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**PRINCIPLES OF
CONSTRUCTION PROJECT MANAGEMENT**

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IN THE NAME OF ALLAH THE MERCIFUL THE COMPASSIONATE

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PREFACE

Nowadays most construction work is carried out as a project. This means that an effort should be made to achieve this work within certain defined time and cost limits. Close management of the projects is required if they are to be completed within the specified targets.

The complex nature of construction projects places a heavy demand on the management skill of those involved in every phase of the project. Such skill depends more and more on familiarity with modern techniques of construction project management. These techniques are directed toward the control of cost, time, resources and finance.

This book provides the reader, in a single volume, with necessary skills required to manage construction projects. The discussion is presented in language that a beginner in this subject can easily comprehend. Although basically prepared as a reading material for a first course in construction project management for civil engineering students, the book is helpful for project managers, consultants and contractors.

Chapter 1 presents information applicable to organization of construction projects. Project stages are outlined first. Then organization of the project by the client and his advisors and the contract by the contractor and his staff are described. The role of every party in order to achieve project success is highlighted.

Planning and scheduling construction projects is the subject of chapter 2. Complete coverage of all ingredients of this topic is presented. The planning process contains determination of the project activities, calculation of the duration of these activities and establishment of the relationship among the activities. Several scheduling techniques for construction projects are then described. The methods covered include activity-on-arrow and activity-on-node networks, time-scaled diagrams and bar charts. The PERT method is reviewed in order to introduce the reader to the use of probability in the project scheduling. Scheduling-related techniques are also discussed. Procedures are given for smoothing single as well as multiple resources and for resource scheduling. Scheduling techniques devoted to linear projects, namely summary diagrams and line-of-balance are also included. The text provides numerous examples to describe the use of the above techniques for preparing construction schedules.

Chapter 3 covers the topic of contract strategy. Key decisions for the project organizational structure, type of construction contract, conditions of contract and tendering method for selecting construction contractor should be made in order to satisfy project objectives and constraints. Factors affecting the choice and description of the choices available in each of the above areas are discussed.

In chapter 4, procedures are given for forecasting a contract cash flow. Profitability indicators for a construction project are also discussed. The remainder part of the chapter is devoted to demonstrate the application of the economic techniques (NPV, IRR and EUAC) to the solution of problems of the type the engineer is likely to encounter during the course of his professional work. Dealing with the effect of inflation both in project appraisal and in construction contracts are also highlighted.

Chapter 5 deals with the processes employed to produce estimates and tenders. Arrangements for the estimating process are presented. Preparation of the method statement is highlighted where the process of construction risk management is given in some detail. Two methods to produce the direct cost rates are described. These are the operational and unit rate estimating methods. Estimating the contract indirect cost is then presented. The optimum contract duration is established by making time-cost adjustments. Factors affecting the production of the tender price are then discussed. Different policies available for the contractor to price bills of quantities are reviewed. Examples are given throughout the chapter to demonstrate different calculations.

Chapter 6 is the last chapter in the book. In this chapter, three important topics related to construction progress control are treated. These are updating construction schedules, controlling construction costs and evaluating work changes and delays. Examples are given to provide the reader with practice in using the relevant methods.

References are included to allow serious readers to increase the depth of their knowledge of the presented techniques. The book concludes with three appendices. Examination papers of the Construction Project Management course studied by civil engineering students at Mansoura University during past years are given in appendix A. These examinations are useful in testing whether the newly acquired knowledge is fully understood. Model answers to these examinations are given in appendix B. An English-Arabic dictionary of about 500 words is provided in Appendix C to make understanding of the new sentences and idioms of construction project management is easier.

Finally, I hope that the book will fulfill its objectives.

ADEL I. ELDOSOUKY

CONTENTS

1 ORGANIZATION OF CONSTRUCTION PROJECTS

1.1 Stages of a Construction Project	1
1.2 Project Organization	3
1.3 Contract Organization	6

2 PLANNING AND SCHEDULING

2.1 The Planning Process	9
2.2 Determination of Project Activities	10
2.3 Estimating Activity Duration	13
2.4 Logical Relationships	16
2.5 Project Scheduling	19
2.6 Activity-On-Arrow Networks	21
2.7 Activity-On-Node Networks (Precedence Method)	28
2.8 Time-Scaled Diagrams	35
2.9 Bar Charts (Gantt Charts)	37
2.10 Program Evaluation and Review Technique (PERT)	39
2.11 Allocation of Resources	46
2.12 Unconstrained Resource Allocation (Resource Smoothing)	48
2.13 Smoothing Combined Resources	55
2.14 Constrained Resource Allocation (Resource Scheduling)	58
2.15 Resource Scheduling by the Current Float Technique	64
2.16 Summary Diagrams	65
2.17 The Line-Of-Balance (LOB) Method for Scheduling Repetitive Construction Works	69

3 CONTRACT STRATEGY

3.1 Project Objectives and Constraints	78
3.2 Organizational Structures for a Construction Project	81
3.3 Types of Construction Contract	85
3.4 Contract Administration	87
3.5 The Tendering Process	90

4 CASH FLOW AND INVESTMENT APPRAISAL

4.1 Contract Cash Flow	96
4.2 Project Cash Flow	108
4.3 Discounted Cash Flow (D.C.F.)	110
4.4 Equivalent Uniform Annual Cost (E.U.A.C.)	113
4.5 Breakeven Analysis (Equal Cost Analysis)	118
4.6 Inflation	120

5 ESTIMATING AND TENDERING

5.1 Arrangements for the Estimating Process	124
5.2 Preparation of Method Statement	127
5.3 Risk and Uncertainty Management	128
5.4 Estimating Direct Cost	132
5.5 Estimating Indirect Cost	135
5.6 Optimum Contract Duration	138
5.7 Producing Tender Price	147
5.8 Pricing Policy	150

6 CONSTRUCTION PROGRESS CONTROL

6.1 Updating Construction Schedules	156
6.2 Cost Control	157
6.3 Evaluation of Work Changes and Delays	168

REFERENCES	175
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APPENDIX A Examination Papers	177
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APPENDIX B Model Answers to Examinations	193
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APPENDIX C English - Arabic Dictionary of Sentences and Idioms	225
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**PRINCIPLES OF
CONSTRUCTION PROJECT MANAGEMENT**

CHAPTER 1

ORGANIZATION OF CONSTRUCTION PROJECTS

A construction project is defined as a planned undertaking to construct a facility or group of facilities. The principal participants in construction projects are the clients, consultants and contractors. The client is the individual, the firm or the organization that funds the construction project and will own the completed facility. The consultants design the facility that meets the need of the client and that complies with applicable codes. The contractor is the firm that performs required work. On a typical project, there are two prime contracts (legal agreements) with the client: one with a consultant for the design of the project; the other with a contractor to construct the project

The objective of this chapter is to declare main stages of the construction project and to highlight how the client will manage his project and the contractor will manage his contract in order to achieve project success. Types of construction contracts will be discussed in Chapter three.

1.1 Stages of a Construction Project

The development of a construction project, from its initiation into its operation, may be divided into the following consecutive stages, see Fig. 1.1:

Appraisal

When the need to develop a new project is identified, the process of appraising all alternatives commences. A thorough investigation which includes a comprehensive assessment of the merits and problems of the project and of the various feasible alternatives is carried out. All potential risks to the investment will be identified and evaluated. This study, which is known as feasibility study and will normally span several years, determines whether the project is truly worthwhile and which of the various alternatives for carrying it out will be the best. A master programme using approximate durations of various operations is prepared in order that the client may know how long it will take to reach his objectives.

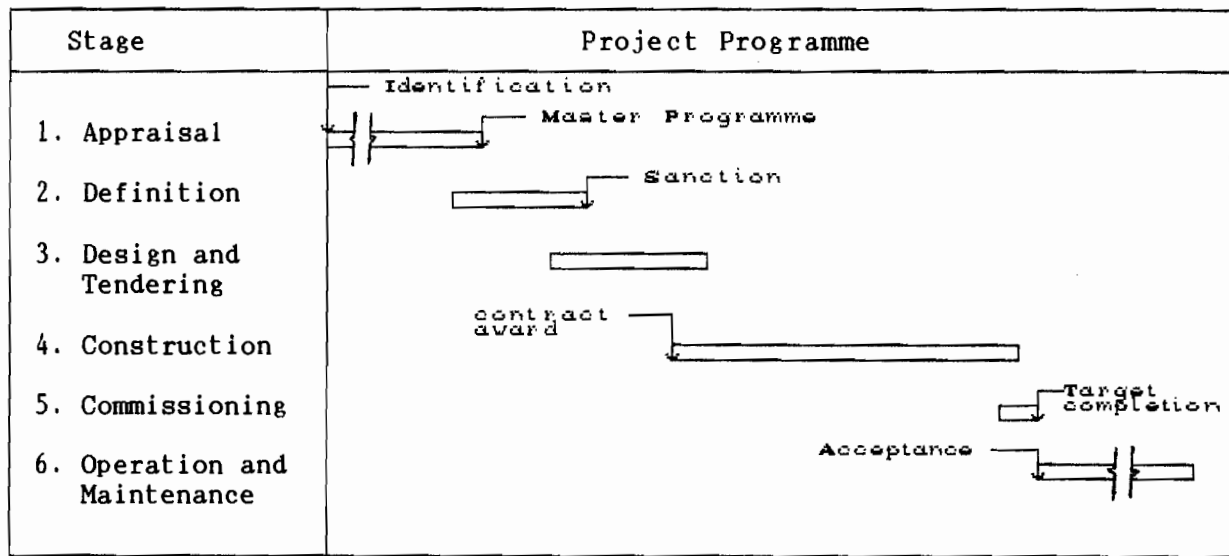


Figure 1.1 The Main Stages of a Construction Project

Definition

In this stage, further details of the preferred scheme are prepared and evaluated. A decision is taken concerning the sizes and types of structures required. A conceptual design is then prepared. This will involve preparation of outline drawings and details of all services. This conceptual design should be reviewed as this is the main opportunity both for cost saving and for ensuring that it meets the client's objectives. An appropriate contract strategy which satisfies project objectives and constraints is proposed. This includes consideration of the responsibilities for design and construction and their interface, type of contract and method of selecting contractors. This strategy will be greatly influenced by the previously chosen target completion date of the project. A report is then submitted to the client for sanction. It will include project technical specification, cost estimate, programme and a plan for risk management included in the contract strategy proposal. Proceeding with investment in the project may then be approved by the client. The following three stages of the construction project, named as the engineering phase, will proceed within the guidelines of scope, cost, and time defined at sanction.

Design

Traditionally, the following activities are performed during this stage: preparation of detailed design, specification, quantities and other tender documents, full development of the project contract strategy, procurement of bids and contract award. The design office can prepare its own detailed programme so that all its activities are suitably scheduled using available resources.

Construction

The chosen project completion date will determine the overlap between the design and construction stages. The general contractor will carry out site construction. Any mechanical and/or electrical installation may be subcontracted under the supervision of the general contractor. The consultants will be employed for contract administration and construction supervision. The contractor would seek the most efficient use of his resources using construction management techniques.

Commissioning

This is the period for engineering and performance tests which lead to project acceptance.

Operation

The operation and maintenance of the project may be carried out by the client's own employees. Project review may be required for future interests.

1.2 Project Organization

Good project management by the client is an ingredient for a successful project. Within the client's organization, it is essential that one person has responsibility for organizing and coordinating all appraisal studies carried out by the appraisal team. He will later become Project Manager. He should have sufficient seniority to exercise effective control both within and outside the client organization.

The responsibilities of the project manager normally span design, construction and commissioning. His function is to control the sequence of

events and decisions leading to the completion of the project. For many projects he will be supported by a small team experienced in engineering management. This Project Management Team may be composed from the client's own engineering and technical staff if possible, from specialist project management firms, or from a combination of in-house and an external organization.

The project management team is responsible for:

- realizing the project defined at sanction
- overseeing the client's diverse interests
- selecting a suitable contract strategy
- coordinating of design and construction
- forecasting project cash flow
- appointing of consultants and contractors
- solving problems with local authorities and inhabitants
- coordinating of work of different contractors
- public relations
- project commissioning
- transferring responsibility for the completed work from contractor to operator
- on turnkey contracts, controlling quality of construction
- on target cost contracts, examining construction actual cost.

The client and his project manager will appoint a consulting engineer in order to prepare conceptual design, design programme, detailed design, specification of work and bills of quantities.

Supervision and administration of the construction contract will be the job of the Engineer. "The Engineer" is the title given to an engineer named in the contract and given duties of considerable power. Usually, the Engineer is chosen from the senior staff of the consulting engineer. It is not good practice to name the consulting firm itself as the Engineer. On the other hand, the Engineer may act as the project manager on small projects.

However, the Engineer should act as agent for the client and ensure value for money by supervising both design change and construction. He should also, independently and fairly, administer the contract between client and contractor. He should use modern construction management techniques for administration of the contract. However, his main duties are:

- pre-tender evaluation of contractors
- preparation of tender documents
- evaluation of bids
- recommendation for appointment of contractors
- approval of the contractor's plan
- review of shop drawings
- construction quality assurance
- issuing of variation orders
- assessment of variations and claims
- forecast final cost
- evaluation of completed work
- certification of contractor's payment requests
- on target contracts, development and adjustment of the target and joint planning of construction resources
- final inspection of work.

The Engineer must guard the client, through his field inspection forces, against deficiencies in the work. Adequate design and carefully prepared specification are not, by themselves, enough to produce the desired quality of work. Continuous on-site inspection should be performed during progress of work to provide quality assurance on the job.

The Resident Project Representative is the Engineer's representative on site. This is the title given to a Resident Engineer and his team of inspectors. The Resident Engineer is an on-site full time project representative. He has the authority and responsibility of administering the field operations of a construction project. He should be the sole spokesperson representing the client's interests.

Inspectors, known also as Quality Assurance Supervisors, are the on-site eyes and ears of the Engineer. Each of them is likely to take responsibility for a specific section of work. The job of the inspector is identical in all respects to that of the resident engineer except for the responsibility for field administration. An inspector may be assigned the responsibility of resident project representative for several small projects at the same time.

The responsibilities of the resident project representative can be summarized as follows. He should:

- be familiar with the contract documents in order that the project will be constructed in strict accordance with them
- be familiar with the construction schedule in order to complete the

work within the contract period

- cover the work of any activity as long as the work proceeding
- prepare a daily report to serve as a record of the day's happenings, contractor's activities, as-built details, instructions given to the contractor, any agreements made and any dangerous conditions observed on site
- check materials as soon after they are delivered as possible
- inspect work as it progresses and give decision on acceptance of it
- notify the contractor if any material or portion of work does not conform to the requirements and advise the Engineer if the contractor ignores the notice
- seek advise from the Engineer to solve any problem
- assist in obtaining additional details or information when required for proper execution of the work
- consider and evaluate the contractor's suggestions for modifications in drawings or specification and report them with his recommendations to the Engineer
- report to the Engineer any unrealistic tolerance in the contractor's work and any situation which appears to cause delay in the completion of the contract
- control site testing laboratory and observe all contractor's tests
- anticipate any problems in advance of their occurrence
- follow up daily any work to be corrected by the contractor
- review application for payment with the contractor.

1.3 Contract Organization

Having decided to tender on a certain work, the contractor should prepare a realistic and competitive tender. The head office departments will be jointly responsible for tendering for new work. A construction company head office may contain the following departments: estimating, planning, purchasing, accounting, administrative, personnel, engineering services and plant. Workable relationships between these departments are very important if the company is to operate successfully. However, the main functions of the head office are:

- selection of projects for tendering
- estimating costs of such projects
- preparation of bids and tender programme

- procurement of construction materials
- management of contractor-owned equipment
- allocation of staff and resources to the various contracts
- design of temporary works
- training and education
- records and bookkeeping
- negotiation of variation orders and payment for claims
- monitoring overall financial position of the company
- legal and insurance facilities

The general contractor is responsible for all work on the project whether constructed by the firm's own forces or by subcontractors. The contractor's senior representative on site is called the Agent. He may also be given the title "Superintendent". He is to be constantly on the site and shall give his full charge to the works. He should have adequate knowledge of the methods and techniques required for the work. He is responsible for:

- success of the contract
- ensuring maximum cooperation of site staff in all matters affecting the efficiency, economy and smooth running of the construction operation
- reviewing possibilities of design changes to suit particular methods of working which will result in cost savings
- reviewing any requirement for additional resources
- identifying and dealing with problems arising at site level which will result in delays or increase in cost
- ensuring compliance with contract documents and the Engineer's instructions
- organization and deployment of the contractor's site staff, plant, labour and all other resources
- operating and maintaining site testing laboratory
- billing
- providing and updating all the programmes, budgets, expenditures and other records required by the Engineer
- administering purchases for the supply of materials and services
- coordination of subcontractors work
- protection of persons and property on, and adjacent to the construction site.

The agent may be supported by subagents and engineers. Each one of the subagents has a particular responsibility such as labour relations or technical matters. Each one of the engineers will be allocated to a different section of work. The section engineers may be involved in the design and installation of temporary works, detailed planning and managing the day-to-day works.

Specialist engineers or quantity surveyors will be employed to value the completed works. Other administrative staff may include cost and wages clerks and buyers responsible for the ordering and progressing of materials.

A General Foreman, who is an experienced tradesman, will be employed to organize the allocation of tradesmen, labour, machines and materials to the various sections of the job on a day-to-day basis. He may contribute expertise in plant operation and methods of construction.

The agent may also be supported by an office manager to manage stores and workshops, plant manager and fitters for maintenance of plant and experienced staff to provide site facilities.

Under a contract requiring a contractor quality control program, a contractor quality control representative is also required. His primary function is to assure that all inspections and tests are made and to prevent defective work. This includes the checking of all material and equipment delivered to the site.