# COURSE TITLE

## CONSTRUCTION ENGINEERING AND MANAGEMENT

# Chapter 2

## CONSTRUCTION PLANNING AND SCHEDULING

# Lecture 2 (week 2)

## Introduction, Step and Stages of Planning, Planning by Contractor and Client, Construction Schedule, Fast Track Construction and Time Cost Trade off.


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**Learning Objective**

The main objective of this lecture is to understand about:

2.1 Construction Planning.
2.2 Step and Stages of Planning.
2.3 Planning by Contractor and Client.
2.4 Construction Schedule.
2.5 Fast track Construction
2.6 Time Cost Trade off

## 2.1 INTRODUCTION TO CONSTRUCTION PLANNING

In the simple sense, planning means thinking ahead of an operation to be performed. It is the function of selecting the enterprise objectives and establishing the policies, procedures, and programs necessary for achieving them. [1] It forms the basis for the project scope, schedule, resources, quality, risk, and integration. Planning is the course of action to achieve the desired results taking into consideration the present needs and future requirement. The main reason for construction planning is: [2]

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

**Objective of Planning**

- Proper design of each element of the project.
- Proper selection of plant and equipment.
- Proper arrangements of repair of plant and equipment at site.
- Procurement of required materials well in advance.
- Ensure employment of skilled and unskilled employees.
- To arrange constant flow of funds in entire project duration.
- To provide required level of safety and compensations.
- Proper arrangements of communication and mobility in site.

**Principles of Planning**

- The plan should be readily understandable.
- The plan should be realistic not an optimistic.
- The plan should be flexible.
- The plan should be comprehensive.
- The plan should incorporates the system of monitoring and controlling.

### 2.2 STEP AND STAGES OF PLANNING

**Steps involved in planning**

- Identifying the likely problems to be encountered in the execution of the work and obtaining necessary information useful in the execution of the work.
- Ascertaining alternative feasibility of execution of work.
- Fixing the time of starting the execution of work.

- Deciding the time of delivering the materials at site.
- Deciding the quantities and duration of various types of machines and equipment.
- Deciding the number of different types of labors for various works and duration of their employment.

**Stages of Planning [2]**

1. *Pre Tender Planning*

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

2. *Pre Contract Planning*

- After the award of the project, it is essential that planning takes place prior commencing work on the site.

3. *Contract Planning*

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

**Reasons for Pre-Tender Planning**

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

**Reasons for Pre-Tender Planning**

- To monitor master programme – monthly, weekly, daily.
- To optimise and review resources and report on variances.

**Reasons for Pre - Contract Planning**

- To provide a broad outline plan and strategy for the project.
- To comply with contract condition.
- To establish a construction sequence on which the master program may be based.
- To identify key project dates.
- To highlight key information requirements,
- To schedule key dates with respect to key material and subcontractor requirements.

## 1.3 PLANNING BY CONTRACTOR AND CLIENT

**Planning by the Client /Owner/Employer**

***Pre-tender stage planning***

- Clients sets clear objectives of the project
- Client communicate the objectives to all the parties and stakeholders
- After proper investigations of the project, client prepares quantity estimates and determines the quantum of money required for the completion of the work.
- Take respective approval of the project from concerned authority
- Selection of project team and project appraisal
- Select the consultant (if required)
- Bidding and contract award (Selection of Contractor)

***Construction stage planning***

- Revision in objectives in responding unexpected events
- Make site available for the contractor
- Timely payment and settlement of claims
- Keep the changes less
- Update performance bond of the contractor
- Timely decision

***Post construction stage planning***

- Prepares project operation schedule
- Prepares project maintenance schedule
- Project ownership

**Planning by the Contractor**

***Pre tender stage planning***

The planning undertaken by the contractor after receipt of tender notice and before submitting the bid is known as pre tender stage planning. [3]

- Careful Study of tender documents and drawings to find out the quantities of each item of work.
- Study of specifications and workout the detailed quantities of materials required for different items.
- Determine the availability of construction materials at site or nearby site.
- Determine the method of work execution i.e. by labor or equipment.
- Thorough study of site and site investigations.

***Construction stage planning***

After the acceptance of the tender, the contractor further needs in-depth planning. This stage of planning is also known as contract planning.

- Studying the alternative methods of construction and to decide about subcontracting.
- Working out detailed quantities of materials required and examine and fixing the methods of procurement and sources of them.
- Working out detailed about construction workforce like skilled and unskilled manpower.
- Working out details of plants, equipment their layout and repair & maintenance strategy.
- Planning for camp facilities, access, accommodations, site offices and layout.
- Planning for surveillance like proper lighting, ventilation, drinking water, sanitation, first aid treatment.
- Study interdependence of different items of works and fixing the sequence of them.
- Finalize the work program of each item of work and to decide the dates of their starting and completing.

***Post construction stage planning***

- Demobilization of plants and equipment
- Demobilization of labors
- Clearance of materials inventory and its stock
- Handover the project to client in targeted date
- Responsible for the defect liability construction within its period

## 1.4 CONSTRUCTION SCHEDULE

A schedule is graphical representation which shows the starting and completion dates of each activity and the sequential relationship among the various activities. Construction scheduling refers to the process of laying out all the actual activities of the project in the time order in which they are to be performed. [4]Now a day's large project consist of innumerable activities interdependent to one another, it is necessary to make the schedule in a systematic way for easy understanding and reference. [5]

**Use of scheduling**

- The quantity of work involved, labor, material, equipment and money required at each stage of work can be determined by scheduling.
- The actual progress of the work can be checked from time to time by scheduling.
- The project can be carried out in systematic manner by the use of scheduling.
- To control financing and payment.
- To manage changes and uncertainties.

**Classification of scheduling**

- Construction schedule
- Materials schedule
- Labor schedule
- Equipment schedule
- Financial schedule
- Control schedule
- Organizational schedule
- Summary schedule

**Methods of scheduling**

- Bar chart or Gantt charts
- Milestone charts
- Network analysis

**Construction schedule and its preparation [6]**

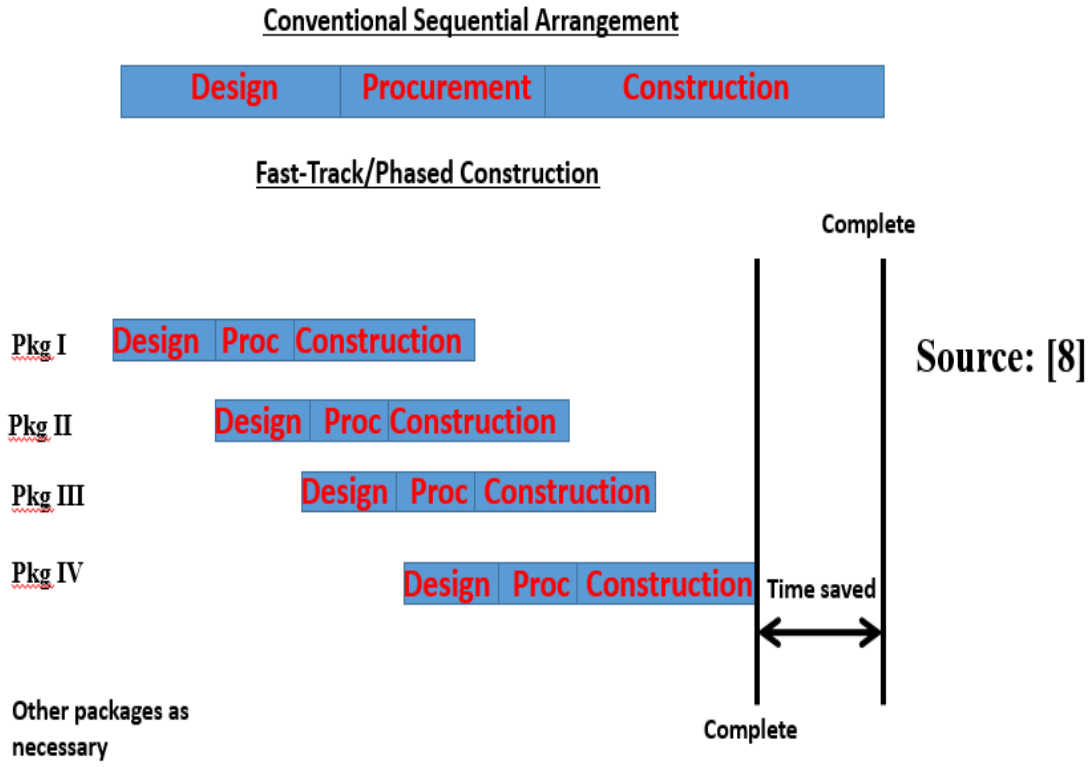
Before preparing construction schedule following information must be known

- Various operations to be done in a particular project.
- Quantum of works to be done in each operation.
- Unit of measurement.
- Rate of progress of work with due allowance of weather conditions.
- Number of labors required.
- Number and types of plants and equipment required.
- Date of starting and completing the activity.
- Correlation between different operations.

## 1.5 FAST TRACK/PHASED CONSTRUCTION

To complete a project successfully many tasks need to be accomplished by project team. The normal way to accomplish these tasks is to complete each phase then move on to next. Conceptual planning is first, then design, then procurement and finally construction. This approach is understood well by project participants and is logical, but very time consuming compared to fast –track project. In fast track/phased arrangement, construction, design, procurement and construction activities occur in parallel.

Fast-track construction, or phased construction, is a project delivery method used to minimize the time required to design and construct a project. Fast-track scheduling (also referred to as multi-track scheduling and phased designed and construction) is an approach used to shorten the overall time between the decision to construct a building and its occupancy. [7] This leads to faster completion of the project than in a conventional, sequential approach. The project is broken down into smaller pieces (work packages), with each package designed and constructed separately. By breaking the project down the work that can logically be done can be designed and performed while later work is still being designed.




**CHALLENGES OF FAST TRACK/PHASED CONSTRUCTION**

- Fast-track project save time and money for the owner but this savings does not come without risk.
- The risk is that the owner begins construction without a complete design and detail estimate.
- If construction and design problem occurs, forcing a budget increase, the owner is committed to more than a simple redesign.
- Good coordination between designer, construction manager and owner is essential because they are working on concurrent tasks that must be coordinated. [8]
- The project should be thoroughly investigated and that an accurate program, estimate and schedule be developed and completed.

## 1.6 TIME COST TRADE OFF

The CPM method of network scheduling is based on the activity performance at lowest practical cost, engaging an adequate number of workers, who can work efficiently during 'normal hours' and supply resources at a 'normal' pace. [5] Projects implemented under such condition are called "normal project" and neither too fast nor too slow. In certain problem situations, it may be required to squeeze or 'crash' a normal program.

**Crashing** a project is the term used to describe the process of accelerating an activity or multiple activities to shorten the overall duration of a project." [8] By adding additional people or equipment or by working additional hours, an activity's duration can be shortened. If it is a

critical activity, this will shorten the project as well. Activities are crashed to achieve any one or more of the following activities.

1. To bring back the project as near as possible to the target, if project is running "off" schedule.
2. To achieve a definite target date of completion, pre assigned by the customer, which can be achieved only by crashing an otherwise normal program.
3. To complete a project by a particular date, in order to avail the advantage of marketing the product, before other competitor enter the fray.

The judicious balance between time and cost is called **Time Cost Trade off**. The main objective of the time-cost trade off in a crash program is to find an optimum low cost schedule. The reduction in time is achieved by allowing an, as low as possible, increase in direct costs. The buying or 'trading off' time against direct costs is called optimization and is done primarily on those activities which lie on critical path. The overall time of completion can be reduced only by shortening the timings of the critical path activities. The objective of the time-cost trade-off analysis is to reduce the original project duration, determined form the critical path analysis, to meet a specific deadline, with the least cost. In addition to that it might be necessary to finish the project in a specific time to:

- Recover early delays.
- Avoid liquidated damages.
- Free key resources early for other projects.
- Avoid adverse weather conditions that might affect productivity.
- Receive an early completion-bonus.
- Improve project cash flow

**Terminologies**

1. **Direct Cost :**

- It includes costs of material, labor, consumables etc. required to perform an activity. Direct cost is inversely proportional to activity duration (direct cost increases on crashing)

2. **Indirect Cost :**

- Includes overhead cost of supervision, penalty, bonus, maintenance. etc. Indirect cost is directly proportional to time (indirect cost decreases on crashing)

3. **Normal cost ($C_n$)**

- It is the minimum direct cost required to perform an activity in the 'normal time'. It does not include any overtime wages, incentives etc.

4. **Crash Cost ($C_c$)**

- Crash cost is the minimum direct cost required to achieve the target date as per cash program.

5. **Normal Time ($t_n$)**

- Normal time is the standard time that an estimator usually allow for an activity.

6. **Crash Time ($t_c$)**

- Minimum possible time in which an activity can be completed, by employing extra resources. Crash time is that time beyond which the activity cannot be shortened by any amount of increase in resources.

7. **Cost Slope**

- It represents the cost of accelerating any of the project activities by one unit of time. It is the slope of the direct cost curve, approximated as a straight line. [9]

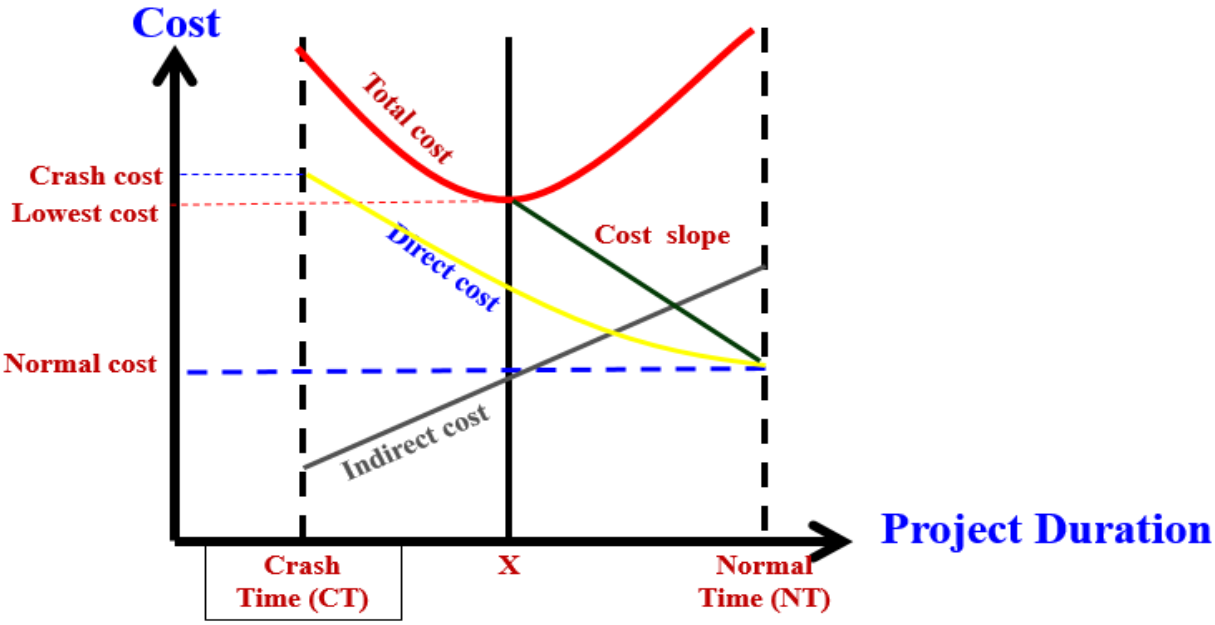



**Fig: Time Cost Trade Off [5]**

The total cost (direct + indirect) curve is drawn by adding the ordinates of the direct and indirect cost curves. The total cost goes on decreasing by crashing a program (i.e. by reducing normal time) up to certain limit. There after the total cost increases sharply and reaches the highest value at a crash time CT. From technological and operational stand point, it may be possible to reduce the normal time NT to crash time CT, but that will increase total cost to a very high level. On the other hand, one can optimize the crash time leading to a minimum total cost indicated by the optimum crash time "X". It may be concluded that regardless of cost involved, will reduce the normal time (NT) to crash time CT, whereas the optimization of the project duration leads to a lowest total cost schedule. of the project

**PROCEDURE OF TIME COST TRADE OFF**

- List all the activities on the critical path.
- Delete all the activities where crashing is not possible.
- Choose activity with the cheapest cost slope

$$\text{Cost Slope} = \frac{\text{Crash Cost} - \text{Normal Cost}}{\text{Normal duration} - \text{Crash duration}}$$

$$CS = \frac{(C_c - C_n)}{(t_n - t_c)} = \frac{\Delta C \text{ (increase in cost)}}{\Delta t \text{ (decrease in time)}}$$

- Assess the time by which the activity duration can be shortened**.**
- Compute revised project duration and its total cost, which is equal Base cost and cost of crashing-overhead cost.
- Repeat above steps successively to all other activities on the critical path, until no further shortening is possible, without increasing the total cost.
- Check whether any new critical path has developed. If so, repeat steps 1-6 for activities on this critical path.
- Prepare a graph of crash time vs. total cost for all the above cases and find out the minimum total cost and the corresponding optimized time schedule.

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