

COST CONTROL SYSTEM  
FOR A LARGE  
INDUSTRIAL PROJECT

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A Major Technical Report

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## ABSTRACT

### COST CONTROL SYSTEM FOR A LARGE INDUSTRIAL PROJECT

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This report presents a description of an actual cost control system used by a project management group to manage and control a large heavy industrial project which has been under construction for the last two years. Emphasis is placed on providing an overview of the reporting system, demonstrating how the components of the system are integrated, examining in detail the site information inputs, describing the flow of information within the system and describing in detail the various output reports generated by the reporting system and their usage by management.

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CHAPTER I  
INTRODUCTION

## CHAPTER I

### 1.1 Introduction

Central to the effective monitoring and control of the construction process is the cost control system. The purpose of this technical report is to describe an actual cost control system used by a project management group to manage and control, on behalf of the client, a large heavy industrial project. Of the various project delivery systems currently in use, this project was executed using the project management delivery system.

When completed, the project will have cost several hundred million dollars and will have taken more than three years for planning, design and construction.

In order to construct the project, the project management group assigned over 100 contracts to several contractors. The contract types most frequently used included: cost plus, fixed unit price, and lump sum.

Emphasis is placed on describing the cost control system used on site during the construction phase of the life cycle of the project.

### 1.2 Types of Project Delivery Systems

A brief description of the various project delivery systems currently in use is presented herein so as to provide a perspective on the functions of the cost control system as

required for the project management delivery system.

A project delivery system is an organizational concept which assigns specific responsibilities and authorities to people and organizations, and which defines the relationships between the various elements in the construction of a project.

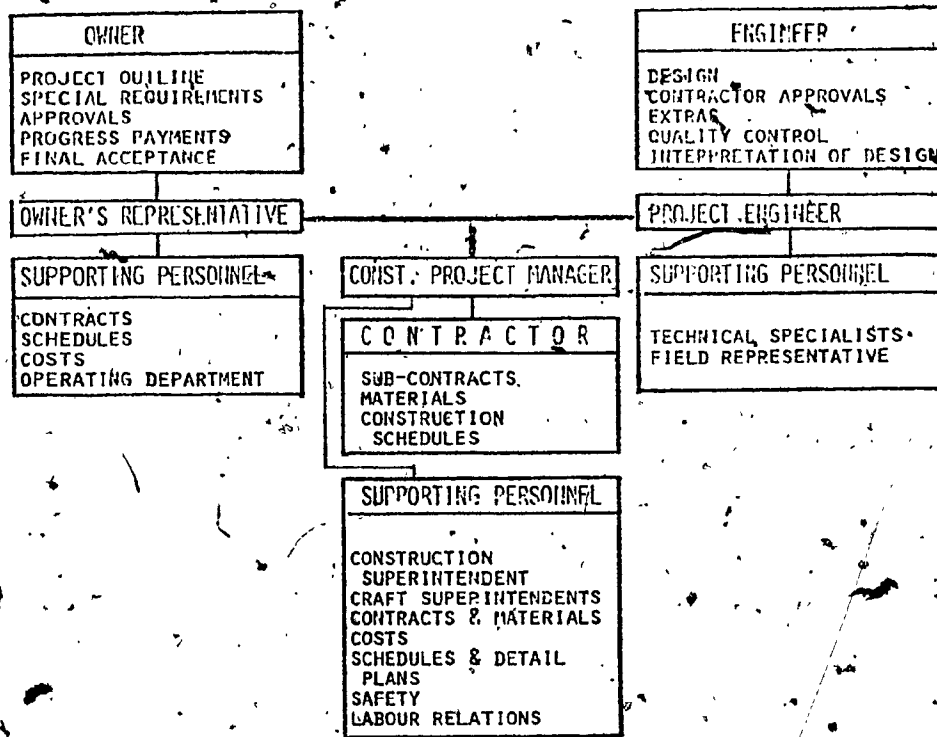


FIGURE 1.1a ENGINEER CONTRACTOR SYSTEM [2]

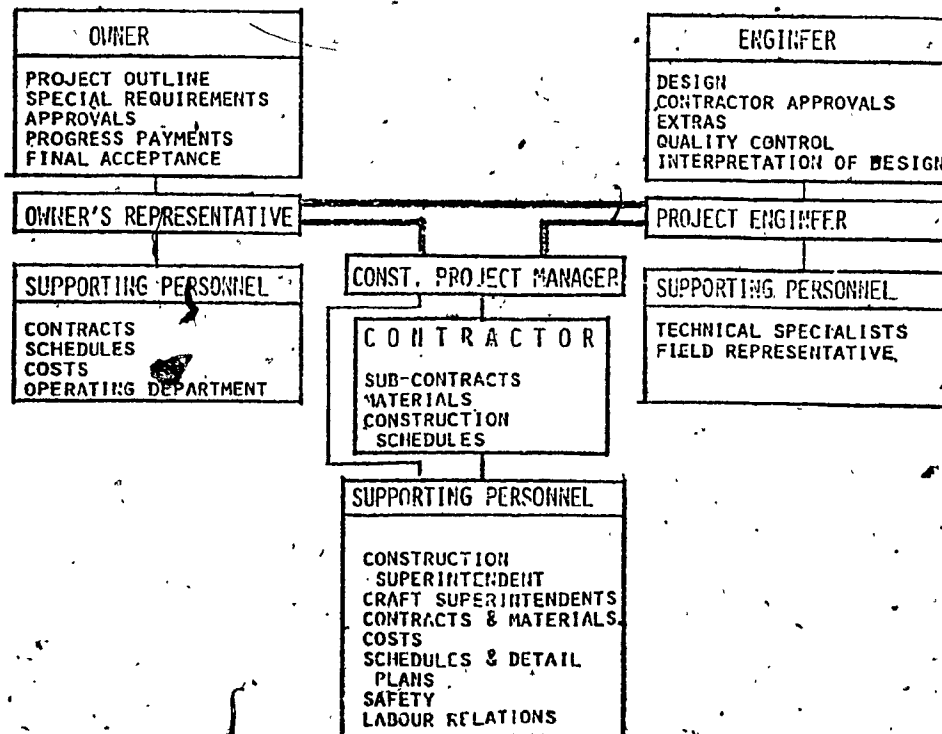


FIGURE 1.1b ENGINEER PLUS CONTRACTOR SYSTEM [2]

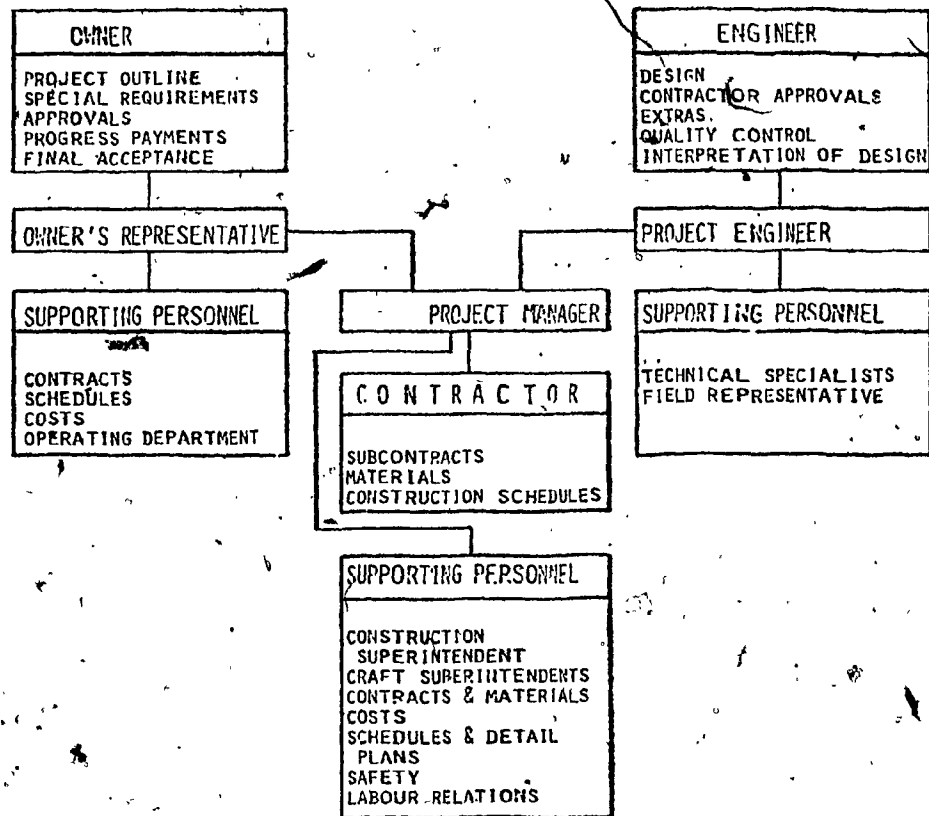
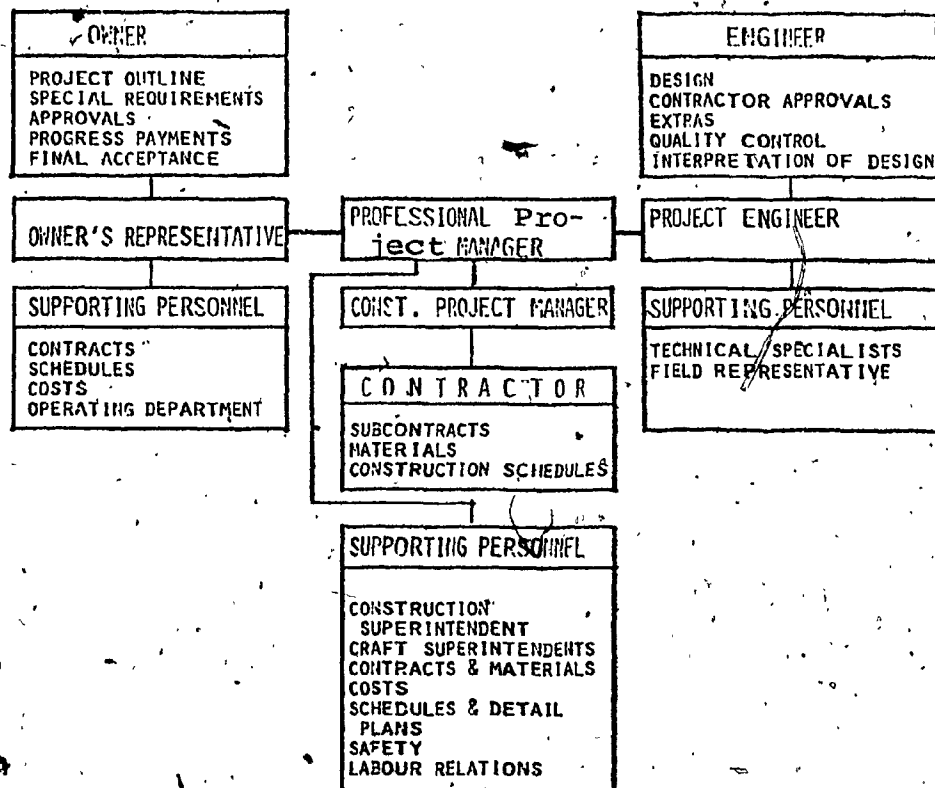


FIGURE 1.1d PERFORMANCE SPECIFICATION SYSTEM [2]

FIGURE 1.1c PROFESSIONAL CONSTRUCTION MANAGEMENT SYSTEM [2]



There are four basic project delivery systems.

- (i) The "Engineer-Contractor" system in which responsibilities for engineering, materials acquisition and construction are assigned to one responsible organization (Figure 1.1a).
- (ii) The "Engineer-plus-Contractor" system, in which engineering is assigned to one organization and after all engineering is completed, materials acquisition and construction are assigned to another organization (Figure 1.1b).
- (iii) The "Professional Project Manager" system, in which a competent Project manager with no vested interests in design or construction brings the practical construction viewpoint to bear during the design phase, and, using phased construction, provides overall management for all construction elements (Figure 1.1c).
- (iv) The "Performance Specification" system, in which a lump-sum contract is placed with one organization which provides a complete "turn-key" project including engineering materials and construction on the basis of a performance-type specification (Figure 1.1d).

Experience to date has shown that, in general, the "Performance Specification" system gives the most satisfying results to the owner. Using this system, his participation will be minimized, the time required for project completion will be shorter than that achieved by other systems, and information flow between the three other parties will be maximized [2].

### 1.3 Professional Project Management

Professional Project Management is an effective method of satisfying an owner's construction needs. It treats the project planning, design, and construction phases as integrated tasks.

Interactions between construction cost, environmental impact, quality and construction schedule are carefully examined by the project manager so that a project of maximum value to the owner is realized in the most economic time frame.

Most engineering firms that offer professional project management services use the principle of matrix organization, as shown in Figure 1.2. Under this organizational system, the department heads assign their personnel to project teams. The project managers direct their day-to-day work, while the department heads retain responsibility for their standards of performance. At any one time, several projects can be in progress. These are coordinated by the project

PROJECTS

		PROJECT 1	PROJECT 2	PROJECT 3	PROJECT 4
DEPARTMENTS	ARCH.				
	CIVIL				
	MECH.				
	ELEC.				

FIGURE 1.2 PROJECT - DEPARTMENT MATRIX

management division.

When forming a project team, the project manager selects his staff from several department disciplines, controlled by basically the four project team members reporting to him (Figure 1.3). These are the project engineering manager, the project services manager, the project construction manager and the project controller.

The project management team shown in Figure 1.3 varies from project to project. Figure 1.4 depicts the structure of the project management team adopted for the specific project which forms the basis of this report. For this project, the Project Site Manager's team consists of three of the basic project team members, the Project Engineering Manager (which in this case was a dual role, consisting of the construction and the engineering manager), the Project Services Manager and the Project Controller.

Since this project was fairly large, an Office Manager and a Labour Relations manager were added to the team to provide better control for the total project. Figure 1.5 summarizes the relationship of the project management team with the client, the designer, the contractor and the suppliers. For this particular project, the design services and project management services were provided by the same company.

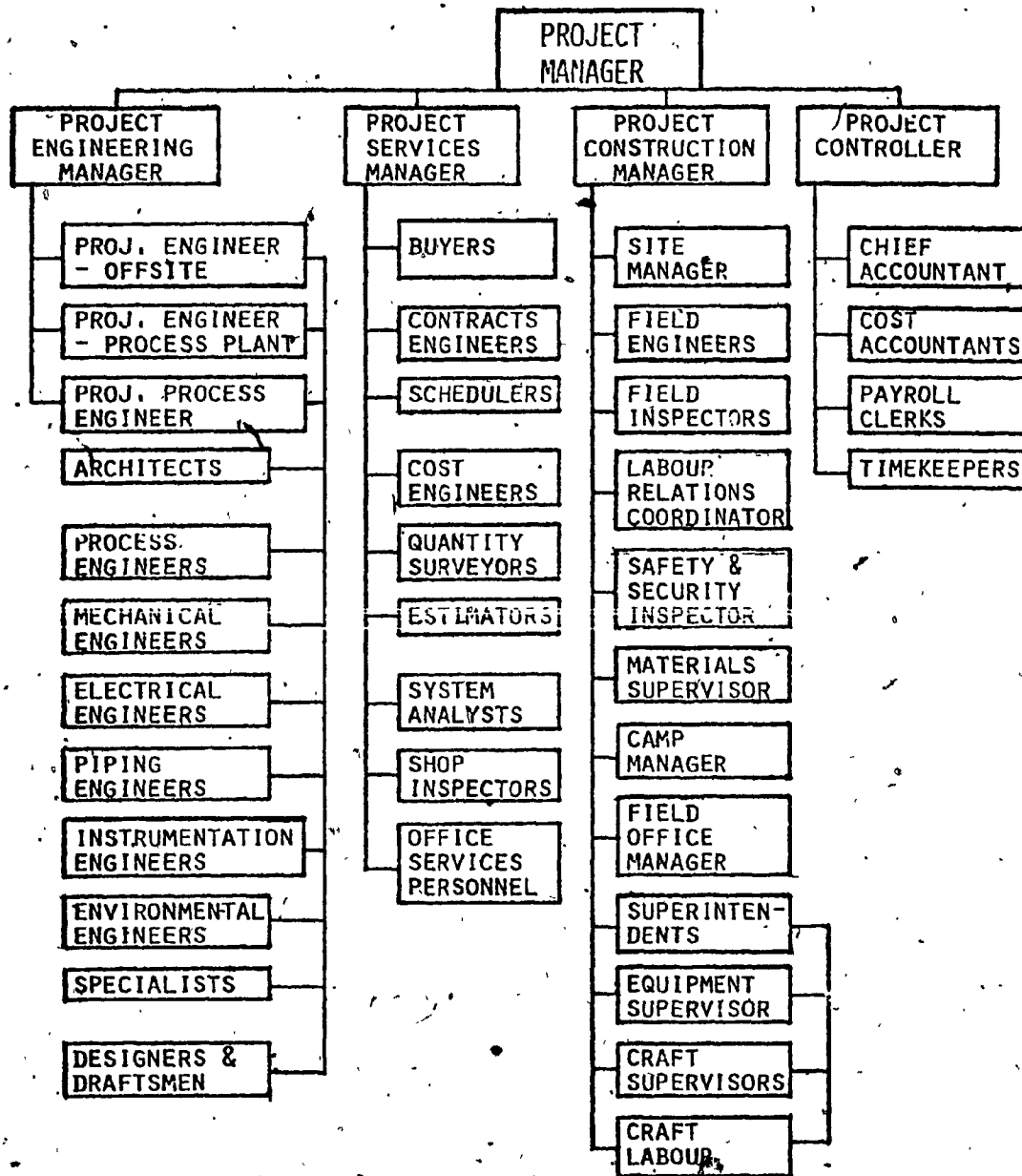


FIGURE 1.3 PROJECT MANAGER ORGANIZATION (General)

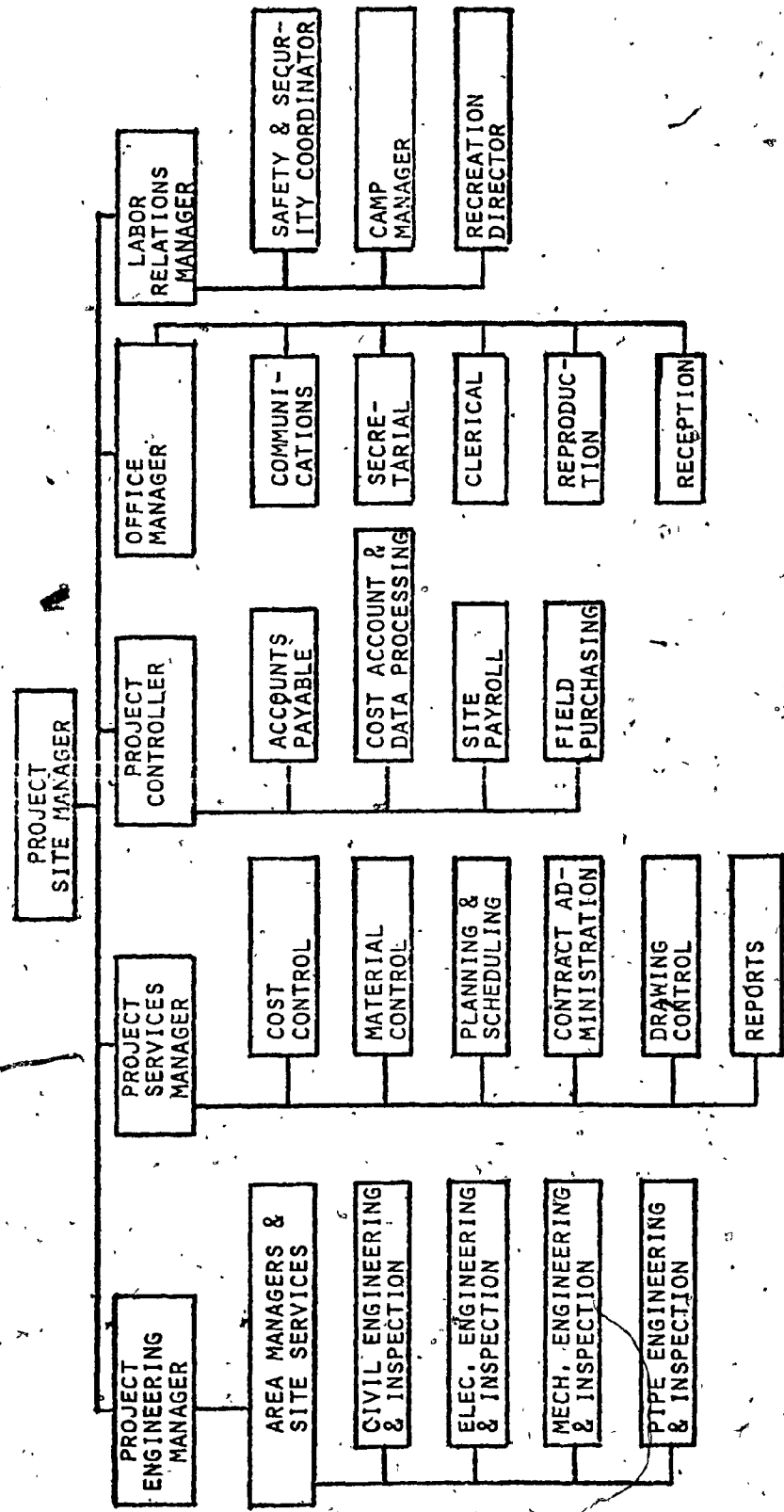


FIGURE 1.4 PROJECT MANAGER ORGANIZATION (For this Project)

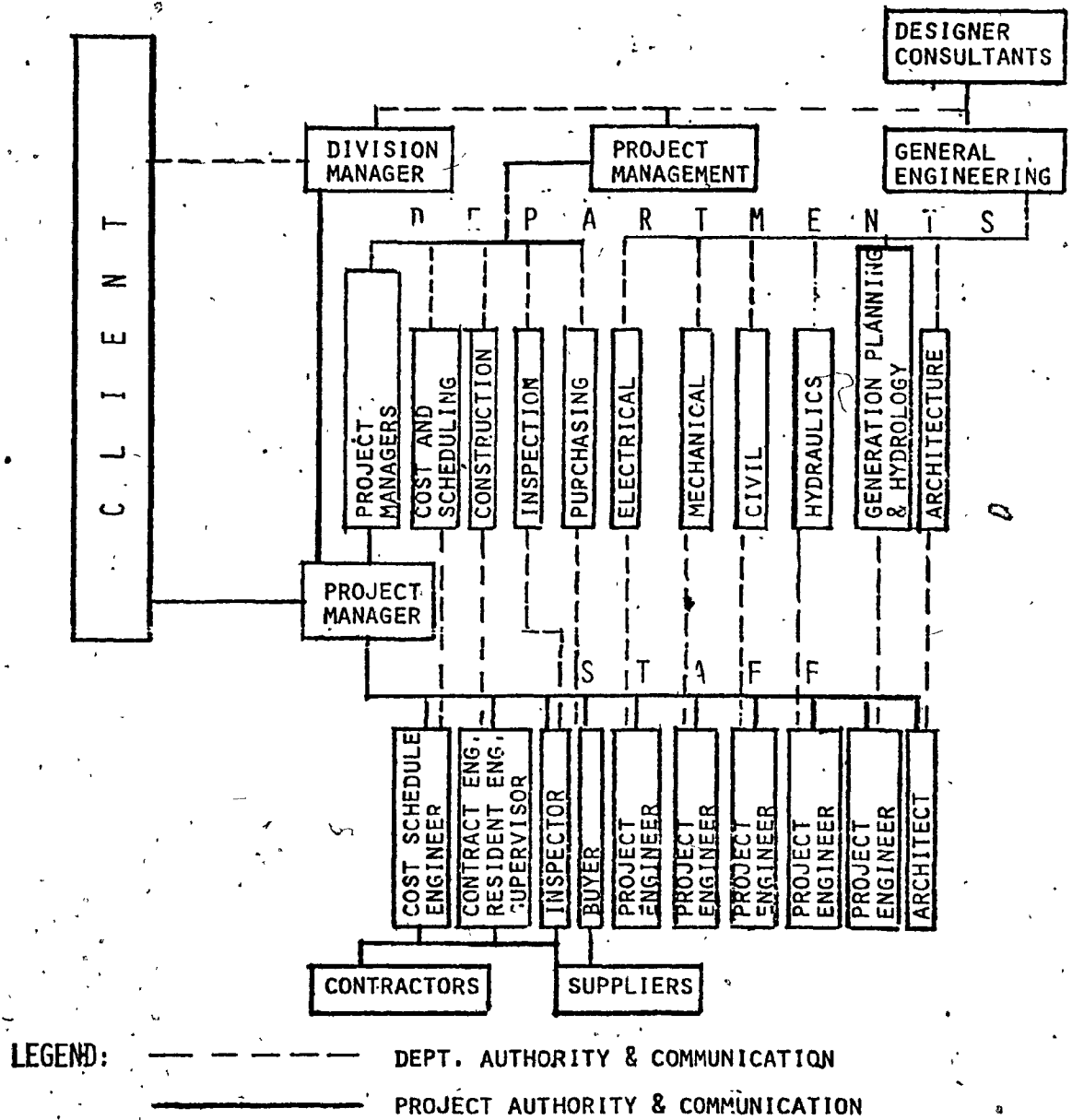


FIGURE 1.5 PROFESSIONAL CONSTRUCTION MANAGEMENT ORGANIZATION

#### 1.4 Project Cost Control

"Cost Control" is defined as all of the action taken by project managers and engineers throughout the life of the project to achieve the minimum possible project cost consistent with the required quality. The greatest savings in project cost are usually achieved through cost decisions during the preliminary planning and engineering phases. Cost control is not a detailed study of past mistakes but rather the focusing of attention on current and future activities to ensure that they are performed in accordance with management's wishes. Progress towards objectives must be observed, measured, and directed if these objectives are to be achieved.

The specific objectives of project cost control are:

- (i) To complete the project at minimum cost within required quality and to an efficiently-attainable schedule;
- (ii) To monitor progressively project time and costs;
- (iii) To project cost trends and make periodic forecasts in relation to a total budget sufficiently early to permit design reconsideration when and where desirable; and
- (iv) To control commitments and expenditures in accordance with pre-planned cash flow.

The effective control of costs requires that specific responsibilities be assigned to the various members of the project management team. Failure to hold individuals responsible for the costs over which they have authority negates the usefulness of a cost control system.

Central to effective project cost control is the cost control system. The purpose of such a system is to assist management:

- (i) in determining the present status of the project in terms of time, cost and content;
- (ii) in forecasting the likely outcome of the project in terms of time and cost;
- (iii) in comparing present performance with predicted performance;
- (iv) in identifying specific causes for deviations of actual performance from predicted performance;
- (v) in presenting information in a manner which will facilitate action initiation.

The main components of the cost control system are:

- (i) The input data collected from the field;
- (ii) A data processing system for determining present project status and comparing it to predicted status;

- (iii) A forecasting system for projecting final performance in terms of time and cost;
- (iv) A reporting system for purposes of producing reports for various levels of management.

The success (or lack of it) of a control system is for the most part a function of the usefulness of the reports generated. Reports must be designed to suit the various levels in the organizational hierarchy. As one moves further up the managerial hierarchy, more cost items (in aggregate form) will be reported at each level, since more costs are controllable as the scope of managerial responsibility is widened. Top management, therefore, will receive a summary of all costs, composed of controllable costs at each subordinate level, plus those relevant to the top level. Such reports can do little to rectify past mistakes, but by pinpointing exceptions to plans they can help in ensuring that an investigation into causes will aid in preventing mistakes from recurring in the future. The orientation of a good management reporting system is clearly towards the future rather than the past.

### 1.5 Report Overview

The remainder of this report is structured as follows. Chapter 2 presents an overview of the site cost reporting and monitoring system and identifies the relationship between the input information sub-systems, record-keeping sub-systems,

the project cost monitoring system and the various output reports generated. Chapter 3 examines in detail the structuring and operation of the cost control process and presents, in graphical form, the generation and flow of information for project control. Chapter 4 examines the specific formats and usage of the various reports which are generated by the cost reporting system. Finally, Chapter 5 presents a summary of the report.

CHAPTER II

COST CONTROL SYSTEM: AN OVERVIEW

## CHAPTER II

### 2.0 COST CONTROL SYSTEM: AN OVERVIEW

#### 2.1 Introduction

This chapter will describe the overall structure of the cost control system. A more detailed description of each individual sub-system and the interface of the sub-systems with each other is discussed in Chapter 3.

#### 2.2 Characteristics of Control Systems

Control systems can collapse if management endeavours to control too much, with the result that the really important issues become submerged in a mass of largely irrelevant detail and scarce management resources are consumed in maintaining the system. A cost control system can be an extremely valuable tool if it is properly used. The effectiveness of a manager in his job will tend to depend upon how much, how relevant, and how good the information he receives is, and how well he interprets and acts upon this information.

For the cost control system to be useful, the information input to and output from the system must be relevant, accurate and timely, and must be presented at the level of detail required, with appropriate yardsticks for comparison and in a manner which identifies the individual or group responsible for it.

The cost control system has two main components. The first, called the home office cost control system, relates to engineering, design, procurement and related services performed at the home office. The second, called construction control system, covers all expenditures incurred at the field. This latter system constitutes the main topic of discussion of this report.

### 2.3 Construction Control System

The construction control system must be comprehensive and permit as much accuracy as possible. It has as its focus the control of expenditures in regard to men, machines and materials during construction, whereas the home office cost control system concentrates on design and procurement activities.

The accounting and bookkeeping chores for the project during the construction phase are better performed at the field office, since almost all of the action takes place there. The home office, however, will offer several support services. These services are combined with field office operations prior to final billings.

For effective control of large projects, the use of a computerized system is unavoidable. A moderately economical computer and hardware configuration installed at the field office can handle the data manipulation and reporting required to control the project. A terminal which has access

to a computer which can be accessed both by the field office as well as the home office constitutes the most useful arrangement. The personnel required to staff the operation may consist of a supervisor, two computer operators and two keypunch operators.

Central to the control system is the cost code system. It is a system of identifying numerically each accountable work element along with a brief alphanumeric description.

A nine-digit cost code system was employed for the project described herein. The format of the cost code used, plus an example, is shown in Figure 2.1. As seen from Figure 2.1, it is possible to sort information according to area, division, description, function and contract. This cost code system, coupled with the sorting capability of the control system permits a high selectivity of information content for the various reports generated for different levels of management.

#### 2.4 Control Factors

One of the fundamental first steps in designing a control system is identifying the critical elements of performance that exert the greatest influence on the attainment of predetermined performance levels. A common failing of many organizations is that they attempt to control too many factors that are unimportant in a control sense, because

<u>1</u>	<u>2</u>	<u>3</u>	AREA						
			<u>4</u>	DIVISION					
			<u>5</u>	<u>6</u>	DESCRIPTION				
			<u>7</u>	FUNCTION				LABOUR,	
			<u>8</u>	<u>9</u>	CONTRACT )				
			<u>X</u>	<u>X</u>	<u>X</u>	MATERIALS			

Example

<u>2</u>	<u>8</u>	<u>0</u>	<u>1</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>9</u>	<u>9</u>	
<u>2</u>	<u>8</u>	<u>0</u>	ADMINISTRATION						
			<u>1</u>	STRUCTURAL					
			<u>4</u>	<u>5</u>	CONCRETE FOUNDATIONS				
			<u>6</u>	FORMING					
			<u>9</u>	<u>9</u>	CONTRACT NUMBER				

FIGURE 2.1

STRUCTURE OF THE COST CODE SYSTEM AND AN EXAMPLE

their behaviour patterns follow those of other more essential factors. Information systems must attempt to highlight the critical factors that govern an organization's success. It was found that the basic and essential control units and factors for this project were as follows:

1. Man-hours
2. Equipment usage and rental hours
3. Material quantities

The input information which is related to the above control factors can be classified into six different types of information as follows:

- (a) Labour man-hours and costs
- (b) Material control and costs
- (c) Equipment usage and cost
- (d) Physical progress
- (e) Contracts, purchase orders, invoices, payment vouchers, and other journals
- (f) Other miscellaneous and indirect costs.

Each one of these information categories can be sub-divided further into two sub-categories:

1. Commitments, which represent all outstanding obligations which have to be fulfilled by contractors and suppliers or by management;
2. Payments: the value of completed work and operations.

The cost control system consists of six major input sub-systems which are designed to accept the six categories of input information previously mentioned. The input sub-systems transfer data to the record-keeping sub-systems and preliminary processing and sorting systems. Information from forecasting and planning systems will be integrated at the next stage with the information from record-keeping sub-systems to form the input data for the project management system monitoring and control system which generates the final higher-level reports in the three areas of: Design/Construction; Project Accounting; and Budget Reporting. Figure 2.2 presents an overview of the project cost reporting and monitoring system.

#### 2.5 Input Information Sub-System

As shown in Figure 2.2, the input information systems are the first stage in the data collection and information generation process. Data is collected in special formats and tables which are discussed in detail in Chapter 3. The purpose of these systems is the collection, verification and entry of the data into the computer system pertaining to labour, materials, equipment usage, physical progress, contracts, purchase orders and invoices. This data is checked, signed and approved by those responsible before entry in the computer. After running some check runs and passing through diagnostic tests, this data is then ready to be used in the second set of sub-systems, called the "record-keeping" sub-systems. (Figure 2.2.)

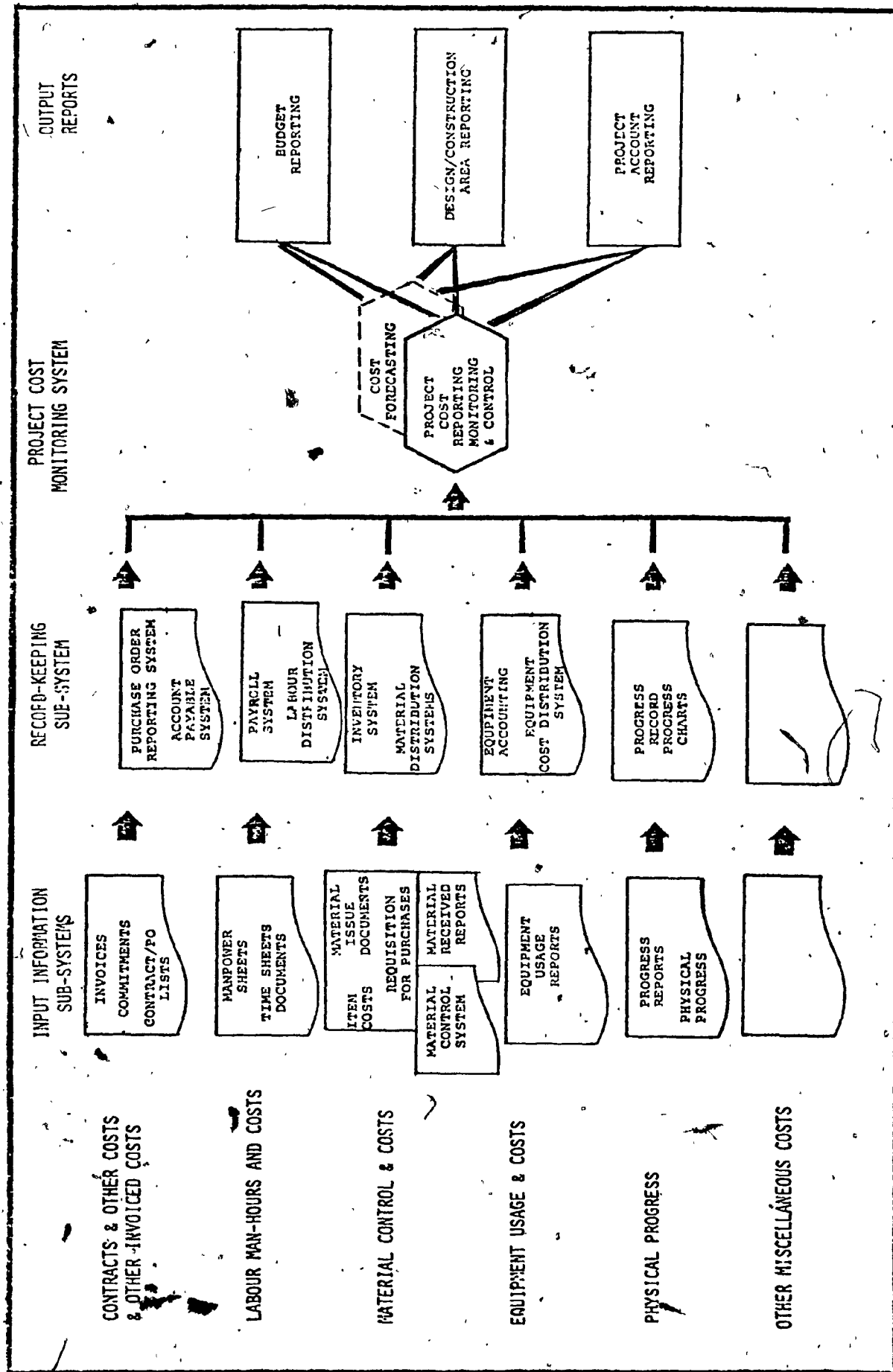


FIGURE 2.2 OVERVIEW OF COST CONTROL SYSTEM

This group of sub-systems will take the basic data from the input information sub-systems and sort it for all weekly and monthly transactions by account number and produce sub-totals for each functional group. Record-keeping sub-systems will also list all booked transactions to date by accounts and will provide batch/journal and check number references for traceability. For example, these sub-systems will produce weekly labour summary reports by mill area and by contractor, as well as providing labour, material and equipment distributions, and payroll, accounts payable, contract/purchase order ledger, commitment ledger, and a cost ledger.

The output from the record-keeping sub-system is then integrated by the project cost monitoring system which consists of project cost reporting, monitoring and control and cost forecasting. The purpose of this system is to produce management reports in which actual expenditures, progress and activities are compared against those planned and forecasted. Several reports are normally generated and include:

1. Project Quantity and Man-Hour Reports
2. Cost Reports
3. Contract Analysis and Forecast Reports
4. Progress Reports
5. Construction Equipment Utilization Report
6. Construction Man-Month Report

Details of the contents of these reports are discussed in the following chapter, and samples of these reports are illustrated in Chapter 4.

CHAPTER III  
STRUCTURE OF COST CONTROL SYSTEM

### CHAPTER III

#### 3.0 STRUCTURE OF COST CONTROL SYSTEM

##### 3.1 Introduction

The purpose of this chapter is to describe in detail the structuring and operation of the cost control process.

While reference is made to cost control, it should be noted here that this includes the following three separate activities:

##### (a) Cost Reporting

The recording and correlating of costs in a manner which permits meaningful analysis.

##### (b) Cost Monitoring

The identification of adverse trends so that proper action can be taken.

##### (c) Cost Control

The actions which change or have an effect on the financial outcome of the project.

This chapter focuses on activities associated with cost reporting and cost monitoring with respect to the input information sub-systems, the record-keeping sub-systems and the project reporting and monitoring systems.

Flow charts illustrating the logical flow of the above sub-systems will be used to describe these activities and to illustrate the allocation of responsibilities. Forms and tables used for collecting data and presenting information will also be illustrated and referred to in the explanations of each of the flow charts.

### 3.2 REQUIREMENTS OF COST CONTROL SYSTEM

In order to achieve cost control, the system must have:

- (a) An Approved Capital Budget, based on a control estimate which has sufficient accuracy so as to form a fundamental basis for comparison with actual costs and trends.
- (b) A Code of Accounts to classify and group all the items contained in the Approved Capital Budget for easy comparison with actual costs and cost trends.
- (c) A Change Notice Procedure to enable cost variations due to changes in scope to be appropriately considered.
- (d) Provision for feedback of actual costs in the same groups and items of the Code of Accounts for comparison with the Approved Capital Budget and for the analysis and prediction of cost trends.
- (e) A means of compiling information to produce monthly

Cost Control reports summarized for management to review and determine where and how to apply corrective measures, if required.

- (f) Data in a form suitable for computerized data processing methods in order to reduce time lags between reports and any corrective action which may be required.

Cost control begins when management makes a positive decision to proceed with the project. Estimates of expenditures are then prepared to provide a meaningful basis for project cost control.

As the project progresses, a continually-increasing degree of definition becomes available which has to be applied to the control of actual expenditure. A revised control estimate can therefore be compiled at, say, six-month intervals.

Monthly cost control statements show the current position regarding expenditure, commitments, estimated final costs, and budget funds. Analysis of these statements will indicate where corrective action is necessary.

Cost control ends with preparation of a final cost statement for the project and reduction of data compiled during the project to a form suitable for estimating future similar projects.

### 3.3 Cost Reporting and Cost Monitoring

An attempt is made in this section to trace each of the six groups of source information, namely:

- (i) Labour man-hours and costs;
- (ii) Material control and costs;
- (iii) Equipment usage and costs;
- (iv) Physical progress;
- (v) Contracts; purchase order, invoices, etc.;
- (vi) Other miscellaneous and indirect costs;

as they proceed through the Input Information Sub-Systems, the Record-Keeping Sub-Systems and the Project Reporting and Monitoring System.

#### 3.3.1 Labour and Man-Hour Sub-System

##### (a) Control Functions

The labour and man-hour sub-system is used for control purposes as follows:

1. Control actions which can be verified by observations:
  - (a) To ensure contractor's adherence to scheduled working hours;
  - (b) To verify presence of contractors' employees on the work site;
  - (c) To ensure that workers are usefully deployed and

are not lacking supervision, tools, or equipment;

- (d) to ensure proper distribution of payroll checks to all contractor's employees.

2. Control actions which can be verified by audit:

- (a) to verify exceptions noted in the field through payroll accounting;
- (b) to secure written evidence of owner's approval for overtime;
- (c) to ensure that rates of pay are in agreement with union contracts or approved by management;
- (d) to ensure that employee deductions are properly taken and properly remitted to government or other agencies.

(b) Information Formats

The basic source of information for this sub-system is the Daily Time Sheet. This information is compiled in the form of a weekly summary report as well as a labour summary by account and area and by contractor. See Figures 3.2, 3.3, 3.4 and 3.5.

(c) Procedure

The main function of this sub-system is to produce reports for purposes of monitoring and controlling manpower on site, and for computing and recording the cost of labour to date. Figure 3.1 provides an overview of the labour and man-hour sub-system and depicts the information flow within this system and the role of the various key actors in the construction

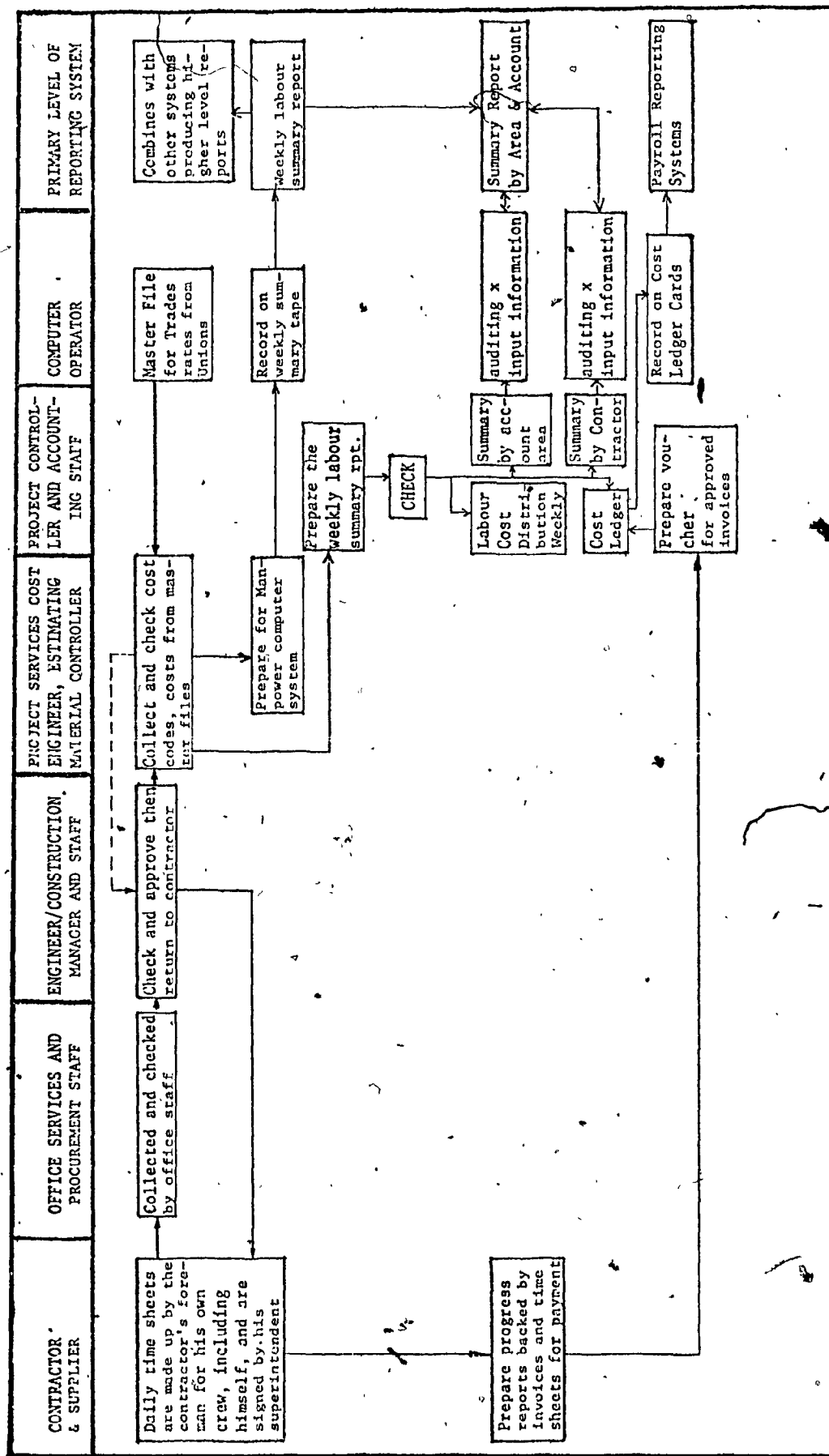


FIGURE 3.1 LABOUR AND MANPOWER SUB-SYSTEM

# DAILY TIME REPORT

CONTRACTOR

CONTRACT #

DATE \_\_\_\_\_

MILL AREA

DIVISION

<u>Employees</u>	<u>Name</u>

Trade

Cost Code  
Dwg. No.:

Total

R = REGULAR    O = OVERTIME

Superintendent

Approval

FIGURE 3.2 DAILY TIME REPORT

# WEEKLY LABOUR SUMMARY

NAME: Cost Code \_\_\_\_\_ Cost Code \_\_\_\_\_  
Function \_\_\_\_\_ Function \_\_\_\_\_  
Contractor \_\_\_\_\_ Contract Number \_\_\_\_\_

[illegible]

FIGURE 3.3 WEEKLY LABOUR SUMMARY



WEEKLY LABOUR SUMMARY BY MILL AREA

		WEEK ENDING										PAGE		OF		AREA	
CONTRACTORS	DIVISION	Men Hours		Men Hours		Men Hours		Men Hours		Men Hours		Men Hours		Men Hours		TOTALS	
		D	N	O	D	N	O	D	N	O	D	N	O	D	N	D	N
Structural																	
Mechanical Install.																	
Elect.																	
Misc. Service																	
TOTALS																	

D = DAY N = NIGHT O = OVERTIME

FIGURE 3.5 WEEKLY LABOUR SUMMARY BY MILL AREA

and control process.

Daily time sheets are made up by the contractor's foreman for his crew, including himself, then signed by his superintendent. These time sheets are then signed by the site manager or his assigned representative with a signed copy being returned to the contractor. The cost engineer then checks cost codes and unit rates against the trades rates from unions entered in the master file. The time sheets are then given to the computer operator to be entered on the weekly summary tape. The machine then computes the premium time costs and labour costs. The purpose of the weekly labour summary is to collect the man-hours in sufficient detail to provide input information for the following reports and cost distributions:

- (a) Labour cost distribution for cost-plus contracts;
- (b) Progress record;
- (c) Weekly labour summary by account and area;
- (d) Weekly labour summary by contractor.

The weekly labour cost distribution is prepared to provide the labour cost distribution to the cost ledger. The most useful form in which to report man-hours is by area and by contractor. The weekly labour summary by area lists all the control units in the area by account and by contractor, so that the total number of men working in each area is known for day and night shifts. This information is used to coordinate the work crews and to eliminate congestion and interference in crowded areas.

The final level of man-hours reporting is by contractor.

This report lists the number of men and man-hours spent each week in each area plus the number of supervisory and indirect staff man-hours. The planned number of men and man-hours expenditures are filled in for about 8 weeks ahead of the reporting date, on a weekly basis, and the balance to complete on a monthly basis. This information can then be used for manpower planning. The detailed man-hour reporting and control that is required for a cost-plus work contract is not so necessary, nor can it be requested from a firm-price contractor. For purposes of site coordination, however, manpower reporting is required even for work done under a lump sum contract. Contractors, therefore, return a weekly labour summary by area and for their whole contract, including indirect man-hours shown separately. These man-hour tables are added to the total for cost-plus and lump-sum work to give the totals for the areas and the project.

### 3.3.2 Material Control Sub-System

#### (a) Control Functions

The Material Control Sub-System is used for control purposes to ensure:

1. Adequacy of contractor's control systems;
2. Accuracy of material take-offs;

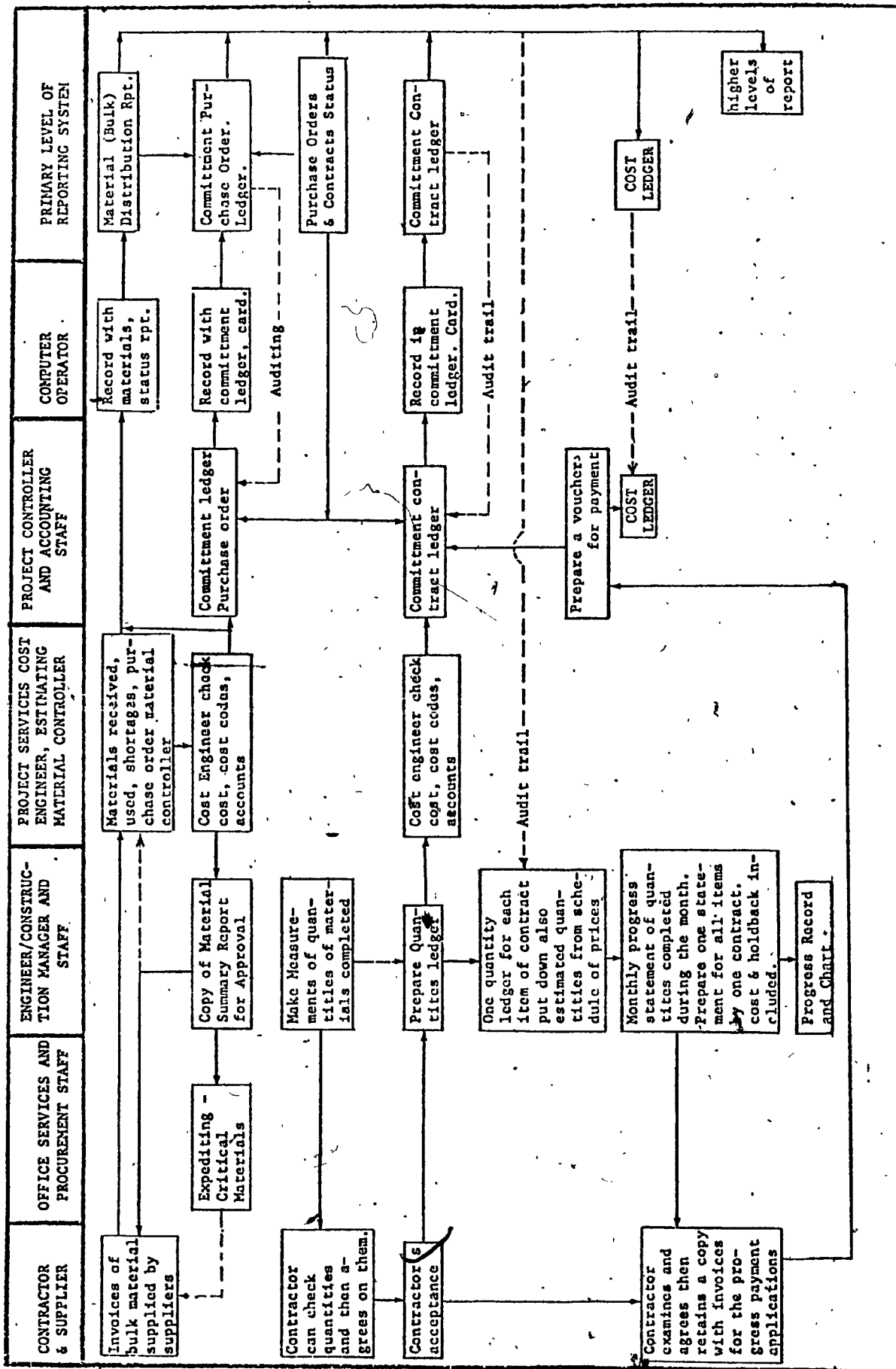
3. Numerical control over drawings entering the system;
4. That the commitment record matches the material record;
5. That the tracking system properly adjusts to changes in work;
6. Adequacy of warehousing procedures in areas of receipts, storing, and issuing of materials;
7. That proper inventory records are maintained;
8. That periodic physical inventories are taken;
9. That surplus materials are properly inventoried and returned for credit at reasonable intervals;
10. That supporting invoices are properly charged for delivered materials, quantities, prices, terms.

(b) Information Formats

Forms used in this sub-system are mainly to record quantities by management such as the quantities ledger and progress chart. There are also commitment ledgers, one for contracts and another for purchase orders, which are combined to form a cost ledger. See Figures 3.7, 3.8, and 3.9.

(c) Procedure

Figure 3.6 provides an overview of the Material Control Sub-System and depicts the information flow within this system and the role of the various key actors in the construction and control processes.



### FIGURE 3.6 MATERIAL CONTROL SUB-SYSTEM



### PURCHASE ORDER COMMITMENTS LEDGER

TYPE: Supply ☐ Supply & Erect ☐ Bulk ☐ Standing ☐

CONDITIONS: Progress Payment        Holdback        Cash  
Discount        Erection Supervision         
Escalation        Final Payment Release         
Warranty       

Purchase Order # \_\_\_\_\_

Requisition # \_\_\_\_\_

Vendor # \_\_\_\_\_

Vendor \_\_\_\_\_

[illegible]

FIGURE 3.8 PURCHASE ORDER COMMITMENTS LEDGER



The basic control unit in this system is a unit of quantity of material. The ultimate aim is not only coordination and monitoring of material quantities, but converting the figures to dollar value for purposes of cost control. Bulk materials are delivered to various storage and warehouse locations on site by suppliers. The suppliers' invoices are approved by the material controller, who prepares a report of materials received, used, shortages, and any damages. Materials received by the material controller are also checked to ensure that they are accompanied by the appropriate test certificate. Copies of this report are sent to the cost engineer and site manager, who check cost against material costs within the master files, which are obtained from previous projects and which are continuously updated. They also check cost codes, for proper cost distribution. They then decide whether expediting is required for certain materials. Just prior to commencement of work, the engineer takes his latest estimate of the quantities and, on the basis of the contract schedule, plots the curve of required production to determine the targets to be achieved. As work progresses, quantities are continuously measured and these are plotted weekly on the same chart. Measured quantities can be checked by the contractor. If he is not in agreement with these, he is required to submit a grievance to the chief construction engineer manager. A quantities ledger is prepared by the site manager and is made available to the contractor for review. The accounting section receives

information from the contractor in the form of approved invoices. These invoices are then used to prepare a payment voucher and are also entered into a commitment ledger. Finally, all commitment ledgers for contracts and purchase orders are combined into a final cost ledger. This ledger is then used by the site manager to prepare a progress report for payment for each contractor. Provisions regarding hold-backs are applied, and a copy of the progress claim is issued monthly to each contractor and to the accounting department.

### 3.3.3 Equipment Usage Sub-Systems

#### (a) Control Functions

The Equipment Usage Sub-System is used to:

1. Tag all tools and equipment, indicating purchase or rental;
2. Provide an inventory of all tools and equipment, identifying those items which are purchased and those that are rented;
3. Verify the contractor's analysis of the economics of renting versus purchases;
4. Ensure that the equipment on site agrees with records and, in the case of rentals, ties in with billings;
5. Ensure that contractor's equipment and tools are not being used for sub-contractors' work;
6. Ensure that maintenance of rented equipment is performed in accordance with rental agreements.

(b) Information Formats

Standard data collection formats are not used because of the diverse nature of the tools and equipment used on the site.

(c) Procedure

Figure 3.10 provides an overview of the Equipment Usage Sub-System and depicts the information flow within this system and the role of the various key actors in the construction and control process.

Invoices and time sheets of hours worked by rented equipment are checked and approved by the site manager or his delegate. The purchased equipment is checked by the warehouse controller as equipment received and by the Inspector for their acceptance and performance. The cost engineer checks the cost codes and also compares cost of unit prices estimated by the contractor with the record of unit prices from his master file for equipment usage lists. He then verifies and approves the costs. If the contractor is not in agreement with the outcome, he may submit a grievance to the chief construction engineer. The accountant receives the approved invoices, then prepares a payment voucher for the contractor and also enters the appropriate information into a commitment ledger using the appropriate purchase order number or contract number with the appropriate cost codes for each item. Finally, all commitment ledgers are combined into a final cost ledger which can be used to pre-

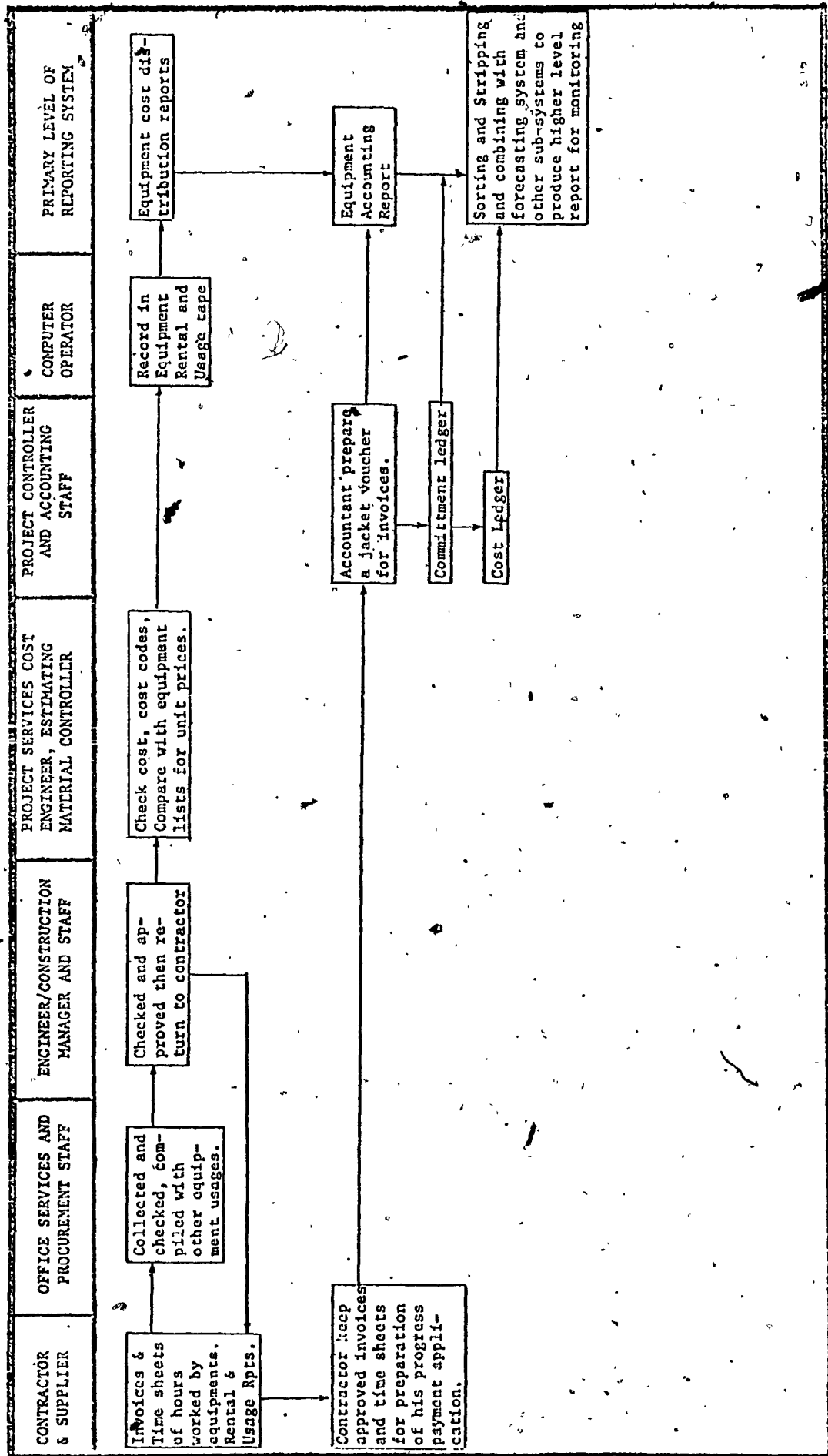


FIGURE 3.10 EQUIPMENT USAGE SUB-SYSTEM

pare a progress report for payment for each contractor.

### 3.3.4 Contract and Purchase Order Sub-Systems

#### (a) Control Functions

The Contracts and Purchase Order Sub-System is used to:

1. Ensure that inquiries are sent to a set of selected vendors for competitive bids and that these bids are properly tabulated;
2. Ensure that purchase orders properly set out terms, pricing, coding, tax, discounts, and arrangements for the return of surplus material;
3. Ensure that discrete packages of work are properly defined;
4. Ensure that efficiency and economic factors are properly evaluated;
5. Ensure that inquiry documents reflect proper completeness and clarity;
6. Ensure that proposals are properly evaluated using the control estimate as the appropriate yardstick or basis of comparison;
7. Ensure that the owner's representative attends pre-award and weekly meetings;
8. Evaluate extra work requests to ensure work not covered in original scope and to ensure that work does not take on new scope definition.

(b) Information Formats

The basic information formats employed in the contracts and purchase order sub-systems are the purchase order requisition form, the contract requisition form, and the purchase order contract commitment ledgers. See Figures 3.7, 3.8, and 3.12, 3.13, 3.14, and 3.15.

(c) Procedure

Figure 3.11 provides an overview of the contract and purchase order sub-system and depicts the information flow within this system and the role of the various key actors in the construction and control process.

There are basically three types of contracts that must be controlled. These are the cost-plus, a fee unit price and lump sum contracts.

The size and type of the work coupled with the characteristics of contractors available on the market constitute the determining factors in choosing which contract type to use.

Generally speaking, it was found from experience that the lump sum contract yielded the most satisfying results to the project manager and minimized his involvement in the direction and coordination of the contract. However, in the present economic climate, where cost escalation is largely unpredictable, few contractors will enter into a

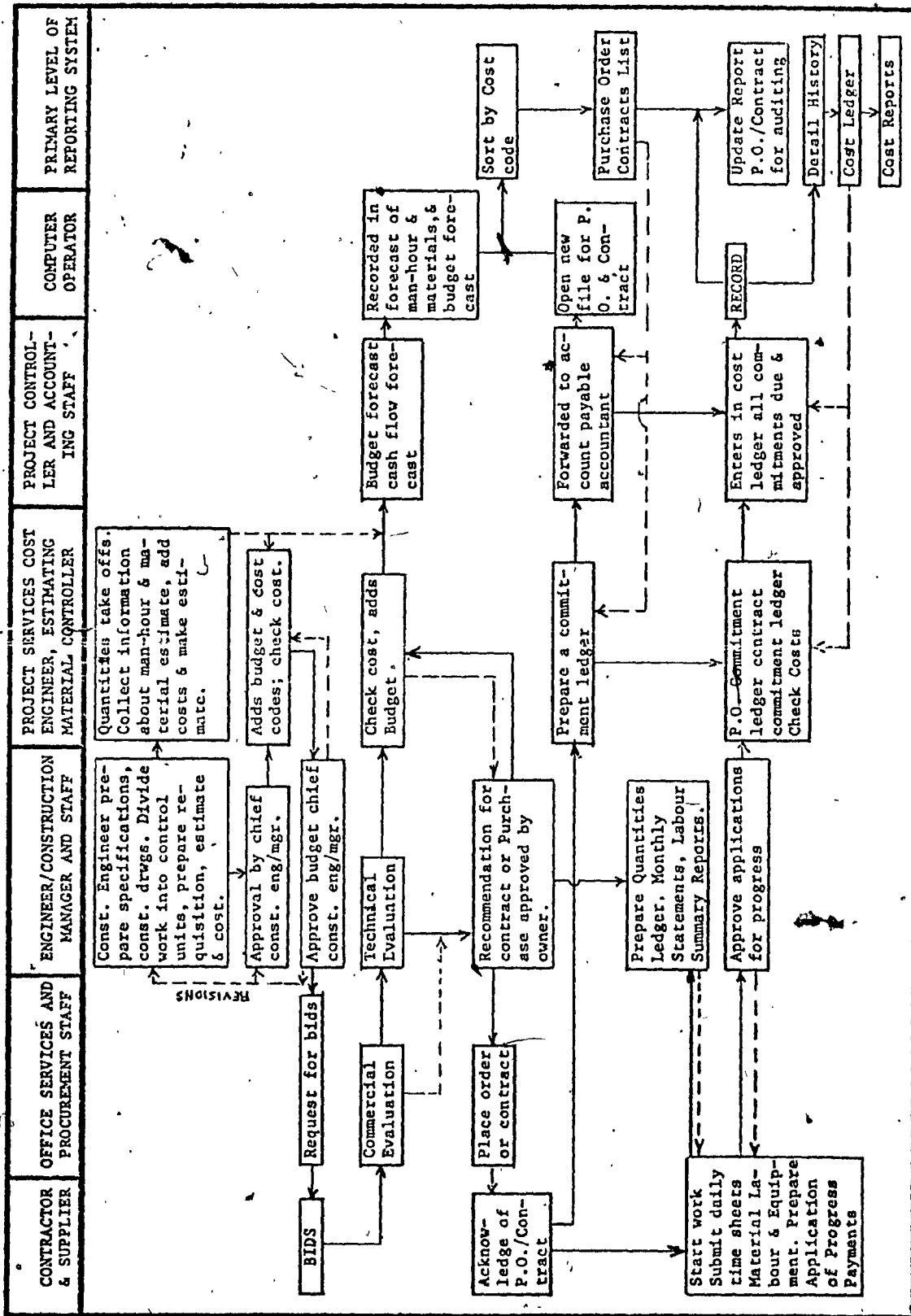


FIGURE 3.11 CONTRACT/P.O. REPORTING SUB-SYSTEM

**CONTRACTOR:**

APPROVAL	DATE	TOTAL THIS REQ'N	Date
Originator		PREVIOUS REQ'N	
Cost. Eng.		TOTAL TO DATE	Page
Const. Mgr.		ORIG. CONTRACT	of
Proj. Direct.		ESTIMATE	
		DIFFERENCE	

**FIGURE 3.12 CONTRACT REQUISITION**

[illegible]

FIGURE 3.13 REQUISITION REGISTER

EXTRA WORK AUTHORIZATION

CONTRACTOR _____								
CONTRACT NUMBER _____					DATE _____			
DESCRIPTION _____								
REASONS _____								
ESTIMATED COMPLETION DATE _____								
REQUISITIONED BY _____					DATE _____			
APPROVED BY _____					DATE _____			
Cost Code								
Estimated Man-Hours								

FIGURE 3.14 EXTRA WORK AUTHORIZATION

REQUEST FOR FORECAST CHANGE

Page \_\_\_\_ of \_\_\_\_  
Date \_\_\_\_

Cost Code	Description	Prev. Total Forecast	Current Changes	New Total Forecast	Reason for Change

Requested by \_\_\_\_\_ Date \_\_\_\_\_ Approved by \_\_\_\_\_ Date \_\_\_\_\_  
Approved by \_\_\_\_\_ Date \_\_\_\_\_

FIGURE 3.15 REQUEST FOR FORECAST CHANGE

lump sum contract, for a large project which extends over a long time frame. Because of the risk involved, the contractor will use a very high contingency factor, which adds considerably to the cost of the project.

Alternatively, the other contract types may be employed as they reduce the risk to be assumed by the contractor. However, they require considerably more involvement from the project manager to control and coordinate the project. Very often, the client prefers the lump sum contract despite the high contingency allowance over the relatively lower cost plus nominal fee contract due because the latter may end up to be a more expensive one, due to cost escalation and the additional cost of managing the contract.

The contract procedure starts with the development of the technical specifications, which are prepared by the construction engineer and which are accompanied by the appropriate drawings. The design and estimation engineers together prepare an estimate and quantity take-off. The cost engineer assigns a cost code to each item and calculates the cost. The calculated budget is then approved by the client after appropriate revisions, if any, are made in the scope of the work. The procurement staff then prepares the commercial and legal parts of the specification and issues tender announcements.

The bids received then undergo both commercial as well as technical evaluation. The best three or four bids are then

selected and forwarded to the owner for approval along with a recommendation prepared by management. Simultaneously, the cost engineer prepares a budget estimate which must also be approved by the client. As soon as the contract is approved by the owner, the contractor will receive a request to proceed. Once the contractor acknowledges the request and signs the contract, work commences and is followed by the generation of invoices, time sheets, etc. A commitment ledger and quantity ledger are prepared to receive invoices to produce a final cost ledger and a cost report.

A list of all contracts and purchase orders are made and recorded in the data file and are used to produce Contract/P.O. status reports and many other higher-level reports. Finally this information is combined to produce a forecasted cash flow requirement.

### 3.3.5 Physical Progress Sub-System

#### (a) Control Functions

The physical progress sub-system is directed at determining the actual progress to date of the project and reporting it in terms of percent complete. Comparing the actual percentage complete with the forecasted values will determine the efficiency with which the work is progressing in a particular area. The purpose of this system is also to determine the percentage of work to be completed and to identify irregular trends, if any.

Central to the effective usage of the physical progress sub-

system is an understanding of what is meant by percent complete. Work performed to date may be measured in several ways such as man-hours expended, elapsed time, materials used, dollars expended.

In order to evaluate the total progress of work done a unit of measurement must be chosen which reflects the contribution of men, money, machines and materials towards project progress in terms of time, cost and content. The most satisfactory basic unit to use for determining progress is man-hours. However, determining the total by itself does not give a complete picture of project status. Also required are interrelation tables and factors. The interrelation tables of man-hours versus work completed are based on data obtained from past construction projects.

(b) Information Formats

The basic information formats employed in the progress subsystem are the progress record, which is the key report for monitoring the progress performance of the work, and a progress chart, giving a visual illustration of the information contained in the progress record. See Figures 3.17, 3.18.

(c) Procedure

Figure 3.16 provides an overview of the Physical Progress Subsystem and depicts the information flow within this system and the role of the various key actors in the construction and control processes.



DATE \_\_\_\_\_

**CONTRACT NO.**

**CONTRACTOR**

PROJECT

[illegible]

MILL AREA - DESCRIPTION

[illegible]

### FIGURE 3.17 PROGRESS RECORD

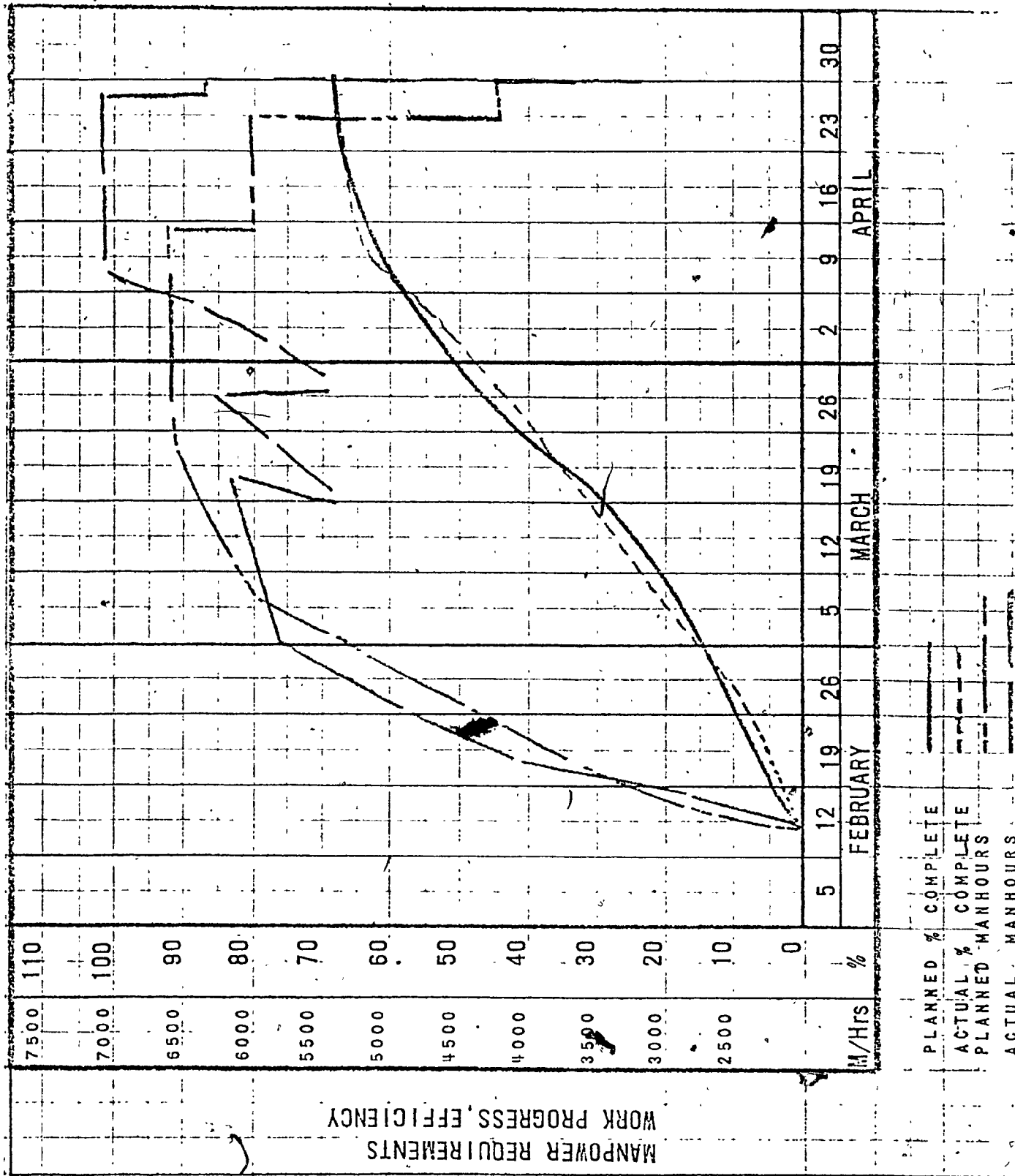


FIGURE 3.18 PROGRESS CHART

The procedure for this sub-system can be divided into three stages, i.e.:

- (i) planning and forecasting stage;
- (ii) on-site information collection stage;
- (iii) progress evaluation stage.

(i) Planning and forecasting stage

Before the work on site starts, the job is divided and broken down into work packages which are assigned to different departments, such as structural, mechanical, electrical, etc. Depending on the scope of the work, each department may further sub-divide the work according to area.

The information generated by each of these departments forms the basis for the physical progress forecasting system. As an example, consider the work of the civil department in area 1, which consists of a steel framed building. The basic components of the structure include the foundation and the superstructure. The superstructure may be described in terms of the following components:

## Superstructure

- 1st floor columns "Fabrication on site if necessary"
- 1st floor beams Erection
- 1st floor bracings, etc.

Using the interrelation tables in conjunction with the drawings, and quantity take-off, an estimate of man-hours is derived as follows:

### Erection

10 feet of 1st level column Type A =  $10 \times .4 = 4$  hours

12 feet of 1st level column Type B =  $12 \times .5 = 6$  hours

TOTAL = 10 hours

The total figures estimated for each drawing are then summarized on a sheet and appropriate allowances are made for other aspects which have to be considered, such as:

Unloading: 15% of the columns' erection man-hours

Scaffolding: 15% of the columns' erection man-hours

Connection: 20% of the columns' erection man-hours

Therefore, the total man-hours =  $10 + .5 \times 10 = 15$  hours.

The above procedure is carried out for all the components comprising the work, and these figures will be recorded as Total Estimated Man-Hours in the progress record.

### (ii) Progress Evaluation Stage

Once construction starts, the actual status of the work in terms of percentage of work completed and the efficiency with which it has been done are determined at regular intervals. Also made is an estimate of the percentage left to complete as well as the determination of any undesirable trends.

The actual number of man-hours spent on the job is calculated by assessing the actual work done on site in terms

of materials, time and cost; then converting these figures to man-hours units by using the appropriate interrelation factors.

The planned percentage complete at a certain date is calculated as follows:

$$\text{Planned percentage complete} = \frac{\text{Estimated Man-Hours Spent}}{\text{Estimated Total Man-Hours}} \times 100\%$$

Determining the actual percentage at any point is computed as:

$$\text{Actual percentage complete} = \frac{\text{Actual Man-Hours Spent}}{\text{Estimated Total Man-Hours}} \times 100\%$$

The efficiency with which the work has been performed is then computed as:

$$\text{Efficiency} = \frac{\text{Estimated Man-Hours Spent}}{\text{Actual Man-Hours Spent}} \times 100\%$$

Finally the man-hours to complete are calculated by the following method. Estimated man-hours minus estimated man-hours spent equals estimated man-hours remaining, divided by efficiency factor to date, equals man-hours to complete. To this total add allowance for contingencies and re-work. The forecasted total will be obtained by adding man-hours to complete and actual man-hours spent to date.

The trend will be derived from the efficiency to date and efficiency obtained during the last time interval.

## CHAPTER IV

### SAMPLE OUTPUT REPORTS OF COST REPORTING SYSTEM

## CHAPTER IV

### 4.0 SAMPLE OUTPUT REPORTS OF COST REPORTING SYSTEM

#### 4.1 Introduction

The format and usage of the various reports that can be output from the cost reporting system are examined in this chapter.

It should be emphasized that the output reports described herein have their limitations in that the level of precision in the output information is solely a function of the level of accuracy of the input information. In essence management reporting implies the preparation and presentation of comparative information so as to assist in the decision-making process. Its purpose is threefold: (i) to provide a picture of current job status; (ii) to determine deviations from the intended plan; (iii) to isolate the causes of these deviations and thus facilitate the management decision function of taking corrective action.

#### 4.2 Output Reports

The following output reports are described herein:

Figure 4.1 Project Account Reporting

Figure 4.2 Design Area Reporting

Figure 4.3 Purchase Order Status Report

- Figure 4.4 Purchase Order Reporting System
- Figure 4.5 Project Cost Reporting System
- Figure 4.6 Purchase Order/Contract Ledger
- Figure 4.7 Construction Cost Report
- Figure 4.8 Account Report
- Figure 4.9 Account Ledger
- Figure 4.10 Construction Progress and Labour Report

#### 4.2.1 Project Account Reporting

The information content of the project accounting report is shown in Figure 4.1. This report is used to compare the current forecast of final project costs with the revised budget for each major account. The report is sequenced by project number, account number, and finally item number. It is used by the accounts payable accountant for a detailed investigation of each account to date. The benchmarks used in this report for comparison are the revised and the current forecast budget. The cost engineer also uses this report to forecast the new total budget required, and to prepare higher level reports and summaries.

#### 4.2.2 Design Area Reporting

Figure 4.2 summarizes the information content of the design area report. It is similar to the cost statement but contains more information regarding the cost breakdown of labour, material and others. This report is sequenced by project number, then by area. For each area, the corresponding

accounts, their description and commitments to date are listed. The report gives totals and sub-totals for an account or series of accounts.

This report is basically prepared for the area manager to monitor the project to determine if it is progressing as planned, and, if not, to indicate the potential trouble spots. The columns of the labour and material breakdown help the manager identify the source of any deviations from what was intended.

#### 4.2.3 Purchase Order Status Report

The information content of the purchase order status report is shown in Figure 4.3. This report provides description and status information for each major piece of equipment and purchase order issued during the course of a project. The report is sequenced by project number, equipment number, description specification, and requisition and purchase order number.

The input information required for this report is provided by the cost engineer who uses the finished report to give a full description of the history of the purchase order. The report is mainly used on site by the equipment and materials controllers for purposes of identifying the materials and equipment required, their time of arrival on site and to determine if there are any delays in their arrival on site.

This report is used to initiate action for expediting the operation. It can also be used by the site manager to set priorities when faced with particularly critical supply and demand situations.

#### 4.2.4 Purchase Order Reporting System

The information content of the purchase order report is shown in Figure 4.4. This report is used to control general purchase orders after being approved and committed to a particular supplier. This report shows commitments and payment status for each purchase order. The sequencing is by project, by department, by area, account and purchase order. Higher level summaries successively drop sub-account then account. Lower level reports are more detailed and contain voucher number and payment columns.

This report is mainly used by the chief engineer of a particular department to follow the progress of purchase orders. By examining the new purchase orders and checking payments to date versus commitments, the accountant can also use this reports when he would like to investigate a purchase order known to be related to a particular department. A more detailed report can be obtained when the voucher number of payments are included.

#### 4.2.5 Purchase Order/Contract Ledger

The information content of the purchase order/content ledger

is shown in Figure 4.5 This report lists the commitments and payment transactions for the current period, and is sequenced by project number, purchase order/contract number, item number, account codes, report month and voucher number. Using the purchase order contract ledger, a higher level report can be generated which summarizes all the contracts and purchase orders in two different ledgers.

The information used in this report is basically obtained from the purchase order/contract status reports and from the cost engineer. A similar report is prepared individually by both the accountant and by the area manager by contract, and by purchase order ledger.

Performance can be evaluated by using this output report and errors can be spotted and necessary changes can be made. This is the most detailed form of description of the status of the progress for each contract during a specific period. Additional benchmarks and yardsticks can be introduced such as the forecasted budget which can replace the column of the voucher description.

#### 4.2.6 Project Cost Reporting System

The information content of the updated project cost report is shown in Figure 4.6. This report shows the status of the project cost reporting master file as a result of the updating process. This report is sequenced by project number, purchase order/contract number, item number and cost code, or account number.

The updated project cost report is used by the cost engineer, the accounts payable accountant and the site and area managers for their respective cost control function. This reports is derived from the purchase order/contract ledger (see section 4.2.5) which includes the forecasted budget and the funds allocated but which does not include the voucher number.

#### 4.2.7 Account Ledger

The information content of the account ledger is shown in Figure 4.7. This report lists the committments and payment transactions for the current period which can be sequenced by project number, account cost code number, purchase order/contract number, or item number. The history of a particular account or of the entire project can be traced through this report.

This report is used by the construction manager to identify whether the costs associated with a particular area or item or account are overrun or underrun.

#### 4.2.8 Construction Cost Report

The information content of the construction cost report is shown in Figure 4.8. This report is the most detailed form generated by the cost reporting system. It compares commitments and expenditures against the control budget. The report presents the cumulative effect of all transactions.

Transaction details can be reported for any or all accounts as required. Data contained in the reports serves as a basis for estimating future projects of a similar kind.

The construction cost report is used by the construction manager to identify whether the costs associated with a particular area, item or account are overrun or underrun.

#### 4.2.9 Account Report

The information content of the account report is shown in Figure 4.9. This report summarizes the information essential for the preparation of a cash flow forecast. It can be sequenced by project, account, purchase order/contract, or item number.

#### 4.2.10 Construction Progress and Labour Report

The information content of the construction progress and labour report is shown in Figure 4.10. This report is more detailed than the previous one and it is directed at lower level management for purposes of monitoring and analyzing construction progress in terms of content and labour input.

The construction progress and labour report is one of several highly detailed reports used by the site managers as well as higher level management. Using various sorts on the cost code, information can be sequenced according

to area, account number and so forth.

The two fundamental control costs used are man-hours expended and material quantities. Based on these units, it is possible to derive the percentage of the job completed to date. The cost of the work completed to date is then compared with that budgeted for the same percentage complete, to determine the extent, if any, of cost overruns and/or expenditures along with their specific causes.

# FIGURE 4.1 PROJECT ACCOUNT REPORTING

Cost Statement by Account

Page \_\_\_\_ of \_\_\_\_

Project #	Date	Original Budget	Revised Budget	Current Forecast	Committed To Date	Paid To Date	Paid This Period
Account, or Building Area							
Cost Code							

Sub-total by account series.

# FIGURE 4.2 DESIGN AREA REPORTING

Design Area by Sub-Account

Page \_\_\_\_ of \_\_\_\_

Project #	Date	Original Budget	Revised Budget	Current Forecast	Committed To Date	PAID TO DATE
Account Description						Total Labour Material Other

Sub-total by account.

# FIGURE 4.3 PURCHASE ORDER STATUS REPORT

Purchase Order Schedule

Page \_\_\_\_ of \_\_\_\_

Project #	Date	Purchase Order Schedule
-----------	------	-------------------------

DATES

Unit Equipment and Material	Dept.	SUPPLIER Name Ref. #	Purchase Order No.	Promised Delivery	Factory Shipment	Required On-Site
	Buyer					

Dept. No. \_\_\_\_\_ **FIGURE 4.4 PURCHASE ORDER REPORTING** Page \_\_\_\_\_ of \_\_\_\_\_  
Project No. \_\_\_\_\_ Purchase Order by Account \_\_\_\_\_ Date \_\_\_\_\_

Purchase Order Code	Supplier	Project Account/Sub-Account	COMMITMENTS		PAYMENTS	
			Period	To Date	Period	To Date

Project No. \_\_\_\_\_ **FIGURE 4.5 PROJECT COST REPORTING SYSTEM** Page \_\_\_\_\_ of \_\_\_\_\_  
Update Report \_\_\_\_\_ Date \_\_\_\_\_

P.O. No. Contract	Item No. Account	Description	Budget Allocation	COMMITMENTS		PAID	
				This Period To Date	To Date	This Period To Date	To Date

Sub-total by P.O./Contract number \_\_\_\_\_

Project No. \_\_\_\_\_ **FIGURE 4.6 PURCHASE ORDER/CONTRACT LEDGER** Page \_\_\_\_\_ of \_\_\_\_\_  
Date \_\_\_\_\_

P.O. No. Contract	Item Number	Account Number	Report Month	Voucher Number	COMMITMENTS		PAID		Voucher Description
					This Period To Date	To Date	This Period To Date	To Date	

Project \_\_\_\_\_ **FIGURE 4.7 CONSTRUCTION COST REPORT** Page \_\_\_\_\_ of \_\_\_\_\_  
Area \_\_\_\_\_ Construction Cost Detail Report  
By Area/Item/Account \_\_\_\_\_ Date \_\_\_\_\_

Account	Item	Description	Original Change Budget Orders	Revised Budget	Forecast	Overrun/ Under-run	Commitment		ACTUAL COST	
							To Date	To Date	Period To Date	To Date

Sub-total by account. \_\_\_\_\_

FIGURE 4.8 ACCOUNT REPORT

Page \_\_\_\_ of \_\_\_\_

Date \_\_\_\_

Project # \_\_\_\_\_

P.O. No.	Item	Report	Voucher	COMMITMENT	DATE	Voucher
Account	Contract	Number	Month	This Period To Date	This Period To Date	Description

FIGURE 4.9 ACCOUNT LEDGER

Page \_\_\_\_ of \_\_\_\_

Date \_\_\_\_

Project # \_\_\_\_\_

P.O. No.	Item	Description	Budget	COMMITMENTS	PAID
Account	Contract	Number	Description	This Period To Date	To Date

FIGURE 4.10 CONSTRUCTION PROGRESS AND LABOUR REPORT

Page \_\_\_\_ of \_\_\_\_

Date \_\_\_\_

Project # \_\_\_\_\_

Field Cost Progress Report

Item	Account	Description	QUANTITIES		MANHOURS Completed To Date	COSTS		UNIT COST x % COMPLETE		
			Revised Budget	Completed in Period		Current Forecast	Manhours Comp Per Unit	Rate	Weight Actual	Total

Quantity Cy.

Manhours

Labour Costs

Budget

To Date

Forecast

CHAPTER V

SUMMARY

## CHAPTER V

### 5.1 Summary

This report presents a description of a cost reporting system used on a major heavy industrial project which has been under construction for the last two years. Emphasis is placed on:

- (i) providing an overview of the reporting system;
- (ii) demonstrating how the components of the system are integrated;
- (iii) examining, in detail, the site information inputs;
- (iv) describing the flow of information within the system;
- (v) describing, in detail, the various output reports generated by the reporting system and their usage.

No attempt is made to assess the strengths and weaknesses of the system. Such an assessment would require extensive interviewing of the users of the system, an exercise which would be beneficial but which is beyond the scope of this report.

The design of an effective cost control system for large projects requires a thorough and extensive understanding of not only how to manage many fields of engineering, especially construction, but equally important, an understanding of what is being managed. Further, it requires

extensive knowledge about the company's organization and accounting systems in order that the system be tailored to meet its needs and mode of operation.

A management reporting system is not an end in itself. It is the heart of the communications system, and the effectiveness of the reporting system will largely determine the control that management has over its operations, since management actions are taken based on information supplied by the system.

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