based on the Singapore Construction Industry Development Board's quality assessment scheme. In its initial form PASS is primarily used to measure the standard of work produced by the contractor. It was recognized that in order to help the Authority assess the contractor's performance and to provide constructive feedback to contractors, an assessment should be made to the contractor's standard and effectiveness of site management.

Accordingly a new PASS Management Assessment has been developed to measure the contractor's site management directly against definite standards, providing a fair means of comparing the performance of individual contractors. The Authority recognizes that without good site management it will be impossible for a contractor to consistently achieve the required standard of workmanship and complete the project on schedule. The results of the assessment will enable the Authority to have a clearer indication of the contractor's performance on individual contracts. This will provide further aid in deciding whether to promote or downgrade a contractor and in awarding preferential tendering opportunities.

PASS can also be viewed as a pre-practice to assist contractors to obtain accreditation under the International Standards Organisation Guide 9000. It is the policy of HKHA to maintain the execution of PASS after the end of March 1991 when the compulsory requirement of ISO 9000 certificate possession for the eligibility of contractors to tender is implemented. At that time, the eligibility of contractors to tender for housing contracts has to be controlled by both the ISO 9000 certification and PASS.

#### **4.3.1 Operation of PASS.**

In accordance with the updated PASS manual published in July 1992, PASS is divided into two parts, namely Output Assessment and Input Assessment. PASS will eventually be divided into three parts with the addition of assessment during the maintenance period which will be developed in the near future.

The structure of PASS is as follows:

##### **a) Output Assessments:**

- **Monthly Assessment for Domestic Blocks:**
  - Work Assessment
    - 1) Structural Works
    - 2) Architectural Works
    - 3) External Works
  - Other Obligation Assessment
    - 1) General Site Safety
    - 2) Site Security, Access and Building Material
    - 3) Health and Other Obligations
    - 4) Cleanliness and Care of the Works
    - 5) Block Related Safety
- **Quarterly Assessment for Non-domestic Blocks:**
  - Works Assessment
    - 1) Structural Works
    - 2) Architectural Works
  - Other Obligations Assessment
    - 1) Cleanliness and Care of the Works
    - 2) Block Related Safety
- **Substantial Completion Assessment:**
  - Works Assessment
    - 1) Architectural Works
    - 2) External Works
  - Other Obligations Assessment:
    - 1) Site Security, Access and Building Material
    - 2) Cleanliness and Care of Works

##### **b) Input Assessments:**



- 1) Management and Organisation of Work,
- 2) Resources,
- 3) Co-ordination and Control, Response to Instructions,
- 4) Documentation,
- 5) Progress.

**c) Maintenance Period Assessment:**

*(Remark: The Maintenance Period Assessment Scoring System is to be developed for implementation by the Housing Department. In the meantime, a document called 'Confidential Report on Contractors during Maintenance Period' is used for reporting and monitoring purpose.)*

**4.3.2 Detailed Description of Output Assessment**

Assessments are conducted at monthly and/or quarterly intervals according to the structure described in Section 4.3.1 above. There is no advance notice of the assessment, except half a day's advance notice for the contractor's representative to make himself available during the assessment. Choice of locations and spots are to be randomly selected. The assessment team should include the representative of the Contractor and the client's consultant who may be the Project Architect, the Project Engineer or the Building Service Engineer according to the type of assessment.

On reaching the sampling location, the team is to examine a particular selected spot against each item in the assessed factor and to judge whether the standard of work produced complies or does not comply with predetermined standards and tolerances. If the assessment standards are satisfied, that item of the assessed factor is to be given a tick on the standard assessment form. If not, a cross (x) is entered. For other obligations, the team is to give a grade A, B, C, D or NA for each of the item being assessed and record the given grade on the standard assessment form.

For the monthly output assessment, the maximum possible score is 100 marks. Other Obligations are allotted 20 marks. The other works aspects (Structural Works, Architectural Works and External Works) are allocated 80 marks.

Each factor of Structural Works, Architectural Works and External Works is allocated with an achievable point. For example the assessment of the structural aspects is divided into three stages with the following factors to be assessed:

**a) Caisson Works Stage:**

Working caisson factor  
Completed caisson factor  
Concrete quality and practice factor

**b) Substructural Works Stage:**

Substructural formwork and formation factor  
Substructural reinforcement and concreting factor  
Substructural finished concrete factor  
Concrete quality and practice factor

**c) Structural Works Stage:**

Formwork and falsework factor  
Reinforcement and concreting factor  
Finished concrete factor  
Concrete quality and practice factor

Criteria have been set up for the assessment of each factor. To permit some degree of scoring tolerance which is necessary for differentiating different levels of performance.

#### **4.3.3 Detailed Description of Input Assessment**

PASS manual edition July 1992 states that PASS management quarterly assessment (input assessment) is developed to measure the contractor's site management and progress directly against defined standards, and it provides a fair means of comparing the performance of individual contractors. The Manual also defines that the consideration of 'input' is the standard and effectiveness of site management. The Input Assessment is divided into five aspects as follows:

- a) Management & Organisation of works is allotted 10% of the total score. The factors covered by this aspect include the contractor's management structure and site planning.
- b) Resources is allocated to 20% of the total score. The factors covered by this aspect are labour, material and plant.

- c) Co-ordination and Control, Response to Instructions is allocated 30% of the total score. The factors covered by this aspect include the effectiveness in co-ordinating and controlling the Works, response to instructions, directives and remedial works.
- d) Documentation is allocated 15% of the total score. The factors covered by this aspect include the contractor's submission for material approval, payment applications and contractual claims etc.
- e) Progress is allocated 25% of the total score. The factors covered by this aspect include programme, work plans, progress of substructure, superstructure, finishes, building services and external works etc.

The assessment is made by giving a grading A, B, C, D or NA (not applicable) for each of the factors being assessed. The gradings are based on objective standards of attainment. In order to obtain a percentage score, the attainment levels are given a numerical value. A copy of the true assessment for the month September 1991 of the Tin Yiu Estate Phase II projects is enclosed herein as the Figure A of Appendix 4.

The assessment will be carried out every 3 months by the whole project team assigned to the project from the Housing Authority. Based on the contractor's submission, the assessment sheet will be completed at a formal meeting on site, attended by all project staff chaired by the project architect in the presence of the Senior Architect.

After the score sheets have been completed, the contractor's representative will be invited into the meeting and shown the completed assessment. Any particular shortcomings in the contractor's performance will be highlighted and discussed in the meeting with the contractor's representative. The contractor's comments are also to be included on the score sheets. The completed score sheets are then signed by the project team and by the contractor's authorised representative. The score sheets should then be returned to the head quarter of Housing Authority for entry into the computer database for processing. In the future it is expected a fully computerised system to be developed for the data transmission from sites to the Authority headquarter.

#### 4.3.4 Achievements of PASS

For this research an interview was conducted with Ms Ada Fung who is a Senior Architect of Housing Department and responsible for the administration of PASS. In addition to this interview, a number of discussions with the contractors regarding their reactions to PASS, have been taken place during the field survey interviews as described in Chapter 3. The reactions from both the Housing Department and the contractors to the implementation of PASS are summarised as follows:

- a) PASS is not a specific contractual requirement but is regarded as an assessment tool for the contract supervisor to assess the performance of contractor. The standard conditions of contract for housing contracts already empowers the contract supervisor to request the contractor to submit information as required. Currently there are about 60 to 70 construction projects implementing PASS at any one time.
- b) There is no concrete evidence proving that the implementation of PASS causes an increase in bidding prices. However, by awarding preferential tendering opportunities based on past performance, HKHA moves away from its traditional open tendering system towards a selective tendering system. Theoretically, selective tendering system may lead to an uplift of tender price. However from the client's overall point of view, the benefits to be gained from better quality achievement should balance the drawbacks of any possible uprisings in tender price due to selective tendering.
- c) The contractors react neutrally to the output assessment of PASS and consider that it is the client's right. For the input assessment, the contractors opine that it increases the burden of paper work on site. However it is generally accepted that the ability to do such paper work is a basic requirement, for which a competent contractor should have in the management of this scale of projects.
- d) Input assessments and output assessments are being assessed separately to produce two individual scores. The correlation of these two sets of scores proves that better site management in terms of information control leads to more satisfactory quality achievement. This proves one of the conclusions drawn by the UK Building Research Establishment (1987), research regarding quality on building sites, which stressed the importance

of management standard in terms of information control on site and the quality, as described in Section 2.4.1 of this thesis.

- e) The result of input assessments so far proves that competent contractors with adopting information technology have achieved higher scores in input assessments for which the relevant benefits come from the timing, precision, quality and presentation of information acquisition.

The study of the implementation of PASS through this research, reveals that the practice of PASS can lead to improved working procedures for ensuring that critical inspections and documentation are carried out. The most significant achievement of this practice is to increase the culture of quality on site.

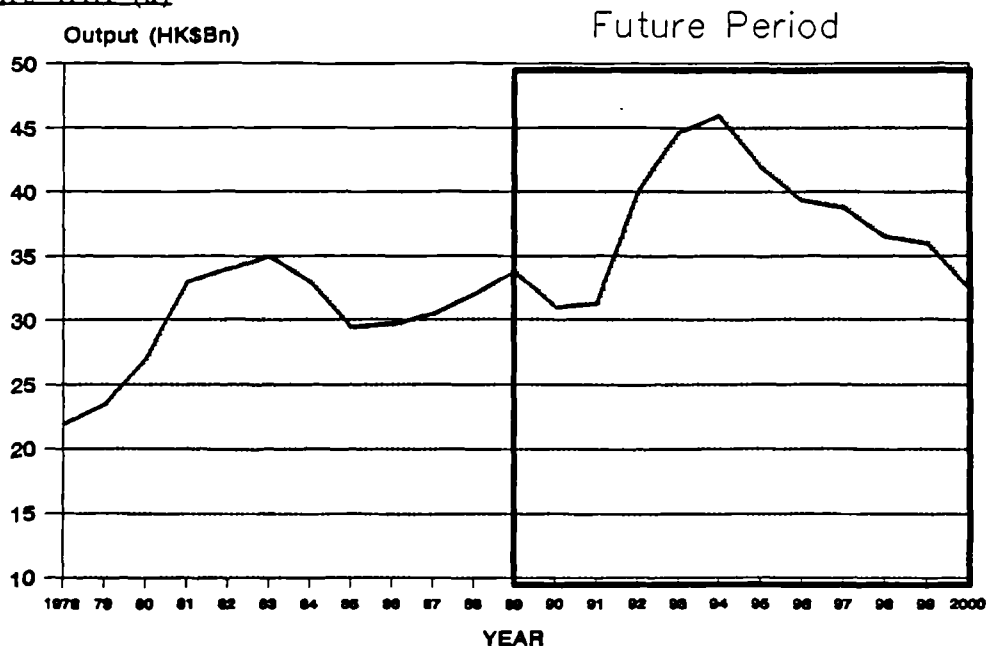
#### 4.4 New Infra-structure Developments in Hong Kong

##### 4.4.1 Overview on Public Sector Construction

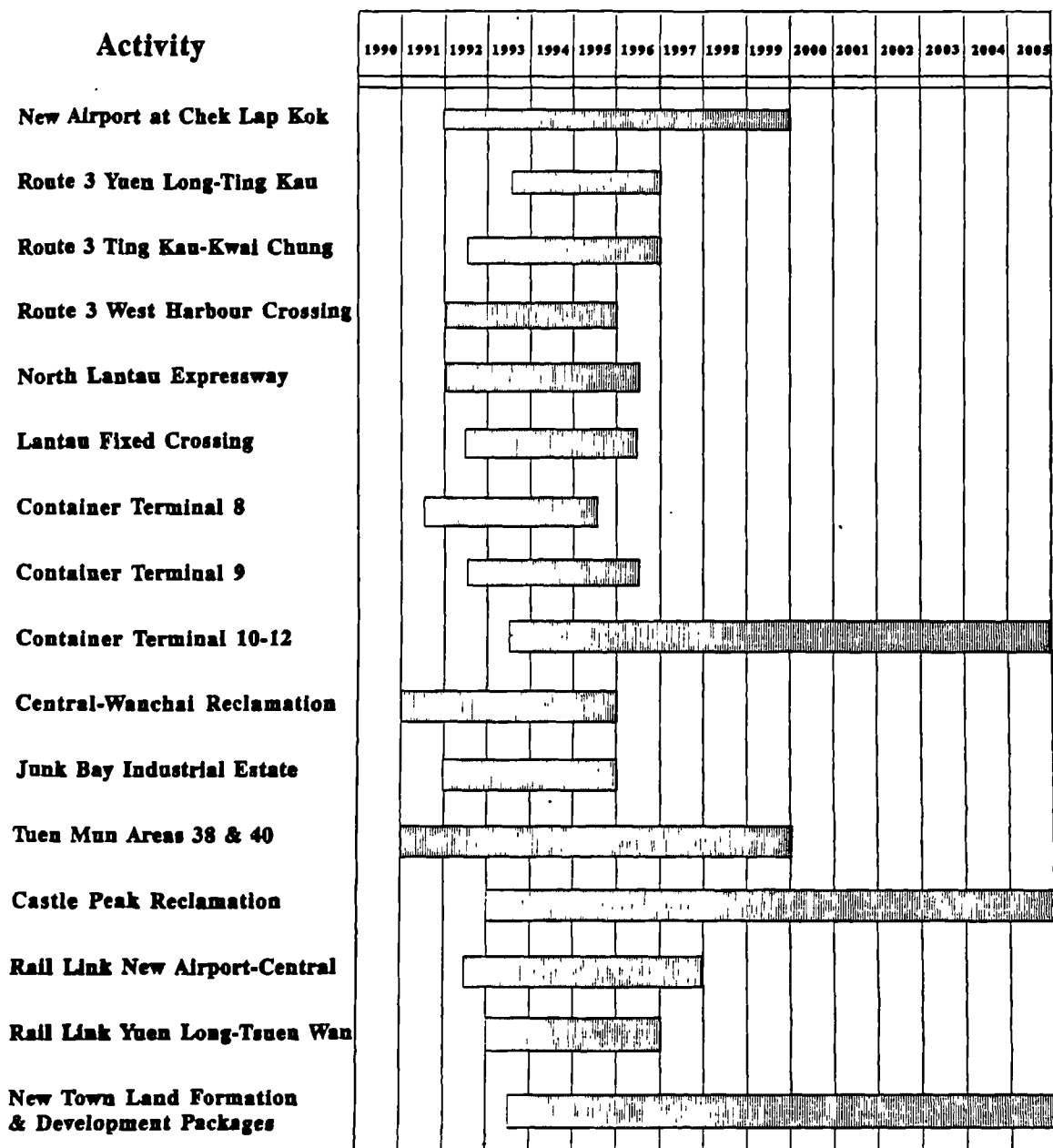
With the rapid economic development in Hong Kong and the fast economic growth in Pacific Rim, trade and communication between cities within the region, which Hong Kong serves as a centre, have been influential in forcing the existing infra-structure of Hong Kong to its full capacities. In response to this, starting in 1989 the Government announced various huge infrastructure development programmes. Fox et al (1990) summarised the construction output with future projections between 1978 to 2000 and the programme of relevant major construction packages. The details are shown in Figure 4.4.1 (a) and Figure 4.4.1 (b).

#### Hong Kong Construction Output with Future Projection (1978-2000) (Value at 1988 constant prices)

Figure 4.4.1 (a)



Notes: 1. Construction Output includes building, civil engineering, airport, ports and infrastructure works planned by the Government and the private sector (those works carried out at other minor construction site locations are not included)  
2. BSD Consolidation Labour & Material Index is adopted for constant prices adjustment

**Figure 4.4.1 (b)****Prospective Construction Programme**

Approaching to 1997, expenditure on public sector construction and infrastructure development by the Government will become more significant in balancing the possible decrease in private investments for real estates.

#### 4.4.2 Background of New Airport Core Projects.

Replacement of Hong Kong's existing international airport at Kai Tak was discussed in early 1970s. Various possible sites were examined and the preferred site was Chek Lap Kok island, directly north of Lantau Island and approximately 28km west of the existing airport. A Master Plan was drawn up in 1982, but it was shelved in 1983 because of the world economic situation and a drop in air traffic growth forecasts.

The new airport plan was revived in late 1980s following the strong growth in Kai Tak's passenger and cargo traffic. The new airport plan was confirmed in late 1989 as part of a comprehensive Port and Airport Development Strategy (PADS) which included major port developments in Hong Kong harbour. In 1991, PADS was changed into an Airport Core Programme (ACP) which includes all the transport and other infrastructure required to open the new airport at Chek Lap Kok. In 1991 a Memorandum of Understanding was signed by the Governments of the United Kingdom and the People's Republic of China. The document confirms both governments' support for the development of the new airport and the related core projects.

The Airport Core Programme comprises 10 interdependent projects with completion dates focussed on the first airport runway opening in 1997. The overall cost of the ACP is estimated at HK\$ 112.2 billion at March 1991 prices, comprising of HK\$ 59.3 billion in Government funding and HK\$ 52.9 billion in private sector financing.

The ACP comprises the following projects:

- a) The New Airport at Chek Lap Kok
- b) Lantau Fixed Crossing
- c) Airport Railway
- d) Western Harbour Crossing
- e) North Lantau Expressway
- f) Route 3 (part)
- g) West Kowloon Expressway
- h) West Kowloon Reclamation
- i) Central and Wanchai Reclamation
- j) Tung Chung Development (Phase 1)



Table 4.4.2 (a) below shows the ACPs estimated costs.

| Project                          | Capital Expenditure | Equity | Other sources of funding to AA/MTRC | Private investment | Government/Private Sector combined estimates April 1992 |
|----------------------------------|---------------------|--------|-------------------------------------|--------------------|---------------------------------------------------------|
| Chek Lap Kok Airport             | 3,100               | 13,600 | 20,100                              | 9,500              | 46,300                                                  |
| North Lantau Expressway          | 5,790               | -      | -                                   | -                  | 5,790                                                   |
| Tung Chung Phase I               | 2,210               | -      | -                                   | -                  | 2,210                                                   |
| Lantau Fixed Crossing            | 11,960              | -      | -                                   | -                  | 11,960                                                  |
| Route 3                          | 6,050               | -      | -                                   | -                  | 6,050                                                   |
| West Kowloon Reclamation         | 10,010              | -      | -                                   | -                  | 10,010                                                  |
| West Kowloon Expressway          | 2,230               | -      | -                                   | -                  | 2,230                                                   |
| West Harbour Crossing            | -                   | -      | -                                   | 4,150              | 4,150                                                   |
| Airport Railway                  | -                   | -      | -                                   | -                  | 22,160                                                  |
| Central and Wan Chai Reclamation | 1,900               | -      | -                                   | -                  | 1,900                                                   |
| Utilities and others.            | 2,360               | -      | -                                   | -                  | 2,360                                                   |
| Subtotal                         | 45,160              | 16,600 | 39,260                              | 13,650             | * 115,120                                               |

All figures in HK\$ million at March 1991 prices

\* Sub-total (HK\$ 115,120 million) minus double counting of Airport Railway in other projects (HK\$ 2900 million) = HK\$ 112,220 million. (Table 4.4.2 (a) ACP Project Expenditures).

#### 4.4.3 The Project Implementation.

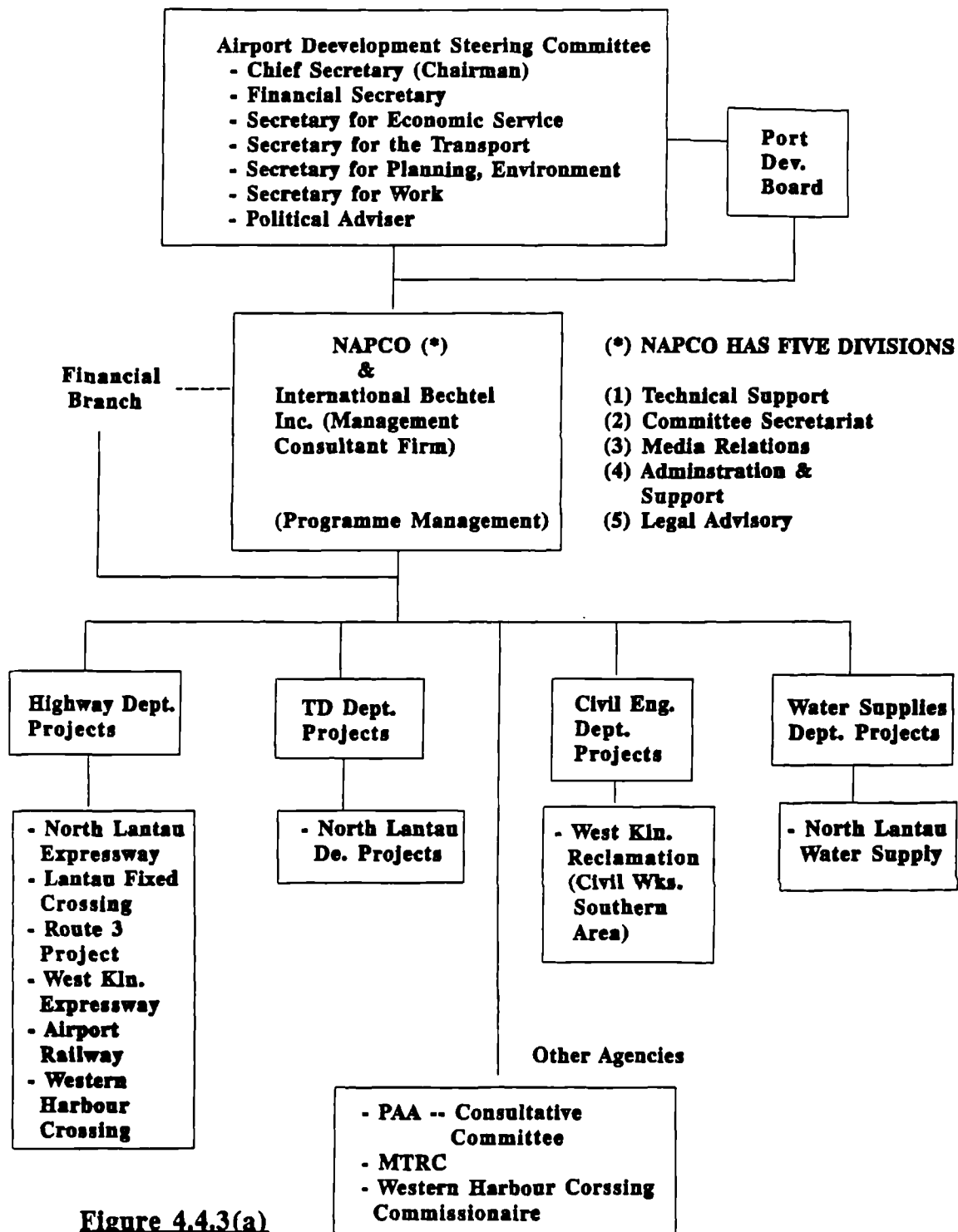
The Airport Development Steering Committee (ADSCOM) is the apex of making strategic policy for the ACP projects. It comprises all Policy Secretaries of Hong Kong Government concerning with the ACP projects and the Financial Secretary.

Under ADSCOM a New Airport Projects Co-ordination Office (NAPCO) has been set up to co-ordinate and implement the ACP projects and it is an integrated team of government and consultant staff to act as project management adviser. The major project management responsibilities of NAPCO include:

- a) Project monitoring and co-ordination - keep a close watch over the progress of the projects, identify and monitor critical progressing and recommend appropriate remedial measures.
- b) Cost control - exercises overall cost control and project contingency fund management in conjunction with Financial Branch.

- c) Interface management - monitor significant interfaces at the project level, identify potential problem at the earliest possible stage and agree solutions with parties concerned. Co-ordinate the provision of utilities to the new airport and ensure that the utility companies programmes fit in with the plans of Government.
- d) Technical support - provide central technical support services such as project insurance, labour importation, mediation serving, site safety and environmental co-ordination etc.

The Government management structure for ACP projects is shown in the following Figure 4.4.3 (a).



**Figure 4.4.3(a)**

## Government Management Structure for ACP Project

#### 4.4.4 Project Controls in ACP Projects

The conditions of contract used in ACP projects is based on a new issue which is called 'Government of Hong Kong General Conditions of Contract for the Airport Core Programme Civil Engineering Works 1992 Edition'. The whole set of the document includes the following parts:

Part I - The General Conditions of Contract.

Part II - Schedules 1 - 8

- Articles of Agreement.
- Performance Bond.
- Parent Company Undertaking.
- Parent Company Guarantee.
- Contractor's Warranty.
- Employees' Compensation Endorsement.
- Marine Vessel Insurance.
- Form of Subcontract.
- Form of Subcontract Warranty.

Part III - Schedule 9

ACP Mediation Rules  
ACP Adjudication Rules  
ACP Arbitration Rules

In accordance with Clause 45 of ACP Conditions of Contract, it requires the contractor to implement a formal quality assurance system. Fan (1992) pointed out that Clause 45 expects a coherent quality system to provide a uniformly structured approach to the management of construction works so that the impact of errors on the construction programme will be reduced and the effective performance can be achieved.

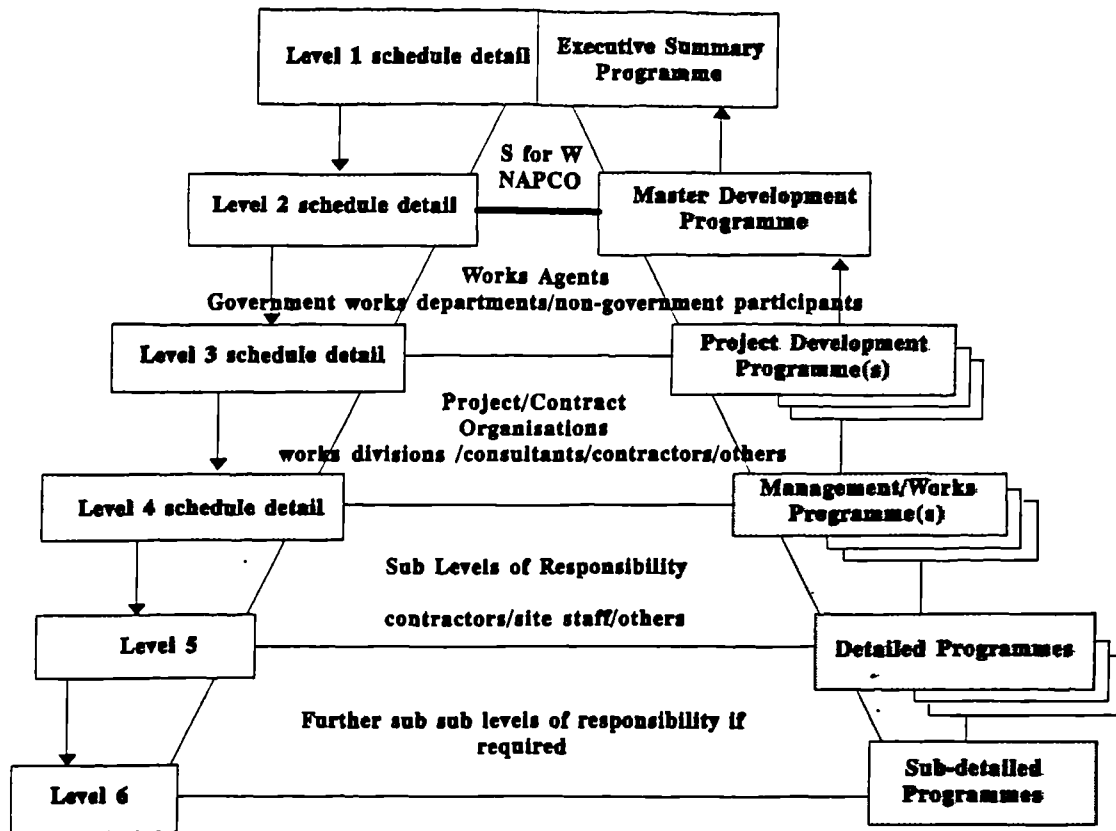
Another important control document for ACP projects is a document called 'Airport Core Programme (ACP) Projects Executive Summary for Project Controls which was issued in the early 1992 jointly by the Secretary of Works and the Director of NAPCO. The document is called ACP Project Control Manual (hereinafter in this section called the Manual). The Manual describes the manner in which NAPCO and the organisations involved in the ACP projects will carry out their project management duties so as to achieve Government's principle aim of completion in-time and in-budget.

For the execution of the Manual, one of the main issues relating to the construction management of contractor is the submission of programmes for establishing and monitoring the implementation plan as required in the Manual. The programmes within the implementation plan is shown in the following Table 4.4.4 (a):

| Programme Name                       | Hierarchical level | By - For                                                                      | Purpose                                                                                                                                                                                                                    |
|--------------------------------------|--------------------|-------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Executive Summary Programme (ESP)    | Level 1            | By NASPCO - for ADSCOM and top-level Government agencies.                     | Developed and monitored by NAPCO for overall ACP summary reporting to ADSCOM and top-level Government agencies. Shows the individual ACP projects in a comprehensive overview of plan versus progress.                     |
| Master Development Programme (MDP)   | Level 2            | By NAPCO - for ADSCOM                                                         | Developed and monitored by NAPCO and approved by ADSCOM. It provides overall ACP planning, control and integration information. Includes requirements for gazetting, statutory and other such approval processes.          |
| Project Development (DPD)            | Level 3            | By Works Agents - for themselves and NAPCO                                    | Provide comprehensive information for individual projects or project areas. Integrate detailed statutory, land, environmental, design, and construction planning.                                                          |
| Management Programmes - various      | Level 4            | By Project Engineer / Consultants - for the Works Agents                      | Used to plan, organise, execute and control design work and to provide framework planning for the construction programme.                                                                                                  |
| Works Programmes (WP)                | Level 4            | By the contractor - for the contractor, site supervision and the Works Agents | Comprehensive, detailed plans for construction of the works. Provides a means by which contractor and project organisation can plan, track progress, identify interfaces, analyze performance and forecast remaining work. |
| Three-Month Rolling Programme (TMRP) | Level 5            | By the contractor - for the contractor, site supervision and the Works Agents | Expands the WP to cover sequential 3-month periods. Indicates progress over the preceding month and detailed planned progress over the next 3 months. Programme is rolled forward monthly.                                 |

The relationship of the implementation plan programmes is shown in the following Figure 4.4.4 (a).

# ADSCOM



**Figure 4.4.4 (a)**

## IMPLEMENTATION PLAN PROGRAMME RELATIONSHIP

**top-down scheduling - bottom-up reporting**

In addition to the daily reports required under the Standard Conditions of Contract, Monthly Progress Report shall be submitted in a format to which the Engineer shall have given his approval and shall contain the following information:

- a) Status of work performed, significant accomplishments including critical items and problem areas, corrective actions taken or planned and other pertinent activities; and shall, in particular, address interface issues, problems and resolutions.

- b) A simplified representation of progress measured in percentage terms compared with percentage planned derived from the Work Programme (Refer to Figure 4.4.4 (a)).
- c) Programme updating to show actual activity completion dates, forecast completion dates, estimates of remaining duration and expected activity completion based on current progress.
- d) A summary of all planning/coordination activities during the month and details of outstanding actions.
- e) A schedule of all submissions and consents/approvals obtained outstanding.
- f) A schedule of the status of all outstanding claims. The report shall in particular provide interim updated accounts of continuing claims.
- g) A summary of all significant procurement activities during the month, including activities taken to overcome problems and other crucial milestone dates.
- h) A review of all production and manufacturing activities during the month and summaries of all production and manufacturing outputs during the month together with forecasts for the next month.
- i) A review of all safety aspects during the month, including reports on all accidents and actions proposed to prevent further occurrence.
- j) A review of all significant outstanding matters and actions proposed or taken, with a schedule indicating the status of all variations and an expenditure forecast.
- k) A report on the status of all milestones due to have been achieved during the month and forecasts of achievement of any missed Milestones, and those due in the next month.
- l) The monthly issue of the Three-Month Rolling Programme (Refer to Figure 4.4.4 (a)).

The implementation of this practice shows a tendency of new developments in construction projects, where the clients require more substantial performance information from the contractors. It is the Hong Kong Government's consideration that if this practice is successful in the ACP projects it will be used in all other public projects in the future. Therefore, the burden of information provision from the contractor to the contract supervisor is getting increasing continually.

#### **4.4.5 Impacts of New Infra-structure Developments to Contractors**

K.L. Chong, the Chairman of the Hong Kong Construction Association 1992, commented on the impacts of the Government New Infra-structure projects on local contractors. The representative of Hong Kong Construction Association has been described in Section 4.2.5 above. Chong (1992)'s comments are summarised as follows:

- a) Except for the Airport terminal building and the concourse, most of the PADS projects are of a large civil engineering nature. In Hong Kong, there are only about 10 large local civil engineering contractors and for their participations in the PADS projects they need to co-operate with overseas contractors. Another form of participation in the PADS contracts from the local industry, is for local contractors to subcontract from successful overseas contractors.
- b) For the smaller PADS contracts, the contractual arrangements are the same as other Public projects. For larger contracts, contractors will have to go through a pre-qualification exercise and only those successful will be permitted to bid for the tenders. Tender bonds are also required and performance bonds of about 10% of the contract value are called for as against the normal 1.5% called for in current public projects.
- c) The new set of conditions of contract used for the airport core projects are onerous in the form of putting the contractors to bear risks which even experienced contractors may not be able to foresee. Some of the onerous Clauses are:
  - i) No provisions for extension of time for adverse weather conditions, including typhoons.



- ii) Responsible for the interpretation of information provided by the Employer, including amongst other things, ground and sub-soil conditions.
- iii) If instructed by the Employer, the Contractor even in the absence of a promise to reimburse, must adopt acceleration measures to complete the works to mitigate the effect of time extension, which the Contractor may be entitled to.
- iv) Strict notice requirements for submitting claims (e.g. for extension of time), which effectively set a time bar of 14 days compared with 28 days or more in Public contracts.
- v) Contracts are lump sum, fixed price with no fluctuation provisions which contractors working for the Government have been accustomed to.
- vi) In case of late payment by the Employer, the rate of interest is only calculated at simple interest upon the payment overdue, whereas contractors have to pay compound interest on money borrowed.
- vii) In the event of disputes with a limited exception on Engineer's power to forfeit, reference to arbitration cannot be commenced until after substantial completion of the works.

In addition to the above comments, another significant impact is the requirement of prequalification. Neale and Austen (1984) pointed out that the particular objectives of prequalification for civil engineering projects are to ensure those contractors invited to tender with the following capabilities to complete the project:

- a) adequate engineering skills and resources to do the work safely and efficiently;
- b) adequate financial and managerial resources to support a project of the scale required; and
- c) integrity

Mr. Lawrence Chan, representative of Hong Kong Government Secretariat Works Branch, through an interview for this research pointed out that prequalification may be used where normal tender procedures are inappropriate for the work which:

- a) is of unusual scope or complexity;
- b) is of unusual high value;
- c) has a rigid time constraint;  
requires a high level of co-ordination, technical expertise or
- d) unusual technology;
- e) requires unusual funding of financial arrangements;  
and
- f) for non-standard forms of contract (e.g. design and build or management contracts).

Prequalification requirements have a substantial impact on the work loads of contractor's estimating department bidding for such new projects. Mr. Lawrence Chan disclosed that about 70% of new infra-structure projects in terms of contract value require tenderers to submit information for prequalification.

#### 4.5 Contractors Strategies

The new developments in Hong Kong construction industry in terms of the scale of projects, the capital investment, the quality required, the planning and control requirement, technology involvement and the tight project schedule, inevitably have created new requirements of construction management from the contractors. It is unavoidable that the project promoters through the contractual arrangements to put the project risks in respect of time, cost and quality into the contractors. It will then be up to the contractors to decide on the strategies to cope with this context. Mortiboys (1991) summarised the situation in response to changes and concluded that the contractors have three options:

- a) Keep doing what have always been done but try harder:

In a rapidly changing business situation, to keep doing what they have always done is a recipe for disaster even if it was successful in the past. Profits today may be the results of strategies developed years ago. In a changed business situation, trying harder with outdated management methods will simply hasten decline.

b) Be aggressive:

Be aggressive to clients, employees, subcontractors and suppliers. This usually has the effect of increasing profits in the short term, but it alienates clients, employees, subcontractors and reduces profitability in the long term.

c) Develop total business management:

It is strongly recommended by the author that each contractor should have a clear vision of what the business is all about and where it is going, and to fully integrate management functions and departments. Employees should be empowered to improve the ways things happen, and the relationships with clients, subcontractors and suppliers.

With the third option as a recommended strategy for the contractors to cope with changes, it needs an overall review for the procedures of site management practices, by which the ways of communication and information flow internally to fulfil the management requirements and externally to comply with the contractual obligations should be emphasised.

Once the contractor has succeeded in a bid for a contract, the next step is to get it done on site for achieving the pre-defined targets in terms of time, cost and quality. Modern construction management tends to decentralise most management functions to project sites. It is understandable that the project site is where the production takes place and the contract supervisor on site through the contract terms has to request the contractor's representative to respond for information with time constraints and pre-defined quality. The site manager is the one who has to be responsible for all the decision making and any subsequent mistakes. Mortiboys (1991) identified that for most managers the daily routine takes far too much of their time because it includes far too much 'firefighting'. Mortiboys then defined that 'firefighting' is doing any job which you are only doing because you or someone else did not do the job right first time.

It is commonly acceptable by most writers that the success of management is influenced by the personal style of the key manager. In construction site management, it relates to how the site manager uses the management techniques. This is the

value of site managers for their success in site management. However, construction projects cannot be put into mass production where the previous success may not be able to be continued and guaranteed in the new projects. Each construction project should be unique to its own particulars to be executed in different requirements and under different circumstances.

With the requirements of quality assurance and other control purposes, the use of procedure manuals is a means adopted by most contractors and recognized by most professionals, for achieving a standardisation of management procedure and demonstrating to outsiders the sense of company policy. This approach is sound in principle and acceptable in practice. Cheetham et al (1991) commented that procedure manuals were seen to focus more on output (what was required) than the way to achieve it. Therefore, the way to achieve it still relies on the management ability of site managers.

#### 4.6 Summary and Observations

The new developments in the Hong Kong construction industry described in this chapter reflects the trend of changes and impacts on the contractors. Those changes and impacts are observed and summarised as follows:

- a) Projects in public sectors will be an important market for most sophisticated contractors in Hong Kong. The scale of coming public projects will be complicated in both the technical, financial and managerial requirements.
- b) Higher competitions in public projects can be anticipated to an extent, by which pre-tender documentations will be of importance as the price competition. Proper records and documentations of the performance of previous projects are significant in supporting the preparation of pre-tender submissions.
- c) Quality assurance should be a definite and compulsory requirement for all public contracts in the future. Most well-established contractors in Hong Kong work for projects in both private and public sectors, by which the requirements of achieving quality assurance accreditation should apply to all projects including private and public sectors. Therefore the private sector clients should also be benefited from the application of quality assurance.

- d) Quality assurance standards require the enforcement of documented procedures executed in the work processing and the records of such procedures. The requirement of such procedures and records will increase the management burdens on site.
- e) Housing projects have a significant proportion of turnover in the public sector. The implementation of PASS (Performance Assessment Scoring System) will be in parallel with the requirement of quality assurance. This system can be viewed as a pre-practice for the contractors to get familiar with quality assurance requirements, by which more paper work on site in comparison with the traditional practices are required.
- f) Hong Kong Government has experienced mistakes in previous huge projects in terms of quality problem, over budget and time overrun, the result of which has induced substantial criticisms from the public. With regard to the New Airport projects, in addition to public accountability, the political issues from the concerns of the Government of Peoples' Republic of China has a substantial impacts forcing Hong Kong Government to impose tighter control procedures. These requirements which have also been applied in other public contracts, postulate the contractors to feedback performance data for satisfying both timing of submissions and quality of information stipulated in the conditions of contract.
- g) Highly complicated projects with substantial inherent risks, force contractors to implement tighter management control systems, which should provide information not just in satisfying external requirements in the contract and internal needs for decision makings, but also the requirements of quality assurance for procedures, records and traceabilities.
- h) The resulting management burdens due to these new requirements, will increase the project overhead costs which may not be possible to be reimbursed through the corresponding uplift of bidding prices due to the high competitions in the market and the involvement of overseas competitors. A way to overcome this problem is to improve management control.
- i) The improvement of management control can be developed by the implementation of management information system with the aid of information technology. With the development of information technology in which the prices of hardware is continually dropping, the potential of

its application to improve and enhance management information system for construction management is highly admirable in industrial and academic researches.

#### 4.7 Conclusions

With the new developments described in this chapter and the existing practices of construction management described in Chapter 3 of this thesis, it is a significant consideration in this research that in addition to procedure manuals and other control procedures, systematic management supports to the routine management tasks should be adopted by a mean of management information system supported by information technology.

This consideration acts a crucial philosophy in the development of the model of construction management described in Chapter 6, and subsequently the design of the management information system described in Chapter 7 to Chapter 12 of this thesis.

## **5 Review of Information Technology and the System Developments**

### **5.1 Introduction**

This Chapter describes the information technologies relating to the development of the integrated computer system for construction management of this research. The system is called 'CCMS' or the 'System' in this Chapter, 'CCMS' stands for Computerised Construction Management System. The functional design of the System is based on the model of construction management described in Chapter 6 of this thesis.

This Chapter concentrates on the discussion for the technical computing aspects of the System. It starts with a section to review the computer developments in both hardware and software of computers, and the use of the other relevant information technology to the development of the System. Following this section, the significant considerations in the system design are described with particular emphases on the selection of programming language, the human factors and the integration with other systems. The final section is a general outline of 'CCMS' and the description of the special features of the System.

### **5.2 A Review of Information Technology**

#### **5.2.1 Background of Information Technology**

The British Advisory Council for Applied Research and Development in 1980 formulated a report, entitled 'Report on Information Technology', in which it defined information technology as the scientific, technological and engineering disciplines and the management techniques used in information handling and processing; their applications; computing and their interaction with men and machines; and associated social, economic and cultural matters.

Longley et al (1989) defined information technology with a more technically-orientated viewpoint which took into consideration of the contemporarily sophisticated technology such as video image processing. The definition of information technology was:

The acquisition, processing, storage and dissemination of vocal, pictorial, textual and numerical information by a microelectronics-based combination of computing, telecommunications and video. Whereby Computing provides the capability for processing and storing

information. Telecommunications provides the vehicle for information communications and video provides high-quality display of images.

Baldwin (1990) quoted a definition of 'information technology' from King (1986) that information technology may be defined as the hardware and software necessary to collect, transmit, process and disseminate data within an organisation and this technology includes the use computers, communications and automation. This definition is the most appropriate to this thesis because of its applicable nature from a viewpoint of management.

This Chapter of the thesis describes the background information of computer hardware and software, and other applications of information technology, relating to the development of 'CCMS'. The initial stage of any computer system development has to involve with the following considerations:

- a) The types of computers under which the system will be run, (the hardware part of the system).
- b) The choice of a programming language to develop the system, (the software part of the system).

Computers and information technology are changing very fast, in pace with the development of electronic science. The study described in this thesis concentrates on the most up-to-date information. Therefore, literature selection was based on the timing of references rather than the quantities of references. The reference book from Dr. Long (1991) and the contemporary 'Byte' computer magazines have been used as the most important literature reference for this section.

### 5.2.2 Computer Hardware

Long (1991) defined computer hardware as the physical devices that comprise a computer system; and vice versa a computer system is a collective reference of all interconnected computing hardware including processors, storage, devices, input and output devices, and communications equipment.

Stern and Stern (1985) pointed out that it is virtually impossible to definitively categorize computers by size, cost or scope, and this lack of any standard method of categorising computers has resulted in a significant amount of confusion for the users.



Lucas (1986) recommended the following criteria to categorise for computers based on the consideration of the contemporary computer technology around 1986 and emphasised that it was not a industrial standard:

| Criteria                  | Micros                | Minis                 | Mainframes            | Supers             |
|---------------------------|-----------------------|-----------------------|-----------------------|--------------------|
| * Cost (US\$ 1986 price)  | 100 to 30,000.        | 30,000 to 5 00,000.   | 250,000 to 4 million. | 8 million +        |
| * Processor Speed (MIPS)  | 0.001 to 0.5          | 0.1 to 1              | 0.5 to 40             | 50 to 500+         |
| * Data Fetch Size (bits)  | 4, 8, 16, 32          | 8, 16, 32             | 32+                   | 64+                |
| * Arithmetic Word (bits)  |                       | 8, 16, 32             | 32                    | 64                 |
| * Primary-memory size (K) | 16 to 512             | 16 to 1,000           | 500 k to 32 megabytes | up to 32 megabytes |
| * Secondary-memory size   | 128 k to 30 megabytes | 10 to 1,000 megabytes | 0.5 to 50 gigabytes   | 256+ gigabytes     |
| * Number of users         | 1                     | 1 to 100              | 100 to 1,000          | 50+                |

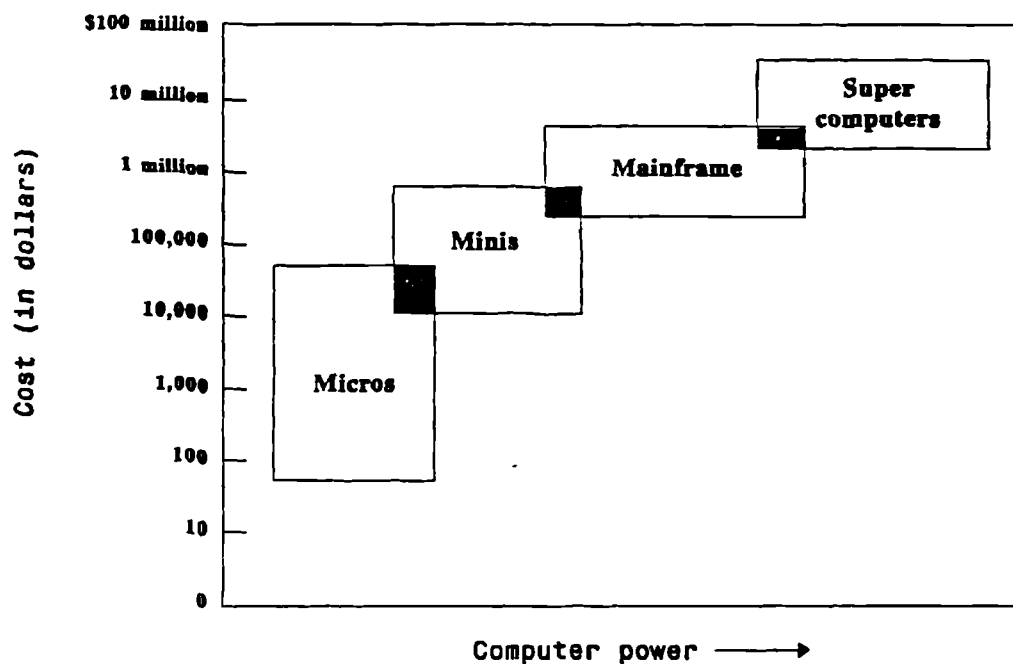
Remark: MIPS - Million instructions per second.  
 One megabytes - One million bytes of storage  
 One gigabytes - One billion bytes of storage.

**Table 5.2.2 (a) - Criteria of Categorising Computers**

The following Figure 5.2.2 (a) shows the concept of computer overlap for computer classifications by Lucas (1986).

Figure 5.2.2 (a)

### Computer Classification



Supercomputers handle the types of computer applications that are used by scientists in research and development. These applications usually require an extremely high speed processing.

The application of mainframe computers is most likely to be used to support the core operation of an organisation. Long (1991) called this type of application 'the corporate workhorse'. A mainframe system can be used in a wide range of applications, which are virtually anything imaginable. It allows users to connect the machine with over 100 terminals simultaneously work on it.

Minicomputers are defined as department-sized computers and are more affordable for smaller companies. Minicomputers can be served as stand-alone computer systems for small business up to 400 employees, and as remote departmental computer systems (Long 1991).

In the recent years, the invention of microprocessors has made a tremendous change in the size and performance of micro-computers. The microprocessor is a product of the microminiaturization of electronic circuitry. In comparison with the other three types of computers, micro-computers are the type with a fastest rate of advancement due to the high level of competition in the market. According to a report by 'Byte' magazine, December 1992 edition, the latest development of micro-computers in the market is the one from NEC model 'PowerMate Express DX2/66e'. Using Lucas's criteria (1986), the features of such machine are as follows:

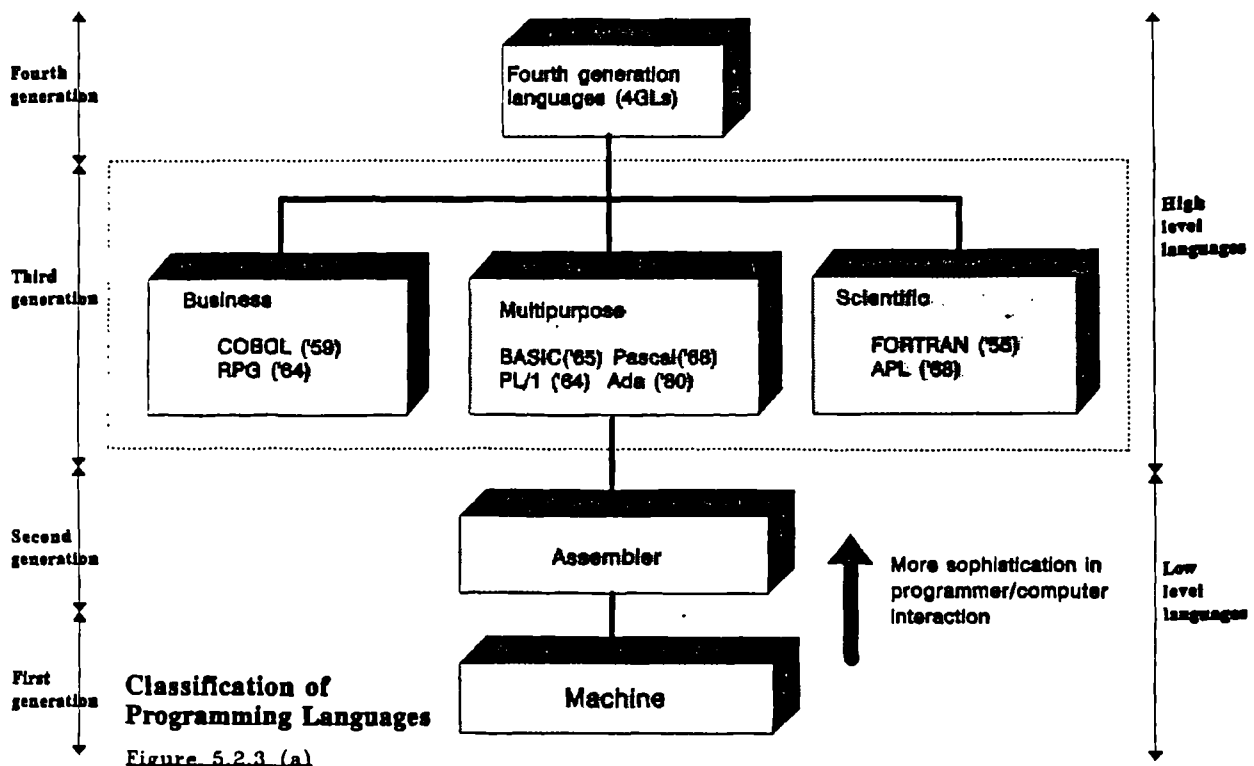
| Criteria                  | NEC<br>PowerMate Express<br>DX2/66e | Comparison<br>to Table<br>5.2.2 (a) |
|---------------------------|-------------------------------------|-------------------------------------|
| * Cost (US\$ 1992 price)  | 5,948                               | less 80% of micro                   |
| * Processor Speed (MIPS)  | 66 MHz (2 MIPS)                     | up to mainframe                     |
| * Data Fetch Size (bits)  | 4,8,16,32                           | equal to mini                       |
| * Arithmetic Word (bits)  | 32                                  | up to mini                          |
| * Primary-memory size (K) | 256 megabytes                       | up to super                         |
| * Secondary-memory size   | 535 megabytes                       | up to mini                          |
| * Number of users         | 1                                   | same as micro                       |

**Table 5.2.2 (b) - Comparison of Current Micro-computer with the Computer Classifications.**

In conclusion most commercial software is now marketed for micro-computer environments.

### 5.2.3 Computer Software and Programming Languages

Long (1991) has defined that 'computer software' means the programs used to direct the function of computer systems and 'computer program' is a set of computer recognizable instructions which are structured and ordered in a manner that when executed cause a computer to perform a particular function. A special type of instructions has to be used to communicate with computers, called programming languages. Programming languages have been developing in 'generations'. The classification of programming languages are as the following diagram Figure 5.2.3 (a) (Long, 1991):



With each new generation, fewer instructions are needed to instruct the computer to perform a particular operation and it is easier to understand and use. Machine and assembly languages, collectively called 'low-level languages', are machine dependent and are written at the most basic level of computer operation. On the other hand, high-level languages are independent the computer in use, but a compiler is always needed to translate the language into machine code. Long (1991) stressed that the trend in software development is toward using high-level, fourth-generation languages.

Fourth-generation languages (4GLs) includes the features of English-like instructions, limited mathematical manipulation of data, automatic report formatting, sequencing, and record selection by criteria. An example of 4GLs by FoxPro version 2 is illustrated in the following Figure 5.2.3 (b):

| System       | File  | Edit | Database | Record      | Program | Window |
|--------------|-------|------|----------|-------------|---------|--------|
| Database     | Files | #    | Records  | Last Update | Size    |        |
| ASD.DBF      |       |      | 0        | 09/21/90    | 353     |        |
| LITD.DBF     |       |      | 85       | 10/27/89    | 55243   |        |
| LITSUR.DBF   |       |      | 85       | 09/28/89    | 55243   |        |
| LIT_COND.DBF |       |      | 7        | 02/07/93    | 1008    |        |
| LITDATE.DBF  |       |      | 710      | 02/07/93    | 472568  |        |
| TERMKEY.DBF  |       |      | 186      | 12/08/92    | 9988    |        |
| TER_COND.DBF |       |      | 2        | 07/31/92    | 358     |        |
| TER_XXX.DBF  |       |      | 2        | 02/15/92    | 198     |        |
| TEMP.DBF     |       |      | 1        | 09/30/92    | 1083    |        |
| RESDAI.DBF   |       |      | 62       | 11/17/92    | 2580    |        |
| TEMPT.DBF    |       |      | 0        | 04/16/92    | 225     |        |
| LITKEY.DBF   |       |      | 231      | 02/03/93    | 12373   |        |
| TERMS.DBF    |       |      | 279      | 01/31/93    | 39565   |        |

650785 bytes in 13 files.  
1609728 bytes remaining on drive.

Command

```

set defa to c:\res\litsu
set defa to c:\litsur
dir
use litdate index litdat
list to print_

```

Figure 5.2.3 (b)  
An Example of  
FoxPro Commands.

#### 5.2.4 Other Relevant Computer Peripheral Equipment

Long (1991) defined that the peripheral equipment of a computer includes any hardware device other than the processor. The definition includes a wide range of instruments and equipment associated with the operation of computers. In this section, only those peripheral related to the operation of 'CCMS' will be discussed. Special attention is drawn to the applications of the System in relation to the characteristics of certain construction management operations. The selected computer peripheral equipment are discussed as follows:

- a) **Mouse:** This is a device used to input data and control computers other than using a keyboard. It provides a quick positioning, drawing and pointing over the desired menu or a graphic image. For some software such as those for computer-aided design or drafting, a mouse is a compulsory input device. However, for some other software the use of mouse may be only an optional selection.

The use of a mouse in 'CCMS' is an optional choice and the mouse should aid the efficiency of data input, especially in case of moving around the different field for a full screen data input.

- b) **Optical character recognition (OCR):** This is a data input technique for original source data entry, by reading certain data in machine-readable format and directly writing to a computer. OCR equipment consists of a family of devices that read and write OCR data, including OCR scanners and the relevant software. OCR data may be of data in a form of bar codes, pictures, and printed or written text.

Construction management operations involve a large volume of data input such as bill of quantities or drawing data etc, for which OCR techniques may lighten the workload of data input. If the construction industry can apply a bar code standard for construction materials similar to the Universal Product Code for supermarket items, OCR techniques can be used to input data for material arrivals on site.

- c) **Devices for high quality printout:** Producing high quality printout is a marketing trend in the development and manufacture of devices for the hardcopy outputs from a computer. The devices include 24-pin printers, laser printers, color printers, plotters, desktop film recorders, and computer output microforms etc.

In terms of the application in construction management systems, high quality printouts should aid for submissions to the contract supervisors and the preparation of internal management reports.

- d) **Modem:** The word 'modem' comes from the first two characters of 'modulator' (mo) and the first three characters of 'demodulator' (dem). It is a device used to convert computer digital signals into telephone analog signals for data transmitting through telephone lines. The tendency of changing most telephone lines from copper wires to optical fibres, has substantially increased the efficiency of data transmitting through modems and telephone lines.

This device should have a special contribution to the connection between site computer workstations and the head office system.

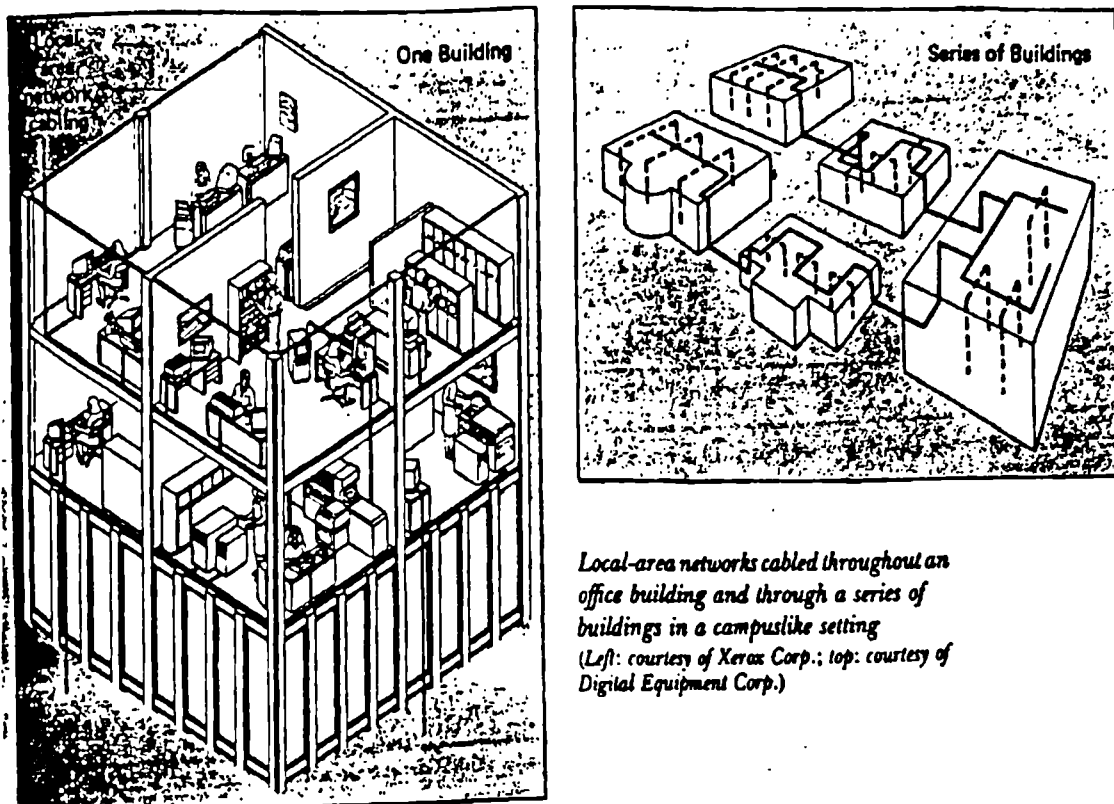
#### 5.2.5 Local Area Network

Long (1991) defined that local area network (LAN) is a system of hardware, software and communications channels that connects devices in close proximity or premises, not involving a public communication carrier such as telephone network. The Unit State Bureau of Standards gives a similar definition.

Local area networks can be built at various levels of sophistication. At the most basic level, it can be used to interconnect microcomputers in a department for users to share files and printers, and communicate with each other through the computers. The more sophisticated local nets permit the interconnection of mainframes, micros, and other peripheral devices throughout a large but geographically constrained area, such as within a building or among a group of adjacent buildings. Dologite and Mockler (1989) illustrated the application of LAN throughout an office building and through a series of buildings as the following diagram.

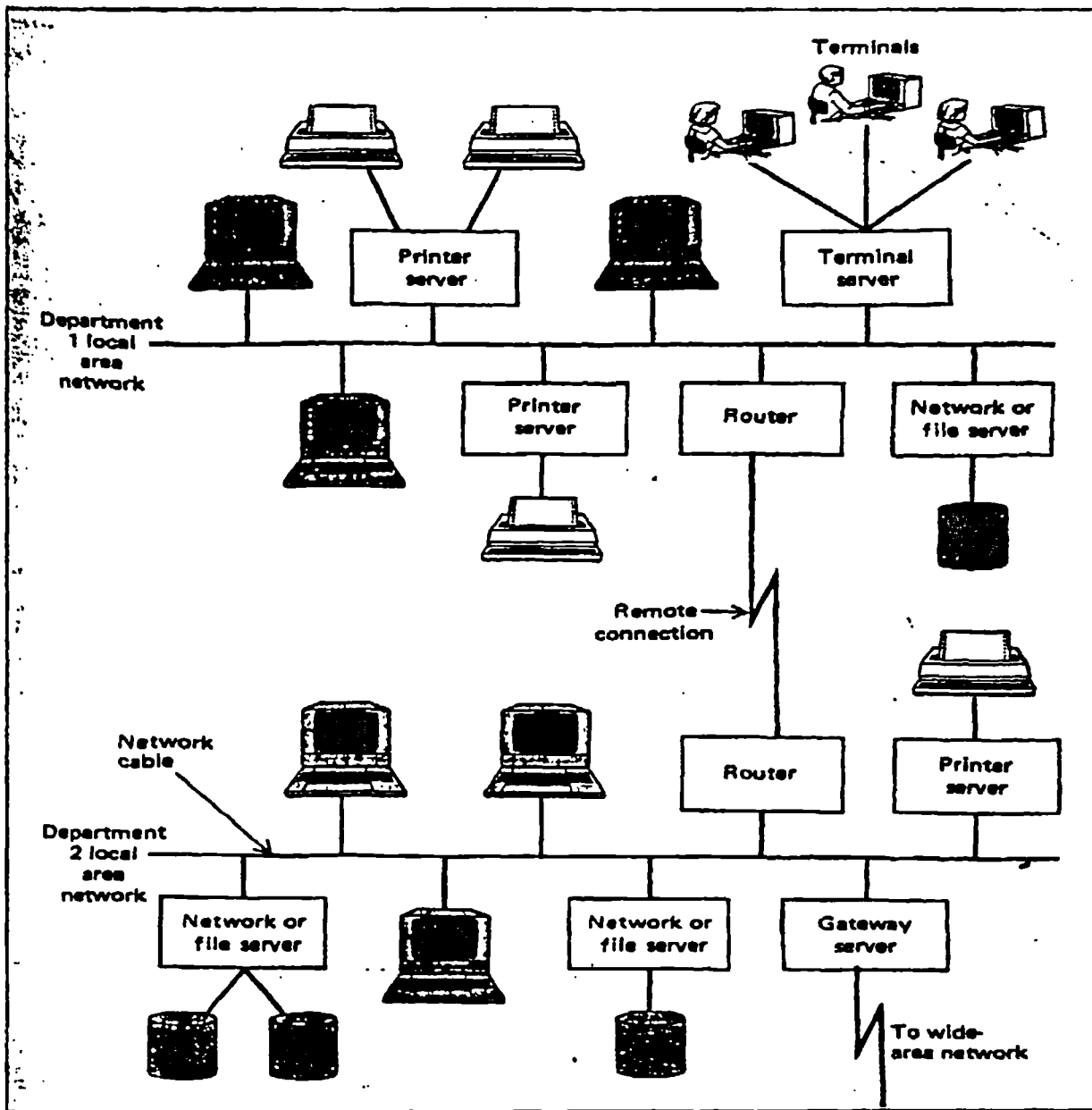
##### Figure 5.2.5 (a) An Example of LAN Layout.

The connection of LAN with separate dedicated devices, according to Dologite and Mickler can be shown as the following diagram.



**Figure 5.2.5 (b) An Example of LAN Connections.**

Nowadays, the enhancement of management needs of organisations requests better co-ordinations and communications within each functional department or division. This request can be served by the use of local area network technologies. In case of contracting organisations, LAN provides a highly effective environment to enable better co-ordination and integration of data flow among different management functions.



### 5.2.6 Telecommunication Environment

Generally, the telecommunication technology in most developed countries around the world is well-developed. Of particular relevance to this thesis are the services provided by the Hong Kong Telephone Company. One interesting aspect of the telephone network, for example, is that telephone subscribers pay a flat monthly subscription for unlimited calls within Hong Kong. Such a system encourages the development of information systems with better communication among any remote offices under a telecommunication environment.



In view of the demand mentioned above, in 1988 the Hong Kong Telephone Co. announced a new service called "DataCom Services" which is responsible for data communication (non-voice) services.

DataCom's areas of activity includes:

**Datapak:** Hong Kong's Public Data Network packed switched, point to point, point to multipoint, point to point multiplexed and text broadcast services. Datapak International is a further connection service to world-wide networks.

**Fax:** World leading support facilities and enhanced Fax services.

**Datel:** Dialled data transmission over the switched telephone network.

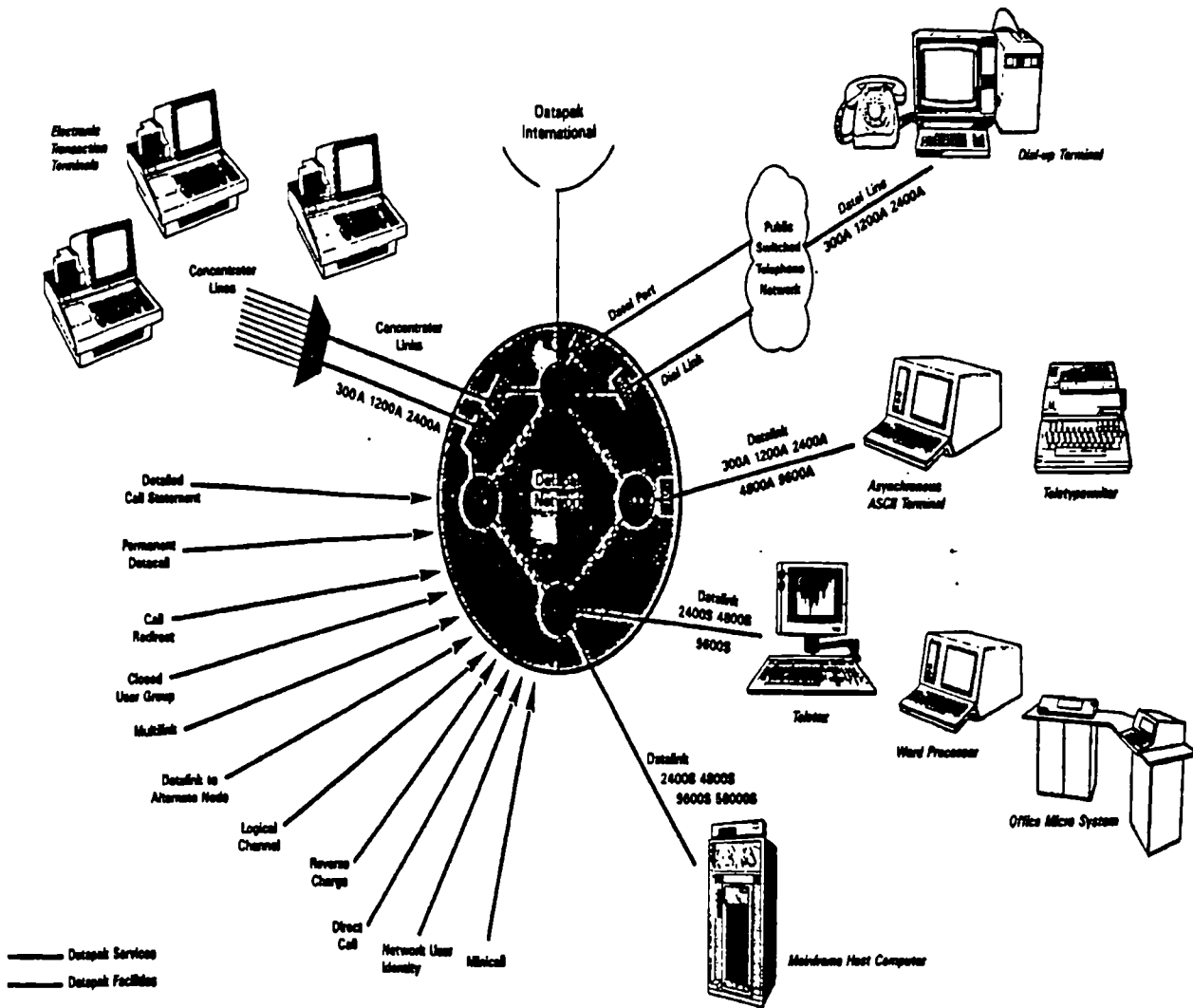
**Private:** Categorized 2 wire and 4 wire circuits.  
**Circuits**

**Digital:** 64 Kbps and 1544 Kbps point to point  
**Services** services.

Within the services mentioned above, the one most significant to the micro-computer workstation environment is "Datapak" which enables terminals and computers to communicate accurately and economically both within Hong Kong and world-wide. The "accurately" just mentioned is in terms of the reduction of data loss due to the possible "noise" in the communication cables and the meaning of "economically" is in terms of the reduction of transaction time because of the high speed data transfer. The operation of datapak is illustrated by the following schematic diagram.

# Datapak

Another Hong Kong Telephone Business Service



**Figure 5.2.6 (a) Datapak Operational Diagram.**

## 5.3 Considerations of System Design

Following the review of computers and the information technology available as described in Section 5.2 above, this section discusses the crucial considerations in the system design of 'CCMS'. The considerations include:

- a) the selection of the programming language;
- b) the human factors considered in the design of the System; and
- c) the integration of the System with other systems.

### 5.3.1 Selection of Programming Language

Abdullah (1988) recommended the use of a structural programming language as a development tool for construction management systems in view of its portable nature. O'Brien (1989) stressed that through the use of 'fourth generation' languages and relational databases it would be possible to construct 'configurable declarative' systems. These systems would be characterised by a built in flexibility and would be changed or configured to meet individual requirements in the functionality and operational features available within the systems.

In view of the recommendations from both the construction academics (Abdullah 1988, O'Brien 1989) and the computing academic (Long 1991), a 'fourth generation' language was selected as the programming language for the system development of 'CCMS'. The nature of the system application in this research, is a database- orientated application, for which a database management system is needed to facilitate the creation, manipulation and maintenance of the database. Therefore, a database management system with programming language ability is appropriate to be the system development tool. FoxPro version 2 from Fox Software Ltd. has been chosen.

'Byte' one of the leading world-wide computer magazines, in January 1991 awarded FoxPro one of 'Byte Awards of Excellence 1991'. The Editor's comments stated that FoxPro is the acknowledged leader among dBase compatible database programs and deserves the 1991 "the most improved" award for its remarkable version 2.0.

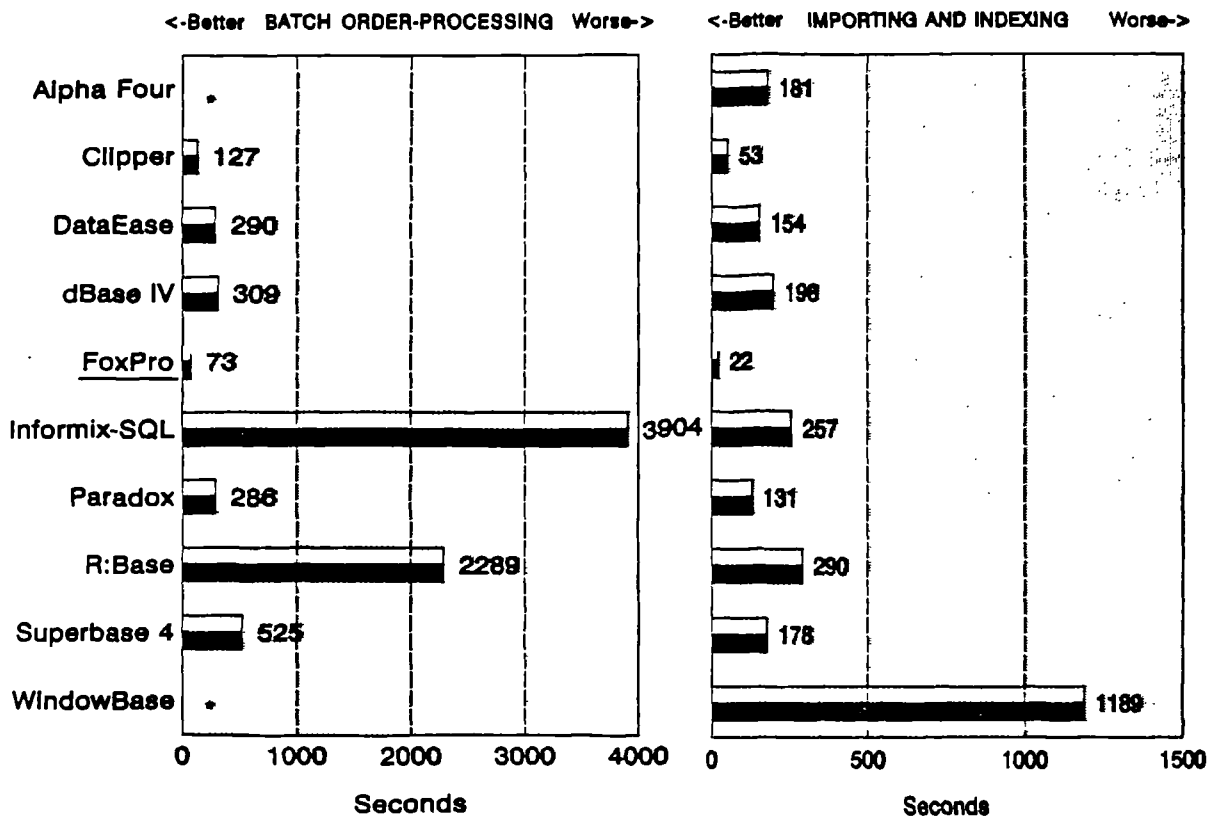
A new retrieval technology called 'Rushmore' which crunches through million-record databases with stunning speed, is used in FoxPro. Other major enhancements include compressed compound indexes, a Structured Query Languages subsystem, a WYSIWYG screen builder, a project manager, an interface to Watcom C and an extended-DOS version. Foxpro version 2 has won the following awards since it comes out the market in 1990:

- a) Byte Award of Excellence 1991 ;
- b) InfoWorld Product of the Year;

- c) PC Magazine's Technical Excellence Award;
- d) PC Magazine's Editors' Choice Award; and
- e) Data Based Adviser and DBMS Readers Choice.

'Byte' computer magazine in January 1992 published a testing report showing the performance of 10 top listed database management systems through an unique performance test. The conclusion of the report commented that FoxPro had displayed the most impressive performance. The performance comparative chart for the test is shown underneath:

## BENCHMARKS



\* Product proved incapable of running this benchmark.

For the Importing and Indexing benchmark, each program had to create a 4000-record database of parts file. The Batch Order-Processing benchmark tests the time it took each package to post a batch of 80 separate database files. In each case FoxPro displayed the most impressive performance.

Figure 5.3.1 (a) Testing Results by 'Byte'

### 5.3.2 Human Factors Considerations

'CCMS' has to be operated both at the head office and construction sites. Most of the users of the System may have clerical or construction technical backgrounds, without much computing trainings. Crane (1987) commented that the interaction with users was the major problem of computers on site. Rubinstein and Herish (1984) described the importance of human factors (ergonomics) in the design of computer systems, for which human factors was defined as the study of how people and machines interacting. The system design of "CCMS" has taken into account the following aspects of human factors:

- a) functional menu;
- b) form type input screen;
- c) use of pop-up windows; and
- d) user friendliness.

The factors listed above are explained in detail in the following sections.

#### 5.3.2.1 Functional Menu

Rubinstein and Herish (1984) pointed out that there are three basic interactive styles of functional control in human-machine interfaces: command, menu, and direct manipulation. They are described as follows:

- a) Command-based designs: It requires formal language commands with rigid limits for computer professionals. The end-users may fail to grasp the syntax that is required.
- b) Menu-based designs: The menu style of control is especially popular for systems intended for the noncomputer oriented. Menus have the virtue of making explicit what choices or operations are available. A menu interface serves as its own memory aid and requires little typing. Five or six items is a practical maximum for frequently used menus. Menu should have some kind of label such as a header, so that they are easily identified.
- c) Direct-manipulation-based designs: Direct-manipulation interfaces represent objects on the screen and allow the user to manipulate them directly by pointing and typing directly. The advantages of direct manipulation is that it helps

create concrete, literal concept models. More information is presented at one time than with menu or command systems.

The main input menus of "CCMS" for functional selections, uses the "direct-manipulated-based" design and the sub-menus of the System adopt the 'menu-based' design, the screen samples of which are shown in the following Figures 5.3.2.1 (a) and Figures 5.3.2.1. (b) respectively.

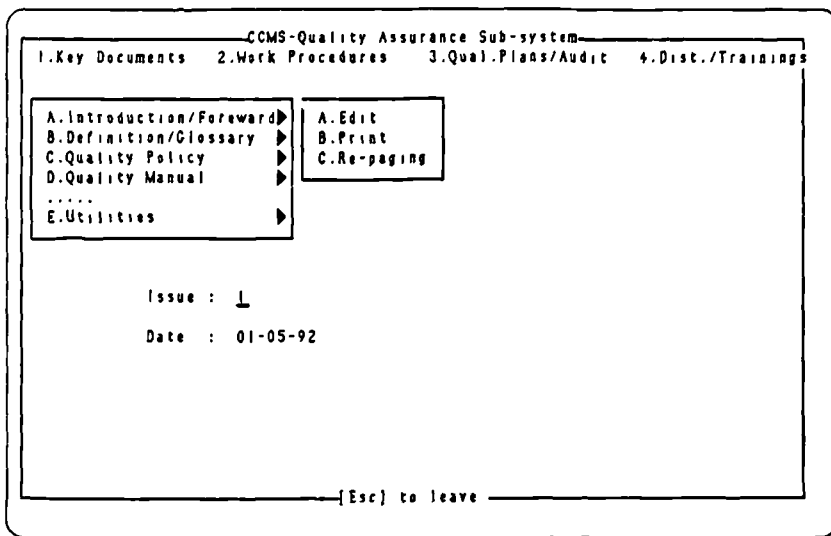


Figure 5.3.2.1  
(a) Direct  
Manipulated  
Based Design.

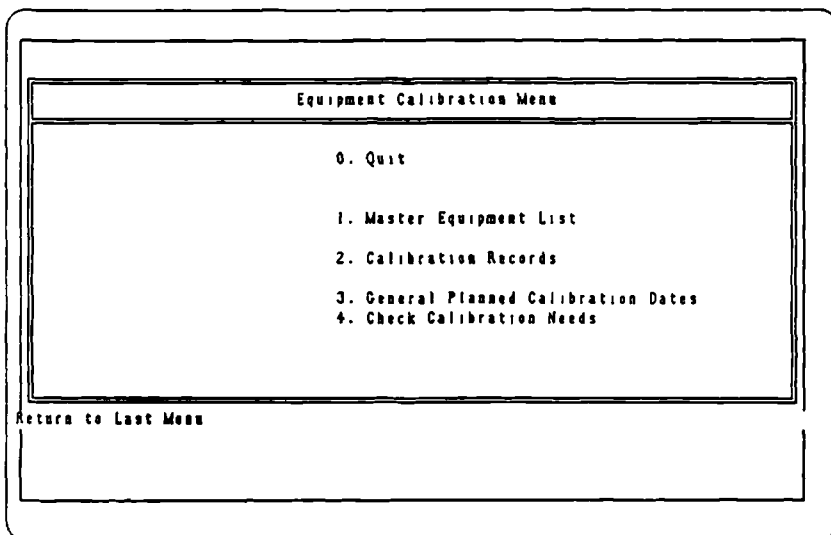


Figure 5.3.2.1  
(b) Menu Based  
Design.

### 5.3.2.2 Form-type Input Screen

Rubinstein and Hersh (1984) identified that forms embody the accepted information-handling procedures of an organisation and the fields to be filled in tell a new user which information is required and which is optional. Thus forms tell the user what information is needed for carrying out a procedure for an operation, and relate directly to the familiar paper forms people use every day.

Most input screens in "CCMS" are those of form type with each column representing a data field. This allows the user to keep track of the previous inputs, facilitating large amount of data input and reducing the possibility of input errors by fixed column disciplines. A sample of schedule input form is shown in the following diagram 5.3.2.2 (a).

Input for Material Arrival : Code -A-25/A-40

| Date     | Supp [*] | Arri Ref | Order Ref [*] | Arri Qty | Unit | P |
|----------|----------|----------|---------------|----------|------|---|
| 08/01/92 | Score    | 9341     | GF-145        | 9401.71  | m2   |   |
| 22/01/92 | Score    | 9342     | GF-356        | 9401.71  | m2   |   |
| 15/02/92 | Score    | 9412     | GF-668        | 9401.71  | m2   |   |
| 28/02/92 | Score    | 9413     | GF-668        | 5341.89  | m2   |   |
| 21/03/92 | Score    | 9438     | GF-4646       | 4700.85  | m2   |   |
| 26/03/92 | Score    | 9472     | GF-4646       | 18803.42 | m2   |   |
| 30/03/92 | Score    | 9482     | GF-6589       | 9401.71  | m2   |   |
| 01/04/92 | Score    | 9521     | GF-6589       | 1141.03  | m2   |   |
| 13/04/92 | Score    | 9552     | GF-7634       | 9401.71  | m2   |   |
| 10/08/92 | Score    | 9557     | GF-7634       | 9000.00  | m2   |   |
| 05/11/92 | Score    | 9889     | GF-3556       | 4500.00  | m2   |   |

[F3] to save; [F5] to add; [F6] to delete; [F8] to sort; [F9] to view sum

List Conditions

Order : Arrive Reference Order

Figure 5.3.2.2  
(a) Typical  
Schedule-Type  
Input Form.

### 5.3.2.3 Use of Pop-up Windows

Monk (1984) identified that multiple pop-up display windows are a useful way of dividing the display according to a logical structure. In fact, most modern commercial software has fully utilised this technique. In the system design of 'CCMS' as a kind of construction management system, the use of multiple display windows has the following advantages:

- a) The use of pop-up windows will not disturb the original execution processing, but allows the user to access to other working areas. This approach is consistent with the characteristics of construction

management, where a management activity may have to rely on quite a number of different sources of information.

- b) It eliminates the need to remember codes for data input and retrieval. This should answer Crane's criticism (1987) that the site managers were facing too many blank screens asking for codes in computer operations.
- c) The pop-up windows can direct the user to access the data input or retrieval through a pre-defined sequence. Accordingly, management procedures can be built-in guiding the user to avoid missing some of the crucial data.

An example of step-by-step pop-up windows for material selections is shown in the following diagram Figure 5.3.2.3 (a)

Ins

Type for : CONCRETOR

| Type Name                  |
|----------------------------|
| CONCRETE SPECIAL MIX 26/20 |
| CONCRETE SPECIAL MIX 30/20 |
| CONCRETE SPECIAL MIX 40/20 |
| CONCRETE SPECIAL MIX 45/20 |
| FORMWORK                   |
| REINFORCEMENT              |

[F5]-Add; [F6]-Delete; [F4]-select

Material Trades

| Type Name     |
|---------------|
| CONCRETOR     |
| DRAINLAYER    |
| PLASTERER     |
| ROOFER        |
| STL & MTL WKR |
| TILE          |

[F5]-Add; [F6]-Delete; [F4]-select

Select Resource Type => MATERIAL

Select Resource Name => "

Press [=] to list items for selection

Press [=] to list items for selection

Figure 5.3.2.3  
(a) An Example of Selecting Material Trade of 'Concretor' by Pop-up Windows.

#### 5.3.2.4 User Friendliness

Sime and Coombs (1983) stated that in terms of achieving "user-friendliness" for computer software the following aspects are important:

- a) the software should address the user in his own terms; and



- b) wherever possible, the software should prevent the user from making errors.

Taking into account Sime and Coombs' principles, 'CCMS' is developed through construction-related research, and is designed by a construction professional with both construction and computing qualifications and experience, rather than a commercial software house product written by a pure computer expert. The terms used in the System are well considered construction phrases and should be familiar to the system users as construction professionals.

In addition to the form-type screen input for reducing input errors as described in Section 5.3.2.2 above, another means adopted in the System to minimise input errors is to reduce the necessity of long statement typing. Especially, in the data put for those crucial fields which are used as the keys for the relational databases, pop-up windows are used to allow the users to select and pick up the items from the libraries. The items in the data libraries are allowed to be built up in parallel with the execution of the System. Since the processing of construction management involves quite a lot of repetitive phraseologies, it should justify the worthiness of this approach.

### 5.3.3 Integration with Other Systems

Anderson (1986) defined that the idea of an integrated system is where all data relevant to the function or business are collected at its point of origin, stored as a central library of information, and made available to any user when required. This interpretation of 'integration' is in line with the findings of Ndekugri and McCaffer (1988) regarding 'integration' in construction management systems, and the research by Thorpe (1992). In this thesis, this interpretation on 'integration' is considered as the conceptual level of 'integration'. Two more levels of integration should be adopted in the system design of integrated system for construction management. They are:

- a) Operation level:

It concerns 'what' to be integrated such as:

- the content of data;
- the accuracy of data;
- the usage of data;
- the target of data;
- the frequency of data passing;
- the duty of data preparing; and
- the cost of data acquiring.

b) Technical Level:

It concerns 'how' to be integrated such as:

- the medium of data recording;
- the means of data transferring;
- the format of data back-up;
- the cost of data handling;
- remedy of data loss;
- training for data handling; and
- the duties of data management.

The details of the operational level of 'integration' for the system development of "CCMS" are mentioned in Chapters 7 to 12 of this thesis.

Regarding the technical level of 'integration', according to the Technical Manual of FoxPro and the field tests of "CCMS", the System can assess and transfer data in and out for the following type of computer file structures:

TXT: ASCII text file with or without line feed.  
DIF: Data Interchange Format used by VisiCalc.  
FW2: Framework II files.  
MOD: Microsoft's Multiplan version 4.01.  
PDOX: Borland's Paradox version 3.5 database files.  
RPD: RapidFile version 1.2.  
SDF: System Data Format file - ASCII text file in which records have a fixed length and end with a carriage return and a line feed.  
SYLK: Symbolic Link interchange format used by Microsoft's MultiPlan.  
WK1: Lotus 1-2-3 spreadsheet revision 2.x.  
WK3: Lotus 1-2-3 spreadsheet revision 3.x.  
WKS: Lotus 1-2-3 spreadsheet revision 1-A.  
WR1: Lotus Symphony spreadsheet versions 1.1 or 1.2.  
WRK: Lotus Symphony spreadsheet version 1.0.  
XLS: Microsoft Excel version 2.0.

"CCMS" can communicate with any commercial application computer systems in the industry. This has solved the most fundamental technical problems mentioned above for system integration. In addition, from the users' point of view, this approach has the following advantages:

- a) The functions of other well developed systems can be procured as part of the integrated system by data sharing and file linking up. It will save the efforts of system development by using the existing expertise, instead of re-developing the same from the script. For example, the critical path analysis and network drafting in "CCMS" is by linking to "Time Line version 5".
- b) It is possible to recruit outsiders to work immediately for large volume of data input, using the system such outsiders are familiar with, and without the necessity of further training. Afterwards, the data could then be transferred to the file format of the system. For example, in case you need to input the last five months data from the daily report of other projects for a claim within one week, you can employ a number of helpers who may only familiar with Lotus or Viscal to do the data input, and then later transfer the data to the format which is accessible by the system.

## **5.4 An Outline of "CCMS"**

### **5.4.1 General Description of the System**

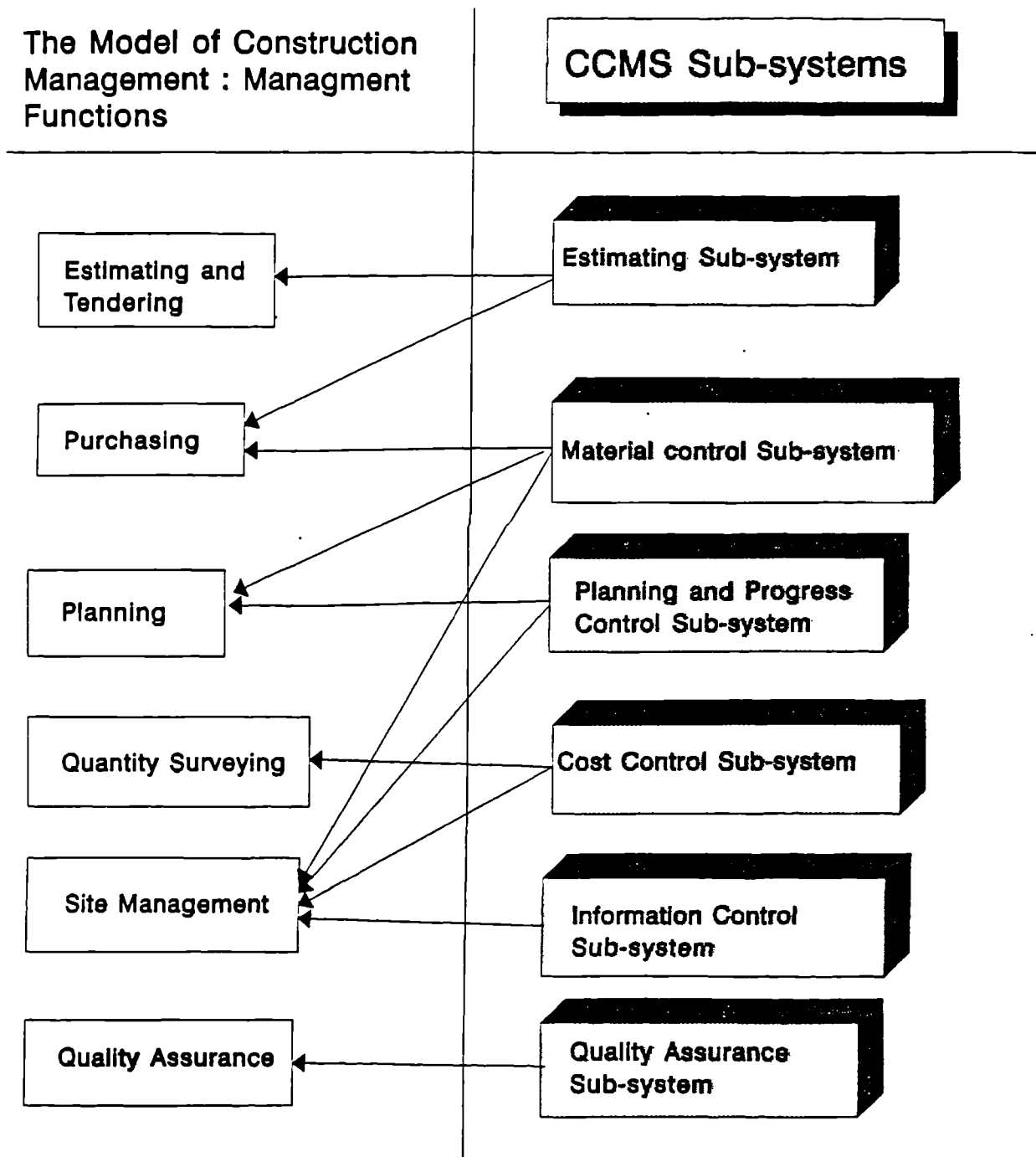
The aim of the System is to support the management tasks under each of the following management functions as described in the next Chapter 6 of this thesis:

- a) Estimating and tendering;
- b) Planning;
- c) Purchasing;
- d) Quantity surveying;
- e) Site management; and
- f) Quality assurance.

'CCMS' comprises the following sub-systems:

- a) Estimating sub-system;
- b) Material control sub-system;
- c) Planning and Progress control sub-system;
- d) Cost control sub-system;
- e) Information control sub-system; and
- f) Quality assurance sub-system.

The relationship of the management functions and the sub-systems of 'CCMS' is shown on the following Figure 5.4.1 (a):



**The Principal Relationships between the Management Functions and the Sub-systems of CCMS**

Figure 5.4.1 (a)

"CCMS" is an integrated computer system for construction management. Its application is divided into two levels with the following sub-systems:

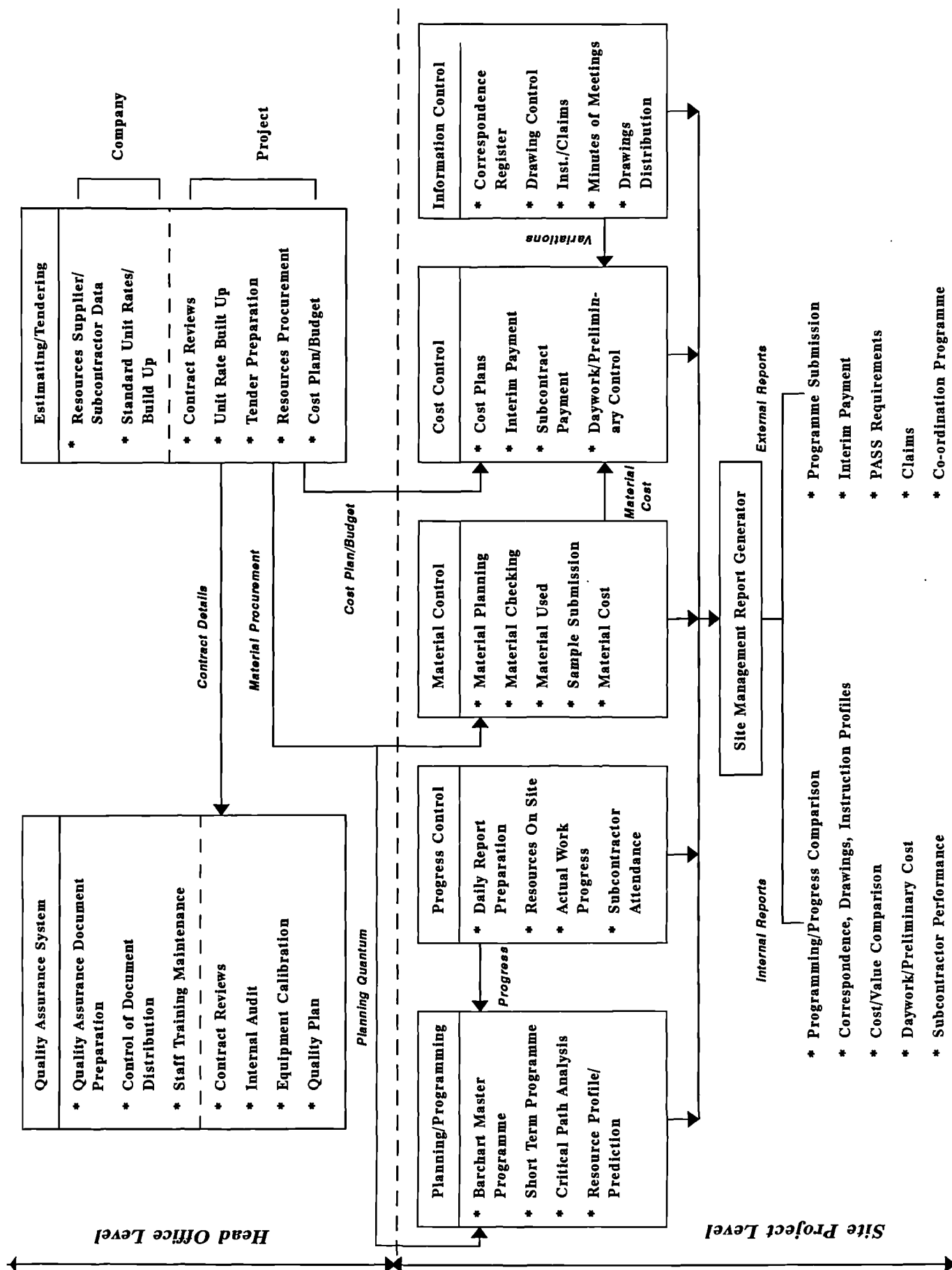
Head Office Level:

- a) Estimation/Tendering Sub-system.
- b) Quality Assurance Sub-system.

Project Site Level:

- a) Information Control Sub-system.
- b) Material Control Sub-system.
- c) Valuation/Cost Control Sub-system.
- d) Planning and Progress Control Sub-system.

All the sub-systems are capable of operating as a single system, and the whole system can be integrated to pass the data from one sub-system to other sub-systems. An outline of the integrated system operation is shown in the following diagram Figure 5.4.1 (b).



**Figure 5.4.1 (b) CCMS System Operational Flowchart**

#### 5.4.2 Application Environment

"CCMS" is developed by about 25,000 lines of FoxPro version 2 and can be run in three modes:

- a) fully attached to the 'FoxPro' main system by compiling to a kind of 'Foxpro' code;
- b) attached to the 'FoxPro' library by compiling to 'FoxPro' code; and
- c) fully compile to an executive program under DOS environment.

The whole system development and field tests are confined to method a). In terms of hardware, "CCMS" can be run in any micro-computer with the following specification:

|                         |                     |
|-------------------------|---------------------|
| <b>CPU Type</b>         | : 80286 or upper;   |
| <b>Coprocessor</b>      | : not required;     |
| <b>Operation System</b> | : DOS 3.0 or upper; |
| <b>Total RAM</b>        | : 640 Kilobyte;     |
| <b>Harddisk Space</b>   | : 10 Megabytes.     |

The above requirements are the standard facilities in any standard micro or notebook computer for personal or commercial use in the industry.

#### 5.4.3 Special Features of the System

The special features of 'CCMS' applicable to all the sub-systems are as follows:

- a) Since part of the sub-systems have to be applied in a construction site environment, a password security function is established to prohibit unauthorised access to the System. The password security system has two levels: system access level and functional access level. For system access level, the System requires the user to input the correct password before it allows the user to start the System. For



functional access level, it limits other unauthorised people to access to the certain functions of the System, especially for those areas involving commercial confidence such as contractual claims or minutes of meetings etc.

- b) A special function has been built-in to prevent any unauthorised copy of the System by "pirates". A special device called 'KepPro' is used to run with the System, by which the System will check a special serial number from the 'KeyPro' during the system execution. The 'KeyPro' has to be plugged into the parallel port (printer port) of the system computer for each execution, otherwise the System will stop the execution if the serial number from the 'KeyPro' does not exist or is incorrect.
- c) Construction management operations involve a lot of background information which are worthwhile to be recorded aiding for the operation itself and the feedback for future reference. The System applied the memo field technique of Foxpro, by which virtually unlimited description can be put into a field of a database. The following diagram Figure 5.4.3 (a) shows a sample of memo field input.
- d) In view of the dynamic requirements of information retrieval in construction management operations, the System allows users to specify conditions for information retrieval, called criteria. Such built-up criteria can be stored up in the System for repetitive uses. The following diagram Figure 5.4.3 (b) shows a sample of information retrieval for site information control.

```

 A Correspondence Detail
 Correspondence Register

Document Reference [=] DF4-35

Type [=] Letter Issue Date 01/02/92
 Receiv Date 05/02/92
From [=] Architect [=] Main Contractor

 Remark
This letter encloses the comments of the Architect for e.
the updated master programme which has incorporated all
the information required by the NSC contractors.
Delays from the Fire Service Installation hindered our
entitlement for the EOT claim.

 [F3] to save; [Esc] to leave
Status [=] SE's work

Comments [=]

Eng File [=] " QS File [=]
 [Esc] to exist

Press [=] to select from the list

```

Figure 5.4.3.(a) shows a sample of memo field input for a correspondence registration.

```

Existing Selection Criteria
C01:View Cost Effect Correspondence

Reference St : 0 Len : 0
Content [*] :

Issue Date From : 01/07/92 To : 30/09/92
Recev Date From : - - - To : - - -

From : Party [*]
To : Party [*]

Type of Correspondence [=] Letter

Status [=] Cost Effect_
Comment [=]

QS File [=] Engineer File [=]

[F4] to finish select; [Esc] to leave

```

Figure 5.4.3 (b)  
data retrieval for  
all the  
correspondence  
with cost effect  
for the period  
from 1 Jul 92 to  
30 Sep 92.

#### 5.4.4 Potential of Future Expansion

In considering the application of 'CCMS' in the construction industry of Hong Kong, mainland China, Taiwan and other Chinese speaking society within the Pacific Rim, one of the advantage of "FoxPro" is its ability to use Chinese characters under the top-up of a Chinese version operating system. Although such an application has not been included in this research, it should have high potential in the future research for the further development of "CCMS".

"FoxPro" systems are capable of running in local area network (LAN) environment. This is particularly significant to the linking up of the communication between project sites and head office through the telecommunication environment.

Although LAN application has not been included in this research, this is another high potential area in the future research for the further development of "CCMS".

The use of other computer peripheral equipments such as optical character recognition (OCR) etc. is an area worthwhile for further studies.

### 5.5 Conclusions and Observations

In this chapter, the development of information technology particularly relating to the system design and development of 'CCMS', has been reviewed and discussed. The system outline of 'CCMS' and its relationship with the management functions established in the model of construction management described in Chapter 6 of this thesis, have been established and exhibited.

The main findings in this chapter are summarised as follows:

- a) The current micro-computers can perform computing tasks similar to minicomputers or mainframes of 1986 standards but with substantial reductions in price (see Table 5.2.2 (b)). In terms of the application of computers in construction management, micro-computers are appropriate.
- b) Both the availability and price of the other computer peripheral equipment for data inputs, communications and output presentations, have a substantial contribution to the overall performance and efficiency of computer systems for construction management.
- c) The study in this chapter has confirmed Abdullah (1988) and O'Brien (1989) that fourth generation language should be used in the development of computer systems for construction management.
- d) This chapter has demonstrated how human factors are taken into consideration in the design of computer systems applicable for construction management, especially in regard to the handling of codes.
- e) The technical concept of data integration in the applications of construction management system has been established.

- f) The LAN and telecommunication environment for the application of computerised construction management systems, have been examined.
- g) A method of preventing authorised copy or software pirate for the computer systems applied in construction sites, has been developed.

The detailed functional operations of 'CCMS' for the management tasks of each management functions, are described in Chapters 7 to 12 of this thesis.

## 6 The Model of Construction Management in Hong Kong

### 6.1 Introduction

Following the studies of Chapters 3 and 4 of this thesis where the structure of the Hong Kong construction industry and its new developments have been discussed, this Chapter describes a model of construction management in Hong Kong. The model developed in this research is an idealized model taking into account the existing practices, published literature, previous studies and the new developments. Some of the principles described are directly related to the Hong Kong environment, but most are of more general application.

Moskowitz and Wright (1979) have defined a model of management as an abstraction or an idealized representation of a real-life system indicating the functional relationships among its elements, for analyzing the behaviour of the system and for the purpose of improving its performance.

Holt (1990) has described that management can be defined as getting thing done through the process of planning, organizing, leading and controlling that encompasses human, material and financial resources in an organization. Similarly the model of construction management discussed in this research, is an organisation model. This chapter includes a description of the model of contracting organisation structures of the Hong Kong construction industry.

Under the organisation structure based on the model of business strategy, the model of management functions can be developed. The scope of management functions discussed in this Chapter is confined to the operating core of a contracting organisation, which covers the works from the procuring of a construction project to the completion of the project.

Kodikara (1990) defined the terms of management functions, management groups and management tasks as follows:

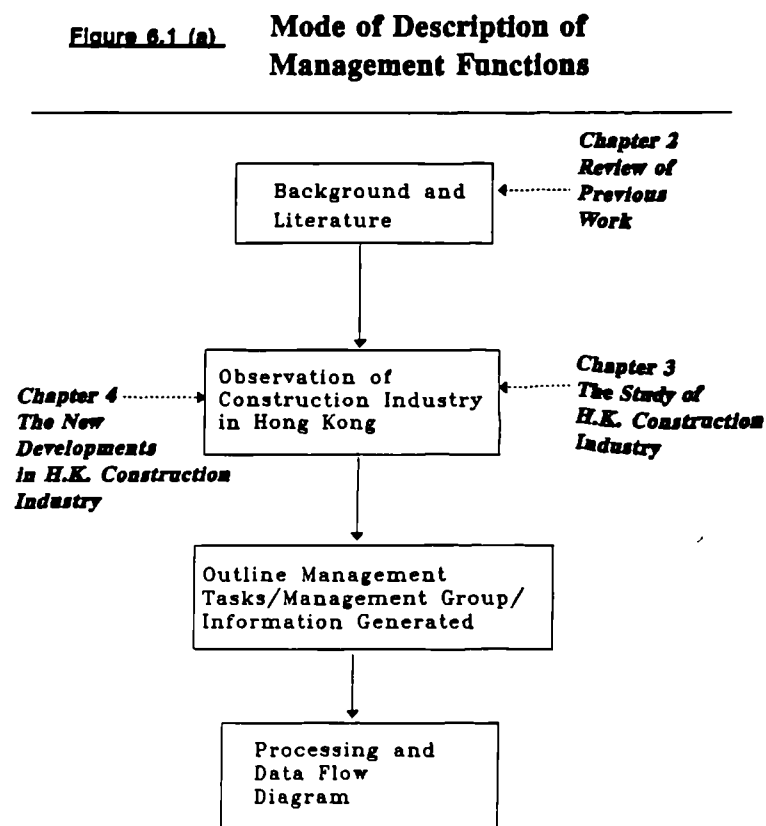
- a) Management functions are the recognizable major functions directly to be grouped from the work of a contract.
- b) Management groups are the professionals who are responsible for work in management functions.
- c) Management tasks are the tasks which are directly related to procurement and execution of contracts.

Kodikara's approach has been used in the study described in this Chapter. The management functions covered in the study include estimating, purchasing, planning, quantity surveying, site management and quality assurance.

The use of data flow models in describing the functional processing and the transfer of information between management tasks of a contracting organisation, have been demonstrated by Carter (1987), Kodikara (1990) and Thorpe (1992). The same approach is used in this chapter to present the processing and data flow between the management tasks of the following management functions:

- a) Estimating and tendering;
- b) Purchasing;
- c) Planning;
- d) Quantity surveying;
- e) Site management; and
- f) Quality assurance.

The way of describing the model of construction management and its linking with the subsequent chapters of this thesis is shown in the following Figure 6.1 (a).



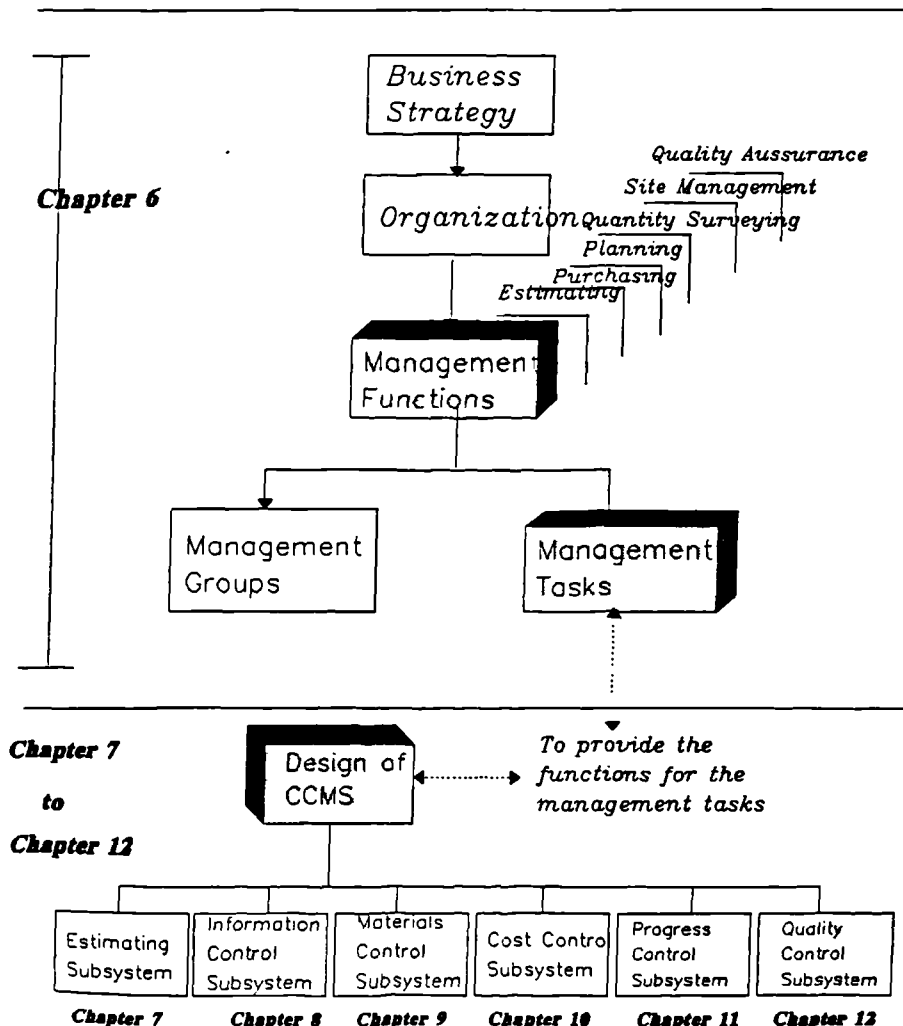
The description of each management function comprises the following aspects:

- background and literature;
- observation in the construction industry of Hong Kong;
- outline management tasks, management group and information generated; and
- processing and data flow diagram.

The relationship of these perspectives are illustrated in the following Figure 6.1 (b).

Figure  
6.1 (b)

### The Model of Construction Management and its Description in this Research



## 6.2 Business Strategy Model of Contracting Organisation

Every business needs its direction as a defined course or courses of action that the business will pursue, in both the long and short term future. Newcombe et al ( 1990) defined three levels of strategies in a contracting organisations:

- a) Corporate strategy: decisions concerning with the businesses or markets that the company should be in.
- b) Business strategy: how to compete in a particular market.
- c) Operational strategy: decisions by heads of functional departments on the mode and means of functional operations.

In this chapter, the corporate strategy of contracting organisations is confined to the construction business itself. Due to the complexity of the construction business, most contracting organisations in Hong Kong are part of an extended diversification of businesses. In Hong Kong, due to the high profitability of the real estate market, some of the public construction consortiums may be involved with real estate developments, as a forward integration to their main stream of construction business. Some of the construction companies may take up a backwards integration approach by incorporating some kind of material suppliers into their group, such as ready-mix concrete supplier and tile manufacturer etc.

In terms of the concerns of business strategy, public contracts generate highest competition in the construction industry as described in Chapter 3 of this thesis. In private sectors, construction projects are mainly procured through price competition bidding but in certain circumstances post-tender negotiations and other commercial considerations, may substantially affect the result of tendering.

For public contracts, the qualifications of contractors in the industry are pre-assessed by the Government on their financial ability and past performance. The details of such a classification system are described in Section 3.4 of this thesis. According to the classification, every contractor in the market for public contracts has been allocated a tender grade. The grade represents the type of tender in terms of budgetary value, for which the contractor is eligible to bid. The business strategy of the contracting organisations catering for public contracts under this circumstance, forms the model of business strategy in this chapter, the characteristics of which are as follows:



- a) The bidders are in full competition on tender prices, leading to low profit margins in the contracts;
- b) The whole contract terms, binding to both parties, will be fully implemented and enforced at the post-contract stage, without exemptions;
- c) The past contract performance will be recorded and affects the opportunities of future tenders;
- d) A strong contract supervising team from the client with sufficient authorities from the contract, will be faced and has to be dealt with during the contract period;
- e) Sufficient public projects from Hong Kong Government are available in the market at least up to the next decade, however the only draw back may be the unstable and uncertainty of the political environment due to 1997;
- f) Well trained technical and highly professional human resources, are adequately supplied from the higher-education and the professional institutions ;
- g) First class world-wide construction expertises are available in the market, providing sufficient external consultancy support as required;
- h) Full competition from the international construction consortiums are expected, and the assistance from the Government to local contractors is extremely limited;
- i) Accordingly, a tight management control system is required to increase the management standard, for which it is not just for increasing the profit, but is essential to support the survival in the market; and
- j) Finally, job opportunities are also available in those special economic zones of China, and other countries of the Pacific Rim.

### 6.3 Contracting Organisation Model

#### 6.3.1 Study of Organisations

Organisational structure studies have produced plenty of literature over the years (for example Mintzberg 1979; Sofer 1973; Johannsen and Page 1986). Mintzberg (1979) has laid down the definition that the structure of an organisation can be defined simply as the sum total of the ways in which it divides its labour into distinct tasks and then achieves co-ordination among them. Johannsen and Page (1986) have further elaborated that the design of an organisation structure involves an arrangement of the work of the organisation into units and management positions between which there are defined relationships involving the exercise of authority and the communication of instructions and information.

Mintzberg (1979) has identified his famous five basic parts of an organisation as a result of organisation growth and elaboration. The five basic parts are:

- a) The Operating Core: The operating core of the organisation encompasses those operators who perform the basic work related directly to the production of products and services.
- b) The Strategic Apex: The strategic apex is charged with ensuring that the organisation serves its mission in an effective way, and also that it serves the needs of those people who control or otherwise have power over the organisation.
- c) The Middle Line: The strategic apex is joined to the operating core by the chain of middle-line managers with formal authority.
- d) The Technostructure: The control analysts of the technostructure serve to effect standardization in the organisation.
- e) The support staff: The staff exist to provide support to the organisation outside the operating work flow but are essential to serve the legal and environmental needs.

An organisation model comprises of a schematic showing the organisational levels and spans of management responsibility for each member of the organisation (Koontz and Weihrich

1988). The model developed by Mintzberg can be applied to most commercial organisations as a standard model to analysis the details of the functional activities of an organisation. Mintzberg's concepts on organisations have been applied in the analysis of site organisations for this research.

### 6.3.2 Study of Contracting Organisation.

The study of organisational structure for construction contracting organisation has also been widely published (for example Harris and McCaffer 1989; Fryer 1990;). Contracting organisations like any commercial organisations should also comprise the five basic parts as defined by Mintzberg (1979). However, the operating core of contracting organisations can be viewed as comprising two levels of operation: head office and construction site. A construction site can also be viewed as a separate organisation in terms of functional operation, based on which an independent organisational model can be built. However, from the viewpoint of overall organisation structure, this kind of structure combining of functional and production departmentation in the same organisation, is defined as a matrix organisation (Kast and Rosenzweig 1979, Koontz and Weihrich 1988).

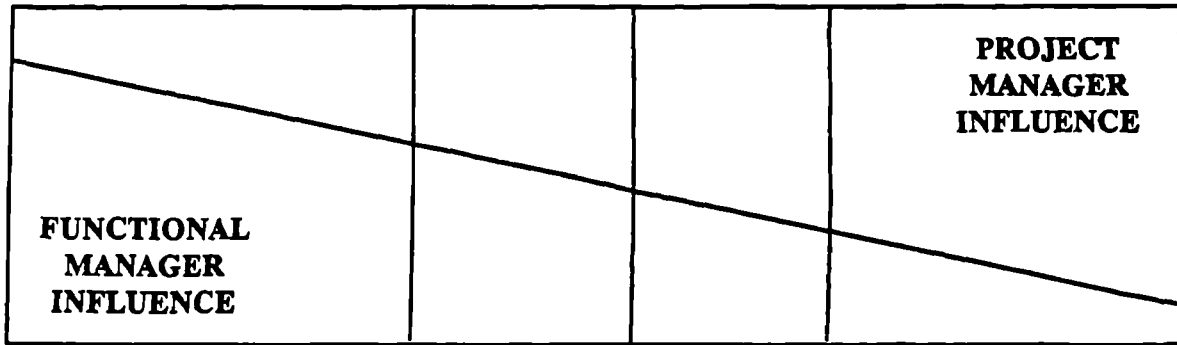
Matrix organisation structure can be viewed as a compromise between the traditional functional organisation and the autonomous project organisation. Kast and Rosenzweig (1979) pointed out that the matrix form is a structural design geared to two primary organisational needs:

- a) the need to specialise activities into functional departments that develop technical expertise and provide a permanent home base for employees.
- b) the need to have units that integrate the activities of these specialised departments on a program, project, product or systems basis.

Bresnen (1990) compiled the models of matrix management taking into the models of matrix management by previous studies (Galbraith 1971, Sayles 1976, Knight 1979). These models range from pure functional forms of organisation at one end, to pure project forms of organisation at the other. A comparative description of these models and their relationships to Galbraith's original continuum, as compiled by Bresnen is given in Figure 6.3.2 (a).

Figure 6.3.2 (a)

## Models of Matrix Management



**Galbraith (1971)**    Functional organisation    —    Project integrators    —    Matrix organisation    —    Functional integrators    —    Project organisation

**Sayles (1976)**    Dispersed systems matrix    —    Product management    —    Bipolar management    —    Development projects    —    Internal consulting services

**Knight (1977)**    Functional organisation    —    Co-ordination model    —    Overlay model    —    Secondment model    —    Project organisation

The form of matrix organisation structure can be applied to most sophisticated contracting organisations in Hong Kong as a model of contracting organisations. The matrix organisation structure is to cater for the model of business strategy as described in Section 6.2 of this chapter. The adoption of matrix organisation structure in contracting organisations of Hong Kong is due to the following observations:

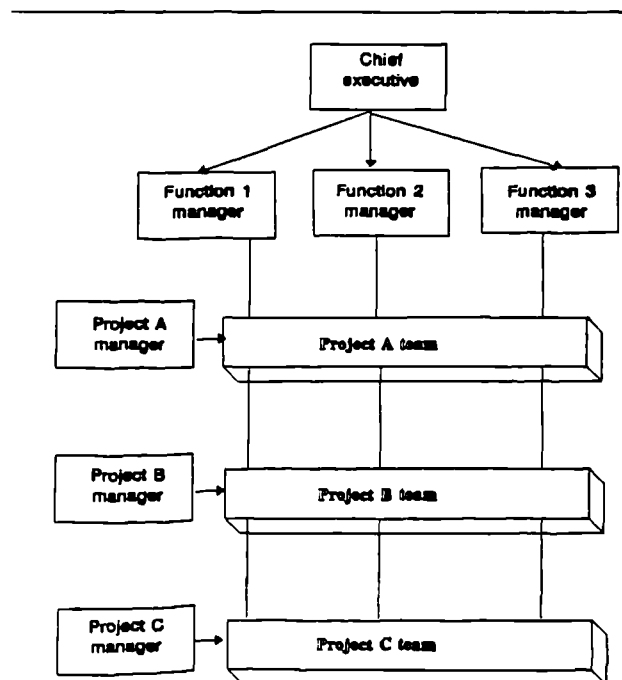
- a) Higher contractual requirements in respect of time, cost and quality of construction projects, require contractors to perform higher professional standards in technical management functions such as temporary structural designs, building services monitoring, planning, quantity surveying, and quality control etc. This situation may create difficulties for the site management for procuring sufficient expertises. A matrix organisation structure can ensure sufficient technical and managerial support from the head office for ensuring the professional standards of such management functions.

- b) Higher competition in bidding for construction projects, and the inherent limitation of project life, create difficulties for contractors to provide job security for site positions. A matrix organisation structure can create a centralised and job stable impression for those professional staff of a contracting organisation.
- c) A matrix organisation structure centralises operational procedures and policies for the management functions, which are supposed to be applied to all the projects under the same organisation, for example quality assurance work procedures.
- d) A matrix organisation structure can provide better co-ordination, flexibility and utilisation of professional resources in a contracting organisation. In case of necessary, the expertises of certain area can be mobilised from one project to another.

A model of matrix organisation structure developed by Bresnen is shown in Figure 6.3.2 (b).

Figure 6.3.2 (b)

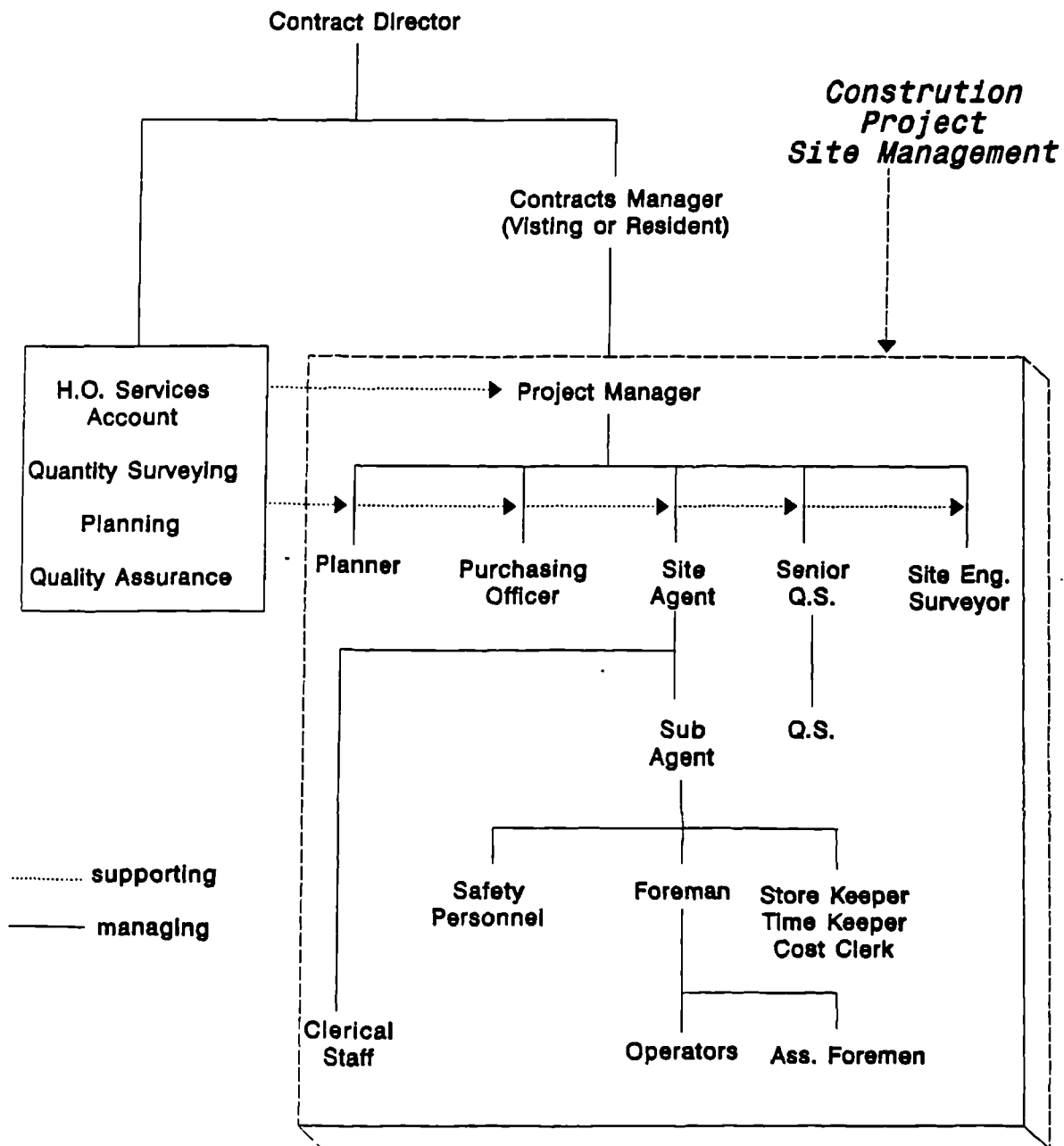
### Matrix Organisation



A typical matrix organisation for contracting organisations based on the study in Hong Kong construction industry as described in Chapter 3, is shown in Figure 6.3.2 (c).

Figure 6.3.2 (c)

## Typical Construction Firm Matrix Organisation



## 6.4 Estimating and Tendering Functions

### 6.4.1 Literatures, Previous Studies and Background

In traditional contract procurement systems, contracting organisations in the construction industry procure their business through a process called tendering. For procuring a construction project, the project promoter employs the consultants to prepare the design and then the tender documents which state the requirements of the project in terms of:

- a) the design and specifications;
- b) the conditions under which the project should be carried out; and
- c) any particular requirements in relation to the project.

RICS Technical Paper 'Tender Action' Quantity Surveyor Practices Pamphlet No 1 states that the tender documents may include:

- a) conditions of tender;
- b) form of tender;
- c) general conditions of contract;
- d) particular conditions of contract;
- e) general specification;
- f) particular specification;
- g) bill of quantities; and
- h) design drawings.

The procedure and format of tendering includes open tendering, selective tendering and negotiated tender and has been thoroughly covered by the publications and through professional practice (Buchan et al 1991; Pickard et al 1992). This is the commercial background under which the estimating and tendering process of a contracting organisation has to be carried out.

Harris and McCaffer (1983) defined that estimation is to determine the cost to the contractor of executing the work defined in the tender documents. McCaffer and Baldwin (1991) pointed out that the estimating and tendering process within a contractor's organisation takes place between two well defined points, the decision to tender and the submission of the tender, and the following steps are involved in producing an estimate for a contracting organisation:

- a) programming the estimating task;
- b) preliminary project study;
- c) materials and sub-contractor enquires;
- d) detailed project study;
- e) calculating labour and plant costs;
- f) estimating the direct costs of the project;
- g) calculating on costs; and
- h) preparing reports for tender adjudication.

#### **6.4.2 Observations in Hong Kong Construction Industry.**

The steps of estimating identified by McCaffer and Baldwin cover most construction projects in normal circumstances. In Hong Kong, most construction contracts are in bill of quantity format. A bill of quantities contains both quantitative and descriptive information of a proposed project, by which it conveys the scope of the proposed project in a quantitative format based on a recognizable standard method of measurement. Seeley (1988) has described that the first and foremost purpose of bills of quantities is to enable all contractors tendering for a contract price on exactly the same information with a minimum effort. The unit rate build-up based on bill of quantities is the most important management task of estimators who are employed to carry out the work of estimating and tendering in contractors' estimating function. Kodikara (1990) in his study also identified this point.

In most cases, unit rates contained in contract bill of quantities are defined as contract rates which will be used as a basis for the valuation of contract variations (JCT 80 Clause 11; ICE 79 Clause 53; HKIS 86 Clause 11; HK Government 90 Clause 61). During the post-tender stage, the consultant quantity survey will then compare the submitted tender rates and query for any serious inconsistency. All the queries and responses should be in written form and will be incorporated into the contract document as part of the contractual considerations which will be legally binding to both parties and are also crucial to the future contract variations.

As pointed out in Chapters 3 and 4 of this thesis, subcontracting is one of the main characteristics of the Hong Kong construction industry. This includes both portions of domestic subcontracts and nominated subcontracts. In respect of unit rate tendering on bill of quantities under a subcontractor orientated situation, a number of studies have addressed this (Ndekugri (1988); Flanagan and Norman (1989); Kodikara (1990)). In addition to these researches, the relevant observations are summarised as follows:



- a) A major advantage in the use of subcontractors as the main contractor's concern is passing the risk of the main contract onto the subcontracts. Most subcontract prices will be provided by the contractor's known regular subcontractors for different trades. A substantial proportion of the time of estimating will be used to negotiate with the sub-contractors on the unit rates based on a comparative method for each rate with different subcontractors.
- b) In most cases, the estimator does not re-measure the quantities stated in the bill of quantities for tendering purpose, unless for ordering of materials in post-contract stage. The quantities will be spot checked for major items in case of necessary. It is allowable in most recent standard forms of contract for the change of relevant unit rates, if a substantial difference is found between the bill quantities and the real quantities.
- c) Costs will be priced on a unit rate basis, but will in fact be some mixture of costs that are:
  - Fixed;
  - Quantity related;
  - Time related;
  - Value related;
  - Project related; and
  - Company related.

The details of these relationships are lost when they are subsumed into unit price rates.
- d) The substantial portion of prime cost and provisional sums to be executed by nominated subcontracts, reduces the contractor's level of financial risk exposure, but the limited amount of information about the work packages will add greater uncertainty.
- e) Due to the complication of projects, the construction costs are affected by the methods of construction in respect of the sequence of work packages, the continuity and repetitive of activities, the degree of interdependence of trades and operations and the extent of possible mechanisation. Some of the work will be priced in an operational format and converted into unit price rates.

In addition to the traditional estimating and tendering procedures developed by previous studies (Mudd 1984; McCaffer and Baldwin 1991), new thinking should be applied, based on the above mentioned observations. In order to tackle this, the following procedures should be adopted within the estimating and tendering function of a contracting organisation:

- a) Standard forms of domestic subcontract should be developed, used and reviewed periodically in the light of the changes in the standard form of main contract. Feedback from previous contracts on the contract administration of both main contracts and subcontracts should be well organised to enable the estimator to use them for tender reference.
- b) A functional and departmental data bank should be established to record the past bill items and its associated unit rates including the build-up and the subsumed subcontract rates. The background situation associated with historical rates should be recorded in an easily accessible format. A productivity data bank should be established to capture the predictable productivity and the actual productivity of previous contracts.
- c) A data bank library for subcontractors and suppliers should be established to record the updated information for each of the parties to the contract, the past performance and the last quoted prices. This should help the estimator to decide on the number of subcontract work packages and the number of subcontract quotations for each work package.
- d) Estimating and tendering is a complicated process involving different parties, procedures and information flow. For ensuring that the tender can be completed within the time during which much of the work must be undertaken in parallel, a tender programme should be used to monitor and control the tendering progress. Project management techniques in terms of planning, organising and controlling should be applied.
- e) It has been recognized that the estimator is the first party in a contracting organisation in touch with the project information. Within such information, the materials specified for the project will crucially affect the overall construction costs, and then of course the tender price. It is important

for the tenderer to ensure that the right information has been abstracted from the right source within the tender documents to the right parties for quotations. Such information should be systematically recorded and should be used to support the post-contract purchasing and material management.

- f) It is important to ensure that the risks contained in the tender documents have been well considered and allowed for in the tender price. A standardised format should be established for the estimator to record the abstracted contract risks in terms of contract parameters, design liabilities, nominated subcontract risks and particular requirements etc. The information should be passed to support the post-contract management in case the bidding is successful, otherwise it should be kept as a reference for future tenders if the tender fails.

#### 6.4.3 Management Tasks and Management Groups

In a contracting organisation, the estimating and tendering process involves the management group of estimators, planning engineers, purchasers, quantity surveyors, various technical engineers, site managers, construction managers. In addition, it may also involve a number of within or outside advisers and specialists including design, insurance, legal and other technical aspects. The outside parties directly involving with the tender include the client's consultants, domestic subcontractors and suppliers.

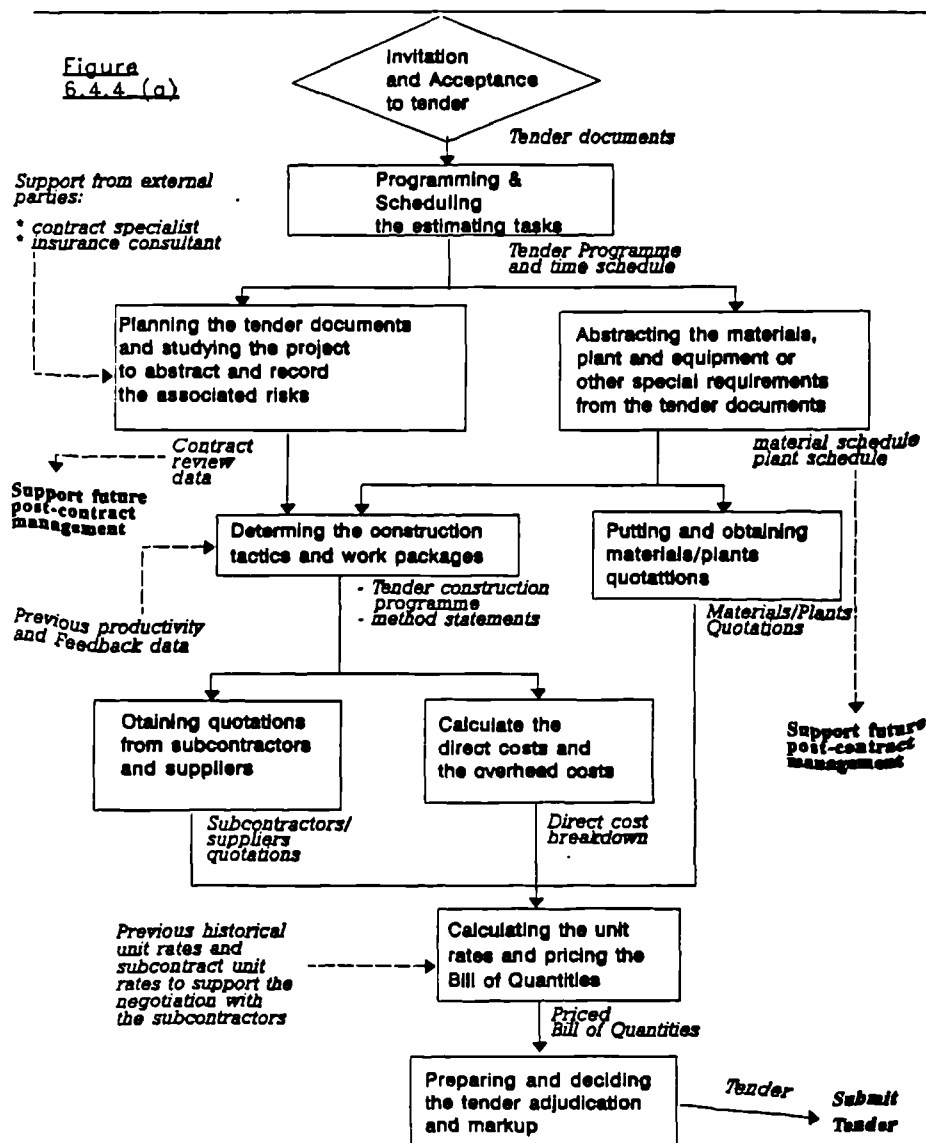
The management tasks and its responsible management groups for the management function of estimating in a contract organisation, are listed as follows:

|    | Management Tasks                                                                                          | Management Group                                                                    | Generated Information                                |
|----|-----------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------------------------------------------------------|
| a) | programming and scheduling the estimating task;                                                           | * Estimator                                                                         | Tender preparation programme and time schedule.      |
| b) | examining the tender documents and studying the project to abstract and record the associated risks;      | * Estimator<br>* Contracts Manager                                                  | Contract review report.                              |
| c) | abstracting the materials, plant and equipment or other special requirements from the tender documents;   | * Estimator<br>* Quantity Surveyor<br>* Purchaser                                   | Materials/equipments enquiry schedule.               |
| d) | determining the construction tactics and methods, the division of work packages and subcontract contents; | * Estimator<br>* Contracts Manager<br>* Planning Engineer<br>* Construction Manager | Tender construction programme and method statements. |

|    |                                                                    |                                       |                                              |
|----|--------------------------------------------------------------------|---------------------------------------|----------------------------------------------|
| e) | obtaining quotations from the suppliers and subcontractors;        | * Estimator<br>* Purchaser            | Materials, plant, and subcontract quotation. |
| f) | calculating the direct costs and the overhead for the project; and | * Estimator<br>* Construction Manager | Overhead and direct cost analysis report.    |
| g) | calculating the unit rates and pricing the bill of quantities;     | * Estimator                           | Priced bill of quantities.                   |
| h) | preparing reports and deciding the markup and tender adjudication. | * Estimator<br>* Contracts Manager    | Tender for submission.                       |

#### 6.4.4 Processing and Data Flow Diagram

##### Estimating/Tendering Process and Data Flow Diagram



## 6.5 Purchasing Management Functions

### 6.5.1 Literature, Previous Studies and Background

Material purchasing and management is an important management function in the whole construction management process. Illingworth (1987) defined materials management as all the actions that are necessary to:

- a) purchase competitively materials of the specified quality;
- b) ensure that materials are delivered to site when needed;
- c) unload and handle materials to the work-place economically and without damage;
- d) minimise waste.

England (1970), McCaffer and Pasquire (1987), Kodikara (1990) and Thorpe (1992) have identified the management function of purchasing with the following attributes:

- a) It is a separate department or function within a contracting organisation, usually in the head office;
- b) The function is performed by a manager called the purchaser;
- c) The management tasks are generally recognized as follows:
  - identifying material requirements;
  - preparing material schedules for purchasing and ordering purpose;
  - reviewing the material quotations and potential suppliers;
  - placing and following-up the orders;
  - arranging deliveries and
  - managing the records.

The previous studies mentioned above, have revealed that materials management as a management concept comprises two main management functions: purchasing and site control. The purchasing function is covered in this section. The site material control will be described as part of site management under Section 6.8 of this chapter and the details of site management operation for material controls will be described in Chapter 9 of this thesis.

Ndekugri (1986) stated in his thesis that a construction company with several on-going contracts had three alternative ways or procuring materials for the various contracts:

- a) complete centralisation, all buying being done by head office or branch office;
- b) complete decentralisation; and
- c) a combination of centralisation and decentralisation.

Baily and Farmer (1990) in their comments on the centralisation or decentralisation purchasing policy said that the advantages of one approach were the disadvantages of the other thus a combination of both was often used to obtain the benefit from the best features each while avoiding the disadvantages of both approaches.

#### **6.5.2 Observations in the Hong Kong Construction Industry**

The study in Hong Kong as described in Chapters 3 and 4, shows the following characteristics and new development of Hong Kong construction industry in respect of material purchasing:

- a) Hong Kong is a small place, most contractors adopt a policy of centralisation purchasing but the control of material ordering will be from each individual site. In view of the expensive rental value of warehouses, in Hong Kong it is seldom for contractors to keep their warehouses for storing materials. Even if necessary the materials will be stored on site. For example in high rise building contracts, the tiling materials will be stored within the building structure after the structural frame has been substantially completed to a stage enabling a quasi-warehouse to be formed. However, due to a fear of overloading to the just-completed structure, there usually is a restriction on the quantity of materials to be stacked on suspended floors, for which an approval should be obtained based on the discretion of contract supervisor before the materials can be placed.
- b) Materials ordering and arranging for materials delivery to site, rely on tight co-ordination between the sites and the purchasing department at the head office.
- c) In most construction contracts, the contract supervisor plays a crucial role in material procurements on top of the requirements of the specifications. Higher flexibility will usually be allowed in the contract conditions through

a requirement of sample submissions, empowering the contract supervisor to have final approval of the quality of materials before they are put into final fixing.

- d) Variation clauses in most standard forms of contract, allow a great flexibility for the client to change both the quantity and the quality of materials in a construction project, for which the contractor has to comply but can claim for extra costs if any. Such changes may create pressure to the purchaser to look for new materials and make the contractor lose the position of getting the probable benefits of full price competition from different suppliers.
- e) There are three categories of materials which will be treated differently in terms of material ordering from site. They are:
  - i) Daily routine critical materials - such as concrete for reinforced concrete structures. It will be the front-line management such as the foremen or the site engineers to initiate the order by filling in the form, and hand it to the assigned material orderer who will then directly make order to the supplier or the batching plant. The front-line management will then decide on the quantity of the order by referring to the concrete quantities allocation by floors or locations from the site quantity surveyor. For those materials, usually a bulk purchasing contract should have been signed before the start of the construction work.
  - ii) Short-term routine critical materials - such as steel bars for reinforcement and timbers for timer formwork in reinforced concrete structure. The acquisitions of such materials will be by batching for next week's work in parallel with the construction progress. It will be the front-line management such as the foremen or the site engineers in consultation with the relevant trade subcontractors to decide on the quantities and timing of the material order. The initiation of the material order is also from the front line management but this time the quantities should be checked and agreed by the site quantity surveyor.
  - iii) Other materials - all the materials other than those materials mentioned above. The ordering of such materials should comply with a material schedule agreed between the site and the purchasing department at the initiate stage of the project. The material ordering

for this categories will be initiated by the assigned material ordered by filling in the form. The quantities of each order will be consulted with the site foremen and store keeper and should be approved by the site quantity surveyor and the site manager.

### 6.5.3 Management Tasks and Management Groups

Illingworth (1987) outlined a table showing the tasks associated with materials management. Based on Illingworth's table and the observations mentioned above, the following table shows the tasks associated with the materials management of construction projects:

#### Pre-tender Stage:

|    | Management Tasks                                         | Management Group | Generated Information                   |
|----|----------------------------------------------------------|------------------|-----------------------------------------|
| a) | Analyse tender documents to list out materials required. | * Estimator      | Materials/equipments enquiry schedules. |
| b) | Send out enquiries to obtain quotations                  | * Purchaser      | Enquiries and responded quotations      |

#### Pre-contract and Post-contact Stage: (After the contract is confirmed)

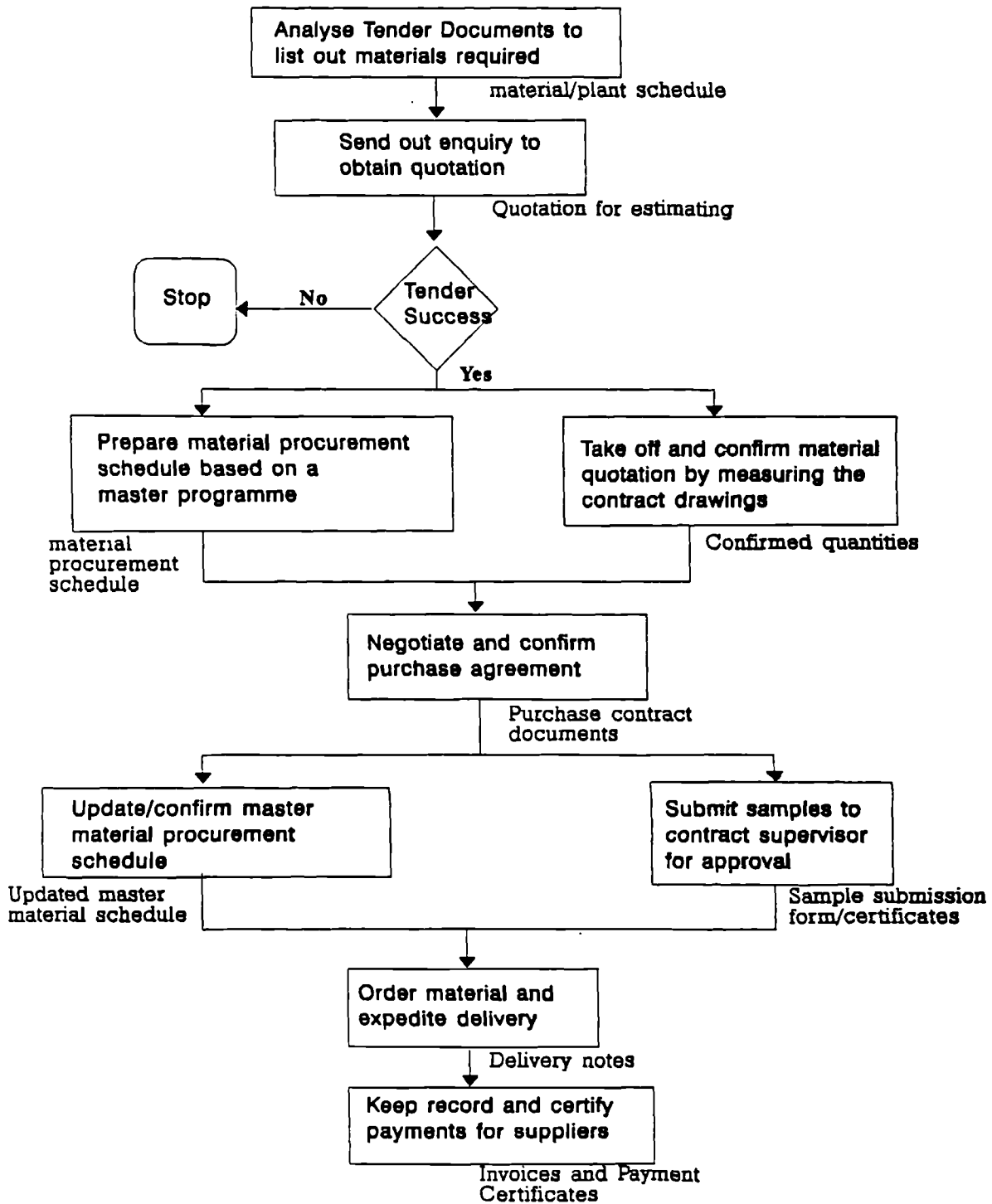
|    | Management Tasks                                                                             | Management Group                                           | Generated Information                                   |
|----|----------------------------------------------------------------------------------------------|------------------------------------------------------------|---------------------------------------------------------|
| c) | Prepare material procurement schedules based on a master construction programme.             | * Purchaser<br>* Planning Engineer<br>* Site Manager       | Material procurement schedules.                         |
| d) | Take off and confirm material quantities by measuring the contract drawings.                 | * Site quantity surveyor                                   | Confirmed quantities and material procurement schedule. |
| e) | Negotiate and confirm purchase agreements.                                                   | * Purchaser<br>* Contracts Manager                         | Purchase contract documents                             |
| d) | Confirm/update master material procurement schedule.                                         | * Purchaser<br>* Planning Engineer<br>* Site Manager       | Material procurement schedule                           |
| e) | Submit samples to contract supervisor for final approval and co-ordinate with the suppliers. | * Site Quality Control Engineer.<br>* Purchaser.           | Sample submission form.                                 |
| f) | Order material and expedite deliver.                                                         | * Purchaser.<br>* Site Manager                             | Raising file, correspondence.                           |
| g) | Keep records for invoices and delivery notes and certify payment to suppliers.               | * Purchaser.<br>* Site Quantity Surveyor.<br>* Accountant. | Invoice, delivery notes and other relevant records.     |

Most activities for materials purchasing in post-contact stage are of a repetitive nature involving various parties. A master materials procurement schedule is important to ensure a tight co-ordination between all parties concerned, especially to cater for the parties between head office and site.



## 6.5.4 Processing and Data Flow Diagram

Figure 6.5.4 (a)

**Purchasing Processing and Data Flow Diagram**

## **6.6 Planning Management Function**

### **6.6.1 Literatures, Previous Studies and Background**

The term 'planning' used in construction management has a wide range of meanings to different people, from drawing up a construction programme to all the work undertaken by the planning department of a contracting organisation. The procedures involved in planning may vary from different organisations. Construction planning from a view of contracting organisation can be divided into pre-tender planning, pre-contract planning and post-contract planning (Pilcher 1976; Cooke 1981; Moder 1983; Neale and Neale 1989).

Kodikara (1990) in his study identified that large contracting organisations had separate planning divisions, whereas small to medium organisations usually allocate the planning tasks of a project to site management. This research confirms Kodikara's finding. The study in this chapter as a model of construction management in Hong Kong reflects most sophisticated contracting organisations in construction planning that involves a matrix functional organisation to handle planning operations. Pre-tender and pre-contract planning are handled at head office level through a central planning division looking after all projects. The post-contract planning tasks for individual projects are the responsibility of the site management as part of the site core management function. Still the head office planning division remains a role of technical support to the site planning, which includes planning techniques and computerisation etc. Planning management function in this section covers pre-tender, pre-contract and post-contract planning and it is emphasised in planning and progress control.

### **6.6.2 Observations in the Hong Kong Construction Industry**

In view of the increasing complexity and inherent risks associated with construction projects nowadays, modern construction management demands a support of highly effective planning and tighter progress control for construction activities. The concept of planning and control for construction management encompasses a wide range of formats in terms of the degree of sophistication. It can be as simple as an ad-hoc day-to-day monitoring for simple domestic projects or an expensive mainframe computer system to handle complicated projects. It is believed that the beneficial break-even in the balance between the degree of planning and control and

the subsequent extra overheads will be variable according to the differentiations of organisation and the type of projects involved.

With a modern construction project, it is not unusual to see a situation combining the techniques of building construction, civil engineering and building service together in one project. In order to let the contract supervisor have a better control on the project from the view point of contract administration, the burden of project planning and co-ordination duties on the main contractor has been getting higher and higher, through the contractual arrangements and the conditions of contract. The common standard forms of contract seldom have specific Clauses in the conditions itself governing the planning submissions such as JCT, HKIA, ICE etc. These standard forms are mainly drafted in 1950s and 1960s. In particular circumstances with the use of such standard forms, the requirements for planning submissions may be put in the special conditions of contract or preliminary bill rather than in the standard form. However, the new forms in Hong Kong public sectors have changed the situation by putting the specific requirements for planning submissions into the standard form of contract itself. Clause 16 of the Airport Core Programme General Conditions of Contract, has specified the procedures and requirements of programme submissions including the time limits in both the contractor's submissions and the Engineer's responses.

### 6.6.3 Management Tasks and Management Groups.

The planning management function should, therefore, serve and satisfy both aspects of internal management needs and external contractual requirements. The management tasks and its responsible management groups of planning management function in a contract organisation, are listed as follows:

#### Pre-tender Planning Stage:

|    | Management Tasks                                                                   | Management Group                              | Generated Information                   |
|----|------------------------------------------------------------------------------------|-----------------------------------------------|-----------------------------------------|
| a) | From the tender documents to decide the construction methods and tactics.          | * Construction Manager *<br>Planning Engineer | Statement of construction method.       |
| b) | Prepare method statement for key operations and construction programme for tender. | * Construction Manager<br>* Planning Engineer | Method Statements;<br>Tender programme. |

## Pre-contract Planning Stage:

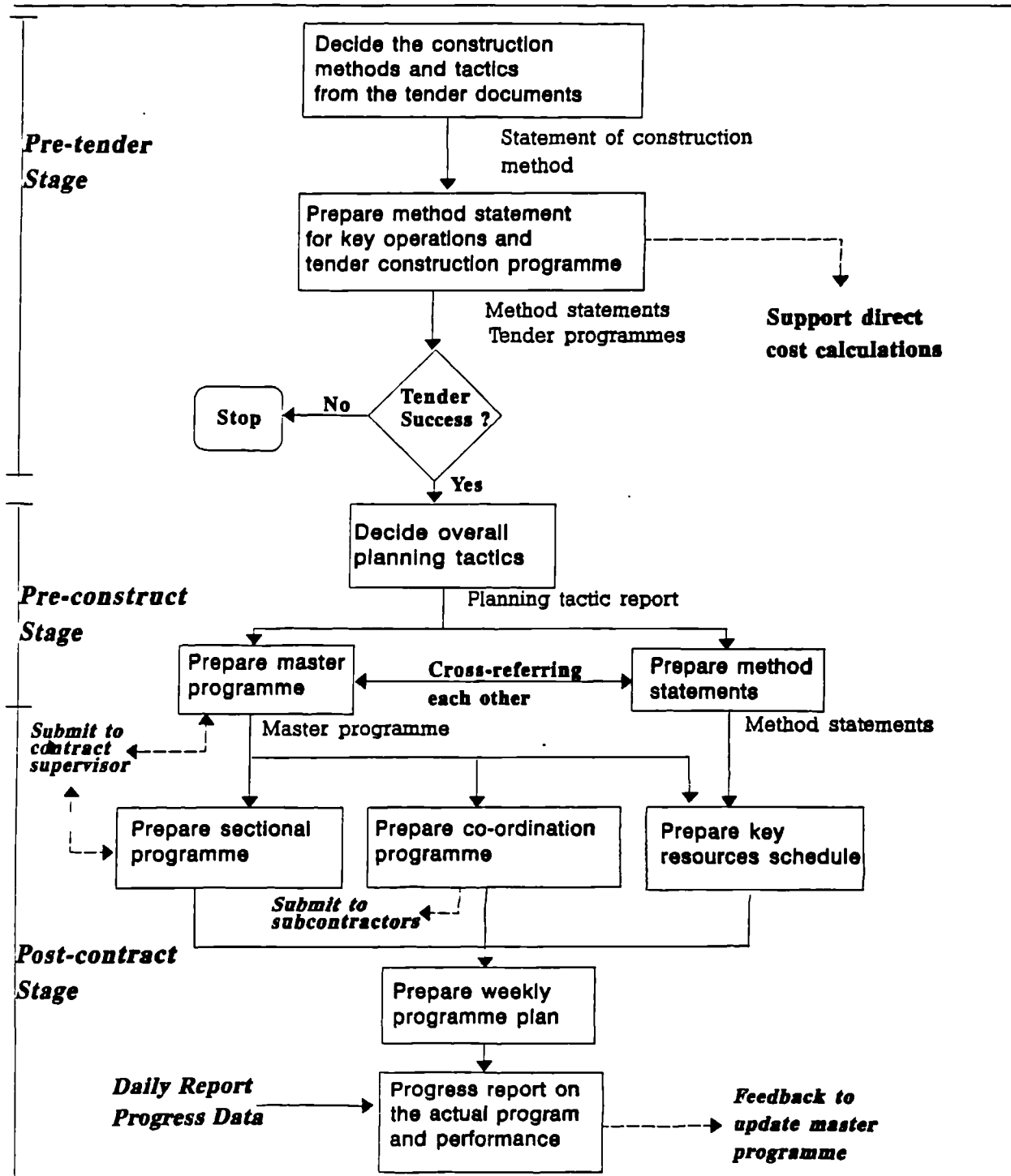
|    | Management Tasks                                                                                                       | Management Group                                             | Generated Information                                                                       |
|----|------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| c) | Decide an overall planning tactic based on the requirements of contract conditions and the characteristics of project. | * Contracts Manager<br>* Site Manager<br>* Planning Engineer | Planning strategy report (stating the planning techniques in use, the span of control etc.) |
| d) | Develop from tender programmes or tender method statements to detailed method statements for key operations.           | * Site Manager<br>* Planning Engineer                        | Detailed method statements for key operations; and Plant schedule.                          |
| e) | Prepare master programme for site operation and submission to contract supervisor.                                     | * Site Manager<br>* Planning Engineer                        | Master programme.                                                                           |

## Post-contract Planning Stage:

|    | Management Tasks                                                                                                                                 | Management Group                                          | Generated Information                 |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|---------------------------------------|
| f) | Review and update master programme for site operation and submission to contract supervisor.                                                     | * Site Manager<br>* Planning Engineer                     | Updated master programme.             |
| g) | Prepare and update key resource planning and forecast (e.g plants, direct labours and information).                                              | * Site Manager<br>* Planning Engineer                     | Resource forecast schedules.          |
| h) | Prepare and update subcontract co-ordination programmes for site operation and submission to the contract supervisor and other relevant parties. | * Planning Engineer<br>* Site Engineers                   | Subcontract co-ordination programmes. |
| i) | Prepare and update short term programmes for different sections of the project.                                                                  | * Planning Engineer<br>* Site Engineers<br>* Site Foremen | Short term sectional programmes.      |
| j) | Attend and hold progress review and co-ordination meetings.                                                                                      | * Site Manager<br>* Planning Engineer<br>* Site Engineers | Minutes of meetings.                  |
| k) | Detailed weekly plans based on sectional programmes.                                                                                             | * Site Engineer.<br>* Site Foremen.                       | Weekly plans.                         |
| l) | Prepare and submit daily progress report to the contract supervisor.                                                                             | * Site engineer<br>* Site foremen                         | Daily progress report.                |
| m) | Prepare and update progress reports for submission to both internal top management and external contract supervisor.                             | * Planning Engineer<br>* Site Engineers<br>* Site Foremen | Progress reports.                     |

## 6.6.4 Processing and Data Flow Diagram.

Figure 6.6.4 (a)

**Planning Process and Data Flow Diagram**

## 6.7 Quantity Surveying Management Function

### 6.7.1 Literature, Previous Studies and Background.

Most current literature regarding quantity surveying practices views the tasks of quantity surveyor more and less from a viewpoint of consultant quantity surveyor rather than a management function within a contracting organisation (Willis and Willis 1975, Hughes 1978, Turner 1983, Seeley 1984). The scope of quantity surveying in a contracting organisation, includes a wide range of tasks. Studies by previous researchers in the quantity surveying management function of a contracting organisation, may use a different terms. Kodikara (1990) used a term of 'quantity surveying/financial control' management function in a similar context and defined the most important tasks in quantity surveying and financial control as follows:

- a) Preparation of interim bills;
- b) Preparation and monitoring cash flow;
- c) Accommodation of variations;
- d) Preparation of claims; and
- e) Preparation of the final bill.

McCaffer and Pasquire (1987) used a term of 'surveying management function' in a similar context and described that the surveyor's tasks revolved around the income and expenditure involved in executing the contract. There are few literatures and studies addressing specifically to the practices of quantity surveying management function for contracting organisations in Hong Kong, where a tighter control in cost will be required as pointed out in Chapter 3 of this thesis. Wong (1991) studied the function of quantity surveying in contracting organisations of Hong Kong and summarised the associated management tasks as follows:

- a) Check documents for post tender acceptance;
- b) Assist in procuring domestic subcontractors;
- c) Assist in contracting for nominated subcontractors;
- d) Prepare interim valuations for both the main contract and subcontracts;
- e) Reconcile cost/value reports;
- f) Forecast budgets and cash flows;
- g) Evaluate valuations and prepare contractual claims;
- h) Measure quantities for materials procurements;
- i) Assist in controlling material wastages; and
- j) Compile final account and aid to settle disputes.

### 6.7.2 Observations in the Hong Kong Construction Industry

According to the study of the Hong Kong construction industry as described in Chapters 3 and 4 of this thesis, the quantity surveying management function of a contracting organisation in Hong Kong covers a much wider scope of tasks than the above mentioned literatures. Like the 'estimating and tendering' management function, the 'quantity surveying' management function usually is served by an independent department or division in most contracting organisations. But it is also similar to 'planning' management function as a matrix structure under double leadership including the quantity surveying management at the head office and the site manager. Most quantity surveying management tasks are carried out on site in post-contract stage, by a dedicated position called 'site quantity surveyor' or 'project quantity surveyor'. The head office quantity surveying division provides a kind of policy making and technical supports similar to the planning division, and it is particularly significant in contractual claims and computer applications.

The following situations in Hong Kong construction industry, have substantial influences in the scope of management tasks for the quantity surveying management function of a contract organisation:

- a) The high competition in construction contracts due to the participation of international contractors, makes the bidding prices for succeeded tenders more or less marginally below costs. The contracting organisations in the industry therefore, have to pay more attention in budgeting and cost controls;
- b) The complexity of construction projects, involves the main contractor with more trades and specialists, which are usually put in a form of nominated subcontractors or nominated supports by the client. This makes the contractual arrangement in construction contracts more complicated and the main contractor has to accommodate the interim payments and variations for the nominated subcontracts. A similar situation also applies to domestic subcontracts, under which managing subcontract payments is a source of heavy workload for site quantity surveyors;
- c) The variation clauses of construction contracts, usually allow a great flexibility for the client and the contract supervisor to change the project in terms of design, quality and quantity. The trend in the modern standard forms of contract conditions gives more flexibilities

to the contract supervisor, but requires more tight controls on both the timing and the quality of responses from the contractor to the issued variations and the subsequent contract claim submissions. In response to this tendency, the contractors have to pay more attention to contract administration and data recording; and

- d) Most construction contracts nowadays are lump sum with bill of quantities. Although the quantity of each bill item is calculated by the consultant quantity surveyor, and supplied with the bill of quantities, the contractor has to re-measure the quantities from the drawings for material procurements. The workload of quantity re-measurements from working drawings is one of the massive jobs in site management.

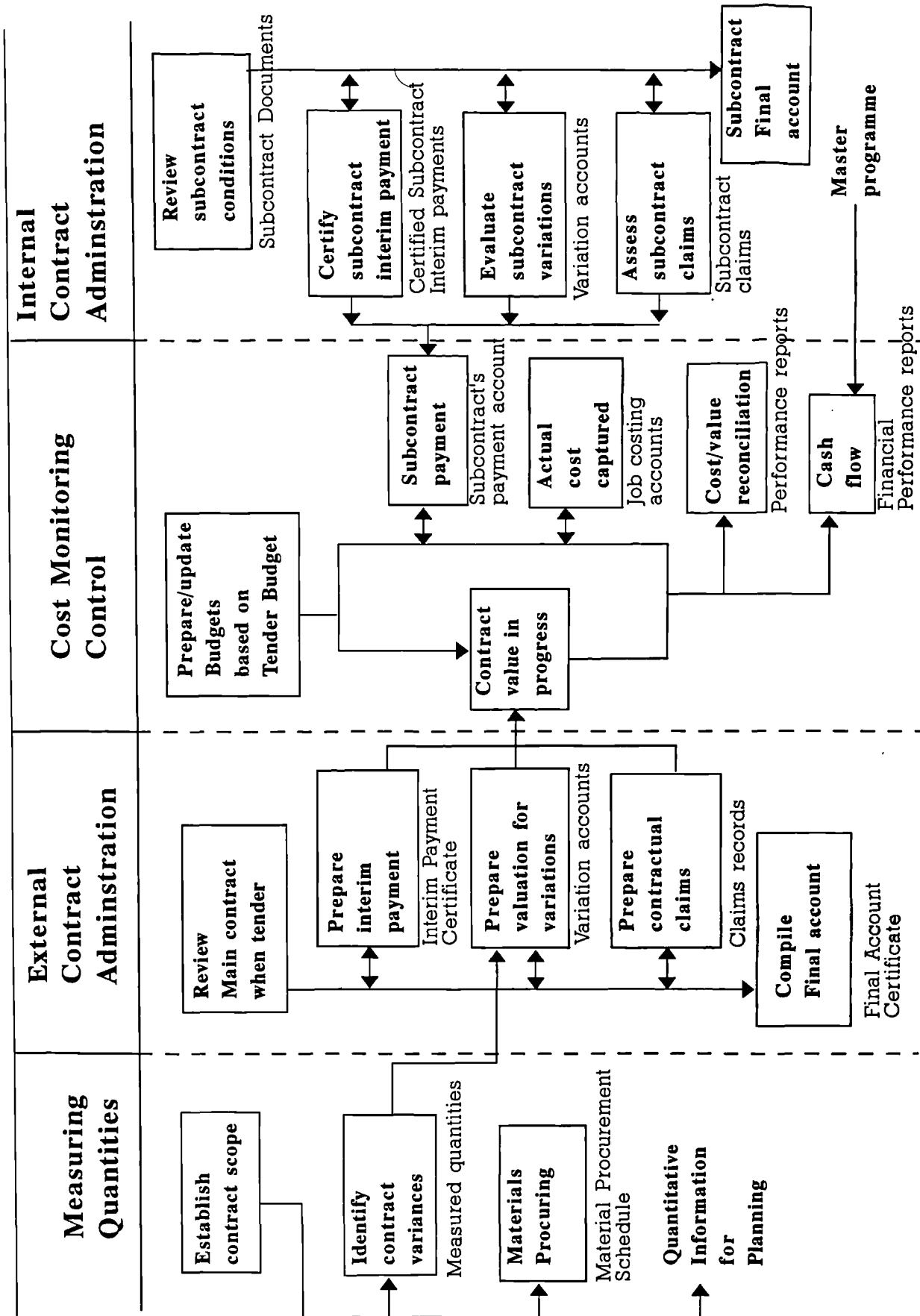
### 6.7.3 Management Tasks and Management Groups.

The management tasks and its responsible management groups for the management function of quantity surveying in a contract organisation, are listed as follows:

|    | Management Tasks                                                                 | Management Group                                | Generated Information             |
|----|----------------------------------------------------------------------------------|-------------------------------------------------|-----------------------------------|
| a) | Comparing the finalised contract documents with the original tender assumptions. | * Contracts Manager<br>* Site Quantity Surveyor | Contract review report            |
| b) | taking off quantities from drawings.                                             | * Site Assistant<br>Quantity Surveyors          | Updated quantity schedule         |
| c) | preparing main contract interim valuations.                                      | * Site Quantity Surveyor                        | Interim payment submission        |
| d) | certifying subcontract interim valuations.                                       | * Site Quantity Surveyor<br>* Site Manager      | Subcontract payment certificate   |
| e) | certifying payments for suppliers.                                               | * Site Quantity Surveyor<br>* Purchaser         | Supplier payment certificate      |
| f) | preparing cost budgets.                                                          | * Site Quantity Surveyor                        | Updated cost budget               |
| g) | valuing variations.                                                              | * Site Quantity Surveyor                        | variation submission              |
| h) | preparing cost value reconciliations.                                            | * Site Quantity Surveyor                        | cost/value reconciliation report. |
| i) | preparing cash flow forecasting.                                                 | * Site Quantity Surveyor                        | cash flow forecasting report.     |
| j) | compiling contractual claims.                                                    | * Site Quantity Surveyor<br>* Contracts Manager | Contract claim submission.        |
| k) | compiling final accounts.                                                        | * Site Quantity Surveyor                        | Final account submission.         |



## 6.7.4. Processing and Data Flow Diagram



**Figure 6.7.4 (a)**  
Quantity Surveying Processing and Data Flow Diagram

## 6.8 Site Management Function

### 6.8.1 Literatures, Previous Studies and Background.

Newcombe et al (1990) has indicated in their system concept for construction management that in construction the production process takes place largely on sites and the system boundary is set by the site activity. Forster (1991) has commented that the organisation structure of any site varies considerably depending on the size of the construction firm and the type of contract work being undertaken.

McCaffer and Pasquire (1987) studied the management functions of site management and reported that the site management involved the allocation of resources, the enforcement of the standards of workmanship required by the client, the practical incorporation of variations into the works, monitoring the progress of the works and taking the appropriate action if delays or difficulties occur.

Abdullah (1988) in his study for developing an integrated computer system pointed out that the main elements of any site control system were:

- a) to observe the records of the actual cost and performance of particular aspects of the project by regular intervals; and
- b) to compare the observed cost and performance with that estimated or planned.

Abdullah further highlighted that the use of the information were as follows:

- a) If any operation is proving uneconomical compared with the estimate, then management can take corrective action if necessary;
- b) By comparing actual site data about use of resources against that planned, the expected use of resources can be forecasted and corrective action be taken to maintain the project plan; and
- c) The data gathered from such an exercise provides the necessary feedback to the original estimate, so that future estimates of a similar nature can be prepared accordingly.

However, Kodikara (1990) in his research observed that although so many studies have been carried out before site monitoring by preparing programmes for total work, work done to-date, balance work and present work was not effectively practised and the very important task of checking of the actual use against the estimated values were also not carried out satisfactorily. Therefore, feedback from sites to offices was rarely seen. Kodikara quoted that the site personnel pointed out the following reasons as the causes for this effective site management:

- a) insufficient site staff (this is related to contractor's allocation of money;
- b) large amount of variations affects the programme;
- c) delays in receiving materials and plant. (This is related to the contractor's cash flow);
- d) substantial time and effort required in existing site monitoring and site controlling. (This is due to the irregular data flow and unnecessary re-work);
- e) the estimate and the programme do not indicate resource requirements for each item. (This is related to the present format of the estimate); and
- f) arrangements to collect data on actual use of resources are not in a suitable format. (This is related to present format of the estimate and stock control systems).

Kodikara (1990) finally concluded that the following management tasks had been identified as the most important tasks in site management:

- a) Identification of material requirements;
- b) Scheduling and allocation of materials;
- c) Identification and allocation of plant;
- d) Monitoring the progress of the work; and
- e) Recording actual use of resources and subcontract work.

#### **6.8.2 Observations in the Hong Kong Construction Industry.**

Most management tasks described by the literatures and previous studies mentioned above, are confirmed in this research. It is commonly recognized that the site management

function is the operating core of a contracting organisation, where the production is taken place. The management input for site management will be more intensive in comparison with other management functions. The following sections are the most important issues.

#### **6.8.2.1 Communication between Head Office and Site Management.**

Hong Kong is a place with around 1,100 square Kilometres, within which only about 13% of the land area has been developed. In terms of geological location, the construction sites are comparatively near the head office in most contracting organisations. Therefore, the communications between the head office of a contracting organisation and the construction sites relied on the 'soft' communications rather than 'hard' communications. 'Soft communication' means using verbal communications through telephones, mobile phones, site visits and meetings. 'Hard communication' means using paper works through memo, letters and instructions etc. The main advantage of 'soft' communication is comparatively high efficiency and effectiveness and it is fitted to an environment of rapid pace in commercial activities, like Hong Kong. By means of 'soft communication' is also in line with the Chinese culture, by which matters are likely to be solved by means of negotiations and off-record compromises. However, obviously the draw backs of 'soft communications' are no records, untraceable, easily fading and unsystematic. The project problems and faults created by 'soft communication', are particularly noticeable within the recent 10 years in Hong Kong construction industry, due to the following reasons:

- a) high rate of turnover in management staff of construction companies and the migration of professionals because of the uncertainty after 1997 when China resumes the sovereignty of Hong Kong;
- b) construction projects are getting more complicated in terms of technical, financial and contractual arrangements. Accordingly, the management and co-ordination burdens on main contractors are much higher than before. In order to cope with the situation, the contracting organisations have to specialise their management terms with more detailed divisions of responsibilities. 'Soft communications' become inadequate. For example an instruction to the site manager from the contracts manager at the head office, may have been through a telephone call. But now the same instruction may have to be copied to 5 different divisions. In this case, the contracts

manager may justify the issue of a memo, and copies to such 5 different parties, rather than make 5 telephone calls.

In addition, 'soft communication' has jeopardised the requirements of most quality assurance standards which emphasise systematic procedures and records. For external communications, due to the contractual requirements and other commercial considerations, 'hard communication' dominates the practices of external communication. This tendency makes the burden of paper work on site management higher and higher.

#### **6.8.2.2 Needs of Tighter Management Control**

The higher competition in tender bidding and the more complicated project nature, has substantially increased the risk of losing money by contractors in construction contracts. Therefore, higher management of contractors requires tighter control of site management in respect of the utilisation of resources.

The conditions in most modern standard forms of contract require a higher standard of submissions from contractors in terms of timing and quality of submission for the following aspects:

- a) temporary designs;
- b) permanent designs;
- c) sample submissions;
- d) getting approvals;
- e) getting legislative certificates;
- g) requested for responses;
- h) interim payments;
- i) valuations; and
- j) contractual claims etc.

The tendency of performance feedback from contractors in modern contract administration has a fundamental change, by which it requires the contractor to explicitly demonstrate the standard of performance, instead of relying on the contract supervisor to dig out or comment on the contractor's performance by observations. The PASS (performance assessment scoring system) adopted by Hong Kong Housing Authority and Singapore Construction Authority, has proved this tendency. (see Section 4.3 of Chapter 4 - New Developments in the Hong Kong Construction Industry).

All these new tendencies have inevitably required contractors to uplift the standard of site management in respect of information control, material control, cost control, quality control and progress control. Such requirements are not only emphasised on the quality of management but also the ability to present the performance information in complying with the requirements on both the timing constraints and the quality of presentations.

#### 6.8.2.3 Subcontract Controls

Ndekugri (1988) pointed out that subcontracting was rapidly expanding nationally and on many individual projects the level of subcontracting could be up to 80-90%, the extent of which showed that the main contractor may be viewed as brokers between the industry's clients and the small specialist firms sprouting all over the industry. He further added that the increasing levels of subcontracting were attributable to the following changes in the construction industry:

- a) increasing complexity of construction;
- b) increasing uncertainty of the environment within which projects are undertaken;
- c) growing desire to overlap design and construction;
- d) a resulting need to spread the risks and financial burdens of construction projects.

One of the most important characteristics of the construction industry in Hong Kong is its sub-contract orientation. It is not unusual to see the works being sub-sub-contracted, finally to a sub-contractor who in fact may be with insufficient technical skill and management knowledge to handle the works. The problems generated from the incapable management of the subcontractor themselves, subsequently may cause the main contractor to suffer at the end. This situation is quite often to be found in those arbitration and litigation cases.

Previously, the attitude of main contractors toward the control of subcontractors usually was by putting pressures to chase up the work progress. This situation often has resulted in sharpening the on-site disputes between the subcontractors and the site management. Nowadays, in view of the previous displeasing experience, many main contractors start aware of the necessity to help the subcontractor manage their works, instead of treating them as outsiders. To achieve this, it is

necessary to have a mechanism for the feedback of the relevant data, based on which the weakness in management can be analysed and predicted.

#### 6.8.2.4 Contingency Management and Procedure Manuals

Fryer (1990) pointed out the adoption of contingency approaches to site management, where large amount of co-ordination work and uncertainties may be encountered by the site manager, and the problems facing in site management are different from those found in factory-based industries.

Mortiboys (1991) identified the situation of 'firefighting' in site management (See Section 4.5 of this thesis). The 'firefighting' described by Mortiboys is similar in context to Fryer's contingency management. 'First right always right' is one of the slogans on site by some contractors for the implementation of quality assurance. The new concept is that getting it first right then the need of 'firefighting' and contingency management will be reduced.

With the adoption of quality assurance standards in contracting organisations, modern construction management has a tendency of applying procedure manuals which are also used to fulfil the requirements of the adopted quality assurance standard. Cheetham and Carter (1991) have pointed out that standard procedures are employed as a means to gain certainty so that everyone knows what to do and when to do it. Cheetham and Carter quoted the contents of the Site Procedure Manual of their case study as follows:

- |                              |                         |
|------------------------------|-------------------------|
| 1) Drawings                  | 16) Wages               |
| 2) Information schedules     | 17) Labour requests     |
| 3) Variations/instructions   | 18) Plant ordering      |
| 4) Mail in/mail out          | 19) Preliminaries       |
| 5) Contract programming      | 20) Internal valuation  |
| 6) Weekly programming        | 21) External valuation  |
| 7) Site meetings             | 22) Site monitoring     |
| 8) Site reports              | 23) Sub-contract pay    |
| 9) Sub-contract assessment   | 24) Forecasting         |
| 10) Sub-contract ordering    | 25) Final account       |
| 11) Post contract procedures | 26) Quality control     |
| 12) Material ordering        | 27) Engineering records |
| 13) Deliveries               | 28) Quality assurance   |
| 14) Store control            | 29) Security            |
| 15) Weekly costs             | 30) Health and Safety.  |

The procedural manual quoted by Cheetham and Carter, is similar to most procedures used in Hong Kong. This approach is sound in principle and acceptable in practice. Cheetham et al (1991) commented that procedure manuals were seen to focus more on output (what was required) than the way to achieve it. Therefore, the way to achieve it still relies on the ability of site management. In fact, a possible draw back is that the application of procedure manuals may reduce the flexibility of site management and increase the workload of site management staff.

#### **6.8.2.5 Proposed Solutions to the Changes**

In addition to procedure manuals and other management policies, it is therefore necessary to add other supports to help the site management achieve what has been stated in the procedure manuals and the policies laid down. One of the ways attempted by this research is to incorporate the procedural requirements into a computer system which should provide the following functions:

- a) to allow the user executing the system in complying with the requirements in the procedure manuals;
- b) to replace the existing manual practices with the aim of increasing the efficiency of operations;
- c) to record what have been required to be recorded by the procedure manuals;
- d) to provide necessary management reports showing the performance feedback of progress works for management controls and decision makings; and
- e) to furnish necessary external submissions required by the contract.

The efficiency of the system should be justified by how quick the information from the system can be got, in what price and the quality of presentation.

#### **6.8.3 Management Tasks and Management Groups.**

In a contracting organisation the site management function takes place in a comparatively clear cut organisation structure apart from the head office organisation, under the leadership of a site manager. In some cases, the site quantity surveyors, the site planning engineers and the quality control engineers



may be under a double leadership by their respective functions from the head office in a kind of matrix structure. Since site management function is the operating core of post-contract management, for a sake of better illustration it is possible to divide the site management functions into the following two levels of sub-functions:

#### **Level 1: Core Operating Functions**

- a) Information control;
- b) Planning and progress control;
- c) Materials control;
- d) Quantity surveying and cost control;
- e) Subcontract control; and
- f) Quality control.

#### **Level 2: Administrative and Safety Functions**

- a) Safety and welfare;
- b) Site clerical support; and/or
- c) Site accounting.

In this research, the study is concentrated on those core operating functions as mentioned above level 1. In order to maintain the continuity of the functional descriptions, the 'planning and progress control', the 'quantity surveying and cost control' and 'quality control' have been covered by the Sections 6.7, 6.6 and 6.9 of this Chapter respectively. These sub-functions will not be repeated in this Section.

The management tasks and its responsible management groups for the other site management sub-functions of a contract organisation, are listed as follows:

#### **Information Control:**

|    | <b>Management Tasks</b>                                                               | <b>Management Group</b>                                   | <b>Generated Information</b> |
|----|---------------------------------------------------------------------------------------|-----------------------------------------------------------|------------------------------|
| a) | Record, distribute, follow-up and file-up the incoming and outgoing correspondence.   | * Site Manager.<br>* All concerned site management staff. | Correspondence register      |
| b) | Record and distribute the incoming and submitting drawings.                           | * Site Engineer.                                          | Drawing register             |
| c) | Record and follow-up the site instructions received.                                  | * Site Engineer.<br>* Site Quantity Surveyor.             | Instruction register         |
| d) | Record and follow-up the contractual claims submitted or subcontract claims received. | * Site Manager<br>* Site Quantity Surveyor.               | Claim register               |

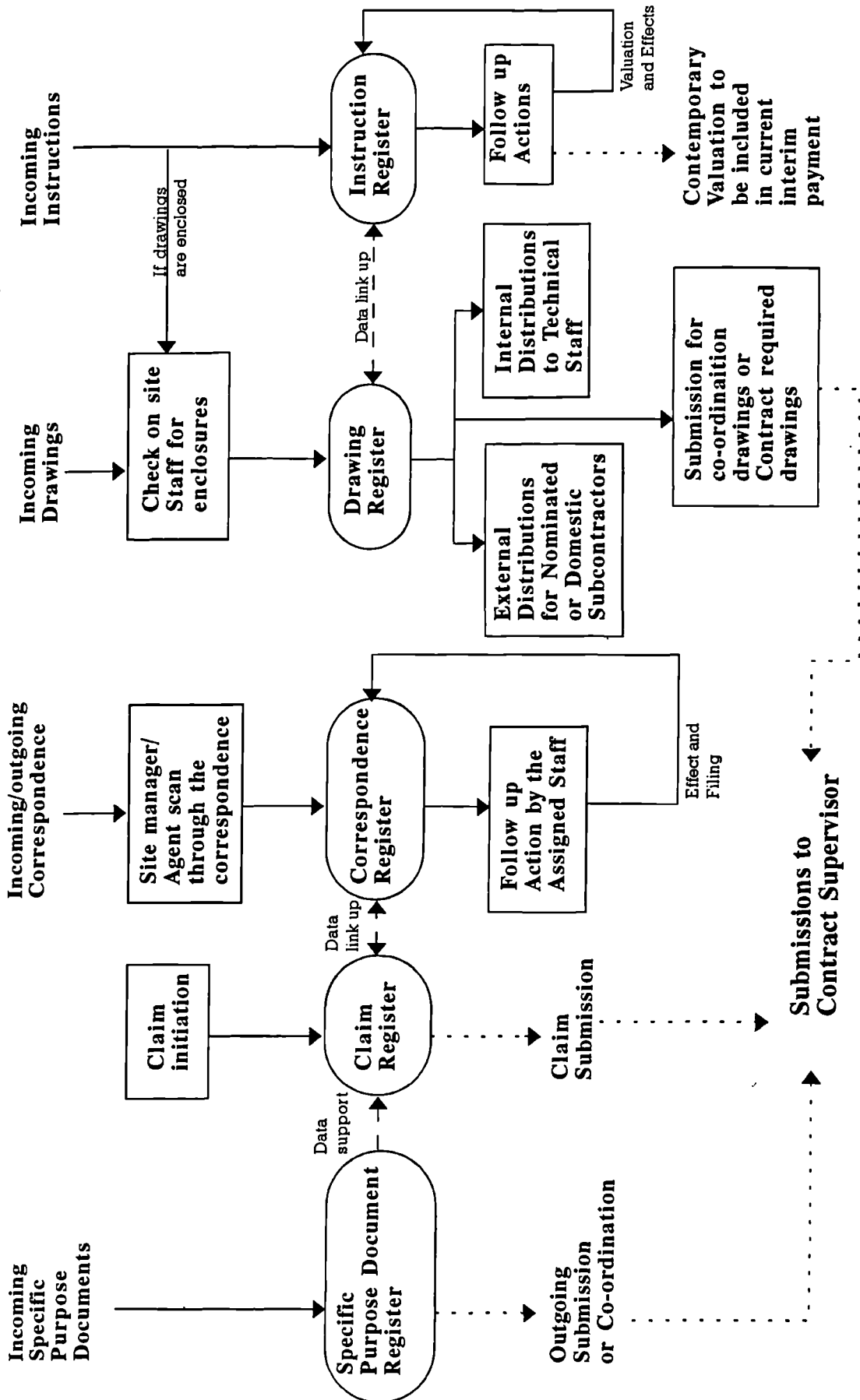
## Materials Control:

|    | Management Tasks                                                                       | Management Group                                  | Generated Information       |
|----|----------------------------------------------------------------------------------------|---------------------------------------------------|-----------------------------|
| e) | Receive and inspect for materials arrival.                                             | * Quality Control Engineer.<br>* Store Keeper.    | Delivery notes              |
| f) | Review material quality for material in store before fixing.                           | * Quality Control Engineer.                       | Quality inspection report   |
| g) | Control material distribution.                                                         | * Store Keeper.<br>* Site Foremen.                | Material distribution form  |
| h) | Update material procurement schedules.                                                 | * Site Quantity Surveyor.<br>* Planning Engineer. | Master procurement schedule |
| i) | Monitor material wastages.                                                             | * Site Manager.<br>* Site Engineer.               | Material wastage report     |
| j) | Keep records for materials delivered for interim valuations and payments to suppliers. | * Store Keeper<br>* Site Quantity Surveyor.       | Delivery note and invoice.  |

## Subcontracts Control:

|    | Management Tasks                                                                                          | Management Group                                         | Generated Information     |
|----|-----------------------------------------------------------------------------------------------------------|----------------------------------------------------------|---------------------------|
| k) | Review the site obligations according to the subcontract conditions.                                      | * Site Manager<br>* Site Quantity Surveyor               | Subcontract review report |
| l) | Prepare sub-contract co-ordination programmes based on the master programme and the sectional programmes. | * Planning Engineer                                      | Subcontract programme     |
| m) | Hold periodic subcontract progress review meeting.                                                        | * Site Manager<br>* Site Engineer<br>* Planning Engineer | Minutes of meeting        |
| n) | Monitor subcontract progress and assess subcontract performance.                                          | * Site Engineer<br>* Site Foremen                        | Progress report           |

## 6.8.4 Processing and Data Flow Diagram.



**Figure 6.8.4 (a)**

**Site Management Processing and Data Flow for Information Control**

Figure 6.8.4 (b)

## Site Management Processing and Data Flow for Materials Control

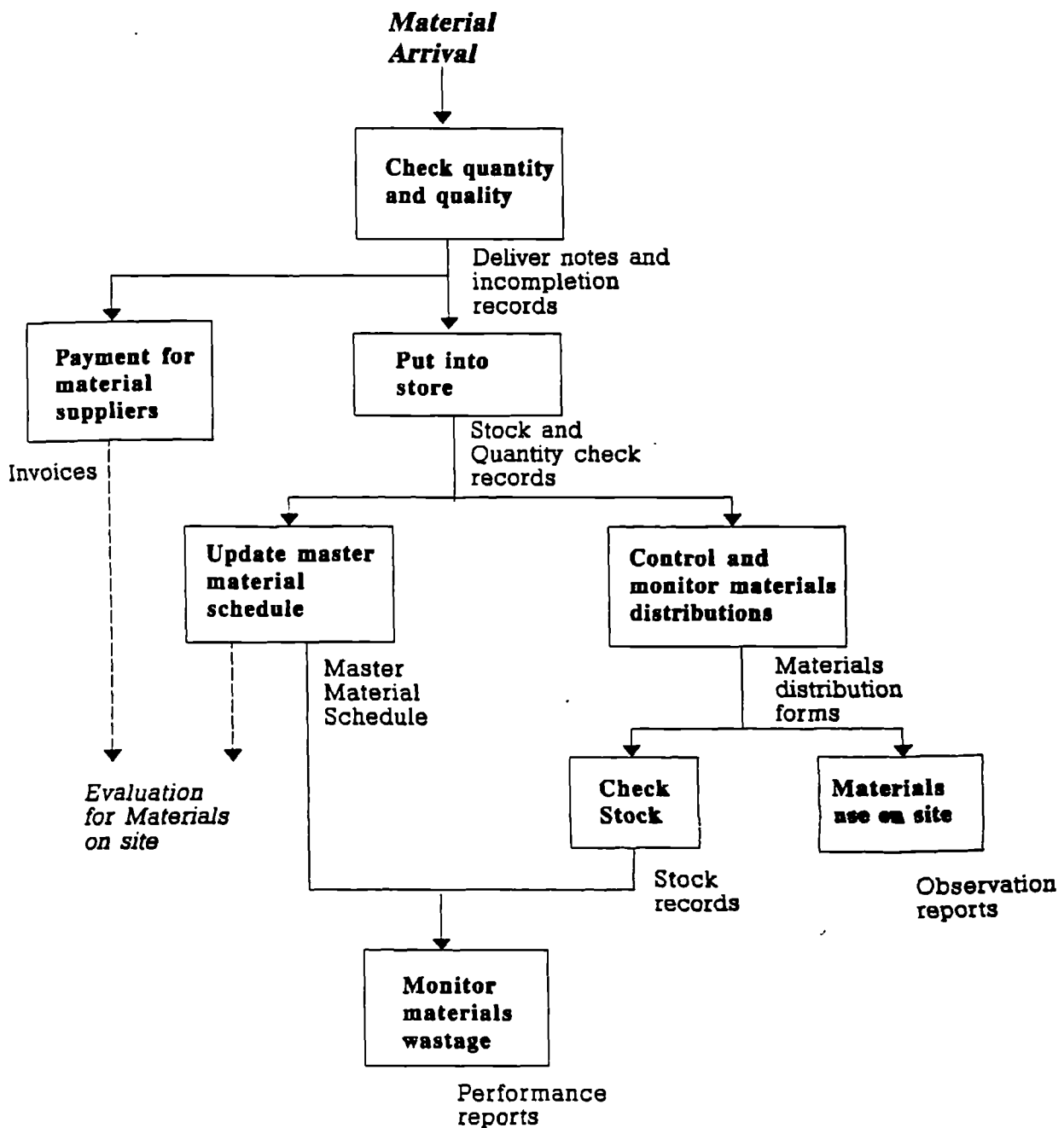
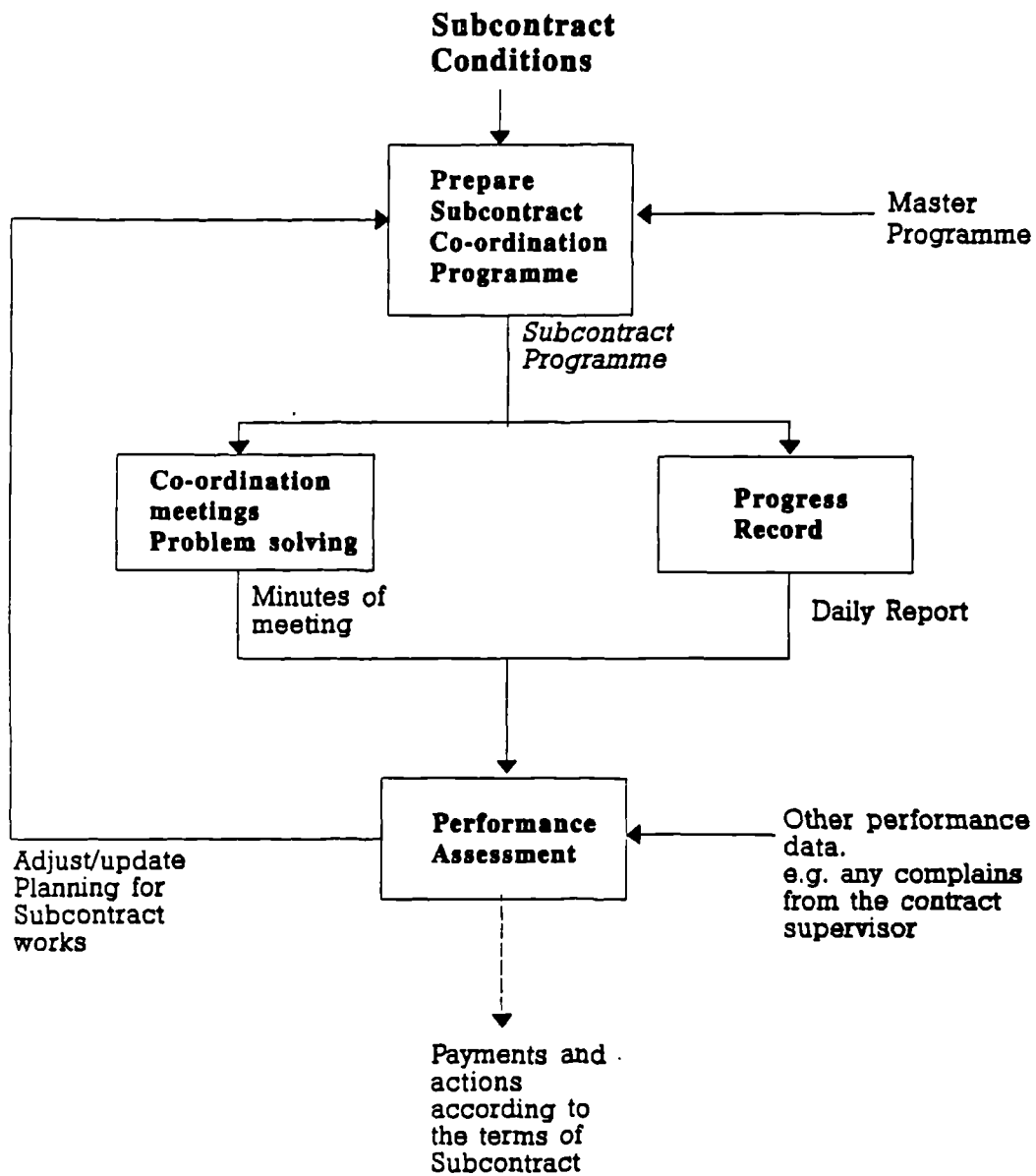


Figure 6.8.4 (c)

## Site Managment Processing and Data Flow for Subcontracts Control



## 6.9 Quality Assurance Function

### 6.9.1 Literatures, Previous Studies and Background

In the United Kingdom, an important research study regarding quality assurance in the construction industry was undertaken for National Economic Development Office (NEDO) by the Building Economic Development Committee (Building EDC). The details of this study has been described as part of the review of previous work in this research under Section 2.4.1 of Chapter 2. Burati et al (1990, 1992) addressed the needs of the application of quality assurance system in the construction industry of the United States and concluded that: 'Companies must institute total quality management or become non-competitive in the national, international and engineering markets within the next five to ten years'

Barrett (1991) pointed out that over the last few years the U.K. construction industry has been no exception to the rapid increase of awareness on quality. However Barrett in his paper also quoted a report from CIRIA 1990 indicating that out of an estimated total of 10,000 professional firms in construction, less than 40 had achieved Quality Assurance registration at that time, which is only less than 0.4% despite the inducements and pressure from the industry.

Tyler (1991) conducted a research and development project for producing and implementing a quality assurance system in a medium sized contracting organisation, which was got along with Bhattari's survey (1990) regarding the quality assurance in U.K. construction industry. Tyler drew the following conclusions on the development and implementation of the scheme:

- a) Take the introduction of quality assurance step by step;
- b) Obtain the complete understanding and backing of the top management;
- c) Ensure the company understands the long term implications of such a scheme ;
- d) Keep all employees informed of developments;
- e) Document the existing systems thoroughly;
- f) Revise existing systems only where necessary;
- g) Keep document simple;

- h) Use seminars to "present" documents and systems to the staff, do not just documentation; and
- i) Have a plan and personnel for future development and maintenance of the system.

Tyler's experience gives a comprehensive recommendation for the implementation of quality assurance in contracting organisations. Ashford (1989) compiled a comprehensive literature for the management of quality in construction based on BS 5750 quality assurance standard which is equivalent to ISO 9000 series international quality assurance standard. Ashford's work has been adopted as an important reference in the design of the management operations for quality assurance described in Chapter 12 of this thesis.

The need of the implementation of quality assurance in contracting organisations has been clearly stressed by academics, the profession and the industry. Most of the previous studies give the indications and recommendations on the needs, requirements and procedures for the implementation of quality assurance as a supporting management function, rather than treating quality assurance as part of the operating cores similar to the other core management functions such as estimating, planning, purchasing, quantity surveying and site management. Effective implementation of quality assurance systems has to rely on the procedures and the records of other core management functions. However, the implementation of quality assurance system has its own management tasks executed by individual management group in a contracting organisation. Therefore, in the design of a model for construction management it should be appropriate to treat it as a separate management function.

#### **6.9.2 Observation in the Hong Kong Construction Industry**

According to the study of the new developments in Hong Kong described in Chapter 4, the requirements of quality assurance by the projects in public sector have created substantial impact. This gives a fundamental change of quality concept in contracting organisations. Previously, quality in the contractors' mind, means to comply with the contract specifications and satisfy the needs of the contract supervisor. However, now the requirement of most quality assurance standards is not just on the end products or end services but a wide scope of total company involvements from setting up policy, compiling documentation, implementing procedure to recording performance.

The clauses in major standard form of conditions of contract in public sector such as Clause 45 General Conditions of Contract for the Airport Core Programme Civil Engineering Works 1992 edition, specifically request the contractor to apply a quality assurance system in the contract. In some public or private contracts, the client may request a pre-qualification submission from all potential tenders before they are eligible to tender. Definitely, the applied quality assurance standard should be one of the pre-qualification items.

There is a tendency in the industry that the application of quality assurance system in a contracting organisation is not just a marketing exercise but it directly affects the survival of the company in the industry. The next question concerned by the top management of contractors is how to apply a quality assurance system and at what price. Gosselin (1991) addressed a concept of 'cost of quality' (See Section 4.2.1). The design and implementation of a quality assurance system in a contracting organisation, has to consider the concept of 'the cost of quality'. With the use of a quality assurance standard, it is the aim of the standard to provide the guide-lines helping the contractor to achieve a lowest cost of quality (also called conformance). It is in a similar context to the degree of control in planning and control concept, in which the break-even point will be various according to different organisations and different projects.

### **6.9.3 Management Tasks and Management Groups**

In view of the requirements in current quality assurance standards, most contracting organisations have a separate division leading by a Quality Assurance Manager for implementing the quality assurance system. However in most cases, a Quality Strategy Group or Committee will be formed comprising the senior management of most core management functions to formulate the strategic decisions for the implementation of the quality assurance system. The Quality Assurance Manager, with the help of a few assistants at head office level, is responsible for executing the decisions by the Committee.

At site level, there may be a 'Quality Control Engineer', under a double leadership of the Site Manager and the Quality Assurance Manager at head office level, in a kind of matrix organisation structure. In some cases, particularly in public contracts involving intensive structural works, the qualifications and experience of the Quality Control Engineer will be governed by the conditions of contract.



The management tasks of quality assurance can be divided into the following three levels:

- a) Company level;
- b) Departmental level; and
- c) Project level.

The management tasks and its responsible management groups for implementing a quality assurance system of a contract organisation, are listed according to the above mentioned three levels, as follows:

#### Company Level:

|    | Management Tasks                                                                                        | Management Group                                                                                                                            | Generated Information                                  |
|----|---------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|
| a) | Formulate the company quality policy.                                                                   | <ul style="list-style-type: none"> <li>* Directors</li> <li>* Top management of the company</li> <li>* Quality Assurance Manager</li> </ul> | Quality Policy                                         |
| b) | Prepare and submit the quality documents including quality policy, quality manuals and work procedures. | <ul style="list-style-type: none"> <li>* Top management of each division</li> <li>* Quality Assurance Manager</li> </ul>                    | Quality Manual                                         |
| c) | Implement the contents stated in the quality documents.                                                 | <ul style="list-style-type: none"> <li>* All company staff</li> </ul>                                                                       | Performance records required in the quality documents. |
| d) | Accommodate and facilitate the external accreditation body for getting certification.                   | <ul style="list-style-type: none"> <li>* Quality Assurance Manager</li> </ul>                                                               | Accreditation certificate.                             |
| e) | Accommodate and facilitate the external audits by the accreditation body.                               | <ul style="list-style-type: none"> <li>* Quality Assurance Manager</li> </ul>                                                               | External audit reports.                                |
| f) | Control the distributions of quality documents.                                                         | <ul style="list-style-type: none"> <li>* Quality Assurance Staff</li> <li>* Top management of each division.</li> </ul>                     | Document distribution register.                        |
| g) | Review the strategy and the status of implementing the quality assurance system.                        | <ul style="list-style-type: none"> <li>* Top management of the company</li> <li>* Quality Assurance Manager</li> </ul>                      | Revised or updated quality manual.                     |

## Departmental Level:

|    | Management Tasks                                                                        | Management Group                                                 | Generated Information                     |
|----|-----------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------------------|
| h) | Prepare and review the work procedures for each functional department or division.      | * Top management of each division<br>* Quality Assurance Manager | Revised or updated work procedures.       |
| i) | Conduct internal audits.                                                                | * Top management of each division<br>* Internal Auditor          | Internal Audit                            |
| j) | Identify training needs. Implement and monitor training policy and training programmes. | * Quality Assurance Staff                                        | Training records and training programmes. |

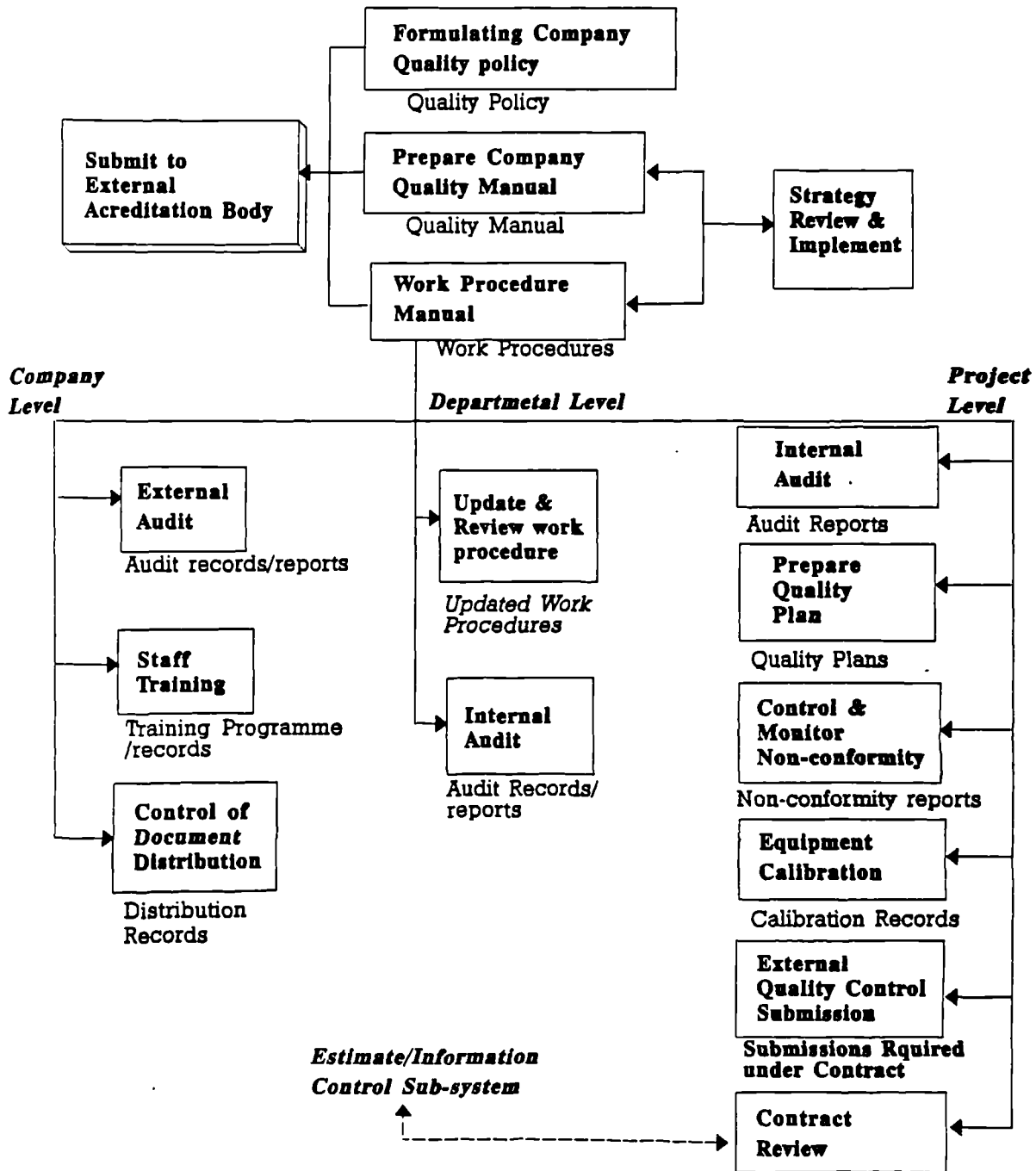
## Project Level (for any specific project):

|    | Management Tasks                                                                                                                     | Management Group                                                               | Generated Information                       |
|----|--------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|---------------------------------------------|
| k) | Monitor the contract review.                                                                                                         | * Estimator<br>* Site Quantity Surveyor.                                       | Contract review report.                     |
| l) | Compile the quality plan.                                                                                                            | * Site Manager<br>* Quality Control Engineer.                                  | Project quality Plans.                      |
| h) | Prepare and review the work procedures affecting the site operations.                                                                | * Site Manager.<br>* Quality Control Engineer.<br>* Quality Assurance Manager. | Revised or updated work procedures.         |
| m) | Monitor and control non-conformities.                                                                                                | * Quality Control Engineer.                                                    | Non-conformity records and reports.         |
| n) | Monitor and control equipment calibrations.                                                                                          | * Quality Control Engineer.                                                    | Equipment calibration records and reports.  |
| o) | Conduct site internal audits.                                                                                                        | * Quality Control Engineer.<br>* Internal Auditor.                             | Internal audit reports.                     |
| p) | Prepare and submit the documents required in the contract for quality control and performance assessment to the contract supervisor. | * Site manager<br>* Quality Control Engineer                                   | Various mandatory documents and submissions |

## 6.9.4 Processing and Data Flow Diagram

Figure 6.9.4 (a)

# Quality Assurance Processing and Data Flow Diagram



## 6.10 Summary

A model of construction management based on studies of the Hong Kong construction industry has been established and described in this chapter. The studies leading to the establishment of the model of management are described in Chapters 3 and 4 of this thesis, which are related to the structure of the Hong Kong construction industry and its new developments.

Published literature and previous studies relating to the establishment of a model of management, have been reviewed. It has then been confirmed that the establishment of a model of management should be based on an organisation model under a business strategy model. Accordingly, a business strategy model and an organisation model of contracting organisations are included in the Section 6.2 and 6.3 of this chapter respectively.

The model of construction management established in this chapter comprises the management functions, the management groups and the management tasks. The management functions of the model are: estimating and tendering; purchasing; planning; quantity surveying; site management; and quality assurance. These functions form the operating core of contracting organisations. The examination of each management function is based on the following procedures:

- a) Reviewing the relevant published literature, previous studies and background information;
- b) Considering the observations and studies in the Hong Kong construction industry;
- c) Establishing the management tasks, the management groups and the generated data from the task; and
- d) Prepared the data flow and processing model of the management tasks.

The management tasks of each management function and the responsible management groups, have been established and illustrated in a table form. The table of management tasks for each management function includes a description for the information generated from each management task. Accordingly, the data flow model of each management function has been developed and included in this chapter. The use of data flow models is to show the flow of data and information from the

source where it is generated to other users, and the inter-relationships of the management tasks and their relevant data.

The model of construction management developed in this research and described in this chapter, forms the basis for the development of a computerised construction management system, called 'CCMS'. The computer related part of 'CCMS' is described in Chapter 5 of this thesis. The operations of each sub-system under 'CCMS', are used to aid and support the management operations relating to the management tasks in the model of construction management. The aim of 'CCMS' is to improve the performance of the model of construction management. The details of each sub-system developed in this research, are described in Chapters 7 to 12 of this thesis.

## **7 Estimating Sub-system**

### **7.1 Principle of the Sub-system Design**

Baldwin (1982) listed the parameters of system design for computer-aided estimating systems as follows:

- a) Calculate each bill item cost from the input data on resources via a unit or operational rate process or the entry of a rate to cover each of the cost code categories.
- b) Apply calculated item rates against all relevant bill items.
- c) Calculate the extension of each item to produce an item price and provide a summation of bill items at several levels to produce a total direct cost for the contract.
- d) Produce reports showing the division of the total rate for each bill item into labour, plant, materials and sub-contractor costs.
- e) Produce listings of all the resources used in the contract including the total quantity and total direct cost.
- f) Provide listings of information required for job functions related to the estimating process.
- g) Store data on resource (materials, labour, plant) prices in a reference library.
- h) Store data on methods of construction in a reference library.
- i) Hold data on gang make-ups and production standards for use in pricing commonly recurring bill items. This data to include different method of construction.
- j) Store a list of materials prices for the contract.
- k) Store a list of sub-contractor rates for the contract.
- l) Store a list of all-in labour and plant rates for the contract.
- m) Store the full build-up of each bill item within the contract with the facility to retrieve, check and re-work item if required.
- n) Ability to handle input of data and data changes in any order and at any time.

Baldwin classified the above 14 requirements as primary requirements necessary to assist with the main functions of the estimator's task. In addition Baldwin further pointed out that there are secondary requirements necessary to support other aspects. These are:

- a) Assist the estimator in his communication with other parties both inside and outside the contractor's organisation.
- b) Maintain the estimator's skill and extend his knowledge of the construction processes.
- c) Limited potential errors within the estimating process.

Oteifa (1991) confirmed through the survey in his research that over the last decade estimation systems had been developed in line with what Baldwin identified in 1982. A review of the current software by Stephenson (1991) showed that most system developers have responded to the needs by Baldwin. Oteifa's survey pointed out some desired modifications in existing systems:

- a) better analysis of resources;
- b) a facility to provide a more logical and consistent explanation of the basis of the estimate;
- c) self checking facilities;
- d) good interface with supplier/subcontractors database, other administrative and management functions;
- e) greater flexibility in data library handling;
- f) reduce time required to adjust database for a particular requirement;
- g) improve speed, ease of learning, user friendliness while maintaining accuracy and quality of output;
- h) improve report facilities; and
- i) improve on 'user friendliness'.

O'Brien (1989) indicated that the current generation of estimating systems represent a failure on the part of information technology to supply satisfactory systems to estimators. O'Brien stressed that through the use of 'fourth generation' languages and relational databases it would be

possible to construct 'configurable declarative' systems. These systems would be characterised by a built-in flexibility and would be changed or configured to meet individual estimators' requirements in the functionality and operational features available within the system. O'Brien highlighted the following three fundamental demands that an estimating system must meet.

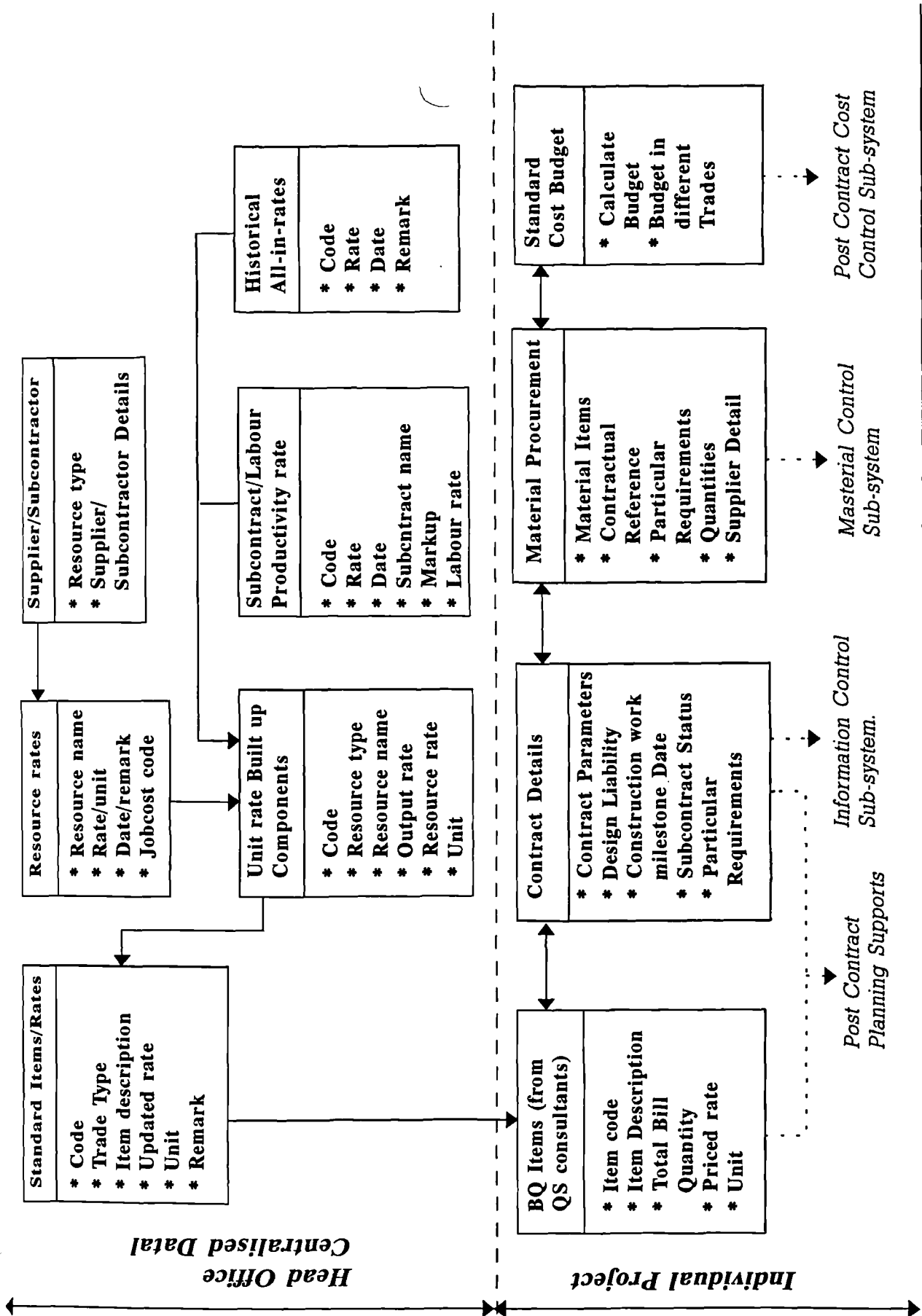
- a) An estimating system must be capable of being integrated into a larger system that will support all the business functions of a construction enterprise.
- b) Any estimating system must be capable of changing its own internal mechanisms to match the requirements demanded by an individual estimator.
- c) A computer system must allow new and more efficient methods of working to be developed through the use of the underlying database and the efficient retrieval systems which are built in.

The model of construction management described in Chapter 6 includes a management function of estimating and tendering. This chapter describes the operational details of 'CCMS' estimating sub-system (also called the Sub-system in this chapter) used to support the same management function of the construction management model. The design of "CCMS" estimating sub-system has taken into consideration of the above comments from the previous researches and studies. The use of 4th generation language as the development tool for "CCMS" as described in Section 5.3.1, enables the sub-system to get more flexibility in terms of integration, reporting and future changes.

In this chapter, the primary functions of computer estimating system in "CCMS" estimating sub-system will not be repetitively described. The general functions of computerised estimating system have been well attempted and documented by numerous literatures and documentations. In this thesis, only the pioneer functions which are considered as a contribution to knowledge, will be described in the underneath sections. The operational flow chart of the Sub-system is shown in Figure 7.1 (a).

The main sub-system menu is shown in Figure 7.1 (b).





**Figure 7.1 (a) CCMS Estimating Subsystem Operational Flow Chart**

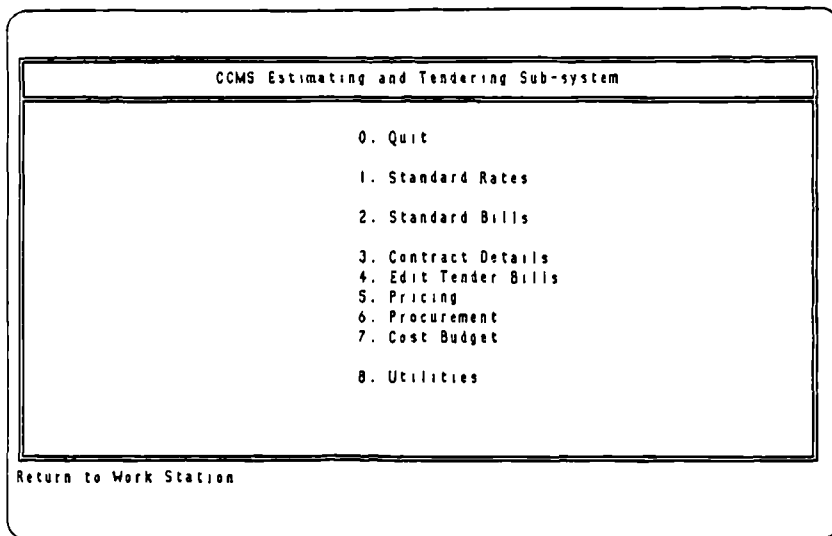


Figure 7.1 (b)  
Main Sub-system  
Menu.

## 7.2 Access to Floppy Disk Tendering Data

The concept of using computer files to store bill of quantities for tendering purpose, is not new, but it was only sophisticated enough to be implemented in the live projects of the construction industry of Hong Kong in the middle of 1992.

Floppy Disk Tendering (FDT) is a tendering technique developed in May 1992 by Davis Langdon and Seah which is one of the famous consultant quantity surveying firms serving world-wide. The technique involves the storing of bills of quantities in the format of computer file contained on a floppy disk. In addition to the paper format of bill of quantities as part of the tender document, the tenderer could get another version of the bill of quantities in floppy disk format by paying a small amount of addition cost.

After the estimating, the tenderer can insert the unit rates for each bill item to the unit rate column of the FDT files and return the FDT disks together with the completed tender documents to the consultant quantity surveyor as a format tender submission. The FDT is only an aid to the tendering, and the computer files would not be treated as part of format tender document with legal effects. Still the original paper bill of quantities is the format offer from the tenderer. However, the advantages of FDT serving both the tenderer and consultant quantity surveyors are as follows:

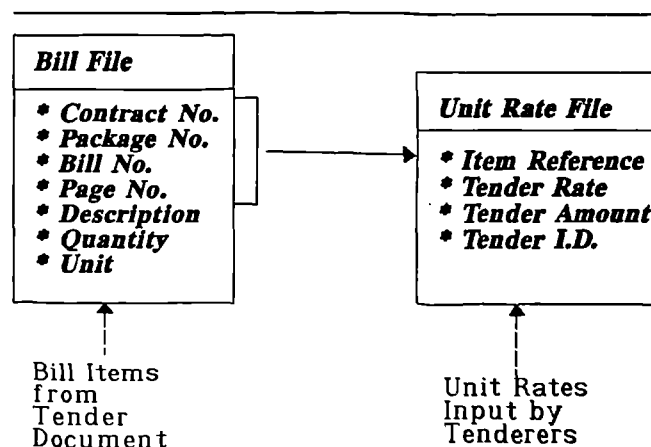
- a) It would not cause too much additional cost to the consultant quantity surveyor since the FDT data file is a by-product of the mini or main frame system which connects to a number of terminals to directly input the

taking off data from drawings for the preparation of bills of quantities. Therefore any re-typing of the bill of quantities data is unnecessary.

- b) It saves up the time of post-tender follow-up works by the consultant quantity surveyor in terms of checking arithmetic errors, unit rate comparison, tender assessment etc.
- c) It reduce the arithmetic error of the tenderer in the tender price calculation.
- d) The tenderer could prepare subcontract bills by abstracting from the FDT computer files directly without a necessary of re-typing the bills.
- e) It should aid the manipulation of estimate data to be used in the post-contract stage for construction management.

By coincidence, the FDT has also been developed by "FoxPro version 2" system, therefore it is capable for "CCMS" to access data from the FDT files without any conversion. This approach will save up tremendous efforts for the tenderer to input bill items to computer system. According to the information from the Director of Langdon Mr. M.C. Lo, the average bill items of single tender package in Hong Kong ranges from 1,000 to 8,000 items which involve a lot of work loads in tenderings. The data structure of FPT is illustrated in Figure 7.2 (a).

*Figure 7.2 (a) FDT (Floppy Disk Tendering) File Structure*



The data accessing screen of 'CCMS' estimating sub-system to FPT data is shown in Figure 7.2 (b).

Access to FPT System

Contract No : HK-1131                      Package No :

Bill No : 2                      Bill Section : 1                      Page No : 2

---

Bill No : 2 Page No : 2

| Item_ref | Description [F2] to edit                 | Qty | Unit  |
|----------|------------------------------------------|-----|-------|
| A        | - INTERNAL FLOOR FINISHES : TILE, SLAB A | 1   | RUN   |
| B        | - INTERNAL WALL AND CEILING FINISHES : 1 | 6   | SUPER |
| C        | - INTERNAL WALL AND CEILING FINISHES : 1 | 104 | SUPER |
| D        | - INTERNAL WALL AND CEILING FINISHES : 1 | 5   | SUPER |
| E        | - INTERNAL WALL AND CEILING FINISHES : 1 | 4   | SUPER |
| F        | - INTERNAL WALL AND CEILING FINISHES : 1 | 1   | SUPER |
| G        | - INTERNAL WALL AND CEILING FINISHES : 1 | 1   | SUPER |
| H        | - INTERNAL WALL AND CEILING FINISHES : 1 | 1   | SUPER |

Figure 7.2 (b)  
Access to FPT data  
from the  
Sub-system.

### 7.3 Information Handling by Codes

With the best use of computing abilities in data base management, standard libraries for estimation department of contractor organisations should be regarded as a basis of any computer-aided system. However it may take up time for a company to establish their own standard libraries as the base of estimating information.

Baldwin (1989) pointed out:

"The acquisition of a CAE (computer aided estimation) system unlikely to result in manpower and cost saving. The staff requirement and the time span involved is unlikely to be changed with the adoption of computer-aided estimating system. The introduction of new coding systems and unfamiliar library systems would create confusion and more work in early stages."

Such type of information is capable and effective to be handled by database with an assigned item code for each record. Kodikara (1990) indicated that researches had pointed out two major disadvantages with the use of codes:

- a) coding of items would be tedious job and a record check is necessary to minimise the possibilities of choosing wrong codes; and

- b) the interactive between the computer and the user requires the user looking up the right code from a large voluminous library.

"CCMS" estimating sub-system uses codes as the keys for relational database operation within the Sub-system itself and it is totally transparent to the user. In the interactive between the system and the user, it introduces step-by-step pop-up windows and pulldown menus for the user to select data from the libraries. This technique as one of the characteristics of 'CCMS', has been described in Section 5.3.2.3. An example of the data selection from step-by-step pop-up windows for a particular set of unit rates is illustrated in Figure 7.3 (a).

Ins

| Type for : CONCRETOR       | Material Trades |
|----------------------------|-----------------|
| Type Name                  | Type Name       |
| CONCRETE SPECIAL MIX 40/20 | CARPENTOR       |
| CONCRETE SPECIAL MIX 45/20 | CONCRETOR       |
| FORMWORK                   | DRAINLAYER      |
| REINFORCEMENT              | PLASTERER       |
|                            | ROOFER          |
|                            | STL & MTL WKR   |
|                            | TILE            |

[F5]-Add; [F6]-Delete; [F4]-select

Select Resource Type => MATERIAL  
 Select Resource Name => \*

Press [=] to list items for selection

Press [=] to list items for selection

Figure 7.3 (a)  
Step by Step  
Window for  
Selecting an Item  
of Standard Unit  
Rate.

The above example in Figure 7.3 (a) shows a selection of resource item from the following steps:

- a) resource type: material;
- b) material trade: concretor; and
- c) trade type: reinforcement;

Therefore, in accessing to any resource library, the user has to identify the following parameters:

- a) resource type - select from labour, plant, material or subcontractor.
- b) resource name - select from the list of the corresponding type.

The information has to be input into any resource item including: rate, unit, date and remark. In traditional data base, there may have limitation on the number of characters for data fields. But by the use of 4th Generation Language as described in Section 5.4.3, there is technically viable to accommodate virtually unlimited number of characters by a text file format for a data record. This is particular significant for such kind of function to be used in the remark field of resource rates, by which the background information of the rate can be recorded including the reference of relevant quotations etc. Ashworth (1987) pointed out that due to the effects of inflation and the variance of delivery costs, the estimator is required to obtain a quoted price for every material to be used on the project. Therefore, a remark field for each resource rate is significant and has been taken into account in the design of "CCMS" estimating sub-system. An example of the input of 'remark' for resource unit rates is illustrated in Figure 7.3 (b)

Ins

| Historial Unit Rates for MIXER |      |          |                                                                  |
|--------------------------------|------|----------|------------------------------------------------------------------|
| Rate                           | Unit | Date     | Remark [F2] to edit                                              |
| 1000.00                        | Hr   | 03-06-91 | The rate was based on the quot<br>Daywork rate from New Territor |
| 1300.00                        | Hr.  | 05-07-92 |                                                                  |
| 1400.00                        | Hr.  | 01-08-92 |                                                                  |

Remark

The rate was based on the quotation from Luen Cheong Co. for Yuen Long Industry Project Lot No. 2511. The unit rate includes driver and transportation to site, but excluding petrol. Mini hiring period will be two weeks.

[F3] to save; [Esc] to leave

Select Resource Type => PLANT  
Select Resource Name => MIXER

Press [=] to list items for selection  
Press [=] to list items for selection

Figure 7.3 (b)  
Example Showing  
the Use of Remark  
Field.

#### 7.4 Unit Rates for Standard Library

According to the study in Hong Kong construction industry as described in Chapter 3, the practice of most estimator for contractors is to deal with unit rate estimating. The practice of estimation has substantially affected by the tendering formats in the industry where bills of quantities are the main procurement document. The main screen for accessing to the unit rate functions of each standard unit rate is shown in Figure 7.4 (a).

Item Detail for =>E02

|                                                               |                                                                                                      |         |
|---------------------------------------------------------------|------------------------------------------------------------------------------------------------------|---------|
| Full Description                                              | Excavation for pile caps commencing from existing ground floor level to underside of blinding layer. | e       |
|                                                               |                                                                                                      | TH      |
|                                                               | All in Rate                                                                                          | \$97.75 |
|                                                               | Unit                                                                                                 | m3      |
| Remark [F2] to edit memo                                      |                                                                                                      |         |
| -----                                                         |                                                                                                      |         |
| Access to the historical all - in unit rates = <u>N</u>       |                                                                                                      |         |
| Access to the historical labour productivity rates = <u>N</u> |                                                                                                      |         |
| Access to the detail of unit rate built up = <u>N</u>         |                                                                                                      |         |

Select Master File Type => EXCAVATION  
 Select Subheading Type => ALL  
 Press [\*] to list file names

Figure 7.4 (a)  
Main Screen for  
Accessing to the  
Unit Rate  
Functions of Each  
Standard Unit  
Rate.

This section describes the functions provided by the Sub-system to tackle with unit rates. These functions are described in the following sections.

#### 7.4.1 Built Up and Update of Unit Rates

McCaffer and Baldwin (1991) pointed out that the calculations undertaken by estimators in the process of producing an estimate fall into two categories, calculating costs and calculating direct cost rates for items of work. The built-up of unit rates in the Sub-system has applied the classical unit rate estimation approach, with which the cost component of labour, plant, material and subcontract will be tackled. Those cost components are assessed in a form of output rate times resource rate. A standard item in the standard item library (SIL) contains the following fields:

- Code;
- Trade Type;
- Item Description;
- Contemporary Unit Rate;
- Unit; and
- Remark.

The contemporary unit rate in any particular item is built up by the resource unit rates and the relevant output rates. A sample illustration for the built up is shown in Figure 7.4.1 (a).

Item Detail for =>E02

Full Description: Excavation for pile caps commencing from existing ground floor level to underside of blinding layer.

Built Up of : Excavation for pile caps commencing from existing

|                        |                 |                          |  |
|------------------------|-----------------|--------------------------|--|
| Labour : [=] to select |                 | Material : [=] to select |  |
| -                      | 0.00 @ 0.00 per | 0.00 @ 0.00 per          |  |
|                        | 0.00 @ 0.00 per | 0.00 @ 0.00 per          |  |
|                        | 0.00 @ 0.00 per | 0.00 @ 0.00 per          |  |
|                        | 0.00 @ 0.00 per | 0.00 @ 0.00 per          |  |
|                        | 0.00 @ 0.00 per | 0.00 @ 0.00 per          |  |

|                       |                         |                             |                        |
|-----------------------|-------------------------|-----------------------------|------------------------|
| Plant : [=] to select |                         | Subcontract : [=] to select |                        |
| BULLDOZE              | 0.03 Hr @ 600.00 per Hr | POLY-ACT                    | 1.00 m3 @ 65.00 per m3 |
|                       | 0.00 @ 0.00 per         |                             | 0.00 @ 0.00 per        |
|                       | 0.00 @ 0.00 per         |                             | 0.00 @ 0.00 per        |

---

Prime Rate => 83.00      Adjustment : 1.15

All-in-rat \$95.45

[Tab] to jump; [ ] to next; [PgDn] to finish; [Esc] to left

Figure 7.4.1 (a) A Sample Screen of Unit Rate Built Up.

Any updating of the resource unit rates in the resource unit rate library, can be functioned in the discretion of the user to automatically update the standard item unit rates. In this operation, it also allows the user to adjust the percentages of overheads and wastages for the creation of bidding rates.

#### 7.4.2 Labour Productivity Unit Rates

The design of these functions has particularly contemplated the sub-contract orientated situation of the construction industry. Abdel-Razek (1987) pointed out that the choice of subcontractor was important and most companies maintained a list of approved subcontractors for various trades. He also highlighted the growth of subcontracting and the risk of selecting an unqualified subcontractor. The study in Chapter 3 regarding the construction industry of Hong Kong has also confirmed this situation.

The labour productivity unit rate function has been designed to cater for labour only subcontractor contracts. According to the study in Chapter 3, the extent of labour only subcontracts occurs 25 to 35% of the contract value. An example of this function is illustrated in Figure 7.4.2 (a).



Item Detail for =>E02

Full Description Excavation for pile caps commencing from existing ground floor level to underside of blinding layer.

All in Rate \$95.45  
Unit m3

Remark [F2] to edit memo

---

Subcontract Labour Productivity

| Date     | Subname [=] | Rate  | Markup | L.rate [0] | Productivity [F2] |       |
|----------|-------------|-------|--------|------------|-------------------|-------|
| 01-05-91 | WONG'S      | 60.00 | 0.10   | 200        | 0.2700            | Sp.Te |
| 01-08-91 | POLY-ACT    | 65.00 | 0.15   | 220        | 0.2511            | Sp.Te |

[F3] to save; [F5] to add; [F6] to delete  
Press [=] to list file names

Figure 7.4.2 (a) A Sample Showing the Dealing of Subcontract Labour Productivity.

In this example, a labour only item of 'Excavation for pile caps commencing from existing ground floor level to underside of blinding layer'. A subcontract 'Wong's' priced HK\$ 60/m3 on 1st May 1991 and is the first unit rate in the same item under the library. The details of the unit rates are copied from the Figure 7.4.2 (a) and are illustrated in vertical order as the following table:

| Column Heads             | 1st Rate              | 2nd Rate              |
|--------------------------|-----------------------|-----------------------|
| Date                     | 01-May-91             | 01-Aug-91             |
| Subcont. Name            | Wong's                | Poly-act              |
| Unit Rate (HK\$/m3)      | 60                    | 65                    |
| Market Mark Up           | 10%                   | 15%                   |
| Market Labour Wage       | 200                   | 220                   |
| Productivity (m3/manday) | 3.667                 | 3.895                 |
| Remark (memo field)      | Full text description | Full test description |

Date: Date of the subcontractor's tender.

Subcont. Name: Subcontractor's name.

Unit Rate: The unit rate quoted by the subcontractor.

Mark up: It bases on the reckoning of the market trend by the estimator.

Labour Wage: From the trade unions or Government statistical information.

$$\text{Productivity} = \frac{\text{Labour Wage} \times \frac{1 + \text{MarkUp}\%}{\text{Tender Unit Rate}}}{\text{Tender Unit Rate}}$$

Remark: It uses the memo field function of "FoxPro", by which any terms and particulars relating to the unit rate or productivity can be recorded for future reference. It is particular important for the estimator to have such information of previous completed contract to support their negotiations with the subcontractor and even the overall tender strategy.

According to the survey in the construction industry of Hong Kong as described in Chapter 3, it is highly recognized that the trade subcontractors based on their experience and expertise of their trade have the most reliable prediction on the productivity for any particular tender than the estimators. Such productivity derived from the unit rate will be used to monitor the performance of the subcontract in "CCMS" progress control sub-system, the feedback of which will be used to aid for future estimation. The details of this approach are described in Section 11.6.

#### 7.4.3 Historical Unit Rates

Historical all-in unit rate function is used to store the previous tender unit rates of a particular standard item for main contract tenderings. It contains date of the rate, unit rate and remark, by which any terms and particulars relating to the unit rate and the actual feedback can be recorded in this field with full description. As revealed in the findings of the characteristics of Hong Kong construction industry described in Chapter 3, 'by-negotiation' is the most common means of settling differences or disputes between main contractors vs subcontractors and main contractors vs consultant quantity surveyors for prices. In fact, this is also in line with the mentality of business practices in Hong Kong society, which is biased substantially by Chinese culture as described in Section 3.2 of this thesis.

An illustration of historical unit rate input is shown in Figure 7.4.3 (a).

Item Detail for \*E02

Full Description      Excavation for pile caps commencing from existing ground floor level to underside of blinding layer.

All in Rate      \$97.75  
Unit      m3

Remark [F2] to edit memo

---

Historical Unit Rates

| Date     | Rate  | Remark                                         |
|----------|-------|------------------------------------------------|
| 01-04-90 | 80.00 | The unit rate from the completed contract at t |
| 01-08-90 | 90.00 | Tender rate for Central Commercial Building    |
| 10-12-91 | 86.00 | Quotation from Luen Wah Co, for Housing Projec |
| 01-06-92 | 88.00 | Direct labour rate for the Project in China.   |

[F2]-details; [FS]-add; [F6]-delete;

Press [=] to list file names

Figure 7.4.3 (a)  
List of Historical  
Unit Rates for a  
Specific Items.

## 7.5 Aids to Post-Contract Construction Management

### 7.5.1 System Design Consideration

McCaffer and Pasquare (1987) reported their research findings regarding the interchange and use of data by contractor's management functions. They are:

- Large quantities of data are passed within and between the management function groups of construction organisations.
- Many of these data have to be reworked or generated by each function group in order to perform the tasks required.
- There are two main sources of information, the estimator and the site. The estimator provides information about the proposed project and the site, data about the actual construction process.
- The purchaser, planner and surveyor use the estimator's data to endeavour to predict the data returned by the site.
- The amount of reworking and regenerating of data by the management functions could be reduced if the estimator's initial data could pre-empt the efforts of the purchaser, planner and surveyor by attempting to anticipate the site's needs and problems at the initial conception of the contract.

The major conclusion of their works was that where the estimator generated the initial measured data for the contract, these data could be compiled in a form that could be more easily used by the other management function groups who then work together to execute the contract. McCaffer and Pasquare added that the preparation of these data should not consume any more time than was currently spent on preparing an estimate and should ideally make the estimating task easier.

The above mentioned principles have been adopted in the design for the functions used to support the practices of construction management at post contract stage. Such functions are described in the following sections.

### 7.5.2 Contract Reviews

All the construction contracts should include some particular issues which have significant influences on the tender price and subsequently such issues will be put into a form of contractual obligations binding both parties. The crucial problem is that such issues should be reviewed from time to time during the whole process of the contract period. An input menu of "CCMS" estimate sub-system for contract review is shown in Figure 7.5.2 (a) and an access to the contract parameters is shown in Figure 7.5.2 (b).

| Ins                                |                                        |
|------------------------------------|----------------------------------------|
| Job Detail                         |                                        |
| Job Number [=] 01                  | Job Description Yuen Long Bus Station. |
| Project Type [=] Public Utility    |                                        |
| Management Team                    |                                        |
| QS Group Leader [=] Yung Ying Ming | Superintendentant [=] Chan Ping Ning   |
| Contract Details                   |                                        |
| Contract Parameters..... F         | Domestic Subcontracts ..... F          |
| Design Liabilities ..... F         | Internal Management Needs ... F        |
| Nominated Subcontracts.... F       | .....                                  |
| Construction Works..... F          |                                        |

Figure 7.5.2 (a)  
Input Menu for  
Contract Reviews  
for a Specific  
Contract.

| Ins<br>Job Detail                         |                          |                                        |        |        |
|-------------------------------------------|--------------------------|----------------------------------------|--------|--------|
| Job Number [=] 01                         |                          | Job Description Yuen Long Bus Station. |        |        |
| Project Type [=] Public Utility           |                          |                                        |        |        |
| Management Team                           |                          |                                        |        |        |
| QS Group Leader [=] Yung Ying Ming        |                          | Superintendent [=] Chan Ping Ning      |        |        |
| Contract Parameters and Details           |                          |                                        |        |        |
| Seq                                       | Description              | Planned                                | Actual | Remark |
| 02                                        | Tender Sum               | 2.5 million                            |        |        |
| 03                                        | Contract Completion Date | 365 days                               |        |        |
| 04                                        | Liquidatd Damage         | 10,000 per day                         |        |        |
| 05                                        | Mini Interim Payment     | 200,000                                |        |        |
| [F3] to save; [F5] to add; [F6] to delete |                          |                                        |        |        |

Figure 7.5.2 (b)  
Access to the  
Contract Parameter  
of Contract Review  
Function.

The contract review can be classified under the following headings with data examples to illustrate:

**a) Contract Parameters:**

such as contract start date; contract sum; contract period; original contract completion date; extended contract completion date; predicted contract completion date; extension of time claimed; extension of time granted; liquidated damage rate; incurred liquidated damages; potential liquidated damages; minimum amount of interim payment, cut off date of interim payment etc.

**b) Design Liabilities:**

such as some kind of permanent designs; most of temporary designs; special strutting; large panel formwork; sample rooms etc.

**c) Construction Milestone Dates:**

such as special arrangements for public utilities; special access handover dates; temporary or permanent electricity connection; temporary or permanent water connection; lift shift handover date; transformer room handover dates etc.

**d) Nominated Sub-contract Status:**

the status including briefing; detailed design; preparing tender document; tendering stage; tender return date; contract award date; construction started date; commissioning start date etc.

**e) Domestic Sub-contract Status:**

similar to the above status for nominated sub-contracts but more internal controls may have to build in such as internal audit and consulting in-house consultant etc.

**f) Special Requirements:**

Here is a contingent area to allow flexibility to build in for some kind of special requirements such as special tests for certain kind of materials or equipments, special installation requirements and special co-ordination duties etc.

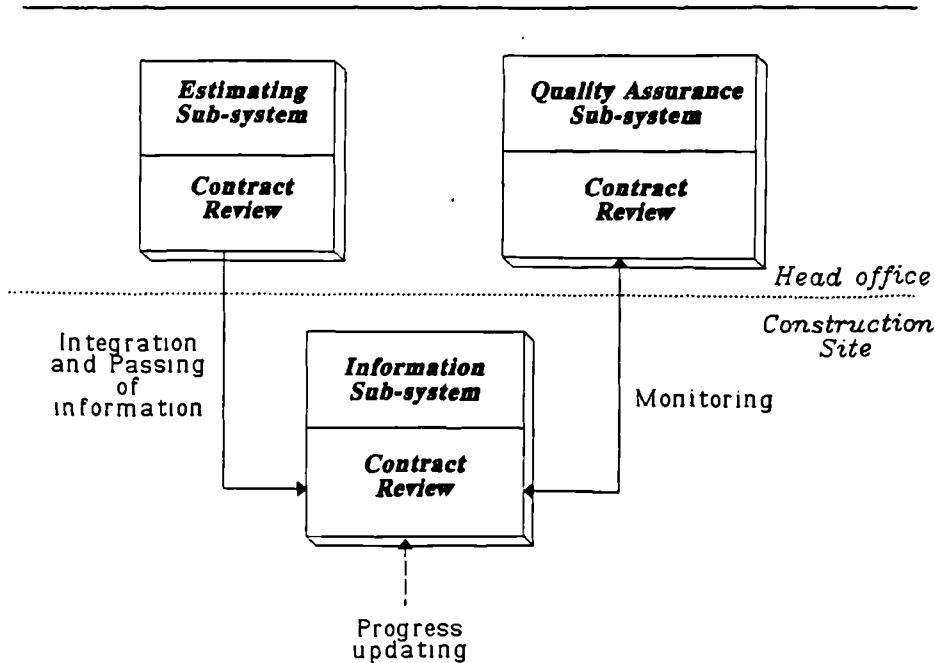
**g) Internal Management Needs:**

Here is used to input some kind of internal management requirements such as internal audits for quality assurance, dates of internal meetings, dates of site visits by senior management etc.

Theoretically, all the above information will have affected the cost of construction and thus the cost effects should have been allowed in the tender price. The estimator is supposed the first party in a contracting organisation in touch with such information. Presumably, there should have a system, no matter by computer or by manual, to systematically record those information in a form that can be passed to the other management functions. It is not assumed that all the above information should have been filled in by the estimator at the tender stage but at least some of the critical issues should be initiated by the estimator.

"CCMS" estimating sub-system provides a functions to record all those information. The data file will be passed to "CCMS" information control sub-system on site for the site management staff to update the information from time to time during the contract period. This approach also complies to the 'contract review requirements' under the standard of most quality assurance system and will also be monitored by 'CCMS' quality assurance sub-system. A flow chart showing the relationship among these Sub-systems for contract reviews is illustrated in Figure 7.5.2 (c).

**Figure 7.5.2 (c) Operational Flow Chart for Contract Reviews**



### 7.5.3 Material Procurement

Abdel-Razek and McCaffer (1987) highlighted that typically the value of material within a project accounted for between 30% and 60% of a project's value. The study in this research has revealed that the material procurement is one of the serious problems in construction site management. One of the methods to tackle this problem is to prepare a material procurement schedule at the start of contract. Such a schedule will be updated from time to time during the contract period and will be used as a co-ordination tool between the project site and the purchasing department of head office.

The estimator is the first party in a contracting organisation in touch with the material requirements in the tendering documents, because such requirements have a great influence on the tender price. Presumably, there should have a system, no matter by computer or by manual, to systematically record those information in a form that can be passed to the other management functions. Accordingly, "CCMS" estimating sub-system has included a functions to deal with the material procurement. A screen illustration is shown in Figure 7.5.3 (a).

Material Details for =>A01

Full Description : 20x20 mm External Wall Mosaic Tile.

---

Total Quantity : 0.00 Unit : Insp. Reqm memo  
Storage Reqm memo

Area per Pack 0.00 Unit :

Location to Use [=] : Block 6

Supplier [=] Yung's Company Take Off Comp - -  
Earliest Start - -

Manufacturer [=] Score

Spec/Drg/BQ Reference BQ Item 01-P04  
Particular Specification Clause 45/b

Input Material Type => TILE  
Material Type Press [=] to List

Figure 7.5.3 (a)  
An Example of  
Initiation for  
Material  
Procurement.

The materials will be classified under a user definite trade categories. Any specific item of materials should included the following details:

| Details                              | Initiated by whom        | Check/Update by whom                 |
|--------------------------------------|--------------------------|--------------------------------------|
| Full Description                     | Estimator                | Site Quantity Surveyor               |
| Total BQ Quantity                    | Estimator                | Site Quantity Surveyor               |
| Total Measured Quantity              | Site Quantity Surveyor   | Site Quantity Surveyor               |
| Area per Pack                        | Purchaser                | Site Store Keeper                    |
| Location to Use                      | Estimator                | Site Engineer                        |
| Supplier Details                     | Purchaser                | Site Store keeper                    |
| Manufacturer Details                 | Purchaser                | Site Store Keeper                    |
| Specification/BQ/Drawing Reference   | Estimator                | Site Quantity Surveyor/Site Engineer |
| Estimated Taking Off Completion Date | Site Quantity Surveyor   | Site Quantity Surveyor               |
| Estimated Work Earliest Start Date   | Site Engineer            | Site Engineer                        |
| Inspection Requirements              | Quality Control Engineer | Site Engineer                        |
| Storage Requirements                 | Quality Control Engineer | Site Engineer                        |

Those information marked 'initiated by estimator' will be tackled by this Sub-system. The use for the above information are detailed in Chapter 9 regarding the description of 'CCMS' materials control sub-system.



#### 7.5.4 Cost Plan and Budget

According to the survey in Hong Kong construction industry as described in Chapter 3, nearly all the contracting organisations have a set of their own pre-defined account code used as cost centres to account the actual expenses of project. This system called job costing. Drebin and Bierman (1978) defined that the job order cost system is to accumulate costs for each job, usually a specially ordered product or services. According to CIMA official terminology (1991), a job cost is the 'aggregated costs relative to a single specific order or specific tasks'. The management functions of budgeting, job costing and cost control for post contract cost control are supported by 'CCMS' cost control sub-system. To initiate the execution of post contract cost control, "CCMS" estimating sub-system allows a function to establish the relation of resource rates and job cost codes. By the setting up of this relationship, the system can calculate the budgetary value of each cost center through the assigned job cost code. Figure 7.5.4 (a) shows the menu for allocating job cost codes to resource unit rates.

Ins

Assign Jobcost Codes to Resource Rates

| Resource Rate Name | Jobcost Code [F2] |
|--------------------|-------------------|
| ASPHALT            | D375              |
| ASST. FOREMAN      | P0 0              |
| BATH TUB           | D325              |
| BR CKLAYER         | D320              |
| CARPENTER          | D255              |
| CLEANER            | D235              |
| CONCRETOR          | D225              |
| DRAINLAYER         | D400              |
| ELECTRICAL         | D567              |
| EXCAVATOR          | D210              |
| FIRE SERVICE       | D081              |

[F2] to master job codes; [F5] to add; [F6] to delete

Select Resource Type => LABOUR  
 Select Job Cost Code Type => DIRECT LABOUR  
 Press [=] to list items for selection

Figure 7.5.4 (a)  
Company Level  
Allocation of Job  
Cost Code to  
Resource Unit  
Rates.

The resulting calculation of tender budget is shown in Figure 7.5.4 (b).

Ins  
Job Detail

---

Job Number [=] 01      Job Description    Yuen Long Bus Station.

---

Tender Cost Budget

| Code | Descrip              | Tender Budget | [F2] to edit     |
|------|----------------------|---------------|------------------|
| D013 | SUBLETTERED LEVELLER | \$1,023,750   |                  |
| D014 | SUBLETTERED GEN.LAB. | \$87,752      |                  |
| D050 | TEMP.ELECTRICITY     | \$26,266      |                  |
| D051 | TEMP. WATER          | \$3,565       | From other site. |
| D062 | P & M MISC.          | \$563,536     |                  |
| D070 | TEMP. OFF & SHEDS    | \$22,526      |                  |
| D080 | REMOVAL OF REFUSE    | \$26,672      |                  |
| D081 | SCRAPING FLOOR       | \$62,337      | Direct labour    |
| D082 | WASH CLEANING        | \$37,207      |                  |
| D090 | TEMPORARY WORKS      | \$27,267      |                  |

[F3] to save; [F5] to add; [F6] to delete

Total Sum

Tender Budget    \$1,880,878

Figure 7.5.4 (b)  
Resulting  
Calculation of  
Tender Budget for  
a Particular Set  
of Job Codes.

The principle and application of cost budget will be detailed in Section 10.2 of this thesis.

## 7.6 Summary of the Aids to Estimating and Tendering

The system design of "CCMS" estimating sub-system has taken into account the recommendations of previous researches and the findings from the study in Hong Kong construction industry. In summary, its contributions to estimating and tendering are as follows:

- a) The basic functions specified by Baldwin (1982) for computer-aided estimating system have been included.
- b) Basically, the user needs not to remember codes in the operation of the system, because all the selections are based on step-by-step windows. This is in line with the comments from previous researches.
- c) 'Memo' field column is used to allow virtually unlimited remark notes to type in for most items. This allows a greater feasibility for the background information to be recorded, which usually are the crucial issues of the tendering process. Since construction projects most often are complicated and unpredictable, during the tendering stage, more reference information from previous projects shall aid for contractors' negotiations to both subcontractors or client's consultant quantity surveyors. It is important to note that 'Resolving by negotiation' is a main mentality of running business in Chinese society for all disciplines.

- d) Its interface with 'Floppy Disk Tendering' has solved out the most critical data input problem for the original contract bill.
- e) The use of 4th generation language allows more flexibility in data exchange through different file types.
- f) The integration of estimate data to support the functions of post-contract construction management, reduces much repetitive work and also lays down a valid initiation for the tasks to be continued such as contract review and materials procurement.
- g) It allows the preparation of the cost budget based on the estimate through the assigned job cost codes.

## 8 Information Control Sub-system

### 8.1 Principle of the Information Control Sub-system design

Munday (1979) presented data showing that construction managers spend almost 50% of their working time on tasks devoted exclusively to the transmission of information and suggested that the flow of information is particularly important to construction companies due to the unique nature of each project.

Pearson (1991) at a seminar in Hong Kong presented that the volume of information involved in a typical construction projects in public sector may be as follows:

- a) Drawings - 1,000 to 1,300 sheets.
- b) Instructions - 600 to 1,000 issues.
- c) Correspondence - 5,000 to 7,000 items.

These figures indicate the work load of Hong Kong contractors in handling information on site.

Ndekugri and McCaffer (1988) consolidated a summary of information flow among the contractor's management system which contained about 50 generic entities, with sources of information and usage of information. However, the summary did not identify the specific information on site and without classifying the information.

Fisher and Shen (1992) identified the classification of information involved within a contractor including:

- a) Financial information;
- b) Marketing information;
- c) Project nature information;
- d) Technological information; and
- e) Personal information.

The information classification in this research is concentrated on financial, project nature and technological information handling on construction site. According to the field test described in Chapter 13 and the survey in Hong Kong construction industry described in Chapter 3, the types of document handling on site by the site management can be classified by three methods with the details as follows:

#### a) By Contract:

- Contractual Documents: Defined as those documents, the nature of which has been identified in the conditions of the contract such as original contract documents,

contract drawings, site instructions, variation orders, sample submissions etc.

- Non-contractual: any documents other than contractual Documents documents.

**b) By construction operation:**

- Production: Defined as those documents that can Documents be used directly on the construction work such as construction drawings, specification, method statement, sample submission, setting out data etc.
- Performance: Defined as those documents recording Documents the information of value, status or performance of the completed works such as daily report, progress charts, cost data, interim payment certificates and testing and inspection reports etc.
- Co-ordination: Any documents on site other than Documents production documents and performance documents, can be classified as co-ordination documents.

**c) By management execution:**

- Daily correspondence: Any documents other than drawings, instructions, minutes of meeting and specific documents.
- Drawings: All the drawings including contract drawings, construction drawings, submission drawings etc.
- Instructions: All the instructions in a specific form with assigned serial number issued from the contract supervisor, the authority of which has been defined in the contract.
- Minute of Meetings: All the minutes of meeting throughout the contract period.

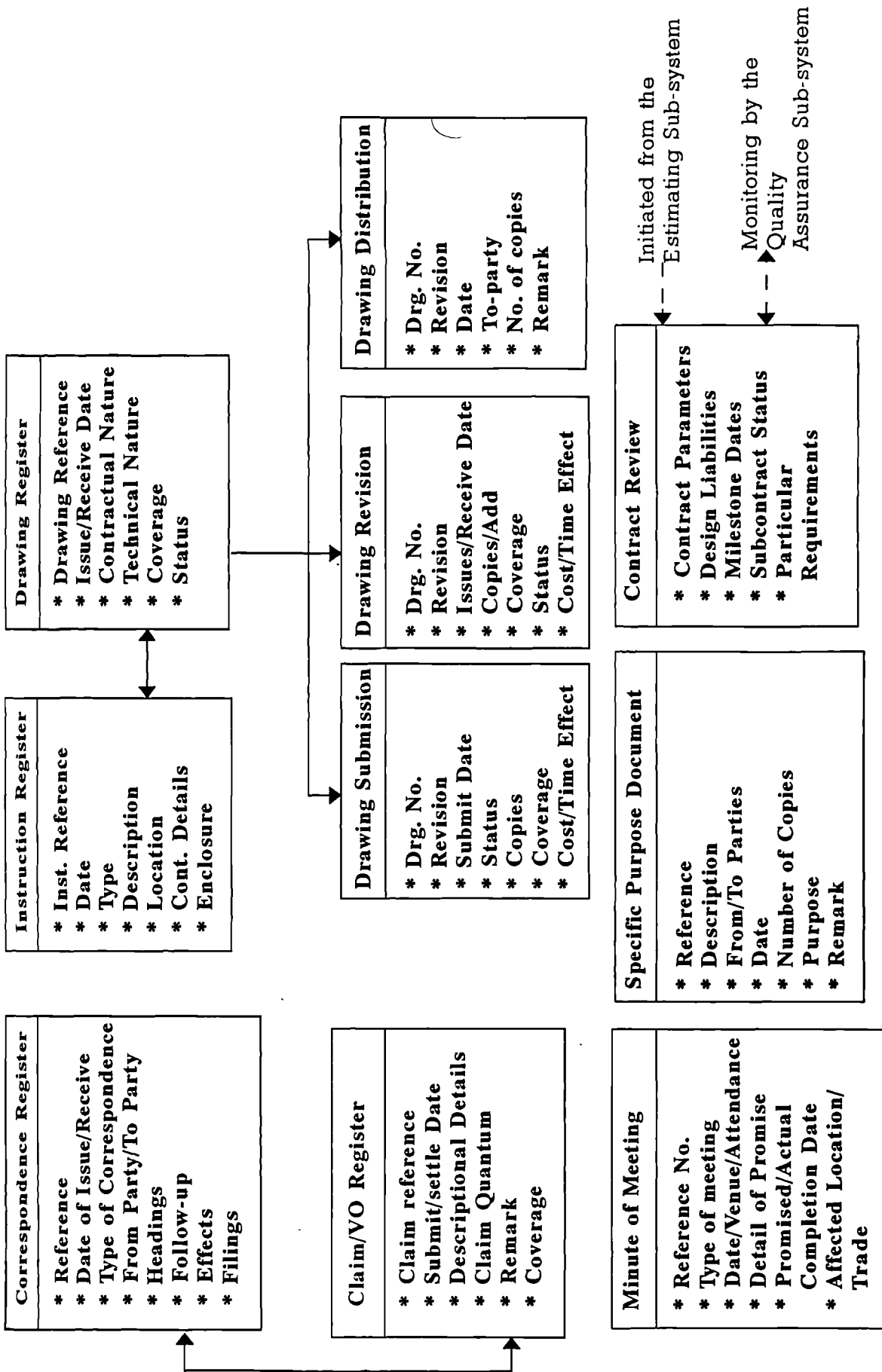
|                     |                                                                                                                                                                                                       |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Specific Documents: | Defined as the documents with a unified specific purpose recognized by the contract such as interim payment certificate, sample submission, master programme, method statements and daily reports etc |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

The above classification provides an identity of the nature of information control on site. The model of construction management described in Chapter 6 includes a management function for site management, within which information control is one of the key issues. In order to support the management tasks for site information control, the system design of "CCMS" information control sub-system (also called the Sub-system in this Chapter) has adopted the 'management execution' classification as mentioned in item c) above. The main reason behind the adoption is to enable the system operation to simulate as much as possible the existing site practices. It is because even without the use of computers the site management has still to take up some manual procedures for information control.

Previous studies on the use of computers for site management have concentrated on the design of coding system. Crane (1986) commented that even with fast codes the site managers still have to face too many "blank screens". The system design described in Chapter 5 of this thesis has taken into account the comments from site management practices. This allows the user to build up their own standard phraseology from script. By picking up data from the pop-up windows, it will save up a lot of typing efforts on site for data input. This is in line with the comments from both the academic and the industry that the new computer system design for the construction industry should try to eliminate and reduce codes and typing. (Crane 1986, Baldwin 1989, O'Brien 1989, Kokikara 1990)

The functional operations of "CCMS" information sub-system is shown in Figure 8.1 (a).

The Sub-system main menu is shown in Figure 8.1 (b).



**CCMS Information Control Sub-system  
Operational Flow Chart**

**Figure 8.1 (a)**

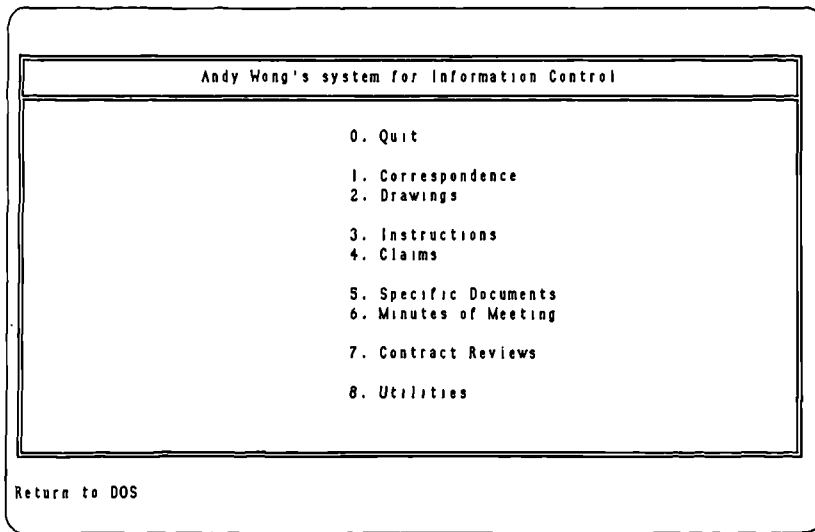


Figure 8.1 (b) The Sub-system Main Input Screen.

The details for each function are described by the following sections.

## 8.2 Correspondence Register

### 8.2.1 Requirement for Correspondence Register

The definition of daily correspondence on site has been stated in the Section 8.1 above. Any daily correspondence register, no matter by the use of computers or by manual, has to serve the following basic purposes:

- a) To record the factual issues of a correspondence received or issued including issue party name, date of issue, date of receive, correspondence reference if any, correspondence heading if any, file reference where the correspondence will be put etc.
- b) To give a quick identity to the file in which a desired correspondence is contained.

With the use computers, in addition to the above functions, more feasibility and better efficiency should be achieved in order to:

- a) To make the task easier in comparison with the original manual procedure .
- b) To increase the feasibility of information retrieval by allowing the output of more different types of reports.



### 8.2.2 Stages of Correspondence Handling

According to the study in Hong Kong construction industry as described in Chapter 3, there have two stages of job handling for the correspondence received on site as follows:

- a) First stage - Distribution of the correspondence received before action:

In most cases, the site manager or the site agent, supposed as the first site staff to read for received correspondence, should decide the actions of follow up and the staff to response for the follow up actions. After the decision has been made, the correspondence will be handed to the site clerk for registration and then it will be sent to the assigned responsible staff for action. In this stage, the following issues are crucial:

- i) the identity of the site staff who has been assigned to take up the follow up action.
- ii) it is necessary to have a mechanism to enable constant reviewing for the follow up status.
- iii) the received correspondence will be traceable.

- b) Second stage - Filing of the correspondence completed after follow-up action:

After the follow up action completed, the correspondence will be put into filing according to an unique filing system. Filing systems may be different in each organisation, each project, each site manager or even each individual practice. According to the study, in this stage the following issues are crucial:

- i) The identity of the file where the correspondence will be put.
- ii) The effect of the correspondence to the overall performance of the project.

### 8.2.3 Input for the Correspondence Register

According to the stage one mentioned above, in order to simulate the manual operation of correspondence receiving, it should initially identify from whom the correspondence was issued. In the input of correspondence received, the

first question from the Sub-system is the name of the issue party. The Sub-system allows the user to choice from the window where the party names are contained. The party names in the window library can be built up from script that means the library will be growth up in line with the construction progress because more parties will have involved in the project. Following the selection of the issue party name, a list of the previous correspondence will be listed and the list can be sorted in any specific order. A screen illustration for this operation is shown in Figure 8.2.3 (a).

| Correspondence List |          |               |                                       |
|---------------------|----------|---------------|---------------------------------------|
| Issue               | Receive  | Reference [=] | Heading                               |
| 03-07-91            | 04-07-91 | HD(AR)14/88/2 | protection to Precast Staircases and  |
| 26-06-91            | 04-07-91 | HD(AR)14/88/2 | 50 X 50 X 5mm Vitreous Unglazed Mosai |
| 15-07-91            | 26-07-91 | HD(AR)14/88/2 | Domestic Blocks - Cement / Sand Rende |
| 19-07-91            | 25-07-91 | A-57          | Dwg. No. 47-DR-01 to 3                |
| 16-07-91            | 25-07-91 | A-56          | 145/P/1, 145/2/A/1,5,6,7,8            |
| 16-07-91            | 26-07-91 | HD(AR)14/88/2 | Revision to Pipe Duct Enclosure       |
| 18-07-91            | 26-07-91 | HD(AR)14/88/2 | Query Steel - Windows to Assembly Hal |
| 15-07-91            | 31-07-91 | HD(AR)14/88/2 | Domestic Blocks - Cement / Sand Rende |
| 19-07-91            | 02-08-91 | HD(AR)14/88/2 | Steel Window Shop Drawings (Domestic  |
| 16-07-91            | 31-07-91 | HD(AR)14/88/2 | Revision to Pipe Duct Enclosure       |
| 16-07-91            | 20-07-91 | A-52          | Domestic Blocks 6,7,8 & 9             |
| 03-07-91            | 18-07-91 | HD(AR)14/88/2 | Protection to Precast Staircases and  |
| 05-07-91            | 17-07-91 | A-53          | Drawings No. 145/2/A/10(A), 11(A)     |
| 03-07-91            | 17-07-91 | HD(AR)14/88/2 | Domestic Blocks - Cement/Sand Rende   |
| 25-06-91            | 28-06-91 | A-51          | SSI & SS2 Details of Water Tank       |

[F2]-details; [F3]-save; [F5]-add; [F6]-delete; [F7]-carry on/off; [F8]-sort

From Party [=] Architect

Press [=] to select from the list

Figure 8.2.3 (a)  
List of Previously  
Inputted  
Correspondence  
from a Specific  
Party.

For the stage one of correspondence handling, the following attributes of a correspondence can be input into the Sub-system:

**Reference No:** In most commercial cases, each correspondence should have an independent reference number. If it is absent, the issue date together with the initial of the issue party can be used as a 'quasi reference' in case of necessary.

**Type:** Input the type of the correspondence such as letter, memo and quotation etc.

**From Party:** Input the name of the correspondence issue party.

**To Party:** Input the name of the correspondence receive party.

**Issue Date:** Input the correspondence issue date.

**Receive Date:** Input the date of the correspondence received and the default is the computer system clock date.

**Last Reference:** This is a special function to allow the input of the reference number referred by the received correspondence as its last reference. By such a reference, the Sub-system can produce the reports based on the chain of relative correspondence. This is particularly useful in chasing up the relevant correspondence of a particular subject or retrieving the background information of a contractual claim.

**Heading:** Input the corresponding heading if applicable. In case the original letter heading is absent, it should then be the duty of the site manager or the site agent when the correspondence is read, to highlight the key words or key phrases as the correspondence heading.

**Follow Up:** Input the identity of the assigned follow up person. It can use the name of staff or the position as an identity in the library.

**Remark:** A pop-up window will be available for the user to type the remark notes without limitation on input characters. This allows any background information or valid data to be recorded, for example a description of the enclosure with the correspondence etc.

The second stage is to input the follow up information. The cut off point of the second stage information is when the follow up actions has been completed and the correspondence is going to be put into file. The second stage information includes:

**Responded Action:** Input the responded action for the correspondence by the follow up staff. For received correspondence, the responded action may be: replied, settled and acknowledged etc. For issued correspondence, only 'waiting for response' will be used in case of necessary. If the demand for response is unnecessary, this part should be left blank for issued correspondence. The user can pick up such standard phraseologies from the pop-up window.

**Further Action Day:** Input the number of days, by which further actions is action day expected from the correspondence issue date. Based on this day number, the Sub-system is able to alert for any outstanding action beyond the expired date which is calculated by the correspondence issue date plus the number of estimated action day.

**Effect:** Input the considered effect of the correspondence to the contract. Depending on the division of responsibility, sometime the correspondence will be returned to the site manager or the site agent from the follow up staff for the site top manager to decide the effects of such correspondence, or may be the follow up staff to decide the effects of such correspondence by themselves. The description for a specific effect can be selected from a set of standard phraseologies from the pop-up window. The common phraseologies may be: cost effect, time effect, time cost effect, deduct subcontract account, quality problem etc.

**File:** Input the file reference of where the correspondence will name be put.

A sample input screen for a received correspondence is shown in Figure 8.2.3 (b).

A Correspondence Detail

Correspondence Register

Document Reference [=] HD(AR)14/88/2

Type [=] Letter                      Issue Date 03/07/91  
                                               Recev Date 04/07/91

From [=] Architect                      [=] Main Contractor

Heading    protection to Precast Staircases and Barriers to Window  
                  Openings

                 Remark for the Correspondence

memo            [F2] to details

Last Reference [=]                      N

Status [=]    QCE' work

Comments [=] Quality Control

Eng File [=]    B                      QS File [=]    1a

[Esc] to exist

Press [=] to select from the list

Figure 8.2.3 (b)  
Input Screen for  
the Details of a  
Received  
Correspondence.

#### 8.2.4 Information Retrieval from the Correspondence Register

The information from the correspondence register can be abstracted and filtered from the fields of the query sheet which is designed to allow user to specify any filtrating

condition. It allows a great flexibility and virtually unlimited combination of conditional filtrations. A sample of the query sheet is shown in Figure 8.2.4 (a).

Existing Selection Criteria  
C04: All letters from Architect for June 91 by QSE's Wo

Reference St : 0 Len : 0  
Content [=] :

Issue Date From : 01/06/91 To : 30/06/91  
Recev Date From : - - To : - -

From : Party [=]  
To : Party [=] Main Contractor

Type of Correspondence [=] Letter

Status [=] QS' work  
Comment [=]

QS File [=] Engineer File [=]

[F4] to finish select; [Esc] to leave

Figure 8.2.4 (a)  
Input Screen for  
Specifying  
Filtration  
Conditions to  
Abstract  
Correspondence  
Records .

It enables various reports to be prepared from the Sub-system for example:

- \* All the correspondence received/issued last week, last month or any specific period.
- \* All the correspondence with cost effects and replied for a specific period.
- \* All the correspondence from a specific party.
- \* All the previous relevant correspondence regarding the argument on the 'setting out error' as stated in the letter Ref. HYG/154/BHY dated 11th July 1991 etc.

### 8.2.5 Advantages of the Correspondence Register

The advantages of the correspondence register are summarised as follows:

- a) It replaces the manual practice of correspondence register, therefore it should not create extra burden to site management by the use of the Sub-system.
- b) It makes the correspondence registration work easier, since it reduces the typing work by picking up data from pop-up window.

- c) It does not increase much the workload of the site manager or the site staff who has taken up the follow up action for the correspondence. Most information needed, such as headings, effects and responses etc, are already on their mind when they are reading or processing with the correspondence. The Sub-system provides a systematic means by which it allows this crucial information in their mind to be recorded. It is important to note that according to the studies in the industry, the site manager and/or site agent is the one on site with the largest volume of different types of managerial work to deal with. Kodikara (1990) in his study in Sri Lanka also confirmed this situation.
- d) Monthly, biweekly or weekly routine reports can be printed out showing the correspondence received or issued, the following up works, the status and the effects. This will aid the top management on site to have a better understanding on the work progress and the contract status.
- e) The Sub-system can alert the user on any outstanding issues beyond the expired date. The same information can be sent to the contract supervisor for those specific contractual issues under the conditions of contract, such as notice of claim, confirm of verbal instruction, submitted for approval etc.
- f) Ad-hoc enquiry on any specific information can be retrieved through the query sheet. It creates a great flexibility in the preparation of reports to suit different requirements.
- g) It complies the requirements of most quality assurance standard in respect of the traceability of document and information.

### 8.3 Drawing Controller

#### 8.3.1 Requirements for Drawing Control

Drawings are essential to construction projects. It outlines the features, dimensions and location of a construction project. Fryer (1985) said: "In construction there is heavy reliance on graphical and numerical communication, notably

in the form of drawings, diagrams schedules and charts". In UK, the Project Information Group reported to Department of the Environment in 1978 recommending the establishment of Co-ordinating Committee on Project Information (CCPI) . One of the reports from the Committee in 1978 was called "Production Drawings, a code of procedure for building works". The report gives a important reference for the production of drawings.

The contract drawings should be regarded as an important contract document setting out the obligations for the contractor in a construction project. The General Conditions of Contract for the Airport Core Programme Civil Engineering Works 1992 defines "Drawings" means:

"the drawings referred to in the Specification and any modification of such drawings approved in writing by the Engineer and such other drawings as may from time to time be furnished or approved in writing by the Engineer."

Construction projects inevitably may have to involve with design changes which are usually reflected in a form of drawing amendment. Therefore, it is important for the contractor to keep trace those drawing amendments which may affects the original contract obligations in both time and cost. It is known as 'variations', the subsequence of which may induce claims. Furthermore, there is usually an additional responsibility on most main contractors to co-ordinate the drawing issues for nominated subcontracts or specialist subcontracts. Such an obligation will be stated in the preliminary bill or the special conditions of contract with the wordings similar to the following:

"Shop and installation drawings ..... shall be submitted as described in the Specification or as required by the Contract Supervisor....."

To facilitate the function of drawing control in satisfying both contractual obligating and internal management needs, it is the practice of most construction sites to keep a drawing register. Forster (1991) noted that a drawing register should be prepared at the beginning of contract and need to be kept up to date, particularly when drawings are amended or superseded. A drawing register, no matter by manual or by the use of computers, has to serve the following basic purposes:

- a) To record the factual issues of the drawing received or issued including the issue party name, the date of issue, the date of receive, the drawing reference, the drawing title and the drawing nature.
- b) To give a quick reference on the location or party, where the drawing can be found.

With the use of computers, in addition to the above functions, more feasibility and better efficiency should be built in for the following purposes:

- a) To make the task easier in comparison with the original manual procedure .
- b) To increase the feasibility of information retrieval by allowing more different types of output reports.

### 8.3.2 Input for the Drawing Controller

In "CCMS" information control sub-system, the system design of the Drawing Controller is similar to the Correspondence Register by using the pop-up windows for the fields with repetitive nature of data input. The first system operation menu is shown in Figure 8.3.2 (a)

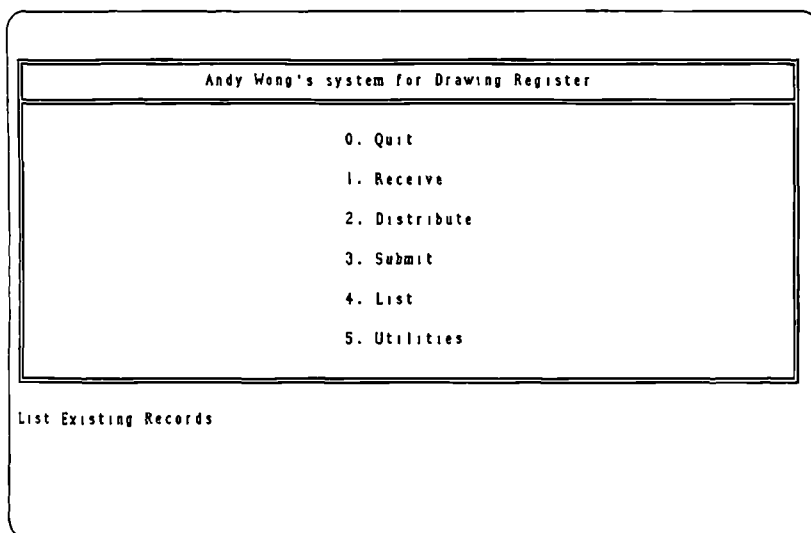


Figure 8.3.2 (a)  
Input Menu for  
Drawing Controls.

As simulating the manual operation of drawing receiving, the first question from the Sub-system is the name of the issue party. The Sub-system allows the user to choice from the pop-up window where the party names are contained. Following the selection of a party name, the second question asked by the Sub-system will be the technical type of drawing, by which it allows different parties to have different types



of drawing. After having specified the above parameters, a list of the previously received drawings can be listed in any specific order. A screen illustration for this operation is shown on Figure 8.3.2 (b).

| Drawing List   |     |                                         |
|----------------|-----|-----------------------------------------|
| Drg No         | Rev | Title (F2) to edit                      |
| STD/HC/A/AS-01 | A   | Finishes Details - Sheet No. 1          |
| STD/HC/A/AS-02 | 0   | Finishes Details - Sheet No. 2          |
| STD/HC/A/CO-10 | 0   | Timber Door Details - Sheet No. 2       |
| STD/HC/A/CO-12 | 0   | Timber Door Details - Sheet No. 4       |
| STD/HC/A/CO-13 | 1   | Aluminium Window Details - Sheet No. 1  |
| STD/HC/A/CO-14 | 1   | Aluminium Window Details - Sheet No. 2. |
| STD/HC/A/CO-15 | 1   | Aluminium Window Details - Sheet No. 3. |

F2-details; F3-save, F5-add, F6-delete, F7-Carry on/off, F8 to sort  
 Technical Drawing Type [=] Architectural Drawings  
 Drawing Issue Party [=] Architect  
 Carry on  
 Press [=] to select : Contractual Types of Drawing

Figure 8.3.2 (b)  
List of Previously  
Received Drawings.

The following attributes of a drawing can be input into the Sub-system:

**Drawing Reference:** Almost all the drawings should have a reference number.

**Drawing Issue Date:** The date of the drawing issue stated in the drawing.

**Drawing Receive Date:** The date of the drawing actually received on site.

**Revision Number:** It is an important reference for the version of the drawing.

**Contractual Nature:** In all cases, it is essential to know the contractual nature of the drawing received such as whether it is an original contract drawing, revised drawing for construction purpose, revised drawing for comments or submission drawing for approval etc.

**Technical Nature:** The technical nature of the drawing should have been selected in the first step as the second parameter to be input for short listing the drawings. Technical natures are such as architectural drawing, structural drawing, electrical drawing or drainage drawing etc.

**Referred Location:** Input the relevant construction locations specified by the drawing such as main building, shopping area and external works etc.

**Covering Reference:** Input the reference of covering correspondence enclosing the drawing. For example if the drawing is the original contract, the covering reference should be the clause number of the relevant specification. If the drawing is a revised drawing, the covering reference should be the architect instruction number or the variation order reference.

**Number of Copy:** Number of copies of the drawing enclosed with the original issue.

**Number of Additional Copy:** Number of copies of the drawing additional requested by the contractor.

**Remark:** A pop-up window will be available for the user to type the remark notes without limitation on characters. This allows any background information or valid data to be recorded, for example the details how the additional copies of the drawing have been acquired.

A sample input screen for the above mentioned information is shown in Figure 8.3.2 (c).

| Drawing List                    |                                | Drawing Details      |          |
|---------------------------------|--------------------------------|----------------------|----------|
| Drawing No                      | [*] STD/HC/A/AS-02             | Rev                  | 0        |
| Drawing Issue Date              | 01-03-92                       | Drawing Receive Date | 01-05-92 |
| Title                           | Finishes Details - Sheet No. 2 |                      |          |
| Covering Reference              | Particular Specf. Appendix B   | Copies               | 4        |
| Nature                          | [*] Contract Drawings          | Additional           | 0        |
| Location                        | [*] Harmony Blocks             |                      |          |
| Remark                          | [F2] to edit Remark            |                      |          |
| -----                           |                                |                      |          |
| Access to revisions             | F                              |                      |          |
| Access to external distribution | F                              |                      |          |
| Access to internal distribution | F                              |                      |          |

Figure 8.3.2 (c)  
Input Screen for  
the Details of a  
Received Drawing.

### 8.3.3 Control of Revised Drawings

In respect of drawing controls from a view point of the main contractor, a tighter control policy is required as reflected by the industry in view of the increasing complexity of

construction projects and the escalating risks associated with construction contracts. This demand has been proved by the survey in the industry as described in Chapter 3 and the field tests described in Chapter 13. It can be defined that the first revision of the drawing received on site will be called " the base drawing". The functions for controlling revisions, in addition to the functions described above for base drawings, include the control of:

- a) drawing revision ;
- b) drawing distribution ;and
- c) drawing submission.

The details of these functions are described in the following sections

It is the practice of the construction industry to issue revision drawings from time to time for amendments and keep the original attributes of the base drawing unchanged, such as the location to use or the technical nature etc. A sample input screen for drawing revisions is shown in Figure 8.3.3 (a).

The input screen for drawing revisions is divided into several sections:

- Drawing List**: Drawing No. [-] STD/HC/A/AS-02, Rev 0
- Drawing Details**: Drawing Issue Date 01-03-92, Drawing Receive Date 01-05-92, Title Finishes Details - Sheet No. 2
- Covering Reference**: Particular Specf. Appendix B, Copies 4, Additional 0
- Nature**: [-] Contract Drawings
- Revisions Table**:
 

| Revi | Issue    | Receive  | Cover  | Qty | Cost Eff -F2 | Time Eff -F2 |
|------|----------|----------|--------|-----|--------------|--------------|
| 1    | 12-07-92 | 20-07-92 | SI-132 | 4   | Additional f | No time effe |
| 2    | 01-08-92 | 13-08-92 | SI-143 | 4   | To be assess | -            |

At the bottom, there is a prompt: [F3] to save; [F5] to add; [F6] to delete.

Figure 8.3.3 (a)  
Input Screen for  
Drawing Revisions.

The details of each column in the input screen are explained as follow:

**Revision:** The revision number on the drawing.

**Issue Date:** The date of the drawing issue marked on the drawing.

**Receive Date:** The date the drawing physically received on site.

**Coverage:** Input the reference of the covering correspondence enclosing with the drawing. In case for revised drawings, the covering reference usually is the architect instruction number or the variation order reference.

**Number of Copy:** Number of copies of the drawing enclosed with the original issue.

**Number of Additional Copy:** Number of copies of the drawing additional requested by the contractor.

**Contractual Nature:** It is important to check the contractual nature of the revised drawing which may be different to the base drawing or the precedent drawing. For example the last revision 'B' was issued for information but the *next revision 'C' is* the one approved for construction.

**Time Effect:** It is a memo field on a pop-up window and allows the input of the comments on the time effects of this revised drawing to the contract. The information on this field may not be able to be filled in immediately when the drawing is received. But it lays down a procedure to alert the management in respect of the time effects of the revised drawing to the contract.

**Cost Effect:** A similar design as mentioned above, is adopted for the aspect of cost effect.

#### 8.3.4 Control of Drawing Distribution

The distribution of drawing from the main contractor to other parties on site can be divided into two sides as follows:

a) Internal:

To internal management staff such as site agent, site quantity surveyor, site engineer etc.

b) External:

To external parties other than submission to the contract supervisor. Therefore the external parties here may include nominated subcontractors, domestic subcontractors and public utility companies etc.

In view of the management burden of the main contractor on site for co-ordinating and controlling the information to both external and internal parties, it is essential for the site management to have a high efficiency control mechanism for the drawing distribution. "CCMS" information control sub-system has included a function to control drawing distributions.

For internal distribution, A sample input screen for internal drawing distribution is shown in Figure 8.3.4 (a).

**Drawing List**

**Drawing Details**

Drawing No [=] STD/HC/A/AS-02 Rev 0

Drawing Issue Date 01-03-92 Drawing Receive Date 01-05-92

Title Finishes Details - Sheet No. 2

Covering Reference Particular Specf. Appendix B Copies 4

Nature [=] Contract Drawings Additional 0

**Internal Distribution Window**

| Date     | Rev | Copy | Staff [=]         | Remark [F2] to edit           |
|----------|-----|------|-------------------|-------------------------------|
| 18-07-92 | 1   | 1    | Quantity Surveyor |                               |
| 19-07-92 | 1   | 1    | Site Agent        |                               |
| 21-08-92 | 2   | 1    | Quantity Surveyor | Prepare variation submission. |

[F3] to save; [F5] to add; [F6] to delete

Figure 8.3.4 (a)  
Input Screen for  
Internal Drawing  
Distributions.

The details of each column in the input screen are explained as follow:

**Date**: The date of the drawing sent out.

**Revision**: The revision number on the drawing.

**Staff**: Input the identity of the staff to whom the drawing is sent. Pop-up window to select is allowed.

**Number of Copy**: Number of copies of the drawing sent out.

**Remark**: It is a memo field to input for the remark notes of the distribution.

For external distribution, a sample input screen for external drawing distribution is shown in Figure 8.3.4 (b).

|                                           |                                |      |                   |                                |
|-------------------------------------------|--------------------------------|------|-------------------|--------------------------------|
| Drawing List                              |                                |      |                   |                                |
| Drawing Details                           |                                |      |                   |                                |
| Drawing No                                | [=] STD/HC/A/AS-02             |      |                   |                                |
| Rev                                       | 0                              |      |                   |                                |
| Drawing Issue Date                        | 01-03-92                       |      |                   |                                |
| Drawing Receive Date                      | 01-05-92                       |      |                   |                                |
| Title                                     | Finishes Details - Sheet No. 2 |      |                   |                                |
| Covering Reference                        | Particular Specf. Appendix B   |      |                   |                                |
| Copies                                    | 4                              |      |                   |                                |
| Nature                                    | [=] Contract Drawings          |      |                   |                                |
| Additional                                | 0                              |      |                   |                                |
| External Distribution Window              |                                |      |                   |                                |
| Date                                      | Rev                            | Copy | Subcontractor [=] | Remark [F2] to edit            |
| 21-07-92                                  | 1                              | 3    | Chuen Lee         | Mr. Chan came to collect the d |
| 01-09-92                                  | 2                              | 3    | Chuen Lee         | Sent with covering memo AK-27. |
| [F3] to save; [F5] to add; [F6] to delete |                                |      |                   |                                |

Figure 8.3.4 (b)  
Input Screen for  
External Drawing  
Distributions.

The details of each column in the input screen are explained as follows:

**Date:** The date of the drawing sent out.

**Revision:** The revision number on the drawing.

**Subcontractor Name:** Input the identity of the subcontractor to whom the drawing is sent. Using pop-up window to select is allowed.

Number of Copy: Number of copies of the drawing sent out.

**Remark:** It is a memo field to input for the remark notes of the distribution.

In case for external distributions, a corresponding transmittal can be printout from the Sub-system on enquiry to cover the drawing distribution. This will save up the manual procedure for filling in and typing the transmittals. A sample printout of distribution transmittals is shown in Figure A of Appendix 8.

### 8.3.5 Control of Drawing Submission

Most construction contracts for complex and capital intensive projects, will impose heavy duties and tight control procedures for the main contractor to deal with drawing submissions which usually are part of the obligations under both the main contract and the nominated subcontracts. Under

the preliminary or the conditions of contract, it will state a specific time limits and the procedures for drawing submission.

In accordance with Clause 7. (1) (a) of General Condition of Contract for the Airport Core Programme Civil Engineering Works 1992 edition, it states:

"When the Contractor is required to provide drawings or other documents in connection with the Works ..... should be submitted to Engineer in accordance with any schedule for release of information agreed with the Engineer or otherwise as reasonably required in writing by the Engineer or at a reasonable time before the work shown or described thereon is to be carried out as to permit the Engineer..... sufficient time to examine the drawings or other documents properly"

Clause 7 (3) of the same standard form states:

"Within 14 days of notification of the Engineer' approval or consent under Clause 7 (1)(b), the Contractor shall provide the Engineer with the type and numbers of sets of the relevant drawings or documents as stipulated by Clause 7 (1)(a).

In respect of the design obligations of nominated subcontracts, it is also the contractual obligations of the main contractor to take up the co-ordination duty in respect of information submission. The contract terms used to govern this aspect may be as follows (example from Clause 6.10 under the Bill No 1 Preliminaries from Hong Kong Baptist College Sports Centre):

"The Main Contractor shall be responsible for preparing or obtaining all shop drawings, 'as built' drawings .....etc., called for either under the Main Contract or Nominated Subcontracts and for handing them to the Architect."

The whole submission procedure should include the return and feedback from the contract supervisor in respect of the submission. The return and feedback from the contract supervisor for the drawing submitted should be treated as an updating of submission, rather than treating it as a drawing received. By this approach, the whole historical background of the drawing submission can be kept. It is

important to maintain such information, by which the liability of faults if any can be traced in case of involving disputes or contractual claims.

"CCMS" information control sub-system includes a function for monitoring drawing submissions. It allows the drawing submissions to be clearly classified as shown in Figure 8.3.5 (a).

| Type Name            | To Parties |
|----------------------|------------|
| ABSE/C3              |            |
| Architect            |            |
| BSE                  |            |
| Landscape Consultant |            |
| Structure Engineer   |            |
| Waden                |            |

[F5] to Add; [F6] to delete; [F4] to

Technical Drawing Type [=] Electrical

Submit from Party [=] Waden

Submit to Party [=] "

Press [=] to select : from the Party List

Figure 8.3.5 (a)  
Input Screen for  
Classifying  
Drawing  
Submissions.

As simulating the manual operation of drawing submission, the first question from the Sub-system is the technical drawing types and then following that the Sub-system will ask the name of the submitter and the name of the receiver. For example in case there is a submission of the fire service sprinkler layout design to the Building Services Engineer for approval. The submitter will be the fire services nominated subcontractor and the receiver will be the Building Services Engineer. According to the contract, this kind of submission has to go through and acknowledged by the main contractor. The Sub-system allows the user to choice from the pop-up window where the identities are contained. After having specified the above parameters, a list of the previous drawing can be listed and sorted based on any specific order. A screen illustration for this operation is shown in Figure 8.3.5 (b).



| Drawing List |     |                                               |
|--------------|-----|-----------------------------------------------|
| Drg No       | Rev | Title [F2] to edit                            |
| TY2-E-003 B  | 0   | Cable Pit for External Area for Blk 8 & 9, SS |
| TY2-E-005 B  | 0   | 4/F Electrical Layout Plan (each of the two   |
| TY2-E-009 C  | 0   | G/F Public Lighting Builder's Work & Conduit  |

[F2] to details; [F3] to save, [F5] to add, [F6] to delete

Technical Drawing Type [=] Electrical

Submit from Party [=] Waden  
Submit to Party [=] ABSE/C3

Press [=] to select : from the Party List

Figure 8.3.5 (b)  
List of Previously  
Submitted  
Drawings.

After having selected a specific drawing from the list, the details of such drawing will be popped up with the attributes similar to the input for drawings received. The following additional attributes for drawings submission are highlighted as follows:

**Revision Number**: It is an important reference for the version of the drawing.

**Submit Date**: The date of the drawing issue stated in the drawing.

**Status**: Input the status of this drawing submission. It allows the user to select from the pop-up window. The common phrases of drawing submission status are such as submit for approval, submit for information, approved and disapproval etc.

**Coverage**: Input the reference of covering correspondence enclosing with the drawing for submission. In another word, it is the reference of the submission transmittal.

**Number of Copy**: Number of copies of the drawing enclosed with the original issue.

**Time Effect**: It is a memo field on a pop-up window and allows the input of the comments on the time effects to the contract due to the submission or the feedback from the contract supervisor regarding the submission. The information for this field should be contributed partly from the nominated

subcontractors because they should have the first hand information and the expertise on the status of their own subcontract works.

**Cost Effect:** A similar design as mentioned above, is adopted for the aspect of cost effect.

A sample input screen for the above mentioned information is shown in Figure 8.3.5 (c).

| Drawing List       |                                                     |                 |                      |        |               |          |
|--------------------|-----------------------------------------------------|-----------------|----------------------|--------|---------------|----------|
| Drawing Details    |                                                     |                 |                      |        |               |          |
| Drawing No         | [=]                                                 | TY2-E-009 C     | Rev                  | 0      |               |          |
| Drawing Issue Date |                                                     | 01-03-92        | Drawing Receive Date |        | 12-03-92      |          |
| Title              | G/F Public Lighting Builder's Work & Conduit Route. |                 |                      |        |               |          |
| Covering Reference | CSCEC/TYE2/F(1a)/078                                |                 |                      | Copies | 0             |          |
| Nature             | [=]                                                 | Design Drawings | Additional           | 0      |               |          |
| Submissions        |                                                     |                 |                      |        |               |          |
| Rev                | Date                                                | Status [=]      | Reference            | Qty    | Cost Eff -F2  | Time Eff |
| 1                  | 26-05-92                                            | for Approval    | 059                  | 1      | Add HK\$ 300, |          |
| 1                  | 01-08-92                                            | Approved        | SI-347               | 1      |               |          |

[F3] to save; [F5] to add; [F6] to delete

Figure 8.3.5 (c)  
Input Screen for  
the Details of a  
Submitted Drawing.

A drawing transmittal can be printout from the Sub-system upon enquiry to cover the drawing submission. This will save up the manual procedure for filling in and typing the transmittals. A sample drawing transmittal for submission is shown in Figure B of Appendix 8.

### 8.3.6 Information Retrieval from the Drawing Controller

The information from the Drawing Controller can be abstracted from the fields of the query sheet which is used to allow user to specify any filtrating condition. A sample of the use of the query sheet is shown on Figure 8.3.6 (a).

Existing Selection Criteria  
01:For all P2 drawing

|             |        |         |
|-------------|--------|---------|
| Reference   | St : 5 | Len : 2 |
| Content [=] | P2     |         |

Issue Date From : - - To : - -  
 Recev Date From : - - To : - -

From : Party [=] Architect  
 To : Party [=]

Technical Type [=] Architectural Drawings

Contractual Type [=] Contract Drawings

Location Affected [=] \_

[F4] to finish select; [Esc] to leave

Figure 8.3.6 (a)  
Input Screen for  
Specifying  
Filtration  
Conditions to  
Abstract Drawing  
Records.

It enables the various reports to be prepared from the Sub-system for example:

- \* All the drawings regarding the drainage of the main building received last week, last month or any specific period.
- \* All the drawings for the electrical installation with cost effects.
- \* All the drawings from a specific party for a particular location.
- \* All the contract drawings for the external works.
- \* All the drawings submitted and waiting for approval.
- \* All the drawings handed over to a particular subcontractor so far from beginning of the contract etc.

### 8.3.7 Advantages of the Drawing Controller

The advantages of the Drawing Controller are summarised as follows:

- a) It replaces the manual practice of drawing register, therefore it should not create extra burden to site management by the use of the Sub-system.
- b) It makes the drawing registration work easier, since it reduces the typing work by picking up data from the pop-up windows.

- c) It maintains a checking up procedure to alert the management on the effects of drawing amendments. It is the tendency of most standard forms of contract imposing time limits to qualify the contractor's eligibility to claim. Early awareness of the effects of the revised drawing definitely should aid for the efficiency of the contractor's contract management.
- d) With a higher efficiency of drawing control for both nominated and domestic subcontracts, it enable a better control on the performance of the nominated and domestic subcontracts.
- e) It can provide a summary list for the drawings which are still waiting for further actions from the contract supervisor. Carter (1987) pointed out that the site information system was not only used to monitor the performance of building works but was also used to monitor the performance of the architects.
- f) Monthly, biweekly or weekly routine reports can be printed out showing the drawing received or issued, the status and effects etc. This will aid the top management on site to have a better understanding on the work progress.
- g) Ad-hoc enquiry on any specific information can be retrieved through the query sheet. It creates a great flexibility in the preparation of reports for different requirements.
- h) It complies the requirements of most quality assurance standards in respect of the traceability of document and information.

## **8.4 Instruction Register**

### **8.4.1 Requirements for Instruction Register**

Under most standard forms of contract, the instructions from the contract supervisor is a format contractual document addressing the orders, intentions and requirement of the contract supervisor.

Hibberd (1986) pointed out that when even instructions are issued they should, as a general rule in the majority of standard form of contract, be given in writing because this is a simple and straightforward way of ensuring that there is a record.

In accordance with Clause 15 (2) (a) of General Condition of Contract for the Airport Core Programme Civil Engineering Works 1992 edition, it states:

"..... the Contractor shall take instructions only from the Engineer, and shall comply with and adhere strictly to the Engineer's instruction on any matter related to the Contract whether mentioned in the Contract or not."

In fact 'instruction' is also a type of correspondence, therefore requirements on correspondence register should also apply to it. But instructions should be more emphatic on the following aspects:

- a) Recording the effects of the instruction;
- b) Showing the relevant enclosures attached with the instruction;
- c) Aiding the preparation of responsive works to the instruction; and
- d) Aiding a quick assessment on the overall status of the instructions.

#### **8.4.2 Input for the Instruction Register**

As simulating the manual operation of instruction receiving, the initial identity will be to know the type of the instruction issued. The first question from the Sub-system is the type of instruction. The Sub-system allows the user to choice from the window where the instruction types are contained. For some complicated projects, there may have different types of instructions from different contract supervisors such as architect instructions, structural engineer instructions and building service engineer instructions etc. Following the selection of the instruction type, a list of the previous instruction can be listed and sorted according to any specific order. A screen illustration for this operation is shown in Figure 8.4.2 (a).

| Instruction List |          |                                |              |               |
|------------------|----------|--------------------------------|--------------|---------------|
| Ref              | Date     | Description [F2] to edit       | Est Cost Eff | Cert Cost Eff |
| AI-01            | 07-07-91 | Update the setting out plan.   | \$0.00       | \$0.00        |
| AI-02            | 10-08-91 | Enclosed the revised door sche | \$3,000.00   | \$3,000.00    |
| AI-03            | 10-10-91 | Additional Details for Roof In | \$30,000.00  | \$20,000.00   |
| AI-09            | 01-12-91 | Revise Painting Color for Exte | \$150,000.00 | \$0.00        |
| AI-10            | 23-01-91 | Additional Alu. Windows for Sh | \$245,200.00 | \$234,573.00  |

[F2] to detail; [F3] to save; [F5] to add; [F6] to delete; [F9] to sum  
 Input Instruction Type Architect  
 Press [=] to select from the list window

Figure 8.4.2 (a)  
List of Previously  
Received  
Instructions.

The following attributes of an instruction can be input into the Sub-system:

**Reference No:** In most cases, there should have an independent reference number for each instruction.

**Date:** The date of the instruction issue marked on the instruction.

**Description:** The heading or a brief description for the instruction.

**Location:** Input the construction locations to be affected by the instruction.

**Estimated Amount:** The total corresponding estimated omission to the contract value and the total corresponding estimated addition to the contract value.

**Certified Amount:** The total corresponding certified omission to the contract value and the total corresponding certified addition to the contract value.

**Remark:** It allows the user to input any remark notes.

**Access to Attachment:** It allows the input of the details for the attachment enclosing with the instruction. In most likely cases, the attachment will be drawings. This function is integrated with the Drawing Register. That means any input here can be accessed in the drawing revision function of the Drawing Register.

**Access to Break Down Costs:** It allows the user to access and store the break down details for the valuation of the instruction.

A sample input screen for the above mentioned information is shown in Figure 8.4.2 (b).

Instruction List  
Detail of Instruction Ref : AI-02

Reference AI-02 Date 10-08-91

Description Enclosed the revised door schedules A-13 to A-14.

| Estimated |             | Certified |            |
|-----------|-------------|-----------|------------|
| Addition  | \$6,000.00  | Addition  | \$3,000.00 |
| Omission  | \$-3,000.00 | Omission  | \$0.00     |
| -----     |             | -----     |            |
| Net       | \$3,000.00  | Net       | \$3,000.00 |

Location [=] Domestic Blocks

Remark Subject to the quotation from the subcontractor Ref. 4234\_

-----

Access to attached information F  
Access to item break down cost F

[F3] to save; [Esc] to leave

Figure 8.4.2 (b)  
Input Screen for  
the Details of an  
Received  
Instruction.

#### 8.4.3 Information Retrieval from the Instruction Register

The records from the Instruction Controller can be abstracted or filtered from any field of the query sheet which is designed to allow user to specify any tailor-made filtrating condition similar to the format of correspondence and drawing retrievals. A significant function of the instruction register is its rapid updating of total financial commitment and status involved in the issued instructions. A screen sample of total financial involvement summed up from the issued instructions is shown in Figure 8.4.3 (a).

Instruction List  
Calculated

Press any key to continue ...

There are totally 5 instruction(s)

| Total Estimated |              |
|-----------------|--------------|
| Addition        | \$431,200.00 |
| Omission        | \$-3,000.00  |
| Net             | \$428,200.00 |

| Total Certified |              |
|-----------------|--------------|
| Addition        | \$257,573.00 |
| Omission        | \$0.00       |
| Net             | \$257,573.00 |

Figure 8.4.3 (a)  
Summing up  
Financial  
Commitments  
involved in the  
issued  
instructions.

It enables various reports to be prepared from the Sub-system for example:

- \* a list of the received instructions subject to the choice of the following criteria:
  - instruction type
  - specific period
  - location
- \* an updated financial status of the instructions received.
- \* the attached information with the selected instructions etc.

#### 8.4.4 Advantages of the Instruction Register

The advantages of the Instruction Controller are summarised as follows:

- a) It replaces the manual practice of instruction register, therefore it should not create extra burden to site management by the use of the Sub-system.
- b) It makes the instruction registration work easier, since it reduces the typing work by picking up data from the pop-up windows and provides word processing functions for the necessary typing
- c) It can promptly prepare reports showing the financial status of the instructions. This helps the site quantity surveyor incorporate the financial status of the instructions into the monthly interimpayment application and aid to improve the cash flow of contract .



- d) Monthly, biweekly or weekly routine reports can be printed out showing the instruction received and the effects. This will aid the top management on site to have a better understanding of the work status.
- e) Ad-hoc enquiry on any specific information can be retrieved through the query sheet. It creates a great flexibility in the preparation of reports for different requirements.
- f) It complies with the requirements of most quality assurance standards in respect of the traceability of documents and information.

## **8.5 Contractual Claim Register**

### **8.5.1 Requirements for Claim Register**

The dictionary definition of 'claim' means 'to demand something as due'. JCT Contract Conditions 1980 under Clauses 13, 25 and 26 explains the term claim as:

"a written application for additional payment or time as a result of any loss and/or expenses in the execution of the contract or as a result of any reference to delay the progress of the work".

Under Clause 69 and 70 of General Conditions of Contract for the Airport Core Programme Civil Engineering Works 1992 Edition, the control procedures are stated in respect of the notice of claim and the maintenance of claim records. Those procedures and its influences have been described in the Chapter 4 of this thesis.

Most existing standard forms of contract put a heavy burden on the notice and initiation of claim into the main contractor. The timing of the notice and the on-account information inherent to the claim, become more significant for determining the success or failure of a claim. Therefore it is important to have a mechanism by which management is able to constantly review the status of claims. A claims register to serve this purpose becomes essential.

Any claim register should be able to provide the following functions:

- a) to record the basic parameters of claim such as the claim reference number, the first submit date, the clause number in the conditions of contract on which the claim is based, the brief description, the claim type, the on account quantum submitted, the on account quantum granted and settled date if any.
- b) to record the costs, expenditures and resources engaged in the claim.
- c) to reflect the status on the claims submitted.

### 8.5.2 Input for the Claim Register

"CCMS" information control sub-system includes a function of claim register, a screen operation of which is shown in Figure 8.5.2 (a).

Claim List

Detail of Instruction Ref : Claim 2

Reference Claim 2

Submit Date 01-05-92  
Settle Date - -

Description Extra Cost due to the Suspension of the  
Excavation for Foundation CL01

| Estimated |              | Certified |        |
|-----------|--------------|-----------|--------|
| Addition  | \$300,000.00 | Addition  | \$0.00 |
| Omission  | \$0.00       | Omission  | \$0.00 |
| <hr/>     |              | <hr/>     |        |
| Net       | \$300,000.00 | Net       | \$0.00 |

Extension of Time Claimed 15.00 day(s)  
Extension of Time Granted 0.00 day(s)

Remark The case has been referred to the Consultant CMS.

-----

Access to supporting information F

[F3] to save; [Esc] to leave

Figure 8.5.2 (a)  
Input Screen for  
the Details of a  
Claim.

The following attributes of a claim can be input into the Sub-system:

**Claim Reference:** According to the study in the construction industry, it will be a good practice for all the claims initiated from the main contractor to be assigned an independent reference.

**Submit Date:** The date of the claim submission.

**Settle Date:** The date of the claim settlement.

**Type of Claim:** Access to the pop-up windows containing the type of claims for selection such as extension of time and loss and/or expenses etc.

**Contract Clauses**: Clause number in the conditions of contract on which the claim is based.

**Submitted Amount**: The total on-account submitted omission to the contract value and the total on-account submitted addition to the contract value.

**Granted Amount**: The total on-account granted omission to the contract value and the total on-account granted addition to the contract value.

**Submitted Extension of Time**: On-account extension of time claim submitted.

**Granted Extension of Time**: On-account extension of time granted.

**Remark**: It allows the user to input any remark notes.

**Access to Relevant Correspondence**: It allows the user to input and access the reference of the documents relating to this claim, and is integrated with the Correspondence Register and the Instruction Register.

**Access to Quantum Assessment**: It allows the user to input and access the quantum associated with the claims. The function used to record the quantum relating to a claim, includes the following parameters:

- a The date of the assessment;
- b The quantity (a figure);
- c The unit (sum or day); and
- d The substantiation (a memo field).

### 8.5.3 Information Retrieval from the Claim Register

The information retrieval from the Claim Register is comparatively simple than the other information control functions such as Correspondence Register, Drawing Register and Instruction Register etc. Basically, there are two types of reports associated with the Claim Register as follows:

- a) to list the claim heads with basic parameters showing the overall status of the claims submitted and/or settled in respect of the contract timing and the contract value.
- b) to show the details of each individual claim including the list of relevant correspondence and the break down of assessment for quantum claimed.

In view of the confidentiality of claims involving, there has a separated password to control and limit the users accessing to the Claim Register.

#### **8.5.4 Advantages of the Claim Register**

The advantages of the Instruction Controller are summarised as follows:

- a) It replaces the manual practice of claim register, therefore it should not create extra burden to site management by the use of the Sub-system.
- b) It makes the claim registration work easier, since it reduces the typing work by picking up data from the pop-up windows and provides word processing functions for the necessary typing.
- c) It provides the functions to integrate the relevant information and data to the claim, by which the overall picture of the claim can be grasped.
- d) It provides the overall information of the claim status of a project to enable the management to constantly review and monitor the claim achievement.

### **8.6 Handling of Minutes of Meetings**

#### **8.6.1 Significant of Minutes of Meetings**

According to the study in the construction industry as described in Chapter 3, one of the essential management procedures of site manager is to chair meetings. Due to the increasing complexity of construction projects, inevitably the co-ordinating duty of main contractor will be very intense. In normal circumstances, the routine meeting of a construction project on site may be as follows:

- a) Monthly progress meeting with the contract supervisor, attending by all the key parties of both the main contractor and contract supervisor.
- b) Monthly nominated subcontract co-ordination meeting, attending by the project management staff of the main contractor, the nominator subcontractors and the contract supervisor.

- c) Monthly public utilities co-ordination meeting, attending by the project management staff of the main contractor, the public utility companies and the contract supervisor.
- d) Bi-weekly progress monitoring meeting for main contract, attending by the site sectional management staff of the main contractor and the site contract supervision staff of the contract supervisor.
- e) Bi-weekly internal management meeting, attending by the site management staff of the main contractor).
- f) Weekly or biweekly domestic subcontractor meeting. It depends on the progress status to decide whether it will be weekly or biweekly. The meeting will be between the sectional management staff of the main contractor and the corresponding trade subcontractors.
- g) Ad-hoc meeting depending on the circumstances etc.

To record the matters and issues discussed in the meeting, has to rely on the minutes of meeting. Abrahamson (1979) advised that meetings provided a means of raising and recording facts and disagreements on programs and method statements, and it was therefore very important to ensure that minutes reflected accurately all what had been discussed. Powell-Smith and Sims (1983) recommended that parties should check the minutes of meeting carefully and challenge any inaccuracies and ambiguities and ensured that the relevant corrections were recorded both in correspondence and in the record of the next meeting.

#### **8.6.2 Input for the Minutes of Meeting Handler**

By manual practice, a minutes of meeting register will be used similar to a correspondence register to record the minutes of meeting as a correspondence. In most construction sites, the use of computers to handle minutes of meeting is for word processing.

"CCMS" information control sub-system includes a functions to handle the minutes of meeting, not just as the functions provided by normal correspondence register. But it is vitally to record the commitments recorded in the minutes and enables a routine checking by the Sub-system on the status of those commitments input into the Sub-system.

The screen menu for the input of minutes of meeting is shown in Figure 8.6.2 (a).

Meeting List  
Details of the Meeting Ref : WPM001

Reference WPM001                      Date of Meeting 27-06-92

Description No 8 - Bi Weekly Progress Monitoring Meeting.

Venue of the Meeting [=] RE Site Office

| Item | Committed Party | Commitment [F2]                | Location/Trade [=] |
|------|-----------------|--------------------------------|--------------------|
| 1    | Hawaii Eng.     | Rectification of defective pla | SS Joiner Fixing   |
| 2    | Hong's Decorati | Furniture frame fixing at S/F. | SS Joiner Fixing   |

[F3] to save; [F5] to add; [F6] to delete

Figure 8.6.2 (a)  
Input Screen for  
the Details of a  
Minute of Meeting.

The first input requested by the Sub-system is the type of meeting, by which the user is allowed to select from the pop-up window library. The following attributes of a minutes of meeting can be input into the Sub-system:

**Reference No:** It will be a good practice to assign an individual reference number for each meeting. The meeting type abbreviations together with the number of meeting can made an unique reference number for each minutes.

**Date of the Meeting:** The date when the meeting was held.

**Title:** Input the meeting heading including the title of the meeting and the number of the meeting if any.

**Venue:** The place where the meeting was held.

**Remark:** It is a memo field and usually the name of the parties attended the meeting will be recorded. In case the meeting was an ad-hoc meeting, the background of the meeting would be recorded in this remark field.

**Access to Commitment:** It is used to record the commitments agreed in the meeting and subsequently the same is recorded in the minutes. The following attributes will be input:

- a) Committed party name;
- b) Commitment details;
- c) Affected location and trade;
- d) Promised completion date;
- e) Actual completion date;
- f) Completion remark.

It is not the design of this function to let the site manager do the input of the minute of meeting. According to the field test as described in Chapter 13, it will be appropriate in terms of operation to let the site manager after having read the minutes highlight those significant commitments in respect of the party name, the promised completion date, the affected location and the trade. The marked minutes will then be passed to a junior staff for input into the computer. The other information such as the meeting date, the meeting title etc. are self-explanatory in the minutes.

### 8.6.3 Information Retrieval from the Minutes of Meeting Handler

It allows the user to list and access the reports based on the types of meeting selected from the pop-up window upon enquiry. The main information and usage from the Minutes of Meeting Handler is to control and monitor those commitments recorded in the minutes. The Sub-system allows the user to input conditions for retrieving comments stated in the minutes of meetings based on the query sheet shown in Figure 8.6.3 (a).

```

A01 E/M Progress Meeting for the Month April 1992

Woon Lee 01-05-92 Provide shop drawing for Transformer Room Door

Select committed party Woon Lee
Select committed location/trade DB Shopping
For the period from - - to - -
Show for non-completed job only F

```

Figure 8.6.3 (a)  
Input Screen for  
Specifying  
Filtration  
Conditions to  
Abstract  
Commitments  
Recorded in the  
Minutes of  
Meetings.

The reports can be prepared based on the selection of the following criteria such as:

- \* Committed Party Name;
- \* Location / Trade;
- \* Checking Period from Date to Date.

A sample report is shown on Figure C of Appendix 8.

The reports should be used as part of the site routine management reports to be reviewed in the internal management meetings with other management information reports in respect of daily correspondence, drawings, instructions and claims.

#### **8.6.4 Advantages of the Minutes of Meeting Handler**

Unlike the other functions in the same Sub-system, the Minutes of Meeting Handler adopts the practice which is not common on site as a day to day routine job. But it helps better organising the information which in before should be relying on memory. The concept of this function is come from the awareness of the co-ordination burdens on the main contractors due to the increasing complicated construction projects at present.

In view of the operation of this function, the price in terms of management efforts or staff hours for getting such commitment information is inexpensive. The time spent for the senior management on site, is just to highlight those significant commitments recorded in the minutes by a colour pen while they are reading it. Once this practice of handling the minutes of meeting has been established, it will enable a smooth flow of the useful information from the Sub-system.

#### **8.7 Handling of Specific Purposes Document**

According to the classification of documents handling on site as described in Section 8.1, specific purpose documents can be defined as the documents with an unified specific purpose recognized by the contract such as interim payment certificate, sample submission, master programme, method statements and daily reports etc. These can be regarded as key documents for the management of construction projects. It is well recognized in both professional and academic for the information control of construction management that for handling key documents a comprehensive recording system is essential.

The Sub-system provides a provision to handle the documents of a construction project. The type of key document is subject to be specified by the user. In the handling of a specific document, the first question from the Sub-system is the name of document type. The System allows the user to choice from the window where the names of document types are contained.



The document names in the window library can be built up from script that means the library will be growth up in line with the construction progress because more document types will have involved in the project. Following the selection of document type, a list of the previous involved specific purpose document will be listed. A sample input screen illustrating this operation is shown on Figure 8.7 (a).

Specify Document Types [=] E&M Co-ordination Programme

Document Details : E&M Co-ordination Programme

| Doc Ref | Date     | Document Name                  | From Party [=] |
|---------|----------|--------------------------------|----------------|
| DE-120  | 01-02-91 | Fire Services Co-ordination Pr | Architect      |
| DE-130  | 02-03-92 | Electrical Installation Co-ord | Architect      |
| DE-210  | 05-06-92 | Fire Services Co-ordination Pr | Architect      |

[F3] to save; [F5] to add; [F6] to delete

Figure 8.7 (a)  
Input Schedule for  
Specific Documents

The following attributes of a specific document can be input into the Sub-system:

**Reference**: An independent reference number for each specific No document.

**Document Description**: The description of document.

**From**: Input the name of document issue party.

**To**: Input the name of document receive party.

**Copies**: Number of copies.

**Purpose**: The purpose of document issue can be specified through the standard phraseology contained in a pop-up window.

**Remark**: A pop-up window will be available for the user to type the remark notes without limitation on characters. This allows any background information or valid data to be recorded.

Similar to the advantages of the Sub-system provisions described in the above sections of this chapter, the function of handling specific purpose documents provides a facility to better control the key information in the management of construction project.

### 8.8 Updating the Contract Reviews

It is an updating of the information passed from the 'CCMS' estimating and tendering sub-system as described in Section 7.5.2. The information contained in the contract review provision should have been initiated at the tendering stage and the same information could then be passed to this information control sub-system in an electronic file format or through telecommunication system. The 'CCMS' quality assurance sub-system as described in Chapter 12 includes a function to monitor the data of contract review for each project in order to fulfil the contract review requirements of ISO 9002. The information flow among these sub-systems is shown in Figure 12.5 (a) of Chapter 12 of this thesis. The contract review parameters includes:

- a) Contract parameters;
- b) Design liabilities;
- c) Nominated subcontracts;
- d) Domestic subcontracts;
- e) Construction works;
- f) Internal management needs; and
- g) Special requirements.

The input screen for accessing to these information is shown in Figure 8.8 (a).

Update Contract Review Data

- 1- Contract Parameters
- 2- Design Liabilities
- 3- Nominated Subcontracts
- 4- Construction Works
- 5- Domestic Subcontracts
- 6- Internal Management Needs
- 7- Special Requirements

---

Contract Parameters and Details

| Seq | Description                   | Planned        | Actual    | Remark   |
|-----|-------------------------------|----------------|-----------|----------|
| 00  | BASE MONTH for fluctuation pr | 04/90          |           |          |
| 01  | Contract Start Date           | 01 Jan 92      | 01 Feb 92 | Submitte |
| 02  | Contract Sum                  | 2.5 million    |           |          |
| 03  | Contract Completion Date      | 365 days       |           |          |
| 04  | Liquidatd Damage              | 10,000 per day |           |          |
| 05  | Mini Interim Payment          | 200,000        |           |          |

[F3] to save; [F5] to add; [F6] to delete

Figure 8.8 (a)  
Input Screen for  
Accessing to the  
Contract Review  
Parameters.

The contract review information should be updated in line with progress of the project. The updating of these information, provides a mechanism for the top management to control and monitor the status of the project.

### 8.9 Summary of the Aids to Information Control

The system design of "CCMS" information control sub-system has taken into account the recommendations of previous research and the findings from the study in Hong Kong construction industry. In summary, its contributions to information control on site are as follows:

- a) Most functions in the Sub-system are used to replace the manual practices of information control on site, which will have been done even without the use of computers. Therefore it should not create much extra burden to site management to use the Sub-system.
- b) The use of pop-up window technique for data selection in the system, should make the tasks easier, since it reduces the need of typing and remembering codes. Even in case typing is necessary, but with the use of word possessing functions in the system it should make the work easier.
- c) The Sub-system provides systematic procedures to help the organising, storing and monitor those fragmentary but significant information which in before is relied on the memory of site management staff and is easy to be lost by memory fade. The aggregate effects of those fragmentary information, will have a great influence on the efficiency of site management. For example early awareness to the effects of revised drawings, chasing up of outstanding information in time, promptly confirming the information supplied to other parties etc.
- d) The routine reports form the Sub-system showing the status of the information flow in terms of the nature of the correspondence received, the outstanding issues for the site management to respond, the status of the claims, the commitments in the minutes of meeting, the effects of the instruction and the status of the drawing submissions etc, aid the site management as well as the top management at the head office to assess and be aware of the performance of the site. In fact, those reports mostly are the by-product of the daily management tasks on site.

- e) The routine reports from the Sub-system showing the outstanding information from the contract supervisor, not only provides a good defence of the contract performance due to the late information from the contract supervisor, but also give a useful reference to aid the contract administration job of the contract supervisor. This evolves the concept of using the contractor's information to monitor the performance of contract supervisor as pointed out by Carter (1987).
- f) The Sub-system can be considered as part of the quality assurance system in respect of document control, contract review and part of processing control.

## 9 Materials Control Sub-system

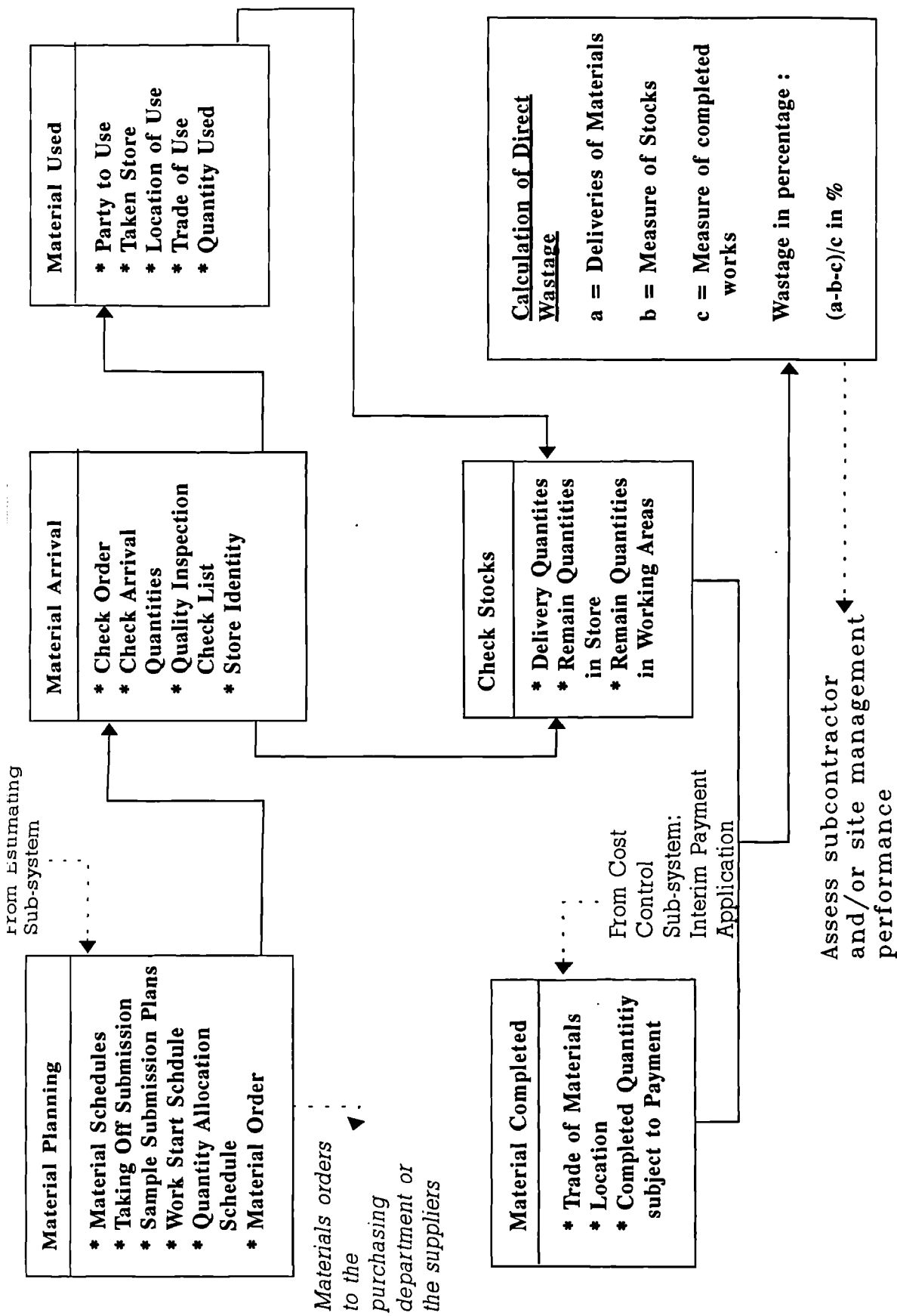
### 9.1 Principle of Materials Control Sub-system Design

The model of construction management described in Chapter 6 includes a management function for materials purchasing. The purpose of materials purchasing in this aspect is to provide a management function of materials procurement for construction projects. As pointed out in Section 6.5.1, materials management as a management concept comprises two main management functions: purchasing and site control. The management function of materials control on site should be regarded as part of the site management practice, of which the management tasks are described in Section 6.8.3. This chapter describes the operational details of 'CCMS' materials control sub-system (also called the Sub-system in this Chapter) used to support both the purchasing and part of the management function of the construction management model described in Chapter 6.

In 1976 the BRE reported that 10-20% of all materials delivered to site either ended up as waste or were illegally removed during the contract. Johnston (1981) confirmed this statistic and deplored the loss to the whole economy due to the material wastage in construction projects. Therefore it is not new for contractors as well as the industry to concern about materials control on site.

Materials control should be regarded as part of materials management. From the management tasks described in Section 6.5.3, it can be seen that once the contract has been confirmed and the work is started on site, most materials management activities are site related. Those site related activities are executive type in terms of control nature, therefore it can be defined as material control.

The Sub-system provides the functions covering most procedures associated with material control on site with the details shown on the management tasks described in Section 6.5.3. In line with the main stream of the system design of "CCMS", the Sub-system is used to provide the functions which firstly should replace and/or increase the efficiency of the current manual practices which should have been done even without the use of computers, and secondly provide the reports that are not provided before. The functional flow chart of the Sub-system is shown in Figure 9.1 (a).



**Figure 9.1 (a)** **'CCMS' Material Control Sub-system Operational Flow Chart**

The main input screen of the Sub-system is shown in Figure 9.1 (b).

```

 Ins

 Material Information Input

 0. Quit
 1. Master Material

 2. Material Arrival
 3. Material in Stock

 4. Material Used
 5. Material Completed

 6. Material Planning

 7. Key Data

 Finishing Materials Arrival

```

Figure 9.1 (b) The Sub-system Main Input Screen.

## 9.2 Requirements of Material Planning

Material planning is a division of materials management in terms of planning and control, which should be viewed as a dynamic activity of site management in parallel with the construction progress. Abdullah (1988) pointed out that the control of material on site must be effected from the inception to the completion of the project as part of any site control system, which meant that any approach of controlling the material must start at the tender stage when the contractor's estimator commenced pricing the bills.

At the tendering stage, "CCMS".estimation sub-system allows the input of material information derived from the tender documents such as drawings, specifications and bills of quantities. The details of this operation are described in Section 7.6.3 of this thesis. At that time, the estimator should input the information marked 'to be initiated by estimator' as shown in the following table to the Estimation Sub-system as described in Section 7.6.3: (Table 9.2 (a) Material Information Initiation Schedule).

| Details                                 | Initiated<br>by whom   | Check/Update<br>by whom                 |
|-----------------------------------------|------------------------|-----------------------------------------|
| Full Description                        | Estimator              | Site Quantity Surveyor                  |
| Total BQ Quantity                       | Estimator              | Site Quantity Surveyor                  |
| Total Measured Quantity                 | Site Quantity Surveyor | Site Quantity Surveyor                  |
| Area per Pack                           | Purchaser              | Site Store Keeper                       |
| Location to Use                         | Estimator              | Site Engineer                           |
| Supplier Details                        | Purchaser              | Site Store keeper                       |
| Manufacturer Details                    | Purchaser              | Site Store Keeper                       |
| Specification/BQ/Drawing<br>Reference   | Estimator              | Site Quantity Surveyor/Site<br>Engineer |
| Estimated Taking Off Completion<br>Date | Site Quantity Surveyor | Site Quantity Surveyor                  |
| Estimated Work Earliest Start<br>Date   | Site Engineer          | Site Engineer                           |
| Inspection Requirements                 | Quality Controller     | Site Quality Control Engineer           |
| Storage Requirements                    | Quality Controller     | Site Quality Control Engineer           |

The above information will be passed from 'CCMS' estimation sub-system to the this material control sub-system. Material planning on site and its updating, involve the principle of reviewing actual status and forecasting future actions from the point of review. Material control should be regarded as a follow up procedure from material planning, based on which remedial or adjustable actions can be taken place by comparing the current targets and the objectives. Material planning should involve the following tasks:

**a) Item identification:**

- identifies any material changes from the issued instructions or the revised drawings.

**b) Quantities:**

- re-measures the quantities from the updated drawings and update the required procurement quantities.
- prepares the quantity allocation schedules for major materials for example in case of high rise buildings such as reinforcement, concrete and tiles per floor.
- shows the quantities arrived, used and kept in store.

**c) Timing:**



- prepares earliest start date schedules showing the dates when the materials are required to enable the start of relevant activities.
- prepares order date schedules showing the dates when the materials should be ordered.
- shows the status of the previous material orders.

**d) Quality:**

- identifies reference in the quality plan under the quality assurance procedures in respect of material inspection, material storage and material handling.
- prepares sample submission schedule showing the date when the sample should be submitted to the contract supervisor.
- shows the status of historical sample submissions.

"CCMS" material control sub-system provides the functions tackling the daily operations of material management on site, which will generate the information needed for material planning. The key report for material planning is the Master Material Procurement Schedule (MMPS) which will be printed out from the Sub-system by integrating the information from other functions of the System. A sample print out of the Master Material Procurement Schedule is shown in Figure (A) of Appendix 9. The details of the functions in the Sub-system are described in the following sections.

**.3 Item Identification and Quantities**

In those construction projects under the traditional procurement system, the items of materials to be used in the project should be contained in the specification and the drawings. The consultant quantity surveyor will use these documents to prepare the bill of quantities, under which at the tendering stage the quantities and items of materials can be identified by the estimator. However, for the contractor's materials procurement, the quantities in the bill of quantities are not guaranteed by the consultant quantity surveyor. It is therefore required by most construction contracts for the contractor to re-measure the quantities from the drawings before placing the material orders. The provision used in the preliminaries or the particular conditions of contract by most typical construction contracts will be as following:

"The Contractor should not order materials or commence work based only on quantities or sizes stated in the Bills without reference to the Drawings and/or site measurement, and the Employer shall not be liable for any expense incurred by the Contractor in connection with incorrect ordering or abortive work caused by the Contractor's failure in this connection".

One of the job duties of site quantity surveyors is to identify the material items and re-measure the quantities from the contract drawings even without any amendments. In response to the revised drawings, re-measurements from the drawings are inevitable.

"CCMS" material control sub-system provides a function to update the items and quantities of materials. In the input screen, the Sub-system will request the user to input the material type, for which it can be selected from the pop-up window library. After that, the items under the same material type will be listed for selection. The sample screens showing this operation are illustrated in Figure 9.3 (a) and Figure 9.3 (b).

Ins

| Material Types   |      |
|------------------|------|
| Type             | Name |
| IRONMONGREY      |      |
| JOINERY          |      |
| MISC             |      |
| PAINT            |      |
| PIPES            |      |
| SANITARY FITTING |      |
| TILES            |      |

[F5]-Add; [F6]-Delete; [F4]-select

Input Material Type => "  
Material Type Press [=] to List

Figure 9.3 (a)  
Pop-up Windows for  
material types.

| Material Type - TILES |                                              |
|-----------------------|----------------------------------------------|
| Mat. Code             | Description [F2] to edit                     |
| IJ-77/s               | Int. Mosaic Tile 18x18x5 mm for S.S. or P.S. |
| IJ-77NT               | Unglazed Step Mosing Tile                    |
| IJ-83/s               | Int. Mosaic Tile 18x18x5mm for S.S. & P.S.   |
| IJ-85/s               | Int. Mosaic Tile 18x18x5mm for S.S. & P.S.   |
| WH/100                | Int. White Glazed Wall Tile 108x108x5 mm     |
| PS/1                  | Cove Base Skirting Tile for Refuse Rooms     |
| R/15                  | Red Quarry Tile - flooring for Refuse Rooms  |
| SO-23/s               | Int. Colour Glazed Ceramic Wall Tile         |
| SP-22                 | Int. Mosaic Tile 18x18x5 mm for S.S. or P.S. |
| SP-24                 | Int. Ceramic Floor Tile 100x100x7 mm         |
| SP-29                 | Int. Mosaic Tile 18x18x5 mm for S.S. or P.S. |
| SP-29NT               | Unglazed Step Mosing Tile                    |
| SP-63NT               | Unglazed Step Mosing Tile                    |
| SP-67                 | Int. Ceramic Floor Tile 100x100x7 mm         |
| ST-EA-RR              | Skirting Tile for Refuse Rooms - External An |
| ST-1A-RR              | Skirting Tile for Refuse Rooms - Internal An |

[F2] to detail; [F3] to save; [F5] to add; [F6] to delete  
 Input Material Type => TILES  
 Material Type Press [=] to List

Figure 9.3 (b)  
List for material  
selected items.

Referring to the new developments in the construction industry of Hong Kong, in respect of PASS system for Housing projects described in Section 4.3 of this thesis. There is a requirement under the Section 7 of the PASS regarding 'Quality Standards for Input Assessment' which is concerned with the site management quality. In Clause 2.3.1 under the Section 7 of PASS, there is an assessment for 'Material Forecast' with the details as follows:

| Grade | Standard                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (A)   | Up to date comprehensive material forecast available, and breakdown of the quantities of all materials available.                                                                                                                                                                                                                                                                                                                                                                               |
| (B)   | Up to date comprehensive material forecast available, but breakdown of the quantities of some materials not available.                                                                                                                                                                                                                                                                                                                                                                          |
| (C)   | Forecast covering only a few trades or forecast not up to date.                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| (D)   | Material forecast unavailable.                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| (NA)  | Not applicable. (No material to be delivered at the completion stage of contract).                                                                                                                                                                                                                                                                                                                                                                                                              |
| Note  | <p>a) Comprehensive forecast means:</p> <p>i) a reasonable and updated forecast to the end of the contract;</p> <p>ii) covering materials for major trades, including domestic subcontractors, NSCs and the main contractor's direct labour, inadequacy or un-availability of which would cause a significant adverse effect to other parties or delay to programme of works.</p> <p>b) Separate Contractors' materials are excluded.</p> <p>c) The forecast shall be reviewed as required.</p> |

The Sub-system can produce a report showing the items and quantities of materials based on the user's discretion for submission to PASS assessment. A sample report for this submission is shown on Figure B of Appendix 9.

#### 9.4 Sample Submissions and Quality Assurance

It is the industry practice for the specification to describe the quality and standard of material to be used in a construction project. The research by BRE (1987) and Bhattacharai (1990) confirmed that traditional specifications frequently failed to specify quality requirements for particular contracts.

In most construction contracts of Hong Kong, the specification together with the conditions of contract allows some flexibility for the contract supervisor to make the final decision on the use of materials. This procedure is called 'sample submission', by which the contractor is required to submit material samples for approval before any material to be used in permanent works. The statements used in the contract under the Preliminaries or Particular Conditions of Contract will be as following:

"Submit samples of materials as may be selected or required by the Architect and do not confirm orders until Approval has been obtained. Keep Approved samples on the site for comparison with materials used in the Works. Where there is a choice of material, colour or texture, samples must be submitted for Approval"

"CCMS" material control sub-system provides a function to control and print out the sample submission form directly. An example of 'sample submission form' used in Housing projects of Hong Kong is shown in Figure (C) of Appendix 9.

A typical sample submission form contains the following key information:

- a) Submission reference;
- b) Submission date;
- c) Material description;
- d) Specification reference;
- e) Drawing reference;
- f) BQ reference;
- g) Location;
- h) Brand name;
- i) Manufacturer;
- j) Source of origin;
- k) Supplier;
- l) Catalogue;
- m) Technical data;
- n) Test report;
- o) Job reference; and
- p) Anticipated date of approval.

In fact, part of the information for sample submission are contained in the master material procurement file which should have been initiated by the Estimation Sub-system and passed to the Material Control Sub-system. The file should also be updated as described in Section 9.3 above. Therefore, by using the Material Control Sub-system to prepare the forms for sample submission, the user has just needed to pick up the material item from the Sub-system by the pop-up windows and fill in part of the above information such as:

- a) Submission reference;
- b) Submission date;
- c) Catalogue;
- d) Technical data;
- e) Test report;
- f) Job reference; and
- g) Anticipated date of approval.

The Sub-system will then record the submission event and print the submission form which can be issued with the site agent's signature. The key data of such a submission will also be reflected in the Master Material Procurement Schedule (MMPS) as described in Section 9.3 for material planning. After the submission, the response from the contract supervisor to the submission should be input into the Sub-system. It should reflect whether the submission is approved or not. If it has been approved, then the date of approval should be input. If it has been disapproved, then the date of disapproval and the reasons of the disapproval should be input. The input screen is illustrated in Figure 9.4 (a). The print out of such a submission form is similar to the form shown in Figure (C) of Appendix 9.

| Sample Submissions for : TILES |               |                                |             |          |    |
|--------------------------------|---------------|--------------------------------|-------------|----------|----|
| Ref                            | Item Code (*) | Item Description [F2] to edit  | Submit Date | App Date |    |
| 122                            | 11-72-W       | Int. Wall Mosaic Tile 50x50x5  | 01-06-90    | 02-07-90 |    |
| 123                            | A-90          | Ext. Wall Mosaic Tile 20x20x4  | 12-06-90    | 05-07-90 |    |
| 216                            | T03           | 100x100x18mm artificial granit | 05-12-91    | 23-12-91 |    |
| 217                            | T02           | 152x152x7 mm non-slip clay qua | 05-12-91    | 05-01-92 |    |
| 227                            | T01           | Impact absorbing tile          | 27-12-91    | 12-01-92 |    |
| 326                            | SO-23/s       | Int. Colour Glazed Ceramic Wal | 01-03-92    | 12-03-92 | Su |
| 328                            | SP-67         | Int. Ceramic Floor Tile 100x10 | 17-03-92    | 10-04-92 |    |
| 340                            | SP-29NT       | Unglazed Step Nosing Tile      | 10-04-92    | 23-04-92 |    |
| 342                            | ST-EA-RR      | Skirting Tile for Refuse Rooms | 12-05-92    | 30-05-92 |    |
| 343                            | ST-1A-RR      | Skirting Tile for Refuse Rooms | 15-07-92    | 23-07-92 | No |
| 353                            | T01           | Impact absorbing tile          | 20-07-92    | 28-07-92 |    |
| 383                            | SP-67         | Int. Ceramic Floor Tile 100x10 | 26-08-92    | 11-09-92 |    |
| 434                            | 11-77NT       | Unglazed Step Nosing Tile      | 30-08-92    | 20-09-92 |    |
| A345                           | A-25/A-40     | Glass mosaic tile for external | 01-11-92    | 15-11-92 | Su |
| A350                           | A-23/A-40     | Ceramic external wall tile     | 01-12-92    | 15-12-92 |    |

[F3] to Save; [F5] to add; [F6] to delete; [F8] to order

List Conditions

Order : Reference Order

Figure 9.4 (a)  
Input Screen for  
Sample  
Submissions.

This function achieves the principle of "CCMS" design which is to aid the site management tasks (in this case it is the submission of the formal sample submission form) and to provide feedback information (in this case it is the record of the sample submission event and its outcomes).

Following the description of PASS for site material management as described in Section 9.3 above, in Clause 4.2.1 under the Section 7 of PASS, there is an assessment for 'Submission of Materials for Approval - Time of Submission' including domestic and nominated subcontractor's submissions and amendment submissions, with the details as follows:

| Grade | Standard                                                                                                 |
|-------|----------------------------------------------------------------------------------------------------------|
| (A)   | Consistently on time for approval.                                                                       |
| (B)   | Instances of submitting later than the scheduled time inadequate time for approval before placing order. |
| (C)   | Instances of submitting after placing order.                                                             |
| (D)   | Instances of submitting extremely late or not submitted together.                                        |
| (NA)  | Not applicable. (No material to be delivered at the completion stage of contract).                       |

Note:- If the time of submission is not specified, assess against contractor's programme or material submission schedule where available; otherwise make judgement as appropriate.

In Clause 4.2.2 under the Section 7 of PASS, there is an assessment for 'Submission of Materials for Approval - Quality of Submission' similar to Clause 4.2.1, with the details as follows:

| Grade | Standard                                                                                                                                        |
|-------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| (A)   | Consistently obtaining approval upon first submission. (No non-compliance unless with justifiable reasons e.g. inadequate information from BQ.) |
| (B)   | Instances of obtaining approval upon second submission.                                                                                         |
| (C)   | Instances of obtaining approval upon third submission.                                                                                          |
| (D)   | Instances of obtaining approval beyond third submission; or not submitted together.                                                             |
| (NA)  | Not applicable. (No material to be delivered at the completion stage of contract).                                                              |

In respect of the above requirements, the printout of material submission forms from the Sub-system as well as the overall management procedures for sample submissions by the use of the System, should give a contribution to the scoring of PASS assessment.

The contribution of "CCMS" material control sub-system for quality assurance is to provide provisions by which the description of the inspection requirements and the storage requirements can be stored. The initial input of such information should be responsible by the head office quality controller through the Estimation Sub-system as part of the job for the preparation of the quality plan. The site quality control engineer should implement those quality assurance procedures recorded in the System accordingly.

### 9.5 Material Scheduling

Thomas et al (1989) presented a quantitative estimate of the work hour losses resulting from ineffective material practices. Their study showed that the investment of US\$ 1,570 in material management would have saved US\$ 8,942 in material-rated quantified disruptions - a benefit/cost ratio of 5.7. It can be seen that material scheduling has a great influence on the progress of construction work.

Material scheduling involves assigning the following dates to the material items based on the master materials list initiated from the Estimation Sub-system:

- a) the earliest start dates - regarding the time when the material is required to enable the relevant activity to be started on site. Those dates should be derived from the updated master programmes by consulting to the planning engineer.
- b) the anticipated material arrival dates - regarding the time when the material should arrive on site. Those dates should be derived by referring to the earliest start dates and taking into account the capacity of stores in connection with the site layouts.
- c) the material order dates - regarding the time when the orders should be put to the suppliers. Those dates should be derived by referring to the anticipated material arrival dates and consulting the relevant material supply agreements if any.
- d) the anticipated material approval dates - regarding the time when the approval from the contract supervisor can be obtained. Those dates should be derived by referring to the material order dates and the specifications regarding the conditions under which the material will be approved.

- e) the sample submission dates - regarding the time when the samples should be submitted to the contract supervisor for approval. Those dates should be derived by referring to the anticipated material approval dates and the requirements in the specifications.

"CCMS" material control sub-system provides the provisions for the input of the above mentioned dates. The above dates for each material items are developed by backwards logic relations. That means the basic date is 'the earliest start date' and the other dates will be derived based on such a basic date up to the last date which should be 'the sample submission date'. In practice the latest start date of the activity is not considered in order to allow the floats as a contingency factor. In case for the materials of those critical activities, special allowance should be put to allow longer periods for the material scheduling dates. The input screen for material scheduling is shown in Figure 9.5 (a).

| Mat. Code | Description                     | Mea. Complete | E. Work Sta |
|-----------|---------------------------------|---------------|-------------|
| MH/100    | Int. White Glazed Wall Tile 108 | 01-02-91      | 01-08-91    |
| PS/1      | Cove Base Skirting Tile for Ref | 01-02-91      | 01-09-91    |
| R/15      | Red Quarry Tile - flooring for  | 01-02-91      | 01-10-91    |
| SO-23/s   | Int. Colour Glazed Ceramic Wall | 01-03-91      | 01-10-91    |
| SP-22     | Int. Mosaic Tile 18x18x5 mm for | 01-03-91      | 15-11-91    |
| SP-24     | Int. Ceramic Floor Tile 100x100 | 01-04-91      | 15-11-91    |
| SP-29     | Int. Mosaic Tile 18x18x5 mm for | 01-05-91      | 01-12-91    |
| SP-29NT   | Unglazed Step Nosing Tile       | 01-05-91      | 01-12-91    |
| SP-33NT   | Unglazed Step Nosing Tile       | 01-06-91      | 15-12-91    |
| SP-67     | Int. Ceramic Floor Tile 100x100 | 15-06-91      | 01-01-92    |
| ST-EA-RR  | Skirting Tile for Refuse Rooms  | 01-07-91      | 01-02-92    |
| ST-1A-RR  | Skirting Tile for Refuse Rooms  | 01-07-91      | 01-02-92    |
| T01       | Impact absorbing tile           | 01-10-91      | 01-03-92    |

—F2-actual; F3-save; F5-add; F6-delete—

Input Material Type => TILES  
Material Type Press [=] to List

Figure 9.5 (a)  
Input Screen for  
Material  
Scheduling.

The actual dates corresponding to the scheduling dates for each item will also be input to the Sub-system for the preparation of the Material Scheduling Status Report (MSSR). MSSR is similar to the Master Materials Procurement Schedule (MMPS) as described in Section 9.2, but only the quantitative information are excluded because those information are irrelevant to the contract supervisor. A sample print out of MSSR is shown in Figure (D) of Appendix 9.

In respect of the timing of sample submission required in PASS as described in Section 9.4 above, the submission of the Material Scheduling Status Report to the contract supervisor



will give a good reference indicating the quality of timing for sample submissions by comparing the planned schedule and the actual events.

## 9.6 Material Ordering

According to the study of in the Hong Kong construction industry as described in Chapter 3 in terms of material ordering on site, there are three categories of materials which will be treated different as follows: (reply from Section 6.5.2 here)

- i) Daily routine critical materials - such as concretes for reinforced concrete structure. It will be the front-line management such as the foremen or the site engineers to initial the order by filling in the form and hand to the assigned material orderer who will then directly make order to the supplier or the batching plant. The front-line management will then decide on the quantity of the order by referring to the concrete quantities allocation by floors or locations from the site quantity surveyor. For those materials, usually a bulk purchasing contract should have been signed before the start of the construction work.
- ii) Short-term routine critical materials - such as steel bars for reinforcement and timbers for timer formwork in reinforced concrete structure. The acquisitions of such materials will be by batching for next week's work in parallel with the construction progress. It will be the front-line management such as the foremen or the site engineers in consultation with the relevant trade subcontractors to decide on the quantities and timing of the material order. The initiation of the material order is also from the front line management but this time the quantities should be checked and agreed by the site quantity surveyor.
- iii) Other materials - include all the materials other than such two types of materials mentioned above. The ordering of such materials should comply in principle with the Material Scheduling Status Report described in the above Section 9.5. The material ordering for this categories will be initiated by the assigned material ordered by filling in the form. The quantities of each order will be consulted with the site foremen and store keeper and should be approved by the site quantity surveyor and the site manager.

By manual practices, the material ordering forms for item i) mentioned above, will be the one shown in Figure (E1) of Appendix 9 and the material ordering forms for item ii) and iii) will be the one shown in Figure (E2) of Appendix 9.

"CCMS" material control sub-system provides two separated functions to cater for the data input of such two forms. It is the target of the system design for the data to be transferred to the computer system of the purchasing department at the head office through the site telephone line. The technology of the telecommunication environment in Hong Kong is described in Section 5.5 of this thesis. This approach not only replaces the existing manual practice of sending the form by fax or by hand to the head office, but the Sub-system also records the event of such order placing which will be integrated with the function in the Sub-system to deal with material arrival.

The following information of each material order will be input into the Sub-system after having selected the material identity from the pop-up window:

- a) date of order;
- b) reference of order;
- c) order quantities/unit;
- d) expected arrival date and
- e) remark.

A screen input of material ordering is shown in Figure 9.6 (a).

Material Details for =>A-25/A-40

Full Description : Ext. Wall Mosaic Tile 20x20x4 mm

Total Quantity : 149800.00 Area per Pack : 12.00

Location to Use [=] : Domestic Portion

Supplier [=] Score

Manufacturer [=] Kodak Supplier

Spec/Org/BQ Reference

| Order Ref | Order Date | Order Qty | Unit | Exp A date |
|-----------|------------|-----------|------|------------|
| CF-4762   | 01-04-92   | 1000.00   | m2   | 02-05-92   |
| CF-4770   | 07-06-92   | 1200.00   | m2   | 20-06-92   |
| CF-4782   | 10-07-92   | 1500.00   | m2   | 30-07-92   |
| CF-4790   | 12-09-92   | 1500.00   | m2   | 05-08-92   |

[F3] to save; [F5] to add; [F6] to delete

Figure 9.6 (a)  
Material Order  
Input Screen.

### 9.7 Material Arrival

Coombs and Palmer (1984) suggested that the typical minimum receiving procedures involving in construction sites were:

- a) Unloading the materials or supplies;
- b) Counting the arrived quantities;
- c) Inspecting the quality;
- d) Checking the details of the delivery receipt with the actual; and
- e) Verifying that the items received met the type, specification, or characteristics detailed in the purchase order.

Ndekugri (1986) recommended that there was a potential for improving performance by allowing the delivery clerk to access the purchase orders and the specifications held in computer systems and the delivery clerk should then provide feedbacks by recording the details of deliveries to the same system. The idea raised by Ndekugri (1986) was tried to be implemented in the system 'PLUS VAL' by his research. Thorpe (1992) commented that Ndekugri's system was proved too cumbersome in practice to be adopted by the industry.

"CCMS" material control sub-system adopts a similar concept from Ndekugri, but by applying more advanced computer techniques as described in Chapter 5. It improves the efficiency of man-machine dialogue. The improvements include the following:

- a) The input is divided by different material types through the selection from the pop-up window.
- b) The input will be in an on-screen schedule form.
- c) It allows to select from the pop-up windows for the key data of any delivery entry such as name of supplier, identity of location to store the material and the location of the material to be used etc.
- d) It allows on-screen copy of the previous data to be a new data which will then be amended as a new entry.
- e) The user when inputting the data for material delivery, can access to the details of the corresponding material order recorded in the same system through the pop-up window. The material order should have been placed through the procedures described in Section 9.6.

The quantities of materials arrival is an important reference to support the evaluation of unfixed materials for interim payment applications.

The following information of each material delivery will be input into the Sub-system:

- a) Date of arrival;
- b) Name of supplier;
- c) Reference of delivery note;
- d) Corresponding order reference;
- e) Arrived quantities/unit;
- f) Arrived number of packs;
- g) Identity of material inspection;
- h) Identity of store on site to put the material; and
- i) Remark

The input screen for material arrival is shown in Figure 9.7 (a).

| Input for Material Arrival : Code -A-25/A-40 |          |          |               |          |      |   |
|----------------------------------------------|----------|----------|---------------|----------|------|---|
| Date                                         | Supp [=] | Arri Ref | Order Ref [=] | Arri Qty | Unit | P |
| 15/02 92                                     | Score    | 9412     | GF-668        | 9401.71  | m2   |   |
| 28/02/92                                     | Score    | 9413     | GF-668        | 5341.89  | m2   |   |
| 21/03/92                                     | Score    | 9438     | GF-4646       | 4700.85  | m2   |   |
| 26/03 92                                     | Score    | 9472     | GF-4646       | 18803.42 | m2   |   |
| 30/03 92                                     | Score    | 9482     | GF-6589       | 9401.71  | m2   |   |
| 01 04/92                                     | Score    | 9521     | GF-6589       | 1141.03  | m2   |   |
| 3/04/92                                      | Score    | 9552     | GF-7634       | 9401.71  | m2   |   |
| 0/08/92                                      | Score    | 9557     | GF-7634       | 9000.00  | m2   |   |
| 05/11/92                                     | Score    | 9889     | GF-8213       | 4500.00  | m2   |   |

[F3] to save; [F5] to add; [F6] to delete; [F8] to sort; [F9] to view sum

List Conditions

Order : Arrive Reference Order

Figure 9.7 (a)  
Material Arrive  
Input Screen.

The Sub-system also provides a function to view the total quantity of materials arrival by comparing to the required quantity, as shown in Figure 9.7 (b).

```

Input for Material Arrival : Code -A-25/A-40
Material Arrival Summary for A-25/A-40

Total Planned Qty : 149,800.00
Total Arrival Qty : 165,949.59

Outstanding Qty : -16,149.59 M2

Do you want to print S)summary, D)etail or N)o print N

List Conditions
Order : Arrive Reference Order

```

Figure 9.7 (b)  
Viewing Material  
Arrival Summary.

### 9.8 Material Distribution

Material distribution can be defined as the processes of transferring the material from where it is stored, to where it will be used and fixed as part of permanent work. Material distribution has a great influence on the efficiency of work progress. The Chartered Institute of Building 1992 published an article titled 'Industry fit for business - cost cutting the American way', in which it mentioned a feature of operative working in the construction industry of American was the 'ten foot rule' by which materials and tools will be put near where the works taking place. The concept of 'ten foot rule' is simple, but the implementation of the same will be difficult. It is because works in construction sites are not static but will be quick dynamic. Especially when involving with finishing and fitting up stage, where many different trades will be working concurrently on site. It is also at this stage material distribution will be more complicated.

According to the study in Hong Kong as described in Chapter 3, the most crucial stage of material distribution is the delivery of finishing tiles to each floor for fixing. Since most sub-contracts for finishing works will be a type of labour only sub-contact, all the materials will be supplied by the main contractor. Although a pre-defined percentage of wastage acceptable to both parties will be put into the subcontract, it is usually a disputable area at the end for the assessment of the actual wastage. In practice, the subcontractor may sublet part of the works to other subcontractors or gangers. In terms of materials distribution, usually the mentality of the gangers or sub-subcontractors will prefer to take more quantity of materials than the work required to the work area

because they do not want their work progress to be disturbed due to the shortage of materials. On site there are two practices to manage the materials distribution as follows:

- a) In the first practice, it relies on the duty of general or sectional foremen based on the Materials Allocation Schedule from the site quantity surveyor, to supervise the distribution of materials taken by the subcontractors. The store keeper will just be informed the items and quantities of the materials to be taken out from the store.
- b) In the second practice, a material requisition form has to be filled in by the general or sectional foremen. The form will be forwarded to the site quantity surveyor who will then check the appropriateness of the required quantities. If it is appropriate, the form will be signed and sent to the store keeper for taking the materials.

In the field test of "CCMS" as described in Chapter 13, a special form in Chinese characters was devised for the trade subcontractors to fill in the material requisition, a sample of which is shown in Figure (F) of Appendix 9. The reasons for requesting the subcontractor to initiate the form are in considering their expertises in the trades and work areas, and it will also reduce the workload of sectional foremen whose duty then is only to check the form. The information contained in the form are as follows:

- a) Form reference number.
- b) Subcontractor company name.
- c) The name of the subcontractor representative on site.
- d) The date of the material going to use.
- e) The date of this application.
- f) The description of the material.
- g) The quantities required.
- h) The identities of where the material will be used in terms of:
  - block,
  - floors,
  - location/trade.
- i) The signature/date of the corresponding foreman
- j) The signature/date of the store keeper
- k) The material taken from store.

The above information will be input into the System by the input screen as shown in Figure 9.8 (a).

A-25/A-40 : Ext. Wall Mosaic Tile 20x20x4 mm

|                                                                                                     |         |                      |          |
|-----------------------------------------------------------------------------------------------------|---------|----------------------|----------|
| Reference                                                                                           | A1      | Date                 | 01-02-92 |
| Used Quantity                                                                                       | 300.00  | UNIT [=]             | M2       |
| Packages                                                                                            | 100.00  | UNIT [=]             | Boxes    |
| Subcontractor Name [=] Tat Lee                                                                      |         |                      |          |
| Take from Store [=] Block 7                                                                         |         |                      |          |
| ----- Where the Materials Use -----                                                                 |         |                      |          |
| Block [=]                                                                                           | BLOCK 7 | From Floor/Level [=] | 3/F      |
|                                                                                                     |         | To Floor/Level [=]   | 7/F      |
| Location ID [=] CORRIDOR                                                                            |         |                      |          |
| Usage [=] FLOORING                                                                                  |         |                      |          |
| Remark : 10 boxes of tile were found with damaged packing<br>due to the water ponding in the store. |         |                      |          |

Figure 9.8 (a)  
Material  
Distribution Input  
Screen.

The advantages of putting the above information into the Sub-system are as follows:

- a) It provides a control to avoid substantial large amount of exceeding quantities being required by the trade subcontractors in respect of each specific location.
- b) It aids the stock checking by knowing the quantities taken out from the store.
- c) It enables the intermediate comparisons between the material used per location, to the measured quantities from the drawing. This practice will help an early identification of the profiles of wastages for different materials.
- d) It aids to assess the performing wastage of the subcontractors for subcontract administration purpose.
- e) It aids to counter check the value of the unfixed materials for interim payment application.

### 9.9 Evaluation for Unfixed Materials

The principle of most standard forms of construction contract, allows the contractor to be paid monies in respect of materials intended for the contract but not yet incorporated into the permanent works. In Government of Hong Kong General Conditions of Contract for Civil Engineering Works 1990 Edition, under Clause 79 (1) (c) it states:

"The Employer shall pay to the Contractor ..... the estimated value of materials for inclusion in the permanent work and not being prematurely delivered to and being properly stored on the Site ....."

However, under the General Conditions of Contract for the Airport Core Programme Civil Engineering Works 1992 Edition, the value of interim payment will be based on the Interim Payment Scheduled submitted with the tender and there is not separated payments for unfixed materials.

The methods of measuring unfixed materials have been identified by the previous literatures (Marks et al 1978, Barrett 1981, Johnston 1981, Ndekugri 1986). The details as summarised as follows:

- a) Detailed Measurement by Physical Inspection - With this method, the consultant quantity surveyor has to bring in a measurement team physically inspect and take inventory of all the materials awaiting incorporation into the works. This method suffers from the drawback that it takes time and effort.
- b) Detailed Measurement from Accounting Records and External Valuation - With this method, the consultant quantity surveyor will come to site to inspect the account value of all the materials delivery and deduct the value of those materials being incorporated into the measured works. This method has a possibility that the quantities of materials so obtained will exceed the quantities required for the remaining work. This is also dangerous to the Employer because waste, pilfering and inadequate storage cannot be detected.
- c) Approximate Physical Measurement and Account Check - With this method, the consultant quantity surveyor will come to the site based on the account record to spot check the status of the major material items and add a rounded lump sum for other miscellaneous items.

Ndekugri (1986) summarised that the purposes of on-site inspection for unfixed materials from the consultant quantity surveyor are to ensure that:

- a) the materials are in accordance with the specification;
- b) unfixed materials off-site are substantially ready for incorporation into the works;



- c) the materials have not been brought to the site prematurely,
- d) the supply contracts between the contractor and his suppliers do not place encumbrances on the Employer's ultimate ownership of the materials;
- e) the quantities are not in excess of requirements;
- f) the materials are properly stored and insured;
- g) the delivery notes and invoices are ready;
- h) there are no errors in the calculation of the amount being claimed;
- i) title in the goods has clearly passed to the Employer.

According to the study as described in Chapter 3, most of the above practices from the previous literatures have been confirmed.

The contributions of "CCMS" material control sub-system to the valuation of unfixed materials, are as follows:

- a) A copy of the updated Material Scheduling Status Report (MSSR) as described in Section 9.5 showing the timings of material arrival in relation to the master planning, will be sent to the consultant quantity surveyor from time to time when the schedule is updated in line with the work progress. Based on this schedule, the consultant quantity surveyor can justify whether the materials are prematurely brought to site or not.
- b) The accumulated quantities of material delivered to site based on the information from the Material Arrival as described in Section 9.7 above, will be listed out from the System and incorporated into interim applications for submission to the consultant quantity surveyor. We hereby call this figure (A)
- c) The quantities of materials being incorporated into the measured works will be automatically passed from the Interim Application Function of "CCMS" cost control sub-system. We hereby call this figure (B).
- d) Theoretically, the quantity of unfixed material should be: (A) - (B) according to the previous literature mentioned above. We hereby call this figure (C). In fact, the figure (C) should include the following quantities:

- in store,
- in adjacent to work area not being used,
- wastage.

- e) It is unjustly for the employer to pay the value of unfixed materials based on the figure (C) mentioned above, because the figure (C) contains the element of wastage which should have been included in the unit rates of measured works.
- f) Therefore, the value of unfixed materials should be equal to the following:

$$A - (B \times \% \text{ of wastage})$$

Such a percentage of wastage will be agreed between the consultant quantity surveyor and the site quantity surveyor.

#### 9.10 Stock Check and Material Wastage

Johnston (1981) listed out the reasons of waste occurring on site as follows:

- a) misinterpretation of drawings;
- b) overestimating the quantity required;
- c) faulty workmanship;
- d) careless handling; and
- e) uneconomic design.

These should be regarded as the technical causes of waste, the improvements for which are depended on the site supervision and training. However, there should have other aspects of material waste caused by mis-management. Skoyles and Skoyles (1987) pointed out that improvement in materials control can be partially achieved by better formal procedures, such as making sure the firm's booking procedures are effective, but significant improvement depends on some feedback from those involved in their performance. Skoyles quoted the study in 1960 by Economic Commission for Europe which had considered to create feedback by assessing waste levels through appraisal techniques and accounting procedures. According Skoyles derived the following three stages for assessing and accounting waste:

- a) An appraisal technique which indicates likely waste on site by observation, as an early indication of waste levels.

- b) An accounting system using some of the data available to the quantity surveyor at the time of interim application.
- c) An accounting system similar to b) in principle but which records waste at a detailed level of materials handling operations.

In this research the Sub-system design has adopted the approach c) mentioned above. It is the main purpose of most material control systems on site to measure the percentages of material wastage. The formula to calculate the material wastage for any specific item will be as follows:

Figure (A) - The quantity of the material delivery.

Figure (B) - The quantity of the material remained in stock.

Figure (C) - The quantity of the material remained in the adjacent work place.

Figure (D) - The quantity of the material fixed in the permanent work.

The percentage of the wastage will be:

$$(A) - (B) - (C) - (D) = (E) .$$

(E) / (D) in terms of percentage.

The crucial steps in the calculation of wastages involve the assessment of the quantities remained in stock and the quantities left in adjacent work place, that means the Figure (B) and Figure (C) mentioned above. Stock checking and surveys for the quantities left adjacent to work places, involve large amount of efforts and man power on site. In the industry practice, such a checking and survey will be done about every three months. The control of material wastage on site will rely on the following practices:

- a) Based on the observations by the site management on the performance of sub-contractors, the problems will be brought out in the domestic subcontractor monitoring meetings.
- b) By setting up a upper limit on the percentage of material wastage in labour only subcontracts, the subcontractor shall reimburse the extra materials costs if the actual material wastage is bigger than the contract wastage.

"CCMS" material control sub-system contributes to the wastage control on site by providing a provision to allow the input of the quantities remained in stores and work areas. Based on these information and the information of material arrival and measured, the corresponding wastage for each material items can be calculated from the Sub-system. The wastage report provides an additional reference on the status of wastages on top of the site observation based on the experience of site management and also gives an intermediate measure to the performance of subcontractors. The figures from the report will also aid the calculation of the actual wastage which should be off-set by the contract wastage stated in the subcontracts. A sample of the input screen for quantities remained in store and working area is shown in Figure 9.10 (a). A printout report on materials wastages is shown in Figure (G) of Appendix 9.

| Ins                                        |              |               |             |                |
|--------------------------------------------|--------------|---------------|-------------|----------------|
| Check Stock/Work Area Remaining Quantities |              |               |             |                |
| Mat. Code                                  | T. Arri (m2) | T. Arri (nos) | Store (nos) | Wrk Area (nos) |
| A-25/A-40                                  | 9401.71      | 2200          | 474         | 1106.00        |
| B-67                                       | 7245.00      | 1800          | 363         | 86.00          |
| FT01                                       | 20800.00     | 130           | 585         | 261.00         |
| IJ-S7                                      | 3536.00      | 834           | 474         | 176.00         |
| IJ-S9                                      | 4647.00      | 2200          | 36          | 128.00         |
| SP-67                                      | 600.00       | 110           | 50          | 12.00          |

[F3] to save; [F5] to add; [F6] to delete

Input Material Store => Block 7      DATE OF STORE CHECKING => 01-02-92  
 Material Stores on Site (\*) to List

Figure 9.10 (a)  
Input Screen for  
Materials  
Remaining in Store  
and Working Area.

### 9.11 Summary of the Aids to Material Control

The system design of "CCMS" material control sub-system has taken into account the recommendations from the previous researches and the findings from the study in Hong Kong construction industry. The aim of the Sub-system is to support the management tasks of the purchasing management function derived from the model of construction management described in Chapter 6. In summary, its contributions to material control on site are as follows:

- a) Most functions in the System are used to replace the manual practices of material control on site, which will have been done even without the use of computers. Therefore it should not create much extra burden to site management by the use of the Sub-system.

- b) The use of pop-up window technique for data selection in the system, should make the tasks easier, since it reduces the need of typing and remembering codes. Even in case typing is necessary, but with the use of word possessing functions in the system should make the work easier.
- c) The reports from the Sub-system showing the identities, quantities, timings, submissions, orderings, arrivals and wastages of materials, provide a significant feedback from time to time of the status of the material control on site. The price of these information is comparatively low because they are the integration of the information from the routine site material handling functions which are computerised in order to increase their operational efficiency in comparison with the manual practices.
- d) It provides information to aid the contract administration of the contract supervisor in terms of the timing and status of sample submissions and material arrival which is an essential reference for the evaluation of unfixed materials.
- e) It provides information and direct printouts for external submissions for example sample submission and PASS assessment etc.
- f) The Sub-system can be considered as part of the quality assurance system in respect of material control and part of processing control.

## 10 Post Contract Cost Control Sub-system

### 10.1 Principle of Cost Control Sub-system Design

Most construction contractors obtain their business in the form of procuring contracts through tendering. The tenderers have to estimate based on the tender documents for their future commitments on both the aspects of time and cost of the project which they need to complete in accordance with the client's requirements. When the project completion time has been fixed in the tender documents, the only competition among the tenderers will be on the 'cost'. Johannsen and Page (1986) defined 'cost' in terms of financial management to be a sum of money or equivalent expended in terms of labours, materials, use of equipment, rent etc., to produce a product or service.

In accordance with the General Conditions of Contract for the Airport Core Programme Civil Engineering Works 1992 Edition, it gives a more precise definition on 'cost' of construction projects, in which "cost" means expenditure wholly and necessarily incurred by the Contractor in connection with the Works including without limitation overheads whether on or off the Site and depreciation in value of Contractor's Equipment owned by the Contractor but excluding profit.

According to the traditional procurement system, the project cost plus the contractor's overheads and profit will be fixed as the contract sum legally binding to both parties between the client and the contractor once the tender is accepted. From the view of contractors, the project cost will then become the cost target which will be subject to intensive control throughout the contract period. In order to achieve such a control target, the contractors should have to include some kind of monitoring system within their management structure. Gobourne (1982) defined contractors' cost and monitoring systems as the complete process of controlling and monitoring expenditure of a project by the contractors from the time of tendering through the construction phases, to the end of the maintenance period and until the last retention payment is released by the client.

Abdullah and Tyler (1989) pointed out by their literature review on the requirements of contractor's cost control system that any system must be interactive and able to be linked to other construction management systems such as estimating, planning and valuation etc, and it must also provide immediate warning of uneconomic operations, relevant feed back, data for assisting in the valuation of variation and a summary of progress. They indicated that based on their survey on 13

construction companies the control systems being used were still accountancy based package rather than control and monitoring systems. In their conclusion, Abdullah and Tyler suggested that the following points would need to be considered in any attempt to improve or integrate cost control systems:

- a) The system should have most, if not all, of these facilities:
  - a) cost/value variance reports;
  - b) overall cost report for preliminaries;
  - c) forecast report for cost to complete;
  - d) activity/cost centre item list;
  - e) feedback reports;
  - f) short term planning reports;
  - g) material utilisation reports;
  - h) graphical reports.
- b) All systems should have a coding system which lists the activities/cost centres to which all the expenses on a project are related.
- c) For identifying precisely the area losing money, the reports should be provided to foreman level.
- d) The number of breakdown figures should preferably be at least four including labour, plant, materials and subcontractors. Preliminaries should also be considered as one of the resources of expenses on the project.
- e) Any system should have the ability to access data from and to the other stages of the project and to remain as efficiency as possible.

According to the study in Hong Kong described in Chapter 3, most cost monitoring and control activities take place on construction sites. The site manager has to take responsibility on any cost over-run. Kodikara (1990) based on his surveys on the construction industry of Sri Lanka and United Kingdom identified the following reasons as the causes of ineffective cost control on site:

- a) Insufficient staff. (Most of the tasks are allocated to the site agent)
- b) Ineffective site controlling and monitoring of actual use of resources. (A result of poor site management).
- c) Large amount of variations which need attention and time. (This is because of the poor designs and variabilities in tender documents)

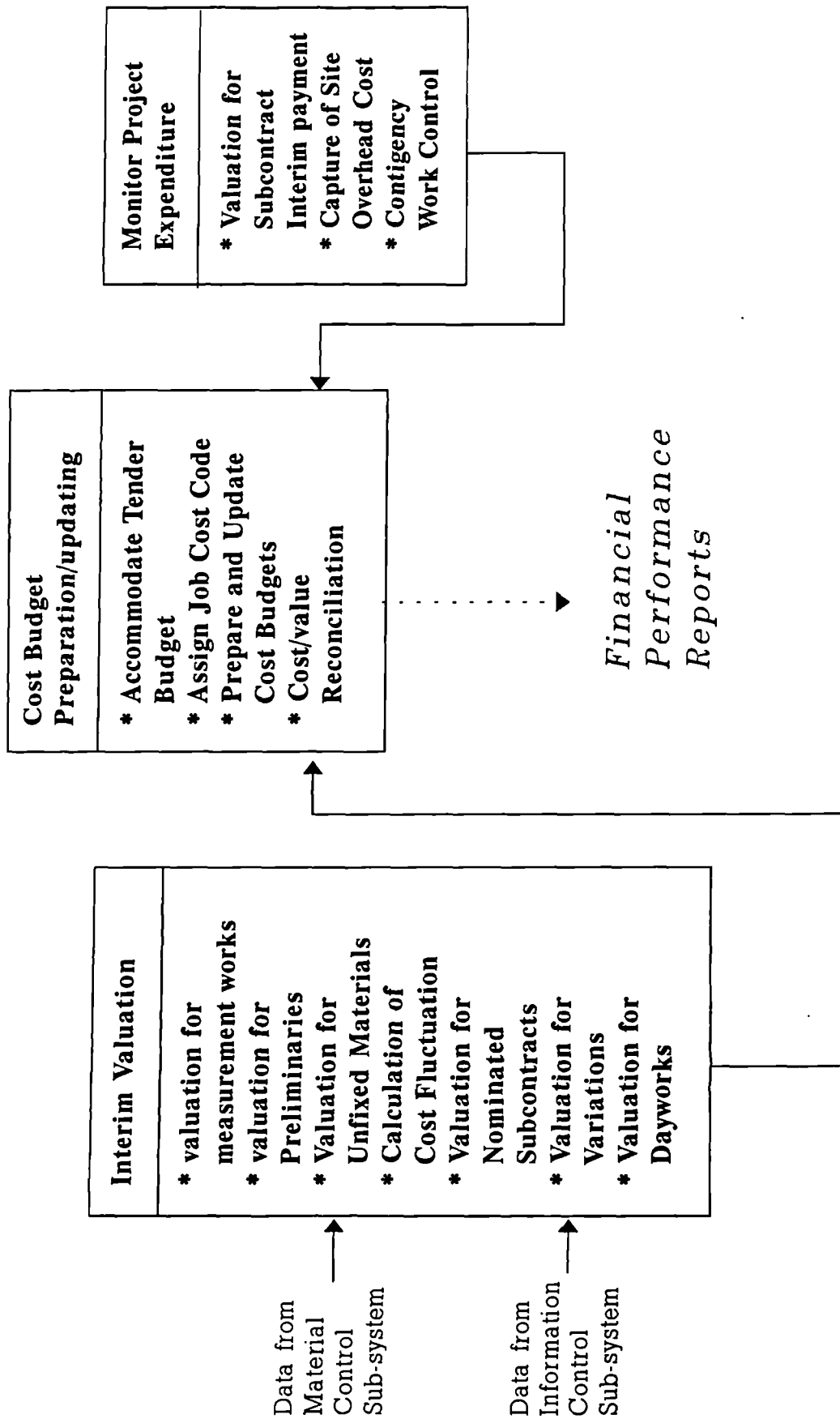
- d) Data available in the estimate are not in suitable format for the direct use. Substantial effort and time required in present methods of cost controlling. (Cost control is not related to bill of quantities).

The study in Hong Kong, shows a similar outcome in comparison with Kodikara's findings. The model of construction management described in Chapter 6 includes a management function of quantity surveying which has to satisfy the objective of cost control for construction projects. In order to support the management tasks of cost control, 'CCMS' incorporates a cost control sub-system (also called the Sub-system in this Chapter) which has taken into consideration of the recommendations and comments of the previous researches and the study on the practices of Hong Kong construction industry. The Sub-system provides the functions covering most procedures associated with the management task as described in Section 6.7.4. The details are shown on the operational flow chart as illustrated in Fig 10.1.(a). The functional divisions of the Sub-system are as follows:

- a) Cost budget and cost control;
- b) Interim valuation for main contract ; and
- c) Monitoring project expenditures.

In line with the main stream of the system design of "CCMS", the Sub-system is used to provide the functions which firstly should replace and/or increase the efficiency of the current manual practices which should have been done even without the use of computers, and secondly provide the reports that are not provided before. The main input menu of the Sub-system is shown in Figure 10.1.(b).





**CCMS Cost Control Sub-system**

**Figure 10.1 (a)**

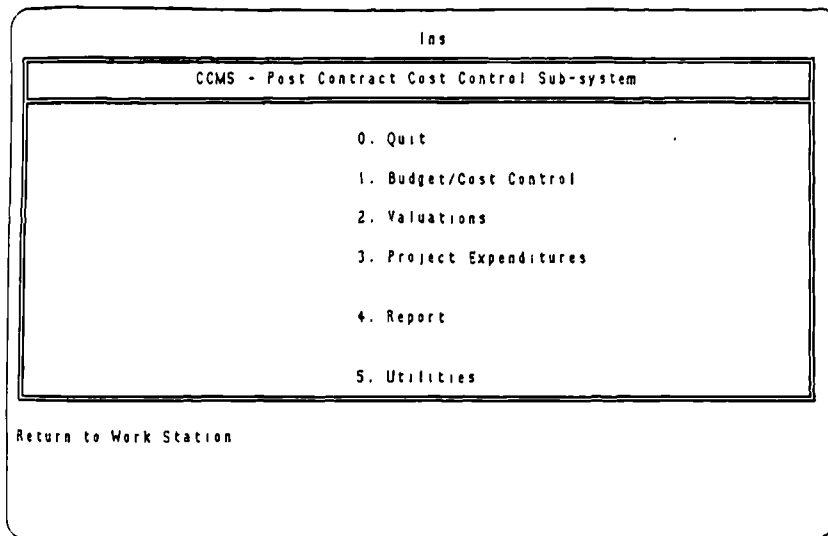


Figure 10.1.(b)  
The Main Input  
Screen of the  
Sub-system.

## 10.2 Cost Budget for Cost Control

### 10.2.1 Principle of Cost Budget

In view of the cost of finance sources and the availabilities of other investment mechanism, contractors are in increasing awareness of budgetary control for construction projects. ACCA (1991) defines that a budget is a plan quantified in monetary terms, prepared and approved prior to a defined period of time, usually showing planned income to be generated and/or expenditure to be incurred during that period and the capital to be employed to attain a given objective. Dyson (1991) has summarised that the essential features of a budget are as follows:

- a) It lays down policies which are expected to be pursued in order to meet the overall objectives of the entity.
- b) It contains both quantitative and financial data.
- c) The data are usually formally documented.
- d) It is prepared for a future period of time.
- e) It covers a defined period of time.

Pilcher (1985) described budget in construction terms and pointed out that budget could be seen in the sense of other resources such as labour and mechanical equipment. In view of the dynamic nature of construction projects, Pilcher further identified that a comparison of the actual and estimated expenditure and income will enable the variances between the two to be established, by which if an appropriate

method of control is used the reasons for such variances can quickly be identified. Pilcher's concept has been applied in the system design for this Sub-system.

According to the study in Hong Kong construction industry as described in Chapter 3, the contractors are seldom to built-in the time element for detailed cost items into their cost budgets by linking up the time and cost relationship of construction projects. The classical means of construction time and cost relationship in construction management described by most literatures is to link up the items of bill of quantities and the activities in master programme. By manual practice it will be a quite cumbersome task especially when it involves with the updating of master programme. However, most site quantity surveyors at the start of contract will be required to prepare a cash flow forecasting based on the master programme, which is used to show the difference between the incomes from interim payment applications and the predicted expenditures from subletting. Such a cash flow forecast is seldom updated in line with the revision of master programmes.

The main input screen for project cost budgeting is shown in Figure 10.2.1 (a).

```

ins

Budget and Cost Control Menu

0. Quit

1. Main Contract Bills
2. Subcontract Bills

3. BQ/Job Code
4. Job Cost/Detail Codes

5. Cost Budget - Value
6. Cost Budget - Time

Return to Main Menu

```

Figure 10.2.1.(a)  
The Main Input  
Screen of the  
Project Cost  
Budgeting.

The application of "CCMS" system for cost control involves the preparation of the following budgets:

a) Company level cost budget:

It will be based on a set of pre-defined standard cost items which is a company-wide standard covering all the projects within the company. At the start of a contract, there should have a tender budget based on the information from the "CCMS" estimation sub-system. At this stage the 'tender cost budget' covers the entire contract period, since the details of the master programme is not yet confirmed at this stage. Having received such budget from the estimation sub-system, it is the duty of the project quantity surveyor to counter-check the figures with the confirmed contract bill. The purpose of such a budget is to review the financial status of each item in the standard list projecting from the time when the review is taken to the final completion of project. *With the use of the Sub-system the budget should be updated every 3 months.* This practice is also called 'cost plan' by some of the local contractors in Hong Kong and normally by manual practice with the assistance of standard package such as 'spread sheet' system etc the budget will be updated every 6 months. An example of this report is shown in Figure A of Appendix 10.

**b) Monthly Project Cost Status:**

The items in this budget will be same as the 'Company level cost budget' but the time element of each item will be added in, by which the break down of monthly budget for each item can be derived. The method applied in the Sub-system is to input the start and finish dates for each items and the method of cost distribution to corresponding budget duration can be chosen by even distribution or 'S' curve formula. To facilitate better flexibilities for preparing budgets, the Sub-system allows the user to adjust the weighting for each month if necessary. A sample screen input for this function is shown in Figure 10.2.1 (b).

| Job Cost Code Details |                     |            |          |         |  |
|-----------------------|---------------------|------------|----------|---------|--|
| Code                  | Description         | Start Date | End Date | Method  |  |
| P010                  | SAL & WAGES         | 01-02-91   | 01-03-93 | S Curve |  |
| P011                  | SAL & WAGES O.T.    | 01-12-92   | 01-03-93 | Liner   |  |
| P012                  | SAL & WAGES-OTHERS  | 01-12-92   | 01-03-93 | S Curve |  |
| P020                  | MESSING             | 01-12-92   | 01-03-93 | Liner   |  |
| P030                  | INS WORKMAN COMP    | 01-02-91   | 01-03-93 | Liner   |  |
| P031                  | INS C.A.R.          | 01-02-91   | 01-03-91 | Liner   |  |
| P032                  | INS. BOND           | 01-02-91   | 01-03-91 | Liner   |  |
| P033                  | INS. OTHERS         | 01-02-91   | 01-04-91 | Liner   |  |
| P040                  | IND. TRAINING LEVY  | 01-02-91   | 01-03-93 | S Curve |  |
| P050                  | TEMPORARY ELEC.     | 01-02-91   | 01-03-93 | S Curve |  |
| P051                  | TEMPORARY WATER     | 01-02-91   | 01-03-93 | S Curve |  |
| P052                  | TELEPHONE (Initial) | 01-02-91   | 01-03-91 | Liner   |  |
| P053                  | TEMPORARY ELEC.     | 01-02-91   | 01-03-93 | S Curve |  |
| P054                  | TEMPORARY WATER     | 01-02-91   | 01-03-93 | S Curve |  |
| P055                  | TELEPHONE           | 01-02-91   | 01-03-93 | Liner   |  |

[F2]-3rd level; [F3] to save; [F5] to add; [F6] to delete

Job Cost Code Headings PRELIMINARIES

Press [Return] to select from the list

Figure 10.2.1.(b)  
The Input Screen  
for Allocating  
Timing to Budget  
Items.

### 10.2.2 Standard Cost Code

It has been widely recognized in both the professional and the academic literatures that the classification and coding of data is an essential procedure for the implementation of management information system for construction projects (Bishop and Alsop 1968, Pilcher 1985, CPI 1987, Abdullah 1988, Kodikara 1990).

British Institute of Management 1971 defined:

"Classification is a systematic arrangement of similar fields or components into suitably defined categories. Coding is the allocation of symbols to the classified categories. Information can be classified in various aspects depending on the objectives of the user."

Kodikara (1990) put forth in his research that the criteria for the classification and coding are:

- Unique and unambiguous identification
- Recognizability
- Level of detail
- Length of code
- Expandability
- Accommodation of Dimensions
- Option for choices

The design of the standard cost codes used in the "CCMS" system, comprises of three levels as follows:

a) 1st Level (Summary Code) - 1 digit.

Summarised trade codes for report presentation such as: daywork (D), direct labour (L), Material (M) etc, the design of which is a company wised standard.

**b) 2nd Level (Sub-head Code) - 3 digits.**

Unit trade codes for cost control such as: excavation (210), temporary shoring (253), formwork (255) etc. The code design is also standardised in company level.

**c) 3rd Level (Detail Code) - 4 digits.**

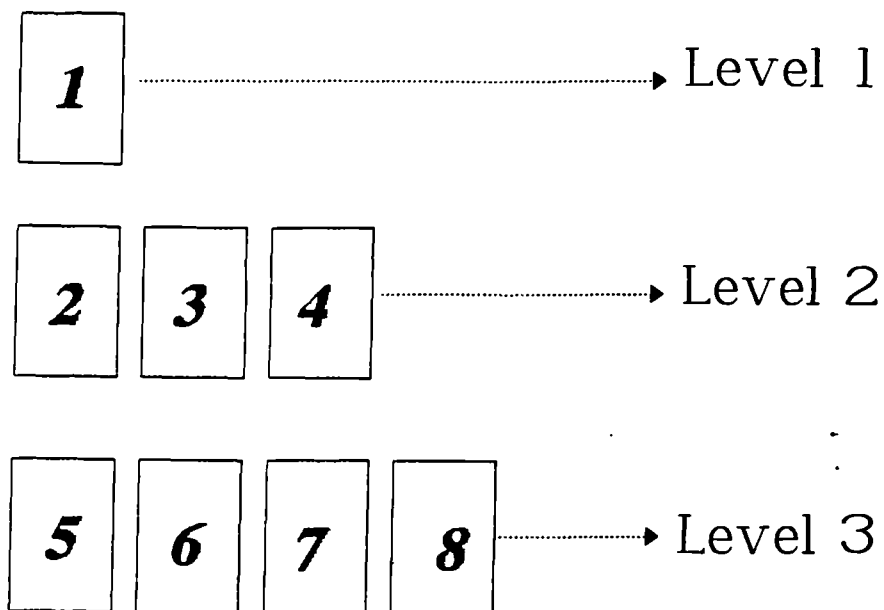
Smallest entry for site job cost and account booking such as: Hong Kong Telephone Co. (1200), Chuen Lee Drainage Co. (2457), Pioneer Ready Mix Concrete Co (4623) etc. Each subcontractor and supplier will be assigned an individual four digits code.

The structure of the standard cost codes is shown in Figure 10.2.2 (a).

Figure 10.2.2 (a)

## ***Standard Cost Code Structure***

---



Level 1 - Summary Code.

Level 2 - Sub-head Code

Level 3 - Detail Code

In conjunction with the use of individual project code as the prefix of the account codes, each account entry for any project should have an individual identity. During the operation of the Sub-system, it is unnecessary for the user to remember the codes but just call up the pop-up windows to select from the listed items.

A sample of the standard cost codes used in the field test project as described in Chapter 13 is shown in Figure B of Appendix 10.

The number of total standard cost codes up to 2nd level is around 250 to 300 numbers. The crucial point of the standard cost code design is in the 2nd level. The itemisation and division of the code should be able to provide a meaningful comparison between the actual cost and the budget for each item. The measurement of meaningfulness for a cost control system is to see whether the problem areas of the project can be able to be identified from the cost feedback.

#### **10.2.3 Linking with Estimation**

Kodikara (1990) pointed out that professionals in the contractor organisations had believed that the current format and presentation of the estimating data is the reason for inefficient site control, site monitoring and cost control of work. In "CCMS" estimation sub-system, there is a function used to set up the relationship between the standard resource rates and the standard cost codes. The details are contained in Section 7.5.4.

During the estimation stage, since the detailed procurements in terms of materials, plants and subcontracts for the project are not confirmed yet, thus the link up between the standard resource rates and the standard cost codes should be up to the second level of the standard cost codes. In fact, once the relationship between the standard cost codes and the standard resource rates has been established in the company level, extra efforts will be minimum in the preparation of cost budgets.

By linking up the estimation and the budget through a set of pre-defined standard cost codes in sub-head level (2nd level), it provides a means of transferring estimation data to cost budget for post-contract cost control. A sample print out of the cost budget is illustrated in Figure C of Appendix 10.

#### **10.2.4 Assign of Job Cost Identity**

Job cost identify is the 3rd level of the cost code design mentioned in Section 10.2.3 above and it should be assigned to the Sub-system after the bidding is succeeded. During the pre-contract stage, the resource procurements in terms of labours, plants, materials and subcontracts, will be commenced in pace with the mobilisation and preliminary works on site.



As part of the company-wide quality assurance system, all the individual commercial identities involving with the affairs of construction projects should be assigned with an independent 4 digits numeric code. The code will form the key of the control file storing the details of each parties. It should be the responsibility of the Contracts Manager to update the relevant information of the control file before it is passed to the site. The site quantity surveyor should be responsible to update the information of the control file from time to time when a new procurement arrangement is confirmed.

The design of the Sub-system for inputting job cost identities comprise of two functions:

a) Update identity details:

The following information of an identity will be included in the file:

- trade unit code (2nd level code),
- identity code (3rd level code),
- company name,
- subcontract brief,
- contract/budget sum,
- estimated start date/complete date,
- correspondence address,
- telephone/fax/telex numbers etc.
- name of the contact person,
- position of the contact person,
- date of the details updated.

b) Assign job cost identity under the trade unit code which is the 2nd level of the standard cost code. The user has to input the corresponding trade unit code through a selection from the pop-up window. After that a schedule form of input screen will be come up for the user to input the following information:

- identity code (3rd level code),
- subcontract brief,
- original contract/budget sum,
- revised contact budget sum,
- projected final contact budget sum,
- accumulated payment,
- estimated cost to complete,
- estimated start/complete date,
- actual start/completion dates

The input screens showing the handling of these information are shown in Figure 10.2.4 (a) and Figure 10.2.4 (b).

Job Cost Code Details  
S140:SCAFFOLDING  
06148:Man Wah Engineering Company

Contract Name: External scaffolding for all domestic blocks

Company Name : Man Wah Engineering Company Ltd.

Address : 701 Wah Fook Commercial Building  
23-27 Queen's Road East  
Hong Kong.

Telephone 1 : 7629432 Fax : 3890645  
Telephone 2 : 7629433

Contact Person 1 : Chan, Wing Kee --> Position 1 : Contract Man  
Contact Person 2 : Lee, Pak Chuen --> Position 2 : Foremen

Date of this updated information : 01/04/92

-----  
Access to the contract details T  
Access to the payment details E

Figure 10.2.4 (a)  
Identifying the  
Details of a  
Subcontractor.

Job Cost Code Details  
S140:SCAFFOLDING  
06148:Man Wah Engineering Company

Contract Name. External scaffolding for all domestic blocks

Contract Details

Original Contract Amt : \$1,311,446.00 Budget Amt : \$1,311,446.00  
Updated Contract Amt : \$1,350,789.00 Budget Amt : \$1,350,789.00

Original Contract Start Date : 01/02/91  
Original Contract Duration : 720  
Original Contract Completion Date : 21-01-93

-----  
Certified Payment : \$567,575.00  
Certified Date : 01/05/92

Remark/Details [F2] to edit memo

Figure 10.2.4 (b)  
The Relevant  
Subcontract  
Details.

Based on these information, the month expenditures in terms of materials, plants and subcontracts will be captured and put to the corresponding job cost identity code, based on which it will then be able to compare with the incomes from the monthly interim payment. All such information will be shown on the monthly budget report as described in Section 10.1 above.

### 10.3 Valuations for Works in Progress

#### 10.3.1 Principle of Interim Valuation

Perceval (1980) defined that 'external valuation' (interim valuation) was referred to the determination of the amount of payment of which the Contractor may apply to the Employer under the appropriate conditions of contract. Perceval further explained the following important reasons for the contractor to obtain a correct and consistent valuation:

- a) statutory requirements for annual accounts in the determination of profit.
- b) cash flow to finance work expenditures.
- c) management control to identify the financial status of project.

Powell-Smith (1983) has made it clear that construction contracts are a kind of entire contract, under which the obligation of the Employer to pay interim payments was based on the express terms in the conditions of contract. Because the necessity of interim payment for contractors in the construction industry, all the common standard forms of construction contract have included a clause for interim payments.

Most of the standard forms of contract (e.g. HKIA 1967, ICE 1979), put the responsibility of preparation for interim valuations on the contractor. The consultant quantity surveyor on behalf of the client will then check for the contractor's submissions. Under most standard forms of contract, detailed procedures for handling interim payment will be stated and any amendments of the same should be put in the special condition of contract or preliminary bill.

In accordance with Clause 78 (2) of the General Conditions of Contract for Civil Engineering Work 1990 Edition, it states:

"The statement (interim application, from the contractor) shall be prepared on a form supplied by and at the expense of the Contractor and the style and number of copies shall be as the Engineer shall determine. ...."

Therefore, it is up to the contractor's quantity surveyor and the consultant quantity surveyor (or the quantity surveyor within the engineer's in-house service), to

determine the style and form of interim payment submission. The main operational screen for interim valuation is shown in Figure 10.3.1 (a).

```

 Ins
 Progress Valuation Menu

 0. Quit
 1. Measured Items
 2. Preliminaries

 3. Fluctuation
 4. Daywork
 5. Unfixed Materials
 6. Nominated Subcontracts
 7. Variations/Others

 Valuation for Variations

```

Figure 10.3.1.(a)  
The Main Input  
Screen of Interim  
Payment  
Applications.

### 10.3.2 Manipulated Bill of Quantities

Under the traditional procurement system, most construction projects will be tendered on bill of quantity basis which will then become a contract bill once the contract is awarded. Seeley (1988) described that the first and foremost purpose of bill of quantities was to enable all contractors tendering for a contract price on exactly the same information with a minimum effort and the other purposes were as follows:

- a) To provide a basis for the valuation of variations which often occur during the progress of the work.
- b) To give an itemized list of the component parts of the building, with a full description and the quantity of each part, which may assist the successful contractor in ordering materials and assessing the labour requirements for the contract.
- c) After being priced, to provide a good basis for a cost analysis, which subsequently will be of use on future contracts in cost planning work.

In 1988, the Architectural Services Department (ASD) of Hong Kong Government issued a publication called "Model Bills of Quantities". The Model Bill is a set of standard descriptions, built up from the ASD phraseology, complying

with the 3rd Edition of the Hong Kong Standard Method of Measurement of Building Works and the ASD General Specification for Building. Under this practice, a description is made up of four divisions as follows:

First Division: This is the main heading and forms the main sub-division within each Trade printed in block capitals and underlined.

Second Division: This is a sub-heading under the main heading and generally contains specification requirements printed in lower case and underlined.

Third Division: This is a further component of the previous sub-heading and in turn the previous main heading. It contains common information applicable to subsequent fourth division descriptions printed in lower case but not underlined.

Fourth Division: This is the last part of a description and contains variables such as sizes and qualifiers etc. The quantity appears against this part of the description. This is printed in lower case, not underlined and indented from the left hand margin.

According to the study in Hong Kong Construction Industry as described in Chapter 3, most private contracts also follow this format in the preparation of bill of quantities for construction projects. A sample of bill of quantities is shown in Figure D of Appendix 10.

If interim valuations are strictly based on the original contract bill of quantities, it will be too cumbersome in time and efforts for the monthly submissions to be tackled by the quantity surveyors of both parties. Under most standard forms of contract, the format of interim application is not fixed by the conditions but it will allow a flexibility to the contract supervisor to decide the type and format of interim payment submissions. Clause 78 (2) of the General Conditions of Contract mentioned in Section 10.3.2 above refers.

In most cases the original contract bill of quantities will be the basis for forming a manipulated bill by grouping and manipulating the bill items of original contract bill. "CCMS" cost-control sub-system provides a function to aid the preparation of manipulated bills. A manipulated bill item includes the following data:

- code;
- bill number;
- trade;
- subhead;
- description;
- total quantity;
- accumulated complete quantity;
- previous complete quantity;
- rate/unit; and
- the related items of the original bill of quantities.

A sample input screen for manipulated main contract bills is shown in Figure 10.3.2 (a).

| Main Contract Operational Bills |                                  |           |      |      |
|---------------------------------|----------------------------------|-----------|------|------|
| Item Code                       | Name F2 to edit; Alt-F2 BQ       | Total Qty | Unit | Rate |
| 04-BLK-03-01                    | 190 mm thick wall                | 459.00    | m2   |      |
| 04-BLK-03-02                    | 190 mm thick wall & dwarf wall   | 345.00    | m2   |      |
| 04-BLK-04                       | S Hollow concrete block "Besser" | 34.00     |      |      |
| 04-BLK-04-01                    | 75 mm thick dwarf wall           | 490.00    | m2   |      |
| 04-BLK-05                       | S Hollow concrete blocks         | 0.00      |      |      |
| 04-BLK-05-01                    | 75 mm thick wall                 | 33,368.00 | m2   |      |
| 04-BLK-05-02                    | 100 mm thick wall                | 8,732.00  | m2   |      |
| 04-BLK-05-03                    | 150 mm thick wall                | 2,156.00  | m2   |      |
| 04-BLK-05-04                    | 300 mm thick filling in          | 23.00     | m2   |      |
| 04-BLK-06                       | S Hollow concrete blocks         | 0.00      |      |      |
| 04-BLK-06-01                    | 200 mm thick infill panel wall   | 159.00    | m2   |      |
| 04-BLK-06-02                    | 300 mm thick wall                | 60.00     | m2   |      |
| 04-BLK-07                       | 450 mm hollow block              | 100.00    | m2   |      |
| 04-BLK-08                       | 450 mm Hollow Block with         | 150.00    | m2   |      |

F3 to save; F4 to save; F5 to add; [Esc] to leave

|              |                |
|--------------|----------------|
| Total Amount | \$6,530,572.80 |
|--------------|----------------|

Bills => BILL 4  
 BLOCK 6-9 SUPERSTRUCTURE & FINISHIN  
 Press [=] to list items for selection

Trades => BRICKLAYER  
 Head => BLOCKWORK

Figure 10.3.2.(a)  
 The Manipulated  
 Bill Input Screen  
 for Main Contract  
 Bills.

### 10.3.3 Valuation for Measured Items

In construction contracts under the traditional procurement system, the measured works should be contained in the bill of quantities, otherwise, theoretically it should be a variation or a claim. As explained in Section 10.3.2 above, for interim application purpose the bill of quantity will be converted to a kind of manipulated bill with the format to be agreed with the consultant quantity surveyor. In practice, due to the volume of data in bill of quantities and the workload of site quantity surveyors, the first version of manipulated bill may not be able to cover the entire original contract bill but may be just enough to satisfy the contemporary interim payment purpose. The development of the manipulated will then be in line with the work progress. With the use of computers as described in Section 10.3.2 above, the efficiency for the preparation of manipulated bill should be much increased.

For example in case of construction contracts for repetitive high-rise building, the total value of external wall mosaic tile paving may be grouped together in one manipulated bill item and it will be evaluated by the number of floors completed for interim payment.

Ndekugri (1986) identified the sources of data on site for interim valuations as follows:

- cost records,
- invoices/receipts,
- sub-contractors' payment applications,
- program/progress schedules,
- daywork sheets/dayworks accounts,

- analysis of stages of construction
- site measurement,
- the contract documents.

It is the duty of the site quantity surveyor to find out the above information for each interim valuation. According to the study in Hong Kong, most site quantity surveyor have to spend quite a lot time on the calculation and documentation works. If such works can be replaced by the use of computers, they can have more time and efforts to put on the measurement and valuation works, by which the quality of interim payment should be increased. This should also aid the consultant quantity surveyor in their verification works.

The payment for the measured works will be governed by the conditions of contract. Most standard forms allow payments for the permanent work executed provided that the workmanship and the standard of the completed work are complied with the contract requirements. But for the temporary works, it will only be paid if there is a separated bill for the temporary works. In accordance with Clause 79 (1) (a) and (b) of the Hong Kong Government General Conditions of Contract for Civil Engineering Works 1990 Edition, it states:

".....the sum based on the rates in the Contract where appropriate, in respect of the following:

- (a) the estimated value of the permanent work executed, and
- (b) the estimated value of any Temporary Works or preliminary item for which a separate sum is provided in the Bill of Quantities, and ....."

In case of the application of "CCMS" in interim valuation for measured works, for each application the following information have to be updated for each item of the manipulated bill:

- a) the agreed and certified quantity from the immediately last payment which should be converted to be the previous payment for this application by the consolidating function.
- b) input the accumulated quantity of the work completed for this interim application.

A sample input screen for the interim valuation of measured items is shown in Figure 10.3.3 (a).

| Main Contract - Interim Payment |                              |          |          |        |
|---------------------------------|------------------------------|----------|----------|--------|
| Item Code                       | Description                  | This Qty | Accu Qty | Bill Q |
| BLK-03-02                       | 190 mm thick wall & dwarf wa | 0.00     | 0.00     |        |
| BLK-04                          | Hollow concrete block "Besse | 34.00    | 34.00    |        |
| BLK-04-01                       | 75 mm thick dwarf wall       | 44.00    | 100.00   |        |
| BLK-05                          | Hollow concrete blocks       | 0.00     | 0.00     |        |
| BLK-05-01                       | 75 mm thick wall             | 45.00    | 45.00    | 33.    |
| BLK-05-02                       | 100 mm thick wall            | 67.00    | 67.00    | 8.     |
| BLK-05-03                       | 150 mm thick wall            | 67.00    | 67.00    | 2.     |
| BLK-05-04                       | 300 mm thick filling in      | 67.00    | 67.00    |        |
| BLK-06                          | Hollow concrete blocks       | 450.00   | 450.00   |        |
| BLK-06-01                       | 200 mm thick infill panel wa | 60.00    | 60.00    |        |
| BLK-06-02                       | 300 mm thick wall            | 30.00    | 30.00    |        |

F3 to save; F5 to add; F6 to delete F7 to consolidate

| Total Summary |                |            |                |
|---------------|----------------|------------|----------------|
| Original Bill | \$6,530,572.80 | Prev Value | \$3,500.00     |
| Accu. Value   | \$2,118,800.50 | This Value | \$2,115,300.50 |

Bills => BILL 4                      Trades => BRICKLAYER  
 BLOCK 6-9 SUPERSTRUCTURE & FINISHIN      Head => BLOCKWORK  
 Press [ ] to list items for selection  
 BLOCK 6-9 SUPERSTRUCTURE & FINISHIN

Figure 10.3.3.(a)  
Input Measured  
Items for Interim  
Application.

#### 10.3.4 Valuation for Preliminaries

Barnes (1977) defined that the preliminary bill covers the contractor's site overheads expenses which are usually incurred on items of an organisational and general nature and which are not restricted to any particular work section. Ramus (1981) distinguished four main types of items in a preliminaries bill as follows:

- time related preliminaries;
- cost related preliminaries;
- single-payment preliminaries; and
- composited items (a combination of the above).

The methods of valuation for preliminaries in construction projects have been well tacked by the previous literatures (Barnes 1977, Ramus 1981, Turner 1983, Seeley 1984, Ndekugri 1986, Abdullah 1988). According to the study in Hong Kong construction industry as described in Chapter 3, the interim valuation for preliminaries is generally complied with the methods established by the previous literature. But in view of the complicated nature of the construction projects in Hong Kong, the valuation for preliminaries will be in the sense of items by items. The payment method for composited items will be divided into the following categories:

- Set up cost - payment will be made at the initial stage of project;



- b) Progress related cost - payment will be made in parallel with the construction progress; and
- c) Take out cost - payment will be made at the final stage of the contract.

For example an item in the preliminaries is for 'setting up the site office for the Resident Engineer'. In this item the value involves the setting up site office, the maintenance of the site office during the construction period, and finally to dismantle the office and cart away the office materials after the contract is completed. Before the contract is started, both the site quantity surveyor and the client's consultant quantity surveyor, have to agree on the proportions of percentage for each preliminary items in respect of the above mentioned three payment categorise. However, as a matter of convenience, the calculation of 'progress related cost' will be either by time-related method or cost-related method for all the composited items of the preliminary bill. In fact the progress related cost of some of the preliminary items may be fair to be evaluated by time-related method rather than by cost-related method or vice versa.

"CCMS" cost-control sub-system provides a function to value the progress related cost of preliminaries by both time-related and cost-related methods. The nature of individual preliminary item should be considered separately in terms of its nature. The Sub-system allows the user to assign whether time related or cost related method should be used for each individual item. A sample input screen for preliminary items is shown in Figure 10.3.4 (a).

| Preliminaries Interim Valuation |                  |                 |                |                |   |
|---------------------------------|------------------|-----------------|----------------|----------------|---|
| Item No                         | Description [F2] | Contract Amount | Initial Amt    | Progress Amt   | M |
| 1/08/GCC6                       | Drawings         | \$4,480,000.00  | \$38.00        | \$70,000.00    |   |
| 1/09/GCC12                      | Sureties or secu | \$70,000.00     | \$0.00         | \$60,000.00    |   |
| 1/10/GCC17                      | Contractor's sup | \$3,200,000.00  | \$0.00         | \$800,000.00   |   |
| 1/10/GCC18                      | Contractor's emp | \$3,930,000.00  | \$0.00         | \$3,102,161.00 |   |
| 1/10/GCC19                      | Setting-out      | \$1,320,000.00  | \$218,000.00   | \$4,582,000.00 |   |
| 1/10/GCC20                      | Safety & securit | \$400,000.00    | \$0.00         | \$100,000.00   |   |
| 1/12/GCC26                      | Accident or inju | \$2,170,000.00  | \$0.00         | \$1,930,000.00 |   |
| 1/13/GCC30                      | Compliance w/ en | \$685,000.00    | \$0.00         | \$1,188,000.00 |   |
| 1/14/GCC38                      | Site cleanliness | \$400,000.00    | \$0.00         | \$890,000.00   |   |
| 1/18/GCC73                      | Removal of const | \$0.00          | \$0.00         | \$4,629,000.00 |   |
| 1/20/SCC21                      | Quality control  | \$440,000.00    | \$0.00         | \$480,000.00   |   |
| 1/21/SCC23                      | Apprentice const | \$200,000.00    | \$0.00         | \$500,000.00   |   |
| 1/21/SCC27                      | Care of works in | \$930,000.00    | \$0.00         | \$1,100,000.00 |   |
| 1/22/ASCC2                      | Large Panel Form | \$430,000.00    | \$4,713,056.00 | \$486,744.00   |   |
| 1/23/GS1.18                     | Fire precautions | \$0.00          | \$0.00         | \$150,000.00   |   |
| 1/23/GS1.31                     | Watchmen/Securit | \$0.00          | \$0.00         | \$1,000,500.00 |   |
| 1/24/GS1.32                     | Storage sheds    | \$100,000.00    | \$52,000.00    | \$343,000.00   |   |

[F3]-save; [F5]-add; [F6]-delete

Interim Payment Number [=] I. P. NO 1

Figure 10.3.4 (a)  
Input for  
Preliminary Items  
for Interim  
Applications.

### 10.3.5 Valuation for Unfixed Materials

The principles and details of the valuation for unfixed materials are stated in Section 9.9 as part of the material control sub-system. The monthly quantities of materials delivered to site will be passed from the Material Control Sub-system to support the valuation of unfixed materials. The quantities of materials used in executed permanent works will be based on measured works plus a acceptable wastage agreed between the consultant quantity surveyor and the site quantity surveyor.

Before using the Sub-system for the valuation of unfixed materials, it needs to establish the linking between the manipulated bill and the master materials procurement file. A link up file is used to establish the relationship between the interim valuation and the material control with the details as follows:

- a) manipulated bill code,
- b) master material code,
- c) description reference,
- d) percentage of wastage,
- e) conversion figure/unit.

The value of unfixed materials can be derived by the materials delivered to site minus the materials used in the measured works plus wastage. A sample input screen for the valuation of unfixed materials is shown in Figure 10.3.5 (a).

| Unfixed Materials Interim Valuation |                      |              |          |           |        |
|-------------------------------------|----------------------|--------------|----------|-----------|--------|
| Item No                             | Description          | Tot Del. Qty | Mat unit | Comp. Qty | Wrk Un |
| A-23                                | Ext. Wall Mosaic Til | 3,000.00     | boxes    | 300.00    | m2     |
| A-24                                | Ext. Wall Mosaic Til | 25,262.00    | boxes    | 1,000.00  | m2     |
| A-25/A-40                           | Ext. Wall Mosaic Til | 6,363.00     | boxes    | 578.00    | m2     |
| A-90                                | Ext. Wall Mosaic Til | 3,636.00     | boxes    | 635.00    | m2     |
| AA01                                | Int. Wall Mosaic Til | 4,363.00     | boxes    | 700.00    | m2     |
| ABC                                 | Int. Ceramic Floor T | 36,323.00    | Nes      | 237.00    | m2     |
| AT-45/s                             | Int. Colour Glazed C | 25,266.00    | Nes      | 189.00    | m2     |
| AT-48/s                             | Int. Colour Glazed C | 63,427.00    | Nes      | 436.00    | m2     |
| AT-52/s                             | Int. Colour Glazed C | 626,272.00   | Nes      | 2,360.00  | m2     |
| AT-8/s                              | Int. Colour Glazed C | 367,276.00   | Nes      | 350.00    | m2     |
| B-34                                | Ext. Wall Glass Mosa | 36,336.00    | boxes    | 363.00    | m2     |
| B-67                                | Ext. Wall Mosaic Til | 36,360.00    | boxes    | 747.00    | m2     |
| FT01                                | Int. Flat Tile (Diam | 763,473.00   | Nes      | 12,456.00 | m2     |
| IJ-42                               | Int. Wall Mosaic Til | 3,677.00     | boxes    | 478.00    | m2     |
| IJ-48                               | Int. Wall Mosaic Til | 47,483.00    | boxes    | 2,267.00  | m2     |
| IJ-57-W                             | Int. Wall Mosaic Til | 43,783.00    | boxes    | 7,477.00  | m2     |
| IJ-57/s                             | Int. Mosaic Tile 18x | 474,377.00   | boxes    | 20,455.00 | m2     |

[F3]-save; [F5]-add; [F6]-delete

Material Types [\*] TILES

Figure 10.3.5 (a)  
Interim Valuation  
for Unfixed  
Materials.

### 10.3.6 Calculation of Cost Fluctuation

Construction contracts involve with the distributions of risks, within which one of the significant risks is the cost escalation due to the price inflation. The conditions of contract will decide on the distribution of such a risk. Even the client puts the risk of price fluctuation to the contractor in the tender document, still the tenderer will allow such risk in their tender price. In most standard forms of contract, there has a clause for contract price fluctuations which provides for the adjustment of the net increase or decrease in the cost of labour and/or materials after the date of tender. Seeley (1988) identified two methods for the assessment of the value of fluctuations. They are:

- assessment by analysis, and
- NEDO price adjustment formula.

The NEDO formula was introduced in 1977 by the Property Services Agency as an alternative to the method of assessment by analysis. Two basic documents from the Property Services Agency was issued in 1977, namely:

- 'Description of the Indices';
- 'Guide to Application and Procedure'

The principle of NEDO formula has been adopted in the practice of Hong Kong public contracts for the assessment of price fluctuations. In accordance with Clause 89 of the Government of Hong Kong General Conditions of Contract for Civil Engineering Works 1990 edition, it states the details of the procedures to assess the value of contract price fluctuations for interim valuation. An example of calculation using this method is shown in Figure E of Appendix 10.

"CCMS" cost-control sub-system provides a function to calculate the cost fluctuations for interim applications based on Hong Kong public work formula approach. The indices used for this assessment should be the index figures listed in the "Index numbers of the costs of labour and selected materials used in Government Contracts" compiled by the Census and Statistics Department of the Government of Hong Kong. The Sub-system requires the user to put the following data after the start of the contract:

- The 'base index figure': It is the index figure applicable to the date 42 days prior to the date for the return of tenders.

- The proportions inserted by the contractor in the Schedule of Proportions submitted with the tender.

For each monthly valuations, the 'Current Index Figure' as defined in Clause 89 (2) (c) of the Hong Kong Government Standard Form should be input into the Sub-system. The Sub-system can base on these information to calculate the monthly consolidated price fluctuation factor. The increase or decrease in the fluctuation cost payable for such month, should be calculated by multiplying the 'effective value' defined in Clause 89 (2) (d) by the monthly consolidated price fluctuation factor. Sample input screens for fluctuation calculation are shown in Figure 10.3.6 (a), Figure 10.3.6 (b) and Figure 10.3.6 (c) respectively.

Ins

Cost Fluctuation Menu

0. Quit

1. Input for the Base Month

2. Input for Current Month

3. Input for Monthly Valuation

Return to Last Menu

Figure 10.3.6 (a)  
The Main Menu for  
Calculating  
Fluctuation Cost.

Index for the month -01/91-

| Seq | Descri                          | Base Index | Index  | Inc/Dec | Flu. Facto  |
|-----|---------------------------------|------------|--------|---------|-------------|
| 01  | Composite labour for building   | 245.30     | 271.20 | 10.55%  | 0.03859132  |
| 02  | Aggregates                      | 143.60     | 140.10 | -2.43%  | -0.00098407 |
| 03  | Portland cement (ordinary)      | 141.70     | 144.20 | 1.76%   | 0.00164211  |
| 04  | 6 mm and below mild steel round | 166.00     | 164.00 | -1.20%  | -0.00026627 |
| 05  | 10 mm to 40 mm high tensile st  | 164.50     | 163.90 | -0.36%  | -0.00044179 |
| 06  | Light structure steelwork       | 168.70     | 165.50 | -1.89%  | -0.00042727 |
| 07  | Timber formwork                 | 130.10     | 135.80 | 4.38%   | 0.00167583  |
| 08  | Hardwood                        | 139.30     | 141.90 | 1.86%   | 0.00020625  |
| 09  | Mosaic tile                     | 201.90     | 211.50 | 4.75%   | 0.00309183  |
| 10  | Glazed wall tiles               | 187.40     | 202.60 | 8.11%   | 0.00258538  |
| 11  | GMS pipes                       | 155.30     | 159.10 | 2.44%   | 0.00023918  |
| 12  | PVC pipes (not exc. 85 mm)      | 178.90     | 204.00 | 14.03%  | 0.00137145  |
| 13  | PVC pipes (exc. 85 mm)          | 181.80     | 210.10 | 15.56%  | 0.00152163  |
| 14  | Glass                           | 116.10     | 116.90 | 0.68%   | 0.00006736  |

[F3] to save; [Esc] to leave

Input for the month => 01/91

Index Sum

Consolidated Index

0.04887294

Figure 10.3.6 (b)  
Input Screen  
Current Cost  
Index.

| Calculation for the Monthly Fluctuation Cost |       |       |        |                 |                |            |
|----------------------------------------------|-------|-------|--------|-----------------|----------------|------------|
| IP N                                         | IP No | Month | Status | Val of Wrk Comp | Val of NSC     | Cur. Price |
| 01                                           | 01    | 10/90 | Firmed | \$2,199,466.89  | \$0.00         | \$0.       |
| 02                                           | 02    | 11/90 | Firmed | \$8,150,040.54  | \$0.00         | \$0.       |
| 03                                           | 03    | 12/90 | Firmed | \$10,946,504.95 | \$0.00         | \$0.       |
| 04                                           | 04    | 01/91 | Firmed | \$23,265,513.88 | \$6,196,080.00 | \$0.       |
| 05                                           | 05    | 02/92 | Firmed | \$35,278,548.46 | \$6,328,194.00 | \$0.       |

[F3] to save; [F5] to add; [F6] to delete

|                   |
|-------------------|
| Total Fluctuation |
| Total Amount HK\$ |
| \$1,213,208.36    |

Figure 10.3.6.(c)  
The Calculation of  
Accumulated  
Fluctuation Cost.

### 10.3.7 Valuation for Nominated Subcontracts

Most standard forms of construction contracts, allow the Employer or his professional advisers to order the Main Contractor to enter into a sub-contract with a specified sub-contractor, in accordance with the specific form of contract and procedures stated in the main contract. This practice is called 'nomination' and such a subcontractor is called 'nominated subcontractor'. Shoesmith (1984) pointed out that the value of nomination works in commercial buildings of Hong Kong could be in a range from 40% to 60% of the main contract value.

The interim payment of nominated subcontracts should be included as part of the interim payment of main contracts according to most of the standard forms for main contracts and subcontracts. In accordance with Clause 79 (1) (d) of the Hong Kong Government General Conditions of Contract for Civil Engineering Works 1990 Edition, it states:

".....the sum based on the rates in the Contract where appropriate, in respect of the following:

.....  
(d) the estimated sums payable in respect of Nominated Sub-contractors  
....."

Based on the nominated subcontract value, the main contractor can add on their percentage of overhead and profit, the rate of which should be subject to the contract terms.

"CCMS" cost control sub-system includes a function to handle the interim payment of nominated subcontract accounts. The information is mainly based on the interim payment applications from the nominated subcontractors. The data input will be categorised into different nominated subcontracts. The following details will be put into the Sub-system for each nominated subcontract application:

- a) Interim payment reference;
- b) Date of interim application;
- c) Brief application description;
- d) Value of accumulated amount;
- e) Value of last certified amount; and
- f) Remark.

A sample input screen for nominated subcontract interim valuation is shown in Figure 10.3.7 (a).

| Nominated Subcontract Interim Valuation |          |                     |                |              |              |
|-----------------------------------------|----------|---------------------|----------------|--------------|--------------|
| IP No                                   | Date     | for the Period      | Accu Amount    | Last Amount  | This Amount  |
| 01                                      | 01-09-91 | 28 Jul 91-27 Aug 91 | \$242,520.00   | \$0.00       | \$242,520.00 |
| 02                                      | 01-10-91 | 28 Aug 91-27 Sep 91 | \$361,278.00   | \$242,520.00 | \$118,758.00 |
| 03                                      | 01-11-91 | 28 Sep 91-27 Oct 91 | \$427,678.00   | \$361,278.00 | \$66,400.00  |
| 04                                      | 01-12-91 | 28 Oct 91-27 Nov 91 | \$527,346.00   | \$427,678.00 | \$99,668.00  |
| 05                                      | 01-01-92 | 28 Nov 91-27 Dec 91 | \$641,789.00   | \$527,346.00 | \$114,443.00 |
| 06                                      | 01-02-92 | 28 Dec 91-27 Jan 92 | \$746,982.00   | \$641,789.00 | \$105,193.00 |
| 07                                      | 01-03-92 | 28 Jan 92-27 Feb 92 | \$826,526.00   | \$746,982.00 | \$79,544.00  |
| 08                                      | 01-04-92 | 28 Feb 92-27 Mar 92 | \$931,424.00   | \$826,526.00 | \$104,898.00 |
| 09                                      | 01-05-92 | 28 Mar 92-27 Apr 92 | \$1,025,252.00 | \$931,424.00 | \$93,828.00  |

[F3]-save; [F5]-add; [F6]-delete

Type of Nominated Subcontract [=] ELECTRICAL INSTALLATION

Figure 10.3.7.(a)  
The Input Screen  
for Nominated  
Subcontract  
Interim Valuation.

### 10.3.8 Valuation for Daywork

Seeley (1988) has defined that daywork is a method of payment for work based on the prime cost of all labour, materials and plant used in carrying out of the work normally with a percentage addition to the total cost of each of the three groups items for overheads and profit. The details and applications of daywork may have slightly differences subject to different standard forms of contract such as:

- a) JCT Conditions of Contract Clause (13.5.4)

Defines daywork as "a type of valuation for work which cannot be properly valued by measurement:..

- b) ICE Contract Conditions Clause (52.3) and FIDIC Clause (52.4)

Explains that "the Engineer may if in his mind it is necessary or desirable, order in writing that additional or substituted work shall be executed on a day work basis".

The Hong Kong Government Standard Form of Contract applies the similar approach as ICE and FIDIC on dayworks. But the HKIA private standard form of contract for building works uses the JCT approach for dayworks.

Gerrity (1980) has laid down a set of useful guide-lines for the preparation of daywork as follow:

- a) Each daywork sheet must state with a specific reference number of site instruction or variation order.
- b) Daywork sheets should be submitted with the main contractor's site authorised signature. Submissions from nominated subcontractors should go through the main contractor.
- c) Daywork sheets must be submitted in time to comply with the contract requirement. (In JCT it is by week. In Hong Kong Government Form it is by day).
- d) Daywork sheet should properly describe the work done. It is not a good practice to prepare the daywork sheet in such a way that only minimal space is allowed for the description of the work.
- e) All expenses in terms of labour, plant and materials involving with the daywork must be recorded in detail and cognisance should be taken for any temporary work only one possible use for the daywork.
- f) All relevant drawings, sketches, instructions and delivery notes for a particular daywork must be recorded and retained on site.

Ndekugri (1986) and Abdullah (1988) derived a design of data file to record the details of dayworks in computers. Having taken into consideration of both Ndekugri and Abdullah's works and the study in Hong Kong construction industry, "CCMS" has included a function to handle daywork records on site. The first part of the function is to record the identity of dayworks with the details as follows:

- a) dayworks sheet reference/date;
- b) corresponding instruction reference/date;
- c) description of task;
- d) total amount;
- e) commencement/completion dates;
- f) subject to retention or not;
- g) location of works;
- h) activity on site affected; and
- i) remark

The second part of the function is to record the following details of the resources used in any particular daywork:

- a) job cost code;
- b) resource name;
- c) quantity of resources;
- d) unit price; and
- e) date of use.

With the use of "CCMS" cost control sub-system to handle daywork accounts, the improvements over the previous systems are as follows:

- a) There is no limit in characters for the input of daywork description. This is in line with the comments from Gerrity (1980) regarding the details of daywork description.
- b) There is an additional remark field to input the background information of dayworks. It allows a greater flexibility to record the contemporary information of dayworks such as the effects to the original contract works and disruptions etc.
- c) The data input for resources and other repetitive fields such as locations of work and work activities etc, can be selected from the pop-up windows.
- d) The payment for the resources used in dayworks, can be integrated with the relevant job cost identity as part of liability for payment.
- e) The daywork sheet for submission to the contract supervisor, can be directly print out from the Sub-system. This will save up the manual procedure of filling in form for formal submissions.

A sample screen showing the input of daywork is shown in Figure 10.3.8 (a). A sample computer printout of daywork sheet are shown in Figure F and of Appendix 10.



Details of Dayworks D-011

Ref No : D-011      Instruction No : A123  
 Instruction Date : 01-12-91

Description : Excavate extra marine mud from DL-12 to DL-18 of the sea water pipe.

Start Date : 10/12/91      Complete Date : 14/12/91

Location of the Work(=) EXTERNAL WORKS  
 Original Activity to be affected (=) SEA WATER SYSTEM

Remark [F2] to edit memo

-----

Access to the cost breakdown F

[F3] to save

[F2]-details; [F3]-save; [F5]-add; [F6]-delete

Figure 10.3.8.(a)  
 Daywork Interim  
 Valuation Input  
 Screen.

### 10.3.9 Valuation for Variations

Under traditional procurement systems, construction projects are inevitably to have involving with changes and alterations in terms of design and its associated implications. Hibberd (1986) stated that 'variation' in the generic sense refers to any alteration to the basis upon which the contract was let. In terms of the concept of variations in construction projects, Hibberd outlined the two streams of application as follows:

- a) Variations according to the provisions of the standard forms of construction contract, including expenditures for provisional sums and other implications etc. ; and
- b) Variation of contract in law by further agreement between both parties.

In this research, the valuation of variations sticks to the item a) mentioned above. Most standard forms of construction contract should have included provisions for variations (Clause 13.1.1 JCT 80; Clause 11 of HKIA 63; Clause 60 HK Government 1990 etc.).

Upton (1987) pointed out that the valuation of variations should be included as soon as possible in the interim valuation as part of the total value of work executed. Upton further stressed that in practice there is a often a tendency for such accurate measurement and valuation to be delayed by either the client's quantity surveyor or the contractor's surveyor or both until after practical completion of work. In most cases, variations often involve with additional

costs to the total contract value, which may induce financial burden to the contractor. Therefore a prompt response to include the additional value of variations into the immediately next interim payment application, will be beneficial to the contractor as a safe guard to the cash flow.

'CCMS' cost control sub-system includes a function to accommodate variation accounts and incorporate such amounts into the contemporary interim payment application. Hibberd (1986) indicated the relationship between instructions and variations that not all instructions will be variations but a variation under contract should be supported with instructions. In most cases, claims for variation payment should be initiated from the contractor, for which sufficient supporting documents. For archiving this objective, the Sub-system allows a link up of the variation account function to the instruction register provided by the information control sub-system.

In the Sub-system, the variation account is accommodated in the database file with the following fields:

- a) Variation reference;
- b) Date of payment claim initiation;
- c) Brief description of variation;
- d) Amount of total claim value;
- e) Amount of last payment;
- f) Amount of accumulated payment; and
- g) Remark.

A sample input screen for variation accounts is shown in Figure 10.3.9 (a).

| Variation Interim Valuation        |                  |                |                |                         |          |
|------------------------------------|------------------|----------------|----------------|-------------------------|----------|
| VO Ref                             | Description [F2] | Clm Date       | Claim Amount   | Accum Amt               | Last Amt |
| FW-01                              | Change of extern | 01-02-91       | \$256,266.00   | \$100,000.00            | \$0.     |
| FW-02                              | Change of cerami | 16-03-92       | \$3,373,732.00 | \$152,525.00            | \$0.     |
| [F3]-save; [F5]-add; [F6]-delete   |                  |                |                |                         |          |
| Total Summary                      |                  |                |                |                         |          |
| Total Claim                        |                  | \$3,629,998.00 |                | Prev Value \$0.00       |          |
| Accu. Value                        |                  | \$252,525.00   |                | This Value \$252,525.00 |          |
| Variation Types [=] FINISHING WORK |                  |                |                |                         |          |

Figure 10.3.9.(a)  
Input for Interim  
Valuation for  
Variation  
Accounts.

### 10.4 Monitor of Project Expenditures

The study in Hong Kong Construction industry and its development as described in Chapter 3 and Chapter 4 show that it is the tendency of management practice in the construction industry for the monitoring of project expenditures and cost control to be put on site. But the payment for the project accounts certified on site, will be controlled by the account department of the head office.

The tasks of quantity surveying management function described in Section 6.7.3 included the control and monitor of project expenditures. 'CCMS' cost control sub-system incorporates a provision to handle project expenditures on site. The details are described in the following sections. The input screen for monitoring project expenditures is shown in Figure 10.4 (a).

```

 Ins Caps

 | Monitor Project Expenditure Menu |
 |_____|
 | |
 | 0. Quit |
 | |
 | 1. Subcontract I.P. |
 | |
 | 2. Site Overhead Costs |
 | |
 | 3. Contingency Costs |
 | |
 |_____|
 | Return to Main Menu |
 |_____|

```

Figure 10.4 (a)  
Main Input Menu  
for Monitoring  
Project  
Expenditures.

#### 10.4.1 Interim Payment for Subcontract

The principle of the needs of interim payments for main contracts should also been applied to subcontracts. According to the study in Hong Kong construction industry as described in Chapter 3, handling interim payments for different trades of sub-contractors, is one of the major workloads of site quantity surveyors. Another drawn back of this issue in Hong Kong is the use of Chinese characters for most domestic subcontracts. This makes the subcontract payment difficult to be handled by computers using standard commercial packages.

"CCMS" cost control sub-system has designed a function to handle the subcontract payments capable of using both English and Chinese character input. For handling Chinese characters, it is regarded as the further development of the Sub-system through the future researches. The input will be classified by the category of trades and subcontractor name. The following information for the interim payment have to be updated in each item of the subcontract bill:

- a) the agreed and certified quantity from the immediately last payment which should be converted to be the previous payment for this application by the consolidating function.
- b) input the accumulated quantity of the work completed for this interim application.

A sample screen showing the input of subcontract interim valuation is illustrated in Figure 10.4.1 (a).

| Subcontract Bill - Interim Payment |                              |          |          |        |
|------------------------------------|------------------------------|----------|----------|--------|
| Item Code                          | Description                  | Prev Qty | This Qty | Accu Q |
| PY07-9                             | Precast Conc. Unit - Typical | 16.00    | 0.00     |        |
| PY08-8                             | Precast Conc. Unit - Roof    | 16.00    | 0.00     |        |
| PY08-9                             | Precast Conc. Unit - Roof    | 0.00     | 1.00     |        |
| PY09-8                             | Conc. Wall Steel Bar Drillin | 22.00    | 0.00     |        |
| PY09-9                             | Conc. Wall Steel Bar Drillin | 22.00    | 0.00     |        |
| PY10-8                             | Conc. Wall Steel Bar Drillin | 0.00     | 1.00     |        |
| PY10-9                             | Conc. Wall Steel Bar Drillin | 0.00     | 1.00     |        |

F3 to save; F5 to add; F6 to delete; F7 to consolidate

| Total Summary |                |            |                |
|---------------|----------------|------------|----------------|
| Original Bill | \$2,361,550.00 | Prev Value | \$3,291,070.33 |
| Accu. Value   | \$3,294,070.33 | This Value | \$3,000.00     |

Trades => Concretor      Subcontracts => Ping Loy  
Press [=] to list items for selection

Figure 10.4.1.(a)  
Input for  
Subcontract  
Interim  
Valuations.

The interim payments for subcontracts should also be covered by the job cost identity (3rd level of the standard cost codes) as described in Section 10.2.4 above. Such payments in the 'Monthly Project Cost Status' report as described in Section 10.2.1 above, are treated as the expenditures for corresponding item code (2nd level of the standard cost codes) and will be compared to the corresponding incomes from the main contract interim payment.

### 10.4.2 Direct and Site Overhead Cost

Barrett (1981) and Seeley (1988) have explained that on a construction project a distinction is usually drawn between site overheads and company overheads, for which the contractor is generally reimbursed for his site overheads by means of the contract preliminaries or sometimes by sums added to the rates contained in the bill of quantities.

In terms of the control for site overhead, Abdullah (1988) pointed out that in his survey on the construction company systems as well as the software available in the market it was found that there was still no consideration in controlling the preliminaries in their systems. According to the study in Hong Kong construction industry as described in Chapter 3, some of the sophisticated contractors have their tailor-made system to control the site overheads through an account orientated approach.

In the application of "CCMS" cost control sub-system for overhead control, it will be based on the standard cost codes as described in Section 10.2.2 above. Accordingly, there is a set of separated standard cost items for site overheads. A sample list is similar to Figure B of Appendix 10. Those items will be come out on the 'Monthly Project Cost Status' reports showing the incomes from the interim payment and the actual expenditures of the corresponding month for each item. The actual expenditure of each item will be input through the job cost code (the 3rd level of the standard cost code) as described in Section 7.6.2.4 above.

For each expenditure entry, firstly the user has to select the cost type through a pop-up window e.g. labour, plant, material, subcontract, preliminaries or daywork etc which represents the 1st level of the standard cost code. A short-listed standard items (2nd level of the standard cost codes) based on the selected cost type will be listed on another pop-up window. After having selected the cost item, the final pop-up window will be turned up showing the assigned job cost identities for such a cost item (3rd level of the standard cost codes), which has been assigned through the procedures as described in Section 10.2.4 above. Accordingly an input screen in schedule form will come out showing the items of previous entries and allow the user to add updated information with the following data:

- a) Date of this expenditure (liability admitted date);
- b) Reference if any;

- c) Brief description;
- d) Amount; and
- e) Remark.

The screens showing the handling of direct and site overhead cost are illustrated in Figure 10.4.2 (a) and Figure 10.4.2 (b).

| Actual Cost Capturing |          |                    |                           |     |
|-----------------------|----------|--------------------|---------------------------|-----|
| Ref                   | Date     | Account Ref [=]    | Description               | Rat |
| A01                   | 12-09-91 | HK Telephone - H09 | August Monthly Payment    | \$  |
| A02                   | 12-10-91 | HK Telephone - H10 | September Monthly Payment | \$  |
| A03                   | 12-11-91 | HK Telephone       | October Monthly Payment   | \$  |
| A04                   | 12-12-91 | HK Telephone       | November Monthly Payment  | \$  |
| A05                   | 01-02-92 | HK Telephone       | December Monthly Payment  | \$  |
| A06                   | 01-11-92 | HK Telephone       | November Monthly Payment  | \$  |

F2=full edit; F3=save; F5=add record; F6=delete; F9=sum

Job Cost Code Heads PRELIMINARIES  
 Job Cost Code Items TELEPHONE  
 Press [Return] to select from the list

Figure 10.4.2.(a)  
Input Screen for  
Direct and Site  
Overhead Cost.

| Actual Cost Capturing        |          |                   |         |
|------------------------------|----------|-------------------|---------|
| Calculation Summary          |          |                   |         |
| Tender Cost Plan :           | \$16,000 |                   |         |
| Est Cost Plan :              | \$22,000 | budget variance : | \$6,000 |
| Actual Cost Up to : 01-11-92 |          |                   |         |
| Total Amount :               | \$12,200 |                   |         |
| Progress % :                 | 55.45    |                   |         |

Job Cost Code Heads PRELIMINARIES  
 Job Cost Code Items TELEPHONE  
 Press [Return] to select from the list

Figure 10.4.2.(b)  
Output of Site  
Overhead Cost by  
Comparing to the  
Budget.

### 10.4.3 Contingency Work Control

According to the study in Hong Kong construction industry as described in Chapter 3, in addition to the daywork described in Section 10.3.8, there is another kind of work valuation on site based on prime cost principle called 'contingency work'. The format of contingency work is similar to daywork, but the nature is different. Daywork is a

contractual requirement and should be initiated by the contract supervisor with a proper instruction, under which any associated costs should be reimbursed from the client based on the terms of contract. However, the nature of contingency work are as follows:

a) The work purposes may be due to the following needs:

- rectifying defects or errors due to the main contractor himself;
- additional works or variation works from the contract supervisor not in daywork nature but for some reasons it is out side the scope of the original subcontracts on site. It may also be too late to call up tender for further subcontracting or the re-calling sub-contract price is too high to be acceptable;
- really urgent nature e.g. remedial works after storm.
- an intentional arrangement by the site management due to some reasons.

b) The works are executed by the direct resources of contractors.

In Hong Kong, most construction works will be *sub-letted* and the speed of construction activity is very high. In general, the volume of contingency work should reflect the extent of problem areas on site. Therefore it is necessary to have a control mechanism to monitor the expenditures of contingency work.

"CCMS" cost control sub-system includes a function to record the expenditures of contingency work. The contingency work will be included as an item in the cost budget report and the cost status report. The budget of contingency work will be assessed by a percentage of the contract value based on the previous feedbacks of any and/or the experience of estimator. The amount of actual expenditures for contingency works will be compared with the budget in order to alert the management for any overrun. The data input for an event of contingency work includes two parts similar to the data input for dayworks. The first part of the function is to record the identity of dayworks with the details as follows:

- a) Contingency work reference/date;
- b) Description of task;
- c) Commencement/completion dates;
- d) Total amount;

- e) Location of works;
- f) Activity on site affected; and
- g) Remark

The second part of the function is to record the following details of the resources used in any particular contingency work:

- a) Resource name;
- b) Quantity of resources;
- e) Unit price; and
- f) Date of use.

A sample screen showing the input of contingency work is illustrated in Figure 10.4.3 (a).

```

Actual Cost Capturing
Full Edit

Reference No A01 Amount $ 1,500.00
Work Date 01-02-92 Report Date 10-02-92
Account Reference [=] Chung Kee Transport
Description 2/F dismantle the completed partition
 wall as instructed by the COW.
Location [=] Block 6
Work Type [=] Brick & Block Work
Remark The details are shown in the sketch D356-89
Contractual Nature [=] Rectify Defects
[F3] to save

```

Figure 10.4.3.(a)  
Input for  
Contingency Work.

## 10.5 Summary of the Aids to Cost Control

The system design of "CCMS" cost control sub-system has taken into account the recommendations from the previous researches and the findings from the study in Hong Kong construction industry. In summary, its contributions to cost control on site are as follows:

- a) Most functions in the Sub-system are used to replace the manual practices of cost and vicarious accounting works on site, which will have been done even without the use of computers. Therefore it should not create much extra burden to site management by the use of the Sub-system.



- b) The printouts from the Sub-system can be directly submitted to the contract supervisor as formal submissions such as interim payment applications and daywork sheets.
- c) Subcontract payments can be handled in the computer, with the output in Chinese characters. This should increase much the efficiency of subcontract payment jobs on site.
- d) Cost handling works involve quite a lot of arithmetic calculations, for which the use of computers should reduce the chance of arithmetic errors. It is especially significant in the calculation of contract cost fluctuations.
- e) The budget reports from the Sub-system provide the monthly feedback of the finance performance of project by comparing the incomes and the expenditures for each standard cost items.
- f) The report showing the financial status of contingency works, acts as a means to reflect and disclose the problem areas on site. It was proved to be an effective measure for the quality of management on site by the system field test as described in Chapter 13.

## **11 Planning and Progress Control Sub-system.**

### **11.1 Principle of Planning and Progress Control Sub-system Design**

#### **11.1.1 Concept of Planning and Control**

Pierce (1988) highlighted that a complete project planning and control process covers from basic management principles and pre-construction planning through scheduling, monitoring, record keeping, and cost control.

Calvert (1986) defined the functions of management including the division of forecasting, planning, organising, co-ordinating, controlling and motivating. It seems that planning and control are two stages in one management procedure. Planning and control for construction projects should be treated as a re-cycling of one procedure consisting of design and implementation, where planning is the design and control is the implementation of the design. The procedure should be continued throughout the construction process as re-design and re-implement and so on. Jackson (1986) defined this procedure as "feedforward" which meant a feedback for forward looking. For any successful planning and control procedure, the "re-design" should be based on the information showing the result of the implementation of last plans, which is called "the progress feedback". Therefore, the quality and timing of progress feedback, is of paramount importance to the implementation of construction planning.

#### **11.1.2 Contractual Requirements on Planning**

The common standard forms of construction contract seldom specify conditions governing planning submissions such as JCT, HKIA, ICE etc. These standard forms were mainly drafted in 1950s and 1960s. In particular circumstances where the standard forms are used, the requirements for planning submissions may be put in the special conditions of contract or preliminary bill, if necessary.

However, the new forms in Hong Kong public sectors have changed the situation by putting the specific requirements for planning submissions into the standard form of contract itself. Clause 16 of the Airport Core Programme General Conditions of Contract, has specified the procedures and requirements of programme submissions. A copy of this clause is included in Figure A of Appendix 11.

The management input for PASS in Housing projects as described in Chapter 4 of this thesis, has included provisions assessing the performance of the main contractor in programme submissions. A copy of the requirements under PASS is shown in Figure B of Appendix 12.

Modern construction projects have a trend of increasing complexity and capital intensiveness. It is common to see a situation of combining the techniques of building construction, civil engineering and building service together in one project. In order to let the contract supervisor have a better control on the projects from the view point of contract administration, it is the tendency of contractual requirements to uplift the burden of project planning and co-ordination duties of the main contractor.

#### **11.1.3 "CCMS" Approach to Planning and Progress Control**

"CCMS" approach to planning is to link up the expertise of other packages in micro-computer environment, by which the advantages of flexibility in micro-computers can be fully utilised. "CCMS" progress control sub-system provides an environment for the user to execute external planning packages as a sub-system under the main "CCMS" system framework. The main system will act a role of supporting and supplementing any short-coming of such an external sub-system. If such an external sub-system has been well developed and accepted in the industry, it is no point to re-built a similar from script in this research. This approach could save up the efforts of research and industrial resources in terms of time, cost, system development, field tests and trainings for users.

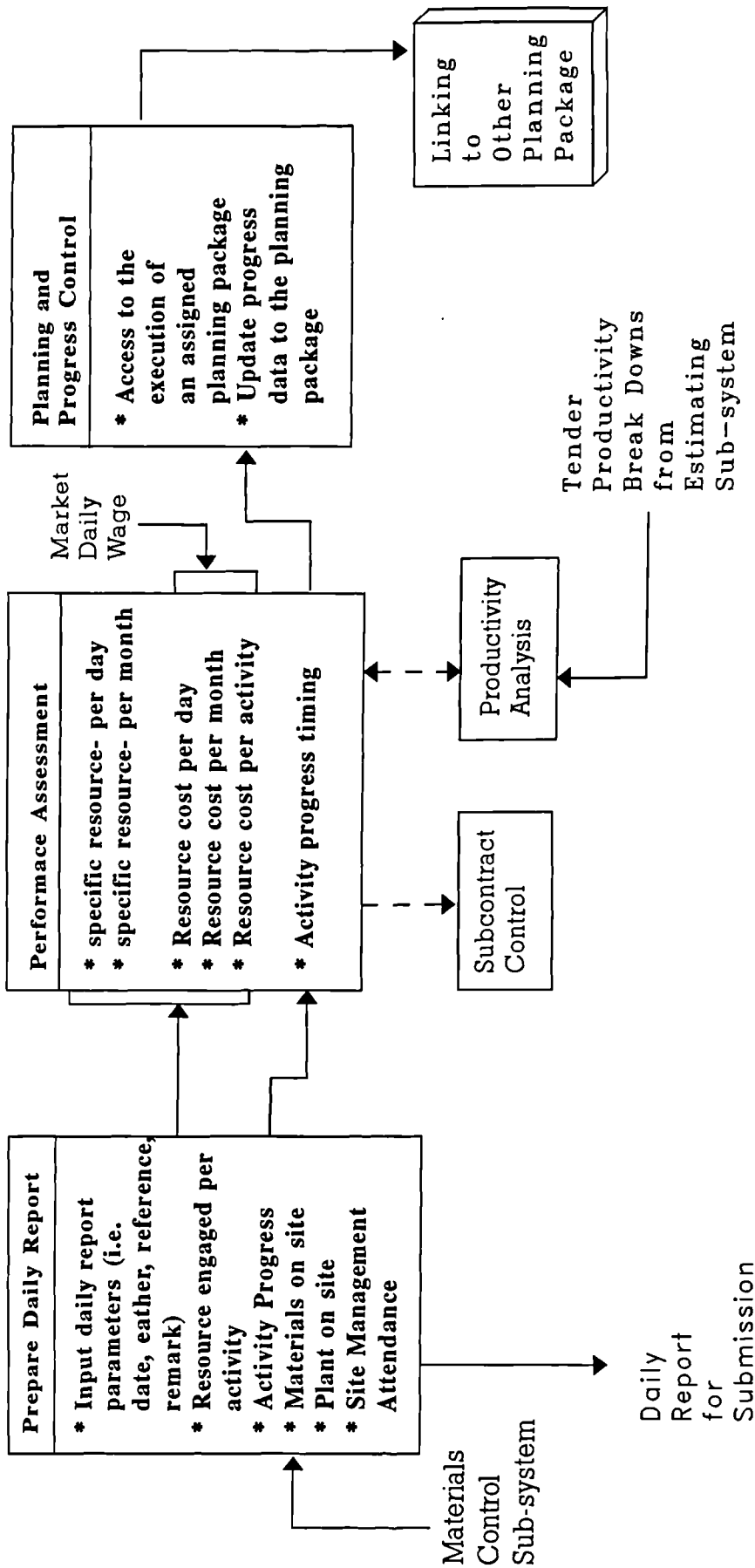
Planning is a separate management function of the model of construction management as described in Chapter 6. In terms of progress control, the relevant management tasks are included in site management function of the model under Chapter 6. "CCMS" progress control sub-system is designed to support the management tasks of planning and progress control (also called the Sub-system in this chapter). The Sub-system provides the following functions:

- a) To allow a provision for the user to access to the assigned planning package which will then be treated as the planning section of the Sub-system.
- b) To prepare the daily reports directly from the Sub-system and to record the progress and associated resources for each activity carrying out on that day.

- c) To record the site management team and plant on site.
- d) To retrieve the materials on site from the material control sub-system and include the material arrival records in the daily reports as required by most conditions of contracts.
- e) To provide progress feedback to the linked up planning package.
- f) To provide work productivity feedback from activities in progress or completed.
- g) To provide information for the performance assessment of subcontractors or any specific resource.

The operational flow chart of the Sub-system is shown in Figure 11.1.3 (a).

The main input menu of the Sub-system is shown in Figure 11.1.3 (b). The details of each function will be described in the following sections.



**Figure 11.1.3(a)**  
**CCMS Progress Control Sub-system**  
**Operational Flow Chart**

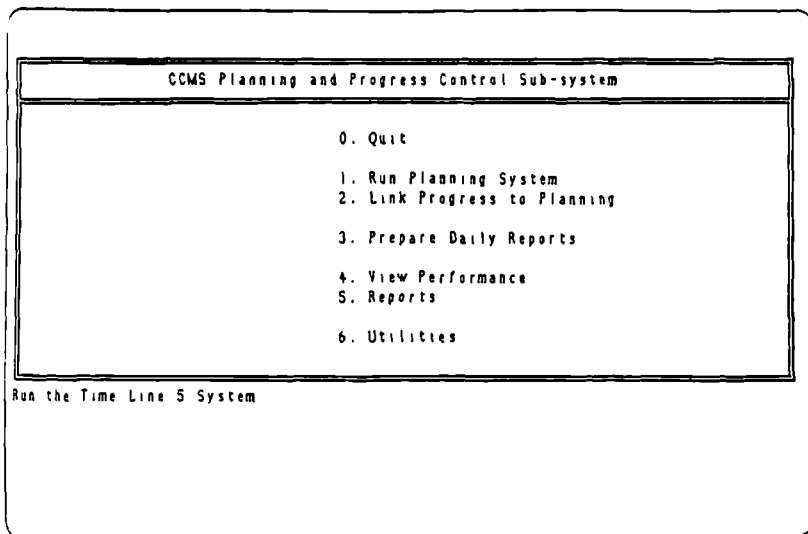


Figure 11.1.3 (b)  
Main Operation  
Menu for the  
Planning and  
Progress Control  
Sub-system.

## 11.2 Construction Planning

### 11.2.1 Planning Technique and Application

Planning for construction projects starts from barcharts known as Grantt charts around 1917 in the context of the first world war military requirement, up to the development of critical path method in 1957 by Kell and Walker at Dupont. Planning techniques have been well developed in the construction industry with lots of researches and studies. (Arditi 1973, Davis 1974, Birrel 1980, Jaafari 1984, Neale et al 1989).

Cole (1985) commented the problems of planning techniques applied to construction projects as follows:

- a) construction site activities from a mathematical/modelling perspective is a complex problem;
- b) the mathematically-based solutions that approach site realities require data that may be beyond a contractor's ability to supply,
- c) the single activity approach (CPM, PERT) is based on the concept that the work can be subdivided into fundamental activities which are arranged into a logical sequence such that resource and other restrictions are not exceeded.

- d) the multiple activity approach (line of balance, flowline) is based on the concept that in any project the work can be subdivided into principal components, each of which has a natural production rate and the production rate may be adjusted so that the combined production of all components is equal to the project's time constraint.
- e) no single planning technique has yet been developed that can encompass both the vagaries of building site works and meet a contractors needs for economy and simplicity.

Critical path method as a scheduling and planning tool was discredited by many researchers as inappropriate for construction works. The questionnaire survey by Aouad (1991) amongst the top 100 contractors in the UK and the top 400 contractors in the USA, with response rates of 33% and 15% respectively, indicated that 100% of the US and 80% of the UK companies were using CPM as a scheduling and planning tool.

Cohenca et al (1989) in his research built up a general pattern of efforts on planning based on a questionnaire survey on 400 construction firms in USA with a 18% responding rate, and concluded that the efforts allocated in the average situation (US\$ 20 million, lump sum project) would be 3.00 man-months of planning before the start of construction, 20.2 man-months for control during construction, with major revisions of the construction program made every 3.5 months. The study in Hong Kong described in Chapter 3 of this thesis, shows a similar result on major programme revisions in construction projects to be 3.0 months. Planning and control is an essential but expensive exercise in terms of expertise, efforts and overheads.

#### **11.2.2 Development of Computerised Planning Package**

Planning techniques should be treated as a tool for management, rather than a solution for it. For achieving an effective application of planning technique in construction projects, it can not be separated with the use of computers. Reiss (1987) summarised the history of the development of computerised planning package as follows:

- a) Late 1960s PERT was used on the Polaris project and other major projects. It was a big number crunching exercise, the computerisation for which was in Mainframe computers.

- b) Early 1970s the construction industry picked up PERT and network planning. But it still had to stick with Mainframe computers and the application was unsuccessful due to the software design and the hardware environment.
- c) Late 1980 and early 1980s, The invention of Micro computer, gave a new direction to project planning, by which it enabled the come out of microcomputer-based planning package. Planning could be carried out on site and an attitude developed where the planning was done by regular review and updates.
- d) Late 1980s, There were approximately 150 micro-based, project planning software packages on sale.

Aouad (1991) pointed out that 88% of the UK and 95% of the US Contractors were using project management software packages. Also, it was found that Primavera systems were the most dominant among the US sample, whereas in UK Pertmaster appeared to be the most popular.

By the author's observation, the efficiency of computerised planning package is well accepted in the industry and the formats of computerised planning packages in the market can be divided into three types as follows:

- a) Ordinary menu driven input such as Permater and Primavera etc. The users based on the screen instructions, carry out the man-machine dialogue.
- b) Database programming driven such as Artemis. The users can apply programming instructions to tailor made certain software environment for specific applications.
- c) Spreadsheet form driven such as Timeline. The application environment is similar to working in spread sheet form.

### 1.2.3 Support from "CCMS" to Computerised Planning Package.

Many people believe that with the aid of advanced technology such as computers the extra cost needed due to the increase of degree of control can be vitally reduced. Accordingly, many commercial software houses as well as academic institutes and consultancy firms have been starting their efforts on the design and promoting the use of computerised



planning software and packages. Their perspective of system design for planning applications has concentrated on the sophistication of the system, in terms of variety of functions, speed of calculation, flexibility of presentation, etc.

Actually these efforts produced impressive systems for commercial purposes. By referring to the concepts of planning and control mentioned in Section 11.1.1 above, it will be obvious that most system designs for computerised planning packages just focus on the planning part of management procedures, but ignore the significance of the feedback of progress data. This problem is always overlooked by those system analysts who may try to tackle the design from a viewpoint of total project management for all disciplines. They may ignore the characteristics of the construction industry, which relies substantially on the feedback of progress data for effective planning updating. The cost implications, efficient use of resources and other consideration, may be important in dominating over the timing consideration of construction activities during the planning updating.

In view of the main problem of computerised planning packages mentioned above, "CCMS" provides a function for the user to update the progress information by linking up to most sophisticated planning packages, provided that it has a function of importing external files. The details of progress updating by "CCMS" is described in next Section 11.4.3.

### **.3 Daily Report Preparation**

#### **.3.1 Contractual Requirements on Daily Report.**

Most construction contracts have a requirement for the main contractor to submit daily reports to the contract supervisor. The requirements for the daily report will be stated in the particular conditions of contract or under the preliminary bill. A typical preliminary item regarding daily reports may be as follows:

"The Main Contractor shall submit to the Engineer each day throughout the Contract Period a report showing a record of the labour employed on Site under each trade, materials delivered to Site, plant and equipment on site and the weather throughout the day.

The format of the daily report shall be submitted to the Engineer for approval before commencement of work on Site.

In all cases where a Resident Engineer or other representative of the Employer is employed upon the Works the daily reports shall be submitted for checking and signing by the Resident Engineer or other representative of the Employer."

Most construction contracts, give more flexibility to the contract supervisor to decide on the formats and practices of daily report submission. In case of contracts involving with nominated subcontracts, typical contract terms for daily report will be as follows:

"The Sub-Contractor shall submit to the Main Contractor each day throughout the Sub-Contract Period a report showing a record of the labour employed on Site under each trade, materials delivered to Site, plant and equipment on Site.

The format of the daily report shall be submitted to the Main Contractor for approval before commencement of work on Site."

It will be the duty of the Main Contractor to co-ordinate the submissions of nominated subcontractors.

### **1.3.2 Information in Daily Report.**

Schaffer (1983) identified that from the viewpoint of contract administration the site diary should contain a concise record of the essential facts relating to the following matters:

- a) A brief description of work carried out, including samples and tests;
- b) A full description of situations which could relate to claims, for example unforeseen underground problems, delay due to lack of information or delay on the part of a nominated subcontractor;
- c) Remedial work and time lost;
- d) Temporary accommodation brought onto or taken off site;

- e) Plant: main items of mechanical equipment brought onto or taken off site;
- f) Materials: note of deliveries, but only if these are pertinent to the progress of the works or to claims by the contractor;
- g) Labour: a note of any head counts made;
- h) Stoppages and delays, including labour disputes, overtime bans or strikes;
- i) Accidents ;
- j) Factors affecting the progress of the work which are beyond the contractor's control ;
- k) Weather conditions: particularly low temperature, high wind, rain and snow.

Powell-Smith and Sims (1985) identified the following items but not exhaustive, were some of the important matters which should be recorded in daily reports:

- a) Climatic conditions;
- b) Deliveries of materials, with particular of any defects or shortages;
- c) Plants with details of any breakdowns, etc.;
- d) Labour with details of any problems, dismissals etc.;
- e) Information received or outstanding;
- f) Visitors to the site;
- g) Progress in relation to programme.

The study in Hong Kong Construction as described in Chapter 3, confirms Schaffer (1983)'s identifications of the information contained in daily reports. Putting it into practice for format submissions, the precise information contained in a daily report should be as follows:

- a) Report reference no;
- b) Date of the event day ;
- c) Contract reference and description;
- d) Weather conditions;
- e) Job activities;
- f) Materials delivered ;
- g) Plants on site;
- h) Site management term;
- i) Remark and special comments.

A typical format of daily report is shown in Figure C of Appendix 11.

### 11.3.3 Data Collection for Daily Reports.

It is the requirement of most construction contracts to put the burden of preparing daily reports to the main contractor. According to the Study in Hong Kong, usually a specific assistant engineer grade staff will be assigned for the routine preparation of daily reports which will be submitted to the contract supervisor next morning with the proper signature of the site agent or the site manager.

The information pass to the assigned site staff for the preparation of daily reports is based on the data from the sectional foremen or sectional engineer rather than finding out by the one who fills in or signs for the report. Laufer (1985) indicated the means of data collection as follows:

- a) Survey methods (or self report data) - questionnaire and interviews.
- b) Observations - unstructured visual observations, structured observations (e.g., work sampling), stop-watch technique, and time-lapse photograph.
- c) Secondary data - documents (e.g. procedures and specifications) and records (e.g., cost and safety report).

The information on site for the preparation of daily reports should be in a form of secondary data according to Laufer. The accuracy of the information will be quite reliable on the quality of the foreman who provides the information. Malony and McFillen (1987) studied the roles of foremen in the construction process and made the following conclusions:

- a) Foremen do have a strong impact on worker motivation, performance and satisfaction.
- b) The job of foreman is truly multidimensional, and improved supervision requires major changes in the selection and training of foremen.
- c) Actions must be taken to improve the support, facilitation, and participation provided by foremen. Special consideration should be given to workers' needs and desires to participate in decision making with regard to their work and work environment.
- d) Actions should be taken to improve planning and scheduling, goal setting, and communication.

The study in Hong Kong construction industry, shows that the industry is becoming more complex and sophisticated, which has forced the contractors to deploy more professional and functional frontline management on site, instead of traditional 'craftsmanship' work. This is in line with the comments by Malony and McFillen regarding the roles of foremen on site. According to the Study in Hong Kong construction industry, the means of communication for the data used to prepare the daily reports from the sectional foremen to the assigned report filler is very loose. It is relied on a form of mutual adjustment, by which the foremen will write down in draft the descriptions of the activities that have been carried out on his/her own section and the associated resources. If there is any query, it will be up to the assigned report filler to solve out with the foreman.

With the application of "CCMS" progress control sub-system to prepare the daily report, it requires a more structural form of data presentation. Tiong (1990) proposed a design of data structure used to capture the resource engaged in construction activities, with the details as follows:

- level 1. Project
- 2. Cost Classification (Direct Labour)
- 3. Location (Building A)
- 4. Work Area (First Floor)
- 5. Work Category (Concrete)
- 6. Sub-Category (Floor Slab)
- 7. Work Task (Formwork)
- 8. Resources (Carpenter)

With the consideration of Tiong's approach and other previous researches (Teicholz 1987, Hendrickson and Au 1989, Ibbs and Kim 1989), the data structure used to capture the activity on site includes the following attributes:

- a) Positional Identities:
  - Main Location (e.g. Block A );
  - Sub-location (e.g. 1st Floor);
  - Structural Element (e.g. Column, beam or slab);
  - Identity (e.g. Wing A);
- b) Operational Identities:
  - Work Type (e.g. Structural works);
  - Job Type (e.g. Fixing reinforcement bar);
- c) Resource Identities:
  - Party (e.g. Direct labour or subcontractor name);
  - Resources (e.g. skillful labour or labourer);

d) Quantum:

- Engaged quantities (e.g. hours or day);
- Weighting (e.g. distribution for resources serving different activities)

For ensuring to have sufficient data to input for the above mentioned data structure used in "CCMS", it is necessary to devise a data communication format between the sectional foremen and the assigned report filler. Accordingly, an input form printed in Chinese characters was used in the field test project as described in Chapter 13 of this thesis. The advantages of using such a form are as follows:

- a) It simplifies the format of the foreman's progress report, by which a schedule form is used instead of a loose descriptive form.
- b) It makes the foreman's progress description more logical and structural and subsequently it should improve the accuracy of the information.
- c) With the use of a pre-defined format all the time, the foremen will get the advantages of familiarity and increase the efficiency of this documentation work.
- d) Two additional fields are used in the form for the foreman to answer the following questions:
  - Does any verbal instruction from the site from the Resident Engineer or Clerk of Works ?
  - Does any on site drawing amendment ?

This approach will help the foreman alert any potential variation works on site.

- e) Using a better record system in written format, should aid the management in complying with any quality assurance system in terms of process control and information traceability.

A sample of the progress report form in Chinese Character is shown in Figure D of Appendix 11.

#### 1.3.4 Data Input for Daily Report.

With the available of the written progress report forms from the sectional foremen as described in Section 11.3.3

above, the data input to the Sub-system will be comparatively simply. The procedures of data input for a daily report into the Sub-system will be as follows:

a) Report Parameters:

- Report reference no;
- Date of the event day;
- Weather conditions; and
- Remark and particular description.

The data will be tackled by the memo field as described in Item c of Section 5.4.3, by which there is no limitation on the characters to be input. This approach should satisfy the requirements from the comments by Schaffer (1983) regarding the contract supervisor's demands from the daily report for their contract administration.

b) Job Activities:

This section will be in a schedule form with the columns representing each field of the data structure described in section 11.3.3 above as follows:

- Main Location ;
- Sub-location ;
- Structural Element ;
- Identity ;
- Work Type ;
- Job Type ;
- Party ;
- Resources ;
- Engaged quantities ; and
- Weighting.

Since the data input for each column is highly repetitive in the sense of describing the activities on site, the pop-up window technique as described in Item D of Section 5.4.3 is applied to allow the user to pick up the data item from the library. The pop-up window library is dynamically growth up by allowing the add-in, amendment and delete of data. That means at the start of the project, the data libraries are empty and the user will built up the data bank in parallel with the use of the Sub-system.

Rasdorf and Abudayyeh (1992) have described that the models of information system design are as follows:

- a) Process-oriented approach focuses on what the output should be and what processing mechanisms are needed to produce the desired output.
- b) Data-oriented approach focuses on the inputs to the process and attempts to build a data representation model of the intended information system without regard to future uses of the data. This approach, which is fairly recent and becoming increasingly more accepted, is thought to be the most fundamental approach to modeling information systems.

The system design of "CCMS" in this section has applied the data-oriented approach to capture the progress activities on site.

c) **Materials Delivered to Site:**

For the input of materials delivered to site, the Sub-system allows the user to draw the information from "CCMS" material control sub-system, with which theoretically all the daily materials delivered to site should be handled. After the information is passed from the material control sub-system, the information can still be edited in this section, without changing the contents of the material control sub-system.

d) **Plants on Site:**

Plants can be tackled as a kind of resources in the job activity input section for those plants engaging to specific activities. But for those plants allowed in the general preliminaries will be input in this section. The format of data input is in a schedule form with the support of the pop-up window libraries, similar to the job activity section described above.

e) **Site Management team:**

The site management team of the main contractor on site includes the technical, managerial and administrative staff. The records for the site management team on site will be an evidence to support the calculation of actual site overhead cost, therefore it should form part of the daily report. The format of data input is also in a schedule form with the support of the pop-up window libraries, similar to the job activity section described above.



Since construction activities and site establishments will always last for a short period, the activities and establishment on site today may be similar to those on the preceding day. Therefore the Sub-system allows the user to copy the data from yesterday or any specific previous day to be the data of current date, and then any amendment can be edited in the copied current data. This approach reduces much documentation workload on site for the preparation of daily reports.

The input screens for the preparation of daily reports are shown in the following figures.

Ins

---

Daily Report Details

---

0. Quit  
1. Works  
2. Material  
3. Managment

---

Site Overheads, Plants

Date => 01-02-92 Ref No => 745 Weather => CLOUDY  
Input the Date of the Daily Report [DD-MM-YY]

Figure 11.3.4 (a)  
Operational Menu  
for the  
Preparation of  
Daily Reports

View Information

| Bk         | Fir | Ele         | Idc       | Wrktyp            | Job T  |
|------------|-----|-------------|-----------|-------------------|--------|
| BLOCK 6    | 4/F | Parapet     | SS1       | Structural Works  | Concre |
| BLOCK 6    | 4/F | Facade Wall | Al,A2     | Structural Works  | Fix St |
| BLOCK 7    | 5/F | Staircase   | Ass. Hall | Structural Works  | Concre |
| BLOCK 7    | 5/F | Lift Shaft  | SS1       | Building Services | Fix El |
| BLOCK 7    | 4/F | Ext. Wall   | Al,A2     | Building Services | Fix Co |
| BLOCK 8    | 6/F | Column      | Ass. Hall | Structural Works  | Formwo |
| BLOCK 8    | 6/F | Column      | SS1 & SS2 | Structural Works  | Conc C |
| EXT. WORKS | G/F | Excavation  | SPORT GRD | Misc Works        | Trench |
| EXT. WORKS | G/F | Excavation  | Pump Rm   | Pipe Laying       | Pipe L |

Date => 01-02-92 Ref No => 745 Weather => CLOUDY  
Input the Date of the Daily Report [DD-MM-YY]

Figure 11.3.4 (b)  
Input for the  
Activities  
Executed on that  
day.

| Material Arrival Details |                     |        |        |                 |
|--------------------------|---------------------|--------|--------|-----------------|
| Type                     | Descr               | Qty    | Unit   | Usage           |
| Concrete                 | 30/20 Mix           | 200.00 | m3     | Domestic Blocks |
| Concrete                 | 35/20 Mix           | 165.00 | m3     | External Works  |
| Reinforcement            | 40 mm high yield    | 160.00 | Tonnes | Column Structur |
| Reinforcement            | 32 mm high yield    | 450.00 | Tonnes | Column Structur |
| Reinforcement            | 20 mm mild steel    | 360.00 | Tonnes | Column Structur |
| Tiles                    | B25/35 Mosaic Tiles | 130.00 | Boxes  | External Wall   |
| Tiles                    | B20/40 Mosaic Tiles | 150.00 | Boxes  | External Wall   |
| Sanitary Fittin          | Water Closets       | 50.00  | Sets   | Block 6         |

Date => 01-02-92 Ref No => 745 Weather => CLOUDY  
Input the Date of the Daily Report [DD-MM-YY]

Figure 11.3.4 (c)  
Input for the  
Materials on Site  
from the Material  
Control  
Sub-system.

| Managment/Plant |                 |    |
|-----------------|-----------------|----|
| Type            | Name            | No |
| Plants          | Backhoe         | 5  |
| Plants          | Air Compressor  | 7  |
| Plants          | Tower Crane     | 5  |
| Plants          | Pneumatic Drill | 3  |
| Site Management | Project Manager | 1  |
| Site Management | Site Agent      | 1  |
| Site Management | Surveyor/Eng    | 3  |
| Site Management | Gen. Foreman    | 7  |

Date => 01-02-92 Ref No => 745 Weather => CLOUDY  
Input the Date of the Daily Report [DD-MM-YY]

Figure 11.3.4 (d)  
Input for the Site  
Management and  
Plants on Site.

### 11.3.5 External Use of Daily Report.

The daily report for submission can be directly printout from the Sub-system. This will save a manual procedure to fill in the form and should provide a better presentation than hand-written traditional daily reports. A sample printout of the computerised daily report from the Sub-system is shown in Figure E of Appendix 11.

Since the information in the daily reports does not directly relate to payments or performances, in most cases both parties, the main contractor and the contract supervisor will always treat it in low profile. Unless there are disputes, claims, arbitrations or litigations evolving from the pass events on site, both parties will then try to dig out the relevant information from the daily reports.

Most legal jurisdictions accept the information of daily report as a valid evidence in construction contract disputes. Powell-Smith and Sims (1985) have pointed out that accuracy and truthness are important because if the diaries are later tendered in evidence, for example in an arbitration or are used to refresh the memory of a witness, such information will be rejected if they are clearly one-sided.

For this research, an interview was made with the senior consultant of Housing Authority Mr. C.K. Hui regarding the submission of daily reports from main contractors. It was highly appreciated that if the main contractor could prepare their daily report in a format of computerised structural database and submit such information through the telecommunication system to the computer of the contract supervisor, it should aid the contract supervisor's assessment on the progress and performance of the main contractor. The advantages from the Employer's viewpoint in terms of contract administration as discussed with Mr. Hui, are summarised as follows:

- a) The contract supervisor can quickly assess the detailed progress of the project by comparing with the programmes submitted for identifying any deviation.
- b) The contract supervisor can quickly assess the strength of resources on site and keep trace for any change, for example whether it has improved or worsened.
- c) The information will be a significant reference for the calculation of extra costs subject to the loss and/or expense claims from the main contractor.

#### **11.4 Progress Reports**

##### **11.4.1 The Principle of Progress Control.**

Armstrong (1986) has defined that 'progress control' monitors the progress of works against the master schedule so that corrective action can be taken to overcome progress problems. Therefore, progress control should be treated as the control element of planning and control procedure. Before the control action can be determined, it is necessary to get the information of progress by some means.

In terms of simple construction projects involving such as structural and architectural works, the work progress is discrete and highly visible. However, modern construction projects and increasingly complex "smart building" which involves quite a lot of building service engineering works, challenge conventional monitoring techniques. Tatum (1985) identified three key types of information, as a minimum, to evaluate projects during bulk production:

- a) Firstly an indication of scope growth, both in quantities and man-hours, is essential to determine "where we are going".
- b) Resource supply, the second information type, includes the status of engineering information, purchased materials, critical crafts ,and other essential resources.
- c) Third, evaluating bulk production requires interim measures of both progress and resource use.

Cost control and progress valuation as described in Chapter 10 can be treated as a kind of measurement for the progress and performance of construction projects. However, cost control systems are accountancy based and orientated, for which many information collected are used to compare with the budgets. Wootton (1982) pointed out that cost control systems tended to collect information which was both irrelevant and ineffective from a site manager's point of view and cost information related to progress always arrived too late for any action other than maybe remedial.

Jayawardance (1987) reflected that 'financial progress' was not always realistic measure of 'physical progress' on construction projects such as the completion of major critical but possibly low value items or further distortions due to heavy critical expenditure on plant and advance payments on long order items etc. Planning and progress control system is essential to be independent from cost control system to aid for the construction management.

"CCMS" progress control sub-system has taken into consideration the needs of progress control for the modern construction projects. The information input into the Sub-system through the preparation of daily reports will be converted to a form of progress control information which can also be linked to the standard planning packages.

#### 11.4.2 Contractual Requirements for Progress Reports.

Most standard forms of contract for construction projects, do not specify the requirements of progress reports in their standard clauses. In case of necessary, such kind of requirements will be specified in the particular conditions of contract or under the preliminary bill. A typical example of the contract clause for progress reports will be as follows:

"The Main Contractor shall at fortnightly intervals report the status of the Programme and show the current stage of progress of all activities" (Hong Kong Baptist College Contract Clause 9.02 Bill No 1 Preliminaries).

However, due to the tighter requirements in the project control for the Airport Core Programmes in Hong Kong, under Clause 16 (9) of the Government of Hong Kong General Conditions of Contract for the Airport Core Programme Civil Engineering Works 1992 edition, it states:

- (a) The Contractor shall submit to the Engineer by the end of each calendar month its Monthly Progress Report which shall, amongst other things, highlight actual or potential departures from the Work Programme and state the measures which the Contractor proposes to take in order to make good or reduce any delays.
- (b) If required by the Engineer, the Contractor shall submit to the Engineer at weekly intervals a written report as to the progress of off-Site manufacture of goods and materials.
- (c) The Contractor shall also submit to the Engineer such other reports as may reasonably be required by any relevant authority public body.

The Clause grants a great feasibility and authority to the Engineer for demanding reports from the main contractor. This shows the tendency of contract administration, by which the employers will be more demanding and the contractors should be well prepared for themselves with their proper management information systems in order to satisfy such demands.

#### 11.4.3 Conversion of Daily Report Data to Progress Reports.

Al-Sadairy (1985) on behalf of the Highway Research Board of the "American National Academy of Engineering" carried out an exhaustive examination in the field of reporting and consider that a good report has the following characteristic:

- a) It contains all the essential facts of the situation reported without extraneous information or unnecessary details to waste the reader's time or confuse him.
- b) It is presented in a format which permits a quick and easy grasp of the essential information, and is expressed in terminology with which the reader is completely familiar.
- c) It permits the user of the reports to concentrate on exceptions by focusing attention on comparisons which highlight trends or deviations from target performances.
- d) It is timely, and, if routine, is produced on a regular schedule, so that executives may expect reports at specific times and reply on them.
- e) It is tailored to fit the requirements, personality, performances and capacity of the recipients as to format the amount of back-up detail, and other report characteristics.
- f) It shall be supported by appropriate analysis of the financial information supplied and shall be accompanied by significant summaries.
- g) It shall be sufficiently useful to justify completely the time and cost involved in its preparation and presentation.

The design of progress reports printout from the Sub-system has taken into consideration the above principles. Any desired progress information can be abstracted from the database which is created by the job activity section in the preparations of daily reports. The abstracted progress data will be stored in a new ad-hoc database file. The principle of abstract for progress information is based on the user defined criteria through a query sheet format. The criteria can be built up through the following data fields in single or any combination:

- Date Range ;
- Main Location ;
- Sub-location ;
- Structural Element ;
- Identity ;
- Work Type ;
- Job Type ;
- Party ; and
- Resources.

Sample screens showing the handling of progress data are illustrated in Figure 11.4.3 (a), Figure 11.4.3 (b) and Figure 11.4.3 (c).

| Existing Selection Criteria |          |                                                  |          |
|-----------------------------|----------|--------------------------------------------------|----------|
| Code                        | Criteria | Job Description                                  | Selected |
| A1                          |          | Progress in 02/92 for Block 2 Structure          |          |
| A2                          |          | Monthly Progress Report for External Submissions |          |
| A3                          |          | Monthly Progress Report for Internal Use         |          |
| A4                          |          | Progress Report for Reinforcement Subcontractor  |          |
| A5                          |          | Progress Report for External Works from 09/91    |          |
| A06                         |          | Progress Report for Block 7 Structure Works      |          |

[F2]-detail; [F3]-save; [F5]-add; [F6]-delete; [F4]-select

Figure 11.4.3 (a)  
Report Types  
Stored in the  
Sub-system, which  
are freely  
compiled by the  
user.

| Existing Selection Criteria                |                  |  |   |
|--------------------------------------------|------------------|--|---|
| A1:Progress in 02/92 for Block 2 Structure |                  |  |   |
| Block [=]                                  | BLOCK 2          |  | 0 |
| Floor [=]                                  |                  |  | 0 |
| Element [=]                                |                  |  | 1 |
| Identity [=]                               |                  |  | 2 |
| Work Type [=]                              | Structural Works |  | 0 |
| Work Item [=]                              | Concreting       |  | 3 |
| Resources [=]                              |                  |  | 0 |

[F4] to finish select; [Esc] to leave

Figure 11.4.3 (b)  
Example of  
Criteria for Data  
Abstraction.

```

01-02-92 : - Staircase - Ass. Hall - Concreting Concretor (6)
07-02-92 : - Slab - Wing C - Concreting Concretor (6)
11-02-92 : - Wall - Wing C - Concreting Concretor (8)
11-02-92 : - Facade Wal - - Concreting Concretor (0)
13-02-92 : - Slab - Wing A - Concreting Concretor (6)
13-02-92 : - Facade Wal - Wing A - Concreting Concretor (0)
14-02-92 : - Wall - Wing B - Concreting Concretor (8)
15-02-92 : - Slab - Wing C - Concreting Concretor (6)
17-02-92 : - Wall - Wing A - Concreting Concretor (8)
17-02-92 : - Facade Wal - Wing A,B - Concreting Concretor (0)
19-02-92 : - Slab - Wing B - Concreting Concretor (6)
19-02-92 : - Facade Wal - Wing B - Concreting Concretor (0)
20-02-92 : - Wall - Wing C - Concreting Concretor (8)
20-02-92 : - Facade Wal - Wing B - Concreting Concretor (0)
20-02-92 : - Parapet - - Concreting Labourer(M) (2)
21-02-92 : - Slab - Wing A - Concreting Concretor (6)

```

Figure 11.4.3 (c)  
List of the Data  
based on the  
Criteria mentioned  
in 11.4.3 (b).

The new progress data file contains a very detailed work structure breakdown from 'main location' to 'job type' as mentioned above, totally in 6 levels. This should be able to provide the progress information in any detail required by the work break down structure (WBS) of the planning activities.

The type of the new progress data file can be defined by the users as described in Section 5.3.3 regarding the integration of 'CCMS' to other outside systems. For example, the user can choose the output file to be ASCII form, Lotus 123 form or Dbase III form etc. The field head names of those transfer files can also be assigned by the users subject to the requirements of the standard planning package, to which the progress data file is going to link. Most sophisticated planning packages such as Timeline, Artemis and Premevira, have the functions to import external files in common formats such as Lotus, ASCII or Dbase III. This approach has much enlarged the scope of application for micro computers in construction management.

With the link up between planning and actual, it enables the progress reports showing the two bars comparison between the programme and the progress. This should satisfy the requirements of Clause 16 (9) Hong Kong Airport Core Programme Conditions of Contract as described in Section 11.4.2 above.

A sample graphical progress report is shown in Figure F of Appendix 11.



## 11.5 Subcontract Control

### 11.5.1 Principle of Subcontract Control

Ndekugri (1988) pointed out that subcontracting was rapidly expanding nationally and on many individual projects the level of subcontracting could be up to 80-90%, the extent of which showed that the main contractor could be viewed as brokers between the industry's clients and the small specialist firms sprouting all over the industry. Ndekugri further added that the increasing levels of subcontracting were attributable to the following changes in the construction industry:

- a) increasing complexity of construction;
- b) increasing uncertainty of the environment within which projects are undertaken;
- c) growing desire to overlap design and construction;
- d) a resulting need to spread the risks and financial burdens of construction projects.

One of the most important characteristics of the construction industry in Hong Kong, is its sub-contract orientation. It is not unusual to see the works being sub-sub-contracted, finally to a sub-contractor who in fact may be with insufficient technical skill and management knowledge to handle the works. The problems generated from the incapable management of the subcontractor themselves, subsequently may cause the main contractor to suffer at the end. This situation is quite often to be found in those arbitration and litigation cases.

Previously, the attitude of main contractor toward the control of subcontractors usually was by putting pressures to chase up the work progress. This situation often has resulted in sharpening the on site disputes between the subcontractors and the site management. Nowadays, in view of the previous displeasing experience, many main contractors start aware of the necessity to help the subcontractor manage their works, instead of treating them as outsiders. To achieve this, it is necessary to have a mechanism for the feedback of the relevant data, based on which the weakness in management can be analysed and predicted.

### 11.5.2 Subcontract Performance Data.

Thomas and Kramer (1988) defined 'performance evaluation' as the process involving the comparison of the actual progress and productivity to the control budget and it should include the comparison of quantity installation rates and work-hour consumption rates, and forecasting should be a part of performance evaluation. Alfeld (1989) put the definition of performance simply as:

$$Performance(worth) = \frac{accomplishment(value)}{methods(cost)}$$

According to Alfeld, the evaluation of performance for subcontractors, should be the value of the subcontract work completed over the total costs spend by the subcontractor. But from the main contractor's viewpoint, the value of the subcontract works completed should be the subcontract interim payment paid by the main contractor, and conversely the corresponding actual cost of the subcontract work should be a kind of commercial secret of the subcontractor. Therefore, the evaluation of performance for subcontractors should be from a viewpoint of work productivity rather than a financial appraisal.

In terms of productivity, there should have the 'budget productivity' and the 'actual productivity' for each subcontract item. By the use of "CCMS" estimation sub-system, the budget productivity for each subcontract item can be derived by the calculation of productivity unit rate function as described by Section 7.4.2. By the use of the estimating sub-system, the budgetary productivity for subcontract items can be calculated by the following approaches:

A = labour only subcontract unit rate (\$/Unit);

B = contemporary market mark up (%);

C = predicted labour wage (\$/day or hour);

Accordingly, the budgetary productivity (unit/day or unit hour) should be calculated as:

$$E = \frac{C}{Ax\left(\frac{1}{1+B}\right)}$$

The actual productivity can be derived from the "CCMS" progress control sub-system through the job activity section, which involves the built up of the database for the preparation of daily reports. The job activity database includes the following fields as described in Section 11.3.4 above:

- Main Location;
- Sub-location;
- Structural Element;
- Identity;
- Work Type;
- Job Type;
- Party;
- Resource;
- Engaged quantity; and
- Weighting.

The 'Party' field can be used to record the identity of the subcontractor involving in the job activity with the relevant 'resource', 'engaged quantity' and 'weighting', which are used to record the details of the subcontractors resources consumed. The summation of these resources data, shows the total resources needed for the completion of a specific activity (say for example hereby called 'x' men-day or men-hour). The output quantities for such activity can be assessed through the monthly interim payment application of the subcontractor (say for example hereby called 'y' m2). Accordingly, the actual productivity can be calculated by 'x'/'y'.

Thomas and Kramer (1988) has described the use of 'performance factor' as a measure of construction efficiency, which is based on the planned productivity divided by the actual productivity. A ratio greater than 1.0 signifies better-than-planned performance. The performance factor of subcontract work item is used to measure the efficiency of subcontractors by comparing the budget productivities and the actual productivities. The monitoring will be focused on those significant items in terms of their criticalities to the overall completion of project. The monthly performance factors for each significant items, will be printed out in graphic form showing the trend of performance. The trend of performance is an important monitoring tool for subcontract control which helps forecasting the potential problem areas of subcontracts on site before they are too late to be solved out. This is in line with Thomas and Kramer's definition on performance evaluation, which claims that forecasting should be included in the evaluation process, and not just

reflecting something that have been passed. The illustration of performance trend is shown in Figure 11.5.2 (a) and Figure 11.5.2 (b).

### Assessment for Performance

*Example Labour and Plant*

| BQ Item              | Description            | Qty                   | Rate                 |  |
|----------------------|------------------------|-----------------------|----------------------|--|
| 2.03.01              | General Site Clearance | 10,000 m <sup>2</sup> | \$200/m <sup>2</sup> |  |
| Activity No          | Description            |                       |                      |  |
| (Cost Center) 00CE11 | General Site Clearance |                       |                      |  |

|                                                                                                                                                                                                                         |           |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| July                                                                                                                                                                                                                    | August    |
| <ul style="list-style-type: none"> <li>- total working hrs @ daily wages</li> <li>total cost = \$ x1</li> <li>- works completed according to interim application</li> <li>areas completed = y1 m<sup>2</sup></li> </ul> |           |
| <div>Performance Rate<br/>\$ x1/y1 per m<sup>2</sup></div>                                                                                                                                                              |           |
| August                                                                                                                                                                                                                  | September |
| <ul style="list-style-type: none"> <li>- ditto by similar calculation</li> </ul>                                                                                                                                        |           |
| <div>Performance Rate<br/>\$ x2/y2 per m<sup>2</sup></div>                                                                                                                                                              |           |

Figure 11.5.2 (a)  
Assessing the Performance for a Specific Item.

### Assessment for Performance

*Percentage of Efficiency*

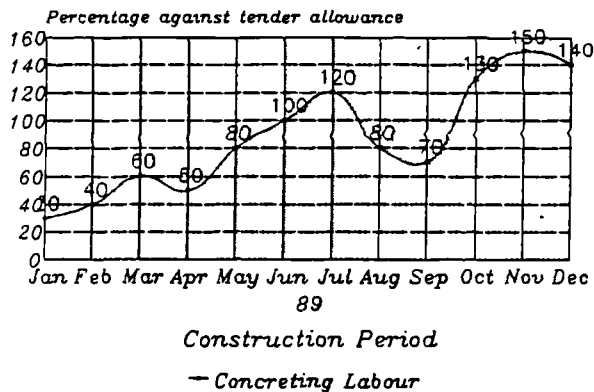


Figure 11.5.2 (b)  
Plotting the Trend of Performance for that Item.

The attendance of a specific resource or subcontract can also be abstracted from the Sub-system as shown in Figure 11.5.2 (c).

View Attendance - per Block by Date

|                                           | BLK 6 | BLK 7 | BLK 8 | BLK 9 | EXT WK | P. SCH | S. SCH |
|-------------------------------------------|-------|-------|-------|-------|--------|--------|--------|
| 19-02-92                                  |       |       | 6     | 8     | 6      | 9      |        |
| 20-02-92                                  | 6     | 8     | 4     | 8     | 3      |        |        |
| 21-02-92                                  | 8     | 6     | 6     | 11    | 3      |        |        |
| 22-02-92                                  | 6     | 8     | 12    | 13    | 6      |        |        |
| 24-02-92                                  | 8     |       | 14    | 5     | 2      |        |        |
| 25-02-92                                  |       | 6     | 16    | 11    | 2      | 1      |        |
| 26-02-92                                  | 6     | 8     | 4     | 12    |        |        |        |
| 27-02-92                                  | 8     |       | 10    | 4     | 2      |        |        |
| 28-02-92                                  | 6     | 6     | 12    | 10    | 4      |        |        |
| 28-02-92                                  |       |       |       |       |        |        |        |
| -----                                     |       |       |       |       |        |        |        |
| Total Qty                                 | 111   | 96    | 142   | 114   | 49     | 1      |        |
| Total Quantity :                          | 513   |       |       |       |        |        |        |
| Press any key to continue; [Esc] to leave |       |       |       |       |        |        |        |

Resource Type => Concretor Start Date => 01-02-92 End Date => 28-02-92  
Input the Type of Resources ( press [=] to list)

Figure 11.5.2 (c)  
List of Attendance  
of a Specific  
Resource or  
Sub-contractor per  
Day for a  
Specified Period .

## 11.6 Productivity Feedback for Estimation

### 11.6.1 Principle of Feedback.

Johannsen and Page (1986) in the International Dictionary of Management defines that 'feedback' is a term borrowed from electronic where it means the coupling of the output of a process to the input, and in terms of management it means an arrangement to check performance of a system or process against certain standards and 'feeding back' any variations so that future performance can be adjusted and improved.

Abdullah (1988) defined the construction management feedback as:

"the process of return to the input resource of part of the output data of the site management system. This returned data will be compared to the input data, so that the construction operations of uneconomic indication or bad performance can be identified. Corrective action may then be ordered by the management on these operations".

In terms of estimation feedback, Braid (1984) carried out a study by sending questionnaire to 100 construction companies from large national organisations to small 'local' builder, and of these 60% responded. The conclusions made in Braid's survey were as follows:

- a) Larger contractors often employ computer operators allowing access to data that can be used by all departments. Feedback on a continuously up-dated basis will be useful to the buyers, site management, bonus department and estimators.
- b) The larger builder operating a manual system will have the same information but it will not be as readily available to all departments. It may not, therefore be used to the maximum benefit of the firm.
- c) Smaller builders think that feedback is important, that it will pay for itself, yet they still do not use it due to the reasons as: 15% thought that it would be too expensive; 20% thought that it would take up too much time to operate; 65% thought that it would be too complicated.

The survey from Braid mentioned above, indicates an important message that the effectiveness of estimation feedback is quite relied on the application of information technology. This is in line with the direction of this research.

#### **11.6.2 Conversion of Daily Report Data to Estimation Feedback.**

Kodikara (1990) commented that the reasons of poor feedback from site level to estimators in the construction industry is due to the mismatch between what the estimator provides for the site staff and what the estimator requires from them. Kodikara then proposed that the change of the format of estimation data passing to site level might improve the situation.

According to the study of this research, Kodikara's proposal may not be able to solve out the estimation feedback problem because this involves a fundamental problem. The problem is that the objective of site management is to complete the project according to the pre-defined targets and is not to fieldtest for the estimation data. Therefore the fundamental principle of estimation feedback from site level, should concern with how to record and organise the data on site to a format which the estimators can be used to compare with what they have allowed in their estimates. The operation of such an information acquisition system on site should not disturb the normal site practices but if possible it should also be used to support the management tasks on site. The system design of "CCMS" is based on this principle to provide feedback information to estimation.

As it has been pointed out in Section 11.5.1 above that modern construction projects are heavily sub-contract orientated. The estimator's works during the tendering stage, involve quite a substantial time on tackling and negotiating with subcontractors on subcontract rates. The productivity data as described in Section 11.5.2 above, should provide a useful reference to support the estimators for their negotiations with the subcontractors. The productivity of any specific activity multiplying the current labour wages plus the estimated inflation and the allowance for other factors, should derive a reasonable contemporary unit rate for such item.

The feedbacks to estimation from "CCMS" all sub-systems can be summarised under the following table:

| Estimation Functions                    | Name of Sub-system | Format of Feedback                                                                        |
|-----------------------------------------|--------------------|-------------------------------------------------------------------------------------------|
| Direct Labour Productivity.             | Progress Control.  | Database file in 6 levels work breakdown structure as described in Section 11.5.2. above. |
| Labour Only Subcontractor Productivity. | Progress Control.  | Database file in 6 levels work breakdown structure as described in Section 11.5.2. above. |
| Plant Costs                             | Progress Control.  | Database file in date, plant type and attendance.                                         |
| Site Management Cost                    | Progress Control.  | Database file in date, job type and attendance.                                           |
| Site Overheads                          | Cost Control.      | Database file in date, expenditure item and amount.                                       |
| Contingency Work                        | Cost Control.      | Database file in date, expenditure item and amount.                                       |
| Material Cost                           | Material Control.  | Database file in material item and wastage.                                               |

### 11.7 Summary of the Aids to Planning and Progress Control

The system design of "CCMS" planning and progress control sub-system has taken into account the recommendations from the previous researches and the findings from the study in Hong Kong construction industry. In summary, its contributions to planning and progress control on site are as follows:

- a) The core of the Sub-system is to provide a function to aid for the preparation of daily reports which is a must under most standard forms of contract even without the use of computers. The Sub-system allows previous daily report data to be copied to be the current daily report, by which it should substantially reduce the documentation works of

preparing daily reports on site. A computer printout daily report definitely should have a better presentation than hand written one.

- b) With the daily report data ready in computer file format, there is a potential for the daily report submissions to be transferred to the contract supervisor's computer through the application of telecommunication system. The benefits from this approach are foreseeable and worthwhile of subject to a further research.
- c) With a better presentation and more accuracy of information contained for daily report submissions, it will aid the site supervisor staff to counter-check and verify the submission as a true record.
- d) The recording of proceeding site activities, is through a schedule input form with the aid of pop-up windows enabling standard item selection. This provides a systematic way of data capturing for the work progress and should aid for a better communication with the frontline management such as the site foremen.
- e) With the identity of parties, resources and quantum associated with each activity, the relevant work productivity can be derived by the total resources consumed over the completed quantities for a fixed period such as the monthly interim payment.
- f) The work productivity data in progress, can be used to compare with the budget productivity derived from the break down of unit rate through the use of "CCMS" estimation sub-system. Accordingly the work performance of completed works and performance trends can be assessed. This provides a valid information for the monitoring and control of subcontracts.
- g) The available of work productivity data provides a significant feedback to estimators for supporting their future estimation and subcontract negotiations.
- h) A main contribution of the Sub-system, is its ability to provide the invaluable work productivity information in a low price in terms of extra cost for data acquisition, since both the data for daily



reports and interim valuations under the cost control sub-system should have been available anyway for their own and sole function.

- i) In terms of planning on site, the Sub-system uses the advantages of micro-computer environment by allowing the share of expertise from other sophisticated planning packages which will then be procured as a sub-system under the operational framework of "CCMS".
- j) The Sub-system provides the actual progress feedback to the associated planning package through the data file format which are commonly recognisable in micro-computer applications.
- k) The approach of the progress and productivity records provided by the Sub-system, are acceptable by most quality assurance system as a proper procedure for process control and information traceability.

## **12 Quality Assurance Sub-system.**

### **12.1 Principle of Sub-system Design.**

#### **12.1.1 Quality Assurance and Computerisation.**

There are few previous researches and current literatures exploring the relationship between quality assurance and computerisation. Also those well-recognised quality standards do not require the quality systems to be proceeded with computerisation.

Anderson and Herne (1969) pointed out that the use of computers which could handle many figures and do much analysis, could make quality control more comprehensive and realistic. Salagnac (1991) has pleaded the need of future computer integrated construction to emphasise on site management and quality.

According to the practical surveys by visiting the quality assurance consultants as described in Chapter 4 of this thesis, putting a simpler way of expression, it is concluded that any quality standard will require the following actions to be implemented:

- Write what you do.
- Do what you write.
- Record required actions completed.
- Audit required actions completed.
- Corrective action on non-compliance.

The principle of these actions requires the management to set up and implement procedures for quality and with records to prove the procedures have been properly implemented. Setting procedures and keeping records are functions befitting for computing operations. It has been well acknowledged by both the academic and professional that computerisation is a trend for construction management, for which the problem of individual organisation's adaptation will only be the timing and the pace of implementation.

Earl (1989) pointed out that for implementing computerisation in any existing management organisation it should inevitably involve with changes to the existing management practices. Most quality assurance consultants according to the study in Hong Kong agree that for applying any quality assurance systems some kind of changes may have to be taken place for ensuring that more specific procedures and better recording system will be adopted for improving the existing management practices. In fact for the changes due to the computerisation and the application of quality

assurance system, it may involve with organisational, functional and operational changes and enhancements. It is, therefore, rational to consider both changes in one goal. That means in the sense of the concern of computerisation, quality assurance procedures should also have been considered.

#### **12.1.2 Operation of "CCMS" Quality Assurance Sub-system.**

The model of construction management described in Chapter 6 includes a management function for quality assurance. This chapter describes the operational details of 'CCMS' quality assurance sub-system (also called the Sub-system in this Chapter) used to support the management tasks of the quality assurance management function described in Section 6.9. The Sub-system is one the two head office based sub-systems in the operational structure of "CCMS". The aim of the Sub-system is to provide functions supporting the implementation of quality assurance procedures required by ISO 9000. The operational concept of the Sub-system can be divided into three levels:

- a) Company Level;
- b) Departmental Level; and
- c) Project Level.

The details of each level are described as follows:

##### **a) Company Level:**

###### **Quality Documents Preparation:-**

It aids the preparation and maintenance of quality system documents and their subsequent amendments, including:

- Quality Policy,
- Quality Manual.

##### **b) Departmental Level:**

###### **Work Procedure Documents Preparation:-**

It aids the preparation and maintenance of standard work procedures and their subsequent amendments for each functional department in an organisation.

###### **Control of Document Distributions:-**

It provides a function to record and keep track the

distributions of quality documents for all the internal and external distributions.

**Staff Training Control: -**

It preserves the training needs of individual staff, based on which the Sub-system can generate an attendance list for any particular training programme. The Sub-system also records the training details of individual staff.

c) **Project Level:**

**Quality Plan Preparation:**

The Systems provides the provisions to aid for the preparation and maintenance of quality plan for individual project.

**Project Staffing Maintenance:**

It records the details of site project staff in terms of their qualifications, job descriptions, responsibilities and authorities.

**Contract Review:**

It helps the review of the contract parameters of a project and links with the site information control system.

**Record of Non-conformity and Corrective Action:**

It records the internally or externally identified non-conformities and the subsequent corrective actions.

**Internal Audit:**

It provides functions to record and keep track the details of site internal audits.

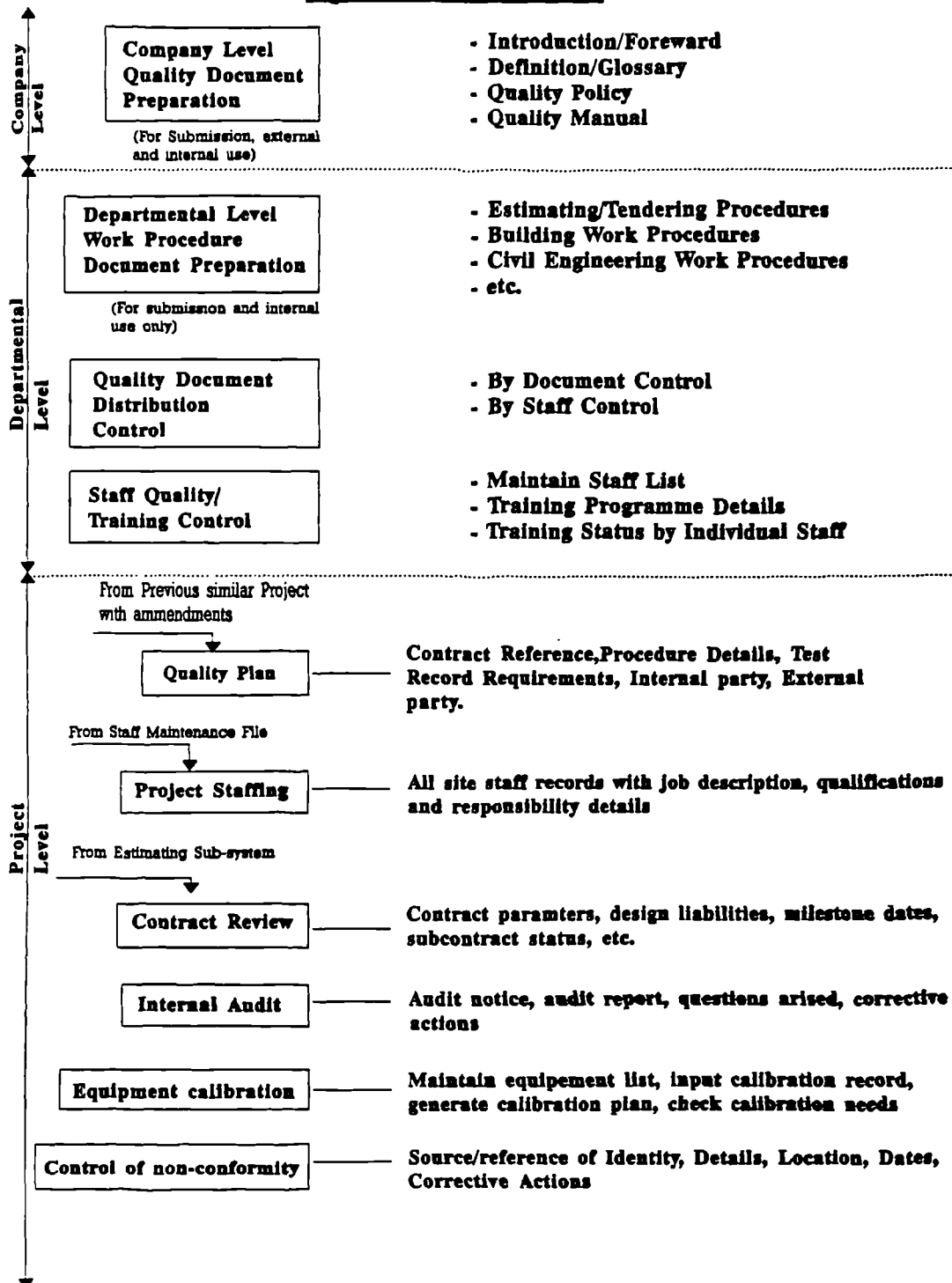
**Equipment Calibration:**

It helps maintain a master equipment list with calibration requirements for each item, based on which the Sub-system will generate calibration plans and record the calibration details.

The operation flow chart of the Sub-system is shown in Figure 12.1 (a).

Figure 12.1(a)

### CCMS Quality Assurance Sub-system Operation Flow Chart



The main input screen of the Sub-system is shown in Figure 12.1 (b).

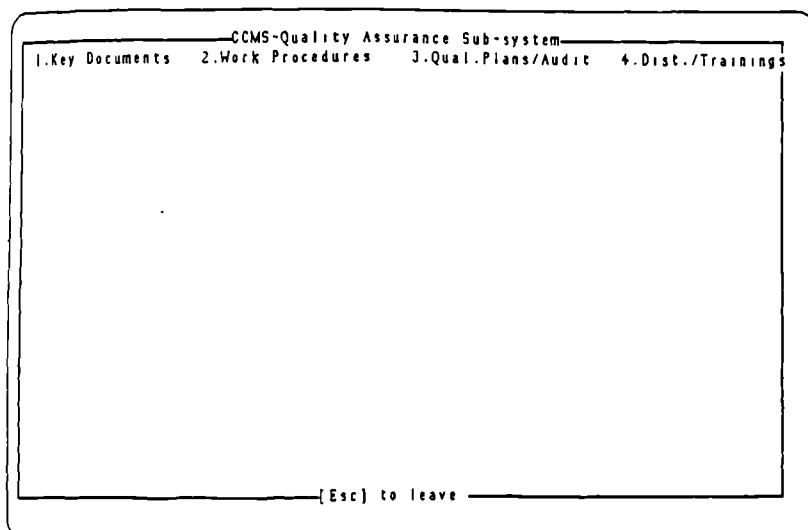


Figure 12.1 (b)  
The Sub-system  
Main Input Screen.

The detailed explanations for each function will be described in the following sections.

## 12.2 Preparing Quality Sub-system Documents.

ISO 9002 Clause 4.2 Quality Sub-system states: "The supplier shall establish and maintain a documented quality system as a means of ensuring that product conforms to specified requirements". The Guidelines for Quality Sub-system Implementation issued by Hong Kong Construction Association in May 1992 (hereinafter called "the Hong Kong Contractor Quality Guide"), recommends that the contractor's Quality Sub-system will minimally contain the following six general elements:

- Quality policy;
- Quality manual;
- Standard operating procedures;
- Work instructions;
- Forms;
- Project quality plans.

Ashford (1989) has defined that policy is the direction in which the top management of an organisation wishes the organisation to move. Quality Policy should be a short document with one or two pages stating the corporate objective of an organisation for quality.

BS 5750 Part 0.2 identifies the purpose of a Quality Manual as:

"To provide an adequate description of the quality management system while serving as a permanent reference in the implementation and maintenance of that system".

The Quality Manual shall describe in general terms, the contractor's quality assurance activities in specific areas stated in the quality system standards. The manual should also identify supporting procedures which have been established to guide and control the activities specified in the manual.

The Work Procedure is another set of document covering the operational procedures for achieving the quality standards mentioned in the quality manual. Every functional department within an organisation such as estimation department, construction project sites for building work, construction sites for civil engineering works and piling work section etc, should have a set of comprehensive work procedures for controlling their functional operations so as to meet the requirements identified in each section of the Quality Manual. The Hong Kong Contractor Guide identifies that the work procedure should include the following:

- a) a description of purpose of the scope of work to which they apply;
- b) a list and description of the steps to be carried out;
- c) identification of person or persons responsible for each step;

Both Quality Manual and Quality Policy, are a kind of external quality documents which not only are used internally but also can be acted as a marketing credential. The Work Procedures for different functional departments are a kind of internal quality documents which should be treated as a confidential document to outsiders. However, they are all essential documents for accreditation submissions to certification bodies. Ashford (1989) identified a sample of quality documents. The attributes of these documents in terms of presentation are as follows:

- a) Every document should have a title page which contains the following information in the top and bottom parts:

- Organisation identity and/or logo;
  - Document reference number;
  - Page identity;
  - Date of document version;
  - Brief revision description to last version;
  - Signature of quality assurance manager and date;
  - Signature of chief executive and date;
  - Issue number;
  - Issue date;
  - Independent copy number;
  - Name of party this copy sent to.
- b) Within the document itself each page should have the following attributes:
- Organisation identity and/or logo;
  - Document reference number;
  - Page identity and number of total pages;
  - Date of document version;
  - Issue number;
  - Issue date;

The contribution of the Sub-system to the preparation of these quality documents are summarised as follows:

- a) According to Ashford each paragraph of the documents contains the following attributes:
- Under a specific heading;
  - With an individual sub-heading;
  - Having a paragraph code;
  - The content.

The model of the above information structure can be converted into a database form using memo field technique to store the data of 'the content'.

- c) The above information can be treated as the expression part of quality documents, which will be printed out in paper form for format issues. In fact, there should have some other information which relates to the background of the format statements in those quality documents such as the names of reference documents and details of amendment records etc. ISO 9002:1987 (E) Clause 4.4.2 states:

Changes to documents shall be reviewed and approved by the same functions/organisations that performed the original review and approval unless specifically designated otherwise. The designated organisations



shall have access to pertinent background information upon which to base their review and approval.

.....

The Sub-system provides the provisions to accommodate such kind of background information by allowing two more fields in the database. This approach increases the efficiency of document handling and provides the functions to keep track the amendment details, the general result of which aids to comply with the requirement of traceability for quality documents,

In every screen edit for the quality document, the Sub-system will prompt to ask the input of the following document parameters:

- Issue number;
- Revision date.

The input menu for handling quality documents is shown in Figure 12.2 (a). and Figure 12.2 (b).

```

CCMS-Quality Assurance Sub-system
1.Key Documents 2.Work Procedures 3.Qual.Plans/Audit 4.Dist./Trainings

A.Introduction/Foreward▶ A.Edit
B.Definition/Glossary▶ B.Print
C.Quality Policy▶ C.Re-paging
D.Quality Manual
.....
E.Utilities▶

Issue :
Date : 01-05-92

[Esc] to leave

```

Figure 12.2 (a)  
Editing Version  
Number and Date  
for Quality  
Documents.

| CCMS-Quality Assurance Sub-system                         |                                               |      |
|-----------------------------------------------------------|-----------------------------------------------|------|
| Edit - Policy Manual - Heading                            |                                               |      |
| Code                                                      | HEAD                                          |      |
| 1.0                                                       | MANAGEMENT RESPONSIBILITY                     |      |
| 2.0                                                       | QUALITY SYSTEM                                |      |
| 3.0                                                       | CONTRACT REVIEW                               |      |
| 4.0                                                       | DESIGN CONTROL                                |      |
| 5.0                                                       | DOCUMENT CONTROL                              |      |
| [F3] to save; [F4] to select; [F5] to add; [F6] to delete |                                               |      |
| Detail - Code : 1.0 MANAGEMENT RESPONSIBILITY             |                                               |      |
| Code [F2]                                                 | Definition [F2] to edit; Alt+[F2] to add hist | Page |
| 1.1                                                       | Quality Policy                                | 1    |
| 1.2.1                                                     | Organisation                                  | 1    |
| 1.2.2                                                     | The Quality Assurance Coordinator shall       | 1    |
| 1.2.3                                                     | The task of developing the Quality System     | 1    |
| 1.3                                                       | Management Review                             | 1    |
| [F3] to save; [F4] to select; [F5] to add; [F6] to delete |                                               |      |
| Update Reference for 'Policy Manual'                      |                                               |      |
| Issue : 1                                                 |                                               |      |
| Date : 01-01-92                                           |                                               |      |

Figure 12.2 (b)  
Editing the  
Content of Quality  
Documents.

The formal documents for issues can be printed from the Sub-system. A sample print out for one page of Quality Manual is shown in Figure A of Appendix 12.

### 12.3 Control of Document Distributions.

ISO 9002:1987(E) Clause 4.4 specifies the requirements of document control. Under Clause 4.4.1 it states:

The supplier shall establish and maintain procedures to control all documents and data that relate to the requirements of this International Standard. These documents shall be reviewed and approved for adequacy by authorised personal prior to issue. This control shall ensure that:

- a) the pertinent issues of appropriate documents are available at all locations where operations essential to the effective functioning of the quality systems are performed;
- b) obsolete documents are promptly removed from all points of issue or use.

Accordingly, all the quality documents except those for marketing purpose, should be classified as controlled documents, for which a mark should be chopped as 'Controlled Copy' on the title page of the document. For the marketing copies, such as those issued to the client for prequalification submission, should be marked as 'Uncontrolled Copy'.

The System provides a function to record the details of document distributions for controlled documents. In addition, the Sub-system will prompt to ask for the input of a quality document type such as quality manual, work procedures and addendum etc. An input screen in schedule form will be turned up showing the previous input data and allow the user to append new data. The columns of the schedule allow the user to input the following information for each distribution:

- Issue number;
- Issue date;
- Copy number;
- Party name to whom the copy will be sent;
- Site name/organisation name;
- Status of this copy;
- Remark.

When the user inputs the party name, the Sub-system provides a pop-up window function for the user to access and select from the items of the database which stores the staff and other relevant parties' details including the staff name/party name and the site name/organisation name. A sample pop-up screen is shown in Figure 12.3 (a). Once the user has selected the party name, the site name or organisation name of such party will be automatically transferred to the schedule column from the staff database.

| CCMS-Quality Assurance Sub-system  |          |                 |                     |           |          |
|------------------------------------|----------|-----------------|---------------------|-----------|----------|
| Staff List - in staff number order |          |                 |                     |           |          |
| Staff N                            | Staff No | Grade [=]       | Name                | Site_code | Site [=] |
| 12345                              | 12345    | Site Quantity S | Mr. Kan Chi Kwong   | 01        | Yuen Lon |
| 12346                              | 12346    | Site Engineer   | Mr. Lo Kam Din      |           | Sai Wan  |
| 12347                              | 12347    | Site Manager    | Mr. Chan Kwong Pon  |           | Yiu Tung |
| 12348                              | 12348    | Director        | Mr. Chuen Ming Kwan |           | Head Off |
| 1264                               | 1264     | Site Agent      | Mr. Lai Chi Kuen    | 01        | Yuen Lon |
| 12657                              | 12657    | Site Agent      | Mr. Lai Chi Kin     |           | Yiu Tung |
| 12756                              | 12756    | Site Quantity S | Mr. Wong Chin Yuen  |           | Airport  |
| 1564                               | 1564     | Site Manager    | Mr. Kong Wing Keung | 01        | Yuen Lon |
| 2347                               | 2347     | Site Agent      | Ho Wing Ming        | 02        | Transfer |
| 2678                               | 2678     | Site Quantity S | Tai Ming Kee        | 02        | Transfer |
| 2761                               | 2761     | Site Manager    | Chan Ming Kong      | 02        | Transfer |

[F4] to select; [F5] to add; [F6] to delete; [F8] to sort 'in order'

Figure 12.3 (a)  
Pop-up Window  
Listing the Staff  
Details for  
Selection.

It is important to record also the status of each distribution for different party. A set of standard phraseology can be set up in the pop-up window library, within which the typical phraseology may include the follows:

- 'For comments'
- 'For implementation'
- 'For submission'
- etc.

It allows the standard phraseology library to expand in line with the use of the Sub-system. Knowing the status of each distribution, it helps the user have a better control on the utilisation of quality documents.

Since the name of the document receiver has been recorded in the Sub-system, it allows the user to list, based on the name of party, the names of the documents so far held by such party. This provides a counter-check function to ensure that all the key persons should have received the right documents in the right time. A sample input screen showing the details of the documents held based on the holder's name is illustrated in Figure 12.3 (b).

CCMS-Quality Assurance Sub-system  
Check Distribution of Document - by Staff

Staff Number : [=] 1264      Staff Name : Mr. Lai Chi Kuen

Position : Site Agent

Site : Yuen Long Bus Station

| Documents Holding |    |              |          |                        |
|-------------------|----|--------------|----------|------------------------|
| Document Name [=] | No | Status [=]   | Date     | Issue/Remark [F2] to e |
| Definition        | 03 | For Comments | 01-04-92 | 3                      |
| Quality Manual    | 03 | To Implement | 01-06-92 | 2                      |
| Resubmitted to HK |    |              |          |                        |

[F3] to save; [F5] to add; [F6] to delete

Figure 12.3 (b)  
List the Documents  
Held by a Specific  
Staff.

The above is the means of document control for the quality documents issued internally. In case of documents such as drawings and instructions etc. issued from the outside parties such as architects or engineers, the document control procedures should be implemented on project site level. Ashford (1989) commented that organisations in receipt of documents such as construction sites should establish procedures for controlling the receipt and re-issue of documents and for large sites particularly those employing substantial numbers of subcontractors may find it beneficial to introduce computerised systems. "CCMS" information control sub-system provides the instruction register and correspondence register functions to control the receipt, distribution and submission of drawings and instructions. The details are described in Section 8.4 and 8.3 of this thesis.

#### 12.4 Preparing Quality Plans.

ISO 9000 under International Standard 8402 Quality Vocabulary defines 'Quality Plan' as a document setting out the specific quality practices resources and sequence of activities relevant to a particular product, service, contract or project.

BS 5750:Part 0.2 advises that quality plans should define:

- a) The quality objectives to be attained;
- b) The specific allocation of responsibility and authority during the different phases of the project;
- c) The specific procedures, methods and work instructions to be applied;
- d) Suitable testing, inspection, examination and audit programmes at appropriate stages;
- e) A method for changes and modifications in a quality plan as projects proceed;
- f) Other measures necessary to meet objectives.

Ashford (1989) has further explained that the purpose of quality plans is to specify how the quality system described in the quality manual will be applied to a particular project and to give details of the specific practices, resources and activities which either have been or will be developed for this purpose.

The first issue of a quality plan should be made at the pre-contract stage, for which it should be prepared once the contract is confirmed as part of the normal routine of construction planning.

Romagna (1991) in Hong Kong has defined that a project quality plan should include the following details in terms of:

**a) Responsibility, organisation and people:**

- Project organisation plans including project organisation chart and site organisation chart;
- List of subcontractor and sub-sub-contractors;
- List of suppliers and sub-suppliers;
- List of nominated sub-contractors/suppliers;
- List of site personnel.

**b) Project schedules:**

- Master programme;
- Sectional detail programme;
- Project budget;
- Sub-contracts schedule;

- Materials schedule;
- Plant schedule.

**c) Operational Quality Assurance Plan:**

- Works quality assurance plan;
- Materials quality assurance plan - warehouse;
- Materials quality assurance plan - site;
- Special plan and status reports;
  - \* Sub-contract works and inspection plan status reports.
  - \* Sub-contractors' corrective action reports.
  - \* Materials storage and inspection reports.
  - \* Sub-contractors'/suppliers' performance reports.

The data model of quality plan can be converted into a database structure with the following fields in a record:

- Related work type;
- Related document references;
- Description of procedures, methods and instructions for the works;
- Details of test records required;
- Responsibilities and authorities of internal party;
- Responsibilities and authorities of external party;
- Amendment details/remark;

"CCMS" quality assurance sub-system provides a function to handle the quality plans which will be divided into different types of work categories. It allows the user to abstract any set of quality plan based on the work types such as excavation, concreting and finishing works etc. The original contract specifications should be used as the basis for the quality plan. Programmes and other schedules can be treated as an independent work type within the quality plan database. A sample input screen for quality plans is shown in Figure 12.4 (a).

|                                                   |                                                   |      |                     |                         |
|---------------------------------------------------|---------------------------------------------------|------|---------------------|-------------------------|
| Contract Review/Quality Plan                      |                                                   |      |                     |                         |
| Job Detail                                        |                                                   |      |                     |                         |
| Project Reference [=] 01                          | Description Yuen Long Bus Station<br>Lot No. 3322 |      |                     |                         |
| Project Type [=] Public Utility                   |                                                   |      |                     |                         |
| Management Team/Quality Plans                     |                                                   |      |                     |                         |
| Contract Staff : Position and Job Description : F |                                                   |      |                     |                         |
| Quality Plans : Description and Records to : T    |                                                   |      |                     |                         |
| Quality Plan List : in code order                 |                                                   |      |                     |                         |
| Trade : Programme                                 |                                                   |      |                     |                         |
| Wh                                                | Code                                              | Code | Docu. Ref           | Description (F2)        |
| 01                                                | 01                                                |      | GCC Cl. 16 SP Cl 45 | Initial Works Programme |
| 02                                                | 02                                                |      | GCC Cl. 16 SP Cl 45 | Expanded Initial Work P |

Figure 12.4 (a)  
Input Screen for  
the Quality Plan  
by Trade.

The particulars of management staff on site should be regarded as part of the quality plan. The Sub-system provides a function to record the particulars of each site management staff. These include the staff identity number, staff name, grade and position. Also it is important to note down a brief for the qualifications and experience of each site staff, and the most important issue for management staff on site is a job description for each staff in respect of their responsibilities and authorities. A sample input screen for site management staff particulars is shown in Figure 12.4 (b).

|                                                    |          |                                                     |                 |                 |           |
|----------------------------------------------------|----------|-----------------------------------------------------|-----------------|-----------------|-----------|
| Contract Review/Quality Plan                       |          |                                                     |                 |                 |           |
| Job Detail                                         |          |                                                     |                 |                 |           |
| Project Reference [=] 01                           |          | Description   Yuen Long Bus Station<br>Lot No. 3322 |                 |                 |           |
| Project Type [=] Public Utility                    |          |                                                     |                 |                 |           |
| Management Team/Quality Plans                      |          |                                                     |                 |                 |           |
| Contract Staff : Position and Job Description : T  |          |                                                     |                 |                 |           |
| Staff List - in staff number order                 |          |                                                     |                 |                 |           |
| Staff N                                            | Staff No | Grade [=]                                           | Name            | Job [F2]        | Quali [1] |
| 1234S                                              | 1234S    | Site Quantity S                                     | Mr. Kan Chi Kwo | Responsible for | Assessat  |
| 1264                                               | 1264     | Site Agent                                          | Mr. Lai Chi Xue | Responsible for | Higher C  |
| 1S64                                               | 1S64     | Site Manager                                        | Mr. Kong Wing K | Top management  | Member 1  |
| [F5] to add; [F6] to delete; [F8] to sort in order |          |                                                     |                 |                 |           |

Figure 12.4 (b)  
Input Screen for  
Site Management  
Staff.

## 12.5 Contract Review and Its Linking with the Estimating Sub-system.

ISO 9002 Clause 4.3 Contract Review states:

"The supplier shall establish and maintain procedures for contract review and for the co-ordination of these activities.

Each contract shall be reviewed by the supplier to ensure that

- a) the requirements are adequately defined and documented;
- b) any requirements differing from those in the tender are resolved;
- c) the supplier has the capability to meet contractual requirements;

Records of such contract reviews shall be maintained.

The Hong Kong Contractor Guide has pointed out that the contract review is particularly important in the construction industry in which the projects are large and unique. The Guide added that in order to ensure that adequate and appropriate contract review takes place contractors shall establish procedures to ensure:

- a) that client tender documents are sufficiently clear, that the contractor can adequately estimate costs, plan work and otherwise prepare a proposal which can meet client requirements;
- b) that unclear or inconsistent requirements are identified and brought to the client's attention;
- c) that the contractor reviews and makes a formal judgement that it has the capability to deliver the work specified in the contract as per quality, cost and schedule;
- d) that the contractor reviews the awarded contract, identifies inconsistencies with tender documents and formally resolves them with the client.

In the construction industry under the traditional procurement system, contractors should have gone through a similar approach as contract review before tendering. In fact, the Contract Review requirement of ISO 9000 covers the pre-tender activities which contractors normally associate with such as quantity surveying, estimating and tendering. It is, therefore, sensible for the contractor to set up sub-procedures under 'Contract Review' such as "tender evaluation", "estimating", "tender preparation" and formal "contract review".



Since it has been agreed by most professionals and academics (Ashford 1989, Romagna 1992) that the application of Contract Review for contractors has a great relevance to the practices of estimating and tendering, it will be logical and appropriate in the system design of "CCMS", to link up the data initiated from the Estimation Sub-system to the Quality Assurance Sub-system through the Site Information Control Sub-system. In fact, even without the application of quality assurance system, the contract review data initiated from the Estimation Sub-system will be passed to the site Information Control Sub-system and the data in the data review file will be reviewed by the site quantity surveyor to compare with the details of the awarded contract for identifying any deviation. With the application of quality assurance system, such contract review data from site should be accessible by the Quality Assurance Sub-system at the head office. In practice, it will be the Site Information Control Sub-system periodically sending the updated contract review data to the Quality Assurance Sub-system at the head office through the telecommunication system. It means that for the implementation of formal Contract Review, the Quality Assurance Department at the head office acts a supervisory role to check the contract review status on site. The contract review execution under the Estimation Sub-system is described in Section 7.5.2 of this thesis. The contract review procedure under the Information Control Sub-system is described in Section 8.8 of this thesis. A flow chart showing the information among these Sub-systems for contract reviews is illustrated in Section 7.5.2. A sample screen showing the access to the contract review function is illustrated in Figure 12.5 (a).

| Contract Review/Quality Plan                      |                                                   |
|---------------------------------------------------|---------------------------------------------------|
| Job Detail                                        |                                                   |
| Project Reference [=] 01                          | Description Yuen Long Bus Station<br>Lot No. 3322 |
| Project Type [=] Public Utility                   |                                                   |
| Management Team/Quality Plans                     |                                                   |
| Contract Staff : Position and Job Description : F |                                                   |
| Quality Plans : Description and Records to : F    |                                                   |
| Contract Review                                   |                                                   |
| Contract Parameters..... F                        | Domestic Subcontracts ..... F                     |
| Design Liabilities ..... F                        | Internal Management Needs ... F                   |
| Nominated Subcontracts.... F                      | Special Requirements..... F                       |
| Construction Works..... F                         | .....                                             |

Figure 12.5 (a)  
Contract Review  
Input Parameters.

## 12.6 Control of Non-conformity and Corrective Action.

During any production process, the come out of non-conforming products is unavoidable. The problem, therefore, is how to identify it and to handle it for the same to be properly recorded. ISO 9002 Clause 4.12 states the requirements for control of non-conforming product and Clause 13 states the requirements for corrective action.

It should be clear that those procedures for getting ride of non-conformity should be stated in the proper quality plans as described in Section 12.4 above. The Hong Kong Contractor Quality Guides makes it more specifically related to quality plans and states that:

"As part of defining, using and updating the Project Quality Plan, including works quality assurance plan and materials quality assurance plan, the contractor establishes procedures for tracking and preventing the inadvertent use of non-conforming materials and advertent release of non-conforming intermediary or final works."

In terms of corrective actions for non-conformities, the Hong Kong Contractor Quality Guides proposes that the procedures shall include:

- a) using the data generated in the process of carrying out the works quality assurance plan and the materials quality assurance plan to identify recurring instances of non-conforming works and non-conforming materials;
- b) conducting regular (monthly or quarterly) project review meetings at which corrective action is an explicit item in the agenda.
- c) explicitly addressing the causes as well as the fixes to formal complaints raised by the Client Representative in writing;
- d) maintaining records of Client complaints concerning completed works during the contract maintenance period, or longer, if required, when such information is available.

The system design of "CCMS" has considered the effects to the site management due to the requirements of the quality assurance system. To facilitate this consideration, part of the functions from the sub-systems on site, provide a

significant contribution to the control of non-conforming works. The identity of non-conformity from the viewpoint of contractors, usually involves with two sources:

- a) The first source is from the site frontline management, such as sectional foremen or site engineers. They may identify the quality problems on the working area where the production is carrying on. If the problem is minor, it may be able to be solved out on site with the co-operation of the subcontractors or direct resources. In this situation, the problem may not be able to be identified under the site management system unless it is reported by the corresponding site foremen. If the problem is so minor, of course it can be negligible. If any such problems involve with extra cost or time, it should be able to be captured by other well functioned site management systems. For example, "CCMS" site cost control sub-system provides a means to control contingency work which may be used to remedy quality problems. The details of this function are described in Section 10.4.3 of this thesis. "CCMS" site progress control sub-system, requires the site frontline management to report the job activities with the detailed resources engaged (see Sections 11.3 and 11.4 of this thesis). With these Systems to be properly functioning, all these mechanisms not just aid for their own functions but should also be able to contribute for identifying non-conformities.
- c) The second source of identifying non-conformity should be from the external contract supervision. Most construction projects should have representatives from the client or the contract supervisor, in the capacity of resident engineer or clerk of works. They should perform their responsibilities and authorities under the contract to ensure that the works on site have been carried out in compliance with the requirements in the contract. Any non-conformity identified should be recorded and given notices to the contractor pursuant to the channels provided in the contract. It will then rely on the contractor's internal procedures to handle for such non-conformity notices or complaints which may be in a form of site memo, site instruction or formal letter. "CCMS" site information control sub-system, provides a function of correspondence register with the details described in Section 8.2 of this thesis. One of the main functions of the Sub-system is to classify the nature and effects of correspondence and prepare reports based on a pre-defined criteria in order to show the details of certain effects such as the status of quality

complaints from the contract supervisor etc. Another channel of complaints from the external supervision for work quality may be through the site meetings and of course the same should be recorded in the minutes of meeting. "CCMS" site information control sub-system provides a functions to handle the events recorded in minutes of meeting, the details of which are described in Section 8.6 of this thesis. These mechanisms help the site management identify and alert for the non-conformities identified and noticed through external channels.

In addition, an independent function has been included in the Quality Assurance Sub-system to handle the identified non-conformities and their subsequent follow-up actions. A record for a non-conformity event includes the following fields:

- Record reference;

An independent reference number will be given for the non-conformity event recorded in the system.

- Source of identity;
- Reference for source of identity;
- Non-conformity identify date;
- Non-conformity happen date;

The details of the notice for the non-conformity.

- Inspection head;
- Inspection item;
- Non-conformity description;

The inspection head is the type of work to be inspected under the quality plan such as concrete work, reinforcement bar, brick work, door frame and window sill etc. The inspection item is the item of work to be inspected under a specific inspection head. Non-conformity description is a description for the details of a non-conformity.

- Main location;
- Sub-location ;
- Structural element;
- Identity;

These are used to identify the location and the structural identify of a non-conformity. The break down structure is same as the job activity identification used in the preparation of daily reports as described in Section 11.3 of this thesis.

Against an input of a non-conformity event as mentioned above, the Sub-system will pop-up underneath a schedule providing the provisions to access and input the corresponding follow up actions. It includes the following items:

- Date of the follow up work;
- Reference of the follow up work;
- Brief description for the follow up work;
- Cost effect of the follow up work;
- Time effect of the follow up work.

A sample input screen showing the handling of non-conformity is illustrated in Figure 12.6 (a). A report is shown in Figure F of Appendix 12.

| Control of Non-conformity                       |           |                                |                     |
|-------------------------------------------------|-----------|--------------------------------|---------------------|
| Job : 01-Yuen Long Bus Station Lot No. 3322     |           |                                |                     |
| Non-conformity Reference A01                    |           | Happen Date 01-02-92           |                     |
|                                                 |           | Report Date 04-02-92           |                     |
| Source of non-conformity [ = ]                  |           | Site Meeting                   |                     |
| Reference of non-conformity                     |           | AF12                           |                     |
| -----                                           |           |                                |                     |
| Main Location [ = ]                             |           | Block 6                        |                     |
| Sub-Location [ = ]                              |           | Level 1                        |                     |
| Structure Element [ = ]                         |           | Wall                           |                     |
| Identity [ = ]                                  |           | Wing A                         |                     |
| -----                                           |           |                                |                     |
| Inspection Head [ = ]                           |           | BRICKWORK & BLOCKWORK          |                     |
| Inspection Item [ = ]                           |           | Wet Brick                      |                     |
| Non conformity Detail                           |           | Irregular alignment            |                     |
| Follow-up Actions                               |           |                                |                     |
| Date                                            | Reference | Follow Up { F2 }               | Cost Nature { = }   |
| 02-02-92                                        | CK1-230   | Dismantled the original work a | Insurance Claimable |
| -----                                           |           |                                |                     |
| [ F3 ] to save; [ F5 ] to add; [ F6 ] to delete |           |                                |                     |

Figure 12.6 (a)  
Input for  
Non-conformity  
Records and the  
Follow- up  
Details.

## 12.7 Handling of Internal Audits.

ISO 9000 under International Standard 8402 Quality Vocabulary defines 'Quality Audit' as a systematic and independent examination to determine whether quality activities and related results comply with planned arrangements and whether these arrangements are implemented effectively and are suitable to achieve objectives.

The comment notes from the Quality Vocabulary further governing 'quality audit' are as follows:

1. The quality audit typically applies, but is not limited, to a quality system or elements thereof, to processes, to products, or to services. Such audits are often called "quality system audit", "process quality audit", "product quality audit", "service quality audit".

2. Quality audits are carried out by staff not having direct responsibility in the areas being audited but, preferably, working in cooperation with the relevant personnel.

3. One of the purposes of quality audit is to evaluate the need for improvement or corrective action. An audit should not be confused with "surveillance" or "inspection" activities performed for the sole purpose of process control or product purposes.

The definition of 'Quality Audit' above gives an outline of the auditing purpose for quality. In terms of auditing format, Ashford (1989) noted that there were three types of audit:

**a) Internal Audits (1st Party)**

There are audits undertaken by an organisation to examine its own systems and procedures. The internal auditors must be independent of the people being audited in order that their objectivity will not be compromised.

**b) External Audits (2nd Party)**

There are audits undertaken by an organisation to examine the quality systems of its suppliers (i.e. contractors).

**c) Third Party Audits**

There are audits undertaken by bodies with no existing or intended contractual relationship with either the purchaser (i.e. clients) or the supplier (i.e. contractors).

Under the ISO 9000 International Standard, there is an explicit requirement for the suppliers to carry out internal quality audits. ISO 9002 Clause 4.16 'Internal Quality Audits' states:

"The supplier shall carry out internal quality audits to verify whether quality activities comply with planned arrangements and to determine the effectiveness of the quality system.

Audits shall be scheduled on the basis of the status and importance of the activity.

The audits and follow-up actions shall be carried out in accordance with documented procedures.

The result of the audits shall be documented and brought to the attention of the personnel having responsibility in the area of audited. The management personnel responsible for the area shall take timely corrective action on the deficiencies found by the audit."

From the viewpoint of contractors' implementation of ISO 9000, the purposes of internal audit are as follows:

- a) To monitor the capability of the quality system and the processes;
- b) To analyse the results of the implementation;
- c) To satisfy the requirements of ISO 9002 Clause 4.16.

According to the study in Hong Kong construction industry as described in Chapter 3 of this thesis, the procedures of internal audit adopting by the contractors are as follows:

- a) An Internal Audit Group should be formed under the Quality Assurance Manager or Department. The members of the Internal Audit Group may include one or two permanent staff from the Quality Assurance Section and the rest members should be from the top management of other sections, departments or sites on an ad-hoc basis. No members will audit their own section. The advantage of this arrangement is to let each section have a better communication for exchanging the knowledge and experience with each other, and enable the assessment for each audit to be more objective.
- b) The contents of each audit should only relate to what have been stated in the quality documents. The objective is to assess the capability of the quality system in use and to analyse the result of the implementation.

- c) A standard notice should be given to the audit target at least one week before the date of the audit. The audit notice should included the following information:
  - Notice reference;
  - Notice issue date;
  - Name of the top management of the audit target;
  - Audit date;
  - Approximate audit times from/to;
  - Name of the audit leader;
  - Description for the purpose of the audit.
- d) During the audit, the procedures, methods and instructions stated in the quality manuals should be formed as the basis of the audit.
- e) After the audit, the audit group should prepare an audit report stating the problems observed during the audit and the general comments. The questions aroused should be stated in a schedule form describing the problem itself and the relevant clause reference in the quality documents. The audit target should respond to those questions with their proposed corrective actions and a proposed implementation date. Finally the auditor should fill in the date of their acknowledgement in respect of the completion of the corresponding corrective action.
- f) A summary report in periodical interval such as every 6 months, showing the overall internal quality audit results from different sections, should be prepared for the purpose of top management review in pursuance of Clause 4.1.3 of ISO 9002.

By analysing the information model of internal audit, it finds that the data structure, involves two levels of data in relational form, which are capable to be computerised. The level one is the standard notice of internal audit and the level two is the associated questions and queries. "CCMS" quality assurance sub-system, provides a function to handle internal audits for different sections or sites. Like the other functions in the Sub-system, it will be the head office internal auditor to handle the Sub-system. The information will be kept according to different sections or sites. The Sub-system operations for handling internal audits, are similar to the manual procedures mentioned above, but with the following enhancements:



- a) With the input of the audit parameters such as audit reference, audit request issue data, audit date, proposed audit times, name of audit leader and purpose of audit, the Sub-system will automatically printout the audit notice form and store the event of this notice. A sample input screens showing the input of these parameters is illustrated in Figure 12.7 (a). A sample audit notice printout is shown in Figure B of Appendix 12.

| Internal Audits                        |              |                                                   |                                |
|----------------------------------------|--------------|---------------------------------------------------|--------------------------------|
| Job Detail                             |              |                                                   |                                |
| Project Reference [*] 01               |              | Description Yuen Long Bus Station<br>Lot No. 3322 |                                |
| Project Type [*] Public Utility        |              |                                                   |                                |
| Reference                              | Request Date | Audit Date                                        | Purpose [F2] to edit           |
| A01                                    | 01-02-92     | 01-03-92                                          | Concrete Batching Plant        |
| A02                                    | 01-06-92     | 01-07-92                                          | Inspection for tile stores .   |
| A03                                    | 01-09-92     | 01-10-92                                          | Site Documents Handling Proced |
| A04                                    | 01-12-92     | 05-01-93                                          | Internal Finishing Work Qualit |
| F2-details; F3-save; F5-add; F6-detail |              |                                                   |                                |

Figure 12.7 (a)  
List of Internal  
Audits for a  
Specific Project.

- b) The associated questions aroused during the audit can be treated as another set of data to be stored into the Sub-system. After the audit, the auditor will input the associated questions into the Sub-system for a specific audit event with the following details:

- Question number;
- Question type (e.g non-compliance or observation);
- Question itself;
- Relevant quality document reference;
- Relevant clause number in the document.

The Sub-system will then printout the question sheets and the audit report for responding to the completed audit. Such report with the questions will be sent to the audited target and will request a response from the audited target for the questions in the audit report.

- c) After the audited target has responded to the questions, the internal auditor should input into the Sub-system for the following information from the response:

- Proposed corrective action;
- Proposed implementation date.

d) The final column will be filled in by the internal auditor for the date when it is acknowledged that the corresponding corrective action proposed by the audited target has been completed. A sample input screen showing the input for the data mentioned in b), c) and d) is illustrated in Figure 12.7 (b).

| Internal Audits                                                     |                |         |                             |                      |                 |   |
|---------------------------------------------------------------------|----------------|---------|-----------------------------|----------------------|-----------------|---|
| Job : 01-Yuen Long Bus Station Lot No. 3322                         |                |         |                             |                      |                 |   |
| Audit Reference A01                                                 |                |         | Request Issue Date 01-02-92 |                      |                 |   |
| From Chan Ping Wan                                                  |                |         | To Wong Pang                |                      |                 |   |
| Audit Date 01-03-92                                                 |                |         | Audit Time from 10.30 AM    |                      |                 |   |
| Audit Leader Chan Ping Wan                                          |                |         | Audit Time to 11.20 AM      |                      |                 |   |
| Purpose : Concrete Batching Plant                                   |                |         |                             |                      |                 |   |
| Comments : To see the compliance of the plant to Work Procedure C01 |                |         |                             |                      |                 |   |
| Question/Corrective Actions                                         |                |         |                             |                      |                 |   |
| Qs No                                                               | Qs Type        | Prod No | Cl No                       | Question [F2]        | Correction [F2] | P |
| 01                                                                  | Non-compliance | 3       | 3a                          | How many quality con |                 |   |
| 02                                                                  | Observation    | 12      | 2b                          | The stacking of aggr |                 |   |
| [F3] to save; [F5] to add; [F6] to delete                           |                |         |                             |                      |                 |   |

Figure 12.7 (b)  
Details of  
Internal Audit  
with Questions and  
Corrective  
Actions.

e) With the assembling of these internal audit data, the Sub-system will generate a summary report upon request showing the status of the internal audits taken plan within the specific period. In the summary report, all the questions or problems relating to the specific clause number of the quality documents can be grouped together. This shows the pattern of the problems at the execution of such particular clause and should then provide useful information to aid for the management review in pursuance of Clause 4.1.3 of ISO 9002. A sample of summary report printout is shown in Figure C of Appendix 12.

## 12.8 Equipment Calibration.

Equipment calibration is under Clause 4.10 of ISO 9002 'Inspection, measuring and test equipment'. It is the longest clause in the whole ISO 9002 document, containing a number of requirements. Since ISO 9000 is an international standard and can be used to cover most of the production and service industries, the equipments for measurement, inspection and test are extremely critical for those high technology

industries such as electronic or chemical etc. The production of construction projects, is mainly relied on the assembling and co-ordinating of different resources on site rather than a direct product from an equipment. The safety factors and other allowances in the construction technology, will accept certain degrees of deviation. However, this should not be a reason to neglect the importance of equipment calibration for quality assurance. Since any defaults due to equipment errors, may induce the contractor to lost in both project time and cost.

ISO 9002 Clause 4.10 'Inspection, measuring and test equipment' states:

"The supplier shall control, calibrate and maintain inspection, measuring and test equipment, whether owned by the supplier, on loan, or provided by the purchaser, to demonstrate the conformance of product to the specified requirements. Equipment shall be used in a manner which ensures that measurement uncertainty is known and is consistent with the required measurement capability.

....."

The Hong Kong Contractor Quality Guide has identified that in order to comply with the requirements of ISO 9002 Clause 4.10 the contractor shall establish and maintain procedures as listed below:

- a) The contractor shall establish and maintain a list of the measuring and test equipment allocated by the contractor to each project. Each item on the list (theodolite, laser level, tape rule, steel rule, etc.) shall be physically identified (labelled or tagged) and traceable to the list.
- b) For measuring and test equipment requiring calibration, the contractor shall identify the requirements for calibration frequency, the means of calibration, and track that each item of equipment is calibrated as required.
- c) For routine measuring equipment, such as steel rulers and masonry levels, the contractor shall procure for the contract at least one instrument traceable to a national standard. This instrument shall be labelled as the "site standard" for that category of instrument and shall be used to verify other "official copies"

owned by the contractor. Records of such checking and verification against the "site standard" shall be maintained.

- d) For tasks identified in the Quality Plan as requiring controlled measuring or test equipment, the contractor shall assure that only properly controlled inspection or measuring equipment is used. For tasks not so identified, such as in-process "referencing" (e.g., aligning course of block in an interior partition), the contractor is not required to use instruments verified against the "site standard".
- e) The burden of proof is on the contractor to show that all controlled equipment is in an acceptable state of calibration. All such equipment shall be so labelled, marked or engraved. Non-controlled equipment is identified by the *absence* of such label, mark, or engraving.

"CCMS" quality assurance sub-system provides a provision to handle equipment calibrations. The concept of the system design has taken into account the recommendations from the Hong Kong Contractor Quality Guide and the study of Hong Kong construction industry described in Chapter 3 of this thesis. The functions provided by the Sub-system for equipment calibrations, are described as follows:

**a) Maintain a master calibration list:**

The details of all the controlled equipments which should be subject to periodical calibrations, are recorded in a database file with the following structure:

- Item number;
- Item name;
- Model number;
- Manufacturer identity;
- Supplier identity;
- Procuring date;
- Essential calibration interval;
- Calibration/inspection notes;
- Allocated site reference;
- Date of allocation.

A sample input screen for master controlled equipments is shown in Figure 12.8 (a).

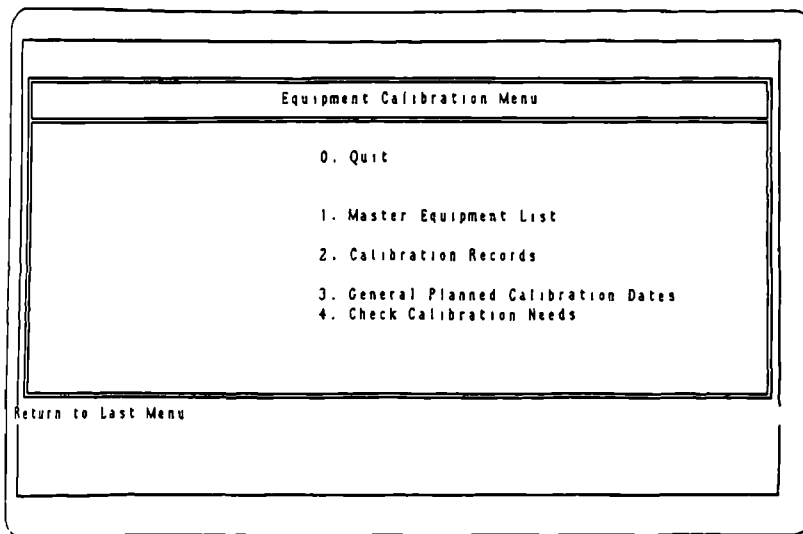


Figure 12.8 (a)  
The Details of  
Master Controlled  
Equipments Subject  
to Calibration.

**b) Generate planned calibration dates:**

The Quality Assurance Department should have the information of the allocated equipments for each project site, based on the database mentioned above. The information will be subject to the co-ordination between the Plant or Equipment Department and the Quality Assurance Department. The Sub-system holds the equipment calibration records in separated files for different sites. Once a controlled equipment has been assigned to a project, the user can request the Sub-system to generate a list of planned calibration dates. The dates are calculated by the input of a proposed time period when the equipment will be using on this site, and the 'essential calibration interval' input in the master equipment file mentioned above. The Sub-system will then create a new database file based on the planned calibration dates, the structure of which includes the following fields:

- Original planned calibration date;
- Actual calibration date;
- Actual calibration reference;
- Result of the calibration;
- Deviation of the calibration;
- Who was responsible the calibration;
- Remark.

A schedule form showing the above information will then be printed out from the Sub-system and it should be passed to the site. A sample printout is shown in Figure D of Appendix 12. Another alternative for passing this

information to site for the future development of the Sub-system, is by sending such data file to the site computer through the telecommunication system.

**c) Record of the actual calibration:**

Based on the Planned Calibration Date Schedule mentioned above, the site Quality Control Engineer should carry out the calibration work sticking to the planned calibration dates. The actual calibration result should be filled in an actual calibration form by the site Quality Control Engineer and pass the same back to the head office Quality Assurance Department. Based on such feedback information, the Quality Assurance Department at the head office, should update the Sub-system accordingly.

With the use of telecommunication system, the actual calibration result can be input into database mentioned above through "CCMS" Information Control Sub-system. The updated file can then be sent back to the Quality Assurance Sub-system at the head office.

A sample input screen showing the input of the actual calibration result is illustrated in Figure 12.8 (b).

| Equipment/Instrument Calibration        |           |                                                   |          |              |           |     |
|-----------------------------------------|-----------|---------------------------------------------------|----------|--------------|-----------|-----|
| Job Detail                              |           |                                                   |          |              |           |     |
| Project Reference [=] 01                |           | Description Yuen Long Bus Station<br>Lot No. 3322 |          |              |           |     |
| Project Type [=] Public Utility         |           |                                                   |          |              |           |     |
| Equipments/Instruments Calibration : 01 |           |                                                   |          |              |           |     |
| Equipment Type [=] Theodolite           |           |                                                   |          |              |           |     |
| Equipment Ref. [=] CBF01                |           |                                                   |          |              |           |     |
| Theodolite:CBF01                        |           |                                                   |          |              |           |     |
| Insp. Ref                               | Insp. Ref | Pln Date                                          | Act Date | Result [P/F] | Deviation | R A |
| JK01                                    | JK01      | 30-11-92                                          | 01-12-92 | Passed       | 0.5 mm    |     |
| JK02                                    | JK02      | 26-12-92                                          | 01-01-93 | Failed       | 2.5 mm    |     |
| JK03                                    | JK03      | 14-01-93                                          | - -      |              |           |     |
| JK04                                    | JK04      | 28-02-93                                          | - -      |              |           |     |
| JK04                                    | JK04      | 14-04-93                                          | - -      |              |           |     |

Figure 12.8 (b)  
Input Screen for  
Actual Calibration  
Details.

**d) Check calibration needs:**

Check calibration need is a function provided by the Sub-system to check the need of equipment calibration on a specific due date for a particular site. The Sub-system will firstly ask for an input of site identity. The user can then select to check for a

particular type of equipment through a pop-up window. If without specifying any equipment type, the default of the Sub-system will check all the controlled equipments of the selected site. The principle of this operation is for the Sub-system to compare the planned calibration dates in the file with the user specified due date. Accordingly, any record with the planned calibration date earlier than the due date and without the corresponding actual calibration date, will be prompted on the screen to alert the user that there may have problems. A report showing the outstanding calibration items can be printed out from the Sub-system, a sample of which is shown in Figure E of Appendix 12.

A sample screen showing the checking of calibration needs is illustrated in Figure 12.8 (c).

```

 _____Equipment/Instrument Calibration_____
 |_____Job Detail_____|
 |Project Reference [=] 01 Description Yuen Long Bus Station|
 |Project Type [=] Public Utility Lot No. 3322 |
 |_____Check Calibration Dates_____|
 |Equipment Type [=] Theodolite|
 |Due Date : 01-02-92|
 |Do you want to show completed calibration T|
 |_____ [F3] to save; [Esc] to leave _____|

```

Figure 12.8 (c)  
Parameters to  
Generate the  
Calibration Needs  
for a Particular  
Equipment.

### 12.9 Identify and Record Staff Training.

Ashford (1989) pointed out that the construction industry had suffered for many years from a chronic neglect of training due to the cyclic nature of the construction work load and the nomadic life style of many construction workers. The study in Hong Kong construction industry has also confirmed this point and the problem will be more serious with regard to the tendency of subcontract orientation in the construction industry. It will be difficult for the main contractor to control the trainings for subcontractor or sub-subcontractor staff. The output for subcontracts will be controlled through the other procedures of the quality system. Training in this section should only include trainings for the contractor's own staff.

Any quality system has to be operated with people. Without proper trainings to let staff in all sections fully understand and adapt to the operation of the system, no matter how good is the system it will fail. Therefore, to have an appropriate training system for staff within an organisation is required by most international quality standards. ISO 9002 Clause 4.17 Training states:

"The supplier shall establish and maintain procedures for identifying the training needs and provide for the training of all personnel activities affecting quality during production and installation. Personnel performing specific assigned tasks shall be qualified on the basis of appropriate education, training and/or experience, as required. Appropriate records of training shall be maintained."

In view of the industrial wise difficulties in the construction industry regarding training, the Hong Kong Contractor Quality Guide has identified the procedures to be adopted by contractors regarding training requirements by Clause 4.17 ISO 9002 as follows:

- a) The contractor shall establish a personnel record for each permanent employee in the company. This record shall identify the position; assignment; skill requirements; qualifications based on education, training and/or experience; training received; and plan for additional training, if any. For temporary labour not normally covered by the contractor's training procedure, the contractor shall ensure that appropriate guidance and instructions are given.
- b) The contractor shall establish a formal period for which training records are kept.

According to the study in Hong Kong Construction Industry as described in Chapter 3 of this thesis, it will be comparatively difficult for all individual contractors to provide in-house trainings to their own staff. The propensity of the industry will prefer more trainings provided by the academic or professional institutes and the contractors are willing to support and encourage their staff to attend such programmes which may be in the form of seminars, workshops and short time courses. This approach, not just saves up individual efforts for holding in-house trainings but also ensure that the quality of trainings can be up to professional standards. Therefore, it is important for the contractors to know the training needs for each staff, to be aware of the trainings



in the market and to identify who should attend for such a training and finally to record the details of the trainings attended by their staff.

The system design of the Sub-system for handling staff trainings, conceptually divides the operation into three parts:

**a) Maintain staff particulars:**

It provides a database function to store the particulars of a staff member, a record of which includes the following fields:

- Staff identity number;
- Grade position;
- Staff name;
- Qualifications/experience;
- Site code/name;
- Job description/responsibility/authority;
- Training needs.

The input for training needs is based on a standard library containing the items of training keywords such as contract administration, quality control or computerised planning etc. The user can select such keywords through a pop-up window and the database will be expending in line with the use of the Sub-system. A sample screen showing the input of staff particulars is illustrated in Figure 12.9 (a).

The screenshot displays a terminal window titled "CCMS-Quality Assurance Sub-system". Below the title is a header "Staff List - in staff number order". The main area contains a table with columns: "Staff M", "Site\_code", "Site [=]", "Train", and "[F2] to edit". The "Staff M" column lists various management techniques like "Management Technique", "Quality Assurance", and "Personnel Management". The "Site\_code" column shows "2761" and "02". The "Site [=]" column lists locations such as "Bus Statio", "Estate Phas", "ce", "Bus Statio", "Estate Phas", "terminal Ext", "Bus Statio", "er Rm Bay 3", and "Transformer Rm Bay 3". The "Train" column lists "Job" and "Train Needs". The "[F2] to edit" column is empty. At the bottom, there is a footer with instructions: "[F5] to add; [F6] to delete; [F8] to sort in order".

| Staff M              | Site_code | Site [=]             | Train | [F2] to edit |
|----------------------|-----------|----------------------|-------|--------------|
| Training for : 12346 |           |                      |       |              |
| Train [=]            |           |                      |       |              |
| Management Technique |           | Bus Statio           | Job   | Train Needs  |
| Quality Assurance    |           | Estate Phas          | Job   | Train Needs  |
| Personnel Management |           | ce                   | Job   | Train Needs  |
|                      |           | Bus Statio           | Job   | Train Needs  |
|                      |           | Estate Phas          | Job   | Train Needs  |
|                      |           | terminal Ext         | Job   | Train Needs  |
|                      |           | Bus Statio           | Job   | Train Needs  |
|                      |           | er Rm Bay 3          | Job   | Train Needs  |
|                      |           | er Rm Bay 3          | Job   | Train Needs  |
|                      |           | Transformer Rm Bay 3 | Job   | Train Needs  |

Figure 12.9 (a)  
Details and  
Particulars with  
Training Needs for  
a Specific Staff.

### b) Identify training needs:

Any relevant training programme, not matter is in-house or external programme, will be considered by the personnel department, human resource department or any body assigned by the top manager to look after staff training. The decision will be made to see whether the programme is appropriate for sending staff to attend or not. If it is decided that staff should be supported to attend the programme, the decision maker shall then assign a keyword or a number of keywords representing the content of the programme and give all this information to the Quality Assurance Department. The following information relating to the training programme will then be input into the Sub-system:

- Assigned programme code;
- Programme title;
- Hold date;
- Time of start;
- Duration;
- Venue the programme to be held;
- Assigned keyword or keywords;
- Remark.

The Sub-system will scan through the staff database and generate a list of staff, to whom the assigned keyword of the training programme is matched with their training need keywords recorded in the Staff Particulars Maintenance File. Based on the short list, the management will then finally decide who should attend the programme. A sample screen output of such a short list is shown in Figure 12.9 (b).

CCMS-Quality Assurance Sub-system

Programme Details for : A01

---

Programme Name : Briefing for ISO 9000

Date : 01-04-92                      Venue : Head Office Conference Room  
 Time : 9.30 AM                      Duration : 2.00 hrs

Remark HKQAA Consultant presented                      Train Type [F2] to edit  
 [F2] to edit memos                      [F2] to edit training types

Suitable Staff for this Programme : A01

| Staff No | Name            | Grade         | Site                    |
|----------|-----------------|---------------|-------------------------|
| 12346    | Mr. Lo Kam Din  | Site Engineer | Sai Wan Ho              |
| 12657    | Mr. Lai Chi Kin | Site Agent    | Yiu Tung Estate Phase 2 |
| 2761     | Chan Ming Kong  | Site Manager  | Transformer Rm Bay 3    |

[F4] to put into attendant list

Figure 12.9 (b)  
Short List for the  
Staff Suitable for  
a Particular  
Training  
Programme.

### c) Record the trainings attended:

Under this section, the Sub-system allows the user to input the identity of the staff who has attended the training programme. The user can directly type in the staff identity number or through a pop-up window to select from the Staff Particulars Maintenance File.

According to these inputs, the Sub-system provides a function to list out all the training programmes attended by a specific staff based on the input of the staff identity. This function is very significant for the management to check and be aware of the status of trainings for each staff.

A sample list out screen showing the programmes attended by a specific staff is illustrated in Figure 12.9 (c).

The screenshot displays a software window titled "CCMS-Quality Assurance Sub-system" with a subtitle "Trainings for Staff - List by Staff". It contains the following information:

Staff Number : [\*] 1264      Staff Name : Mr. Lai Chi Kuen  
 Position : Site Agent  
 Site : Yuen Long Bus Station

Below this, a section titled "Trainings attended by : Mr. Lai Chi Kuen" contains a table with three columns: Code, Date, and Programme Name.

| Code | Date     | Programme Name                   |
|------|----------|----------------------------------|
| A01  | 01-04-92 | Briefing for ISO 9000            |
| A02  | 10-04-92 | Working Procedures for Tendering |
| A03  | 01-05-92 | Computerisation and ISO 9000     |

At the bottom of the window, a status bar indicates: [F2] to detail; [F3] to save; [F5] to add; [F6] to delete.

Figure 12.9 (c)  
Training  
programmes  
attended by a  
Specific Staff.

## 12.10 Summary of the Aids to ISO 9000 Implementation.

### 12.10.1 Contributions from the Quality Assurance Sub-system Itself.

The system design of "CCMS" quality assurance sub-system has taken into account the recommendations from the previous researches and the findings from the study in Hong Kong construction industry. The overall contributions of "CCMS" to the implementation of ISO 9000 for quality assurance can be divided into two parts:

- a) Part one is the functions from the Quality Assurance Sub-system itself.
- b) Part two is the functions from "CCMS" other Sub-systems.

The contributions from the Quality Assurance Sub-system itself for the implementation of ISO 9000, are summarised as follows:

- b) The Sub-system provides the functions to handle the quality documents including editing, printing, putting reference and recording the details of amendments. This approach of document handling complies with the requirements under Clause 4.4 'Document Control' of ISO 9002.
- c) The function for controlling document distributions, enables the user to record and monitor the distributions of controlled quality documents. It provides a cross-reference function, by which the status of the documents held by a particular staff can be checked and traced. This has strictly complied with Clause 4.4 of ISO 9000 in terms of document control.
- d) The computerisation of quality plan handling, provides a set of standard framework under which the information should be filled in for the preparation of a proper quality plan. It provides a kind of transferability for quality plans. That means the quality plan data file which has been proved workable in this project can be easily transferred to other similar projects with proper adjustments. This approach aims to increase the efficiency of quality plan handling.
- e) In respect of contract review which is specifically required under Clause 4.3 of ISO 9002, "CCMS" provides a function for the same information to be passed from the site Information Control Sub-system when it is needed. Such kind of contract review information should be initiated from the Estimation Sub-system and then to be passed to site Information Control Sub-system when the contract has been confirmed. The Quality Assurance Department will act as a supervisory role to ensure that the contract review has been carrying out on site from time to time and the same has been recorded.

- f) The Quality Assurance Sub-system provides a function to record and monitor the follow up actions for non-conformities. The function can be considered as part of the control to ensure that corrective actions are taken and that they are effective as required by Clause 4.13 d) of ISO 9000 for corrective action.
- g) With regard to internal audits, the Sub-system not only just aids for the handling of documentation works such as print out audit notices, but also provides a systematic means to record the problems found in the audits. The grouping of similar problems together in the periodical summary report, gives the significant information to aid for the management review as required by Clause 4.1.3 of ISO 9002.
- h) In order to comply with the requirements of Clause 4.10 of ISO 9002 for equipment calibrations, the Sub-system provides a provision to aid for the contractors' implementation of the necessary procedures. The functions include maintaining a master equipment register for all controlled equipments, generating calibration plans for each controlled equipment, recording actual calibration details and checking calibration status based on a due date.
- i) The importance of staff training for the implementation of quality assurance system is obvious and the requirements of the same have been documented as a formal provision under Clause 4.17 of ISO 9002. The Sub-system provides the functions to aid for the implementation of the following staff training procedures:
  - maintain a staff particulars database which includes the keywords of training needs for each staff,
  - generate a short list of staff with whom their training-need keywords are matched with the training-type keyword of a particular training programme.
  - record the details of staff attendance for a particular training programme.
  - counter-check the training programmes attended for a specific staff.

### 12.10.2 Contributions from the Other Sub-systems of "CCMS"

In addition to the direct contributions from the Quality Assurance Sub-system mentioned above, the other sub-systems of "CCMS" described under the separated sections of this thesis provide also a significant contribution to the implementation of ISO 9000. They are summarised as follows:

- a) The Site Information Control Sub-system provides a function for document controls which includes the handling for those controlled documents such drawings and instructions. The details are describe in Section 8.3 and 8.4 of this thesis. The approach should aid for the compliance of Clause 4.4 of ISO 9002 in terms of document control.
- b) As a means of support from the site management control mechanisms, the control of contingency work under "CCMS" site cost control sub-system and the method of job description for the preparation of daily reports, provide the information to aid for identifying non-conformities and quality problems. The details are described in Section 10.4.3 above.
- c) The correspondence register under the Site Information Control Sub-system, provides a function to record the nature and effects of daily correspondence. With a proper set up of report generation, it should aid for identifying non-conformity and quality complaints from the external parties. The details are also described in Section 8.2 above.
- d) The maintenance of a master material list for each individual project under the Site Material Control Sub-system, provides a provision to accommodate the inspection and storage requirements from the Quality Assurance Department, other the contract specifications which usually just specify the requirements of the end product. This aids for the site compliance to Clause 4.9.1 of ISO 9002 for receiving inspection and testing.
- e) The details contained in the master material list for each material item as initiated from the tendering stage and verified at the pre-contract stage, helps the contractor identify the compliance of materials with the contract requirements. This should aid for the contractor's materials procuring and ordering in pursuance of the requirements under Clause 4.5.3 of ISO 9002 for purchasing data.

- f) The procedures and functions provided by the Site Material Control Sub-system for handling materials delivery, materials distribution and checking stock, should aid for the contractor's compliance to Clause 4.14 of ISO 9002 in respect of handling, storage, packaging and delivery.
- g) The sample submission handling and recording functions provided by the Site Material Control Sub-system, should aid for the contractor's compliance to Clause 4.8.1 of ISO 9002 in terms of process control in general.
- h) The function of recording work productivity for each job activity and subcontractor under the Site Progress Control Sub-system, provides a significant reference for assessing the performance of subcontractors. This information should aid for part of the considerations in the selection of subcontractors. Clause 4.5.2 of ISO 9002 for assessment of sub-contractors, clearly states that the selection should be on records of subcontractors' previously demonstrated capability and performance.
- i) The computerisation of site daily report preparation by the Progress Control Sub-system, makes an comparatively easier for retrieving progress data of each job activity on site (production activity) and its resources used. This approach will be particularly significant for works involving insitu-concrete. This should aid for the contractor's compliance with Clause 4.7 of ISO 9002 for product identification and traceability.

#### **12.10.3 General Comments on the Use of Computers for Quality Assurance.**

It has been pointed out in Section 12.1 that same as most quality assurance standards ISO 9000 also requires the set up of procedures for implementing the quality systems and to prove the compliance with the requirements by records. Clause 4.15 of ISO 9002 for quality records, clearly indicates the essential of quality records. The same clause is referred by a number of other clauses in ISO 9002 such as follows:

- |                    |                          |
|--------------------|--------------------------|
| Clause 4.1.3       | - Management review;     |
| Clause 4.2 note g) | - Quality system;        |
| Clause 4.3         | - Contract review;       |
| Clause 4.7         | - Product identification |

- and traceability;
- Clause 4.9.4 - Inspection and test records;
- Clause 4.10 f) - Maintain calibration records;
- Clause 4.11 - Inspection and test status;
- Clause 4.12.1 - Nonconformity review and disposition;
- Clause 4.17 - Training.

Proper maintenance of records generated in parallel with the work progress, enables the traceability of problems relating to quality. ISO International Standard 8402 Quality Vocabulary defines traceability as the ability to trace the history, application or location of an item or activity, or similar items or activities, by means of recorded identification.

The use of computers with proper systems, in general sense, is undoubtedly and positively capable of handling, storing, marshaling, transforming and retrieving masses of data at phenomenal speeds and reliability. The continuously dropping prices in hardware of computer system and data storage mediums, makes the use of computers for information preserving become a tendency and eventually a must.

By this research it demonstrates that the approach of applying quality assurance procedures into the computerised management system, enables two goals: increasing the management efficiency and complying with the quality system requirements, to be achieved at once.



## 13 Project Field Test and System Evaluation

### 13.1 Introduction.

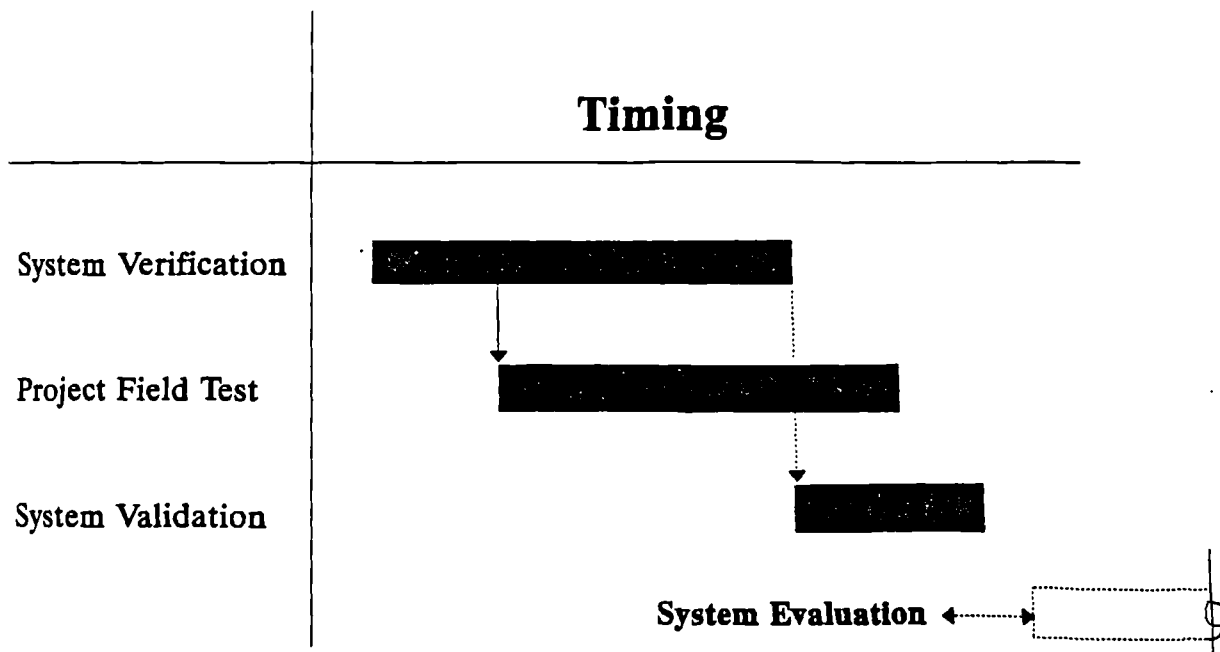
One of the core activities of this research was the development of a computer system. For this activity, computing and software engineering techniques have been applied, the details of which are described in Chapter 5 of this thesis. For any software development one of the important steps is system testing in order to assess how much of the original system objective has been achieved. Tah (1989) pointed out that system testing, in the context of software engineering, involves running the system using data which is similar to the real data on which the real system is designed to use; observing the output; and inferring programme errors or inadequacies from anomalies in that output. Sommerville (1989) elaborated that the notion of system test comprises program verification and program validation which are defined as follows:

- a) Verification involves checking that the program conforms to its design specification.
- b) Validation involves checking that the program as implemented meets the expectation of the user.

Tah and Sommerville's concept of program and system test is a classical type of system test and should be sufficient for the development of computer systems involving single purpose or catering only for a single management function of an organisation. For example the researches by Tah (1989) and Aouad (1991). Tah's (1989) research included a development of computerised formwork design system. Aouad's (1991) research involved a development of integrated planning system linking AutoCAD and Artemis packages which was used to automatically prepare planning programmes for the structure work of concrete, formwork and reinforcement trades. The system tests used in both Tah and Aouad's researches were classical system tests involving verification and validation.

However, in the case of a system involving information flow and data integration between different management functions of the same organisation, the classical approach to system testing may not be sufficient. The development of 'CCMS' (also called the System in this Chapter) is based on the model of construction management as described in Chapter 6 of this thesis and the model comprises six management functions which form the operating core of most contracting organisations in the construction industry. The operational details are described in Chapters 7 to 12 of this thesis. Development of this kind of complicated sub-systems, has to rely on a cycle

of system development and system testing. In terms of system testing in this research for 'CCMS', a project field test was added between the system verification and the system validation. The purpose of project field test was to put the System into a live project, and use the real data to test the functions of the System. Accordingly the system verification, the system validation, the human reactions to the System and the impacts on the organisation can be observed and assessed. The relationship among system verification, project field test and system validation is shown in the following Figure 13.1 (a).



**Figure 13.1 (a)**

### **Verification/Field Test/Validation Relationship**

For the system test, it includes the following procedures as explained above:

- a) System verification;
- b) Project field test; and
- c) System validation;

The project field test for 'CCMS' described in this chapter should be viewed as part of the system design and development since a lot of concepts were revealed during the field test stage. The system tests were carried out on sub-system basis. Following the system tests, the system evaluation for the

whole System were taken through an extension course follow-up by questionnaire survey and the several industrial visits with computer demonstrations on a notebook computer.

This chapter describes the system test and the system evaluation of the System.

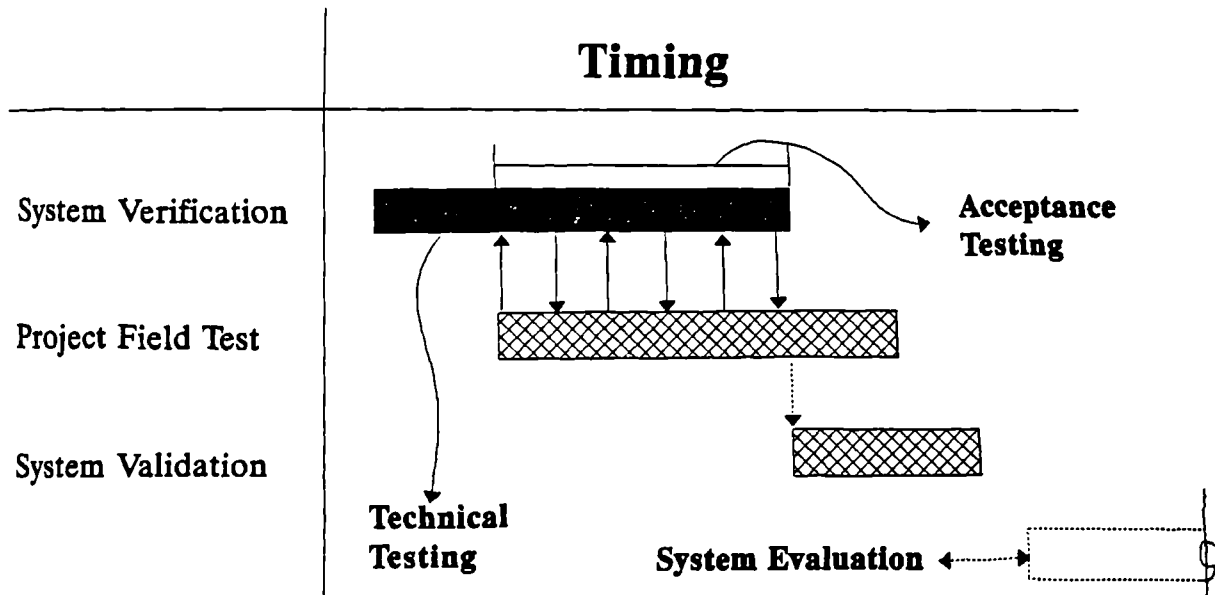
### 13.2 System Verification and Debugging.

Sommerville (1989) identified that the testing process for large computer systems includes the following stages:

- a) Unit testing: It is the basic level of testing where individual components treating as stand alone entities, are tested to ensure that they operate correctly.
- b) Module testing: A module is a collection of interdependent and related units. Module testing as a stand-alone entity without the presence of other system modules, should follow unit testing.
- c) Subroutine testing: is the next step up in the testing process where modules are put together to form subroutine. The subroutine test process should concentrate on the detection of interfacing errors by rigourously exercising these interfaces.
- d) Integration testing: is carried out when the subroutines are integrated to make up the entire system. At this stage, the testing process is concerned with finding errors which normally result from unanticipated interactions between subroutines.
- e) Acceptance testing: is the process of testing the system with real data and to produce the information which the system is intended to manipulate. As well as a verification process, acceptance testing is also a validation process. Acceptance testing often demonstrates errors in the system requirements definition.

In view of the above definitions, the system verification process can be divided into two parts, as technical testing and final real-data testing. Technical testing comprises unit testing, module testing, subroutine testing and integration testing. Final real-data testing just mentioned means acceptance testing as defined by Sommerville. Placing

Sommerville's approach into the system test model for 'CCMS' as illustrated in Figure 13.1 (a), a combined model can be made as the following Figure 13.2 (a).



**Figure 13.2 (a) Combined System Test Model**

System verification as a testing procedure is a process of establishing the presence of faults in a developing system. However, eventually for the completion of the system it is necessary to find out where the fault is, and finally remove it. This subsequent process is called debugging (Coleman and Pratt 1986, Sommerville 1989). The processes of system testing and debugging are closely related to each other, and sometimes may be viewed as one procedure.

FoxPro version 2 includes a powerful debugging tool, by which a tracing window and a debugging window can be opened simultaneously on the screen. The debugging window allows the programmer to specify the desired variables of the program and see the change of such variables when the program is executed in the tracing window, and the results can be monitored by a line by line execution. This kind of facility provides a tremendous help for system development and becomes one of the standard functions of most high level language compilers.

For the system testing and debugging in the development of 'CCMS', the FoxPro debugging tool makes a tremendous contribution to the debugging tasks, and make the job much easier. FoxPro allows the system to be run line by line in the 'Trace' window and the variables can be viewed and checked in the 'Debug' window. A sample screen of debugging is shown in Figure 13.2 (b) below

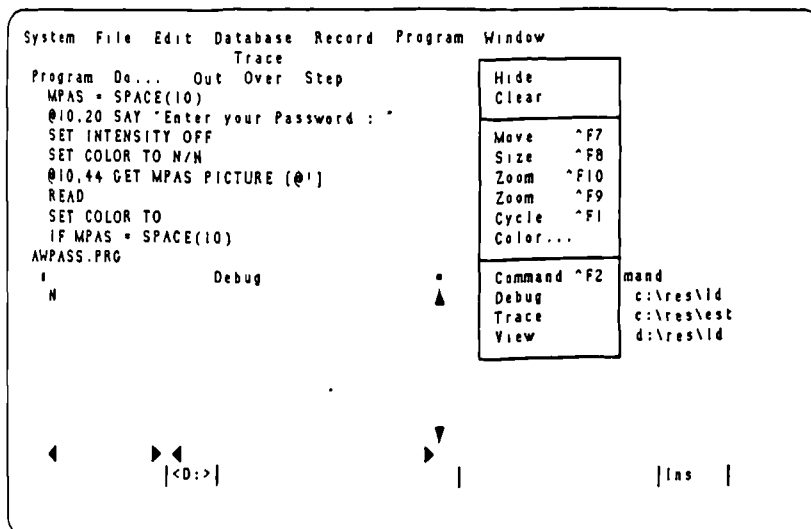


Figure 13.2 (b)  
FoxPro Debug  
Window.

### 13.3 System Field Test

#### 13.3.1 Purpose of Field Test

'CCMS' is a complicated management information system including six sub-systems for the operations at both head office and site level. The System involves not just relatively complicated information flows and data integrations, but has also to fulfil the aim of replacing part of the existing manual practices, for the purpose of increasing the efficiency of such management tasks. The performance of the System in this circumstance has to rely on the following aspects:

- The technical capability of the System itself;
- The right type of data input for the System;
- The timing and quality of data being input into the System;
- How the data is being acquired, and the efforts and costs of the data acquisition;

- e) The staff reaction to the use of the System, as the manual practices are going to be replaced by the System; and
- f) The actual use of the reports from the System for both internal controls and external submissions.

The system technical test as defined in Section 13.2 can only test the technical capability of the System itself as mentioned in item a) above. The purpose of the system field test is to find out and answer such other questions.

### 13.3.2 Field Test Project.

As agreed with a leading China-based international contractor in Hong Kong (hereinafter in this thesis called 'the Company'), one of their housing contracts (hereinafter in this Chapter called 'the Project') was assigned as the field test project for the development of 'CCMS' in this research. The Company is the largest state-owned construction conglomerate in the Peoples' Republic of China and started their business in Hong Kong in 1979. Prior to 1981, the Company was only involved in building and civil construction in Hong Kong. In April 1981, the Company was approved by the Hong Kong Government as a List II contractor, holding five licences of all the public projects. The Hong Kong Government contract administration system has been described in Section 3.4 of this thesis. The details of the Project are as follows:

**Contract Name:** Tin Yiu Estate Phase 2.

**Location:** Tin Shui Wai Area 5, New Territories.

**Client:** Hong Kong Housing Authority.

**Contract Value:** 400,000,000.00 (Hong Kong Dollars) .  
34,782,608.69 (Pound Sterling) at 1  
Pound to 11.5 Hong Kong Dollars.

**Form of Contract:** Lump sum fixed price with fluctuation.

**Contract Period:** 29 months.

**Contract**  
**Commencement** 26th September 1990.  
**Date:**

The Project was the construction of Tin Yiu Estate Phase 2 at Tin Shui Wai Area 5, New Territories for the Hong Kong Housing Authority. The works to be executed under the contract included the construction of the following major items:

- a) Four 37-storey Harmony 2 Type Blocks (Blocks 6, 7, 8 and 9). Each block is approximately 112 m high from ground floor to upper floor level. The total gross floor area of the four blocks is 171,100 m<sup>2</sup>.
- b) The blocks contain a total of 2,536 No. domestic flats with non-domestic facilities on the ground floors of Blocks 6, 7, 8 and 9 and the first and second floors of the Block 6.
- c) One 7-storey Flexi Primary School 3 approximately 6,285 m<sup>2</sup> in gross floor area, with associated single storey menial staff quarters, transformer room and pump room.
- d) One 6-storey Full Interlock Secondary School approximately 13,759 m<sup>2</sup> in gross floor area, with associated single storey menial staff quarters and pump rooms.
- e) Piling, pile caps and starter bars have been executed by a previous separate contractor as described in the contract documents.

### 13.3.3 Organisation and Site Management.

The organisation of the Company was a matrix structure, similar to most sophisticated contracting organisations in Hong Kong. A model of this kind of organisation structure is described in Section 6.3 of this thesis.

The Project was led by a site manager who was the top management on site and should be accountable to the top management of the Company for the project performance. The positions and responsibilities of the site management in the Project are shown in the following **Table 13.3.3 (a)**:

| Positions<br>(number of<br>position): | Responsibilities                                                                                                                         |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| Site manager (1)                      | All the top management decisions on site.                                                                                                |
| Assistant site manager (2).           | One for the planning and control of the structure works. One of the routine site administration.                                         |
| Site agent (1).                       | For the matters of external contractual administration.                                                                                  |
| Sub-agents (3).                       | One for the structural work quality controls. Two for the subcontract work plannings, co-ordinations and progress controls.              |
| Quantity surveyors (3).               | One project quantity surveyor leading two other quantity surveyors, responsible for all the tasks of quantity surveying function.        |
| Quality control engineer (1).         | A qualified engineer responsible for all the tests and sample submissions.                                                               |
| Building services engineer (1).       | For the planning and co-ordination of all the building services works.                                                                   |
| Store keepers (2)                     | For all the material arrivals and distributions.                                                                                         |
| Assistant engineer (2).               | For drawing controls and other routine submissions.                                                                                      |
| General foremen (7)                   | For the works supervision for the 4 high rise blocks, 1 for the secondary school, 1 for the primary school and 1 for the external works. |
| Account and clerical staff (2)        | One for the accounting works. One for the secretary works.                                                                               |

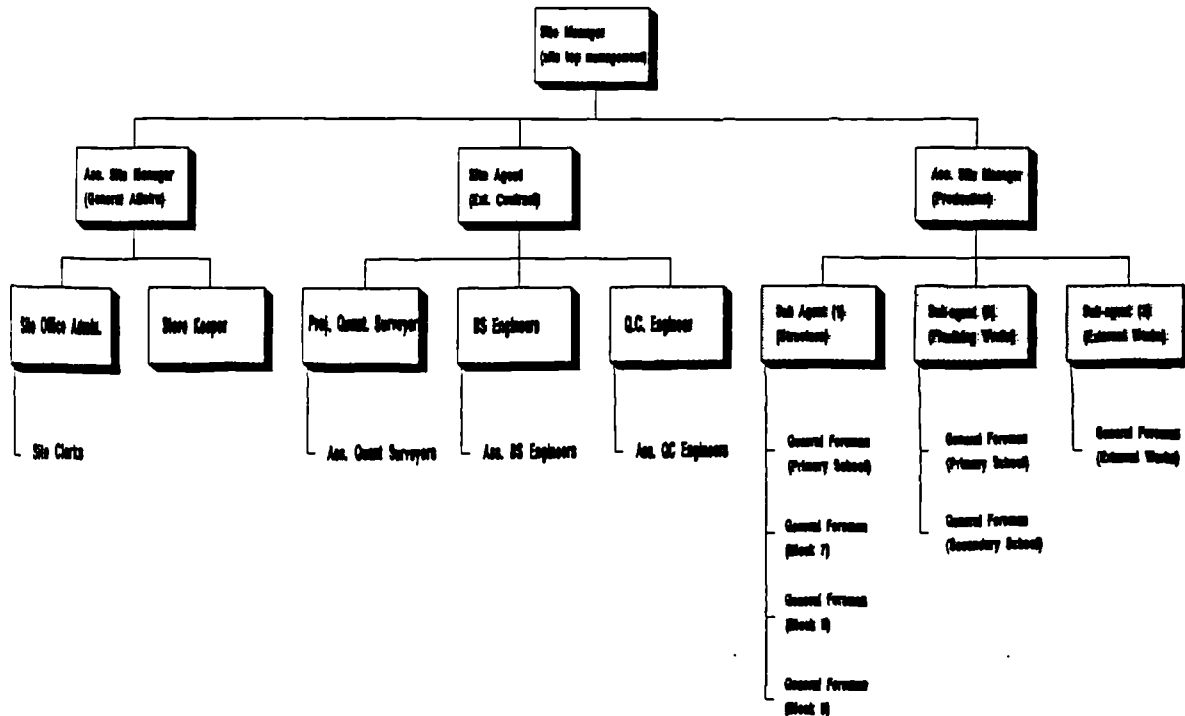
These 25 positions formed the site management of the Project and most of them previously were without any computing experience. The organisation chart is shown on the Figure 13.3.3 (a).



Figure 13.3.3 (a)

## Site Organisation Chart

### Tin Yiu Estate Phase 2



#### 13.3.4 Field Test Arrangement.

The field test in the Project was not a formal joint research or consultancy arrangement, but was an industrial support for academic research. The relationship could be considered as an industrial attachment on a research basis. The attachment was based on the previous relationship between the top management of the Company and the author of this thesis (hereinafter called the Author). Before the Author engaged in his academic career, he had been working as an external management consultant for the Company for 5 years on various construction projects involving contractual claims, pre-tender advices and computerisation. The top management of the Company fully understood the objective of this research, and was confident in the subject of the study.

Therefore this attachment for the project field test was based on the trust established between the Author and the Company. It was considered as a mutual benefit for both parties, where the Author could get some real data for his research, and the Company could get some advice from the

Author for enhancing their management standards. The attachment did not involve any pre-defined targets and the detailed arrangements were as follows:

- a) An IBM PC compatible computer system, exclusive for this field test, was set on site including 80286 CPU, 40 megabytes harddisk, one 3.5 inches and one 5.5 inches floppy drives, monochrome monitor and a 24 pins 11" dot matrix printer.
- b) The Author could freely access all the information relating to the Project in both head office and site levels, and was able to attend all the internal management meetings, and external contract administration meeting in a capacity of site planning engineer.
- c) Every week the Author would have one day full time on site, which was fixed as every Saturday. A small room was dedicated to the Author, with chair, table and file cabinets and where the field test computer system was put.
- d) The Author could freely discuss with the site management to get familiar with their work practices, the data flow and the use of the information.
- e) The site management could seek the advice from the Author for the matters on contract administration, planning and other submissions for the Project.
- f) The Author could advise and propose to both the site management and the head office top management for any changes of existing management and site practices due to the application of the System.
- g) Every month the Author would prepare a monthly report to the top management of the Company, informing of the status of the research works on site.
- h) Every 6 to 8 weeks, the Author would have a meeting with the top management of the Company by visiting their head office, and would also take this opportunity to talk to the other departments of the Company such as the estimation department, the quality assurance department and the computing department, etc.

### 13.3.5 Approach of Field Test

To facilitate the start of the attachment work, a formal meeting was held on site with most of the senior site management staff to brief the purpose and the details of the attachment. After that several lectures were held at the site office on Saturday afternoons, for the Author to introduce the concepts of construction management computerisation, and the use of computers. It was pleased to see that not just the site staff of the Company attended the lectures, but some of the staff from the contract supervisor's office, including the clerk of works and the works inspectors also attended the lectures. This arrangement helped the establishment of friendship with the site staff.

Before this research attachment, most staff on site were rarely using computers in their daily jobs, even to touch computer keyboards was unusual. In addition to the training for the staff to use the systems developed in this research, a computer game was also installed in the computer, called Mah Jong which is a most popular gambling game in Hong Kong, as well as other Chinese society. The site staff were very interested in the game and played the game during their lunch break time. This approach provided a good opportunity for some of the site staff to get familiar with the keyboard and reducing their possible resistance to the use of computers at the initial stage. This can be regarded as a kind of 'familiarisation sessions' for promoting learning according to Eason (1988).

Thorpe (1992) pointed out the problems of staff attitudes toward the applications of computers and concluded with the following observations:

- a) The only way to reduce and remove the fear of staff in the implementation of a computer system, is by a process of education and training; and
- b) Disruption can also be minimised by designing the system around existing practices and forms.

Thorpe's approaches were adopted and confirmed in this research. In addition, by this research mutual trusting, establishing friendship and recreational approach have been confirmed to be of significant in certain extent at the initial stage for the implementation of computer systems in an contracting organisation. Another observation is that such kind of informal arrangement in the project field test may reduce the possible impacts to the organisation and resistance from the staff. If the computerisation for the

site management is a commercial activity, or through a format consultancy arrangement, the activities involved may be more aggressive, and this may create negative reactions from the site staff, in case the new methods jeopardised their existing practices.

#### 13.3.6 Significance of Field Test.

In this research the system test and the system development are two stages in a cyclical relationship due to the system development being attached to a live project. The observations of the site practices, the discussions with the site staff, and the follow-ups in the industry, did make tremendous contributions to the research, and the subsequent system developments. The management practices, due to the new developments in the industry, may not be available promptly in the published literature or previous studies. High level academic researches for construction management have to rely on some kind of industrial attachment or studies, which should be considered as a *significant supplement* to the inadequacy of published literature. This is noticeable in research relating to the construction industry of Hong Kong where the industrial developments are quick, but relevant academic research is comparatively rare.

The system field test in the Project for 'CCMS', involved the following sub-systems of 'CCMS' and the details are shown in the following table:

| Sub-system<br>Name           | % of functions<br>used in Project |
|------------------------------|-----------------------------------|
| Estimation and<br>Tendering. | 20%                               |
| Quality Assurance.           | 20%                               |
| Information Control.         | 90%                               |
| Materials Control.           | 80%                               |
| Cost Control.                | 70%                               |
| Progress Control.            | 80%                               |

The percentage of functions used in the Project for each sub-system mentioned above is a subjective assessment by the Author in comparison with the functions described in Chapters 7 to 12 of this thesis. At the final stage of the project

field test for the System, the following management tasks were replaced by the System with the site staff's own operations:

- a) Main contract interim payment submissions;
- b) Sample submissions monitoring;
- c) Master programmes and sectional programmes;
- d) Daily report submissions;
- e) Monitoring material receipts and distributions;
- f) Incoming and outgoing correspondence registration;
- g) Drawing receipt and distribution registration;
- h) Variation and claim register

#### 13.4 System Validation.

Boehm (1981) gave a succinct expression of the difference between verification and validation as follows:

Verification: Are we building the product right ?  
Validation: Are we building the right product ?

Pressman (1982) defined that validation succeeds when system functions can be reasonably expected by a requester or user. Therefore it can be concluded that the validation process of a system development is intended to demonstrate the adequacy of the system rather than its conformance to a specification. The classical approach of system validation requires the use of a validation plan to outline the procedures for demonstrating the adequacy of the system (Pressman 1982, Sommerville 1989).

For the purpose of justifying the achievements of the computer system involved in research, some researchers have used the term 'system evaluation' (Abdullah 1988, Thorpe 1992) and some others used the term 'system validation' (Tah 1989, Aouad 1991). These two terms sometimes may have a complicated interactive relationship. In some cases the validation for a system may have to be based on certain evaluations and the evaluation on a system may include its validations for certain achievements. These two terms in the context of this research, are defined as follows:

- a) System validation is confined to be the considerable acceptance of the System by the Company, as part of the works associated with the project field test. The system validation therefore should have a more confined scope of entity.
- b) System evaluation is considered as a process of justifying the significance of the System by the other professionals in the industry, who are not involved with this research. The system evaluation therefore should be more open without any particular constraints and the considerations should only be the design of the system itself. (The details are described in next section).

The system validation of 'CCMS' was taken sub-system by sub-system and the validation criteria had taken into consideration the template of system evaluations initiated by Wroe (1986) and modified by Thorpe (1992). The criteria used in this research for the validation of each sub-system of 'CCMS' are explained with the following details:

- a) Identification of problem area and the system objectives in terms of the relevant management functions.
- b) Determination of mandatory and desirable information needs internally for the management control and externally for the contract administration required in the contract. Accordingly what information can be provided by the system.
- c) Comment on the reports generated from the system in terms of the timing, format, presentation and achievement to the requirements mentioned in item b) above.
- d) Identification of the input data needed for the system to provide the information mentioned in item c) above. Consideration should be on how the data can be acquired and how the data can be integrated to other sub-systems.
- e) Consideration of the portability of the system in other projects or other circumstances.
- f) Comparison of the new approach and the existing practice in respect of the relevant management tasks.
- g) Selection of hardware configuration in respect of the existing System requirements and the potential of future expansions.

The system validation for each sub-system of 'CCMS' took place in the regular meetings with the top management of the Company as mentioned in Section 13.3.4 above. In case the meeting concerned with system validations, the site manager and the other relevant site management staff would be invited to attend the meeting.

### 13.5 System Evaluation.

In addition to the system verification, the system field test and the system validation as described in the Sections 13.2, 13.3 and 13.4 of this chapter, the definition of the system evaluation for the context of this research is described in Section 13.4 above. This section describes the details of the system evaluation for 'CCMS'.

Abdullah (1988) used a seminar-questionnaire method to evaluate the system developed in his research, by demonstrating in slides and on-computer to the selected industrial personnel, to seek their personnel viewpoints and comments on the system through a seminar-end questionnaire survey. However, in this research it has been considered that the system developed covers a wide range of management functions of a contracting organisations. A seminar may not be able to show all the functions of the System and the associated research findings, by which therefore the comments from the participants may be too subjective and superficial.

During this research, at the system evaluation stage, the Author installed the System into a notebook computer, by which system demonstrations could be given by the Author during visits to high calibre professionals in the industry. This approach was very successful, since a lot of valuable comments were sought from these visits and demonstrations. It should be considered as a supplement to the research findings, because using the practices of solely one project might have a risk of being biased. During the industrial visits with the notebook computer demonstrations, the following companies were visited:

- Shui On Construction Co. Ltd.
- Gammon Construction Co. Ltd.
- Hsin Chong Construction Co. Ltd.
- Fook Lee Construction Co. Ltd.
- Chubb Hong Kong Co. Ltd.
- Industrial Centre of Hong Kong University.
- Mortiboys Hong Kong Ltd.
- Teak Maunsell Consultants Co. Ltd.
- High-Point Rendal (HK) Ltd.

Henderson Land Development Co. Ltd.  
Ryoden Building Services (HK) Ltd.  
Hong Kong Quality Assurance Agency Ltd.

Subsequently, the main system evaluation activity for 'CCMS' was taken by a questionnaire survey following an extension course. The details of the extension course are as follows:

- Organiser:** An evening extension course in the campus of Hong Kong Polytechnic under the scheme of continuous professional development.
- Duration:** 2.5 hours per lecture, totally 7 lectures (at 2 lectures per week ).
- Lecturer:** The Author of this thesis.
- Course fee:** HK\$ 1,000 (most participants were sponsored by their employer).
- Procurement:** Open to the public by newspaper advertisement and brochure with other extension courses. (It was clearly stated in the brochure that this course was a system valuation exercise of a high level research and expecting the participants should be those middle to senior management of contractors).
- Participants:** About 30 application forms were received mainly from different contractors, Finally 20 applicants were selected by the Author. There were 8 quantity surveyors, 5 contracts managers, 2 construction manager, 3 planning engineers and 2 government officers, from 16 different organisations
- Course Content:** The course comprised the following 7 lectures:
- |       |                                                                        |
|-------|------------------------------------------------------------------------|
| Day 1 | Introduction to the research and the model of construction management. |
| Day 2 | Estimation sub-system.                                                 |
| Day 3 | Information control sub-system.                                        |
| Day 4 | Material control sub-system.                                           |
| Day 5 | Cost control sub-system.                                               |
| Day 6 | Progress control sub-system.                                           |
| Day 7 | ISO9000 and Computerisation.                                           |
- Course Format:** The course was taught by using the transparencies on overhead projector and the computer system was demonstrated through a



computer connecting to video projector. The data and reports from the field test project without naming the identity of the Project and the comments from the industrial visits, were used as the main contents of teaching and computer demonstration. At the course, not just the system was demonstrated but the academic concepts and the practical considerations behind the system were explained. At the end of each lecture from day 2 to day 7 which involved the demonstration of each sub-system of 'CCMS', a questionnaire survey was taken to seek the feedback from the participants on the comments for the sub-systems.

A set of standard questionnaire was used in the course for each sub-system of CCMS and included the following questions:

- a) Do you see or use a similar system before ? (Yes/No)
- b) If yes, please specific the system you seem.  
(Statement)
- c) Do you find the system easy to use ? (Yes/No, comments)
- d) Do you think the data input too much ? (Yes/No, comments)
- e) Do you find the report output useful ? (Yes/No, comments)
- f) Do you think the system will improve the functional efficiency of the management tasks for which the system is designed ? (Yes/No, comments)
- g) Do you have any further suggestions and comments ?  
(Yes/No, comments)

The results of the questionnaire surveys for each sub-system are summarised in the figures in Appendix 13. In view of the content of this research, the main advantage of using extension course format instead of a single seminar is that more details of the research and system development can be explained in a structural manner. Based on this, the comments on the system evaluation should be considered as more reliable.

The results of the system evaluation for 'CCMS' was maintained by a simple tailor-made database system using FoxPro. The system was used to store the comments from the people attending the demonstrations. This information is considered to be

significant for the future development of the System. The evaluation system is based on the questions of the questionnaire mentioned above and includes the following fields:

- a) Date of the demonstration;
- b) Event of the demonstration;
- c) Name of the respondent;
- d) Company or organisation of the respondent;
- e) Position of the respondent;
- f) Version identity of the sub-system;
- g) Answers to the questions (by various fields); and
- h) Details of comments (memo field).

A sample screen of the 'system evaluation' system is shown in the following Figure 13.5 (a).

QUESTIONNAIRE QUESTIONS :

- a) Do you see or use a similar system before ? (Yes/No)
- b) If yes, please specific the system you seem. (Statement)
- c) Do you find the system easy to use ? (Yes/No Comments)
- d) Do you think the data input too much ? (Yes/No Comments)
- e) Do you find the report output useful ? (Yes/No Comments)
- f) Do you think the system will improve the functional efficiency ? (Yes/No Comm)
- g) Do you have any further suggestions and comments ? (Yes/No Comments)

| Results for System : Progress Control |          |            |            |            |         |        |
|---------------------------------------|----------|------------|------------|------------|---------|--------|
| Source                                | Date     | User       | Organ      | Position   | Q-a Yes | Q-a No |
| Extension                             | 12-08-92 | Lam, Peter | Chimmeny   | Site Manag | 0       | 1      |
| Extension                             | 12-08-92 | Law, Chi K | Mott Macdo | Survey Off | 0       | 1      |
| Extension                             | 12-08-92 | Wong, Tamm | MTRC (Civi | Inspector  | 0       | 1      |
| Extension                             | 12-08-92 | Chan, Wing | Franki Con | Assistant  | 0       | 1      |
| Extension                             | 12-08-92 | Leung, Y M | Tai Cheung | Quantity S | 0       | 1      |
| Extension                             | 12-08-92 | Lee, K.H.  | Henderson  | Project Ma | 0       | 1      |
| Extension                             | 12-08-92 | Ko, M. K.  | Gammon     | Site Quant | 0       | 1      |
| Extension                             | 12-08-92 | Cheng, Chi | Eton Prope | Senior Cle | 0       | 1      |
| Extension                             | 12-08-92 | Jim, Shui  | ASD        | Senior Cle | 0       | 1      |

F3 - save; F5 - add; F6 - delete; F8 - sort; F9 - summary

Figure 13.5 (a)  
Input of  
Questionnaire Result  
for the Progress  
Control Sub-system.

Figure 13.5 (b) below shows a quick screen access to the summary of the questionnaire for a specific system.

QUESTIONNAIRE QUESTIONS :

a) Do you see or use a similar system before ? (Yes/No)  
 b) If yes, please specify the system you seem. (Statement)  
 c) Do you find the system easy to use ? (Yes/No Comments)  
 d) Do you think the data input too much ? (Yes/No Comments)  
 e) Do you find the report output useful ? (Yes/No Comments)  
 f) Do you think the system will improve the functional efficiency ? (Yes/No Comm  
 g) Do you have any further suggestions and comments ? (Yes/No Comments)

---

Results for System : Progress Control

Summary of Results

|                   |    |      |    |
|-------------------|----|------|----|
| Question a) Yes - | 1  | No - | 16 |
| Question c) Yes - | 16 | No - | 1  |
| Question d) Yes - | 4  | No - | 13 |
| Question e) Yes - | 16 | No - | 1  |
| Question f) Yes - | 16 | No - | 0  |

---

F3 - save; F5 - add; F6 - delete; F8 - sort; F9 - summary

Figure 13.5 (b)  
Summary of the  
Answers.

### 13.6 The Summary and Conclusion.

This chapter started with an academic review of system verification and system validation from the viewpoint of software engineering. These two procedures were considered as the essential steps in the development of computer systems. The outcomes of these tests are sufficient for most system developments involving single purpose or single management function software.

However, the tests involved in these procedures may not be sufficient to justify the achievements of 'CCMS' developed in associate with this research. Since the System is developed as an aid for the six management functions which form the operating core of most contracting organisations. According to the model of construction management defined in this research, it has to cover quite a wide range of data flows and data integrations for the associated management tasks. The design and development of the System has also to consider the human factors of existing management procedures and site practices. A combined procedure of system design, development and testing, called project field test, has been adopted in this research based on a live construction project in Hong Kong. This approach has been demonstrated to be crucial in the research for the construction industry of Hong Kong where the development is fast but relevant research is comparatively rare.

This chapter describes the details, the arrangements and the significances of the project field test for the System. A

model showing the relationship of system verification, project field test and system validation has been developed and described in this chapter.

Both the terms of 'system validation' and 'system evaluation' were interactively used in some of the previous researches involving computer system developments. In this research, the definitions of both terms have been made. The concept is that the system validation should concentrate on an organisation or under a more confined scope; in this case the field test Project and the Company. Conversely the system evaluation should be more open to the industry in general. Two system evaluation methods were used in this research. One method was based on industrial visits with the system demonstrations using a notebook computer, and another method was by questionnaire surveys in association with lectures of the extension course. For better maintenance of the system evaluation records, a simple tailor-made computer system was developed and implemented in this research. The details of these system evaluations have been described in this chapter.

The results from both the system test and the system evaluation conclude that 'CCMS' has achieved the objectives of the system design developed in this research. The methodologies used should act as an important reference for future research of a similar nature.

## 14 Conclusion and Recommendation

### 14.1 Introduction

The objectives and the contribution to knowledge of this research as described in Section 1.3 are summarised as follows:

- a) To examine the construction industry/management practices of the construction industry in Hong Kong and the new developments due to the implementation of the huge infrastructure projects and other critical issues in Hong Kong.
- b) To develop a model of construction management based on a model of business strategy of contractors in Hong Kong and its associated organisation structure. Accordingly the management tasks and the data flow within the model of construction management can be derived.
- c) To examine the new developments of information technology for computer system designs in associate with academic research for construction management.
- d) To develop a computer-aided management information system to improve the efficiency of the management tasks. The developed system in this research is called 'CCMS'.
- e) To implement the project field test as part of the system test and the system evaluation for 'CCMS'.

This chapter describes the findings of these objectives as the conclusions of this research. The details of each finding are discussed in the following sections. Finally, this chapter lists the recommendations for further research. By the end of this chapter, this research will have been completed, in which the author has studied the practice and new development of the Hong Kong construction industry, identified a model of construction management in Hong Kong, developed a computer system to aid the management tasks of the construction management model, tested the system by a live project and conducted the evaluation of the system to prove its workability.

### 14.2 Conclusions of the Research

#### 14.2.1 Review of Previous Works Relevant to This Research

In order to establish the theoretical context for this research, a review of the previous works was complied under

a separate chapter of this thesis (Chapter 2). The previous works included published papers and articles, higher degree research and industrial research. The review concentrated on the areas of communication for contract administration, data flow within contracting organisations, quality assurance in contracting organisations, computer-aided construction management systems and relevant research in the Hong Kong construction industry. Eleven authoritative literatures were included in this chapter, based on which ten items were summarised to form the theoretical context of this research.

Apart from other theoretical context of this research, the review of previous works revealed that there were insufficient research on construction management in the Hong Kong construction industry. This research should be regarded as an important reference for relevant future researches, which are considered to be of definitely necessary in view of the scale of the industry.

#### **14.2.2 Construction Management Practice in Hong Kong and its New Developments**

The methodology used in this research for the study of the construction management practice was by questionnaire, followed by personnel interviews. The study environment was the Hong Kong construction industry and the study target was the contractors working in public sector, for which a brief introduction on Hong Kong and the construction industry with the Government control system was included in Section 3.2 to Section 3.5 of this thesis. The theoretical justification of the format of questionnaire design and the approach of survey sampling was described in Section 3.6.1 and 3.6.2 respectively. Ten contractors in three categories were selected as the survey targets. The survey approach was detailed in Section 3.6.3. The questionnaire comprised 105 questions divided into the following sections: estimating and tendering, time control, resources control, cost control, material control, quality assurance, information control, communication between head office and sites and other comments. The details of each question with the comments on each answer were included in Section 3.6.4. Accordingly a conclusion and observation was drawn for eleven items.

A separate chapter in this thesis (Chapter 4) was used to describe the new developments in Hong Kong construction industry. The term 'new development' implies the timing of application from the early 1991 to the next ten years. The study of the new development was confined to the aspects of quality assurance, Performance Assessment Scoring System (PASS) in housing projects, and the new infrastructure

development in Hong Kong. Literature reviews and interviews to those experts with high calibre in their fields were adopted as the methodology of this study. In addition to the description of these new developments under separate sections, the impacts of the new development on the target contractors of this research were emphasised and described at the end of each section. In response to the necessary changes due to the new developments, the overall tactics were addressed with emphasis on the enhancement of site management performance. This demand supported the development of the model of construction management in Hong Kong.

#### **14.2.3 Model of Construction Management**

Following the review of previous studies and published literature regarding construction business strategies, contracting organisation structures, construction management functions and data flow within contracting organisations, the structure of a conceptual model of construction management was developed and described in Section 6.1, 6.2 and 6.3. The studies of the business strategy and the organisation structure were taken into account the management practices and the new developments in the construction industry of Hong Kong. It was then identified that there are six management functions within the model of construction management, namely estimating and tendering function, purchasing management function, planning management function, quantity surveying management function, site management function and quality assurance function. All these functions were considered as the operating core of contracting organisations.

Each of these core management functions was critically examined with a standard prototype, by which each management topic would be studied based on the following areas:

- a) literature reviews and background studies;
- b) observations in Hong Kong construction industry;
- c) management tasks and management groups; and
- d) preparation of processing and data flow diagram.

The details of each management function and its associated management tasks are described in Sections 6.4 to 6.9.

In this study, it was considered that site management is the most crucial management function for contractors at the post-contract stage of a construction project. With the requirements of contract administration used in most public contracts, the management performance of contractors on site has a direct influence not just on the current profit and loss of the project but also the opportunities of future tendering. At the post-contract stage, it is the construction site where the performance data will be generated, as the work progresses. Therefore, the management information system should be put on site as a core to link up other management functions.

The model of construction management in this research included a separate management function for quality assurance, which was treated as one of the operating cores in a contracting organisation. This arrangement was unusual in previous studies, whereby quality assurance might be viewed as a technical function supporting to the operation cores of contracting organisations. However, with both internal and external expectations on quality, most well-recognized quality assurance systems require the implementer to follow the pre-defined procedures and to prove with records that the procedures have been successfully implemented. This kind of high profile requirements may urge the implementer to consider putting quality assurance as a management function in the operating core.

The management tasks of each management function and the associated data flow, formed the basis of the system objectives for the development of a computer-aided management information system in this research.

#### **14.2.4 New Developments in Information Technology**

In this research, the review of the new developments in information technology included a wide range of functional applications such as computer hardware, computer software, other peripheral equipment, local area network and telecommunication. All such functional applications were considered to be relevant to the development of a computer-aided management information system. The details of such reviews are described in Section 5.2 and 5.3.

With the support of sufficient technical data, it was decided that the management information system should be run in micro-computer environments. The hardware configuration of micro-computers in terms of system efficiency, equipment



price, system portability, pace of development and potential of future expansions were considered to be appropriate for this application.

In terms of the selection of programming languages, this research confirmed that fourth-generation language should be used in the development of computer systems for construction management. The study of the software developments in this research justified the choice of FoxPro versions 2 as the programming language for the system development.

For the system design, in addition to the functional considerations, it also emphasized the human factors of the system in use.

#### 14.2.5 Development of 'CCMS'

This research proved that a highly efficient and comprehensive management information system is desirable for increasing the efficiency of construction management. The system should not just aid the internal management tasks but should also support the external submissions.

Based on the model of construction management derived in Chapter 6 and the study of the information technology described in Chapter 5, a computer-aided management information system was developed in this research, which was called 'CCMS'. The System comprises six sub-systems in two levels of operation including the head office and construction sites. The System includes estimation sub-system and quality assurance sub-system at the head office level. At site level the sub-systems adopted are information control sub-system, cost control sub-system, materials control sub-system and progress control sub-system. The integration of information flow among these functions is the main consideration in the development of the system. The details of these systems were described from Chapters 7 to 12, one chapter for each sub-system.

The System has been designed to provide functions which support the existing practices of construction management and aid the tasks that would have to be done, even without the use of computers. This approach is considered as a crucial factor to justify the effectiveness on the use of computers for construction management.

#### 14.2.6 Project Field Test and System Evaluation

'CCMS' was developed to a stage where the skeleton of the System based on the model of construction management, was completed. The System was then put on to a live construction project for field testing. One of the criteria in the selection of the industrial attachment was that the business strategy, the organisation structure and management functions of the contractor undertaken the field test project were befitting from the model of construction management developed in this research. The details of the project field test was described in Section 13.3.

The application of 'CCMS' not only involves a large volume of data handling, but also provides functions to support the management tasks and to replace part of the manual procedures. The success of the use of the System substantially relied on the staff reaction to the changes due to the implementation of the System. The project field test in this research provided an opportunity for the System to be implemented, by which not only the functions of the System could be tested but the staff reactions to the System, the potential impact on the organisation, the actual use of the reports generated, the mode of data input and the means of input data acquisitions could be observed. One of the most significant considerations of the field test is that the field test should be treated as a crucial research activity for getting information to supplement the inadequacy of the published literature due to the time gap between the industrial developments and the academic studies.

Concurrent with the project field test, industrial visits by the author to those professional experts of high calibre in their fields, were treated as a research and system evaluation exercise. During the visits, the System was demonstrated by using a notebook computer, and following that the professional opinions and comments on the research and the System were sought from those experts. This research activity was considered as supplementary to the project field test. Since the project field test just involved one contracting organisation and a single project, the outcomes accordingly might have a risk of being incomplete and superficial. With the help of a notebook computer, this exercise was successful for getting useful materials for the research. The details of this approach were described in Section 13.4.

At the conclusion of the research, an extension course was held with selected professionals from the industry as the attendants. The course was based on the literature review, the demonstration of 'CCMS', the project field test, and the

comments from the industrial visits. The detailed comments from the attendees were sought for each sub-system through a questionnaire survey. All the comments for the System were maintained and monitored by a tailor made 'system evaluation' system.

The system evaluation through the industrial visits and the extension course proved that the approach and the performance of 'CCMS' was acceptable and satisfactory.

### **14.3 Test of the Hypothesis**

The hypothesis of this research is described in Section 1.2 of this thesis. This research tests the hypothesis by means of the use of a computer system developed in line with this research.

The test of the hypothesis is examined and analysed through the following heading:

#### **a) Information and Management**

The significance of information to management has been developed for long in classical management literature and previous research. Focusing on the management of construction projects, it has been well recognised and widely admitted that the management of construction processes is a complicated issue. More efficient management of contractors can be achievable by streaming and integrating the information flows between the various management functions.

Through a study of the development of the hypotheses described in Section 1.2.2, the significance of information to construction management has been regarded unequivocal and absolute in this research, for which it is no need to prove again in this thesis.

#### **b) Comprehensiveness of Information**

In this research, comprehensive management information is qualified as the effectiveness of information which should be determined by the quality, timing and cost of acquiring such information.

Chapter 5 of this thesis describes the new development of information technology with particular emphasis on software developments. The new concepts of software developments have been applied in the development of a

computer system in line with this research. The system is called 'CCMS' and the details are described inclusively from Chapter 7 to Chapter 12.

'CCMS' is designed to provide functions supporting the practical procedures of construction management, and aiding the tasks that should have to be done, even without the use of computers. The summary section of each chapter from Chapter 7 to Chapter 12 has identified the achievement of this approach. The corresponding information generated from the System can be regarded as the by-products of routine management tasks, rather than an one-off acquisition for information which may be expensive and time consuming in terms of resources input. The routine practice of continuous information supply is able to ensure the accuracy and quality of information because of the procedural wise formalities

With the use of computers, most information can be prepared by printings with comprehensive graphical presentation. The continuous dropping of hardware prices increase much the validity of this outcome.

This approach has achieved the requirement of quality, timing and cost of information acquisition for comprehensive information.

### **c) Efficiency of Management**

The efficiency of construction management is defined as the effectiveness to be measured by its achievement in fulfilling both aspects of external contractual obligations and internal management objectives.

Internal requirement of construction management has its classical objective for achieving the pre-defined core standards in terms of time, cost and quality. In addition to these core objectives, there are two administrative objectives: safety and social morality. This context has been considerably attempted by previous research and existing literature. This research examines this context from a viewpoint of external factors, a better handling for which should aid the achievement for these objectives. Such factors are come from external contractual obligations.

Chapter 6 outlined a model of construction management which has been developed through the study of both existing practices and new developments in the Hong Kong construction industry. By these studies, it shows that the consequence of such five internal management objectives by contractors is in line with the ultimate objective of the client which is to complete the project in time within budget with satisfactory quality. Due to the scale and the complexity of projects involved in Hong Kong construction industry, tighter requirements and control procedures are used to monitor the performance of contractors during the construction progress, for example quality assurance requirements, PASS and other procedures described in Chapter 4 and other Sections of this thesis.

The comprehensive information required by the contractual obligations is able to support a better management for achieving such well distinguished internal management objectives.

#### **14.4 Future Research Recommendation**

As a result of the works completed in this research, areas of further research identified by this research are as follows:

- a) It is the tendency of most construction contracts to require contractors to submit large volumes of mandatory information regarding the project performance, and for the purpose of contract administration. 'CCMS' developed in this research is used to provide information for contractors aiming not just for internal management controls but also for external submissions. Such kind of external submissions at this stage are still in the form of paper. In view of the sophisticated telecommunication environment and the modern local area network technology, it is worthwhile to study the computer link up between contractors and contract supervisors. This link up enables instructions from the contract supervisor and submissions from the contractor to be taken through the linked computers. Both the hardware and software technologies are sophisticated and ready for this kind of link up. The use of such direct transferred data, the impacts to both organisations and the significance to the overall contract administration, are subjects to be further explored.

- b) This research has identified and developed the data flow models of the management functions of contracting organisations. In line with the previous research, it has confirmed that contractors in their construction management have to involve a large volume of data input. The current practice of data input by contractors is mainly by keyboard manual input, except for limited practices of direct data file transfer such as floppy disks tendering which involves the bill of quantities to be handled by computer database files. The new data input techniques available, such as barcode scanning, optical character recognition and direct data file transfer (floppy disk tendering), have been applied in some other disciplines such as supermarket goods handling and commercial banks in handling cheques transactions. It will be worthwhile to review these techniques to assess their feasibility in the handling of industrial data for contractors. These data may include issuing bills of quantities for tendering, standardised barcodes for materials or other common resources handling, and construction drawings in computer graphical files for image processing etc.
- c) The model of construction management developed in this research is based on a model of construction organisation structure in connection with a model of business strategy. Based on the model of construction management, accordingly the management functions, the management tasks and the data flow models are developed to form the system objectives of the computerised management information associated with this research. This illustration shows the chain of logical sequence in the design of management information system for contracting organisations. The chain, arranged in its logical sequence, includes business strategy, organisation structure, management functions, management tasks and data flow. The business strategy involves the considerations of market competitions and business environments. In this research the mode of business strategy is based on the construction projects in public sector of Hong Kong.

The continuous economic development between Hong Kong and the Special Economic Zones in the southern coast of China, makes the local contractors consider their marketing opportunities in China by changing part of their business strategies. This change may affect the organisation structure and the subsequent management functions of the contractor. Eventually the management tasks and its associated data flow have to follow the change of the management functions.

Based on the development of 'CCMS' in this research, such a tendency of changes in the business strategy of Hong Kong contractors should inevitably cause the modifications of 'CCMS' to a certain extent, for example at least the ability of handling Chinese characters should be added into the System. Therefore this is an area worthwhile to address a further study.

- d) Although most functions of 'CCMS' have been field tested in a live construction project through the industrial attachment, the real organisation impacts to a contractor in the application of the system have not been critically examined. Especially in the system link up between the head office and construction sites using 'CCMS', the conceptual functions have been established by this research but the field test for such functions has not been included in this case. It is therefore significant for the future researches based on the establishment of 'CCMS' to explore further studies in these areas. This study should not just emphasize the technical issues of the system, but the human behaviours of an organisation toward the changes due to computerisation should be examined. A number of previous studies have addressed this problem, but with the new developments of information technology and the new concepts of system design it should be meaningful for the problem to be scrutinised with the application of 'CCMS'.
- e) Quality assurance is one of the significant topics in the modern management studies for contracting organisations. There are comparatively few investigations which bring together quality assurance and computerisation or the application of computers in quality assurance. This research has included part of the study in the application of computers in quality assurance, by which quality assurance has been treated as a separate management functions in the model of construction management. Considering such a new application by this research as an initiation, further explorations to the relationship between computerisation and quality assurance for contracting organisations should be meaningful and sufficient to formulate a new research.
- f) With the successful establishment of a comprehensive management information system by which the regular supply of significant information can be used to support decision makings, it is also necessary to have some other supports in terms of risk analysis and risk management. This approach is in line with the increasing higher information

demands from the contract supervisor through the terms of contract and the increasing complicated situations during the construction progress. The application of computerised expert systems should have a significant contributions in this area. It is predictable that a management information system together with expert system should be an ideal model for management support. Sufficient data from the management information system in terms of quality, quantity and timing of data, are viable to feed the expert system for it to evolve its full potential and capacity. The new development of expert systems in computer technology and more sophisticated studies based on this research, should make the future research in risk analysis on performance information to be vital.



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# **Appendix 4**

## PASS - INPUT ASSESSMENT

PART 3

SCORE SHEETS

Project : \_\_\_\_\_

Contract No : \_\_\_\_\_

Contractor : \_\_\_\_\_

Reporting Period : \_\_\_\_\_

## Grade

A B C D N/A

## 1.0 MANAGEMENT &amp; ORGANISATION OF WORKS

1.1 Management Structure

## 1.1.1 Organisation Structure

## 1.1.2 Site Agent

## 1.1.3 Quality Control Engineer

## 1.1.4 Safety Officer

## 1.1.5 Responsibility and authority defined

## 1.1.6 Listing of sub-contractors

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1.2 Site Planning

## 1.2.1 Comprehensive

## 1.2.2 Up to date

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Total

A1 B1 C1 D1

## 1.0 RESOURCES

2.1 Labour

## 2.1.1 Labour Forecast

## 2.1.2 Labour Resource

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2.2 Plant

## 2.2.1 Plant Forecast

## 2.2.2 Plant Resource

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2.3 Materials

## 2.3.1 Material Forecast

## 2.3.2 Material Delivery

## 2.3.3 Material Storage &amp; Handling

## 2.3.4 Material Compliance

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Total

A2 B2 C2 D2

## 3.0 CO-ORDINATION &amp; CONTROL, RESPONSE TO INSTRUCTIONS

A B C D N/A

3.1 Co-ordination and Control

- 3.1.1 Co-ordination of sequence of work  
 3.1.2 Obtain & submit builder's works requirements  
 3.1.3 Co-ordination of trades & physical deployment of works  
 3.1.4 Hold regular co-ordination meetings  
 3.1.5 Supervision of progress and standard of work  
 3.1.6 Maintain good communications  
 3.1.7 Provision of general attendance required by Contract  
 3.1.8 Timely execution of builder's work  
 3.1.9 Temporary supply for testing  
 3.1.10 Timely handover of service areas  
 3.1.11 Care of works by other

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3.2 Response to Instructions

- 3.2.1 Response to Site Instructions  
 3.2.2 Response to other written instructions  
 3.2.3 Remedial works proposal

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| A3 | B3 | C3 | D3 | N3 |

## 4.0 DOCUMENTATION

4.1 Submission of Temporary Works Design

- 4.1.1 Time of submission  
 4.1.2 Quality of submission

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4.2 Material Approval Submission

- 4.2.1 Time of submission  
 4.2.2 Quality of submission

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4.3 Shop Drawing Submission

- 4.3.1 Time of submission  
 4.3.2 Quality of submission

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4.4 Statutory Submissions

- 4.4.1 Time of submission  
 4.4.2 Quality of submission

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4.5 Other Submissions

- 4.5.1 Time of submission  
 4.5.2 Quality of submission

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4.6 Submission of Monthly Payment Application

- 4.6.1 Time of claim  
 4.6.2 Quality of submission

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4.7 Submission of Quotations, Extension of Time and/or Financial Claims

- 4.7.1 Time of submission  
 4.7.2 Quality of claim

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4.8 Submission of Notice for Inspection/Examination of Works

- 4.8.1 Time of submission

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4.9 Payment to Nominated Sub-contractors

- 4.9.1 Time of Payment

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| A4 | B4 | C4 | D4 | N4 |

## /5.0 PROGRAMMING AND PROGRESS

Grade

A B C D N/A

5.1 Programme

5.1.1 Comprehensive

5.1.2 Up to date

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5.2 Works Plan

5.2.1 Trades covered

5.2.2 Up to date

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5.3 Substructural Works

5.3.1 Progress

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5.4 Superstructural Works

5.4.1 Progress

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5.5 Finishing Works

5.5.1 Progress

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5.6 Building Services Works

5.6.1 Progress

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5.7 External Works

5.7.1 Progress

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5.8 Critical Path

5.8.1 Progress

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Total

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A5

B5

C5

D5

N5

## MANAGEMENT &amp; ORGANISATION OF WORKS

Calculation of Aspect Score

Total no. of A1 = \_\_\_\_\_ x 3 = \_\_\_\_\_

Total no. of B1 = \_\_\_\_\_ x 2 = \_\_\_\_\_

Total no. of C1 = \_\_\_\_\_ x 1 = \_\_\_\_\_

Total = \_\_\_\_\_ (a1)

Aspect Score =  $\frac{(a1) \times 10}{24}$  =  S1

## RESOURCES

Calculation of Aspect Score

$$\begin{aligned}
 \text{Total no. of A2} &= \underline{\hspace{2cm}} \times 3 = \underline{\hspace{2cm}} \\
 \text{Total no. of B2} &= \underline{\hspace{2cm}} \times 2 = \underline{\hspace{2cm}} \\
 \text{Total no. of C2} &= \underline{\hspace{2cm}} \times 1 = \underline{\hspace{2cm}}
 \end{aligned}$$

$$\text{Total} = \underline{\hspace{2cm}} \text{ (a2)}$$

$$\text{Aspect Score} = \frac{(\text{a2}) \times 20}{24} = \boxed{\hspace{2cm}} \text{ S2}$$

## CO-ORDINATION &amp; CONTROL, RESPONSE TO INSTRUCTIONS

Calculation of Aspect Score

$$\begin{aligned}
 \text{Total no. of A3} &= \underline{\hspace{2cm}} \times 3 = \underline{\hspace{2cm}} & \text{Total no. of N3 (N/A)} &= \underline{\hspace{2cm}} \times 3 = \underline{\hspace{2cm}} \text{ (b3)} \\
 \text{Total no. of B3} &= \underline{\hspace{2cm}} \times 2 = \underline{\hspace{2cm}} \\
 \text{Total no. of C3} &= \underline{\hspace{2cm}} \times 1 = \underline{\hspace{2cm}}
 \end{aligned}$$

$$\text{Total} = \underline{\hspace{2cm}} \text{ (a3)}$$

$$\text{Aspect Score} = \frac{(\text{a3}) \times 30}{(42 - (\text{b3}))} = \boxed{\hspace{2cm}} \text{ S3}$$

## DOCUMENTATION

Calculation of Aspect Score

$$\begin{aligned}
 \text{Total no. of A4} &= \underline{\hspace{2cm}} \times 3 = \underline{\hspace{2cm}} & \text{Total no. of N4 (N/A)} &= \underline{\hspace{2cm}} \times 3 = \underline{\hspace{2cm}} \text{ (b4)} \\
 \text{Total no. of B4} &= \underline{\hspace{2cm}} \times 2 = \underline{\hspace{2cm}} \\
 \text{Total no. of C4} &= \underline{\hspace{2cm}} \times 1 = \underline{\hspace{2cm}}
 \end{aligned}$$

$$\text{Total} = \underline{\hspace{2cm}} \text{ (a4)}$$

$$\text{Aspect Score} = \frac{(\text{a4}) \times 15}{(48 - (\text{b4}))} = \boxed{\hspace{2cm}} \text{ S4}$$

## PROGRAMMING &amp; PROGRESS

Calculation of Aspect Score

$$\begin{aligned}
 \text{Total no. of A5} &= \underline{\hspace{2cm}} \times 3 = \underline{\hspace{2cm}} & \text{Total no. of N5 (N/A)} &= \underline{\hspace{2cm}} \times 3 = \underline{\hspace{2cm}} \text{ (b5)} \\
 \text{Total no. of B5} &= \underline{\hspace{2cm}} \times 2 = \underline{\hspace{2cm}} \\
 \text{Total no. of C5} &= \underline{\hspace{2cm}} \times 1 = \underline{\hspace{2cm}}
 \end{aligned}$$

$$\text{Total} = \underline{\hspace{2cm}} \text{ (a5)}$$

$$\text{Aspect Score} = \frac{(\text{a5}) \times 25}{(30 - (\text{b5}))} = \boxed{\hspace{2cm}} \text{ S5}$$

SHEET 5 OF 6

Calculation of Total Score :

MANAGEMENT &amp; ORGANISATION OF WORKS

RESOURCES

CO-ORDINATION &amp; CONTROL, RESPONSE TO INSTRUCTIONS

DOCUMENTATION

PROGRAMMING &amp; PROGRESS

Add up all  
Aspect Score

|               |       |       |
|---------------|-------|-------|
| 10%           | 10    | S1    |
| 20%           | 18.33 | S2    |
| 30%           | 23.85 | S3    |
| 15%           | 11.07 | S4    |
| 25%           | 22.92 | S5    |
| Total Score : |       | 86.17 |

SignatureHousing Department

[Signature] Project Architect (A/13 )

[Signature] Project Structural Engineer (SE/35 )

[Signature] Project Building Services Engineer (BSE/C3 )

[Signature] Project Quantity surveyor (QS/Law & Bailey)

[Signature] Clerk of Works ( P.L.O.W. )

[Signature] Building Services Inspector (BSI/C6 )

[Signature] PROJECT R.E. SE/28.

Contractor

[Signature] Noted by contractor's authorised representative  
( )

CCFC Company name

8-10-91 Date

Remarks from Project Team :

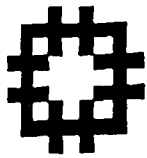
- 1) Generally the management and progress are satisfactory but contractor should further improve their coordination responses to instructions by acting promptly.
- 2) Payment to NSC is unsatisfactory as late payments were reported.

Remarks from Contractor :

No comment.

[Signature]  
8-10-91





# HONG KONG HOUSING AUTHORITY

Housing Authority Headquarters, 33, Fat Kwong Street, Kowloon, Hong Kong.

香港房屋委員會

九龍佛光街33號房屋委員會總辦事處

Our Ref. HD(AR) 11/333/77

本函檔號

Tel. No. 761 6182

電話

Fax No. 711 4401

圖文傳真

Your Ref.

來件檔號

Hong Kong Polytechnic  
Yuk Choi Road  
Hung Hom  
Kowloon

(Attn: Mr. Andy K.D. Wong)

Dear Mr. Wong,

## Information on PASS for PhD Research

I refer to your letter of 29.12.92 and our Subsequent Telephone conversation.

I attach herewith three sheets describing the scoring, score processing and score league for your information.

These are the information we use in our briefing sessions, and the scores are all fictitious, but these should be quite adequate for academic purpose.

Yours faithfully,

(A.Y.S. FUNG)  
Senior Architect/10  
Chairman of PASS Working Group

AYSF/jy

# Appendix 8

ABC Construction Co Ltd.

Date : 27-02-92

Drawing Issue Sheet No. FJU-263To : Chuen LeeThe following drawings are issued for your \* Action \*

| Drawing No... (Version) | Copies | Description                                           |
|-------------------------|--------|-------------------------------------------------------|
| 145/2/A/1... (A)        | 5      | Phase 2 General Arrangement                           |
| 145/2/A/2... (A)        | 4      | Phase 2 General Arrangement                           |
| 145/2/A/5... (A)        | 4      | Layout Plan                                           |
| 145/2/A/EP/S1... (O)    | 2      | Water Supply Layout - Ground Floor                    |
| 145/2/A/EP/S7... (B)    | 2      | Fresh Water Supply Diagram                            |
| 9793/FS/101... (B)      | 4      | Schematic Diagram of Sprinkler System.                |
| STD/H-2/A/LO-55... (O)  | 3      | Typical Floor Plan - Wing A (F4-F3.                   |
| STD/H2/S/EL-01... (C)   | 3      | General Notes, General Layout & Zoning Configuration. |
| STD/HC/A/AS-01... (A)   | 4      | Finishes Details - Sheet No. 1                        |

=====

Please check, then sign and return the tear-off slip below.

-----

Contract \_\_\_\_\_

Sheet No. \_\_\_\_\_

From : \_\_\_\_\_

Date : \_\_\_\_\_

We acknowledge receipt of all documents issued to us on the above numbered issue sheet.

Signed : \_\_\_\_\_

ABC Construction Co Ltd.

Date : 27-02-92

Drawing Submission Sheet : EXT-462To : ArchitectThe following drawings are issued for your \* Approval \*

| Drawing No... (Version) | Copies | Description                                           |
|-------------------------|--------|-------------------------------------------------------|
| 145/2/A/3... (A)        | 2      | Phase 2 General Arrangement                           |
| 145/2/A/5... (B)        | 4      | Layout Plan                                           |
| 145/2/A/EP/S2... (A)    | 4      | Water Supply Layout - 1st Floor                       |
| STD/H2/S/EL-01... (B)   | 3      | General Notes, General Layout & Zoning Configuration. |
| STD/HC/A/AS-01... (A)   | 4      | Finishes Details - Sheet No. 1                        |
| STD/HC/A/AS-01... (C)   | 2      | Finishes Details - Sheet No. 1                        |
| STD/HC/A/AS-02... (1)   | 1      | Finishes Details - Sheet No. 2                        |
| STD/HC/A/AS-02... (1)   | 1      | Finishes Details - Sheet No. 2                        |

=====

The latest date of your response to this submission should be on or before : 15th April 1992

Please check, then sign and return the tear-off slip below.

Contract \_\_\_\_\_

Sheet No. \_\_\_\_\_

From : \_\_\_\_\_

Date : \_\_\_\_\_

We acknowledge receipt of all documents issued to us on the above numbered issue sheet.

Signed : \_\_\_\_\_

ABC Construction Co Ltd.

Date : 15-04-92

Commitments Recorded in Minutes of MeetingsProject : EFG Construction Work

Select Committed Party :

Committed Location :

DB Shopping

For the period from :

to

=====  
Date : 01-04-92 Meeting : E/M Progress Meeting for the Month April 19

Party Name : Woon Lee

Promised Completion : 01-05-92

Location : DB Shopping

Actual Completion : - -

Commentment Details :

Provide shop drawing for Transformer Room Door

-----  
Date : 01-04-92 Meeting : No 8 - Bi Weekly Progress Monitoring Meetin

Party Name : Hawaii Eng.

Promised Completion : 20-07-92

Location : DB Shopping

Actual Completion : - -

Commentment Details :

Submit detailed designs for the shopping panel.

-----  
Date : 27-06-92 Meeting : No 9 - Bi Weekly Progress Monitoring Meetin

Party Name : Hawaii Eng.

Promised Completion : 15-08-92

Location : DB Shopping

Actual Completion : - -

Commentment Details :

Prepare detail design drawings for the shopping  
arcade area GH-45 to GH 61.-----  
Date : 12-07-92 Meeting : No 9 - Bi Weekly Progress Monitoring Meeting

Party Name : Fam Engineering Ltd.

Promised Completion : 01-09-92

Location : DB Shopping

Actual Completion : - -

Commentment Details :

Submit Form 501 to Fire Service Department for  
Fire Inspection for temporary shopping arcade  
occupation.

# Appendix 9

ABC Construction Co Ltd.

Date : 12-09-92

**Master Material Procurement Schedule (MMPS)**Project : EFG Construction WorkMaterial Type : GLASSGL-001 : 6 mm polished wired glass

|                   |                                    |     |                 |               |
|-------------------|------------------------------------|-----|-----------------|---------------|
| Total Quantity :  | 363.00                             | Pcs | Supplier :      | Circle K & Co |
| Location in Use : | High rise domestic block           |     | Brand Name :    | 'Golden Fish' |
|                   | residential lift lobbies           |     | Manufacturer :  | PRC           |
|                   |                                    |     | Area per Pack : | 12 Pcs/Box    |
| BQ/Drg/Spec Ref:  | BQ Item : 10.26B to 10.31D         |     |                 |               |
|                   | G. Spec : Clause 3.66 to 3.72      |     |                 |               |
|                   | Drawing : ARH-G145 to G147; SK-737 |     |                 |               |

GL-002 : 6 mm tinted float glass

|                   |                                     |     |                 |               |
|-------------------|-------------------------------------|-----|-----------------|---------------|
| Total Quantity :  | 630.00                              | Pcs | Supplier :      | Circle K & Co |
| Location in Use : | High rise domestic block            |     | Brand Name :    | 'Golden Fish' |
|                   | residential bath rooms              |     | Manufacturer :  | PRC           |
|                   |                                     |     | Area per Pack : | 12 Pcs/Box    |
| BQ/Drg/Spec Ref:  | BQ Item : 6.63B to 6.72D; 7.28B     |     |                 |               |
|                   | G. Spec : Clause 4.52 to 4.55; 6.88 |     |                 |               |
|                   | Drawing : SK355; SK-G147; SK-737.   |     |                 |               |

GL-003 : 5 mm clear sheet glass

|                   |                                 |     |                 |               |
|-------------------|---------------------------------|-----|-----------------|---------------|
| Total Quantity :  | 654.00                          | Pcs | Supplier :      | Circle K & Co |
| Location in Use : | Primary school class room       |     | Brand Name :    | 'Golden Fish' |
|                   |                                 |     | Manufacturer :  | PRC           |
|                   |                                 |     | Area per Pack : | 12 Pcs/Box    |
| BQ/Drg/Spec Ref:  | BQ Item : 10.26B to 10.31D      |     |                 |               |
|                   | G. Spec : Clause 3.66 to 3.72   |     |                 |               |
|                   | Drawing : ARH-C45 to 47; KD-133 |     |                 |               |

GL-004 : 5 mm rough cast glass

|                   |                                    |     |                 |                |
|-------------------|------------------------------------|-----|-----------------|----------------|
| Total Quantity :  | 837.00                             | Pcs | Supplier :      | Portland Co    |
| Location in Use : | Secondary school sport             |     | Brand Name :    | 'Yellow Tower' |
|                   | hall high level windows            |     | Manufacturer :  | Japan          |
|                   |                                    |     | Area per Pack : | 15 Pcs/Box     |
| BQ/Drg/Spec Ref:  | BQ Item : 8.26B to 8.31E           |     |                 |                |
|                   | G. Spec : Clause 6.61 to 7.2       |     |                 |                |
|                   | Drawing : ARH-E125 to E135; DK-317 |     |                 |                |

ABC Construction Co Ltd.

PASS Material Forecast Submission

Date : 10-06-91  
Ref : PA-KH-01

Project : EFG Construction Work

Material Type : GLASS

| Item   | Material Description | Mile Stone Dates |          |          |          | Quantities |         | Material Arrival Forecasting (3 mths Int) |            |            |            |            |
|--------|----------------------|------------------|----------|----------|----------|------------|---------|-------------------------------------------|------------|------------|------------|------------|
|        |                      | Sample           | Expected | Actual   | B. Work  | I          | N       | 1991                                      | 1992       |            |            |            |
| Code   |                      | Submt            | Approval | Approval | Work     | Total      | Arrived | T                                         | Oct to Jan | Jan to Mar | Apr to Jun | Jul to Sep |
| GL-001 | 6 mm polished wired  | 01-04-91         | 15-04-91 | 20-04-91 | 01-02-91 | 363        | 0       | Pcs                                       | 100        | 0          | 100        | 163        |
|        | glass                |                  |          |          |          |            |         |                                           |            |            |            | 0          |
| GL-002 | 6 mm tinted float    | 15-04-91         | 01-05-91 | 28-04-91 | 01-03-91 | 630        | 0       | Pcs                                       | 0          | 0          | 0          | 150        |
|        | glass                |                  |          |          |          |            |         |                                           |            |            |            | 0          |
| GL-003 | 5 mm clear sheet     | 01-05-91         | 01-06-91 | -        | 01-04-91 | 654        | 0       | Pcs                                       | 0          | 0          | 0          | 0          |
|        | glass                |                  |          |          |          |            |         |                                           |            |            |            | 12         |
| GL-004 | 5 mm rough cast      | 01-05-91         | 01-06-91 | -        | 01-04-91 | 837        | 0       | Pcs                                       | 0          | 0          | 0          | 0          |
|        | glass                |                  |          |          |          |            |         |                                           |            |            |            | 0          |
| GL-005 | 6 mm cast wired      | 01-06-91         | 01-07-91 | -        | 15-04-91 | 362        | 0       | Pcs                                       | 0          | 0          | 0          | 112        |
|        | glass                |                  |          |          |          |            |         |                                           |            |            |            | 0          |
| GL-006 | 6 mm clear float     | 01-06-91         | 01-07-91 | -        | 15-04-91 | 737        | 0       | Pcs                                       | 0          | 0          | 0          | 241        |
|        | glass                |                  |          |          |          |            |         |                                           |            |            |            | 22         |



ABC Construction Co Ltd.

Date : 11-03-91

## Sample Submission Form

Ref : HK-SK-003

Submit No : 237Project : EFG Construction Work-----  
To : Architect

From : ABC Construction Co Ltd

The enclosed sample as described below has been checked for compliance with the Specifications and Drawings, and are herewith submitted for approval.

## =====

(a) Materials Description :

6 mm polished wired glass

(b) Specification Ref :

G. Spec : Clause 3.66 to 3.72

BQ Reference : BQ Item : 10.26B to 10.31D

Drawing Reference : Drawing : ARH-G145 to G147; SK-737

(c) Location in Use :

High rise domestic block  
residential lift lobbies

Attachments

(d) Supplier :

Circle K &amp; Co

Catalogue :

Brand Name :

PRC

Technical Data :

Manufacturer :

'Golden Fish'

Test Report :

Job Reference :

(e) Anticipated Date of Approval : 15-04-91

For and on behalf of the Contractor

-----  
(Quality Control Engineer)-----  
Architect's Comments

To : ABC Construction Co Ltd.

From : Architect's Represent

On the basis of the sample and information given, the above sample submitted is

(a) Approved.

(b) Approved subject to \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_(c) Not approved because \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

and resubmission is required.

Remark : \_\_\_\_\_  
\_\_\_\_\_

Approval does not alter the requirements of the Contract unless specifically noted.

Architect's Representative

cc Project Clerk of Work - with example

PQS

(Date : \_\_\_\_\_ )

ABC Construction Co Ltd.

Date : 13-03-93

**Material Scheduling Status Report (MSSR)**Project : EFG Construction WorkMaterial Type : TILES

| Item Code | Material Description                    | P<br>A | Sample<br>Submit     | Sample<br>Approval   | Material<br>Order    | Material<br>Arrival  | Pln W<br>Start |
|-----------|-----------------------------------------|--------|----------------------|----------------------|----------------------|----------------------|----------------|
| A-23      | Ext. Wall Mosaic<br>Tile 20x20x4 mm     | P<br>A | 01-11-92<br>- -      | 01-12-92<br>- -      | 15-01-92<br>- -      | 01-02-92<br>not arri | 01-03          |
| A-24      | Ext. Wall Mosaic<br>Tile 20x20x4 mm     | P<br>A | 01-11-92<br>- -      | 15-11-92<br>- -      | 01-05-91<br>- -      | 01-02-92<br>not arri | 15-03          |
| A-25/     | Ext. Wall Mosaic<br>Tile 20x20x4 mm     | P<br>A | 05-11-92<br>01-11-92 | 01-07-91<br>15-11-92 | 15-06-91<br>01-04-92 | 01-12-91<br>23-07-91 | 01-03          |
| A-679     | Int. Ceramic Floor<br>Tile 100x100x7 mm | P<br>A | 15-07-91<br>- -      | 01-09-91<br>- -      | 01-12-91<br>- -      | 01-02-92<br>not arri | 01-05          |
| A-90      | Ext. Wall Mosaic<br>Tile 20x20x4 mm     | P<br>A | 15-07-91<br>- -      | 01-09-91<br>- -      | 01-12-91<br>26-08-92 | 01-04-92<br>17-07-91 | 12-05          |
| AY-45     | Int. Colour Glazed<br>Ceramic Wall Tile | P<br>A | 15-06-91<br>- -      | 01-08-91<br>- -      | 01-11-91<br>- -      | 01-04-92<br>21-12-92 | 20-05          |
| AY-48     | Int. Colour Glazed<br>Ceramic Wall Tile | P<br>A | 15-07-91<br>- -      | 01-09-91<br>- -      | 01-12-91<br>- -      | 15-03-92<br>13-12-91 | 25-05          |
| AY-52     | Int. Colour Glazed<br>Ceramic Wall Tile | P<br>A | 15-06-91<br>- -      | 01-08-91<br>- -      | 01-12-91<br>- -      | 15-04-92<br>13-12-91 | 01-06          |
| AY-8/     | Int. Colour Glazed<br>Ceramic Wall Tile | P<br>A | 15-07-91<br>- -      | 01-09-91<br>- -      | 01-01-92<br>- -      | 01-05-92<br>20-01-92 | 01-07          |
| B-34      | Ext. Wall Glass<br>Mosaic Tile 20x20x5  | P<br>A | 01-09-91<br>- -      | 01-11-91<br>- -      | 01-01-92<br>- -      | 01-06-92<br>01-05-92 | 01-08          |
| B-67      | Ext. Wall Mosaic<br>Tile 20x20x4 mm     | P<br>A | 01-09-91<br>- -      | 01-11-91<br>- -      | 01-01-92<br>01-12-91 | 01-06-92<br>17-07-91 | 01-08          |
| FT01      | Int. Flat Tile<br>(Diamond)             | P<br>A | 01-09-91<br>- -      | 15-11-91<br>- -      | 15-01-92<br>- -      | 15-06-92<br>14-03-91 | 15-08          |
| IJ-42     | Int. Wall Mosaic<br>Tile 50x50x5 mm     | P<br>A | 15-09-91<br>- -      | 15-11-91<br>- -      | 15-01-92<br>01-11-91 | 15-06-92<br>01-10-91 | 15-08          |
| IJ-48     | Int. Wall Mosaic<br>Tile 50x50x5 mm     | P<br>A | 01-10-91<br>- -      | 01-02-92<br>- -      | 01-03-92<br>- -      | 01-08-92<br>02-12-91 | 01-09          |

\* P=Plan; A=Actual

THE PURCHASING DEPARTMENT

DATE

BULK ORDER DELIVERY "CALL OFF" CONFIRMATION

|       |              |          |                    |
|-------|--------------|----------|--------------------|
| TRACT | CONTRACT NO. | SUPPLIER | ORIGINAL ORDER NO. |
|-------|--------------|----------|--------------------|

CONFIRM HAVING CALLED FORWARD THE FOLLOWING DELIVERY(IES) AGAINST THE ABOVE ORIGINAL ORDER, PLEASE ISSUE THE NECESSARY CONFIRMATION

FIGURE (E1) OF APPENDIX 9

| DESCRIPTION OF MATERIAL                                                 | QUANTITY | DELIVERY INSTRUCTIONS | DELIVERY DATE |
|-------------------------------------------------------------------------|----------|-----------------------|---------------|
| <div>FOR BUYING OFFICE USE ONLY</div> <div>ACTIONED BY BUYER DATE</div> |          |                       |               |
| THORISED SIGNATORY                                                      |          |                       |               |

| TO:                                                                                                                           |                                                            | AS AGENTS ON BEHALF OF                                                                                                                                                                                                                                                     |           |
|-------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| Telephone No.<br><br>DATE                                                                                                     |                                                            | The Order No. consists of all figures below                                                                                                                                                                                                                                |           |
|                                                                                                                               |                                                            | PURCHASE ORDER No.        /        /                                                                                                                                                                                                                                       |           |
| Acknowledgement and Correspondence to:<br><br>Telephone No.                                                                   | Address for Delivery and Advice Note:<br><br>Telephone No. | Invoices in Duplicate (with/ despatch) and statements to<br><br><br><br><br><br><br><br><br><br>The Order No. consisting of all in the box above, MUST be on documents. Invoices with information will be not completion. No payment will until your statement is received |           |
| Terms of Payment                                                                                                              | Reqn. No.                                                  |                                                                                                                                                                                                                                                                            |           |
| Delivery                                                                                                                      | Signature .....<br>Name .....                              |                                                                                                                                                                                                                                                                            |           |
| Description                                                                                                                   | Quantity                                                   | Price                                                                                                                                                                                                                                                                      | VALUE (ex |
|                                                                                                                               |                                                            |                                                                                                                                                                                                                                                                            |           |
| Standard Conditions of Purchase printed overleaf apply where they do not conflict with any specific written agreement herein. |                                                            | Total Value of Order                                                                                                                                                                                                                                                       |           |

X ES

|                  |                        |                           |                |
|------------------|------------------------|---------------------------|----------------|
| White - Buyer    | Pink - Receiving Point | Green - OS                | Yellow - Buyer |
| Black - Accounts | White - GRS Processor  | White - Contracts Manager | White - QA     |

國建築天耀邨二期. (Project name) 編號: K-1

裝修材料申請表  
(Material Application Form)

下由分判商填寫 (Subcontractor name) (Respondent)

分判商名稱: 合記 負責人: 陳合

料日期: 7/9/91 申請日期: 5/9/91  
(material use date) (apply date)

| 物資名稱<br>(material description) | 數量<br>(qty) | 單位<br>(unit) | 材料用途          |               |                         |
|--------------------------------|-------------|--------------|---------------|---------------|-------------------------|
|                                |             |              | 座數<br>(Block) | 層數<br>(Floor) | 位置及用途<br>(where to use) |
| 外坪地皮石 A30                      | 60          | 箱            | 6座            | 5F            | 外坪地皮                    |
| 地台磚 J-61                       | 30          | 箱            | 6座            | 7F            | 走廊地台                    |
|                                |             |              |               |               |                         |
|                                |             |              |               |               |                         |
|                                |             |              |               |               |                         |
|                                |             |              |               |               |                         |

地盤管工簽名: 王超 (Site Foreman) 日期: 5/9/91

地盤物料負責人簽名: 陳大文 (store keeper) 日期: 7/9/91

原材料存貨位置: 6座大堂 (store of material)

備註: 實支判額表 A30 - 55箱  
(remark) J61 - 28箱

入電腦日期: \_\_\_\_\_ (put in computer date)

ABC Construction Co Ltd.

Date : 10-01-92  
Report Ref : RT-WE23**Material Wastage Report (MWP)**Project : EFG Construction WorkMaterial Type : TILES Cut off date up to : 06-01-92

| Item Code | Material Description                        | Total Delivery | Remain in Store | Remain in Wrk A | Completed Work | % o Was |
|-----------|---------------------------------------------|----------------|-----------------|-----------------|----------------|---------|
| A-23      | Ext. Wall Mosaic Tile 20x20x4 mm (M2)       | 680            | 100             | 150             | 300            | 43.     |
| A-24      | Ext. Wall Mosaic Tile 20x20x4 mm (M2)       | 2,000          | 500             | 350             | 1,000          | 15.     |
| A-25/A-4  | Ext. Wall Mosaic Tile 20x20x4 mm (M2)       | 66,052         | 65,000          | 400             | 578            | 12.     |
| A-679     | Int. Ceramic Floor Tile 100x100x7 mm (M2)   | 3,000          | 2,500           | 230             | 237            | 13.     |
| A-90      | Ext. Wall Mosaic Tile 20x20x4 mm (M2)       | 1,000          | 0               | 300             | 635            | 10.     |
| AY-45/s   | Int. Colour Glazed Ceramic Wall Tile (M2)   | 2,500          | 2,000           | 280             | 189            | 16.     |
| AY-48/s   | Int. Colour Glazed Ceramic Wall Tile (M2)   | 640            | 100             | 75              | 436            | 6.      |
| AY-52/s   | Int. Colour Glazed Ceramic Wall Tile (M2)   | 8,160          | 5,000           | 750             | 2,360          | 2.      |
| AY-8/s    | Int. Colour Glazed Ceramic Wall Tile (M2)   | 1,500          | 1,000           | 100             | 350            | 14.     |
| B-34      | Ext. Wall Glass Mosaic Tile 20x20x5 mm (M2) | 2,000          | 780             | 850             | 363            | 1.1     |
| B-67      | Ext. Wall Mosaic Tile 20x20x4 mm (M2)       | 4,000          | 2,000           | 1,200           | 747            | 7.1     |
| FT01      | Int. Flat Tile (Diamond) (Pcs)              | 7,062,378      | 3,000,000       | 48,000          | 3,632,673      | 10.     |
| IJ-42     | Int. Wall Mosaic Tile 50x50x5 mm (M2)       | 3,000          | 2,000           | 480             | 478            | 8.      |
| IJ-48     | Int. Wall Mosaic Tile 50x50x5 mm (M2)       | 16,260         | 12,000          | 1,800           | 2,267          | 8.      |

\* Wastage=(Total Del. - Rem in Store - Rem in Wrk A - Completion) / Completion

\* Wrk A=Work Area; Wast.=Wastage;

# **Appendix 10**

## OVERALL FINANCIAL SITUATION

| In \$ K                     | TENDER<br>BUDGET | 1ST<br>COST PLAN | ADJUSTMENT | 2ND<br>COST PLAN |
|-----------------------------|------------------|------------------|------------|------------------|
| REVENUE :                   |                  |                  |            |                  |
| Original M.C. Works         | 343,374          | 343,374          | 0          | 343,374          |
| Variations / Remeasurements | 0                | 5,086            | 4,418      | 9,504            |
| Claims                      | 0                | 0                | 0          | 0                |
| Prov. Sums / Dayworks Bill  | 50,570           | 0                | 0          | 0                |
| M.C. Revenue                | 393,944          | 348,460          | 4,418      | 352,878          |
| Nom. Subcontractors         | 79,056           | 64,890           | ( 420)     | 64,470           |
| TOTAL REVENUE (T.R.)        | 473,000          | 413,350          | 3,998      | 417,348          |
| COST :                      |                  |                  |            |                  |
| Preliminaries               | 45,411           | 64,754           | 1,193      | 65,947           |
| Subletting                  | 164,785          | 162,082          | 7,745      | 169,827          |
| Dayworks                    | 0                | 185              | 139        | 324              |
| Materials Purchased         | 111,182          | 112,339          | 5,205      | 117,544          |
| Salvage / Misc. Income      | 0                | ( 200)           | ( 1,074)   | ( 1,274)         |
| Reserve / Provisions        | 0                | 5,940            | ( 3,005)   | 2,935            |
| Prov. Sums / Dayworks Bill  | 50,570           | 0                | 0          | 0                |
| M.C. Cost                   | 371,948          | 345,100          | 10,203     | 355,303          |
| Nom. Subcontractors         | 79,056           | 64,890           | ( 420)     | 64,470           |
| TOTAL COST (T.C.)           | 451,004          | 409,990          | 9,783      | 419,773          |
| (T.R.) - (T.C.)             | 21,996           | 3,360            | ( 5,785)   | ( 2,425)         |
| FLUCTUATION FROM CLIENT     | 0                | 15,000           | 7,300      | 22,300           |
| GROSS PROFIT                | 21,996           | 18,360           | 1,515      | 19,875           |



## BUDGET ADJUSTMENT BY ELEMENT CODE

| ELT.<br>CODE              | DESCRIPTION                | TENDER<br>BUDGET | 1ST<br>COST PLAN | ADJUSTMENT | 2ND<br>COST PLAN |
|---------------------------|----------------------------|------------------|------------------|------------|------------------|
| <u>MATERIAL PURCHASED</u> |                            |                  |                  |            |                  |
| M225                      | CONCRETE                   | 42,205           | 44,235           | 1,246      | 45,481           |
| M230                      | CONCRETE OTHERS            | 2,736            | 2,810            | ( 220)     | 2,590            |
| M240                      | REINFORCEMENT              | 31,836           | 32,100           | 3,189      | 35,289           |
| M245                      | REINFORCEMENT - OTHERS     | 80               | 80               | 0          | 80               |
| M255                      | FORMWORK                   | 569              | 569              | 204        | 773              |
| M260                      | FORMWORK - OTHERS          | 1,023            | 1,023            | 0          | 1,023            |
| M265                      | SYSTEM FORMWORK            | 1,914            | 1,540            | 1,191      | 2,731            |
| M270                      | PLASTERER - BLOCK/BRICK    | 2,209            | 1,748            | ( 26)      | 1,722            |
| M275                      | PLASTERER - SAND           | 1,079            | 1,079            | ( 702)     | 377              |
| M280                      | PLASTERER - CEMENT         | 2,802            | 2,802            | ( 1,327)   | 1,475            |
| M285                      | PLASTERER - OTHER CEMENT   | 1,441            | 1,441            | 0          | 1,441            |
| M286                      | PLASTERER - INSTANT MORTAR | 0                | 0                | 2,379      | 2,379            |
| M290                      | PLASTERER - TILES          | 13,109           | 12,234           | ( 535)     | 11,699           |
| M300                      | PLASTERER - LIME           | 145              | 145              | 0          | 145              |
| M310                      | ADMIX/HARDENER             | 524              | 524              | ( 33)      | 491              |
| M315                      | PLASTERER - OTHERS         | 1,877            | 1,877            | ( 323)     | 1,554            |
| M350                      | IRONMONGERY                | 1,230            | 1,230            | 0          | 1,230            |
| M370                      | JOINTS                     | 63               | 63               | 187        | 250              |
| M375                      | WATERPROOFING              | 1,569            | 2,015            | 67         | 2,082            |
| M380                      | PVC/RUBBER FLOORING        | 192              | 192              | ( 192)     | 0                |
| C / F :                   |                            | 106,603          | 107,707          | 5,105      | 112,812          |

## Sample of Standard Cost Code

| Code | Description          | Code | Description          |
|------|----------------------|------|----------------------|
| D013 | SUBLETTERED LEVELLER | M286 | INSTANT MORTAR       |
| D014 | SUBLETTERED GEN.LAB. | M290 | PLSTR-TILES          |
| D050 | TEMP.ELECTRICITY     | M295 | PLSTR-TILES (P.C.)   |
| D051 | TEMP. WATER          | M300 | PLSTR-LIME           |
| D062 | P & M MISC.          | M305 | PLSTR-MARBLE         |
| D070 | TEMP. OFF & SHEDS    | M310 | ADMIX. HARDENER      |
| D080 | REMOVAL OF REFUSE    | M315 | PLASTER - OTHERS     |
| D081 | SCRAPING FLOOR       | M335 | JOINERY-DR.FR.ARCH   |
| D082 | WASH CLEANING        | M340 | JOINERY - DOOR       |
| D090 | TEMPORARY WORKS      | M345 | JOINERY - WINDOW     |
| D091 | TEMP. REFUSE CHUTE   | M350 | JOINERY - IRONMONG   |
| D100 | TRANSPORTATION       | M370 | JOINTS               |
| D130 | HOARDING             | M375 | WATERPROOFING        |
| D140 | SCAFFOLDING          | M380 | FLOORING/SKIRTING    |
| D145 | SCAFF-BRACKETS       | M385 | FALSE CEILING        |
| D200 | CAISSON/PILING       | M390 | METAL WORKS          |
| D205 | DEMOLITION           | M400 | DRAINLAYER           |
| D210 | EXCAVATOR            | M410 | SANITARY FITTINGS    |
| D220 | SHORING/SHEET PILE   | M415 | KITCHEN FITTINGS     |
| D225 | CONCRETOR            | M435 | PAINTER (P.C.)       |
| D240 | REINFORCEMENT        | M505 | REFUSE CHUTE         |
| D250 | STRUCT STEEL WORK    | M590 | MISC/OTH BLDG WKS    |
| D255 | FORMWORK             | P010 | SAL & WAGES          |
| D265 | SYSTEM FORM          | P011 | SAL & WAGES O.T.     |
| D320 | PLASTERER, LABOUR    | P012 | SAL & WAGES-OTHERS   |
| D325 | PLASTERER, MARBLES   | P020 | MESSING              |
| D330 | TROWE FIN TO CONC.   | P030 | INS WORKMAN COMP     |
| D355 | JOINERY - OTHERS     | P031 | INS C.A.R.           |
| D360 | JOINERY - LABOUR     | P032 | INS. BOND            |
| D370 | JOINTS               | P033 | INS. OTHERS          |
| D375 | WATERPROOFING        | P040 | IND.TRAINING LEVY    |
| D380 | FLOOR SKIRTING       | P050 | TEMPORARY ELEC.      |
| D385 | FALSE CEILING        | P051 | TEMPORARY WATER      |
| D390 | METAL WORKS          | P052 | TELEPHONE            |
| D400 | DRAINLAYER           | P053 | TEMPORARY ELEC.      |
| D405 | PLUMBER              | P054 | TEMPORARY WATER      |
| D420 | GLAZIER              | P055 | TELEPHONE            |
| D425 | BALUSTER GLAZIER     | P060 | P&M RENTAL           |
| D430 | PAINTER              | P061 | P&M FUEL & LUB.      |
| D450 | ELECTRICIAN          | P062 | P&M MISC.            |
| D455 | LIGHT FITTING        | P071 | FURNITURE/FITTINGS   |
| D460 | FIRE SERVICE         | P080 | REMOVAL OF REFUSE    |
| D470 | FIRE CONDITIONERS    | P100 | TRANSPORTATION       |
| D475 | LIFT & ESCALATOR     | P110 | TESTING FEES         |
| D480 | SECURITY INSTAL      | P120 | DWG/STATIONERIES     |
| D485 | SUANA JACCOZZI       | P190 | MISCELLANEOUS        |
| D490 | TELEPHONE/PABX       | R724 | CONSULTANCY FEE      |
| D495 | GONDOLA INSTL.       | R725 | DEFECT               |
| D500 | BUILDING AUTOM.      | R730 | PROV - L.D.          |
| D505 | REFUSE CHUTE         | R745 | PROV-CONTINGENCY     |
| D510 | SWIM PL FILTER SYS   | S013 | SUBLETTERED LEVELLER |
| D515 | CURTAIN WL/SHOP FR   | S014 | SUBLETTERED GEN.LABO |
| D520 | SQUASH/TN            | S070 | TEMP OFF & SHEDS     |
| D530 | SIGNS/GRAPHICS       | S081 | SCRAPING FLOOR       |
| D550 | PLAY EQ/SAFETY MAT   | S082 | WASH CLEANING        |
| D560 | HACKING CONCRETE     | S090 | TEMPORARY WORKS      |
| D590 | MISCELLANEOUS        | S091 | TEMP REFUSE CHUTE    |
| L600 | SALE OF SCRAP MATE   | S130 | HOARDING             |
| L605 | MISCELLANEOUS INCO   | S140 | SCAFFOLDING          |
| L610 | INVENTORY ACCOUNT    | S145 | SCAFF BRACKETS       |
| M070 | TEMP OFF & SHEDS     | S200 | PILING               |
| M090 | TEMPORARY WORK       | S205 | DEMOLITION           |
| M091 | TEMP REFUSE CHUTE    | S210 | EXCAVATION           |
| M130 | HOARDING             | S215 | LANDSCAPING          |
| M140 | SCAFFOLDING          | S220 | SHORING/SHEET PILE   |
| M150 | TOOLS                | S225 | CONCRETOR LABOUR     |
| M200 | PILING               | S235 | CONCRETOR O.T.       |
| M220 | SHORING/SHEET PILE   | S240 | REINFORCEMENT        |
| M225 | CONCRETE             | S250 | STRUCT STEELWORK     |
| M230 | CONCRETE OTHERS      | S255 | FORMWORK             |
| M240 | REINFORCEMENT        | S265 | SYSTEM FORM          |
| M245 | REFINFORCEMENT OTHS  | S320 | PLASTERER, LABOUR    |
| M250 | STRUCT STEELWORK     | S325 | PLASTERER, MARBLES   |

ABC Construction Co Ltd.

Issue Date : 01-04-92

Ref : TYP2/BUD1/01

Tender BudgetProject : EFG Construction WorkCost Head Type : PRELIMINARIES

| Code | Item Description    | Tender Budget  |
|------|---------------------|----------------|
| P010 | SAL & WAGES         | 15,216,000.00  |
| P011 | SAL & WAGES O.T.    | \$200,000.00   |
| P012 | SAL & WAGES-OTHERS  | \$2,682,000.00 |
| P020 | MESSING             | \$356,000.00   |
| P030 | INS WORKMAN COMP    | \$2,980,000.00 |
| P031 | INS C.A.R.          | \$1,153,000.00 |
| P032 | INS. BOND           | \$80,000.00    |
| P033 | INS. OTHERS         | \$207,000.00   |
| P040 | IND.TRAINING LEVY   | \$983,000.00   |
| P050 | TEMPORARY ELEC.     | \$251,000.00   |
| P051 | TEMPORARY WATER     | \$138,000.00   |
| P052 | TELEPHONE (Initial) | \$30,000.00    |
| P053 | TEMPORARY ELEC.     | \$994,000.00   |
| P054 | TEMPORARY WATER     | \$116,000.00   |
| P055 | TELEPHONE           | \$16,000.00    |
| P060 | P&M RENTAL          | \$4,658,000.00 |
| P061 | P&M FUEL & LUB.     | \$60,000.00    |
| P062 | P&M MISC.           | \$624,000.00   |
| P071 | FURNITURE/FITTINGS  | \$100.00       |
| P080 | REMOVAL OF REFUSE   | \$723,000.00   |

IN-SITU PRESTRESSED CONCRETE ;  
POST-TENSIONED WORK TO BEAMS AND  
SLABS ; AS DRAWING NR. 1 (Cont'd.)

High yield bar reinforcement ; ALL  
PROVISIONAL

General reinforcement

\* diameter

0 kg

Sawn formwork

Flat surfaces

B soffits of suspended slabs

0 m2

C sides and soffits of beams

0 m2

Ducts ; permanent sheathing of  
suitable diameter to enclose  
tendons ; in reinforced concrete  
beams and slabs ; pressure  
grouting after tensioning

Curved ducts

D for tendon formed of twelve  
strands, each 15.2 diameter ;  
in lengths \* - \*m (In Nr. 0)

0 m

SUPPLY ONLY tendons comprising the  
following prestressing strands ;  
measured net lengths between outer  
faces of anchorages - allow for  
extra lengths for tensioning

Seven wire strands

E of 15.2 diameter ; UTS \* KN

0 kg

FIX ONLY the following tendons in  
straight or curved sheathing  
(measured separately)

Tendons

F formed of twelve strands, each  
15.2 diameter ; \* long between  
outer faces of anchorages

0 nr

Tensioning the following tendons

Tendons

G formed of twelve strands, each  
15.2 diameter ; jacking force  
of \* KN ; applied from one end

0 nr

MODEL BILL OF  
DESCRIPTIONS

1.6/11

To Collection \$

ABC Construction Co Ltd.

**Fluctuation Cost Submission for Interim Valuation**

Date : 01/28/92  
Ref : IP-FL-0

Project : EFG Construction Work

**Interim Payment No 16 for the period ending : 25th Jan 1992**

| I.P. No | Month | Status | Value of Works Completed | Nominated Subc | Cur. Price Wtk | Effective Value (Acc) | Effective Value (This) | Price Month | Price Factor | Price Fluctuat. | Price Fluctuat. Amount |
|---------|-------|--------|--------------------------|----------------|----------------|-----------------------|------------------------|-------------|--------------|-----------------|------------------------|
| (1)     | (2)   | (3)    | (4)                      | (5)            | (6)            | (7)                   | (8)                    | (9)         | (10)         | (11)            | (12)                   |
| 01      | 10/90 | Firmed | \$2,199,466.89           |                | \$0.00         | \$0.00                | \$2,199,466.89         | 09/90       | 0.024272     |                 | \$53,385.46            |
| 02      | 11/90 | Firmed | \$8,150,040.54           |                | \$0.00         | \$0.00                | \$8,150,040.54         | 10/90       | 0.030911     |                 | \$183,938.18           |
| 03      | 12/90 | Firmed | 10,946,504.95            |                | \$0.00         | \$0.00                | 10,946,504.95          | 11/90       | 0.041866     |                 | \$117,076.77           |
| 04      | 01/91 | Firmed | 23,265,513.88            |                | \$0.00         | \$0.00                | 17,069,433.88          | 12/90       | 0.045428     |                 | \$278,152.41           |
| 05      | 02/92 | Firmed | 35,278,548.46            |                | \$0.00         | \$0.00                | 28,950,354.46          | 01/91       | 0.048872     |                 | \$580,655.51           |
| 06      | 03/92 | Provis | 54,673,267.77            |                | \$36,363.00    | \$46,383,117.77       | 17,432,763.31          | 02/92       | 0.077239     |                 | \$1,346,502.80         |
| 07      | 04/92 | Provis | 67,478,826.70            |                | \$474,889.00   | \$57,477,412.45       | 11,094,294.68          | 02/92       | 0.077239     |                 | \$856,920.88           |
| 08      | 05/92 | Provis | 78,124,636.80            |                | \$530,466.00   | \$67,226,392.80       | \$9,748,980.35         | 02/92       | 0.077239     |                 | \$753,009.09           |
| 09      | 06/92 | Provis | 86,225,677.80            |                | \$623,677.00   | \$74,349,321.81       | \$7,122,929.01         | 02/92       | 0.077239     |                 | \$550,173.46           |

\* Remark : Price Fluctuation x Effective Value (this) = P.P.F. Amount

Total Amount : \$4,719,814.60

ABC Construction Co Ltd.

Date : 10-01-92

Ref : DW-KH-01

Daywork Submission for External ValuationProject : EFG Construction WorkFor the period up to : 06-12-92

| Daywork<br>No | Description                                                 | AI-No<br>AI-Date   | Location            | St. Date<br>End Date | Total<br>Amount |
|---------------|-------------------------------------------------------------|--------------------|---------------------|----------------------|-----------------|
| D01           | Prepare the trial panels for the proposed hanger wall.      | AI-23<br>01-12-91  | BLOCK 6             | 12-01-91<br>15-01-91 | \$91,080.0      |
| D02           | Excavate Soft Spots for the New Access Road                 | AI-68<br>03-02-92  | EXTERNAL WORKS      | 12-03-92<br>20-03-92 | \$97,200.0      |
| D03           | Excavate for boulders in the soft spot.                     | AI-76<br>12-03-92  | EXTERNAL WORKS      | 20-03-92<br>22-03-92 | \$51,750.0      |
| D04           | Prepare temporary access for the new air condition chiller. | AI-87<br>02-04-92  | SECONDARY<br>SCHOOL | 10-04-92<br>12-04-92 | \$17,050.0      |
| D05           | Prepare temporary access for the Director's site visit      | AI-92<br>03-05-92  | PRIMARY SCHOOL      | 05-05-92<br>12-05-92 | \$18,800.0      |
| D06           | Clearing damaged break wall due to the third party car      | AI-103<br>12-06-92 | SECONDARY<br>SCHOOL | 12-06-92<br>13-06-92 | \$8,100.0       |
| D07           | Remove soft spot for the external retaining wall under      | AI-110<br>23-06-92 | EXTERNAL WORKS      | 25-06-92<br>25-06-92 | \$48,300.0      |

Total Amount HK\$ **\$332,280.0**

# Appendix 11

(4) Notwithstanding any other provision of the Contract:

- (a) submission by the Contractor of the requisite performance bonds, parent company undertakings and guarantees in accordance with the foregoing provisions of this Clause 12 and of the warranty in accordance with Clause 3(2)(b) shall be a condition precedent to the Contractor's entitlement to any payment or any further payment as the case may be under the Contract; and
- (b) failure by the Contractor to provide a performance bond or parent company undertaking or parent company guarantee in accordance with the foregoing provisions of this Clause 12 shall entitle the Employer either to suspend the Works or to terminate the Contract forthwith by notice in writing to that effect, notwithstanding that the Contractor may have been permitted to proceed with the Works, and the Contractor shall not be entitled to any compensation whatsoever as a consequence of such suspension or termination.

13. (1) In regard to the carrying out of its obligations under the Contract, the Contractor shall be deemed prior to submitting the Tender to have:

Inspection of the Site

- (a) inspected and examined the Site and its surroundings;
- (b) satisfied itself as to the nature of the climatic, hydrological and general conditions of the Site, the nature of the ground and subsoil, the sea bed and sea surface conditions, the form and nature of the Site, the risk of injury or damage to property adjacent to the Site and to occupiers of such property, the nature of the materials (whether natural or otherwise) to be excavated, the nature of the work, and materials necessary for the execution of the Works;
- (c) satisfied itself as to the means of communication with and access to and through the Site, the accommodation it may require, the possibility of interference by persons other than the Employer who will also have access to or use of the Site after the Employer has given the Contractor possession of the Site, the precautions and the times and methods of working necessary to prevent any nuisance or interference, whether public or private, being caused to any third party;
- (d) obtained for itself all necessary information as to risks, contingencies and all other circumstances which may influence or affect the Tender Total and/or the Final Contract Sum and its obligation to execute the Works and its other obligations under the Contract.

(2) No claim by the Contractor for additional payment or any extension of time shall be allowed on the ground of any misunderstanding or misapprehension in respect of the matters referred to in Clause 13(1) or on the grounds that incorrect or insufficient information was given to the Contractor by any person whether or not in the employ of the Employer or that the Contractor failed to obtain correct and sufficient information nor shall the Contractor be relieved from any risk or obligation imposed on or undertaken by it under the Contract on any such ground or on the ground that it did not or could not foresee any matter which may in fact affect or have affected the execution of the Works, or compliance with its other obligations under the Contract.

14. The Contractor shall be deemed to have satisfied itself before entering into the Contract as to the correctness and sufficiency of the rates and prices contained in the Pricing Document to cover all its risks, liabilities and obligations set out in or implied by the Contract and all matters and things necessary for the proper execution of the Works.

Sufficiency of Tender

15. (1) Save in so far as it is legally or physically impossible the Contractor shall execute the Works in strict accordance with the Contract to the satisfaction of the Engineer.

Works to be to the satisfaction of the Engineer and compliance with Engineer's instructions

(2) Subject only to any delegation of duties and powers by the Engineer in accordance with Clause 2(3), the Contractor shall take instructions only from the Engineer, and shall comply with and adhere strictly to the Engineer's instructions on any matter related to the Contract whether mentioned in the Contract or not.

16. (1) Within 7 days of notification of acceptance of the Tender, the Contractor shall submit to the Engineer its proposed programme for approval as the initial Works Programme in the form and content

Programmes and Progress Reports



prescribed by the Specification. Within 60 days of approval of the initial Works Programme in accordance with Clause 16(2) or such other period as may be prescribed in the Specification, the Contractor shall submit to the Engineer for his approval an expanded and more detailed version of the initial Works Programme in the form and content prescribed by the Specification.

(2) The Engineer shall, within 30 days of receipt of a programme submitted pursuant to this Clause 16, notify the Contractor in writing:

- (a) that the programme is approved; or
- (b) that the programme is rejected, in which case reasons for such rejection shall be given; or
- (c) that further information is required to clarify or substantiate the programme or to satisfy the Engineer as to its reasonableness.

Provided that if none of the above actions is taken within the said period of 30 days the Engineer shall be deemed to have approved the programme submitted.

(3) The Contractor shall within 21 days of receiving notification under Clause 16(2)(c), or within such further period as the Engineer may allow in writing, provide the further information requested failing which the programme shall be deemed to have been rejected. The Engineer shall within 21 days of receipt of such further information approve or reject the programme in accordance with Clause 16(2).

(4) In the event of a programme being rejected under Clause 16(2)(b) or deemed to have been rejected under Clause 16(3), the Contractor shall within 21 days thereafter submit a revised programme taking account of the reasons given for the rejection or incorporating the further information requested by the Engineer, as the case may be.

(5) (a) The Contractor may at any time following approval of a programme as the Works Programme submit to the Engineer an amended or varied version thereof.

(b) The Contractor shall review the Works Programme in the event that:

- (i) the Engineer grants an extension of time in accordance with Clause 53;
- (ii) the Engineer instructs a variation under Clause 64;
- (iii) the Contractor considers for any reason that there is or will be a significant deviation between the actual or anticipated progress of the Works and the Works Programme, including without limitation the Contractor foreseeing an increase or decrease in the quantity of work to be carried out in excess of any relevant percentage limit set out in the preamble to the Pricing Document for the purpose of this Clause 16(5);
- (iv) the Engineer requests the Contractor in writing to reflect or incorporate any other matter in the Works Programme;

and shall within 21 days of such event either submit an amended or varied programme to the Engineer in accordance with Clause 16(2) or inform the Engineer in writing of the reasons why the Contractor considers that such a submission is inappropriate.

(6) Should it appear to the Engineer at any time that there is or will be a significant deviation between the actual or anticipated progress of the Works and the Works Programme, the Engineer shall be entitled by written instruction to require the Contractor to produce a revised version showing such modifications to the Works Programme as may be necessary to ensure or to be consistent with substantial completion of the Works and all Sections and the achievement of all Stages by the Key Dates. The Contractor shall submit such revised programme within 14 days of the Engineer's instruction or within such other time as the Engineer shall allow in writing.

(7) (a) Unless and until an amended version of the Works Programme is approved by the Engineer in accordance with Clause 16(2), the programme previously approved by the Engineer shall remain as the Works Programme for all purposes of the Contract.

(b) Approval by the Engineer of a Works Programme in accordance with Clause 16(2) shall not relieve the Contractor of any of its duties or responsibilities under the Contract nor bind or create any obligation or liability on the part of the Employer nor, in the event that a Works Programme indicates that a Key Date has not or will not be met, constitute any form of acknowledgement that the Contractor is or may be entitled to an extension of time in relation to such Key Date.

(8) Within 14 days of notification of acceptance of the Tender, and thereafter at the end of each calendar month, the Contractor shall submit to the Engineer its three month rolling programme in the form and detail prescribed by the Specification setting out the work to be carried out during the following three months.

Three Month  
Rolling  
Programme

(9) (a) The Contractor shall submit to the Engineer by the end of each calendar month its Monthly Progress Report which shall, amongst other things, highlight actual or potential departures from the Works Programme and state the measures which the Contractor proposes to take in order to make good or reduce any delays.

Progress Report

(b) If requested by the Engineer, the Contractor shall submit to the Engineer at weekly intervals a written report as to the progress of off-Site manufacture of goods and materials.

(c) The Contractor shall also submit to the Engineer such other reports as may reasonably be required by any relevant authority or public body.

17. (1) The Contractor shall submit in accordance with Clause 7 such documents and information pertaining to the methods of construction (including Temporary Works and the use of Contractor's Equipment) which the Contractor proposes to adopt or use and such calculations of stresses strains and deflections that will or may arise in the Permanent Works or any parts thereof during construction from the use of such methods as will enable the Engineer to decide whether, if such methods are adhered to, the Works can be executed in accordance with the Drawings and the Specification and without detriment when completed to the Permanent Works and to the other works comprising the ACP.

Construction  
Methods

(2) The Engineer shall inform the Contractor in writing within a reasonable period after receipt of the information submitted in accordance with Clause 17(1):

(a) that the Contractor's proposed methods of construction have the consent of the Engineer (which consent shall not be unreasonably withheld); or

(b) in what respects in the opinion of the Engineer the Contractor's proposed methods of construction:

(i) fail to meet the requirements of the Drawings and/or the Specification; or

(ii) would be detrimental to the Permanent Works and/or to the other works comprising the ACP; or

(iii) do not comply with the other requirements of the Contract; or

(c) as to the further documents or information which are required to enable the Engineer properly to assess the proposed methods of construction.

In the event that the Engineer does not give his consent, the Contractor shall take such steps or make such changes in the said methods or supply such further documents or information as may be necessary to meet the Engineer's requirements and to obtain his consent. The Contractor shall not change the methods of construction which have received the Engineer's consent without the further consent in writing of the Engineer which shall not be unreasonably withheld.

**Quality Standards for Input Assessment Part 5****7/8****7/8 PART 5 : PROGRAMMING AND PROGRESS****Introductory Notes**

- a) It is considered undesirable to measure progress against contract completion date or extended contract completion date unless the Architect can, without qualification, either state the number of days EOT due or state there is no EOT due. Given the time taken for submission, substantiation, assessment and settlement of EOT claims this is not possible. Progress is therefore measured against the contractor's programmed completion date, as it stands at the time of assessment. This date may be in advance of or behind the contractual completion date.
- b) The present contract conditions only oblige the contractor to produce a programme under GCC Clause 16. The project team cannot therefore insist that the contractor produces various bar charts, critical path analysis, etc. If a contractor does not produce these then the project team will have to use their professional expertise and discretion in completing the forms.
- c) Questions 5.3.1 to 5.6.1 will at various stages during a contract attract N/A and project teams may for instance only have to fill in question 5.3.1 at the start of a contract.

**5.1. Programme****5.1.1 Comprehensive**

| <u>Grade</u> | <u>Standard</u> |
|--------------|-----------------|
|--------------|-----------------|

- |     |                                                                                            |
|-----|--------------------------------------------------------------------------------------------|
| (A) | Comprehensive, realistic programme available with actual progress shown against programme. |
| (B) | Not used.                                                                                  |
| (C) | Programme available but incomplete.                                                        |
| (D) | Programme not available.                                                                   |

Note : Comprehensive programme for the whole of the works should show the duration of major activities and their interrelationship. Activities which are considered to be major under normal circumstances are listed out on the following page.

**5.1.2 Up to date**

| <u>Grade</u> | <u>Standard</u> |
|--------------|-----------------|
|--------------|-----------------|

- |     |                                                                              |
|-----|------------------------------------------------------------------------------|
| (A) | Genuinely reflects the likely progress on site as at the date of assessment. |
| (B) | Not used.                                                                    |
| (C) | Some major activities not updated.                                           |
| (D) | Programme not up to date, unrealistic, incomplete or not available.          |

Contract No. 4-29-1970

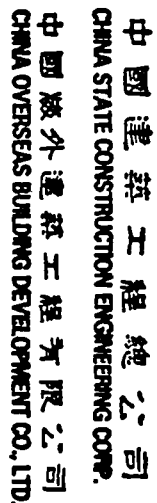
Contract The J. C. Estate Placer

日期  
Day 11.12.91 (Chin)

報告號  
Report No. 451

天氣  
Weather

Fine



20/F, SHUN TAK CENTRE,  
200 CONNAUGHT RD, C, HONG KONG  
TEL: 5463138 (70 LINES)  
TELEX: 60960 COBDC HX  
CABLE: 7787 HONG KONG

地盤代理人簽署  
Site Agent's Signature: *Chia Chia*

| YILL ESTATE PHASE II                                                   |  | 4c of 1990 | 18-12-9 |
|------------------------------------------------------------------------|--|------------|---------|
| 9. Clear slab surface on 630/f, Wing B.                                |  |            | 2       |
| Finishing                                                              |  |            |         |
| 1. Water pipework on 21/f.                                             |  |            | 2       |
| 2. Moving up materials on 19/f.                                        |  |            | 3       |
| 3. Brick laying on 17/f, 11/f.                                         |  |            | 2       |
| 4. Plastering on 7/f, 10/f.                                            |  |            | 6       |
| 5. Tiling on 5/f, 6/f.                                                 |  |            | 4       |
| 6. Mosaic tiles on 4/f.                                                |  |            | 5       |
| Primary School                                                         |  |            |         |
| 1. Moving up material to R/F.                                          |  |            | 3       |
| 2. Plastering on 4/f, 11A.                                             |  |            | 8       |
| 3. Fitting Furniture on 11/f, 11A.                                     |  |            | 2       |
| Secondary School                                                       |  |            |         |
| 1. Cast concrete for slabs, R/F, Assembly Hall.                        |  |            | 5       |
| 2. Fix fix water tank frame on R/F SS.                                 |  |            | 3       |
| 3. Water pipework on 2/f SS.                                           |  |            | 2       |
| 4. Fix door frame on 2/f SS.                                           |  |            | 1       |
| 5. Brick laying on 5/f SS.                                             |  |            | 2       |
| External Work                                                          |  |            |         |
| 1. Draining work for paths for maintenance F.8.1, F.8.5, F.9.2, F.9.7. |  |            |         |
| 2. Formwork for maintenance beside BK 8 and BK 9.                      |  |            |         |
| 3. Constructing for maintenance beside BK 8 and BK 9.                  |  |            |         |
| 4. Cast concrete for precast staircase No. PH379, PH380, P.381, P.386. |  |            |         |

中國建築工程總公司  
中國海外建築工程有限公司  
(Project Name / Company Name)

工程日報表 (Daily Report)

Sectional

1/1

座数 第一座 (Main Location)  
(Block 8)

日期: 5-3-9, Date  
上午天晴  
下午天晴  
(Weather)

FIGURE (D) OF APPENDIX 11

| 位置說明                         | 層数      | 結構工程      | 工作摘要               | 出勤人數          |       | 备注                    |
|------------------------------|---------|-----------|--------------------|---------------|-------|-----------------------|
|                              |         |           |                    | 大工            | 小工    |                       |
| Column "C"                   | 1/2-3/4 | 梁頭        | 搭(鋼)橋架             | 6             |       | 總共 105 M <sup>3</sup> |
| "C"                          | 1/2-3/4 | 梁頭        | 搭(鋼)橋架             | 3             |       |                       |
| "B"                          | 1/2-3/4 | 柱頭        | 搭(鋼)橋架             | 8             |       |                       |
| "B"                          | 1/2-3/4 | 柱頭        | 搭(鋼)橋架             | 4             |       |                       |
| "B"                          | 1/2-3/4 | 柱頭        | 搭(鋼)橋架             | 1             |       |                       |
| Wall "A"                     | 3/4     | 連斗        | 鋪架板                | 2             |       |                       |
| Wall "A"                     | 3/4     | 釘板        | 釘架板                | 14            |       |                       |
| (Sectional Location) (Clear) |         | (Element) | (Work Description) | (Responsible) | (Qty) |                       |

房屋署駐地盤代表臨時指示: (有/无) 內容: 74:00 場 "A" 門牌外 由 "A" 區

房屋署駐地盤工程師臨時指示: (有/无) 內容: \_\_\_\_\_

臨時圖則修改: (有/无) 內容: \_\_\_\_\_

其 茲

## China State Construction Engineering Corporation

To Housing Department :

## Daily Progress Report

Project : Tin Yiu Estate Phase 2

Print Date : 22-11-91

Report for the Date : 19-11-91

Weather : =&gt; FINE

Report No : =&gt; 423

## Work Items by Block Summary in Trade

|                  |                    |                |                  |                    |                 |                |
|------------------|--------------------|----------------|------------------|--------------------|-----------------|----------------|
| 1. Foreman       | 2. Asst. Foreman   | 3. Leveller    | 4. Plumber       | 5. Labourer (H)    | 6. Labourer (F) | 7. Excavator   |
| 8. Concrete      | 9. Steel Bender    | 10. Carpenter  | 11. Bricklayer   | 12. Plasterer      | 13. Tiler       | 14. Joiner     |
| 15. Metal Work   | 16. Painter        | 17. Glazier    | 18. Asphalt      | 19. Scaffold       | 20. Plumber     | 21. Drainlayer |
| 22. Fitter       | 23. Plant Operator | 24. Electrical | 25. Fire Service | 26. Lift/Excavator | 27. S.P.A.C.    | 28. Cleaner    |
| 29. Steel former |                    |                |                  |                    |                 |                |

| Resource Types | 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 |
|----------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| BLOCK 6        |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| BLOCK 7        |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| BLOCK 8        |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| BLOCK 9        |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| PMH. SCS       |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| SCS. SCS       |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

Total Number of Labourers : 3159

Plants on Site :

Lubricant..... ( 1 ) Fibre..... ( 20 ) Toner Crane..... ( 5 ) Bolt..... ( 4 )

Total No. of Plant on Site : 40

Materials Delivered to Site :

Concrete 10/20 Mix Block 1..... ( 10 ) m<sup>3</sup> Concrete 15/20 Mix Block 1..... ( 10 ) m<sup>3</sup> Concrete 15/20 Mix Block 1..... ( 10 ) m<sup>3</sup>

Site Management Staff :

Project Manager..... ( 4 ) Site Agent..... ( 1 ) Surveying..... ( 1 ) Est. Person..... ( 1 )

Clerk..... ( 1 )

Total Management Staff : 11

To Housing Department : China State Construction Engineering Corporation

Daily Progress Report

Project : Tin Yiu Estate Phase 2

Print Date : 22-11

Report for the Date : =>19-11-91

Report No : =>235

Work Items by Block by Trade

BLOCK 6

Building Services

24/F WING A WALL Water Pipe Work.....Plumber( 1)

14/F Water Pipe Work.....Plumber( 1)

Finishing Works

9/F Blockworks.....Bricklayer( 2)

14/F Fix Plaster Net.....Plasterer( 2)

6/F Window Frame.....Metal Work( 4)

Structural Works

23/F WING B WALL Concreting.....Concretor( 6)

23/F WING B WALL Concreting.....Labourer(H)( 3)

24/F WING A WALL Reinforcement.....Steelbender( 5)

24/F WING C Slab Reinforcement.....Steelbender( 5)

24/F Levelling.....Leveller( 2)

BLOCK 7

Building Services

25/F WING B Slab Electrical Conduit.....Electrical( 4)

Finishing Works

1/F Door Frame.....Joiner( 1)

1/F Move Up Material.....Labourer(F)( 3)

3/F Window Frame Pointing.....Metal Work( 2)

2/F Painting.....Painter( 2)

4, 6, 10, 16/ Misc Works.....Labourer(H)( 4)

15/F Levelling.....Leveller( 2)

Structural Works

25/F WING B Slab Reinforcement.....Steelbender( 6)

25/F Levelling.....Leveller( 2)

25/F Misc Works.....Labourer(H)( 4)

18/F 25/F Slab Open Formwork.....Carpenter( 4)

25-26/F WING A C Move Steel Form.....Steel Former( 8)

BLOCK 8

Building Services

26/F WING B Electrical Conduit.....Electrical( 3)

14/F Water Pipe Work.....Plumber( 3)

Finishing Works

16/F Blockworks.....Bricklayer( 1)

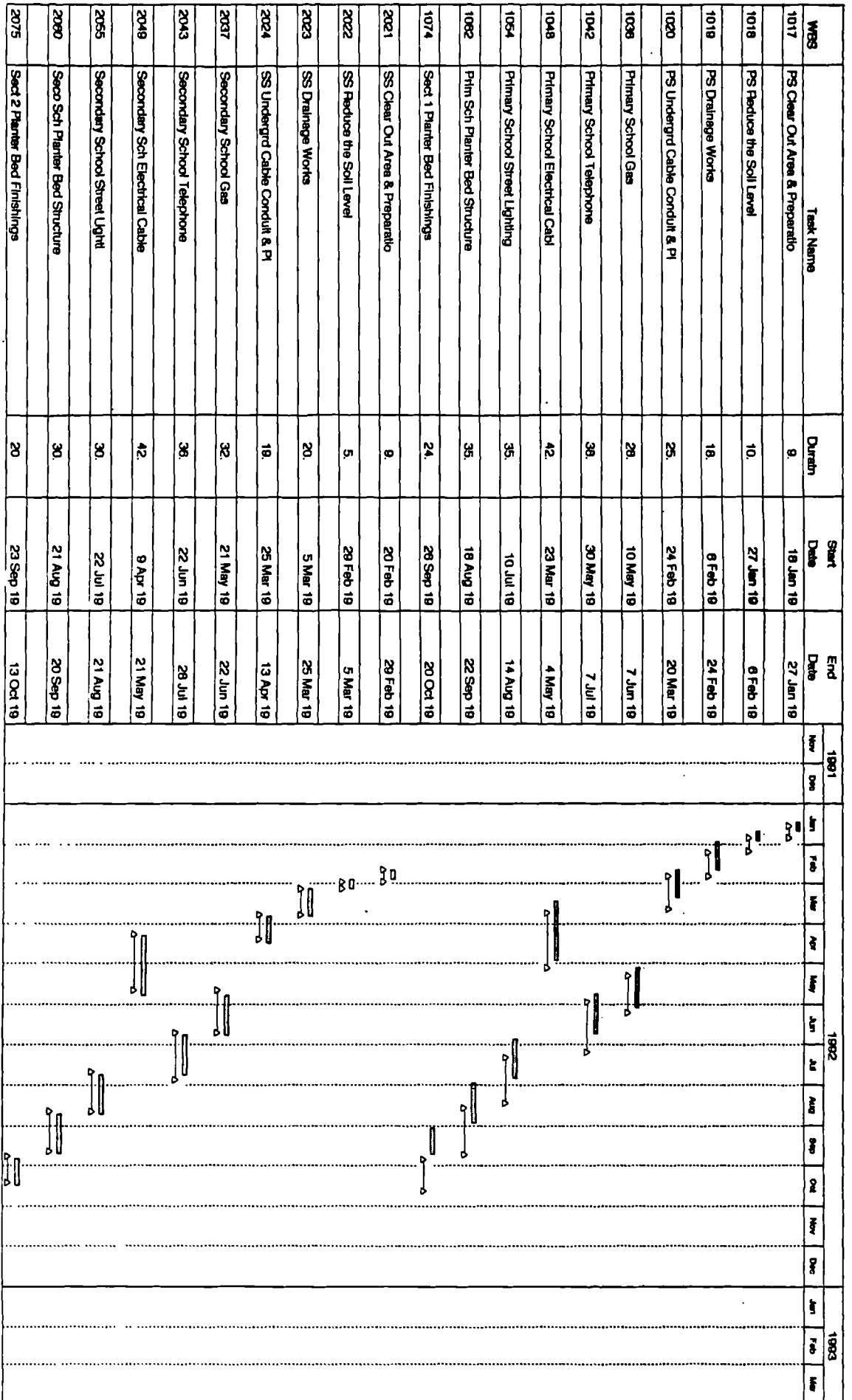
6/F WALL Int. Wall Plaster.....Plasterer( 1)

2/F Wall Tiling.....Tiler( 3)

17/F Misc Works.....Labourer(H)( 1)

Structural Works





ABC Construction Co Ltd.

Actual Progress Report

Date : 25-03-93  
Ref : CK\_RP-01

Project : EFG Construction Work

Information Filtration Criteria :

Main Location : BLOCK 7  
Sub Location :

Stru. Element :  
Identity :

Work Type :  
Work Item :  
Structural Works  
Concreting

Party Name :  
Resource :

From Date : 01-02-92 To Date : 30-04-92

FIGURE (F) OF APPENDIX 11

|          |   |         |   |            |   |          |   |              |       |                    |
|----------|---|---------|---|------------|---|----------|---|--------------|-------|--------------------|
| 07-02-92 | - | 33/F    | - | Slab       | - | Wing C   | - | P*T Subcont. | ..... | Concretor ( 6 )    |
| 11-02-92 | - | 32-33/F | - | Wall       | - | Wing C   | - | P*T Subcont. | ..... | Concretor ( 8 )    |
| 11-02-92 | - | 25-26/F | - | Facade Wal | - |          | - | P*T Subcont. | ..... | Concretor ( 5 )    |
| 13-02-92 | - | 33/F    | - | Slab       | - | Wing A   | - | P*T Subcont. | ..... | Concretor ( 6 )    |
| 13-02-92 | - | 26/F    | - | Facade Wal | - | Wing A   | - | P*T Subcont. | ..... | Concretor ( 7 )    |
| 14-02-92 | - | 32-33/F | - | Wall       | - | Wing B   | - | P*T Subcont. | ..... | Concretor ( 8 )    |
| 15-02-92 | - | 33/F    | - | Slab       | - | Wing C   | - | P*T Subcont. | ..... | Concretor ( 6 )    |
| 17-02-92 | - | 33-34/F | - | Wall       | - | Wing A   | - | P*T Subcont. | ..... | Concretor ( 8 )    |
| 17-02-92 | - | 26/F    | - | Facade Wal | - | Wing A,B | - | P*T Subcont. | ..... | Concretor ( 4 )    |
| 19-02-92 | - | 33/F    | - | Slab       | - | Wing B   | - | P*T Subcont. | ..... | Concretor ( 6 )    |
| 19-02-92 | - | 26/F    | - | Facade Wal | - | Wing B   | - | P*T Subcont. | ..... | Concretor ( 8 )    |
| 20-02-92 | - | 33-34/F | - | Wall       | - | Wing C   | - | P*T Subcont. | ..... | Concretor ( 8 )    |
| 20-02-92 | - | 26/F    | - | Facade Wal | - | Wing B   | - | P*T Subcont. | ..... | Concretor ( 10 )   |
| 21-02-92 | - | 4/F     | - | Parapet    | - | Wing A   | - | Direct Lab   | ..... | Labourer (M) ( 2 ) |
| 21-02-92 | - | 34/F    | - | Slab       | - |          | - | P*T Subcont. | ..... | Concretor ( 6 )    |
| 21-02-92 | - | 4/F     | - | Parapet    | - |          | - | Direct Lab   | ..... | Labourer (M) ( 2 ) |
| 21-02-92 | - | 4/F     | - | Parapet    | - |          | - | Direct Lab   | ..... | Labourer (M) ( 2 ) |
| 22-02-92 | - | 33-34/F | - | Wall       | - | Wing B   | - | P*T Subcont. | ..... | Concretor ( 8 )    |
| 22-02-92 | - | 27/F    | - | Facade Wal | - | Wing A   | - | P*T Subcont. | ..... | Concretor ( 5 )    |
| 25-02-92 | - | 34/F    | - | Slab       | - | Wing C   | - | P*T Subcont. | ..... | Concretor ( 6 )    |
| 25-02-92 | - | 27/F    | - | Facade Wal | - |          | - | P*T Subcont. | ..... | Concretor ( 7 )    |

ABC Construction Co Ltd.

Date : 25-03-93  
Ref : CK\_BR-01

Actual Progress Barchart

Project : EFG Construction Work

Information Filtration Criteria :

Main Location : BLOCK 7      Stru. Element :      Work Type :      Party Name :  
Sub Location :      Identity :      Work Item :      Concreting      Resource :

From Date : 01-02-92      To Date : 30-04-92

Activity Order :

Start Time

Scale : 1

per day(s)

| No | Activity Description     | St. Date | Ed. Date | 11/ 2 | 21/ 2 | 2/ 3 | 12/ 3 | 22/ 3 | 1/ 4 | 11/ 4 | 21/ 4 | 1/ 5 | 11/ 5 |
|----|--------------------------|----------|----------|-------|-------|------|-------|-------|------|-------|-------|------|-------|
| 19 | 33/F Slab Wing C         | 07-02-92 | 15-02-92 |       |       |      |       |       |      |       |       |      |       |
| 1  | 25-26/F Facade Wal       | 11-02-92 | 11-02-92 |       |       |      |       |       |      |       |       |      |       |
| 13 | 32-33/F Wall Wing C      | 11-02-92 | 11-02-92 |       |       |      |       |       |      |       |       |      |       |
| 2  | 26/F Facade Wal Wing A   | 13-02-92 | 13-02-92 |       |       |      |       |       |      |       |       |      |       |
| 17 | 33/F Slab Wing A         | 13-02-92 | 13-02-92 |       |       |      |       |       |      |       |       |      |       |
| 12 | 32-33/F Wall Wing B      | 14-02-92 | 14-02-92 |       |       |      |       |       |      |       |       |      |       |
| 3  | 26/F Facade Wal Wing A,B | 17-02-92 | 17-02-92 |       |       |      |       |       |      |       |       |      |       |
| 14 | 33-34/F Wall Wing A      | 17-02-92 | 17-02-92 |       |       |      |       |       |      |       |       |      |       |
| 4  | 26/F Facade Wal Wing B   | 19-02-92 | 20-02-92 |       |       |      |       |       |      |       |       |      |       |
| 18 | 33/F Slab Wing B         | 19-02-92 | 19-02-92 |       |       |      |       |       |      |       |       |      |       |
| 16 | 33-34/F Wall Wing C      | 20-02-92 | 20-02-92 |       |       |      |       |       |      |       |       |      |       |
| 23 | 34/F Slab Wing A         | 21-02-92 | 21-02-92 |       |       |      |       |       |      |       |       |      |       |
| 6  | 27/F Facade Wal Wing A   | 22-02-92 | 22-02-92 |       |       |      |       |       |      |       |       |      |       |
| 15 | 33-34/F Wall Wing B      | 22-02-92 | 22-02-92 |       |       |      |       |       |      |       |       |      |       |
| 5  | 27/F Facade Wal          | 25-02-92 | 25-02-92 |       |       |      |       |       |      |       |       |      |       |
| 25 | 34/F Slab Wing C         | 25-02-92 | 25-02-92 |       |       |      |       |       |      |       |       |      |       |
| 7  | 27/F Facade Wal Wing B   | 26-02-92 | 28-02-92 |       |       |      |       |       |      |       |       |      |       |
| 21 | 34-35/F Wall Wing A      | 26-02-92 | 26-02-92 |       |       |      |       |       |      |       |       |      |       |
| 24 | 34/F Slab Wing B         | 28-02-92 | 28-02-92 |       |       |      |       |       |      |       |       |      |       |
| 9  | 28/F Facade Wal Wing A   | 29-02-92 | 29-02-92 |       |       |      |       |       |      |       |       |      |       |
| 22 | 34-35/F Wall Wing C      | 29-02-92 | 29-02-92 |       |       |      |       |       |      |       |       |      |       |
| 10 | 28/F Facade Wal Wing C   | 02-03-92 | 02-03-92 |       |       |      |       |       |      |       |       |      |       |
| 27 | 35/F Slab Wing A         | 02-03-92 | 02-03-92 |       |       |      |       |       |      |       |       |      |       |
| 11 | 28/F Parapet Wing B      | 03-03-92 | 03-03-92 |       |       |      |       |       |      |       |       |      |       |
| 20 | 34-35/F Wall Wing B      | 03-03-92 | 03-03-92 |       |       |      |       |       |      |       |       |      |       |
| 8  | 28/F Facade Wal Wing B   | 05-03-92 | 05-03-92 |       |       |      |       |       |      |       |       |      |       |

ABC Construction Co Ltd.

Actual Progress Barchart

Date : 25-03-93  
Ref : CK\_BR-01

Project : EFG Construction Work

4/4

Information Patteration Criteria :

Main Location : BLOCK 7

Sub Location :

Stru. Element :

Identity :

Work Type :

Work Item :

Structural Works

Concreting

Partly Name :

Resource :

From Date : 01-02-92

To Date :

30-04-92

Activity Order :

Alphabetical

Scale : 1

per day(s)

| No | Activity Description     | St. Date | Ed. Date | 11/ 2 | 21/ 2 | 2/ 3 | 12/ 3 | 22/ 3 | 1/ 4 | 11/ 4 | 21/ 4 | 1/ 5 | 11/ 5 |
|----|--------------------------|----------|----------|-------|-------|------|-------|-------|------|-------|-------|------|-------|
| 1  | 25-26/F Facade Wal       | 11-02-92 | 11-02-92 |       |       |      |       |       |      |       |       |      |       |
| 2  | 26/F Facade Wal Wing A   | 13-02-92 | 13-02-92 |       |       |      |       |       |      |       |       |      |       |
| 3  | 26/F Facade Wal Wing A,B | 17-02-92 | 17-02-92 |       |       |      |       |       |      |       |       |      |       |
| 4  | 26/F Facade Wal Wing B   | 19-02-92 | 20-02-92 |       |       |      |       |       |      |       |       |      |       |
| 5  | 27/F Facade Wal          | 25-02-92 | 25-02-92 |       |       |      |       |       |      |       |       |      |       |
| 6  | 27/F Facade Wal Wing A   | 22-02-92 | 22-02-92 |       |       |      |       |       |      |       |       |      |       |
| 7  | 27/F Facade Wal Wing B   | 26-02-92 | 28-02-92 |       |       |      |       |       |      |       |       |      |       |
| 8  | 28/F Facade Wal Wing B   | 05-03-92 | 05-03-92 |       |       |      |       |       |      |       |       |      |       |
| 9  | 28/F Facade Wal Wing A   | 29-02-92 | 29-02-92 |       |       |      |       |       |      |       |       |      |       |
| 10 | 28/F Facade Wal Wing C   | 02-03-92 | 02-03-92 |       |       |      |       |       |      |       |       |      |       |
| 11 | 28/F Parapet WING B      | 03-03-92 | 03-03-92 |       |       |      |       |       |      |       |       |      |       |
| 12 | 32-33/F Wall Wing B      | 14-02-92 | 14-02-92 |       |       |      |       |       |      |       |       |      |       |
| 13 | 32-33/F Wall Wing C      | 11-02-92 | 11-02-92 |       |       |      |       |       |      |       |       |      |       |
| 14 | 33-34/F Wall Wing A      | 17-02-92 | 17-02-92 |       |       |      |       |       |      |       |       |      |       |
| 15 | 33-34/F Wall Wing B      | 22-02-92 | 22-02-92 |       |       |      |       |       |      |       |       |      |       |
| 16 | 33-34/F Wall Wing C      | 20-02-92 | 20-02-92 |       |       |      |       |       |      |       |       |      |       |
| 17 | 33/F Slab Wing A         | 13-02-92 | 13-02-92 |       |       |      |       |       |      |       |       |      |       |
| 18 | 33/F Slab Wing B         | 19-02-92 | 19-02-92 |       |       |      |       |       |      |       |       |      |       |
| 19 | 33/F Slab Wing C         | 07-02-92 | 15-02-92 |       |       |      |       |       |      |       |       |      |       |
| 20 | 34-35/F WALL WING B      | 03-03-92 | 03-03-92 |       |       |      |       |       |      |       |       |      |       |
| 21 | 34-35/F Wall Wing A      | 26-02-92 | 26-02-92 |       |       |      |       |       |      |       |       |      |       |
| 22 | 34-35/F Wall Wing C      | 29-02-92 | 29-02-92 |       |       |      |       |       |      |       |       |      |       |
| 23 | 34/F Slab Wing A         | 21-02-92 | 21-02-92 |       |       |      |       |       |      |       |       |      |       |
| 24 | 34/F Slab Wing B         | 28-02-92 | 28-02-92 |       |       |      |       |       |      |       |       |      |       |
| 25 | 34/F Slab Wing C         | 25-02-92 | 25-02-92 |       |       |      |       |       |      |       |       |      |       |
| 26 | 35-36/F WALL WING A      | 06-03-92 | 06-03-92 |       |       |      |       |       |      |       |       |      |       |

# **Appendix 12**

**QUALITY MANUAL****Cross  
References**

- 10.1.1.5 Procedures for unsatisfactory test results (i.e. non conformance with specification or industry standards) are detailed in section 14.0 of this manual.
- 10.2.1.6 Materials received that do not require testing shall be inspected to ensure that they conform to the requirements of the drawings, specifications or normal industry standards.
- 10.2.1.7 The site representative shall not sign delivery notes etc until he has inspected the materials received. Where this is not possible he shall inspect the material received and record the results of inspection on a goods received register as soon as practicable after delivery. **ABLDG/**
- 10.2.2 **External Testing Procedure**
- 10.2.2.1 Where third party inspections are required this shall be indicated on the Inspection or Test Plans. **AQM/CQ  
ABLDG/**
- 10.3 **INSPECTION OF THE WORKS**
- 10.3.1 **Internal Inspection Procedures**
- 10.3.1.1 The work shall be inspected by the Quality Control Engineer or other authorised person.
- 10.3.1.2 The work shall be inspected internally in accordance with the inspection plan in the Construction Quality Plan (CQP). **AQM/CQ**
- 10.3.1.3 Any inspections required by the specification but not included on the plan shall be inserted in the spaces provided.
- 10.3.1.4 A standard checklist shall be completed for each location of the works that is inspected. When all checklists relevant to the inspection plan item have been completed this shall be indicated on the inspection plan.

ABC Construction Co Ltd.

Issue Date : 02/01/92  
Ref: YLC/QM/ID-1Notice of Internal AuditProject : EFG Construction WorkTo : Wong PangAudit Reference : A01From : Chan Ping Wan

=====

It is our intention to carry out an audit on  
your operation(s) on 03/01/92

commencing at 10.30 AMcompleted by 11.20 AM

The purpose of this audit is : -

Concrete Batching Plant

The functions to be audited are : -

To see the compliance of the plant to  
WorkProcedure C01The lead Auditor will be : Chan Ping Wan

Please acknowledge the receipt of the notice in  
in writing and confirm the audit programme to the  
Quality Manager.

Yours faithfully

Acceptance for this notice

Quality ManagerName :  
Date :

ABC Construction Co Ltd.

Date : 25-03-93  
Ref : CK\_RP-01

Internal Audit Summary

Project : EFG Construction Work

Information Filtration Criteria :

1/1  
From Date :                      To :                     

Quality Manual - Procedure No :                      Clause No :                     

FIGURE (C) OF APPENDIX 12

| Audit Ref | Audit Date | Project Name                              | Audit Questions                                                                                               | Corresponding Actions                                                                                        |
|-----------|------------|-------------------------------------------|---------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| A01       | 01-03-92   | HK Yuen Long<br>Batching Plant            | Do you have records for non-conformity products ?                                                             | Refer to the files KJ01 to KJ03 which are used to keep the records for non-conformity.                       |
| A01       | 01-03-92   | Factory<br>HK Yuen Long<br>Batching Plant | How many quality control engineers who have attended the training programmes for the Document control system. | 3 Engineers have completed the training course. 2 more are attending and should be completed by next months. |
| A01       | 01-03-92   | Factory<br>HK Yuen Long<br>Batching Plant | The stacking of aggregates with problems                                                                      | Re-audit in next month is necessary.                                                                         |
| A02       | 01-07-92   | Factory<br>Tin Yiu Estate<br>Phase III    | How do you keep the subcontractors' return of the acknowledgement of document received ?                      | Use acknowledgement slips and raise the problem in subcontractor meetings.                                   |
| A03       | 01-10-92   | Tin Yiu Estate<br>Phase II                | How can you ensure the domestic subcontractors to have aware of the quality requirements in his own trade.    | Subcontract provisions and liaison meetings.                                                                 |
| A04       | 05-01-93   | Yuen Long lot<br>145.                     | Do you have periodical store checking for the quality of tiles.                                               | The records are kept in File JH10 to JK12.                                                                   |



ABC Construction Co Ltd.

Issue Date : 01-06-92  
Ref: YLC/QM/ID-1Calibration Planning for a Specific EquipmentProject : EFG Construction Work

Equipment Ref : CBF01

Model : JK-013

Type : Theodolite

Manuf : Calbonate, U.K.

Name : High Level Theodolite

Supp : Univercial High Technology

Procurement Date : 03-12-91

Calibration Interval Every : 45 days

Remark : A second hand instrument with one year warranty from 01 Mar 92.

| Pld Date<br>Calibrate | Atl Date<br>Calibrate | Result | Devi<br>ation | Calib. by<br>Whom | Remark              |
|-----------------------|-----------------------|--------|---------------|-------------------|---------------------|
| 01-01-92              | 02-01-92              | Pass   | 0.25 mm       | CEC-Test Co       |                     |
| 15-02-92              | 17-02-92              | Pass   | 0.35 mm       | CEC-Test Co       |                     |
| 31-03-92              | 28-03-92              | Fail   | 0.65          | CEC-Test Co       | Adjustment was made |
| 15-05-92              | 16-05-92              | Pass   | 0.35          | Head Office Lab   |                     |
| 29-06-92              | - -                   |        |               |                   |                     |
| 13-08-92              | - -                   |        |               |                   |                     |
| 01-09-92              | - -                   |        |               |                   |                     |
| 27-09-92              | - -                   |        |               |                   |                     |
| 16-10-92              | - -                   |        |               |                   |                     |
| 11-11-92              | - -                   |        |               |                   |                     |
| 30-11-92              | - -                   |        |               |                   |                     |
| 26-12-92              | - -                   |        |               |                   |                     |
| 14-01-93              | - -                   |        |               |                   |                     |
| 28-02-93              | - -                   |        |               |                   |                     |
| 14-04-93              | - -                   |        |               |                   |                     |
| 29-05-93              | - -                   |        |               |                   |                     |
| 13-07-93              | - -                   |        |               |                   |                     |

\* Pld - Planned, Atl - Actual, Calib - Calibrated.

ABC Construction Co Ltd.

Issue Date : 28-05-92

Ref: YLC/QM/ID-1

Check Calibration Needs for a Specific Period.Project : EFG Construction WorkCheck calibration needs for the period from : 01-06-92 to 27-05-93Equipment Type : Theodolite

| Item<br>Ref. | Item<br>Description   | Pld Date<br>Calibrate | Atl Date<br>Calibrate | Result |
|--------------|-----------------------|-----------------------|-----------------------|--------|
| CBF01        | High Level Theodolite | 29-06-92              | - -                   |        |
| CBF01        | High Level Theodolite | 13-08-92              | - -                   |        |
| CBF01        | High Level Theodolite | 01-09-92              | - -                   |        |
| CBF01        | High Level Theodolite | 27-09-92              | - -                   |        |
| CBF01        | High Level Theodolite | 16-10-92              | - -                   |        |
| CBF01        | High Level Theodolite | 11-11-92              | - -                   |        |
| CBF01        | High Level Theodolite | 30-11-92              | - -                   |        |
| CBF01        | High Level Theodolite | 26-12-92              | - -                   |        |
| CBF01        | High Level Theodolite | 14-01-93              | - -                   |        |
| DBF02        | Electronic Theodolite | 10-02-93              | - -                   |        |
| CBF01        | High Level Theodolite | 28-02-93              | - -                   |        |
| DBF02        | Electronic Theodolite | 27-03-93              | - -                   |        |
| CBF01        | High Level Theodolite | 14-04-93              | - -                   |        |
| DBF02        | Electronic Theodolite | 11-05-93              | - -                   |        |

\* Pld - Planned; Atl - Actual.

ABC Construction Co Ltd.

Issue Date : 10-02-92

Ref: NCR/FG-14

Report of Non-conformity CaseProject : EFG Construction WorkReference : A01 Description : Irregular alignmentSource of Identity : Site InstructionReference of Identity : AF12Non-conformity Happen Date : 01-02-92Non-conformity Report Date : 05-02-92Inspection Head : BRICKWORK & BLOCKWORKInspection Item : Wet BrickMain Location : Block 6Sub-location : Level 1Structure Element : WallIdentification : Wing A

## \* Detail of follow ups

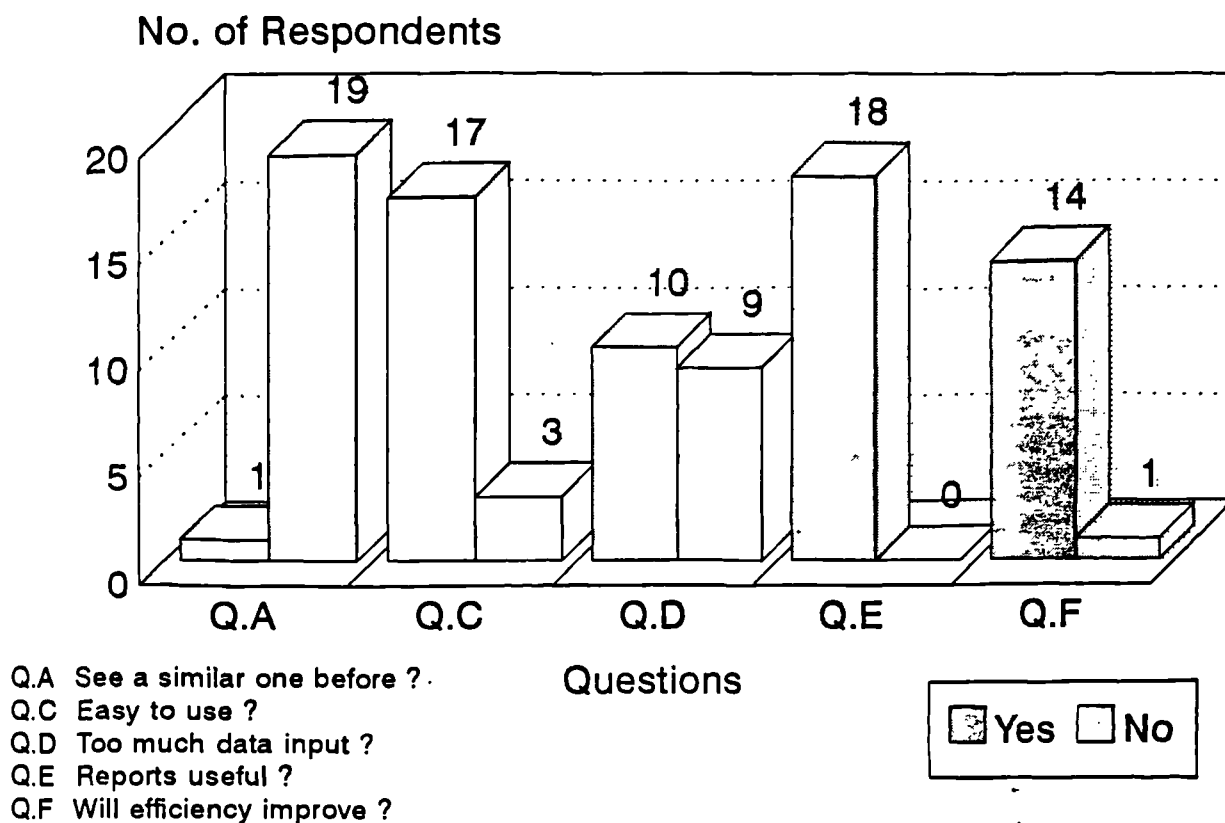
| Follow Up<br>Date | Follow Up<br>Reference | Description                                  | Reinb.<br>Nature               | Time<br>Effect | Cost<br>Effect |
|-------------------|------------------------|----------------------------------------------|--------------------------------|----------------|----------------|
| 02-02-92          | CKJ-230                | Dismantled the original work and reclass.    | Claimable Cost<br>from Subcont | 1              | \$5,00         |
| 03-02-92          | CKJ-230                | Changed the completed conduit works by GEC.  | Claimable Cost<br>from Subcont | 0              | \$8,00         |
| 04-02-92          | CKJ-240                | Reinspection of the partially completed work | Own Absortion<br>Cost          | 0              | \$             |
| 05-02-92          | CKJ-251                | Reinstate services work                      | Claimable Cost<br>from Subcont | 1              | \$7,50         |

\* Reinb. = Reimbursement.

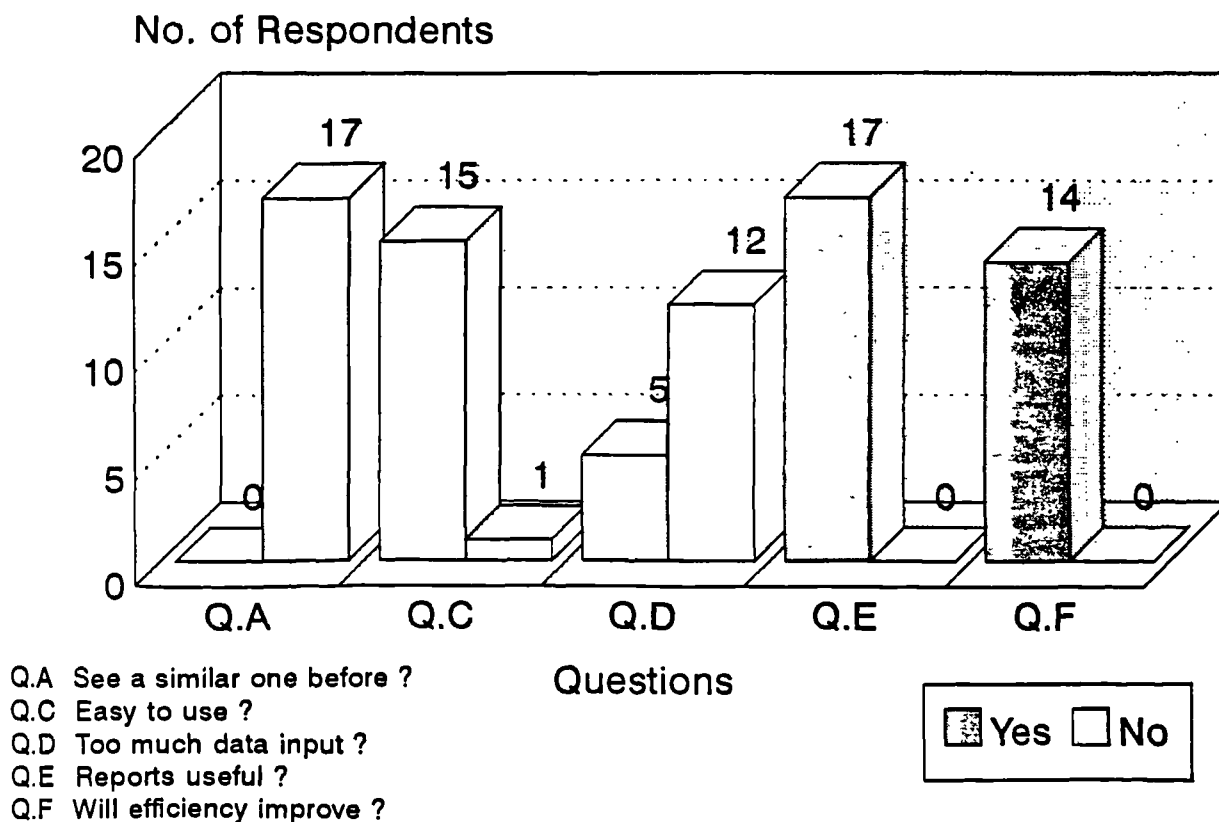
Total Cost Involved : \$20,500.00  
 Total Critical Time Involved : 2 day(s)

# Appendix 13

# OVERALL COMMENTS ON CCMS QUESTIONNAIRE SURVEY

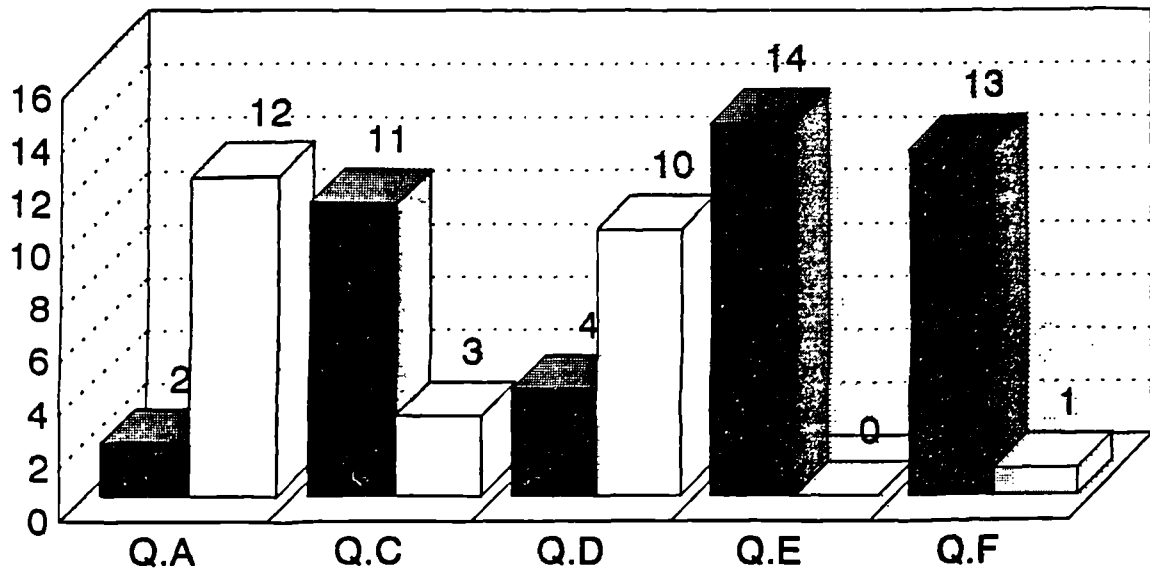


# INFORMATION CONTROL SUB-SYSTEM QUESTIONNAIRE SURVEY



# COST CONTROL SUB-SYSTEM QUESTIONNAIRE SURVEY

No. of Respondents



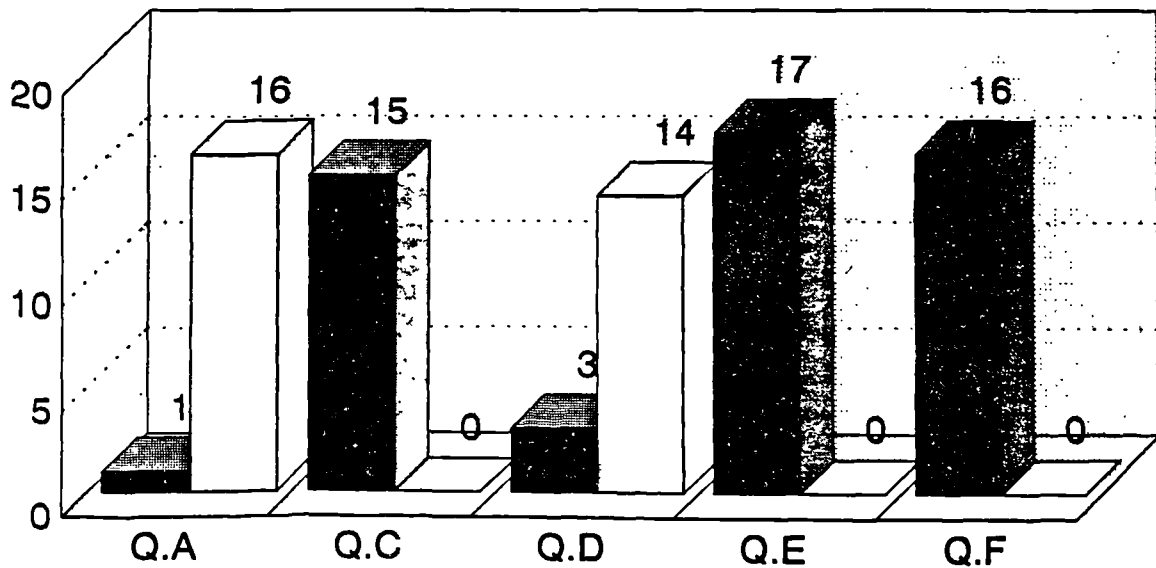
- Q.A See a similar one before ?  
 Q.C Easy to use ?  
 Q.D Too much data input ?  
 Q.E Reports useful ?  
 Q.F Will efficiency improve ?

Questions

■ Yes □ No

# QUALITY ASSURANCE SUB-SYSTEM QUESTIONNAIRE SURVEY

No. of Respondents



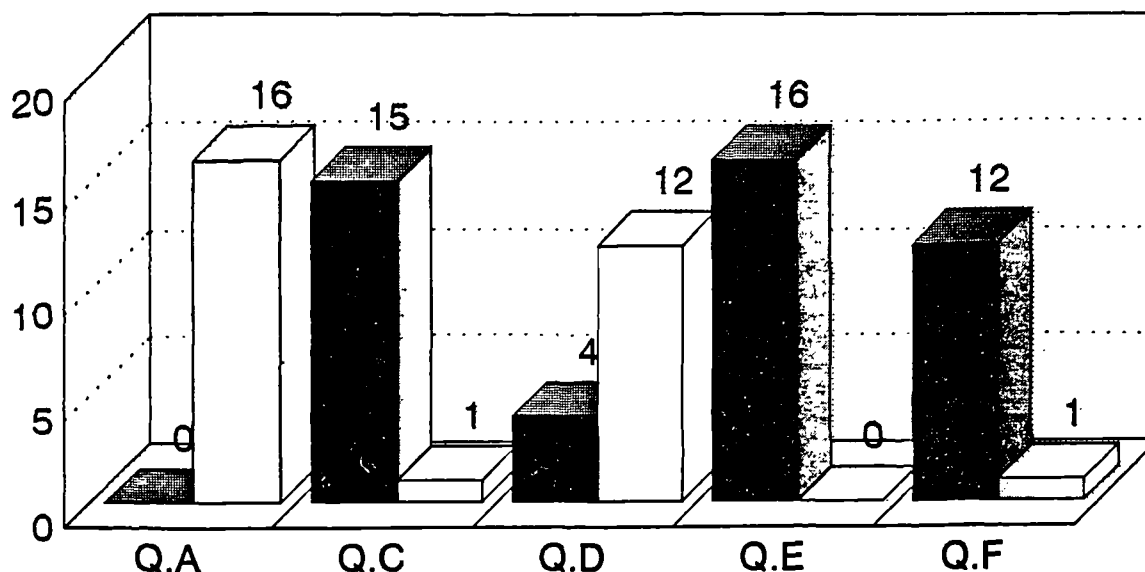
- Q.A See a similar one before ?  
 Q.C Easy to use ?  
 Q.D Too much data input ?  
 Q.E Reports useful ?  
 Q.F Will efficiency improve ?

Questions

■ Yes □ No

# MATERIALS CONTROL SUB-SYSTEM QUESTIONNAIRE SURVEY

No. of Respondents



Q.A See a similar one before ?

Q.C Easy to use ?

Q.D Too much data input ?

Q.E Reports useful ?

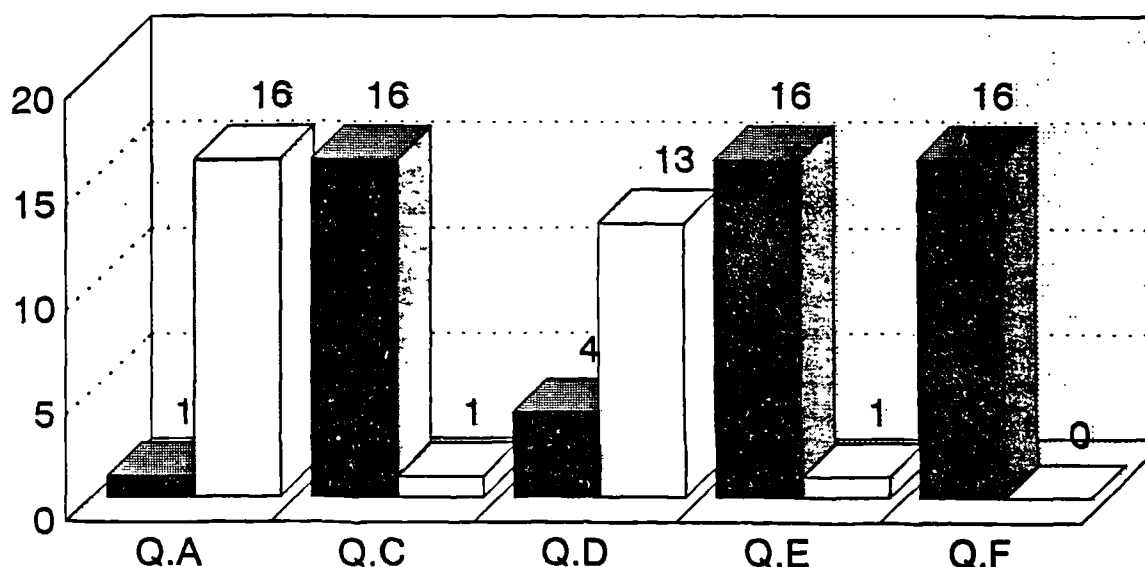
Q.F Will efficiency improve ?

Questions

■ Yes □ No

# PROGRESS CONTROL SUB-SYSTEM QUESTIONNAIRE SURVEY

No. of Respondents



Q.A See a similar one before ?

Q.C Easy to use ?

Q.D Too much data input ?

Q.E Reports useful ?

Q.F Will efficiency improve ?

Questions

■ Yes □ No

4/4

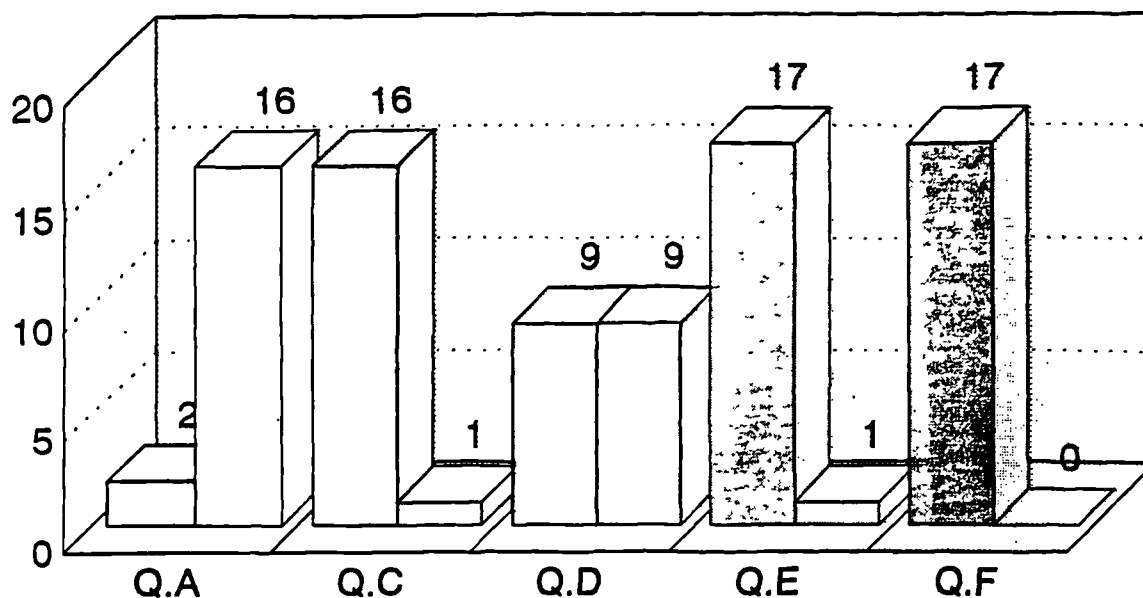
APPENDIX 13

# TENDERING AND ESTIMATING SUB-SYSTEM

## QUESTIONNAIRE SURVEY

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No. of Respondents



Q.A See a similar one before ?

Q.C Easy to use ?

Q.D Too much data input ?

Q.E Reports useful ?

Q.F Will efficiency improve ?

Questions

