



# Nilachal Polytechnic

## Bhubaneswar

**Sem. : 6<sup>th</sup> Subject : Construction Management (CIVIL)**

**Branch: Civil Engineering**

**Name of the Faculty : Madhusmita Biswal**

**Text Book to be followed by Student / Faculty**

**Book- : P.S.Gahlot & B.M.Dhir ( All Chapters )**

## Chapter-2: Constructional planning

### 1.Learning Objectives

Student will learn

- i) about the importance of construction planning
- ii) about the different stages and activities involved in construction projects.
- iii) about the CPM & PERT
- iv) about how to prepare the construction schedule using the bar chart technique
- v) about how to prepare material, equipment, labour & finance schedules.

### 2.Essential Questions (Fundamental Question)

- i) Why planning is necessary for projects?
- ii) What is work-breakdown structure?
- iii) What is pretender stage?
- iv) What is post-tender stage?

### 3. Hours Required

|                             |              |
|-----------------------------|--------------|
| Theory                      | 2hrs         |
| Problems                    | 1 hr         |
| Question & Answer<br>Theory | 1 hr         |
| <b>Total</b>                | <b>4 hrs</b> |

### 4. Question for Teaching / Assignment / Self Practice

|               | 02 Marks      | 05 Marks      | 10Marks       |
|---------------|---------------|---------------|---------------|
| Teaching      | 6 nos         | 5 nos         | 6 nos         |
| Assignment    | 4 nos         | 3 nos         | 3 nos         |
| Self Practice | 4 nos         | 4 nos         | 4 nos         |
| <b>Total</b>  | <b>14 nos</b> | <b>12 nos</b> | <b>13 nos</b> |

### **Lesson Description (Abstract of the Chapter) in the bullet form**

- Construction planning is the specific process construction managers use to lay out how they will manage and execute a construction project, from designing the structure to ordering materials to deploying workers and subcontractors to complete various tasks.
- It involves creating a set of plans to help guide your team through the implementation and closure phases of the project. The plans created during this phase will help you manage time, cost, quality, changes, risk, and related issues.
- Construction planning and scheduling improves work efficiency; having effective materials management and properly distributing resources reduce costs and saves time.
- Planning for construction is undertaken at the pre- tender and contract stages. Pre tender planning is broad based and is carried out by the contractor.
- Construction stage planning commences with the acceptance of the tender and extends till completion of the contract. Planning at this stage involves establishing a good communication system between the members of the construction team; selecting the most economical and efficient construction alternative and determining phased requirements of materials plants, machinery, manpower & other facilities.
- Scheduling is the process of fitting the work plan to time frame indicating the start and completion of each activity and the sequence in which the various activities are to be executed.
- Bar charts are commonly used for preparing the construction schedule. Schedules are also prepared for showing phased requirements of construction resources (materials, equipment, labour & finance).
- Bar charts are extensively used in the construction industry due to their simplicity and ease of understanding.

### **Enclosed :**

1. Course Material.
2. Question Set.

**Faculty**

**HOD**

**Principal**

# **Course Material**

## **Chapter-2**

### **CONSTRUCTION PLANNING**

#### **Construction Planning**

Construction Planning is the process of finding out various alternatives of performing a particular construction project and finding out the best alternative for implementation.

#### **Importance of construction planning**

1. Construction planning is the starting phase of all management functions in a construction project.
2. A construction project can be well managed if it is well-planned.
3. Planning of a construction work includes WBS( Work Breakdown Structure) which includes dividing a large work into simple manageable components.
4. Construction planning is important for controlling the progress of construction work by basing it on a planned schedules and planned strategies for backup provisions.
5. Planning in construction forecasts the resource requirement for the construction process (machinery, funds, materials, etc.)
6. Construction planning is a tool used in planning departments to identify problems that are likely to occur during construction and plan strategies before-hand to tackle such construction problems.

#### **Work Break-down Structure (WBS)**

The Work Break-down Structure is a technique in which a construction work is separated into separate recognisable activity which can be managed properly.

[Example of a WBS of a Boundary Wall Construction is given below]

Boundary Wall

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|        |            |                                 |                          |                      |                               |                               |
|--------|------------|---------------------------------|--------------------------|----------------------|-------------------------------|-------------------------------|
| Layout | Excavation | Plain Concrete<br>in Foundation | Masonry in<br>foundation | Damp Proof<br>Course | Masonry in<br>Super Structure | Masonry in<br>Super Structure |
|--------|------------|---------------------------------|--------------------------|----------------------|-------------------------------|-------------------------------|

## **Stages in construction**

Briefing  
Stage

Design or  
Planning  
Stage

Tendering Stage

Construction  
Stage

Commissionin  
g Stage

### 1. Briefing Stage

- i. Understanding the purpose of the project from the client. (**Conceptualisation** of Construction Project)
- ii. Appointment of project manager to the Client
- iii. Formation of a Project directing committee
- iv. Assess the feasibility of the project
- v. Detail Technical and Non-Technical Investigation of the construction site, material, equipment and labour availability
- vi. Preparation of a brief report describing the purpose of the construction project, the investigation details, their possible alternatives and their feasibility.

### 2. Planning/Designing Stage:

- i. To determine the method of construction
- ii. To prepare detail design, working drawings, specifications, bill of quantities, cost estimates and preliminary construction steps or programme plan including time schedule
- iii. Conduct of Pre-Tendering and Post tendering activities for the contractor to investigate the feasibility of performing construction activities at the site, economy of engaging labour and equipment performance.
- iv. Summarization of the whole construction project including proper design and estimate as per the convenience of the client for approval.

### 3. Tendering Stage:

- i. Quotation formation with details of the construction work, the items of work along with the rates.
- ii. Publish of Notice inviting tenders from various contractors. (e.g. Class A to Class F contractors)
- iii. Evaluation of terms, conditions, work specifications and completion of various bids from individual contractors.
- iv. Choosing of bidder with best term and condition matching the requirements of the project and approval of owner.
- v. Awarding of the contract to the Best Bidder (henceforth called as the Contractor)
- vi. Contract documents are prepared which includes all information of the project to the last detail that binds the Client and Contractor in legal terms until the completion of the project.

#### 4. Construction Stage:

- i. This is the actual Realisation of the project.
- ii. This stage includes construction work starting from surveying, layout, excavation, concreting, masonry works, plastering, flooring, wiring, plumbing, etc.
- iii. The execution of construction work is properly supervised by engineers-at-site as per the planned schedule as designed during the planning stage.
- iv. Coordination between contractor and engineers is important at this stage
- v. Quality of material and workmanship is closely monitored to maintain the quality of construction work.

#### 5. Commissioning Stage:

- i. Performance of the construction work is evaluated and nature of maintenance work is determined
- ii. Quality check of various construction works is conducted by non-destructive techniques.
- iii. Finally after all evaluations are assessed to be perfect the project is handed over to the client denoting the end of construction work and end of contract.

### **Stages in construction planning**

The Planning Stage consists of following two stages:

#### 1. Pre-tender Stage:

Pre-tender stage is the stage in which the contractors are allowed to visit the location of construction for evaluating the feasibility of the construction project for proper bidding. A pre-tender project report is documented which includes all details about the site investigation, local weather report, labour availability, and the working environment of the construction site.

- a) The bidder is allowed to carry out investigations like survey of land, labour, materials, local weather condition and equipment functionality.
- b) The Contractor can examine the drawings and specification of construction work to identify various items of work.
- c) The Contractor can properly estimate various alternatives for most suitable and economical method of construction.
- d) Prepare a tentative schedule of construction works and estimate the completion time of the project. (Final Work Plan)
- e) Finally, the contractor fixes the overheads and the profit margin and finalize the tendering price for completing the work within stipulated time.

#### 2. Post-tender Stage/ Contract Stage:

- i. Contract stage occurs after the award of the contract to the contractor and it extends till the end of the construction project.
- ii. In this stage the contractor evaluates the best alternatives to execute the construction work effectively and most economical way.
- iii. Coordinate for execution of the project as per the planned schedule.
- iv. Various techniques/methods are used to assess the progress of a particular project ( Gantt Chart, CPM, PERT)

### **Construction scheduling**

Construction scheduling or simply **Scheduling** in construction means the process of fitting final work plan into a time scale indicating start and completion time of each and every construction activity.

#### **1. Gantt Chart Scheduling:**

Gantt Chart is a chart that is used for scheduling of construction activities. The Gantt chart consists of the Construction Activity on the Y-axis and the Time duration on the X-axis. Also, called Bar Chart.

The activities are shown separately by bars where the length of bar shows the duration that the particular construction activity takes to complete.

The progress of the construction activity is shown by shading the bar with colour or hatching.

*Note:* The disadvantages of Gantt Chart are:

- \* It does not show inter-dependency between activities. (Does not show if the progress is delayed or not)
- \* Critical activities cannot be known.

#### **2. Network Analysis and Scheduling:**

Network analysis consists of methods to assess the various construction activities, their inter-dependency with each other, and find out the activities that need most attention during the progress of a construction project.

Network Analysis consists of following methods:

### **Features of Network Planning:**

1. The whole project is expressed in graphical form showing events, activities and the interdependencies.

2. The network shows the critical activities and events which need special attention during progress of the project.
3. The network can be used for time-cost optimisation.

(Optimising means not using too much or too less of the resources available, i.e. optimised utilisation)

4. Resources can be allocated or diverted from one activity to other for optimising. (Resource Allocation)

**Following are the terms associated with Network Analysis:**

- a) Activity- Progress of a specific task or construction activity which has a definite beginning or end is called activity.
- b) Event- The beginning or end of an activity is called an event
- c) Network- Network is the inter-connection of multiple events and activities showing their inter-dependency among them.
- d) Dummy- Dummy represents a dummy activity which does not consume any time or resource but shows the importance of completion of an activity before start of another. Dummy serves two purpose:    a) Logical purpose    b) Grammatical purpose

**Critical path method (cpm)**

Critical Path Method is a network analysis technique used for scheduling of construction activities.

**Features of CPM:**

1. CPM is activity oriented method. (i.e. it depends on activity)
2. CPM is used for projects that are repetitive in nature or deterministic in nature.  
(All activities and their time durations are well known before hand)
3. CPM is used for Construction projects.

**Terminology for Critical Path Method:**

1. Activity duration- The time duration that an activity takes to complete. ( $T_{ij}$ )
2. Earliest Start Time- Earliest time at which an activity can start (EST)
3. Earliest Finish Time- Earliest Time at which an activity can finish (EFT)

$$EFT = EST + T_{ij}$$

4. Latest Start Time- Latest time at which an activity can start without delaying the project (LST)
5. Latest Finish Time- Latest time at which an activity can finish without delaying the project (LFT)

$$LFT = LST + T_{ij}$$

**Floats:**

- i. Total Float ( $F_T$ ) - Total Float is the time by which the start or finish of an activity can be delayed without delaying the completion of the project.
- $$\boxed{F_T = LFT - EFT} \quad \text{OR} \quad \boxed{F_T = LST - EST} \quad (\text{remember any one})$$
- ii. Free Float ( $F_F$ )- Free Float is the portion of total float ( $F_T$ ) that can be used without delaying the succeeding activity.
- $$\boxed{F_F = F_T - S_j}$$
- iii. Independent Float ( $F_I$ )- Independent Float is the excess time that exists if the preceding activity ends as late as possible and the succeeding activity starts  $\boxed{F_{ID} = F_F - S_i}$  as early as possible.
- iv. Independence of activity- It is the time duration by which an activity is independent of the completion of its preceding activity and the start of its succeeding activity
- v. Slack( $S$ ) - Slack is the time duration difference between the ( $LST \sim EST$ ) or ( $LFT \sim EFT$ ) of any particular activity.
- Head Event Slack  $\boxed{S_i = (LST - EST)}$
- Tail Event Slack =  $\boxed{S_j = (LFT - EFT)}$
- vi. Interference float is the head event  $\boxed{F_{IN} = F_T - F_F}$

### **Critical Path**

**Critical Path** is the path in the network that connects critical activities having Total Float value equal to zero (i.e. where  $F_T=0$ ).

Critical Activity and Events are those activities and events respectively which lie on critical path

### **Advantages of CPM:**

1. Makes the whole project financially economical.
2. The CPM Network analysis identifies critical activities and events.
3. Proper attention can be given to the critical activities and events.
4. Resource allocation can be done economically basing on the CPM network analysis.
5. The CPM analysis shows the dependency of activities and the activities that can be delayed without delaying project completion. ( It is done by utilising Float Values )

### **Example 2.1**

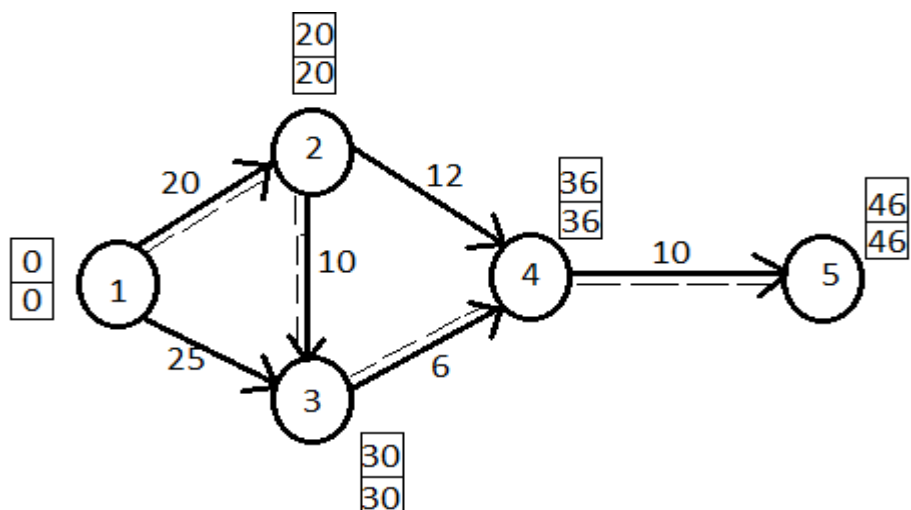
For the following data draw the network, find the EST, EFT, LST, LFT,  $F_T$ ,  $F_F$ ,  $F_{ID}$ . Find the critical path and the project completion period.



| Activity | Duration |
|----------|----------|
| 1-2      | 20       |
| 1-3      | 25       |
| 2-3      | 10       |
| 2-4      | 12       |
| 3-4      | 6        |
| 4-5      | 10       |

Solution:

| Activity |    |    |    |    |    |                                      |  | $F_T$ | $F_F$ | $F_{ID}$ |
|----------|----|----|----|----|----|--------------------------------------|--|-------|-------|----------|
| 1-2      |    |    |    |    |    |                                      |  | 0     | 0     | 0        |
| 1-3      | 25 | 0  | 25 | 5  | 30 | 5                                    |  | 5     | 5     | 5        |
| 2-3      | 10 | 20 | 30 | 20 | 30 | $\begin{bmatrix} 0 \\ \end{bmatrix}$ |  | 0     | 0     | 0        |
| 2-4      | 12 | 20 | 32 | 24 | 36 | 4                                    |  | 4     | 4     | 4        |
| 3-4      | 6  | 30 | 36 | 30 | 36 | $\begin{bmatrix} 0 \\ \end{bmatrix}$ |  | 0     | 0     | 0        |
| 4-5      | 10 | 36 | 46 | 36 | 46 | $\begin{bmatrix} 0 \\ \end{bmatrix}$ |  | 0     | 0     | 0        |



The Critical Path is:

Activity **1-2-3-4-5** as shown in the diagram above (dashed arrow)

The Project completion time is **46 days**.

### **Pert network analysis**

- a. PERT is Programme Evaluation and Review Technique.
- b. This method is a probabilistic approach.
- c. The completion duration of any activity cannot be determined (it means it is generally variable )
- d. This method of scheduling is used for Research organisation. (Not suitable for construction organisation)
- e. The completion time period for any activity is expected time ( $T_E$ ).
- f. There are three time periods in expected time:
  1. Pessimistic time ( $t_p$ ) - The maximum time period that an activity is expected to be completed if everything goes wrong.
  2. Most Likely time ( $t_L$ ) - The time period that an activity is expected to be completed if everything goes under normal condition.
  3. Optimistic time ( $t_o$ ) – The minimum time period that an activity is expected to be completed if everything goes good.
- g. An activity in PERT analysis is represented as:
- h. Expression for Expected time ( $T_E$ ) is shown below:

$$T_E = \frac{t_p + 4t_L + t_o}{6}$$

### **Differentiate Between CPM and PERT**

| Sl. No. | CPM                                                   | PERT                                                |
|---------|-------------------------------------------------------|-----------------------------------------------------|
| 1       | It is called Critical Path Method                     | It called Programme Evaluation and Review Technique |
| 2       | It is Activity Oriented                               | It is Event Oriented                                |
| 3       | It is Deterministic Approach                          | It is Probabilistic Approach                        |
| 4       | This Method is suitable for Construction Organisation | This method is suitable for Research Organisation   |
| 5       | This method is utilised for repetitive projects       | This method is used for completely new project.     |

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# QUESTION SET

## 1. Classroom Teaching

### Group - A

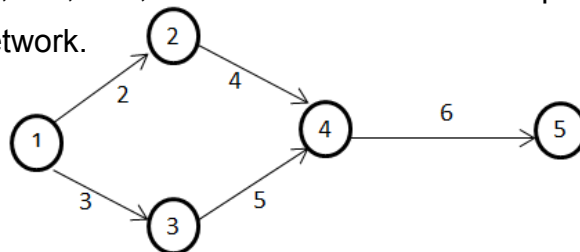
1. What do you mean by scheduling? [2017(S)]
2. What is Construction Planning? [2015(S,W)]
3. What is Bar Chart/Gantt Chart? [2014(S)]
4. Define an event & critical event. [2015(S,W), 2016(S)]
5. Define pessimistic time and optimistic time. [2013(W,S)]
6. What is briefing stage? [2011(w)]

### Group – B

1. Why planning is necessary for projects?
2. What are the limitations of a Bar Chart?
3. Differentiate between CPM & PERT. [2011(W), 2012(W), 2013(S, W), 2014(S,W), 2017(S)]
4. Explain the difference between Briefing and tendering stage. [2017(S)]

### Group - C

1. Explain major activities involved in different stages of planning for a construction project.  
[2011(W), 2014(S, W)]
2. Prepare a construction schedule with the help of Bar Chart for a compound wall describing the various steps in its preparation. [2012(W), 2014(S), 2013(W)]
3. Calculate the EST,EFT, LST, LFT and total free and independent floats in respect of all the activities of the network.



4. Prepare the Bar chart for preparing conference hall chair according to the following information:

Preparation of drawing of all parts= 3 days

Preparation of legs=4 days

Preparation of seats= 3 days

Preparation of backs= 2 days

Joining all parts= 3 days

Polishing the chairs= 2 days

## 2. Assignment Questions

### Group - A

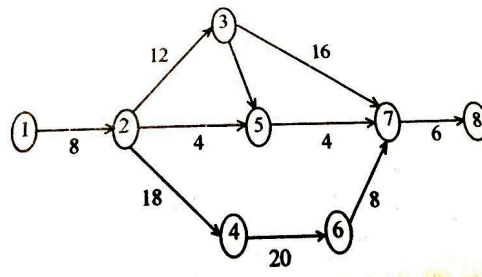
1. Name various types of PERT times estimates [2017(S)]
2. What is pretender stage? [2014(S)]
3. What is post-tender stage? [2014(S)]
4. What is work-breakdown structure?[[2012(W) 2013(W), 2014(S), 2017(S)]

**Group – B**

1. Illustrate with an example, the concept of work breakdown structure in construction planning.
2. Discuss the various construction stages.
3. Differentiate between construction stage and commissioning stage. [2011(W), 2014(S)]

**Group – C**

1. Define Network analysis. Write down the features of network analysis. [2012(w)]
2. Describe the importance of construction planning. [2013(S)]
3. Identify the Critical path in network shown in fig. and determine the project completion time



4. Draw the network and number the events. A project consists of 16 activities having their predecessor relationship as follows:  
 'A' is the first activity of the project  
 'B','C' and 'D' follow 'A' and can be done concurrently  
 'E' and 'G' cannot begin until C is completed and can be performed simultaneously  
 'F' is the immediate successor to activities B and E  
 'H'and 'K' run parallel and both succeed G  
 'L' succeeds 'F' and 'H'  
 'I' and 'J' are immediate successors activities to activity D  
 'M' and 'N' are immediate successors to 'I' and 'K'. However both 'M' and 'N' can be performed concurrently.  
 Activities 'O' and 'P' are last activities. Activity O is the immediate successor to N and L.  
 Activity P is the immediate successor to M and J. [2018(S)]

### 3. Self Practice

**Group - A**

1. What is expected time and critical path?
2. What do you mean by critical events?
3. Define independencies of activities.
4. What do you mean by critical path of an activity?
5. What is tender?
6. Write down the full-form of CPM and PERT

### **Group – B**

1. Explain the difference between pretender stage & post-tender stage.
2. Write short notes about:
  - a. EST
  - b. EFT
  - c. LST
  - d. LFT
  - e. Total Float
3. What are the advantages of network technique?

### **Group – C**

1. Explain the purpose and important activities of different stages in construction works.
2. The following table gives the activities in a construction project (i) Draw the network for the
3. project (ii) Find the critical path (iii) Find free float and total float for each activity.

| i. <u>Activity</u> | <u>Duration(Days)</u> |
|--------------------|-----------------------|
| ii. 1-2            | 20                    |
| iii. 1-3           | 25                    |
| iv. 2-3            | 10                    |
| v. 2-4             | 12                    |
| vi. 3-4            | 06                    |
| vii. 4-5           | 10                    |

4. Draw the network diagram.  
C follows D but precedes F  
C follows B but precedes H  
G follows F but precedes I  
E follows A but precedes I  
D follows A  
H and I terminate at the same time and A and B start at same time.