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LECTURE NOTES

ON

CONSTRUCTION MANAGEMENT

FOR 6th SEMESTER DIPLOMA IN CIVIL ENGINEERING STUDENTS

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INTRODUCTION TO CONSTRUCTION MANAGEMENT

Construction management may be defined as management in which group of people of different categories works together, to execute the project economically without affecting the quality in a well-planned and organised manner.

AIMS AND OBJECTIVES OF CONSTRUCTION MANAGEMENT

Aim of construction management are:

a) Optimum utilisation of human

b) Material

c) Finance and time resources for Economical

d) Safe and timely completion of construction project

The main objectives of construction management are:

i) Project should be completed within the sanctioned time.
ii) Project should be completed well within the budgeted cost.
iii) Quality of the construction work should be maintained by modern construction practices.
iv) A well-defined communication system should be established within and outside of the project to reduce rework and delay.
v) Reduction in material wastage by proper material management.
vi) Work should be executed as per the technical specification.
vii) Work should be executed and supervised by trained and executed supervisions.

FUNCTIONS OF CONSTRUCTION MANAGEMENT

The following are the functions of construction management

a) Planning
b) Organising
c) Staffing
d) Directing
e) Controlling
f) Co-ordinating
g) Communicating

a) Planning:

- Planning is the administrative process which translates the policy into a method of reaching the objective.
- It lays down how a project will be carried out, what materials will be used, what men and staff will be employed, what machines or equipment will be utilized etc. and other details to carry out the policy effectively.

- In the construction field new techniques evolved from time to time should be planned.

b) Organising: (At site)

- Organising as a process consists of defining the responsibilities of those individuals who are employed in the organisation.
- The inter-relationship of one member of organisation with another can be displayed pictorially by using organisation chart.
- It specifies duties and jurisdiction of individuals.
- An organisation structure should be kept as simple and balanced as possible.
- A man should have only one boss immediately above him to whom he knows.
- Any significant member of an organisation should have up to five and never more than seven sub-ordinates. Building up an organisation with this in mind will lead to a proper balance.

c) Staffing:

- The function of staffing is the process of appointing the requisite number of personnel in fulfilling the responsibilities as laid down by the organisation structure.
- Under this right person on right job is to be selected very carefully so that the project in hand may not be hampered due to lack of knowledge on the part of the person appointed for a particular job.

d) Directing:

- This can be defined as the process of shifting of all information, data collected/available during the course of execution to the supervising staff.
- They must learn the interdepartmental relationships of various activities. Also they must become familiar with their duties and usage of their authority.

e) Controlling:

- Controlling is the main process of planning. It is necessary to control the project in such a way that it should conform closely to work as planned. For this actual performance is compared with the estimated one at regular intervals.
- In the event of divergence from the schedule corrective actions can be taken in time to bring it to the schedule. A good control on feedback of information will also assist in framing future policies.
- Control is also required where the material is stored to ensure that the material consumed is as per the progress of the work.

f) Co-ordinating:

- This is a process where the framework or structure of the organisation is made to operate smoothly with the flow of information, decisions and results in every direction.
- In a large organisation and in a large complicated project, as the work is divided into different departments, hence there is greater need for good co-ordination.

- Co-ordination is necessary to ensure that the proper information is made available at the proper time to the correct person and delivery of various materials /items are arranged such that the work progresses as planned.

g) Communicating:

- There should be effective communication in every direction within the organisation.
- Without communication there can be no issue of instructions so that the plans of action can be put into effect, there can be no control or co-ordination.
- Effective management can take place only where there is continuous communication and feedback for control purposes.

THE CONSTRUCTION TEAM

No project can be completed by a single individual but it requires group of person (Team) with specific duties to be performed by each. Thus when an *Owner* recognizes a need for any project, he employs an *Engineer* to prepare plans and specifications for the same. The Engineer designs the project which will satisfy most of the needs of the owner at the lowest possible cost. After this the owner engages a *Contractor* for the successful completion of the project, economically under the strict supervision of the Engineer.

Therefore the construction team consists of

i. Owner
ii. Engineer/Architect/Designer
iii. Contractor

- Owner:

The owner in a building or engineering project is the individual, firm or public body who finances a work or project, recognizes the need for a project and uses it after the completion of the construction.

- Engineer/Architect/Designer:

Being a professional man he gives shape to the proposal of the owner

a. Does the preliminary investigations for the proposed project.
b. Prepare plans and designs the project for the owner.
c. Makes specifications for the construction.
d. Works out quantities and cost of the project in hand.
e. Supervises the construction of the project.

He acts also

- As an advisor, as regards in constructional matters and solving problems which arise during the progress of work.
- As an agent to deal with the contractor on behalf of the owner.
- As an arbitrator in case of disputes between the owner and the contractor.

- Contractor/Builder:

The contractor is the person or firm who undertakes to submit bids to the owner, for the supply of certain materials, or for the execution of any constructional work or service.

When the bid or rate is agreed between the contractor and the owner, he constructs the project or make supplies.

RELATIONSHIP BETWEEN OWNER, ENGINEER AND CONTRACTOR

For the successful completion of the project there must be an inter-relationship between the two categories

1. Co-relationship between the Owner and an Engineer:

- As the owner finances the work and employs an engineer who agrees to perform his professional duties with reasonable efforts and skill. If the engineer makes an unfortunate mistake, in spite of due skill, he is not liable for his mistake, unless the owner proves that he failed to perform his duty carefully.
- It is the responsibility of the engineer to plan for the owner economically.

2. Co-relationship between an Engineer and contractor:

- The contractor has to work as per the design data and drawings in consultation with the engineer so that there may not arise any dispute between the engineer in charge of the project and the contractor later on.
- Therefore, in the interest of economy and quality of work a close co-operation between an engineer and contractor is necessary. Both can help each other to earn reputation.
- The Engineer should give instruction in advance in respect to supply of material etc.
- The contractor on the other hand, can help the engineer by sticking to the specification strictly and faithfully.

RESOURCES FOR CONSTRUCTION MANAGEMENT

Whenever any constructional project is taken in hand the following things are needed

i) Money: First and foremost item required for any project is money which should be arranged before starting any work. The regular supply of money keeps things moving progressively.

ii) Materials: For the completion of any project sufficient quantity of materials as estimated are required, should be available at the site. As it accounts for upto 60% of the total cost of the project, thus the regular supply of the materials in required quantities should be ensured.

iii) Machine or Equipment: Many classes of machinery (semi-automatic, automatic or others) are required, for various types of works. It is economical to use machines for heavy and large works.

iv) Man: Manual power is all the more important, both skilled and unskilled, for the successful completion of any project. To start any project from supervisory staff to unskilled labour, is required according to the planning of the engineer. It is the oldest

resource both economical and dependable. Even for operating different types of machines men are required.

v) Management: It is the set of administration whose function is to plan, organise, control and co-ordinate the use of other resources to achieve the goal.

CONSTRUCTIONAL PLANNING

IMPORTANCE OF CONSTRUCTION PLANNING

In the simplest sense planning means thinking ahead of the operations or activities to be performed. Rather it is the careful consideration of all possibilities in order to complete the project most economically and within the stated time.

Generally following steps are involved in an effective planning:

i) The time for delivering the materials.
ii) The type, quantities and duration of equipment needed.
iii) Classification and number of labours needed and the periods during which they will be needed.
iv) The extent to which financial aid, if any, will be needed.
v) The time required to complete the project.

In the execution of a project, planning has to be done by all the members involved as under:

i) The owner employs an engineer to investigate and plan the project for him.
ii) The engineer after investigation prepares an approximate estimate and determines the finances required for the project.
iii) After getting consent from the owner the engineer undertakes the work for detailed investigation and prepares complete contract documents for bid.
iv) In case the owner is a Government, the detailed plans and estimates have to be checked and approved by competent authority.
v) After the approval, the contractors are invited to bid on the job and an agreement is arrived at between the two parties.
vi) Then the contractor sets his organization into carry out the project in the most efficient and economical way.

DEFINITION OF PLANNING

An administrative process by which suitable line of action is selected out of various alternatives available for a project work is called planning.

OBJECTS OF PLANNING

The main objects of planning are

i) Proper design of various elements of the project.
ii) Proper choice of plant and equipment.
iii) Up to date arrangement for repairs in order to keep plant and machinery in working order.
iv) Procurement of material well in advance.

v) Employing trained and experienced staff.
vi) Constant flow of funds till completion of project.
vii) Following proper safety precautions to avoid accidents.
viii) Providing welfare schemes for the staff and the labours such as medical facilities, recreation etc.
ix) To provide incentives for good workers.
x) Proper arrangement for communication and feedback in order to keep a record of the progress of work.

BREAKDOWN STRUCTURE FOR DEVELOPING WORK

A project is consist of several steps to complete the functionality. Based on its nature of activity and complexity of the job the number of the sub-activity depends. It is very essential to prepare a work breakdown structure from project planning perspective as it is the base of bar chart. Following steps are followed to prepare Work Breakdown Structure.

i) Entire job is divided into broad functions like excavation, structure plastering, plumbing work, internal finishes and painting for a typical building job.
ii) Each broad functions are further divided into logical steps like making layout, mechanical excavation by machines, manual excavation, ramming for excavation work. Logical steps depends on the type of equipment and work method used for the construction.
iii) Logical steps can be divided in further steps in case of repetitive sequences like plastering of a multi-storey building, trenching of sewer line etc.

ADVANTAGES OF A DETAILED WORK BEAKDOWN STRUCTURE

i) Help to prepare schedule and logical sequences.
ii) Determine project duration.
iii) Estimation of project quantity.
iv) Resource calculation.
v) Different kind of tradesman required and their deployment schedule.

STAGES OF CONSTRUCTION PLANNING

1. Pre-tender planning and
2. Contract planning

1. Pre-tender planning:
   - Availability of Site, Land, ROW etc. (or chances of same being available in time).
   - Site Survey and Surface/Sub-surface Investigations.
   - Availability of relevant Designs and Drawings.
   - Availability of Technical Specifications.
   - Manpower for supervision (or alternative arrangements like PMC, measurements by contractor etc.).
   - Sanctioned Detailed Estimate (or chances of same getting sanctioned in time).
   - Availability of Sanction and Funds.
   - Realistic Time Frame.

2. Contract planning:

- Prepare labour requirement chart for various stages of the work.
- Material statement chart as and when required is prepared.
- A master plan is prepared for carrying out the work.
- The sequence of operations and their relationship is prepared.
- The details of key labour and plants required to be moved from any activity to any subsequent one is prepared.

Most commonly used tool for project scheduling are

- Bar chart
- CPM
- PERT

The project schedule is the tool that communicates

- What work needs to be performed
- Which resources of the organization will perform the work and
- The timeframes in which that work needs to be performed.

The project schedule should reflect all of the work associated with delivering the project on time. Without a full and complete schedule, the project manager will be unable to communicate the complete effort, in terms of cost and resources, necessary to deliver the project.

TECHNIQUES USED FOR SCHEDULING

BAR Chart (Gantt chart)

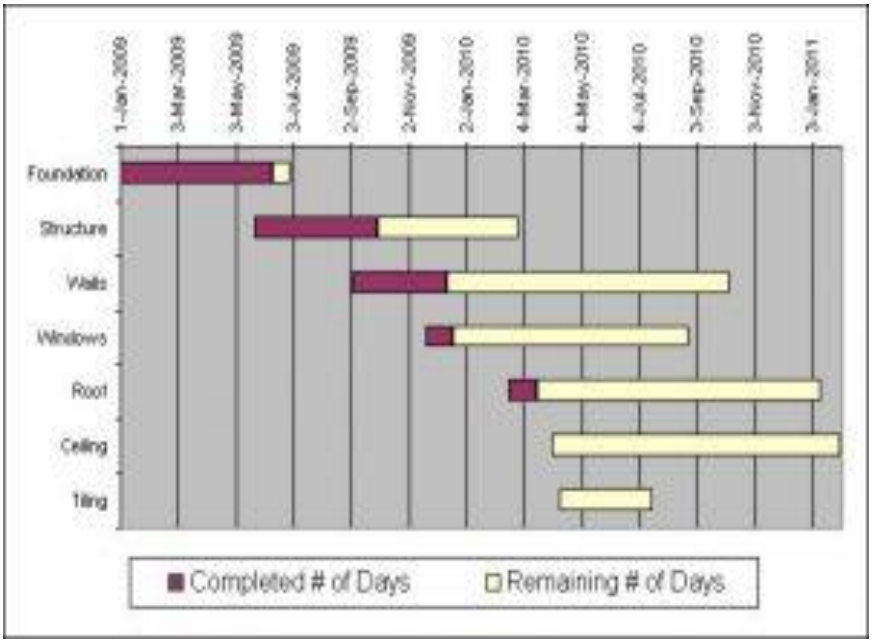
Properties:

- This is a horizontal bar chart plotted over time (e.g. days, weeks or months).
- Each activity is shown as a bar (its length based on a time estimate).
- Depending on task dependencies and resource availability, these bars may be sequential, or run in parallel.
- Each bar is plotted to start at the earlier possible start date.

History:

- A bar chart is also called a Gantt chart since it was developed by Henry Gantt in 1920s.
- It is one of the most popular and widely used techniques for planning and scheduling activities because the graphical representation of a bar chart makes it easy to read and understand.

The plan laid out when the Gantt chart was created can be compared with actual times taken (plotted below the planned time bars in the chart).



- Bar charts are useful and used to detect the amount of resources needed for one particular project.
- Resource aggregation is done by adding resources vertically in the schedule.
- The purpose of this aggregation is to estimate the work production and establishing estimates for man-hour and equipment needed.

Advantages:

- It is simple to understand.
- Easy to prepare, consume less resources.
- Easy to develop and implement, no training is required.
- It can be used to show progress.
- Appropriate for small projects.
- Can be used for resources schedule.
- It gives the clear pictorial model of the project.

LIMITATIONS OF BAR CHART:

- Difficult to construct Bar chart for the large and complex project due to limitations of the size of paper.
- The relationship between activities cannot be shown easily.
- Difficult to find critical path, critical activities, and floats etc.
- Difficulties in seeing immediately and exactly overall project duration if changes occur in any particular activity.
- It cannot be used as control device
- Long duration project may seem to be most important which may not be correct.
- Difficult to manipulate and make corrections i.e. updating means to redraw the entire chart again.

SCHEDULE NETWORK ANALYSIS

- The schedule network is a graphical display (from left to right across a page) of all logical interrelationships between elements of work — in chronological order.

- This order is from initial planning through to project closure.
- As the project progresses, regular analysis of this network diagram is a check to ensure that the project is proceeding ‘on track’.

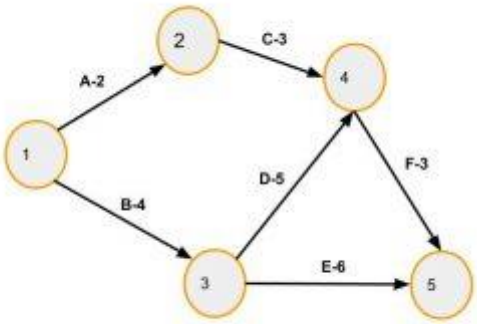
NETWORK DIAGRAMS

- For a project involving a large number of activities, the project scheduling becomes very complex
- The use of the conventional method of scheduling like bar charts will not be effective in such case.
- Complex projects, if not correctly scheduled, will probably result in either under estimation or over estimation of the project implementation period.

Network diagrams are one of the modern tools of project management. There are two popular network based scheduling techniques.

- Critical Path Method (CPM)
  - Graphical network- based scheduling technique.
  - US Government agencies insisted on their use by contractors on major government projects.
- Project Evaluation and Review Technique (PERT)
  - In 1958 US Navy developed project management tool known as PERT for scheduling Polaris Missile Project.

Following is an example network



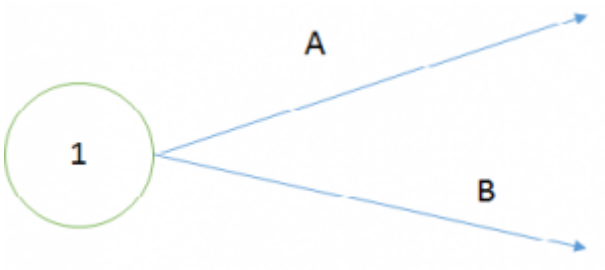
TERMINOLOGIES IN NETWORK DIAGRAMS

Activity (Task):

- An activity is any identifiable job which requires time, manpower, material and other resources to complete.
- The arrow in a network diagram represents activity.

Concurrent (parallel) activities:

- Which can be performed simultaneously and independently to each other.
- In the figure, A and B are concurrent activities.



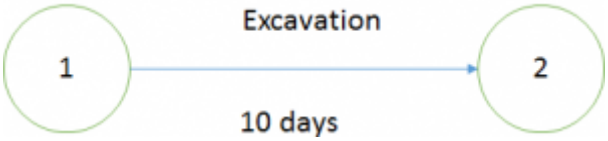
Serial Activities:

- Performed one after the other, in succession.
- In the figure below A and B are serial activities.

Activity duration:

- An activity's duration is estimated the time required for its completion.
- Time unit may be hours, days, weeks or months.

Activity duration= Work quantity/Production rate



Event (Node):

- The beginning or end of the activity is known as event.
- It represents specific time and does not consume time manpower, material, and other resources.

Two conventions can be used for developing networks are:

- Activity on Arrow (AOA)
  - Here arcs represents activities of the project and nodes represents events
- Activity on Node (AON)
  - Here the nodes represent activities, while arc(arrow) represent the precedent relations

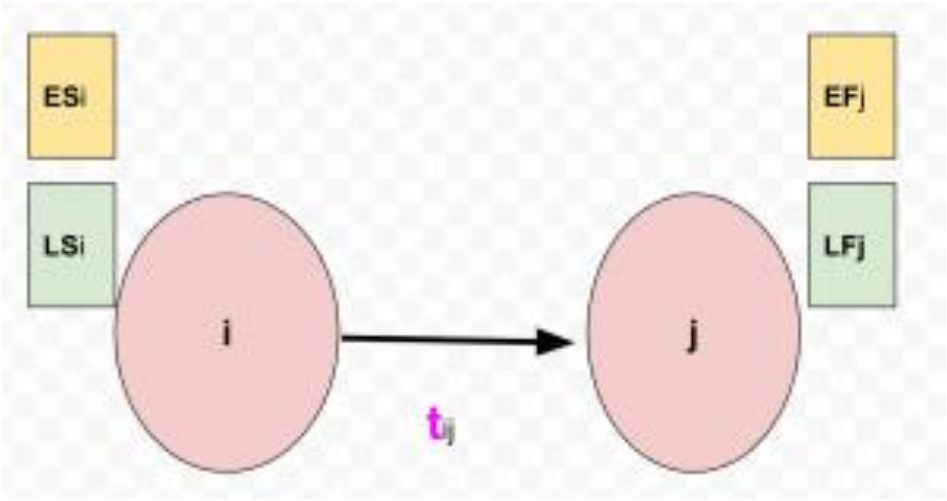
Dummy Activity:

- Which doesn't consume resources like time, cost, manpower, equipment etc.
- But is only used to show relationships.
- It is represented by Dashed Arrow.

Dummies serve two purposes in network:

- Grammatical purpose
  - It is used to prevent two arrows having the common beginning and end nodes for two or more activities.
- Logical purpose:
  - Dummies are also used to give logical clear representation in the network having an activity common to two sets of operations running parallel to each other.

Earliest Start time (ES):



- It is the earliest possible time an activity or operation can be started.
- It is equal to the earliest occurrence time of the tail event of that activity. It is represented either EST or simply ES_i

Earliest Finish Time (EF):

- It is the earliest possible time for completion of an activity without delaying the project completion time.

$$EF = ES + duration$$

$$EF_j = ES_i + t_{ij}$$

Latest Finish Time (LF):

- It is the latest time the activity must be completed without delaying project duration.
- It is equal to the latest occurrence time of the head event.

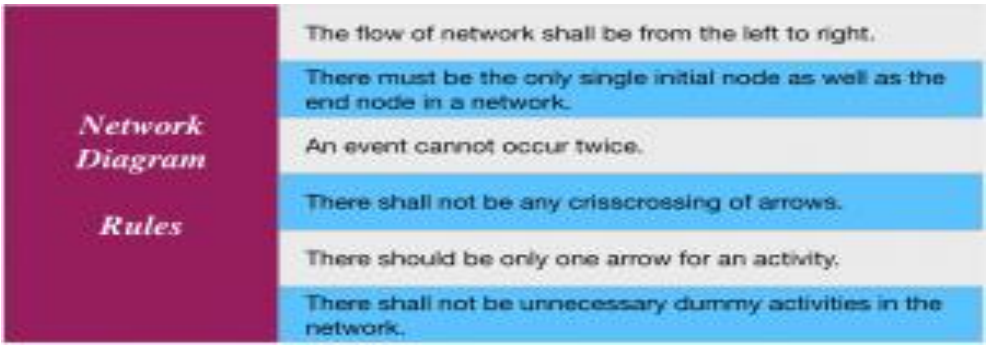
Latest Start time (LS):

- It is the latest possible time; an activity can be started without delaying the project.

$$LS = LF - duration$$

$$LS_i = LF_j - t_{ij}$$

Rules to draw Network diagram



Numbering the Events

Fulkerson's Rule:

- For any activity, the number on the Tail Event should not be greater than that on the Head Event.
- In other words, the number on Head Event must always be greater than that on tail Event.

CRITICAL PATH METHOD (CPM)

Developed by Du-Pont chemical works-USA in 1956/57 and used for preparing maintenance shutdown schedule of chemical plant for the first time.
Unlike bar chart, it uses arrows to represent activities and length of arrows has no relation with activity duration. Start or end of an activity is called event and it is shown by circles with the special designation.

Terminology:

- Starting event is called tail event and ending event is called head event.
- Some event plays dual both the role of head and tail such events are called dual role events.
- Activity which must be completed before start of another activity is predecessor.
- Activity which starts after completion of an activity is its successor.

- Activity B is successor of activity A and activity A is predecessor of activity B.

Critical path:

- The longest path in a CPM network is called critical path.
- There may be more than one critical path in a network.

Project duration:

- The time required to travel critical path is called project duration.

Critical activities:

- The activities lying on critical path are called critical activities.

Floats:

- Float means the available free time for an activity, which is useful for managers to manage the limited resources.

An activity has four types of floats.

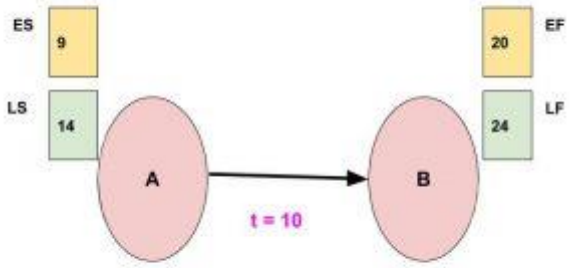
Total Float (TF):

- It is the total free time for an activity i.e. maximum time by which completion of an activity can be delayed without affecting project completion time.

Significance:

- It works as buffer time for managers, to meet contingencies like machine breakdown, labour absenteeism, etc.

$$TF = (LF-ES)-t_{ij} = (LF-t_{ij}) - ES$$
$$= LS - ES$$



Example numerical:
Total float for this activity A-B is (LS – ES) = (14 – 9) = 5

Free Float (FF):

- It is the spare time allowable for an activity so that the start time of succeeding activities are not affected.
- It is based on the possibility that all events occur at their earliest time.

$$FF = (EF - ES) - t_{ij} = EF - (ES + t_{ij})$$

Numerical example:
Free float for the activity A-B is = 20 – (9 + 10) = 20 – 19 = 1

Independent Float (IF or Ind. Float):

- It is the maximum delay allowable for an activity so that the start time of succeeding activities are not affected.
- It may come negative but should be taken as zero.

$$IF = EF – LS – t_{ij}$$

Numerical example:
Independent float for the activity A-B is = 20 – (14 + 10) = 20 – 24 = -4 (considered as 0)

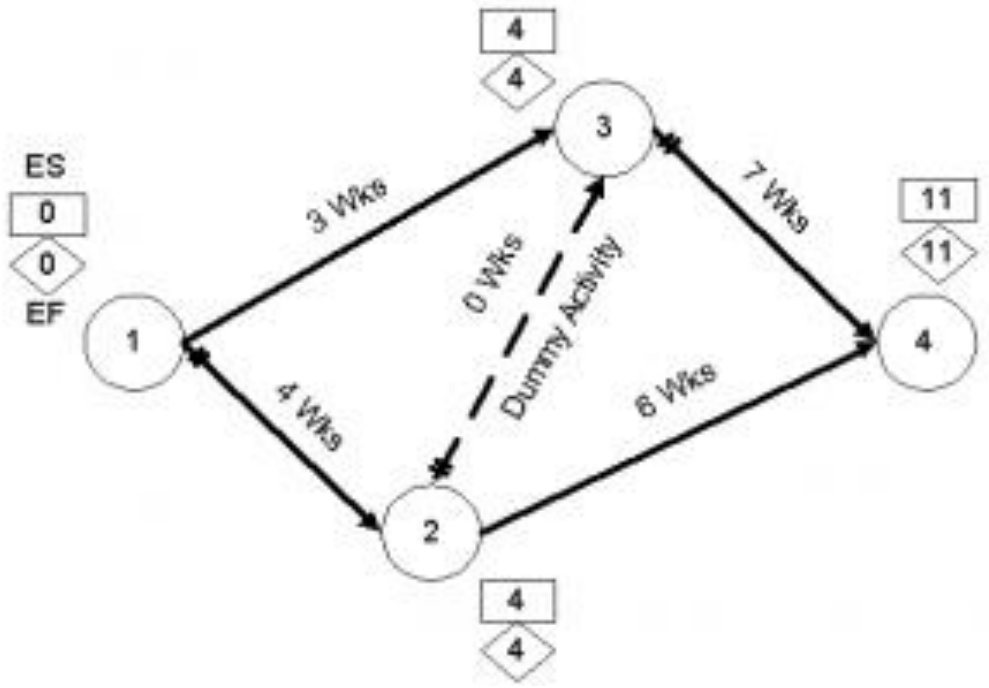
Interfering Float (Int. Float):

- It is name given to head event slack. It is the difference between TF & FF.

$$\text{Int. Float} = TF – FF$$

Interfering float for the activity A-B is = 5 – 4 = 1

CPM example:



There are three paths:

Paths	Duration(weeks)
1-2-3-4	4+0+7=11
1-2-4	4+6=10
1-3-4	3+7=10

Hence from above definition,

- Critical path= 1-2-3-4
- Project duration= 11 weeks(time duration along the critical path)
- Critical activities= 1,2,3,4

Event	Duration (Weeks)	Earliest Start Time	Earliest Finish Time	Latest Start Time	Latest Finish Time	Total Float
1-2	4	0	4	0	4	0
2-3	0	4	4	4	4	0
3-4	7	4	11	4	11	0
1-3	3	0	3	1	4	1
2-4	6	4	10	5	11	1

CHARACTERISTICS OF CRITICAL PATH:

- It is the longest path of activities.
- It determines the total project duration.
- There may be more than one Critical Path in a network.
- A Critical Path may consist of less no. of activities than Non-critical Path.
- The Critical Activities demand the requirement of resources prior to other activities to complete the project in time.

SIGNIFICANCE OF CRITICAL PATH:

- If there is any delay in either starting or if the time taken to complete critical activity exceeds the estimated time, project implementation period will get extended.
- Thus, any delay in critical activities leads to time overrun of the project which ultimately results in cost overrun.

ADVANTAGES OF CRITICAL PATH METHOD

- Makes dependencies visible.
- Organizes large and complex project.

- Enables the calculation of float of each activity.
- Encourages the project manager to reduce project duration.
- Increases visibility of the impact of schedule revisions.
- Provides opportunities to respond to the negative risk going over-schedule.

LIMITATIONS OF CPM:

- In large and complex projects, there will be thousands of activities and dependency relationships.
- This method doesn't account for resource and resource allocation.

PROJECT EVALUATION AND REVIEW TECHNIQUE (PERT)

Like CPM, PERT is also a network based planning tool developed by US Navy in 1958. It was used for scheduling Polaris Missile Project.

But, unlike CPM, PERT is used for novel projects like research and development (R & D) where it is difficult to estimate activity duration accurately.

CPM is used for projects with prior experience such as civil engineering works.

It is a probabilistic approach for estimating project duration of an activity and event-oriented network diagram.

PERT is preferred for those projects in which correct time determination for various activities cannot be made.

PERT uses three-time estimate for each activity with a view to overcoming uncertainty in time estimates.

Optimistic time estimate (t_o):

It is minimum time i.e. the shortest possible time required to complete the activity in ideal conditions.

Pessimistic time estimate (t_p):

Maximum time required to complete the activity in the worst condition.

Most probable time estimate (t_m):

Time required to complete the activity in normal circumstances.

From these three time estimates, we calculate average time i.e. expected time (t_e) using the following formula.

$$t_e = (t_o + 4\, t_m + t_p)/6$$

PERT assumes optimistic time and pessimistic time are equally likely to occur while the most likely time is four times more likely to occur than the other.

Similarly, standard deviation (σ) is calculated using,

S.D. (σ) = $(t_p - t_o)/6$ and

Variance (σ^2) = $[(t_p - t_o)/6]^2$

DIFFERENCE BETWEEN CPM AND PERT

CPM	PERT
Deterministic tool, with only single estimate of duration	Probabilistic tool used with three estimates of duration
Activity oriented	Event oriented
CPM considers less uncertainty	PERT considers more uncertainty
Suited for routine projects requiring accurate time and cost estimates	Suitable for R&D related projects where the project is performed for the first time and the estimate of duration are uncertain
CPM can control both time and cost	This tool is basically a tool for planning and control of time
Easy to maintain	Costly to maintain

SIMILARITIES BETWEEN CPM / PERT

- Both tools lead to the same end.
- A Critical Path and Critical Activities with the slack time equal to zero.
- Extensions of both PERT and CPM allow the user to manage other resources in addition to time and money, to trade off resources, to analyse different types of schedules, and to balance the use of resources.

CONSTRUCTION SITE MANAGEMENT

What is Construction Site Management?

Managing the design and construction of a stated project to achieve an architectural and construction program at the lowest beneficial cost to owner within reasonable profit framework for the participants.

JOB LAYOUT

Job layout is the plan of the construction site and the area around it which shows the exact location for placing the resources of construction.

REVIEW PLANS AND SPECIFICATIONS

For site organisation the first thing required is the detail of different plans and specifications for the execution of work.

SITE PLAN

The site plan shall show:

(i) The boundaries of the plot and of any contiguous land belonging to the owner thereof, including the revenue survey particulars in full;

(ii) The position of the plot in relation to the neighbouring street and its main access;

(iii) The name of such street, if any; and its width, which shall be the width in between the plot boundaries on the opposite sides:

(iv) All existing structures in the plot;

(v) All existing streets or foot-paths within the plot;

(vi) The layout of cul-de-sacs, streets or foot-paths within, adjoining or terminating at the site, existing, proposed to be widened or newly aligned;

(vii) The proposed land/plot sub-division, if any, and the area and use of each sub division thereof;

(viii) The access to each land/plot, if any;

(ix) The layout of service road or foot-path and public parking space proposed or existing, if any;

(x) The area and location of any parcel of land within the plot that is undevelopable such as rocky outcrops, steep terrains, marshes etc.

(xi) The area and location of any parcel of land within the plot that is not proposed to be developed or redeveloped;

(xii) The area and location of any parcel of land that is proposed to be reclaimed.

(xiii) The area and location of any paddy field and/or other agricultural land that is proposed to be reclaimed and/or converted for the said development or re-development;

(xiv) The north direction and predominant wind direction in relation to the site;

(xv) Topographic contours (with contour interval not less than 1.5 metre to show the features of the plot clearly) of the site and any other relevant information of the plot not specifically mentioned, but may be required by the Secretary.

BUILDING PLANS

The plans, elevations and sections of the building shall:

i. Show floor plans of all floors together with the covered area, sizes of rooms and the position of stair-cases, ramps and lift well if any.

ii. Show exact location of local services.

iii. Include sectional drawings showing details of footings, thickness of basement wall, wall construction, size and spacing of framing members, floor slabs and roof slabs with their materials.

iv. Show all street elevations.

v. Give dimensions of projected portions beyond the permissible building line.

vi. Include terrace plan indicating the drainage and slope of the roof.

vii. Give indications of the North line.

SERVICE PLAN

Plans, elevations and sections of water supply and sewage disposal system, if any, shall also be included.

EQUIPMENT MANAGEMENT

Equipment management is one of the essential elements of a quality management system. Proper management of the equipment in the laboratory is necessary to ensure accurate, reliable, and timely testing.

The benefits of a good equipment management program are many:

• helps to maintain a high level of laboratory performance;

• reduces variation in test results, and improves the technologist's confidence in the accuracy of testing results;

• lowers repair costs, as fewer repairs will be needed for a well-maintained instrument;

• lengthens instrument life;

• reduces interruption of services due to breakdowns and failures;

• increases safety for workers;

• produces greater customer satisfaction.

IDENTIFICATION OF DIFFERENT ALTERNATIVE EQUIPMENT

Selecting the best instrument for the laboratory is a very important part of equipment management. Some criteria to consider when selecting laboratory equipment are listed below:

• Why and how will the equipment be used? The instrument should be matched against the service the laboratory provides.

• What are the performance characteristics of the instrument? Is it sufficiently accurate and reproducible to suit the needs of the testing to be done?

• What are the facility requirements, including the requirements for physical space?

• Will the cost of the equipment be within the laboratory's budget?

• Will reagents be readily available?

• Will reagents be provided free of charge for a limited period of time? If so, for how long?

• How easy will it be for staff to operate?

• Will instructions be available in a language that is understood?

• Is there a retailer for the equipment in the country, with available services?

• Does the equipment have a warranty?

• Are there any safety issues to consider?