

AR8017 - CONSTRUCTION AND PROJECT MANAGEMENT

AR DHIVYA SHREE G
Assistant professor

OBJECTIVES:

- ❖ To understand different management techniques suitable for planning and constructional projects.
- ❖ To understand the management system for accomplishing the task efficiently in terms of both time and cost.

OBJECTIVES

- To introduce different management techniques suitable for planning and construction projects.
- To enable understanding of management systems for accomplishing the task efficiently in terms of quality, time and cost.

UNIT I INTRODUCTION TO PROJECT MANAGEMENT**7**

Project management concepts. Objectives, planning, scheduling, Controlling and role of decision in project management. Traditional management system, Gantt's approach, Load chart, Progress chart, Development of bar chart, merits and demerits, CPM networks, merits and demerits, PERT network, Introduction to the theory of probability and statistics.

UNIT II PROJECT PROGRAMMING AND CRITICAL PATH METHOD**11**

Project network, Events activity, Dummy, Network rules, Graphical guidelines for Network, Numbering the events, Cycles, Development of network-planning for network construction, Models of network construction, Steps in development of network, Work break down structure, Hierarchies, Critical path method - process, activity time estimate, earliest event time, latest allowable occurrence time, start and finish time of activity, float, critical activity and critical path problems.

UNIT III RESOURCE PLANNING**7**

Cost model- project cost, direct cost, indirect cost, slope curve, total project cost, Optimum duration, contracting the network for cost optimization, Steps in cost optimization, updating, resource allocation, resource smoothing, resource leveling.

UNIT V COMPUTERIZED PROJECT MANAGEMENT**11**

Creating a new project, building task, Creating resources and assessing costs, refining project, Project tracking, recording actual, Reporting on progress, Analysing financial progress, Introduction to BIM.

UNIT V CONCEPT TO COMMISSIONING**9**

Project feasibility study, Real estate & regulatory strategies, Facility programming and planning, Design management, EPC, testing & commissioning.

Unit :1

INTRODUCTION TO PROJECT MANAGEMENT



What is a project?

Definition of a Project:

A project is made up of a group of interrelated work activities constrained by a specific scope, budget, and schedule to deliver capital assets needed to achieve the strategic goals of an Agency.

- ✓ A defined goal or objective.
- ✓ Specific tasks to be performed.
- ✓ A defined beginning and end.
- ✓ Resources being consumed.

What is Project Management?

- ❖ The art of organising, leading, reporting and completing a project through people.
- ❖ A project is a planned undertaking.
- ❖ A project manager is a person who causes things to happen
- ❖ Therefore, project management is causing a planned undertaking to happen.





THE NEED

The Need for Project Management

- ❖ The construction industry is the largest industry in the world. It is more of a service than a manufacturing industry. Growth in this industry is in fact an indicator of the economic conditions of a country.
- ❖ This is because the construction industry consumes a wide employment circle of labor.
- ❖ While the manufacturing industry exhibit high-quality products, timelines of service delivery, reasonable cost of service, and low failure rates, the construction industry, on the other hand, is generally the opposite.
- ❖ Most projects exhibit cost overruns, time extensions, and conflicts among parties.



Who leads a Project ?



Project manager

- ❖ Project manager is a **professional** in the field of project management. Project managers are in charge of the people in a project.
- ❖ People are the **key** to any successful project. Without the **correct people** in the right place and at the right time a project cannot be successful. Project managers can have the **responsibility** of the planning, execution, controlling, and closing of any project typically relating to the construction industry, engineering, architecture, computing, and telecommunications.
- ❖ Many other fields of production engineering, design engineering, and heavy industrial have project managers.

Project manager

- ❖ A project manager needs to understand the **order of execution** of a project to schedule the project correctly as well as the time necessary to accomplish each individual task within the project.
- ❖ A project manager is the **person accountable** for accomplishing the stated project objectives.
- ❖ Project Managers tend to have **multiple years' experience** in their field.
- ❖ A project manager is required to know the project in and out while supervising the workers along with the project.

Project management concepts

The **purpose** of project management is to foresee or predict as many dangers and problems as possible; and **to plan, organize and control activities so that the project is completed as successfully** as possible in spite of all the risks. The ever-present element of risk and uncertainty means that events and tasks leading to completion can never be foretold with absolute accuracy. For some complex or advanced projects, even the possibility of successful completion might be of serious doubt.

Project management concepts

Project management can involve the following activities:

- ✓ Planning - deciding what is to be done;
- ✓ Organizing - making arrangements;
- ✓ Staffing - selecting the right people for the job;
- ✓ Directing - giving instructions;
- ✓ Monitoring - checking on progress;
- ✓ Controlling - taking action to remedy hold ups;
- ✓ Innovation - coming up with new solutions;
- ✓ Representing - liaising with users.

Project management concepts



What are the objectives of project management ?

The successful development and implementation of all project's procedures. A project, regardless of its size, generally involves five distinctive phases of equal importance: **Initiation, Planning and Design, Construction & Execution, Monitoring, Control & Completion.** The smooth and uninterrupted development and execution of all the above phases ensures the success of a project.

Productive guidance, efficient communication and apt supervision of the project's team. Always keep in mind that the success or failure of a project is highly dependent on teamwork, thus, the key to success is always in collaboration. To this end, the establishment of good communication is of major importance. On one hand, information needs to be articulated in a clear, unambiguous and complete way, so everything is comprehended fully by everyone and on the other hand, is the ability to be able listen and receive constructive feedback.

What are the objectives of project management ?

The achievement of the project's main goal within the given constraints. The most important constraints are, **Scope** in that the main goal of the project is completed within the estimated **Time**, while being of the expected **Quality** and within the estimated **Budget**. Staying within the agreed limitations always feeds back into the measurement of a project's performance and success.

Optimization of the allocated necessary inputs and their application to meeting the project's pre-defined objectives, is a matter where is always space for improvement. All **processes and procedures** can be **reformed and upgraded** to enhance the sustainability of a project and to lead the team through the strategic change process.

What are the objectives of project management ?

Production of a complete project which follows the client's exclusive needs and objectives. This might mean that you need to **shape and reform the client's vision** or to negotiate with them as regards the project's objectives, to modify them into feasible goals. Once the client's aims are clearly defined they usually impact on all decisions made by the project's stakeholders. Meeting the client's expectations and keeping them happy not only leads to a **successful collaboration** which might help to eliminate surprises during project execution, but also ensures the sustainability of your professional status in the future.



who?

why?

what?

when?

where?

PROJECT
planning
5Ws

Project planning generally consists of:

- ✓ Determining the project management methodology to follow (e.g. whether the plan will be defined wholly up front, iteratively, or in rolling waves);
- ✓ Developing the scope statement;
- ✓ Selecting the planning team;
- ✓ Identifying deliverables and creating the product and work breakdown structures;
- ✓ Identifying the activities needed to complete those deliverables and networking the activities in their logical sequence;
- ✓ Estimating the resource requirements for the activities;
- ✓ Estimating time and cost for activities;
- ✓ Developing the schedule;
- ✓ Developing the budget;
- ✓ Risk planning;
- ✓ Developing quality assurance measures;
- ✓ Gaining formal approval to begin work.

Additional processes, such as planning for communications and for scope management, identifying roles and responsibilities, determining what to purchase for the project and holding a kick-off meeting are also generally advisable.

Project

Tasks



Resources



© Can Stock Photo

Planning



After the initiation stage, the project is planned to an appropriate level of detail (see example of a flow-chart). The main purpose is to plan time, cost and resources adequately to estimate the work needed and to effectively manage risk during project execution. As with the initiation process group, a failure to adequately plan greatly reduces the project's chances of successfully accomplishing its goals.

The Project Schedule:

- ❖ outlines the tasks and activities of the project;
- ❖ the duration;
- ❖ start and end dates for each individual task and the project as a whole;
- ❖ and the resources and effort required.

Developing a project Schedule involves a number of **defined steps**.

- Work Breakdown Structure (WBS)
- Work Packages
- Activities and tasks
- Schedule

For most projects there will be at least two separate Schedules developed. One will be for the Initiation Phase (Initial Schedule) and the other for the Planning, Execution and Closure phases. All schedules are added to Eclipse for tracking and updating.

The Initial Schedule is developed in the Initiation Phase of the project to help produce the Project Charter. At this point, the Schedule is not expected to be very accurate or contain firm dates; rather it gives the Project Manager (PM) a rough idea of the project timeline and the assignment of resources. When the initial schedule is approved, a **second Schedule** is developed, with the approval date as the Project **"start date"**.

In the Planning Phase, a Project Management Plan is created and the second Schedule is updated with a more accurate and realistic timeline. In effect, the start and end dates of the first Schedule will be replaced by the start and end dates of the second Schedule. Eclipse allows for the development and saving of multiple schedules. This feature can help in creating **"what if"** schedules without disturbing the **"active"** schedule.

While executing we must know what are the planned terms that need to be executed. The execution/implementation phase ensures that the project management plan's deliverables are executed accordingly. This phase involves **proper allocation, co-ordination and management of human resources** and any other resources such as material and budgets. The output of this phase is the project deliverables.

Project Documentation

- ✓ Documenting everything within a project is key to being successful. In order to maintain budget, scope, effectiveness and pace a project must have physical documents pertaining to each specific task.
- ✓ With correct documentation, it is easy to see whether or not a project's requirement has been met. To go along with that, documentation provides information regarding what has already been completed for that project.
- ✓ With the correct documentation, a project's success can be tracked and observed as the project goes on. If performed correctly documentation can be the backbone to a project's success.

Monitoring and controlling consists of those processes performed to observe project execution so that potential problems can be identified in a timely manner and corrective action can be taken, when necessary, to control the execution of the project. The key benefit is that project performance is observed and measured regularly to identify variances from the project management plan..

Monitoring and controlling includes:

- ✓ Measuring the ongoing project activities ('**where we are**');
- ✓ Monitoring the project variables (**cost, effort, scope**, etc.) against the project management plan and the project performance baseline (**where we should be**);
- ✓ Identifying corrective actions to address issues and risks properly (**How can we get on track again**);
- ✓ Influencing the factors that could circumvent integrated change control so only approved changes are implemented.

Monitoring and controlling

In **multi-phase projects**, the monitoring and control process also provides **feedback** between project phases, in order to implement corrective or **preventive actions** to bring the project into compliance with the project management plan.

Project maintenance is an ongoing process, and it includes:

- ✓ Continuing support of end-users
- ✓ Correction of errors
- ✓ Updates to the product over time



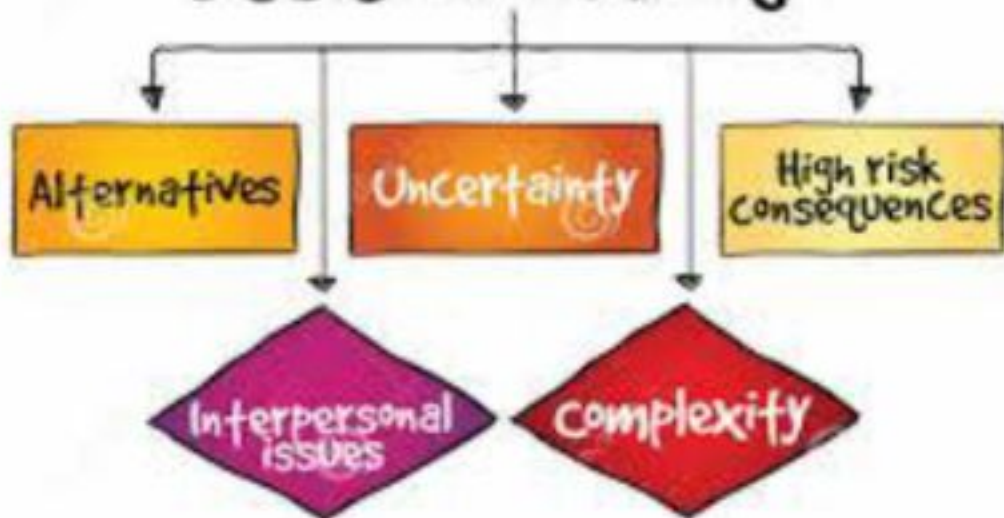
Monitoring and controlling

The tasks of **project controlling** are also:

- ✓ **The creation of infrastructure** for the supply of the right information and its update.
- ✓ The establishment of a way to **communicate disparities** of project parameters.
- ✓ The development of project information technology based on an intranet or the determination of a project key performance indicator system (KPI)
- ✓ Divergence analyses and generation of proposals for potential project regulations.
- ✓ The **establishment of methods** to accomplish an appropriate project structure, project workflow organization, project control and governance.
- ✓ Creation of **transparency** among the project parameters.

Monitoring and controlling

Decision Making



Decision-making

A decision is an act of selection or choice of one action from several alternatives.

Decision-making can be defined as the process of selecting a right and effective course of action from two or more alternatives for the purpose of achieving a desired result. Decision-making is the essence of management.

According to P. F. Drucker – **“Whatever a manager does he does through making decisions.”** All matters relating to planning, organizing, direction, co-ordination and control are settled by the managers through decisions which are executed into practice by the operators of the enterprise. Objectives, goals, strategies, policies and organizational designs are all to be decided upon in order to regulate the performance of the business.

The entire managerial process is based on decisions. Decisions are needed both for tackling the problems as well as for taking maximum advantages of the opportunities available. Correct decisions reduce complexities, uncertainties and diversities of the organizational environments.

Importance of Decision-Making:

Management is essentially a bundle of decision-making process. The managers of an enterprise are responsible for making decisions and ascertaining that the decisions made are carried out in accordance with defined objectives or goals.

Decision-making plays a vital role in management. Decision-making is perhaps the most important component of a manager's activities. It plays the most important role in the planning process. When the managers plan, they decide on many matters as what goals their organization will pursue, what resources they will use, and who will perform each required task.

When plans go wrong or out of track, the managers have to decide what to do to correct the deviation.

In fact, the whole planning process involves the managers constantly in a series of decision-making situations. The quality of managerial decisions largely affects the effectiveness of the plans made by them. In organizing process, **the manager is to decide upon the structure, division of work, nature of responsibility and relationships, the procedure of establishing such responsibility and relationship and so on.**

Importance of Decision-Making:

In co-ordination, decision-making is essential for providing unity of action. In control, it will have to decide how the standard is to be laid down, how the deviations from the standard are to be rectified, how the principles are to be established how instructions are to be issued, and so on.

The ability to make good decisions is the key to successful managerial performance. The managers of most profit-seeking firms are always required to take a wide range of important decisions in the areas of pricing, product choice, cost control, advertising, capital investments, dividend policy, personnel matters, etc. Similarly, the managers of non-profit seeking concerns and public enterprises also face the challenge of taking vital decisions on many important matters.

Decision-making is also a criterion to determine whether a person is in management or not. If he participates in decision-making, he is regarded as belonging to management staff. In the words of George Terry: **"If there is one universal mark of a manager, it is decision-making."**

Importance of Decision-Making:

According to P. F. Drucker:

"Whatever a manager does, he does through making decisions."

In any business, whether large or small, the conditions are never static, they are perceptively dynamic. The old order is always yielding place to new either in personnel or in unforeseen contingencies. Changes in conditions are the usual rule. Such a situation calls for actions that involve decision-making.

So, decision-making is deeply related with management functions and both are bound up together inseparably. When a manager plans or organises, orders or advises, approves or disapproves anything, he will have to move with the process of decision-making. In all managerial functions, decision-making is an indispensable accompaniment.

Roles in Decision-Making

Decider

The Decider (and there is only one Decider for each decision step) has the **ultimate authority** to decide and is in the best position to assess the system value at stake for customers, stakeholders and employees. The Decider is accountable for learning from every issue raised by the Executors and Advisors and making a decision that maximizes system value. The Decider is also **accountable for the consequences** of the decision.

Executors

The Executor is the person or persons accountable for executing the decision. Executors have the duty of giving input **about feasibility, consequences** and value of the decision. Executors must be **skilled** at raising issues with the decider in a way that clearly serves the business purpose at stake.

Roles in Decision-Making

Advisors

Advisors are **subject matter experts** who have important perspectives granted by their specific skills and experience. Advisors have the duty to raise issues related to their areas of expertise; they, too, must **raise issues** that clearly serve the business purpose. Frequently an Advisor can help design the decision team to ensure the **right participation** relative to business risk.

Recipients

The Recipients are those who needs only to be informed of the decision to be able to act accordingly. Recipients play **no role** in the decision-making process.

Quiz Time

<https://quizizz.com/join?gc=033877>

Traditional management systems

- **Gantt's or Bar Chart**
 - **Load chart**
 - **Progress Chart**

- ✓ Bar charts were introduced by **Henry Gantt** around 1900 A.D., Therefore they are also called as **Gantt charts**.
- ✓ Bar chart is a graphical representation of activity v/s time.
- ✓ Usually horizontal axis represents the time duration and vertical axis represents activities or jobs to be performed.
- ✓ The beginning and end of each bar show the “time of start” and “time of finish” of the activity respectively.
- ✓ Therefore the length of the bar represents the time required for the completion of the activity.



Gantt's or Bar Chart

Advantage of Bar chart:

- ✓ It is simple to draw, easy to understand and can be drawn quickly.
- ✓ No trained/skilled personnel is required to make the chart.
- ✓ The progress achieved at the site is expressed in terms of percentage,
- ✓ It may be used for depicting the resource requirement of a construction project.
- ✓ It provides a visual representation of the entire project which shows exactly when each of the above activities is supposed to start and finish.

Limitations of Bar Chart:

1. Lack of Degree of Details

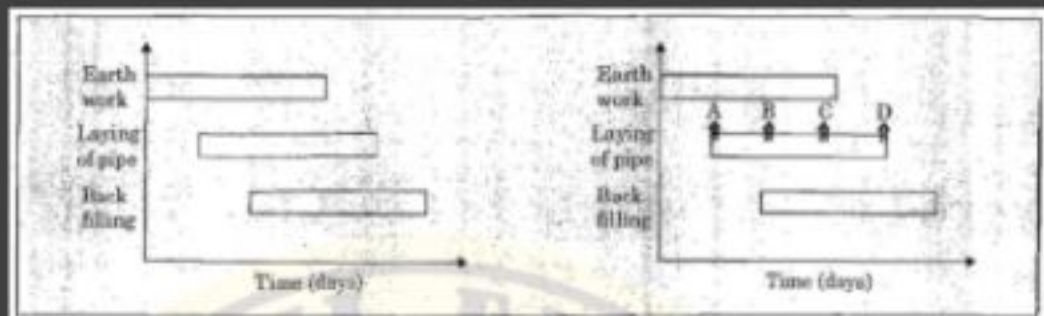
In case of big projects only major activities can be shown, if at all the activities of big project are shown on the bar chart then it may become too clumsy. Therefore bar chart are not preferred for big projects.

An activity is represented as a bar, without any details of sub-activities contained in it due to these effective control over activities can be done.

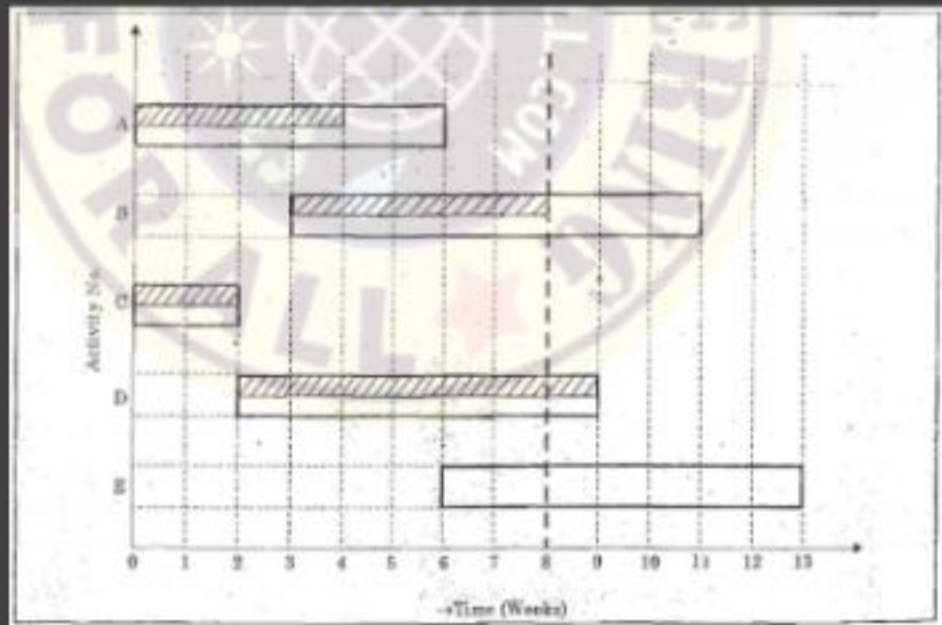
For example consider activities in the below bar chart 'Laying of pipe work' is shown as a bar, but following sub activities controls the satisfactory and timely completion of the activity.

- A. Notice inviting for supply of pipe
- B. Finalisation of bid
- C. Supply of pipes at site
- D. Final laying of pipe

For the satisfactory and timely completion this activity, these sub-activity should be scheduled properly. The above detail can be shown effectively by marking stages (also called 'milestones' on that particular activity bar.



Progress Chart



Gantt's or Bar Chart

2. Review of Project Progress

A bar chart does not show the 'Progress of work in the project and therefore it can be used as a control device.

As progress made at a particular instant of time is required for proper control of the project.

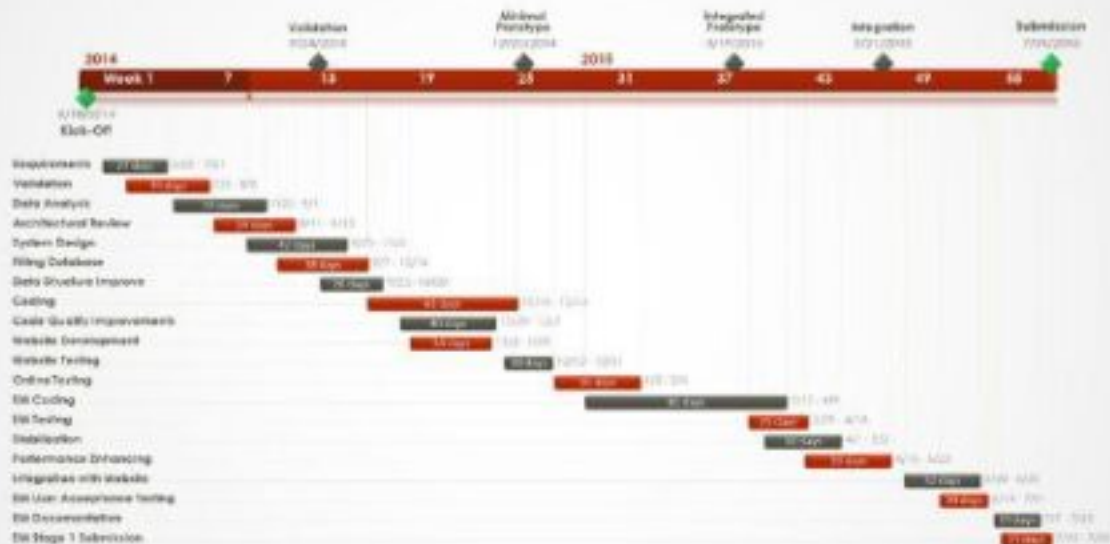
This difficulty or drawback can be overcome by showing of each activity by hatched lines in the half of the width of the bar.

Progress of each activity is marked on the above chart with the help of hatched lines at the end of 8 weeks. Following observations are made.

1. Activity A is behind schedule by 4 weeks
2. Activity B is on schedule and Activity C is completed
3. Activity D is ahead of schedule by 1 week
4. Activity E has not started yet and therefore need to be rescheduled.



Gantt's or Bar Chart



Gantt's or Bar Chart

Problem No.1

The activity break down for a certain project is as under:

- Activity 2 & 3 can be done concurrently and both must follow Activity 1.
- Activity 2 must precede activity 4.
- Activity 5 cant begin until both numbers 2 and 3are completed.
- Activity 6 can be started only after numbers 4 and 5 are completed.
- Activity 7 is the last activity which can be started only after completing activity 5.

Prepare the Bar Chart for the project.

Problem No.1

Bar Chart Info:

Activity No.	Duration (Weeks)
1	1
2	2
3	4
4	3
5	1
6	2
7	4

CPM & PERT

A convenient analytical and visual technique of **PERT** and **CPM** prove extremely valuable in assisting the managers in managing the projects.

PERT stands for **Project Evaluation and Review Technique** developed during 1950's. The technique was developed and used in conjunction with the planning and designing of the Polaris missile project.

CPM stands for **Critical Path Method** which was developed by DuPont Company and applied first to the construction projects in the chemical industry.

Though both PERT and CPM techniques have similarity in terms of concepts, the basic difference is; CPM has single time estimate and PERT has three time estimates for activities and uses probability theory to find the chance of reaching the scheduled time.

CPM NETWORK

Critical Path Method (CPM) is a network analysis approach. It finds out which sequence of activities has the least measure of scheduling resilience by which it can predict the duration of the project. It is based on the estimation of the standard time needed for execution of an activity. CPM manages both time and cost of the project.

In this method, the critical path of the project is established by identifying the critical activities of the project. Critical activities are the activities whose total float value is '0'.

CPM MERITS

It has the following advantages:

- ❖ It figures out the activities which can run parallel to each other.
- ❖ It helps the project manager in identifying the most critical elements of the project.
- ❖ It gives a practical and disciplined base which helps in determining how to reach the objectives.
- ❖ CPM is effective in new project management.
- ❖ CPM can strengthen a team perception if it is applied properly.
- ❖ CPM provides demonstration of dependencies which helps in the scheduling of individual activities.
- ❖ It shows the activities and their outcomes as a network diagram.
- ❖ It gives a fair and concise procedure of documenting of project.
- ❖ It helps in determining the slack time.
- ❖ An explicit and clear approach of communicating project plans, schedules, time and cost performance is developed.
- ❖ It is extensively used in industry.
- ❖ It helps in optimization by determining the project duration.

CPM DE-MERITS

It has the following disadvantages:

- ❖ The scheduling of personnel is not handled by the CPM.
- ❖ In CPM, it is difficult to estimate the completion time of an activity.
- ❖ The critical path is not always clear in CPM.
- ❖ For bigger projects, CPM networks can be complicated too.
- ❖ It also does not handle the scheduling of the resource allocation.
- ❖ In CPM, critical path needs to be calculated precisely.

PERT NETWORK

Before any activity begins related to the work of a project, every project requires an advanced, accurate time estimate. Without an accurate estimate, no project can be completed within the budget and the target completion date. Developing an estimate is a complex task. If the project is large and has many stakeholders, things can be more complex. Therefore, there have been many initiatives, to come up with different techniques for estimation phase of the project, in order to make the estimation more accurate.

PERT (Program Evaluation and Review Technique) is one of the successful and proven methods among the many other techniques, such as, CPM(Critical Path Method), Function Point Counting, Top-Down Estimating, WAVE, etc. PERT was initially created by the US Navy in the late 1950s. The pilot project was for developing Ballistic Missiles and there have been thousands of contractors involved. After PERT methodology was employed for this project, it actually ended two years ahead of its initial schedule. PERT introduces uncertainty into the account by 3 kinds of time estimating of activity duration which are as follows:

PERT AND THREE TIME ESTIMATE

The Optimistic Time Estimate (t_o)

The optimistic time (t_o) is an estimate of the **minimum time required for an activity if nothing exceptionally goes wrong**. Ideal conditions are assumed to prevail during the execution of the activity.

The Pessimist Time Estimate (t_p)

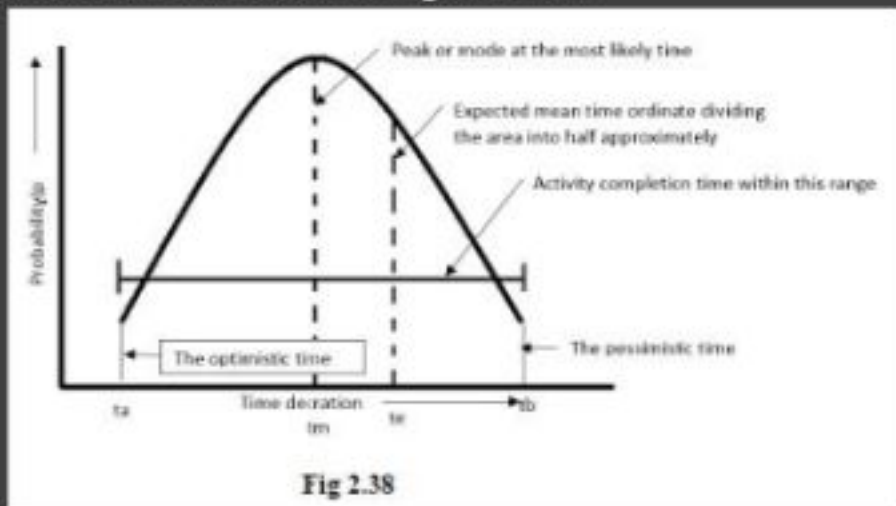
The pessimistic time (t_p) is an estimate of **the maximum time required for an activity if unusually everything goes wrong**, assumed to prevail during the execution. Of course, major catastrophes like labour strike or unrest etc. are excluded from estimate.

The Most Likely Time Estimate (t_m)

The most likely time (t_m) is based on experience and judgment being based on the time required if the activity is repeated a number of times under essentially the same conditions. This time signifies the most frequently occurring time. It reflects a situation "things are as usual, nothing exciting".

PERT AND THREE TIME ESTIMATE

The general shape of probability distribution curve associated with the three time estimates of PERT is shown in Fig 2.38 below



FREQUENCY DISTRIBUTION

As stated above, the three time estimates are very difficult to prepare, unless some guidance is available. The planner should base the estimations on available information and past experience. For example, consider a certain activity 'A' under diverse conditions. The time required for the completion of this activity under each condition is known. Naturally, the time of completion will be short (optimistic time) if better than normal conditions exist. The number of cases when such normal conditions exist for completion of an activity A will be naturally small. Similarly, time of completion will be long (pessimistic time) if adverse conditions are there, and such cases will also be small in number.

FREQUENCY DISTRIBUTION

If a curve is now plotted between the 'time' of completion and the number of jobs completed in that 'time', a *frequency distribution curve*, such as the one shown in Fig. 5.1 will be obtained. From the curve, it is clear that there are large number of cases of the activity that are completed in the *most likely time*. Point *P* corresponds to the *opt. realistic time* (t_0), point *R* corresponds to the *possibilities time* (t_1) while point *Q* corresponds to the *most likely time* (t_2). Such a curve is also called *unimodal curve*, since it has single hump.

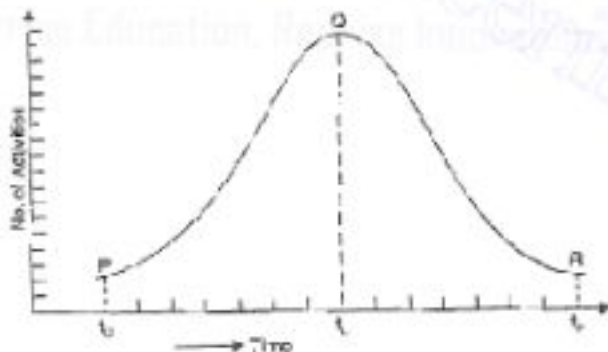


FIG. 5.1. FREQUENCY DISTRIBUTION CURVE.

FREQUENCY DISTRIBUTION

The curve shown in Fig 5.1 is symmetrical on either side of point Q; such a curve is known as the normal curve. It is not necessary that a frequency distribution curve may be normal; it

may have skew due to which it is not symmetrical about the peak Q.

Fig. 5.2 (a) shows the frequency distribution curve for job A, having skew to the left. (The difference between t_2 and t_3 is only 1 day while the difference between t_1 and t_2 is $7-4=3$ days. Fig. 5.2 (c) shows the frequency distribution curve for activity B,

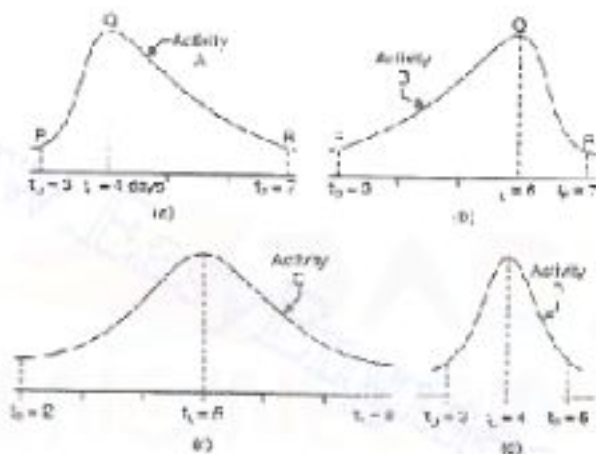


FIG. 5.2 FREQUENCY DISTRIBUTION CURVES

FREQUENCY DISTRIBUTION

having skew to the right ; the difference between t_3 and t_6 is equal to $6 - 3 = 3$ days while the difference between t_5 and t_1 is only 1 day. The frequency distribution curves for activities C and D, shown in Fig. 5.2 (c) and (d) respectively are symmetrical about the peak, and they are therefore *normal curves*. However, curve (c) has wider variation between t_p and t_0 and has therefore *greater uncertainty* in time estimate. On the other hand, curve (D) has smaller variation between t_p and t_1 , and hence more reliable time estimates are expected. To conclude, *a wide range in time estimates represents, greater uncertainty and hence less confidence in our ability to correctly anticipate the actual time that the activity will require.*

MEAN, VARIANCE & STANDARD DEVIATION

From the previous article we find that the frequency distribution curve can be drawn if data about varying durations of time taken for the completion of jobs of a particular type are available. If this curve is symmetrical, then it is called the *normal curve*; otherwise it is said to have a *skew* which could be either to the left or to the right. Whatever may be the form of the curve, the following aspects of the characteristics of the distribution are important:

- (i) Mean time or average time (called the mean of the distribution),
- (ii) Deviation,
- (iii) Variance and
- (iv) Standard deviation.

Mean. Mean of the distribution may be defined by the algebraic sum of time durations taken by various jobs divided by the number of the jobs:

MEAN, VARIANCE & STANDARD DEVIATION

$$t_m = \frac{\Sigma t}{n} \quad \dots(5.1)$$

Deviation. Deviation is the difference between the time under consideration and the mean time. This difference may be either positive or negative.

$$\text{Thus} \quad \delta = t - t_m \quad \dots(5.2)$$

where δ = deviation of any time t from the mean

t = time under consideration, for which deviation is being found.

Variance. Variance is the mean of the squared deviations. It is expressed by σ^2 .

$$\text{Thus,} \quad \sigma^2 = \frac{\Sigma \delta^2}{n} = \frac{\Sigma (t - t_m)^2}{n} \quad \dots(5.3)$$

Variance is calculated in the following steps :

- (i) Obtain the *mean* of the distribution, by Eq. (5.1).
- (ii) Determine the deviation of each time from the mean.
- (iii) Find square of these individual deviations.
- (iv) Find the mean of the squared deviations.

MEAN, VARIANCE & STANDARD DEVIATION

It is to be noted that though the deviations may be negative also, but their squares will always be positive. Hence variance will always be positive. It cannot have zero value unless each individual deviation is zero.

Variance is commonly used in statistics as measure of *variability* of the distribution.

Standard deviation. It is simply the square root of the variance. Standard deviation is denoted by symbol σ .

Thus,
$$\sigma = \sqrt{\frac{\sum(x - \bar{x})^2}{n}} \quad \dots(5.4)$$

PROBABILITY DISTRIBUTION

Probability is connected with *chance* and *uncertainty*. The three time estimates that the estimator selects either from his experience or from the *frequency distribution* has inherent uncertainties. In probability analysis, and in consequent probability distribution, we try to associate numbers with uncertainties. In the frequency distribution one studies the group behaviour, while in the probability distribution, we have the distribution of probability values for all possible outcomes. The probability measures are always between 0 to 1. If an event has probability of 1, it is certain to occur, while if the probability is zero it will not occur. Closer the probability value is to 1, more certain is the occurrence of the event.

NORMAL PROBABILITY DISTRIBUTION

The probability curve is not necessarily symmetrical about its apex. If the curve is symmetrical, then it is known to have *normal* or *Gaussian* distribution, shown in Fig. 5.5.

The mean of the *normal probability distribution* is denoted by μ (i.e. $x = \mu$). It can be proved that :

(a) Approximately 68% of the values of the normal distribution lie within $\pm \sigma$ from the average, where σ is the standard deviation. This means that the shaded area of the curve (Fig. 5.5) between $x = \mu - \sigma$ to $x = \mu + \sigma$ is 68% of the total area.

(b) Approximately 95% of all the values lie within $\pm 2\sigma$ from the average. This means that the area of the curve between $x = \mu - 2\sigma$ to $x = \mu + 2\sigma$ is 95% of the total area.

(c) Approximately 99.7% of all the values lie within $\pm 3\sigma$ from the average. This means that the area of the curve between $x = \mu - 3\sigma$ to $x = \mu + 3\sigma$ is 99.7%.

NORMAL PROBABILITY DISTRIBUTION

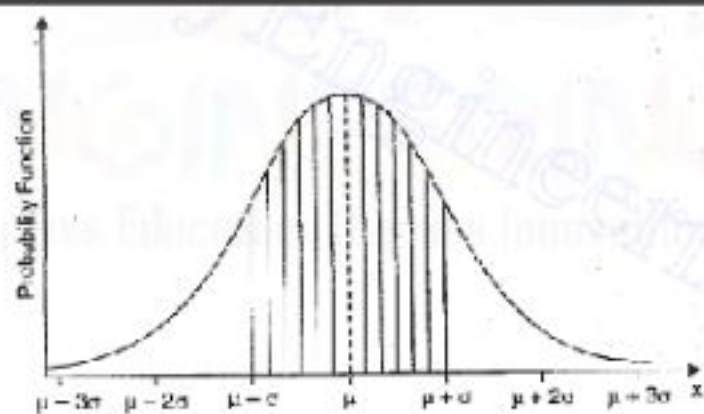


FIG. 5.5. NORMAL PROBABILITY DISTRIBUTION.

The last property (c) can be used to calculate the *standard deviation* directly if the minimum time (t_0) and maximum time (t_f) are known. Let us say that the minimum time is 6 days and maximum time is 18 days for the completion of a job. If 99.7% of all the values (i.e. possible completion times) are assumed to lie between 6 and 18 days then the distance between the extreme left value (6 days) and extreme right value (18 days) should be equal to $\pm 3\sigma$ or 6σ in total. The standard deviation

NORMAL PROBABILITY DISTRIBUTION

$$= \frac{15 - 6}{6} = 2 \text{ days.}$$

Hence we conclude, in general, that standard deviation is given by

$$\sigma = \frac{t_p - t_o}{6} \quad \dots(5.5)$$

or variance
$$\sigma^2 = \left(\frac{t_p - t_o}{6} \right)^2 \quad \dots[5.6(a)]$$

It is seen that the standard deviation is affected by the relative distance from the most optimistic estimate to the most pessimistic estimate. It is not influenced by the most likely estimate (t_p).

The above method of calculating standard deviation is *approximate*. A more exact method is by frequency distribution, explained in example 5.1. However, in PERT problems, the emphasis is one-time, non-repetitive projects for which there is no history of the activity. Hence we must base computations for σ on the given time estimates of the estimator. If the estimator feels that his range of t_o and t_p includes about all the possible values under the curve, then the standard deviation can be computed from Eq. 5.6 with reasonable accuracy.

Standard Normal Curve

302 Chapter 18

Table 18.1
STANDARD NORMAL CURVE

z = The number of standard deviations to the right of the mean



The area under the curve (as shown in the figure) always includes the portion containing the mean.

X	0	1	2	3	4	5	6	7	8	9
0.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
0.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5754
0.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
0.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
0.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
0.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
0.6	.7258	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7518	.7549
0.7	.7580	.7613	.7643	.7673	.7704	.7734	.7764	.7794	.7823	.7852
0.8	.7881	.7910	.7939	.7967	.7996	.8023	.8051	.8078	.8106	.8133
0.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830

$X = 0.76$ gives the probability of completing the project within 28 days as 77.64%

THE BETA DISTRIBUTION

The beta distribution is a typical type of probability distribution, which fits well for PERT analysis. A beta distribution is the one which is not symmetrical about its apex. Fig. 5.6 shows two beta distributions, one having skew to the left (*beta distribution for optimistic estimator*) and the other having skew to the right (*beta distribution for the pessimistic estimator*).

The originators of PERT were interested in finding that type of probability distribution which satisfies the following conditions :

1. The distribution should have a small probability of reaching the most optimistic time (shortest time).
2. The distribution should have a small probability of reaching the most pessimistic time (longest time).
3. The distribution should have one and only one most likely time (*i.e.* unimodal) which would be free to move between the two extremes mentioned in 1 and 2 above.

THE BETA DISTRIBUTION

4. The distribution should be such that the amount of uncertainty in the estimating can be measured easily.

The above mentioned four requirements are met with beta distribution. Hence this distribution is used in PERT analysis.

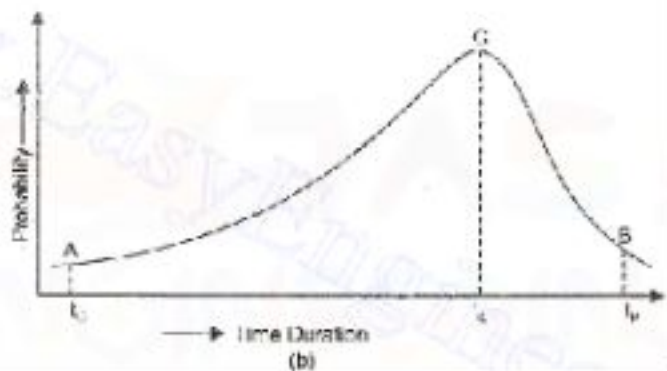
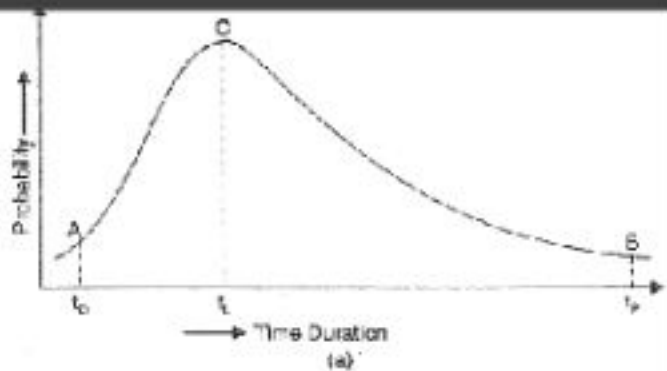
It can be shown that for Beta distribution, the standard deviation is given by

$$\sigma = \frac{t_P - t_O}{6}$$

The variance $\sigma^2 = \left(\frac{t_P - t_O}{6} \right)^2$.

We have already seen that *variance* is the measure of *uncertainty*. Greater the variance, greater will be the uncertainty.

THE BETA DISTRIBUTION



EXPECTED TIME

The three time estimates t_o (optimistic time), t_p (pessimistic time) and t_L (most likely time) are identified on the Beta-distribution. The variance and standard deviation can be computed using t_o and t_p . However, one must combine the three time estimates into one single time—the average time taken for the completion of the activity or job. This average time or single workable time is commonly called the *expected time* and is denoted by t_E . If the exact shape of the probability distribution curve is known, the average time or expected time could be accurately calculated. However, since the precise curves are never available (specially for non-repetitive jobs) we must use *approximation*. This is done algebraically, using a weighted average derived by statisticians. In computing the expected time, a weightage of 1 is given to the optimistic time t_o , weightage of 4 to the most likely time (t_L) and weightage of 1 to the most pessimistic time (t_p).

Thus,

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

...(5.7)

PROBABILITY OF COMPLETION OF PROJECT

Once the expected mean time, variance and standard deviation of the project are determined. It is possible to calculate from probability theory, the chance of meeting the project on scheduled time. To do this, it is considered to have a **normal probability distribution curve** with the mean value and standard deviation.

The reason behind the assumption of normal distribution curve is that we can use information and data available about the normal curve from a book on probability. The curve has a definite character which can be easily integrated to find the area of curve.

To calculate the chances of meeting the time, it is necessary to plot a normal distribution curve, the probabilities for the interval from the mean value to the value of x given by definite integration;

PROBABILITY OF COMPLETION OF PROJECT

The probability factor (z) is the same as normal deviate. We can directly take the value of % probability corresponding to the normal deviate z from the probability Table. Intermediate value may be linearly interpolated.

When z is positive, the chances of completing the project in time are more than 50%.

When z is zero, the chances of completing the project in time are more than fifty-fifty.

When z is negative, the chances of completing the project in time are less than 50%.

If the probability of completion of project in time is assumed, the scheduled time can also be forecasted.

The base of integration is changed by assuming,

$$x - \mu / \sigma = z$$

$$\frac{x - \mu T}{\delta T} = z$$

CPM vs PERT

CPM	PERT
<ol style="list-style-type: none"><li data-bbox="175 280 659 387">1) It is basically having DETERMINISTIC approach in the design of network.<li data-bbox="175 441 652 508">2) Only one time estimate is required for each activity.<li data-bbox="175 562 638 629">3) It is built-up of activity oriented diagram.<li data-bbox="175 643 662 868">4) Time and cost both are controlling factors. There is an optimum duration of the project at which the project cost is minimum and this can be obtained by crashing the network.	<ol style="list-style-type: none"><li data-bbox="746 280 1223 387">1) It is basically having PROBABILISTIC approach in the design of network.<li data-bbox="746 441 1250 550">2) Three time estimate (in the form of pessimistic time, optimistic time and most likely time) for each activity.<li data-bbox="746 562 1180 629">3) It is built-up of event oriented diagram.<li data-bbox="746 679 1247 788">4) Time only is the controlling factor and the cost is assumed proportional to the project duration.

CPM vs PERT

CPM	PERT
<p>5) Critical events must have zero slack.</p> <p>6) It is recommended for repetitive nature of work where past experiences are adequately available.</p>	<p>5) Critical events may be positive/zero/negative depending upon the project scheduled completion time.</p> <p>6) It is recommended for research and development project where no past experience are available or where great uncertainty lies in the time estimation.</p>



UNIT -II

BY AR DHIVYA SHREE G

***PROJECT PROGRAMMING AND
CRITICAL PATH METHOD***

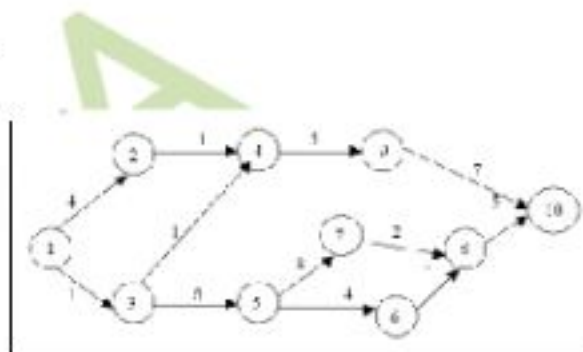
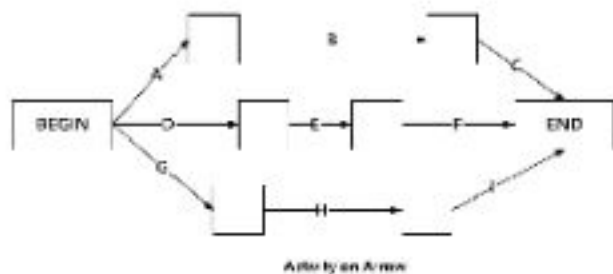
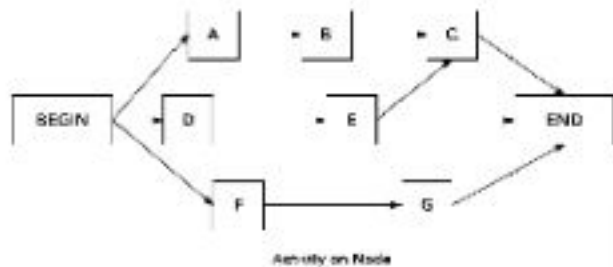
CONTENTS

- Part 1-Project Network-Events Activity, Dummy, Network Rules, Graphical Guidelines for Network, Numbering the events, Cycles, Development of Network-planning for Network Construction, Models of Network construction, steps in development of Network
- Part 2-Work Break Down Structure, hierarchies.
- Part 3- Concepts: critical path method-process, activity time estimate, Earliest Event time, Latest allowable Occurrence time, start and finish time of activity, float, critical activity and critical path problems.

CPM & PERT

- A convenient analytical and visual technique of **PERT** and **CPM** prove extremely valuable in assisting the managers in managing the projects.
- **PERT** stands for **Project Evaluation and Review Technique** developed during 1950's. The technique was developed and used in conjunction with the planning and designing of the Polaris missile project.
- **CPM** stands for **Critical Path Method** which was developed by DuPont Company and applied first to the construction projects in the chemical industry.
- Though both PERT and CPM techniques have similarity in terms of concepts, the basic difference is; CPM has single time estimate and PERT has three time estimates for activities and uses probability theory to find the chance of reaching the scheduled time.

PROJECT NETWORK DIAGRAM



COMPONENTS OF PERT/CPM NETWORK

PERT / CPM networks contain two major components

- i. Activities, and
- ii. Events

Activity: An activity represents an action and consumption of resources (time, money, energy) required to complete a portion of a project. Activity is represented by an arrow, (Figure 8.1).



Figure 8.1: An Activity

Event: An event (or node) will always occur at the beginning and end of an activity. The event has no resources and is represented by a circle. The i th event and j th event are the tail event and head event respectively, (Figure 8.2).



Figure 8.2: An Event

COMPONENTS OF PERT/CPM NETWORK

Merge and Burst Events

One or more activities can start and end simultaneously at an event (Figure 8.3 a, b).



Figure 8.3

Preceding and Succeeding Activities

Activities performed before given events are known as *preceding activities* (Figure 8.4), and activities performed after a given event are known as *succeeding activities*.

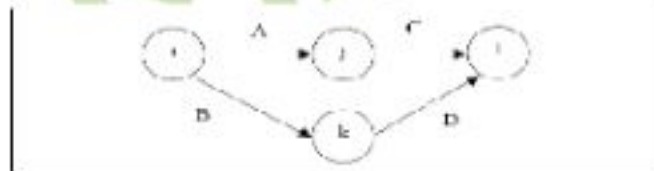


Figure 8.4: Preceding and Succeeding Activities

Activities A and B precede activities C and D respectively.

ERRORS TO BE AVOIDED IN CONSTRUCTING A NETWORK

a. Two activities starting from a tail event must not have a same end event. To ensure this, it is absolutely necessary to introduce a dummy activity, as shown in Figure 8.6.

b. Looping error should not be formed in a network, as it represents performance of activities repeatedly in a cyclic manner, as shown below in Figure 8.7.

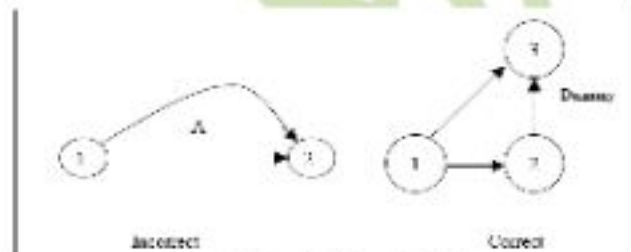


Figure 8.6: Correct and Incorrect Activities

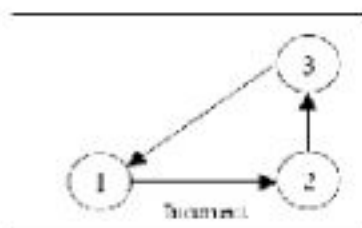
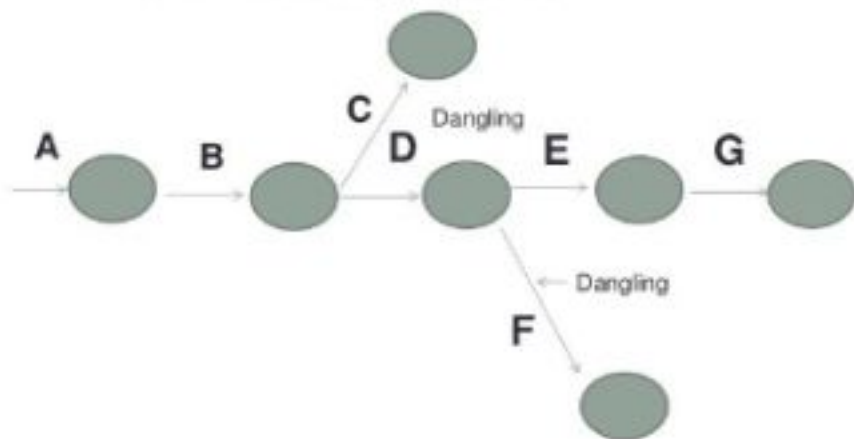


Figure 8.7: Looping Error

ERRORS TO BE AVOIDED IN CONSTRUCTING A NETWORK

Dangling

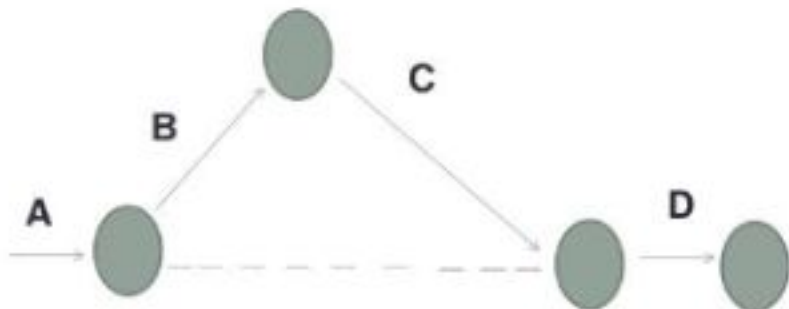
Whenever an activity is disconnected from the network it is called dangling error.



ERRORS TO BE AVOIDED IN CONSTRUCTING A NETWORK

Redundancy

When the dummy activity is introduced and it is not required, it is called redundancy errors.



ERRORS TO BE AVOIDED IN CONSTRUCTING A NETWORK

Find Out what is Wagon
Wheel error....

ERRORS TO BE AVOIDED IN CONSTRUCTING A NETWORK

Wagon wheel error:

As per Fig. 2.17, each of activities P, Q and R cannot start until all the three activities A, B and C are completed. But in reality, this may not be the situation. There is no error visible in the construction of diagram. Logical error has crept into it.

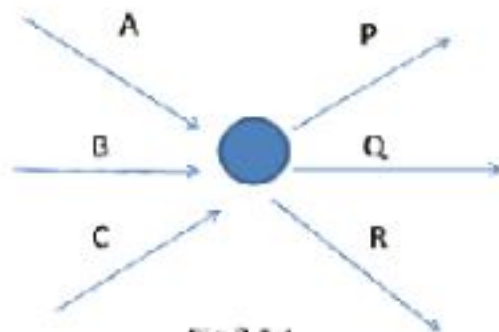
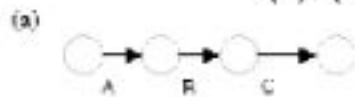


Fig 2.17

RULES IN CONSTRUCTING A NETWORK

1. No single activity can be represented more than once in a network. The length of an arrow has no significance.
2. The event numbered 1 is the start event and an event with highest number is the end event. Before an activity can be undertaken, all activities preceding it must be completed. That is, the activities must follow a logical sequence (or – interrelationship) between activities.
3. In assigning numbers to events, there should not be any duplication of event numbers in a network.
4. Dummy activities must be used only if it is necessary to reduce the complexity of a network.
5. A network should have only one start event and one end event.
6. The direction of arrows should flow from left to right avoiding mixing of direction.

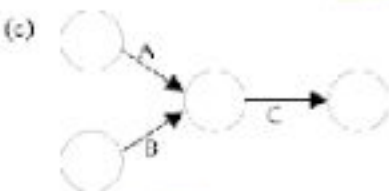
Some conventions of network diagram are shown in Figure 8.10 (a), (b), (c), (d) below:



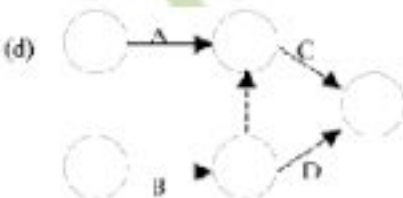
Activity B can be performed only after completing activity A, and activity C can be performed only after completing activity B.



Activities B and C can start simultaneously only after completing A.



Activities A and B must be completed before start of activity C.



Activity C must start only after completing activities A and B. But activity D can start after completion of activity B.

PROCEDURE FOR NUMBERING THE EVENTS USING FULKERSON'S RULE

- ❑ **Step1:** Number the start or initial event as 1.
- ❑ **Step2:** From event 1, strike off all outgoing activities. This would have made one or more events as initial events (event which do not have incoming activities). Number that event as 2.
- ❑ **Step3:** Repeat step 2 for event 2, event 3 and till the end event. The end event must have the highest number.
- ❑ Continue until the final event of the network which has arrows entering into and none coming out of it.

NETWORK TECHNIQUES

Networks - AoA



I Event - Activity Start

J Event - Activity End

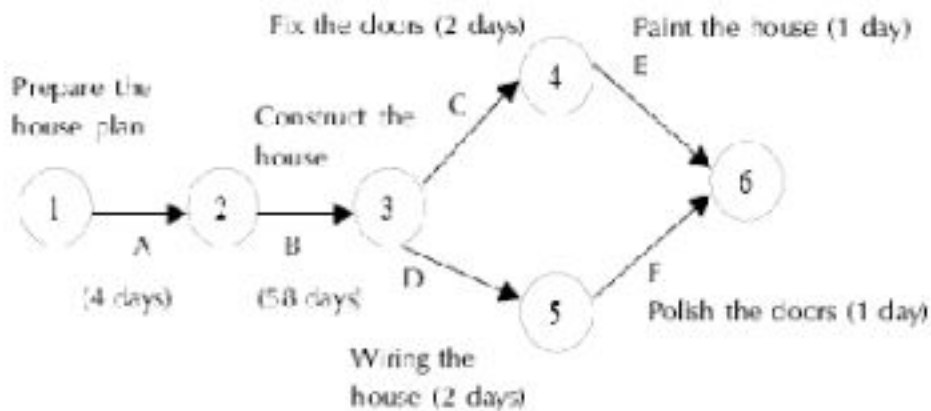
- Basic representation



Networks - AoN

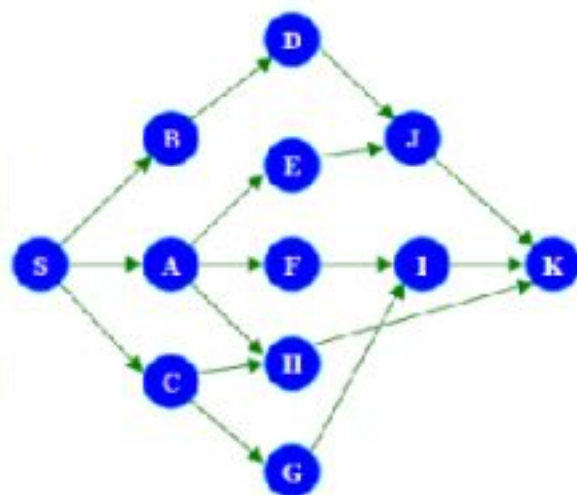


NETWORK - AoA (Activity on Arrow)



NETWORK - AoN (Activity on Node)

Activity	Preceding Activity
Start	-
A	Start
B	Start
C	Start
D	B
E	A
F	A
G	C
H	A,C
I	F,G
J	D,E
K	J,I,H



EXAMPLE 1:

Draw a network for a house construction project. The sequence of activities with their predecessors are given in Table 8.1, below.

Table 8.1: Sequence of Activities for House Construction Project

Name of the activity	Starting and finishing event	Description of activity	Predecessor	Time duration (days)
A	(1,2)	Prepare the house plan	--	4
B	(2,3)	Construct the house	A	28
C	(3,4)	Fix the door / windows	B	2
D	(3,5)	Wiring the house	B	2
E	(4,6)	Paint the house	C	1
F	(5,6)	Polish the doors / windows	D	1

EXAMPLE 1:

Solution:

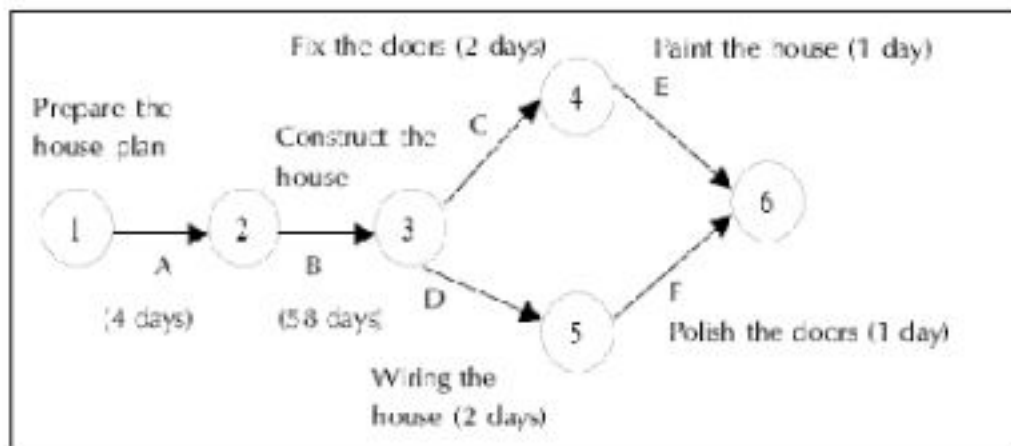


Figure 8.11: Network diagram representing house construction project.

EXAMPLE 1:

The network diagram in Figure 8.11 shows the procedure relationship between the activities. **Activity A (preparation of house plan)**, has a start event 1 as well as an ending event 2. **Activity B (Construction of house)** begins at event 2 and ends at event 3. **The activity B cannot start until activity A has been completed.** **Activities C and D cannot begin until activity B has been completed, but they can be performed simultaneously.** Similarly, **activities E and F can start only after completion of activities C and D respectively.** Both activities E and F finish at the end of event 6.

EXAMPLE 2:

Consider the project given in Table 8.2 and construct a network diagram. Table 8.2: Sequence of Activities for Building Construction Project.

Activity	Description	Predecessor
A	Purchase of Land	-
B	Preparation of building plan	-
C	Level or clean the land	A
D	Register and get approval	A, B
E	Construct the building	C
F	Paint the building	D

EXAMPLE 2:

Solution:

The activities **C** and **D** have a common predecessor **A**. The network representation shown in Figure 8.12 (a), (b) violates the rule that no two activities can begin and end at the same events. It appears as if activity **B** is a predecessor of activity **C**, which is not the case. To construct the network in a logical order, it is necessary to introduce a dummy activity as shown in Figure 8.12.

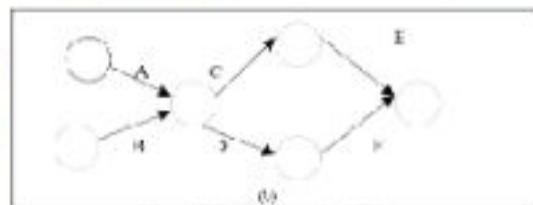
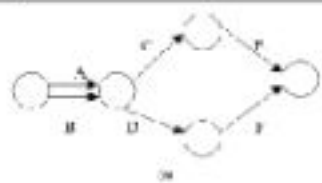


Figure 8.12. Two networks representing the E.C.C.

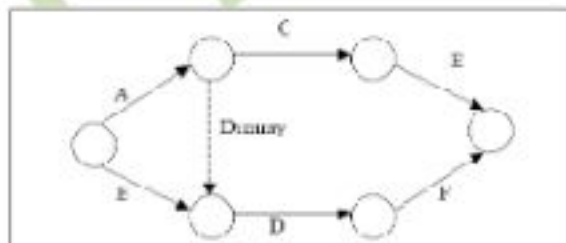


Figure 8.12. Correct representation of the E.C.C. using Dummy Activity.

EXAMPLE 3:

Construct a network for a project whose activities and their predecessor relationship are given in Table 8.3.

Table 8.3: Activity Sequence for a Project

Activity	A	B	C	D	E	F	G	H	I	J	K
Predecessor	-	-	-	A	B	B	C	D	E	H,I	F,G

EXAMPLE 3:

Solution: The network diagram for the given problem is shown in Figure 8.14 with activities A, B and C starting simultaneously.

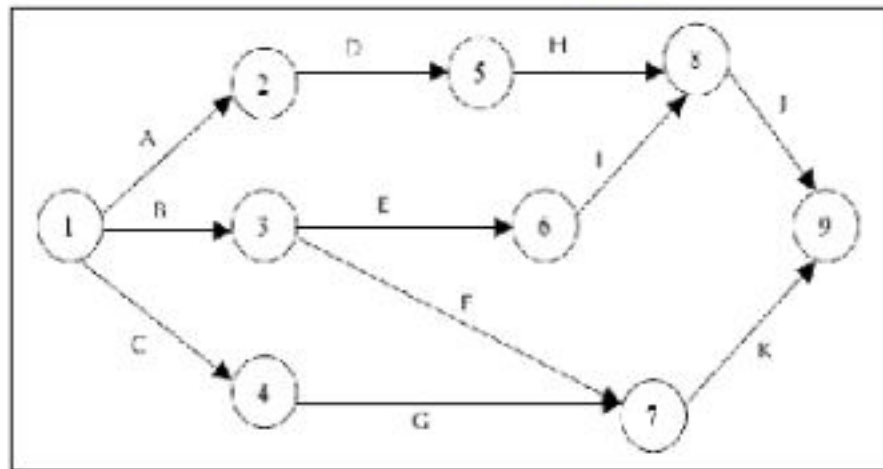


Figure 8.14: Network Diagram

EXAMPLE 4:

Draw a network diagram for a project given in Table 8.4.

Table 8.4: Project Activity Sequence

Activity	A	B	C	D	E	F	G	H	J	K	L
Immediate Predecessor	-	A	B	A	D	C, E	D	D	H	F, K	G, J

EXAMPLE 4:

Solution: An activity network diagram describing the project is shown in Figure 8.15, below:

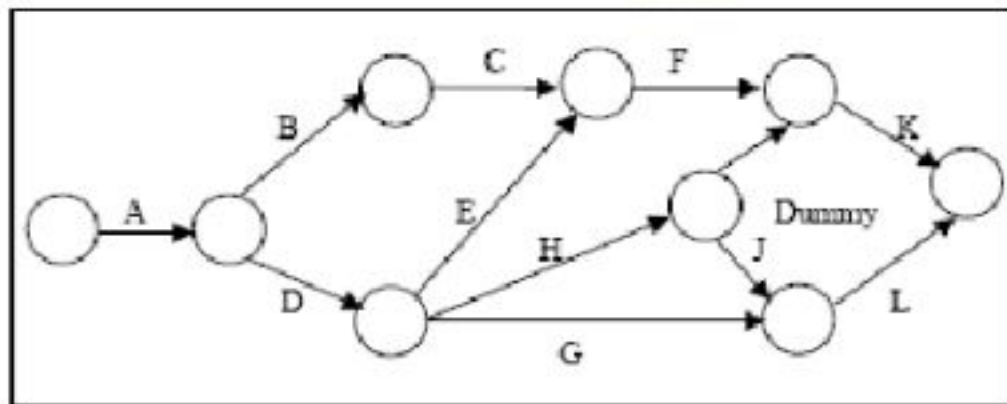


Figure 8.15: Network Diagram

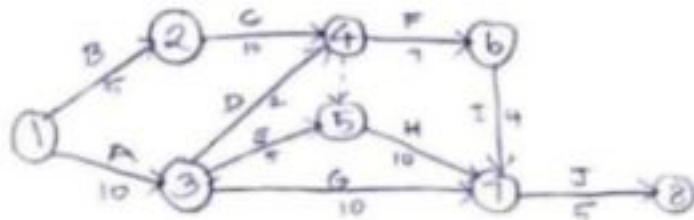
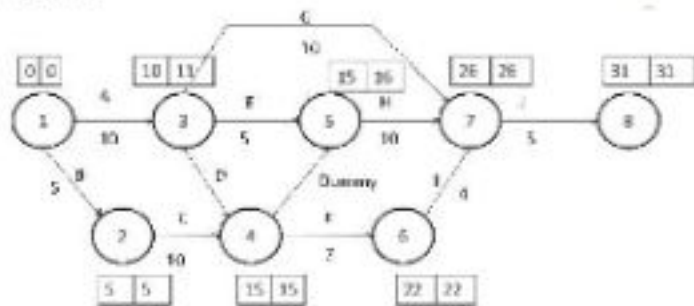
EXAMPLE 5:

Draw a network diagram for the following activities.

Event	Activity	Duration(Days)
1-2	B	5
1-3	A	10
2-4	C	10
3-4	D	2
3-5	E	5
3-7	G	10
4-5	-	-
4-6	F	7
5-7	H	10
6-7	I	4
7-8	J	5

EXAMPLE 5:

Solution: An activity network diagram describing the project is shown in below:



WORK BREAK DOWN STRUCTURE

Project work-breakdown methodology enables splitting of the project work into hierarchical work-breakdown levels of sub-projects, tasks, work packages and activities. Each activity represents an identifiable lower-level job which consumes time, and possibly resources.

Construction projects are best organized by tasks into task responsibility centres. They are best managed by work packages and best planned and monitored by activities.

The project work-breakdown process involves breaking down of the project work into manageable parts arranged in a hierarchical order till the desired level is reached. The work-breakdown levels are broadly categorized into five levels. These levels, arranged in a descending hierarchical order are given here

- Sub-project level
- Task level
- Work-package level
- Activity level
- Operations level

Each level has certain features associated with it (Table 3.1). However, it may be noted that level categorization is a broad concept and at times their overlapping may become unavoidable.

TABLE 3.1 : HOUSING PROJECT WORK BREAK DOWN LEVELS

SL No.	Features	Sub-project	Task	Work Package	Activity	Operations
1	Level designation	Level 1	Level 2	Level 3	Level 4	Level 5
2	Work-breakdown hierarchy	Project to sub-project	Sub-project to tasks, project to tasks (directly)	Tasks to work packages	Work packages to activities	Activities to operations
3	Management responsibility	Project team	Task-responsibility unit	Work centres	Work centres	Site foreman
4	Planning level	Corporate plan	Project summary plan, Design production plan, Construction plan	Project master plan, Contracted work milestone plan, Project budget	Project detailed plan, Contracted work-control plan, Task/work package plan, Short-term work programmes, Resource mobilisation plan	Resource work programmes
5	Plan duration unit	Months	Months/weeks	Weeks	Weeks/days	Days/hours

PROJECT WORK BREAK DOWN LEVELS

The work break down structure of a project forms the basis for listing of activities, modification of systems, sorting data by hierarchy levels, structuring of work organisation and managing similar scope multi level projects.

■ Sub-projects Level

Sub-projects are derived by dividing the project work into independent large-volume mini projects or task groups. For instance, in a housing project, each group of major works which can progress in a systematic manner, without interference from other works can be termed as a sub-project.

The number of sub-projects in a project varies with the nature of the project. Each sub-project comprises one or more substantial work tasks. The sub-project level aids in identifying tasks. In the 2000 Housing Units Project, each type of residential, educational and public building can be taken as a sub-project (See Exhibit 3.1).

EXHIBIT 3.1 : HOUSING PROJECT WORK BREAK DOWN LEVELS

Showing Sub – Project level & Task level



PROJECT WORK BREAK DOWN LEVELS

■ Task Levels



The project or sub-project work can be split up into various tasks. A *task is an identifiable and deliverable major work*. It is an entity in itself and can be performed without much interference from other tasks. A task is supported by its design package. Each task is assigned time and cost objectives and is provided with planned resources for accomplishing the task objectives. The task execution is entrusted to a task responsibility unit, headed by a manager or a senior engineer.

Task level is used in the project-summary plan, the design-preparation plan and the contract tendering plan. In the 2000 Housing Units Project, the construction works in each residential building can be grouped under three main tasks, i.e. foundation, superstructure and finishes (See Exhibit 3.1).

PROJECT WORK BREAK DOWN LEVELS

■ Word-Packages Levels



A project task can be further subdivided into one or more work packages. *Each work package contains a sizeable, identifiable, measurable, costable and controllable package of work.* Exhibit 3.2 shows the work packages for the construction of a residential building of the Housing Units Project.

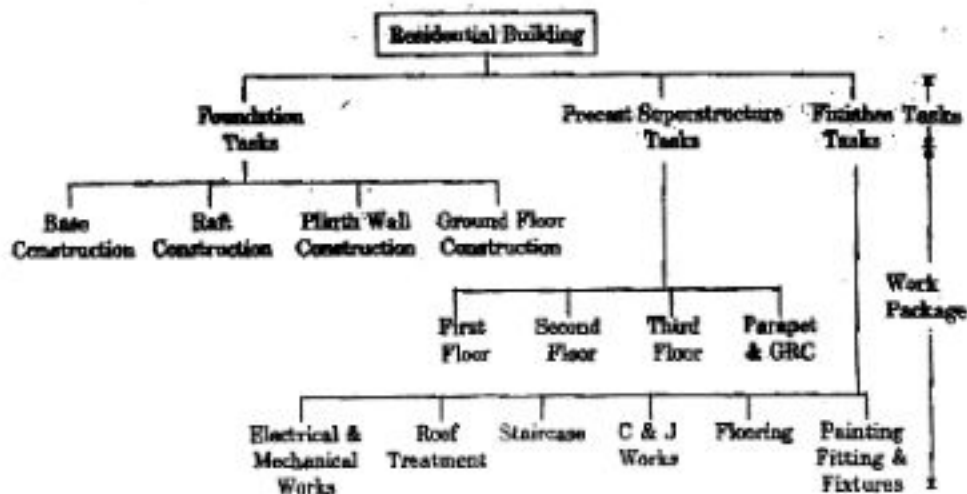
In the project master plan or the contracted works-control plan, each work package is assigned its performance objectives. These are generally stated in terms of its completion period, standard cost, resource-productivity standards and the standard sale price. The measure of performance thus, gets closely linked with the execution of its work packages.

Work packages form a common base for linking the key functions in project management. The work-package concept leads to the simple-management theory of managing, designing, estimating, planning, organizing, directing, communicating and controlling, using these work packages as the base lines. In the 2000 Housing Units Project, foundation work of a residential building can be broken down into four work packages—base, raft, plinth wall, ground floor slab (See Exhibits 3.2 and 3.3).

EXHIBIT 3.2 :

HOUSING PROJECT WORK BREAK DOWN LEVELS

Showing Task level & Work Package Level



PROJECT WORK BREAK DOWN LEVELS

■ Activity Level

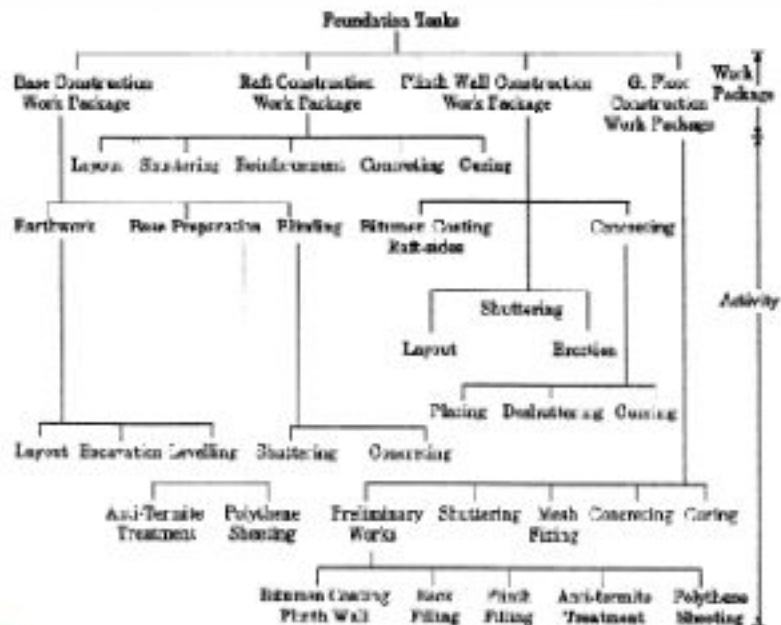
A work package can further be broken down into various identifiable jobs, operations and processes, which consume time and possibly, other resources and are necessary for its completion. Each one of this is called an activity. As an example, the various activities involved in the construction of foundation of a residential building are listed in Exhibit 2.7 and Exhibit 3.3.

The breaking down of a work package into its constituent activities requires a study of the methodology of execution of the work package. This methodology, generally known by the term *method statement*, is evolved by the concerned planning engineer using his construction experience and through his discussions with the respective project engineers.

EXHIBIT 3.3 :

HOUSING PROJECT WORK BREAK DOWN LEVELS

Showing Work Package Level & Activity levels



PROJECT WORK BREAK DOWN LEVELS

■ Operation Level

An activity comprises one or more operations. Each operation contains a part of the work content of the activity. It generally has a particular type or a fixed group of resources associated with it. It is performed during the scheduled time duration of the activity. Some operations may start with the commencement of the activity, while others may take place during its time duration. In some situations, performance periods of operations may overlap.

Operations are not considered during the network modelling and analysis stage except that the sum of the costs of operations equals the activity cost. They form the basis for allocation and scheduling of resources of each activity. In the 2000 Housing Units Project operation involved in activity 'concreting raft' of foundation work include

PROJECT WORK BREAK DOWN LEVELS

■ Operation Level

- **Cleaning and preparing inner side of the raft for concreting**
- **Pumping concrete**
- **Spreading and vibrating concrete**
- **Finishing of top concrete surface**

The construction projects are best controlled by the work packages, and best programmed for day work by using operational level best planned and monitored by the activities. A project planner uses activity as the common data base for project planning. The activity duration forms the basis for time planning and scheduling of project work. Detailed information about resources such as men, materials and machinery needed for execution of each activity enables the preparation of resource forecasts. The activity sale price is used to determine the income and cash-flow forecasts. The activity base is vital for monitoring the progress of the project work. In the 2000 Housing Units Project foundation construction task can be broken down into 27 activities (See Exhibit 3.3).

CRITICAL PATH ANALYSIS METHOD

- Each activity connecting I-node event with J-node event requires a duration time for completion.
- This duration may be deterministic in the case of CPM or probabilistic in case of PERT network.
- The time at which an event occurs is the maximum time of the various paths directed inwardly to that event because an event cannot be accomplished until and unless all the activities flowing into it have been completed.
- While analyzing a network, it is often necessary to estimate the total project time to forecast the particular date when the project will be completed.
- The total project time is the maximum of the elapsed time amongst all paths originating from the initial event and terminating at the final event indicating completion of the project.

CRITICAL PATH ANALYSIS METHOD

- The path of longest duration is defined as the **CRITICAL PATH** and the activities lying in this path are called **CRITICAL ACTIVITIES**.
- Any delay in any of critical activities will result in a consequential delay in the completion of the entire project.
- The project cannot be finished earlier than this project time given by the critical path. So the time taken by the critical path is the shortest possible time to finish the project.
- The project time is calculated by the event time mentioned in time box of each event on the network.

CRITICAL PATH ANALYSIS METHOD

- The time box consists of two compartments. The value in the left compartment stands for **EOT (earliest occurrence time)** or **earliest expected time (TE)** and the value in the right compartment stands for **LOT (latest occurrence time)** or **latest allowable time (TL)**.



- The activity, which does not lie on the critical path, is called **non-critical activity**.
- These **non-critical activities** may have some **slack time**.
- The **slack** is the amount of time by which the start of an activity may be delayed without affecting the overall completion time of the project.
- But a critical activity has **no slack**.
- To reduce the overall project time, it would require more resources (at extra cost) to reduce the time taken by the critical activities to complete.

CALCULATING EOT AND LOT

Before the critical path in a network is determined, it is necessary to find the **earliest and latest time** of each event to know the EOT (earliest occurrence time) at which the activities originating from the event can be started and to know the LOT (latest occurrence time) at which activities terminating at the event can be completed.

Forward Pass Computations (to calculate Earliest Occurrence Time EOT)

- **Step 1:** Begin from the start event and move towards the end event.
- **Step 2:** Put EOT = 0 for the start event.
- **Step 3:** Go to the next event (i.e. node 2) if there is an incoming activity for event 2, add calculate EOT of previous event (i.e. event 1) and activity time.
- **Note:** If there are more than one incoming activities, calculate EOT for all incoming activities and take the maximum value. This value is the EOT for event 2.
- **Step 4:** Repeat the same procedure from step 3 till the end event.

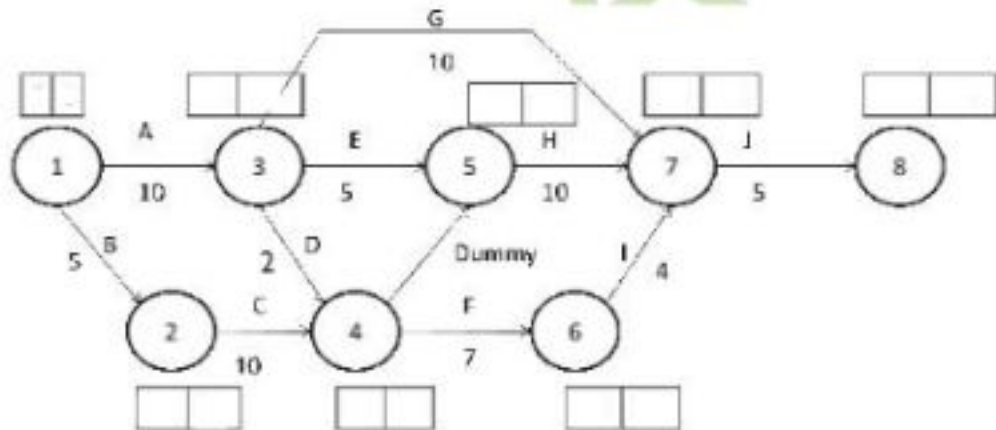
CALCULATING EOT AND LOT

Backward Pass Computations (to calculate Latest Occurrence Time LOT)

- **Step 1:** Begin from end event and move towards the start event. Assume that the direction of arrows is reversed.
- **Step 2:** Latest Time LOT for the last event is the earliest time EOT of the last event.
- **Step 3:** Go to the next event, if there is an incoming activity, subtract the value of LOT of previous event from the activity duration time. The arrived value is LOT for that event. If there are more than one incoming activities, take the minimum EOT value.
- **Step 4:** Repeat the same procedure from step 2 till the start event.

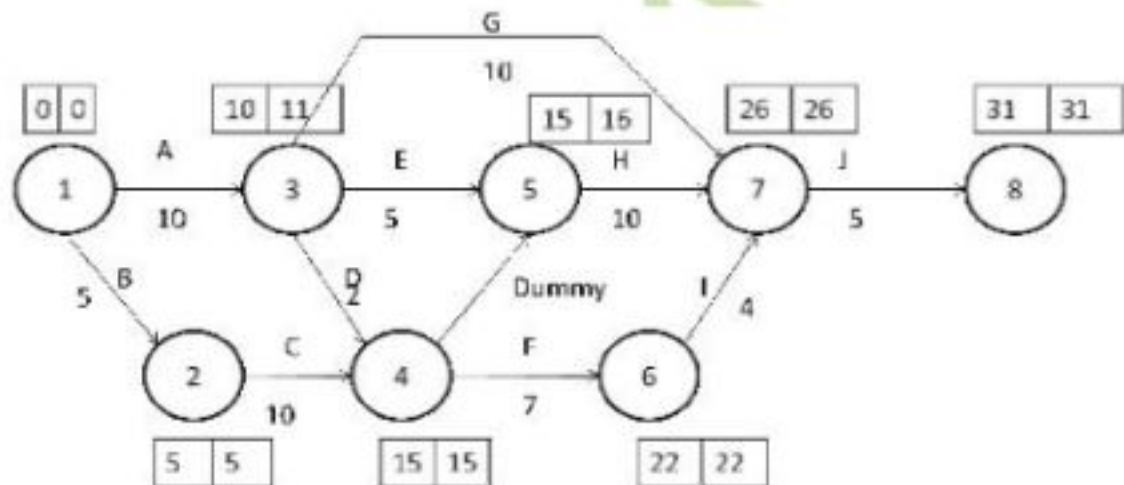
CALCULATING EOT AND LOT

EXAMPLE 6: Determine the Critical Path and Critical activities. List EOT and LOT of each activity in a tabular form.



CALCULATING EOT AND LOT

EXAMPLE 6: Solution



CALCULATING EOT AND LOT

Solution:

EOT CALCULATION

Node Number	No of paths	Activities (i-j)	EOT calculation $(EOT)_i = (EOT)_{i+j}$	EOT
1	-	-	-	0
2	1	1-2	$0+5 = 5$	5
3	1	1-3	$0+10 = 10$	10
4	2	2-4 3-4	$5+10 = 15$ $10+2 = 12$	15
5	2	3-5 4-5	$10+5 = 15$ $15+0 = 15$	15
6	1	4-6	$15+7 = 22$	22
7	3	3-7 5-7 6-7	$10+10 = 20$ $15+10 = 25$ $22+4 = 26$	26
8	1	7-8	$26+5 = 31$	31

CALCULATING EOT AND LOT

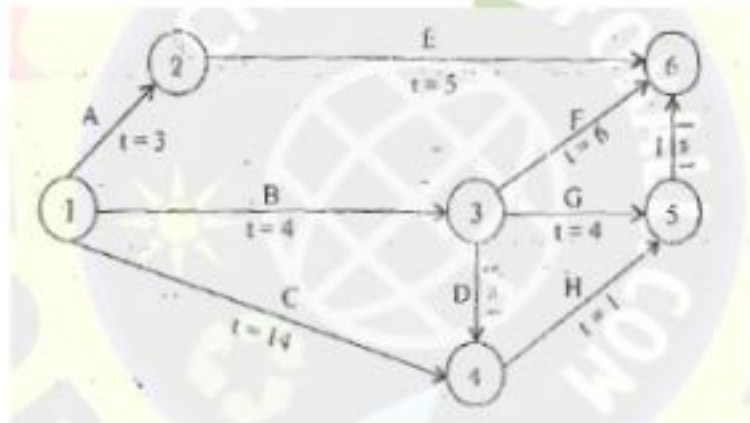
Solution:

LOT CALCULATION

Node no	No. of paths	Activities (i - j)	LOT calculation	LOT
8	-	-	-	31
7	1	7-8	$31 - 5 = 26$	26
6	1	6-7	$26 - 4 = 22$	22
5	1	5-7	$26 - 10 = 16$	16
4	2	4-5 4-6	$16 - 0 = 16$ $22 - 7 = 15$	15
3	3	3-7 3-5 3-4	$26 - 10 = 16$ $16 - 5 = 11$ $15 - 2 = 13$	11
2	1	2-4	$15 - 10 = 5$	5
1	2	1-3 1-2	$11 - 10 = 1$ $5 - 5 = 0$	0

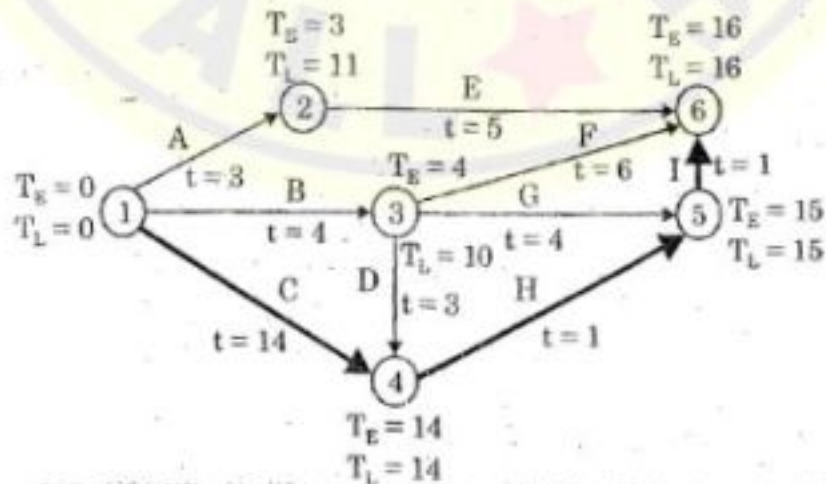
EXAMPLE 7:

Find the critical path and project duration of the given CPM project.



EXAMPLE 7:

Find the critical path and project duration of the given CPM project.



ACTIVITY TIMES AND FLOATS

With respect to the start and finish of an activity between the bounds of limiting event times (EOT & LOT), Several terms for defining activity times can be introduced.



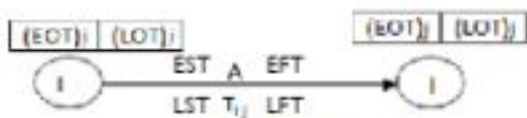
- **EST (earliest start time):** The earliest start time is the earliest possible time at which an activity can start.

$$(EST)_{i-j} = (EOT)_i$$

- **EFT (earliest finish time):** The earliest finish time is the earliest possible time at which an activity can finish.

$$(EFT)_{i-j} = (EOT)_i + t_{i-j}$$

ACTIVITY TIMES AND FLOATS



- **LST (Latest start time):** The latest start time is the latest possible time by which an activity can start without any delay of project time forecast on the basis of earliest occurrence time to the final event.

$$(LST)_{i-j} = (LOT)_j - t_{i-j}$$

- **LFT (Latest finish time):** The latest finish time is the latest possible time that an activity can finish without any delay in completion of the project.

$$(LFT)_{i-j} = (LOT)_j$$

(Subscript i - j denotes activity whereas subscripts i or j are for tail event or head event of the activity respectively).

ACTIVITY TIMES AND FLOATS

FLOATS: Float denotes the flexibility range within which the start time or finish time of an activity can fluctuate without affecting the completion of the project. There are four types of floats as follows.

- **Total float (TF):** Total float of an activity is the excess of maximum available time over the activity time.

$$\begin{aligned} (TF)_{i-j} &= [(LOT)_j - (EOT)_i] - t_{i-j} \\ &= (LST - EST) \\ &= (LFT - EFT) \end{aligned}$$

- **Free float (FF):** Free float of an activity is the excess of available time over the activity time when all jobs start as early as possible. The term 'free' indicates that the use of this float does not affect the succeeding activities.

$$(FF)_{i-j} = [(EOT)_j - (EOT)_i] - t_{i-j}$$

or = EST of the succeeding activity - EFT of the activity under construction.

- **Independent float (IF):** Independent float of an activity is the excess of minimum available time. In some cases the absorption of this float affects neither the predecessor nor the successor activity. That's why, it is called independent. If it is desired to increase duration time in order to release efforts elsewhere, independent float can be used without any replanning.

$$(IF)_{i-j} = [(EOT)_j - (LOT)_i] - t_{i-j}$$

If the value of independent float is negative, it is taken as zero for all practical purposes.

ACTIVITY TIMES AND FLOATS

- **Interfering float (INT.F):** Interfering float of an activity is the difference between the total float and free float. It is equal to the head event slack.

$$(INT.F)_{ij} = [(LOT)_j - (EOT)_j] \text{ or } (TF)_{i-j} - (FF)_{i-j}.$$

The confirmation of the critical path in a CPM network is made only when all the above four floats of each activity lying on the path is zero.

- **SLACK:** Slack denotes the flexibility range within which an event can occur.

$$\text{Slack of an event} = (LOT - EOT) \text{ of the event.}$$

In the CPM network the minimum value of slack is zero and the zero slack event is called the critical event. The critical path is a path joining the critical events but the confirmation of the critical path is only when the conditions of zero floats are satisfied.

ACTIVITY TIMES AND FLOATS

Total Float : The total time that a schedule activity may be delayed

$$\text{Total Float} = (\text{LFT} - \text{EFT}) \text{ or } (\text{LST} - \text{EST})$$

Free Float : Free Float is the time by which the completion of an activity can be delayed beyond the EFT without affecting the EST of succeeding activity

$$\text{Free Float} = \text{EST} (\text{succeeding}) - \text{EFT} (\text{present})$$

Interfering Float : Part of total float that causes reduction in the total float of successor activity

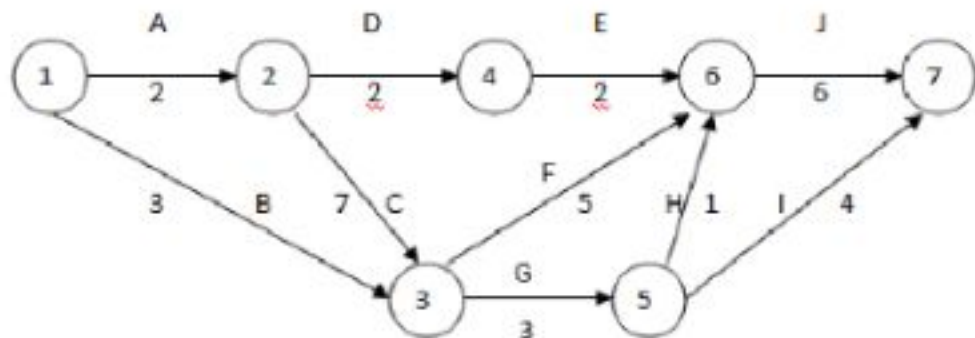
$$\text{Interfering Float} = \text{LFT} (\text{present}) - \text{EST} (\text{succeeding})$$

Independent Float : Amount of float that can be used without affecting either of the succeeding or preceding activity

$$\text{Independent Float} = \text{EST} (\text{succeeding}) - \text{LFT} (\text{preceding}) - \text{Duration} (\text{present})$$

EXAMPLE 8:

Find the critical path and project duration of the given CPM project. Also calculate EST, EFT, LST, LFT and TF, FF, IF, INT.F in a tabular form.

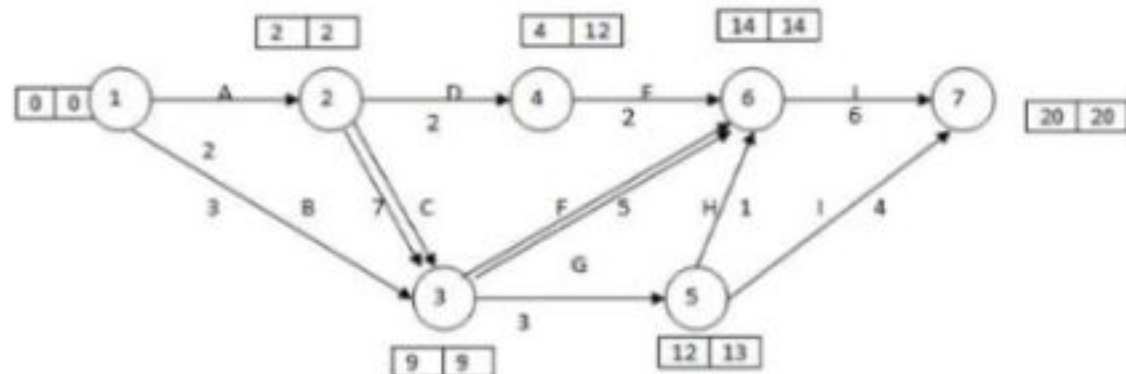


EXAMPLE 8:

Solution: Project duration = 20 days

Critical path = 1 - 2 - 3 - 6 - 7 or A - C - F - J. (Shown by double line)

Event time comprising EOT & LOT has been indicated in the respective time box of each event.



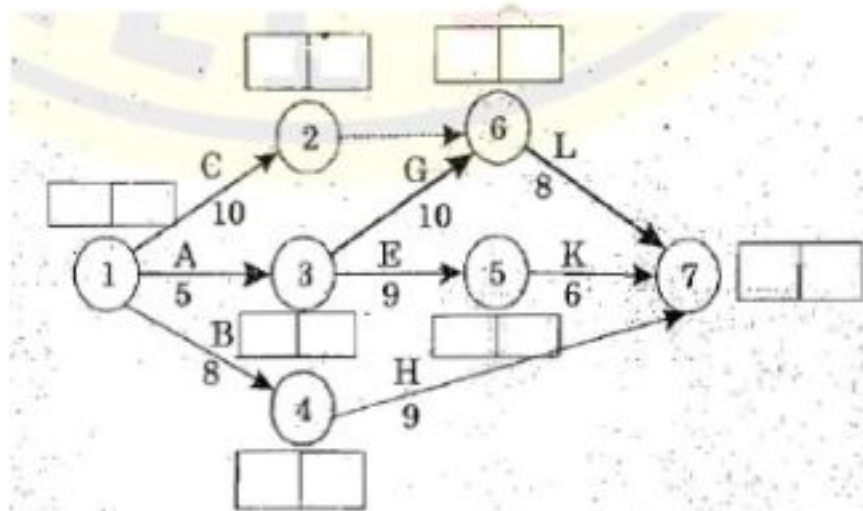
EXAMPLE 8:

Solution: Calculations of EST, EFT, LST, LFT & TF, FF, IF, INT.F are presented in the following tabular form.

Activity	I-Node	J-Node	Duration (days)	Activity time (days)				Float (days)				Remarks
				EST	EFT	LST	LFT	TF	FF	IF	INT.F	
A	1	2	2	0	2	0	2	0	0	0		
B	1	3	3	0	3	3	9	0	6	6	0	
C	2	3	7	2	9	2	9	0	0	0	Critical	
D	2	4	2	2	4	10	12	0	0	0	3	
E	4	6	2	4	6	12	14	0	0	0	0	
F	3	6	5	9	14	9	14	0	0	0	0	
G	3	5	3	9	12	10	13	1	0	0	1	
H	5	6	1	12	13	13	14	1	1	0	0	
I	5	7	4	12	16	16	20	4	4	3	0	
J	6	7	6	14	20	14	20	0	0	0	0	

EXAMPLE 9:

Find the critical path and project duration of the given CPM project. Also calculate EST, EFT, LST, LFT and TF, FF, IF, INT.F in a tabular form.

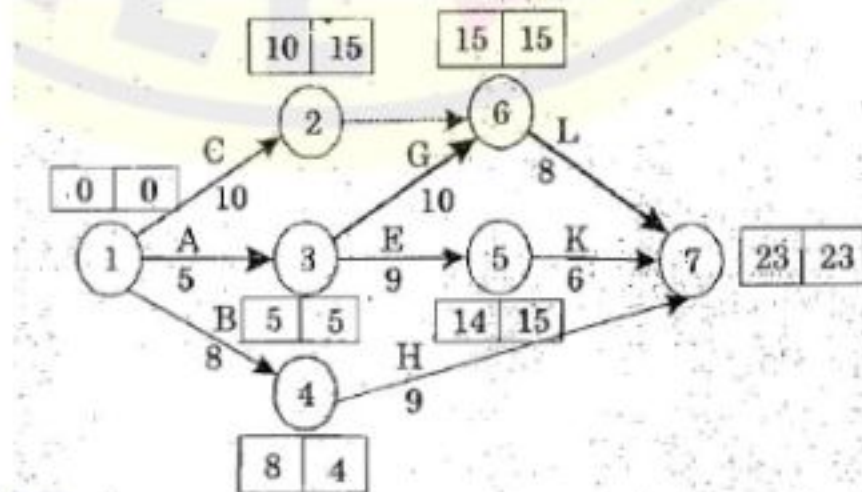


EXAMPLE 9:

Solution: Project duration = 23 days

Critical path = 1 - 3 - 6 - 7 or A - G - L. (Shown by double line)

Event time comprising EOT & LOT has been indicated in the respective time box of each event.



EXAMPLE 9: Solution

ACTIVITY	T _{i-j}	EST	EFT	LST	LFT	TF	FF	IF	Int.F	Remarks
-	0	0	0	0	0	-	-	-	-	
A	5	0	5	0	5	0	0	0	0	CRITICAL
B	8	0	8	6	14	6	0	0	6	
C	10	0	10	5	15	5	0	0	5	
E	9	5	14	8	17	3	0	0	3	
G	10	5	15	5	15	0	0	0	0	CRITICAL
H	9	8	17	14	23	6	6	0	0	
K	6	14	20	17	23	3	3	0	0	
L	8	15	23	15	23	0	0	0	0	CRITICAL
-	0	23	23	23	23	-	-	-	-	

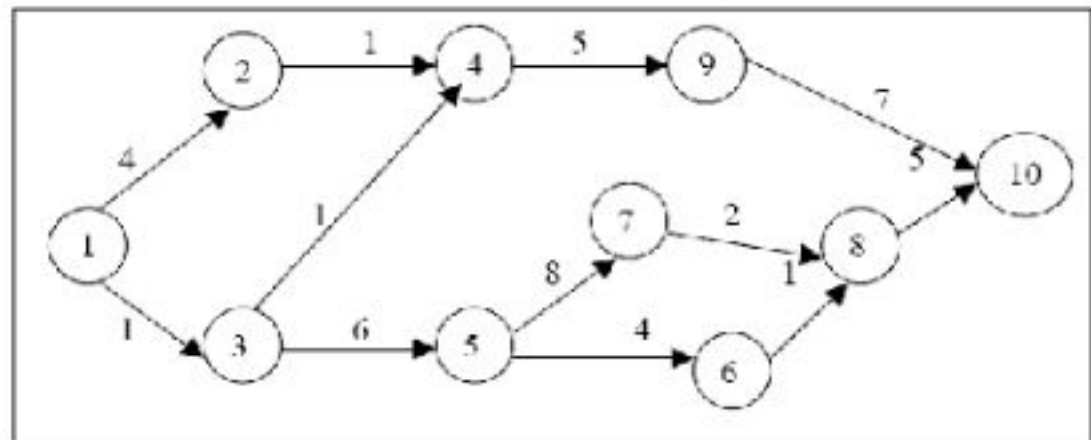
EXAMPLE 10:

Construct a Network. Find the critical path and project duration of the given project. Also calculate EST, EFT, LST, LFT and TF, in a tabular form.

Activity	Name	Time	Activity	Name	Time (days)
1-2	A	4	5-6	G	4
1-3	B	1	5-7	H	8
2-4	C	1	6-8	I	1
3-4	D	1	7-8	J	2
3-5	E	6	8-10	K	5
4-9	F	5	9-10	L	2

EXAMPLE 10:

Solution: From the data given in the problem, the activity network is constructed as shown in Figure given below



EXAMPLE 10:**Solution:**

Activity	Activity Name	Normal Time (D _N)	Earliest Time (TF)		Latest Time (TL)		Total Float
			Start (E _{TS})	Finish (E _{TF})	Start (L _{TS})	Finish (L _{TF})	
1-2	A	4	0	4	5	9	5
1-3	B	1	0	1	0	1	0
2-4	C	1	4	5	9	10	5
3-4	D	1	1	2	9	10	8
3-5	E	6	1	7	1	7	0
4-9	F	5	5	10	10	15	5
5-6	G	4	7	11	12	16	5
5-7	H	8	7	15	7	15	0
6-8	I	1	11	12	16	17	5
7-8	J	2	15	17	15	17	0
8-10	K	5	17	22	17	22	0
9-10	L	7	10	17	15	22	5

EXAMPLE 10:

Solution: From the Table, we observe that the activities 1 – 3, 3 – 5, 5 – 7, 7 – 8 and 8 – 10 are critical activities as their floats are zero.

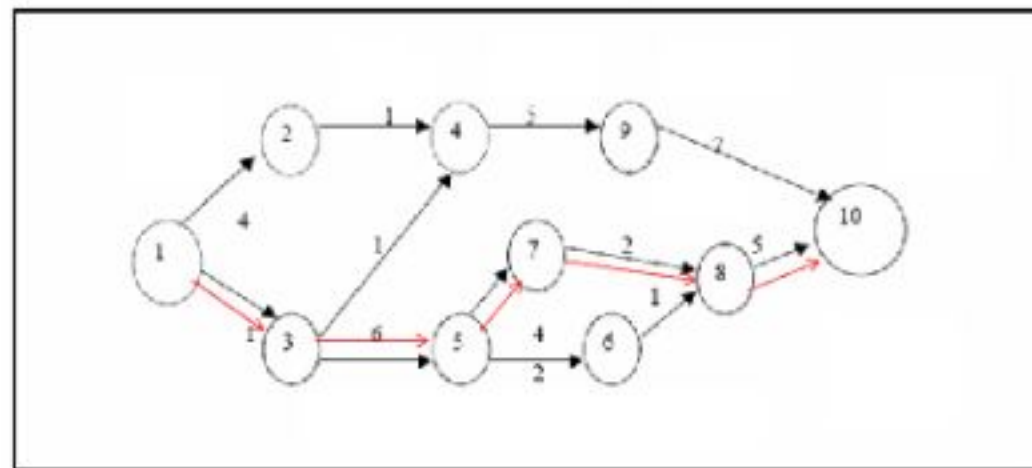


Figure 8.17: Critical Path of the Project

UNIT – III

BY AR DHIVYA SHREE G

ANALYSIS

CONTENTS

- Part 1: Cost model-Project cost, direct cost, indirect cost, slope curve, Total project cost, optimum duration contracting the network for cost optimization.
- Part 2: Steps in cost optimization, Updating, resource allocation-resource smoothing, resource leveling.

MATF

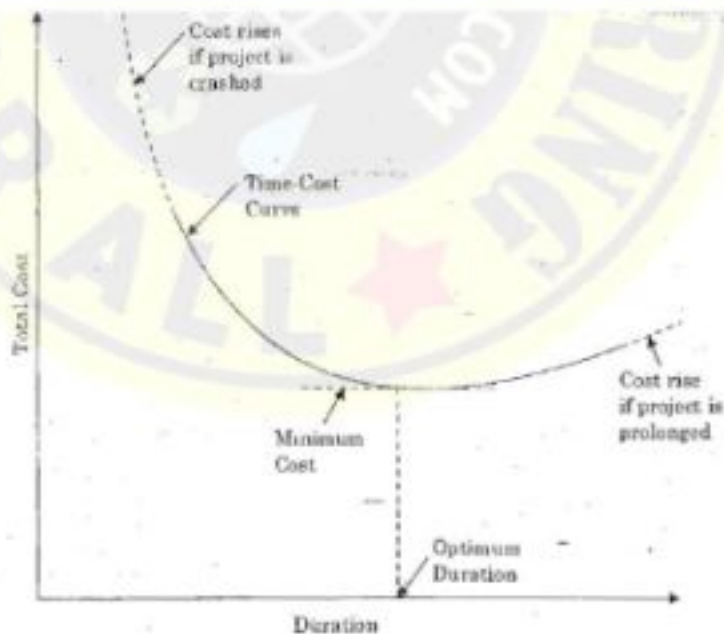
OPTIMIZATION THROUGH CPM TECHNIQUE

- So far we have discussed the project representing by a network and finding out its critical path and scheduling. The object was to identify those activities or events that need full attention with a view to complete the project on time.
- The forecasting of the project finish was based on the estimate of the project duration given by the critical path of the project. But in many instances, it is desirable to cut down the project duration. This naturally leads to the cost consideration of the project.
- Hence there exist a particular value of project duration at which the total project cost is minimum. So the project duration corresponding to the minimum project cost is called **OPTIMUM DURATION** of the project and minimum cost associated with it is known as **OPTIMUM COST** of the project.

OPTIMIZATION THROUGH CPM TECHNIQUE

- For any project the two important aspects to be considered are the project time and project cost.
- Project times are determined by locating the critical and sub critical path in the project network.
- It is observed that in construction, time is related to project cost, but this relationship is not linear.
- To find the minimum cost, a cost model/time cost relationship/project cost function has to be developed.
- The cost model shows "Relationship of the cost" versus "the completion time". Its ordinate represents the cost and the abscissa has a time scale as shown in the figure below.
- During the formulation of cost model, the direct and the indirect cost and the financial gains resulting from early completion are considered. The project time corresponding to the minimum values of the cost function gives the most optimum duration of the project.

OPTIMIZATION THROUGH CPM TECHNIQUE



OPTIMIZATION THROUGH CPM TECHNIQUE

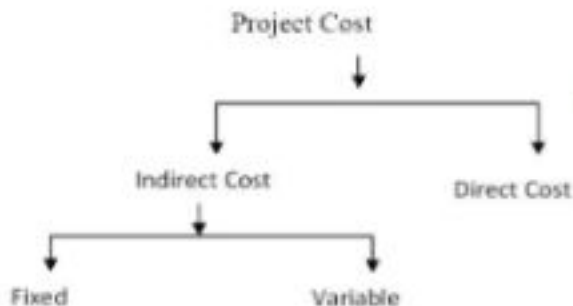


Fig.2.30

Fixed Indirect Cost

As the name suggest that the costs involved are independent of the progress of the project. It includes initial expenditure on office, supervision cost, cost of providing amenities, interest on capital etc.

Variable Indirect Cost

The costs which more or less are directly proportional to the project time and include overhead expenditure on office, supervision cost, cost of the providing amenities, interest on capital etc.

OPTIMIZATION THROUGH CPM TECHNIQUE

Direct Cost

- Direct cost is the amount of cost which is directly depends on the amount of resources involved for completion of activities. The resources include labor, material, plants and machinery, payments to sub-contractors etc.
- When the project time is to be decreased, to get the same work done, it is imperative to increase the amount of labour, equipment and sometimes time saving material (like rapid hardening cement in place of ordinary Portland cement) which means simply increase in the direct cost. Sometimes work has to be done by playing overtime (usually at double rate) or in shifts consequently adding extra cost to the direct cost. Hence it is said that the **direct cost is inversely proportional to the project time.**
- The variation of direct cost, indirect cost and total cost with respect to the project time is shown in **Fig.2.31**. The normal duration, optimum duration and crash duration (minimum duration) of the project are clearly marked in the **Fig. 2.31**.

OPTIMIZATION THROUGH CPM TECHNIQUE

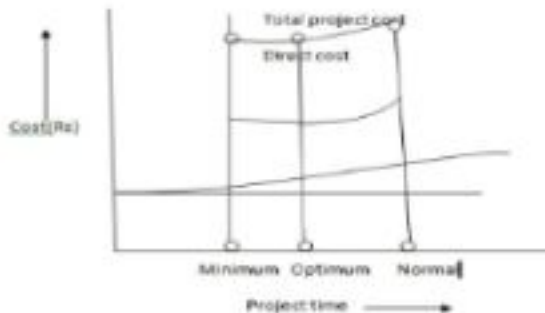


Fig.2.31

Direct cost is the sum total of direct costs of individual activities comprise of the project cost. So the behavior of direct cost of the project is reflected in the behavior of direct cost of an individual activity need to be explained.

OPTIMIZATION THROUGH CPM TECHNIQUE

Normal Cost (NC)

- It is the lowest cost completing an activity in the minimum time employing the normal resources available at the disposal i.e. not using overtime or other special resources.

Normal Time (NT)

- It is the minimum time required to complete a project at the normal cost.

Crash Cost (CC)

- It is the cost of completing an activity by employing all possible means like over time, extra resources, special material etc.

Crash Time (CT)

- Is the absolute minimum possible time associated with the crash cost? Crash time imposes the condition that the duration cannot be further reduced even after expending the extra resources to any extent. Hence, direct cost for expedition an activity per unit time i.e. cost
- Slope of an activity is defined as = $(\text{Crash cost} - \text{Normal cost}) / (\text{Normal time} - \text{Crash time})$

OPTIMIZATION THROUGH CPM TECHNIQUE

Slope of an activity is defined as = $\frac{\text{Crash cost} - \text{Normal cost}}{\text{Normal time} - \text{Crash time}}$

I.e. Cost slope = $\frac{C_C - N_C}{N_T - C_T}$

For each activity, normal time, crash time and cost slope is mentioned on the network along with the total project direct cost (when performed in normal time) and rate of indirect cost, the network is known as **mathematical modeling of network** which is ready for optimization.

OPTIMIZATION THROUGH CPM TECHNIQUE

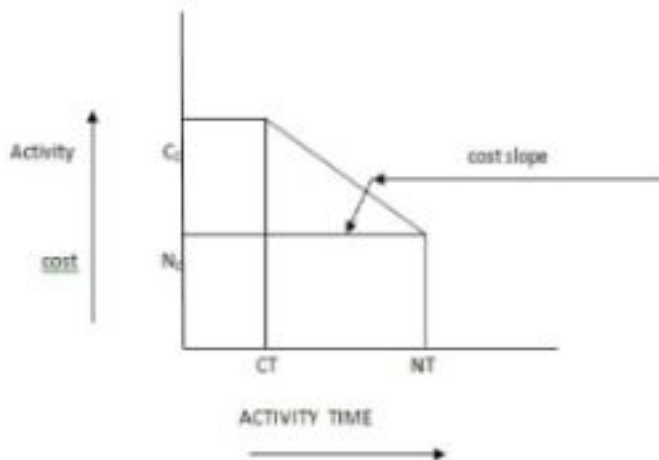


Fig 2.32

CRASHING OF MATHEMATICAL MODEL OF NETWORKS (STEPS INVOLVED IN COST OPTIMIZATION)

CRASHING

- The process of reduction of total project duration along the longest path of the network i.e., along the critical path to obtain the optimum project cost and optimum duration is called as crashing. Crashing is a methodology or a procedure to obtain optimum project cost and optimum duration.

PROCEDURE

- Draw the network diagram.
- Perform the analysis to determine the critical path.
- Indicate the critical path along the network diagram or the timeline diagram.
- Find the cost slope of each activity.
- Start crashing the activity along the critical path having minimum or least cost slope.
- Each activity is shortened or crashed until its crashing potential is exhausted or a new critical path is formed.

CRASHING OF MATHEMATICAL MODEL OF NETWORKS (STEPS INVOLVED IN COST OPTIMIZATION)

PROCEDURE

- If new critical path is formed, reduce the combination of critical activities having minimum cost slope, and continue till there is no further scope of crashing.
- For each crashing note down the cost implication.
- Calculate the indirect cost and saving for early completion, date or time wise.
- Calculate the cumulative effect of direct and indirect cost and savings for early completion.
- Plot the data by selecting a suitable scale with the time along the abscissa axis (X axis) and cost along the ordinate axis (Y axis).

CRASHING

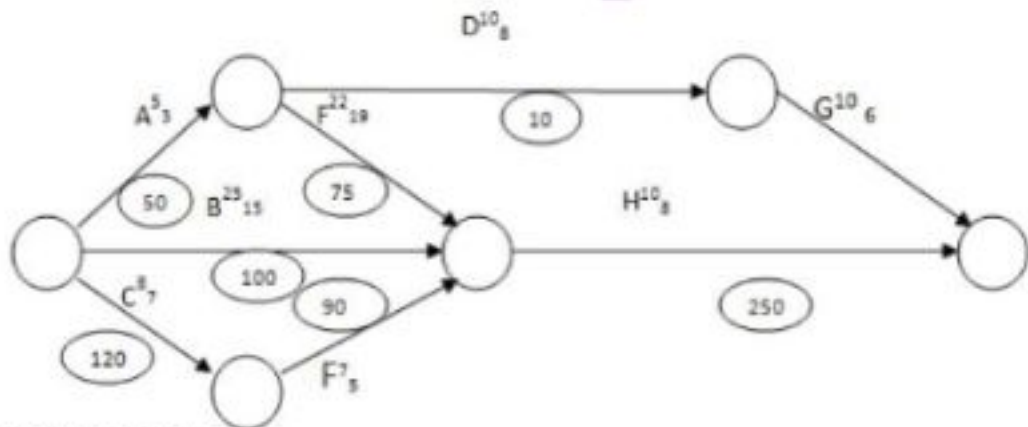
EXAMPLE 1: The following information is available about the various activities of the network. Project Overhead cost is Rs.2000/week. Determine

- Direct Cost-duration relationship
- Total Cost-duration relationship

Activity	Normal Duration (Weeks)	Normal Cost (Rupees)	Crash Duration (Weeks)	Crash Cost (Rupees)
1 - 2	4	4000	3	7000
1 - 3	8	5000	7	8000
2 - 3	5	8000	3	10000

CRASHING

EXAMPLE 2: The following information is available about the various activities of the network. Project direct cost (normal) = Rs 25,500
Indirect cost = Rs 200/per day. Find the Optimum duration and draw the Cost-Duration relationship in a graph.

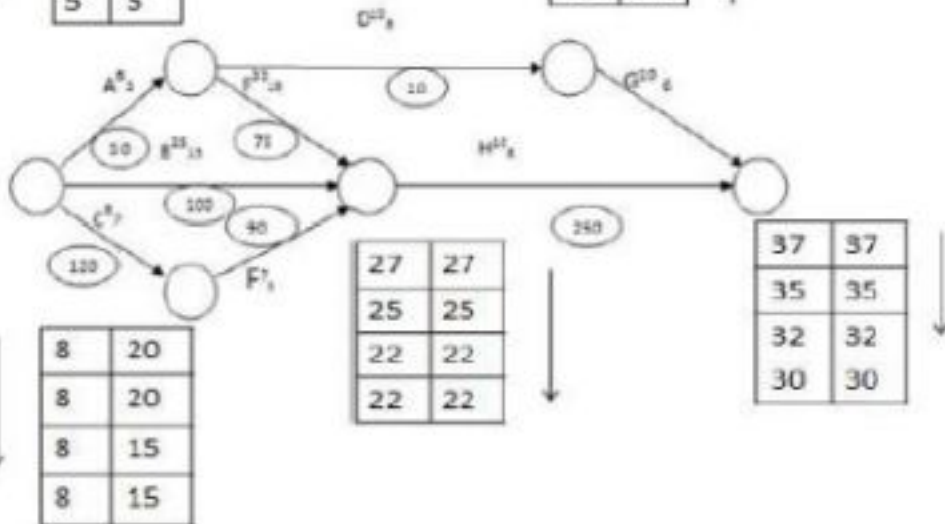


SOLUTION:

3	3
3	3
3	3
5	5

13	24
13	26
13	29
15	31

0	0
0	0
0	0
0	0



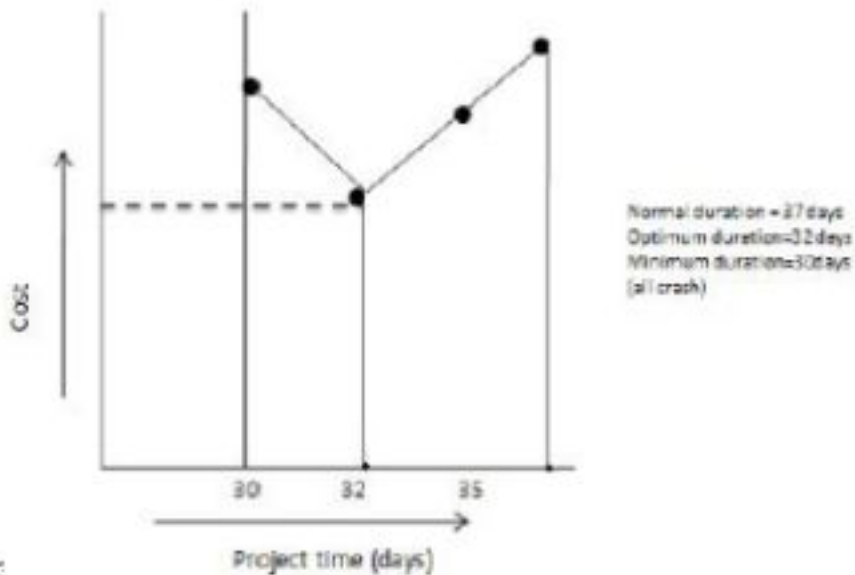
CRASHING

SOLUTION :

S.NO	Description	Duration (days)	Indirect cost (Rs)	Direct cost (Rs)	Total cost (Rs)	Remarks
1	All Normal	37*	7,400	25,500	32,900	Normal Duration
2	Crashing A by 2 days add direct cost @Rs.50/day i.e. add $2 \times 50 = \text{Rs. } 100/-$	35	7,000	25,600	32,600	
3	Crashing B and E each by 3 days simultaneously add @ Rs (100+75)/day i.e. $3 \times 175 = \text{Rs. } 525$ in the direct cost	32**	6,400	26,125	32,525	Optimum Duration
4	Crashing H by 2 days @ Rs 250/day i.e. add direct cost $2 \times 250 = 500/-$	30***	6,000	26,625	32,635	Minimum Duration

CRASHING

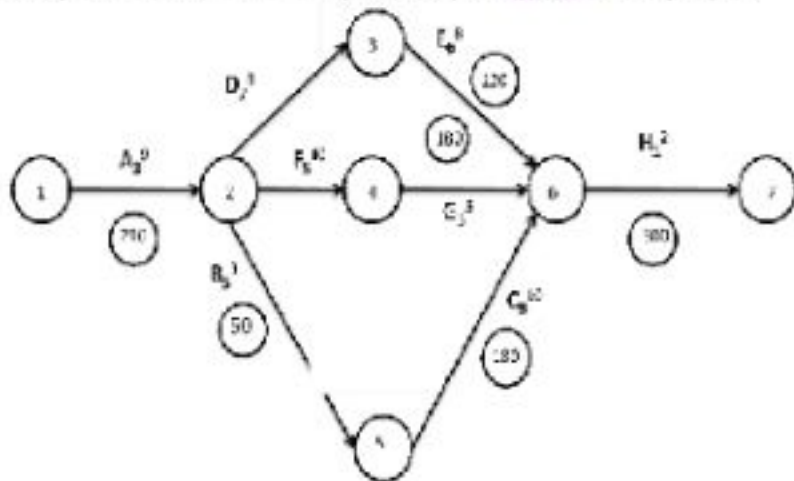
SOLUTION :



CRASHING

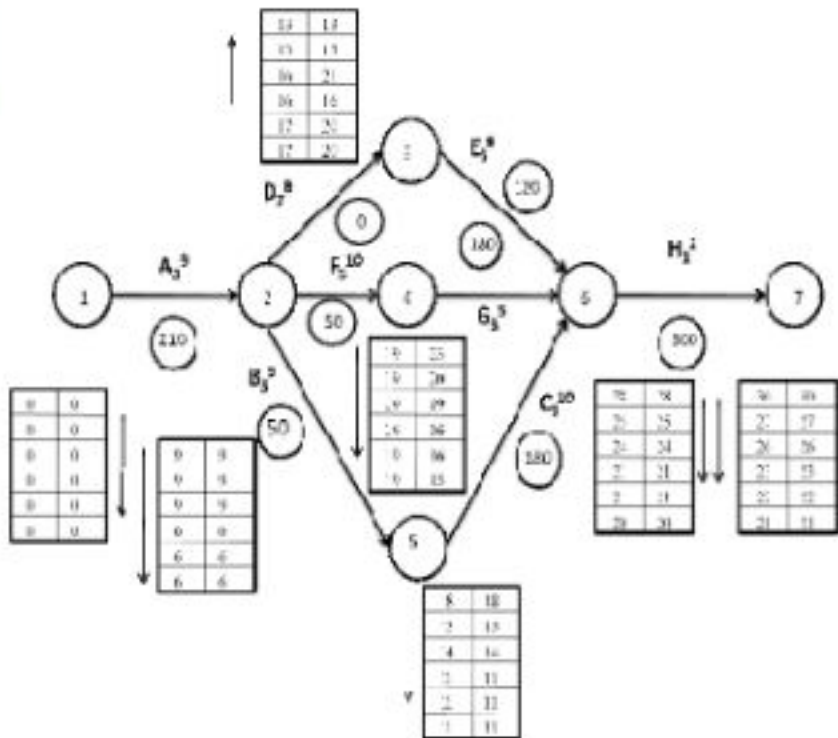
EXAMPLE 3: For the given CPM network, all normal direct cost of the project is Rs.37,500 and indirect expenses are Rs. 250/day.

- Find all possible schedules
- Select the optimum and minimum (all crash) duration of the project.



CRASHING

SOLUTION:



CRASHING

SOLUTION:

S.NO	Description	Duration (days)	Indirect cost(Rs)	Direct cost(Rs)	Total project cost (Rs)	Remark
1	All Normal	30	7,500	37,500	45,000	Normal Duration
2	Crashing B by 3 days	27	6,750	37,650	44,400	
3	Crashing B and D each by 3 days	26	6,500	37,800	44,300	
4	Crashing A by 3 days	23*	5,750	38,430	44,180	Optimum Duration
5	Crashing H by 1 days	22	5,500	38,730	44,230	
6	Crashing E, F and C each by 1 day simultaneously	21**	5,250	39,080	44,330	Minimum Duration

*Optimum duration of the project = 23 days

**Minimum duration of the project = 21 days

CRASHING

SOLUTION:

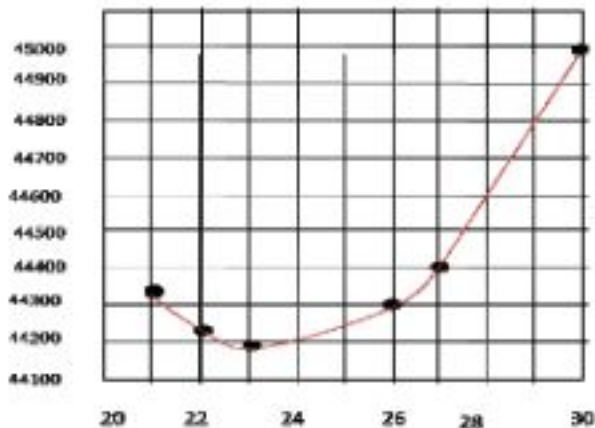


Fig. 2.37

*Optimum duration of the project = 23 days

**Minimum duration of the project = 21 days

RESOURCE ALLOCATION

A resource is a physical variable such as men (skilled/unskilled labor, technical/supporting staff etc) materials, machineries (tools, plants, equipments) and money. These resources are directly responsible for converting plans and specifications into a finished product. But all the necessary resources may not be available in abundance. Some of the resources may be restricted.

- Availability of manpower - supervisory staff, technical and specialized personnel, skilled and unskilled labor may be restricted. Availability of heavy equipment and special equipments may be restricted. In certain cases there may be space limitations which prevent more than one or two jobs working simultaneously. So it is quite pertinent that various activities of the project are to be rescheduled (taking floats into consideration) in such a way that the demand of various resources is more or less uniform all along the project period and this objective can be accomplished by network technique.

There are three steps to derive the above objective:

- a) Resource Allocation
- b) Resource Smoothing
- c) Resource Leveling

RESOURCE ALLOCATION

Resource Allocation simply means deciding what resources each activity of the project requires. For this Resource Usage Profile i.e. Histogram is drawn either on earliest start of each activity or latest start of each activity basis.

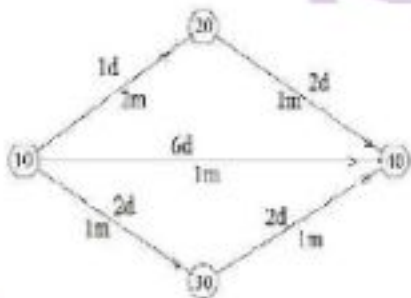


Fig 2.48

- For a simple network as shown in **Fig. 2.48** duration of each activity in terms of days (d) and requirement of labors for each activity in terms of men (m) have been indicated. Resource of 2 men is available during the whole project period.

RESOURCE ALLOCATION

SOLUTION: Critical path = 10-40, Project duration = 6 days

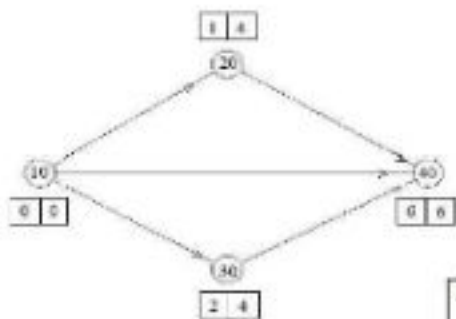


Fig. 2.49

Table 2.24

Activity	Duration (days)	EST	LST	TF	Remarks
10-20	1	0	3	3	
10-30	2	0	2	2	
10-40	6	0	0	0	Critical
20-40	2	1	4	3	
30-40	2	2	4	2	

RESOURCE ALLOCATION

- Based on EST of each activity, a histogram with resource available is drawn and below EST calendar is also exhibited. (Fig. 2.49)

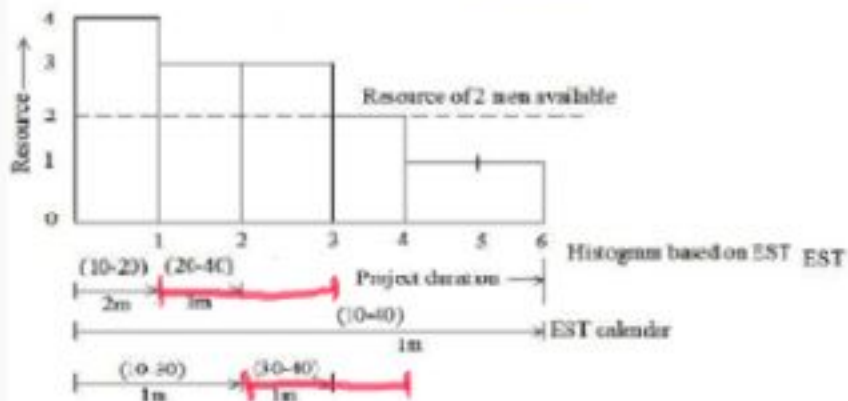


Fig 2.50

RESOURCE ALLOCATION

- Based on LST, a histogram with resource available is drawn and below this a LST calendar is also exhibited (Fig 2.50)

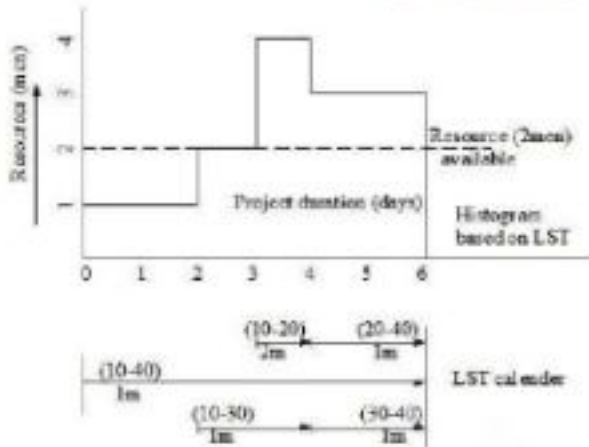


Fig 2.51

RESOURCE ALLOCATION

- Histogram based on EST as well as on LST can be presented in the tabular term also.

Table 2.25

Resource available	2	2	2	2	2	2
Resource required	4	3	3	2	1	1
Day	1	2	3	4	5	6

Based on EST

Table 2.26

Resource available	2	2	2	2	2	2
Resource required	1	1	2	4	3	3
Day	1	2	3	4	5	6

Based on EST

RESOURCE ALLOCATION : CONCLUSION

- It may be seen from **Fig. 2.50** (histogram based on EST) and **Fig. 2.51** (based on LST) or the corresponding tables, requirement of labor fluctuates substantially over project duration of 6 days.
- The process of resource allocation consists essentially of fitting activities into pattern of resource availability within stipulated time period and it is achieved by the following ways, namely:
 - a) Resource Smoothing
 - b) Resource Leveling

RESOURCE SMOOTHING/RESOURCE LEVELING

- In the first approach the total project duration is not changed but some of the activity start times are shifted by their available float so that more or less uniform demand is generated and this is called **Resource Smoothing**.
- In the second approach, the activity start times are also so rescheduled that the peak demand does not exceed the available limit of resource. If it does not give the desirable result by consideration of floats, the total project duration to minimum extent may be extended and this is called **Resource Leveling**.
- It is basically a trial and error method in both the cases. If the first solution is unsatisfactory, the process must be repeated until an adequate distribution is achieved. The trial and error method is done by the best utilization of floats of non-critical activities.

RESOURCE SMOOTHING

Resource Smoothing:

- The project duration (6 days) is maintained, so the crucial activity (10-40) will start earliest and finish in 6 days. But the path (10-20-40) has 3 days floats and path (10-30-40) has 2 days float.
- The period may be distributed among the activities lying on the path or the float may be distributed over one activity on the path. Various trials and errors are taken and finally the resource smoothing is obtained and is presented in the form of histogram and the corresponding network showing start time of each activity.
- Total float of 3 days of path (10-20-40) has been adjusted by 2 days float in 1st activity (10-20) and in 1 day float in the EST of activity (20-40). Similarly, total float of 2 days of path (10-30-40) has been adjusted in one activity (30-40) only by its late start. Histogram drawn on the proposed calendar (Fig. 2.50) is the Resource Smoothing shown in Fig. 2.52

RESOURCE SMOOTHING

Before Resource Smoothing:

DURATION (Days) / ACTIVITY	1	2	3	4	5	6
10-20	2					
10-30	1	1				
10-40	1	1	1	1	1	1
20-40		1	1			
30-40			1	1		
Sum of Resource available each day	4	3	3	2	1	1

Resource Smoothing:

DURATION (Days) / ACTIVITY	1	2	3	4	5	6
10-20			2			
10-30	1	1				
10-40	1	1	1	1	1	1
20-40				1	1	
30-40					1	1
Sum of Resource available each day	2	2	3	2	3	2

RESOURCE SMOOTHING

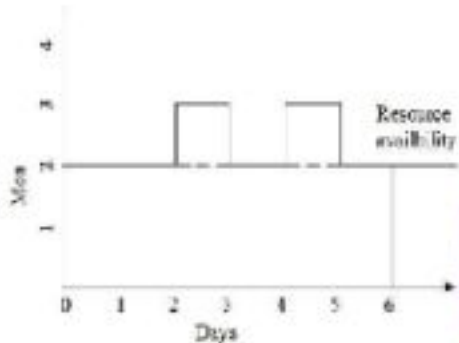


Fig 2.52

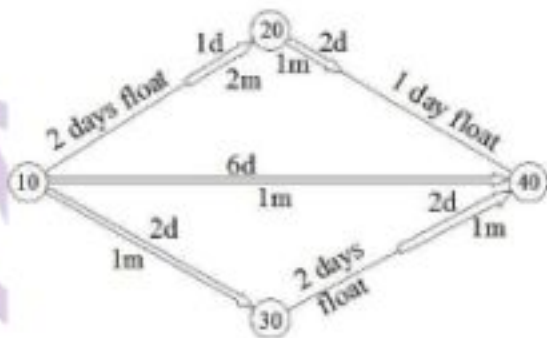


Fig 2.53

RESOURCE LEVELING

Resource Leveling:

- If the resource availability is quite limited, it cannot meet period by period variation. In this case, the project duration may be extended to the minimum possible such that the demand actually agrees with the availability and this is called Resource Leveling.
- Critical activity (10-40) is given one day float in start time making project period of 7 days instead of 6 days. Float of 4 days in the path of (10-20-40) has been totally used in the activity of (20-40) only such that the activity starts 2 days late and finishes 2 days earlier. 3 days float of the path (10-30-40) has been distributed such activity (10-30) starts 1 day late and activity (30-40) starts 2 days late. Consequently a uniform demand of 2 men each days agree exactly with the availability of 2 men. This is called the Resource Leveling.

RESOURCE LEVELING

Before Resource Leveling:

DURATION (Days) / ACTIVITY	1	2	3	4	5	6
10-20	2					
10-30	1	1				
10-40	1	1	1	1	1	1
20-40		1	1			
30-40			1	1		
Sum of Resource available each day	4	3	3	2	1	1

Resource Leveling:

DURATION (Days) / ACTIVITY	1	2	3	4	5	6	7
10-20	2						
10-30		1	1				
10-40		1	1	1	1	1	1
20-40				1	1		
30-40						1	1
Sum of Resource available each day	2	2	2	2	2	2	2

RESOURCE LEVELING

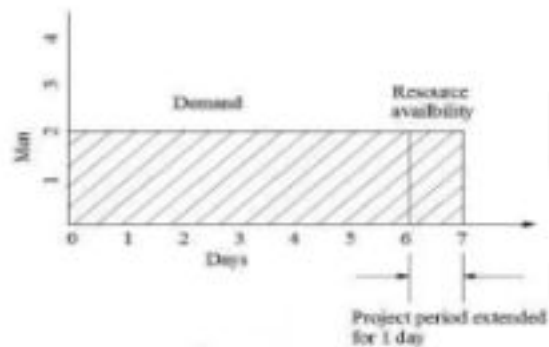


Fig 2.54

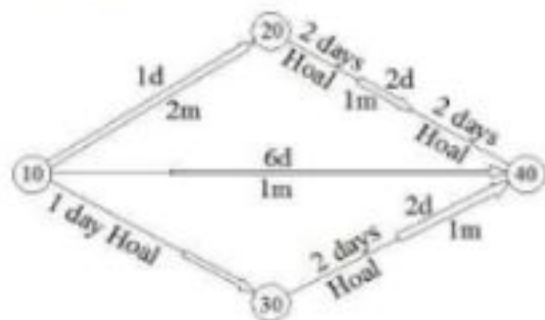


Fig 2.55

RESOURCE SMOOTHING

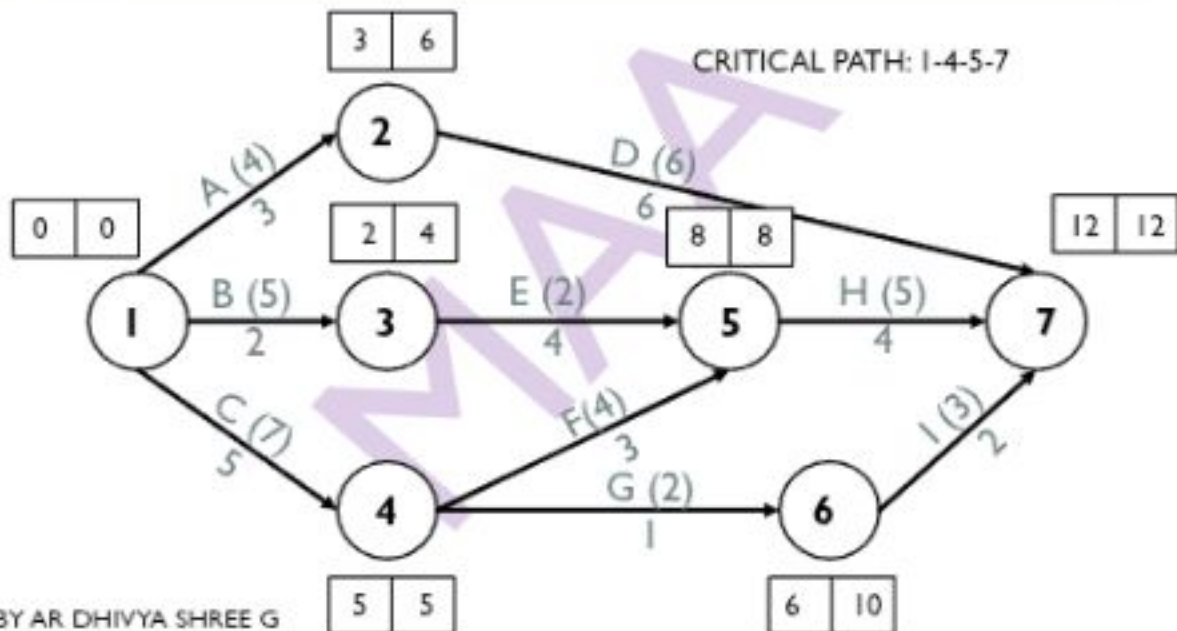
EXAMPLE 4: The expected time and number of labour to finish each activity of the project are shown in the following table. Smoothen the requirement of the resources so that the project may be completed in the scheduled duration.

ACTIVITY	DURATION (Days)	LABOUR REQUIRED
(1-2)A	3	4
(1-3)B	2	5
(1-4)C	5	7
(2-7)D	6	6
(3-5)E	4	2
(4-5)F	3	4
(4-6)G	1	2
(5-7)H	4	5
(6-7)I	2	3

RESOURCE SMOOTHING -

SOLUTION:

STEP 1- Draw the network diagram for the give data. Obtain the critical path and project duration.



RESOURCE SMOOTHING

SOLUTION:

Step 2 - Draw the tabular column with the activity, EST,EFT,LST,LFT and Total Float with remarks.

ACTIVITY	DURATION (Days)	EST	EFT	LST	LFT	TOTAL FLOAT	REMARKS
(1-2)A	3						
(1-3)B	2						
(1-4)C	5						
(2-7)D	6						
(3-5)E	4						
(4-5)F	3						
(4-6)G	1						
(5-7)H	4						
(6-7)I	2						

RESOURCE SMOOTHING

SOLUTION:

Step 2 - Draw the tabular column with the activity, EST,EFT,LST,LFT and Total Float with remarks.

ACTIVITY	DURATION (Days)	EST	EFT	LST	LFT	TOTAL FLOAT	REMARKS
(1-2)A	3	0	3	3	6	3	
(1-3)B	2	0	2	2	4	2	
(1-4)C	5	0	5	0	5	0	Critical
(2-7)D	6	3	9	6	12	3	
(3-5)E	4	2	6	4	8	2	
(4-5)F	3	5	8	5	8	0	Critical
(4-6)G	1	5	6	9	10	4	
(5-7)H	4	8	12	8	12	0	Critical
(6-7)I	2	6	8	10	12	4	

RESOURCE SMOOTHING- SOLUTION:

Step 3 – Form a the tabular column with EST of each activity and determine total resources required each day. Having duration on top and activity on side.

DURATION (Days) / ACTIVITY	1	2	3	4	5	6	7	8	9	10	11	12
(1-2)A												
(1-3)B												
(1-4)C												
(2-7)D												
(3-5)E												
(4-5)F												
(4-6)G												
(5-7)H												
(6-7)I												
Sum of Resource available each day												

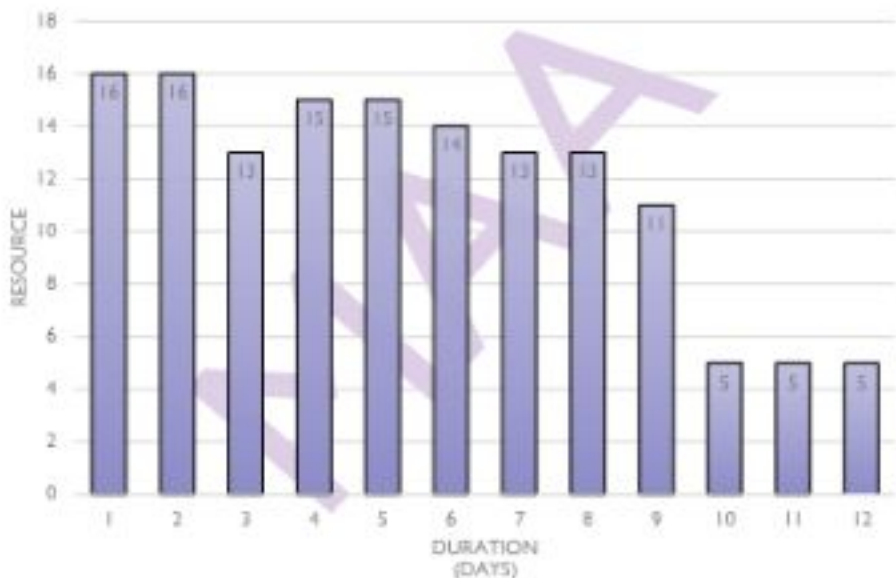
RESOURCE SMOOTHING- SOLUTION:

Step 3 – Form a the tabular column with EST of each activity and determine total resources required each day. Having duration on top and activity on side.

DURATION (Days) / ACTIVITY	1	2	3	4	5	6	7	8	9	10	11	12
(1-2)A	4	4	4									
(1-3)B	5	5										
(1-4)C	7	7	7	7	7							
(2-7)D				6	6	6	6	6	6			
(3-5)E			2	2	2	2						
(4-5)F						4	4	4				
(4-6)G						2						
(5-7)H									5	5	5	5
(6-7)I							3	3				
Sum of Resource available each day	16	16	13	15	15	14	13	13	11	5	5	5

RESOURCE SMOOTHING- SOLUTION:

Step 4 – Draw a the histogram corresponding to the available resource and its duration from the above tabular column



RESOURCE SMOOTHING

SOLUTION:

Step 5 – The activities are rewritten having floats in descending order or identify the one with High total floats.

ACTIVITY	DURATION (Days)	EST	EFT	LST	LFT	TOTAL FLOAT	REMARKS
(4-6)G	1	5	6	9	10	4	Non-Critical
(6-7)I	2	6	8	10	12	4	Non-Critical
(1-2)A	3	0	3	3	6	3	Non-Critical
(2-7)D	6	3	9	6	12	3	Non-Critical
(1-3)B	2	0	2	2	4	2	Non-Critical
(3-5)E	4	2	6	4	8	2	Non-Critical
(1-4)C	5	0	5	0	5	0	Critical
(4-5)F	3	5	8	5	8	0	Critical
(5-7)H	4	8	12	8	12	0	Critical

RESOURCE SMOOTHING- SOLUTION:

Step 6 – Rewrite the tabular column with duration and activity where activities are shifted according to their total floats.

DURATION (Days) / ACTIVITY	1	2	3	4	5	6	7	8	9	10	11	12
(1-2)A												
(1-3)B												
(1-4)C												
(2-7)D												
(3-5)E												
(4-5)F												
(4-6)G												
(5-7)H												
(6-7)I												
Sum of Resource available each day												

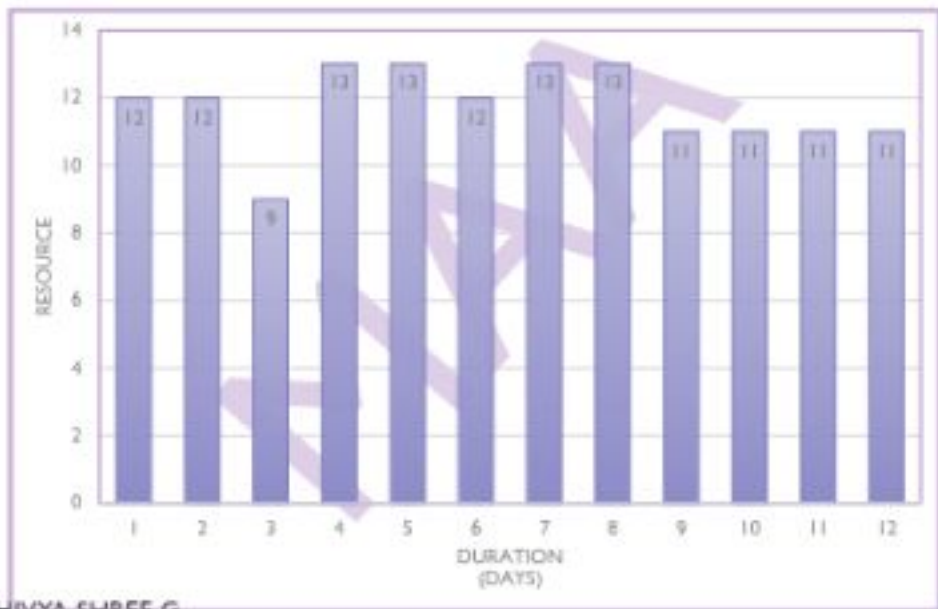
**RESOURCE SMOOTHING-
SOLUTION:**

Step 6 – Rewrite the tabular column with duration and activity where activities are shifted according to their total floats. **SHIFT ACTIVITY(1-2) BY 3DAYS & (2-7) BY 3 DAYS**

DURATION (Days) / ACTIVITY	1	2	3	4	5	6	7	8	9	10	11	12
(1-2)A				4	4	4						
(1-3)B	5	5										
(1-4)C	7	7	7	7	7							
(2-7)D							6	6	6	6	6	6
(3-5)E			2	2	2	2						
(4-5)F						4	4	4				
(4-6)G						2						
(5-7)H									5	5	5	5
(6-7)I							3	3				
Sum of Resource available each day	12	12	9	13	13	12	13	13	11	11	11	11

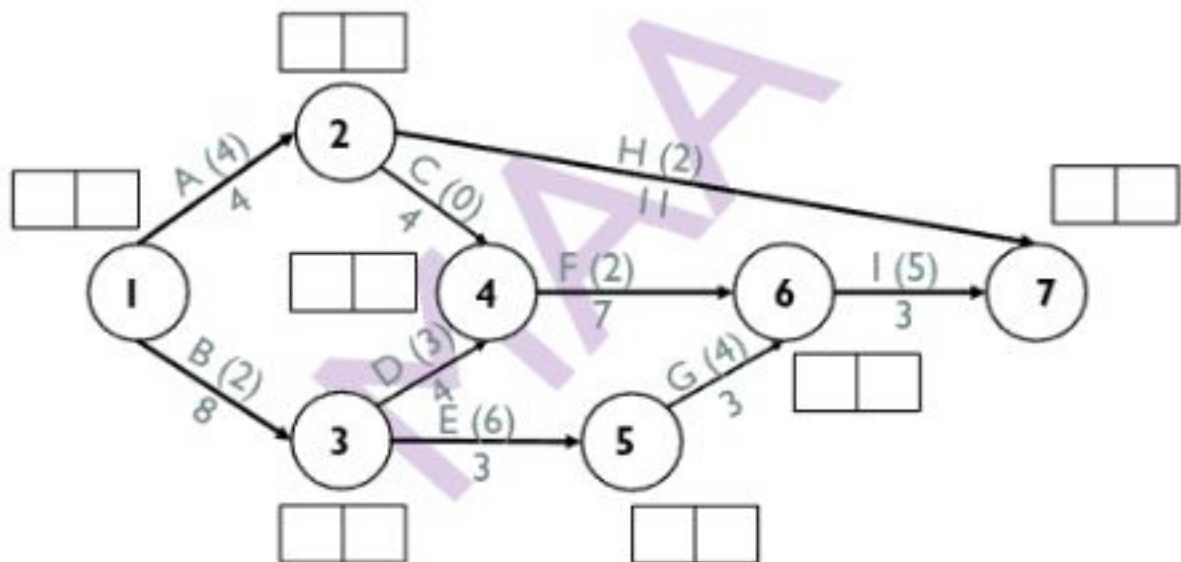
RESOURCE SMOOTHING- SOLUTION:

Step 7 – Draw a the histogram corresponding to the available resource and its duration from the above tabular column



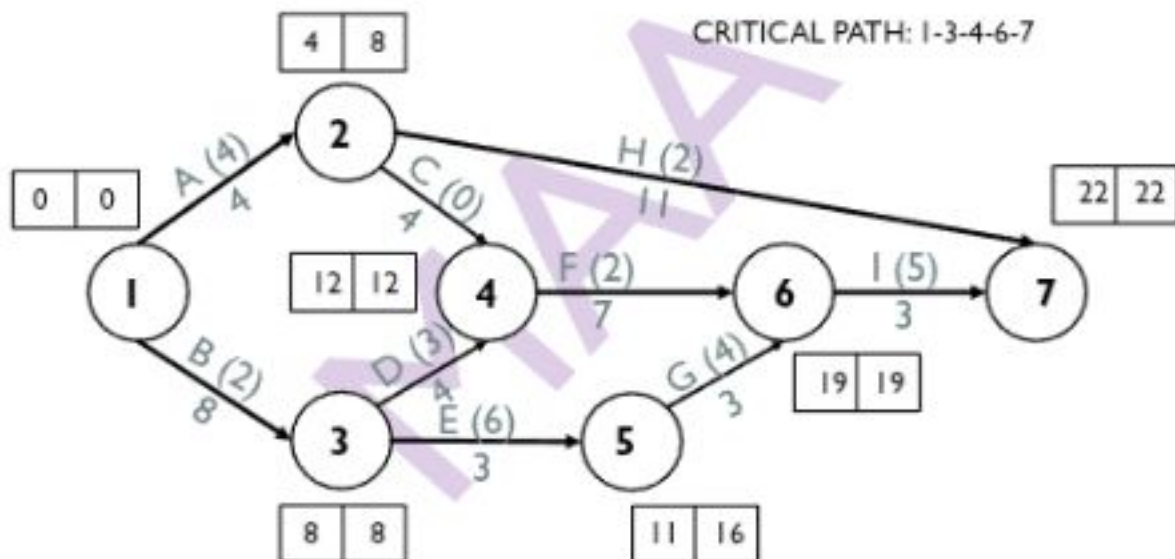
RESOURCE LEVELLING

EXAMPLE 5: Consider the network given below. The requirement of labour for each activity has been shown in brackets over the arrows in the network diagram. Level out the requirement of the resource, if the maximum number of labour, on any day has to be limited by 7.



RESOURCE LEVELLING - SOLUTION:

STEP 1- Obtain the critical path and project duration.



RESOURCE LEVELLING

SOLUTION:

Step 2 - Draw the tabular column with the activity, EST,EFT,LST,LFT and Total Float with remarks.

ACTIVITY	DURATION (Days)	EST	EFT	LST	LFT	TOTAL FLOAT	REMARKS
A	4	0	4	4	8	4	
B	8	0	8	0	8	0	Critical
C	4	4	8	8	12	4	
D	4	8	12	8	12	0	Critical
E	3	8	11	13	16	5	
F	7	12	19	12	19	0	Critical
G	3	11	14	16	19	5	
H	11	4	15	11	22	7	
I	3	19	22	19	22	0	Critical

RESOURCE LEVELLING

SOLUTION:

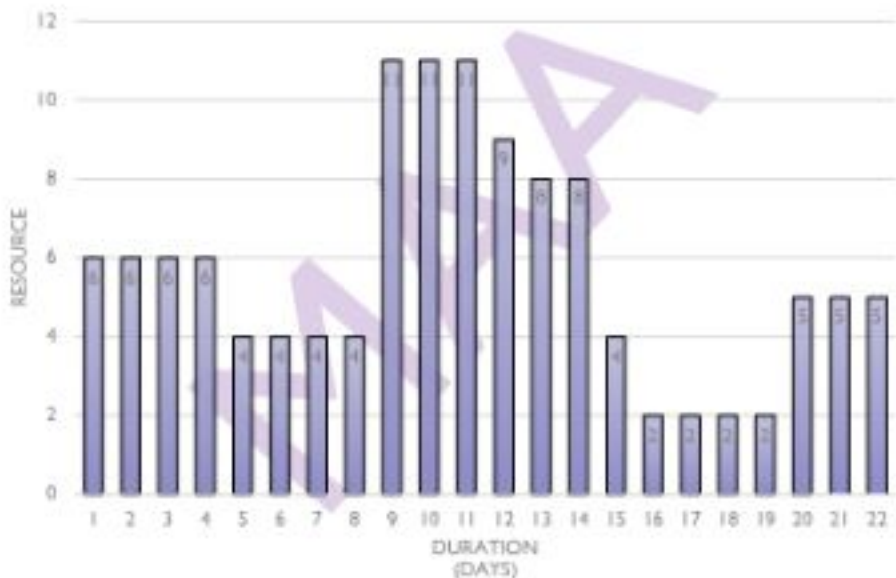
Step 3 – Form a the tabular column with EST of each activity and determine total resources required each day. Having duration on top and activity on side.

DURATION (Days) / ACTIVITY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
A	4	4	4	4																			
B	2	2	2	2	2	2	2	2	2														
C					0	0	0	0															
D									3	3	3	3											
E									6	6	6												
F													2	2	2	2	2	2	2				
G												4	4	4									
H					2	2	2	2	2	2	2	2	2	2	2								
I																					5	5	5
Sum of Resource available each day	4	4	4	4	4	4	4	4	11	11	11	8	6	6	4	2	2	2	2	2	5	5	5

RESOURCE LEVELLING

SOLUTION:

Step 4 – Draw a histogram corresponding to the available resource and its duration from the above tabular column



RESOURCE LEVELLING

SOLUTION:

Step 5 - The activities are rewritten having floats in descending order or identify the one with High total floats.

ACTIVITY	DURATION (Days)	EST	EFT	LST	LFT	TOTAL FLOAT	REMARKS
H	11	4	15	11	22	7	Non-Critical
E	3	8	11	13	16	5	Non-Critical
G	3	11	14	16	19	5	Non-Critical
A	4	0	4	4	8	4	Non-Critical
C	4	4	8	8	12	4	Non-Critical
B	8	0	0	0	8	0	Critical
D	4	8	12	8	12	0	Critical
F	7	12	19	12	19	0	Critical
I	3	19	22	19	22	0	Critical

RESOURCE LEVELLING

SOLUTION:

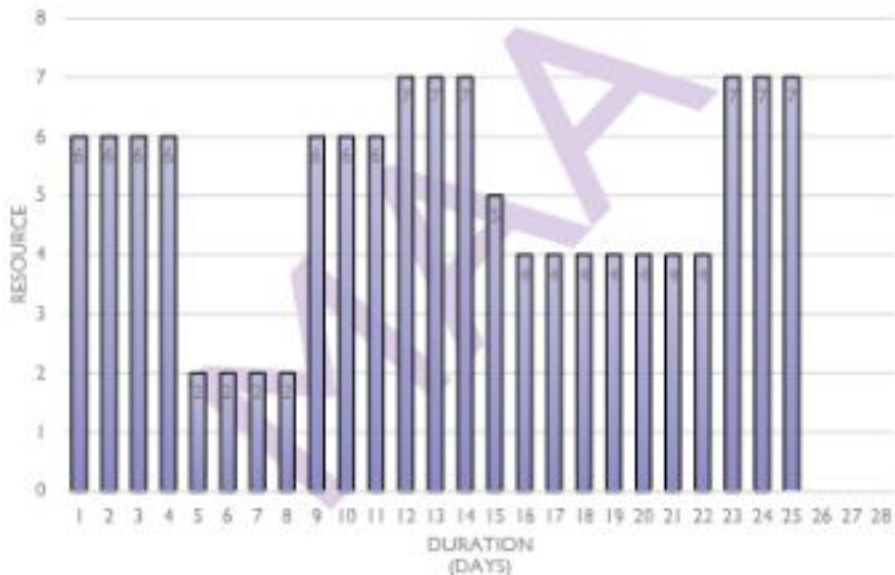
Step 6 – Rewrite the tabular column with duration and activity where activities are shifted according to their total floats. Shift the critical activities D, F & I By 3 days each and activity H by 10 Days.

DURATION (Days) / ACTIVITY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
A	4	4	4	4	4																					
B	2	2	2	2	2	2	2	2	2	2																
C					0	0	0	0																		
D											3	3	3	3												
E								6	6	6																
F															2	2	2	2	2	2	2	2	2	2	2	
G											4	4	4													
H															2	2	2	2	2	2	2	2	2	2	2	
I																							5	5	5	
Sum of Resources available each day	6	6	6	6	2	2	2	2	6	6	6	7	7	7	5	4	4	4	4	4	4	4	4	7	7	7

RESOURCE LEVELLING

SOLUTION:

Step 7 – Draw a histogram corresponding to the available resource and its duration from the above tabular column



RESOURCE UPDATING:

10.2. UPDATING : PROCESS

During the process of implementing the plan according to the network, we may come across one or more of the following possibilities :

1. that some or all activities are progressing according to schedule ;
2. that some or all activities are ahead of schedule ; and
3. that some or all activities are behind schedule.

If all activities are progressing according to the schedule, there is no need for updating the network but this is seldom the case.

Therefore, based on the progress of the work and the revised durations of unfinished activities due to delays, the network diagram has to be redrawn and this process is known as *Updating*.

As stated previously, critical path method is a numerical technique which project management can use as an aid in planning, scheduling and controlling any type of project. The calculations

RESOURCE UPDATING:

taken an entirely new project in hand and tail event of the project has been taken as the base for the calculations. The networks previously developed can also be used to aid planners or managers in decision-making, after the commencement of the project i.e. when project is already in progress.

When the project is partially completed and is at an intermediate stage, it may be possible that :

1. the time durations originally assigned for some activities were erroneous and

2. the planner may himself feel it desirable as a result of experience or he may be enriched with additional information, to reconsider and re-estimate duration times of activities not yet being performed. Now, new information and considerations can be placed on the original network and fresh calculations are made for controlling the project.

RESOURCE UPDATING:

10.3. DATA REQUIRED FOR UPDATING

The following information is necessary to update the plan at an intermediate stage of execution of a project :

1. original network ;
2. original network calculation chart ;
3. stage at which updating is being done i.e., a point in time of updating ;
4. execution position of the project at that stage and
5. new information and knowledge which will affect the duration time of the activities to be performed.

RESOURCE UPDATING:

Table 10.1. Updating

<i>Activity</i>	<i>Whether completed or not</i>		<i>If in progress, additional time required for the completion</i>	<i>Completion required for activities yet to begin</i>
	<i>Yes/No</i>	<i>If yes, time taken for completion</i>		

RESOURCE UPDATING:

10.5. WHEN TO UPDATE

The following points must be kept in view while deciding the time of Updating :

1. for shorter duration projects, the updating must be done frequently by taking into account the latest position of the execution of the project.

2. for large duration projects, the process of updating must be increased as the project is progressing toward completion. Duration of project goes on decreasing as project progresses, and behaving more or less like a small duration project.

3. whenever there is major change in the duration of any of the activity the updating is to be done.

4. updating is essential if there is change in the estimated duration of any activity falling on the critical path. If the duration of a critical activity increases, remedial measures are necessary and if the activity duration decreases, this may allow changes in the project plan which were not possible previously.

RESOURCE UPDATING:

After updating there may be some changes in the completion time of the project. If updating time comes out to be more, the planner has two options:

1. He may ask the executing authorities to perform the operations on the critical path faster than previously estimated. Such execution will require the arrangement of more resources i.e., man-power and material etc., and

2. He may redraw some portion of the network containing those activities which have still not commenced. Such alteration means change in the company's policy of execution which leads to revised inter-dependence of operations.

From the above it is clear that CPM is not only useful in the planning stage of a project but also aids the decision-maker during execution and to some extent in controlling the completion of project on schedule.

RESOURCE UPDATING:

Example 10.1. Fig. 10.2 shows the network of a project which is to be updated at the end of 12 days. The following conditions exist at the time of updating :

1. Activity 1-4 was completed as originally planned.
2. Activity 1-3 was executed more rapidly than originally scheduled, and it took 8 days for its completion.
3. Activity 3-4 commenced following the completion of activity 1-3 and was finished at the end of 11th day.
4. Activity 4-5 was commenced following the completion of activity 3-4 (i.e., at the end of 11th day), and still requires 6 more days for its completion.
5. Completion of activity 1-2 was delayed drastically, and it still requires 10 more days for its completion.
6. Activity 2-7 will commence following the completion of activity 1-2 and will require 9 days for its completion instead of 6 days originally estimated.

RESOURCE UPDATING:

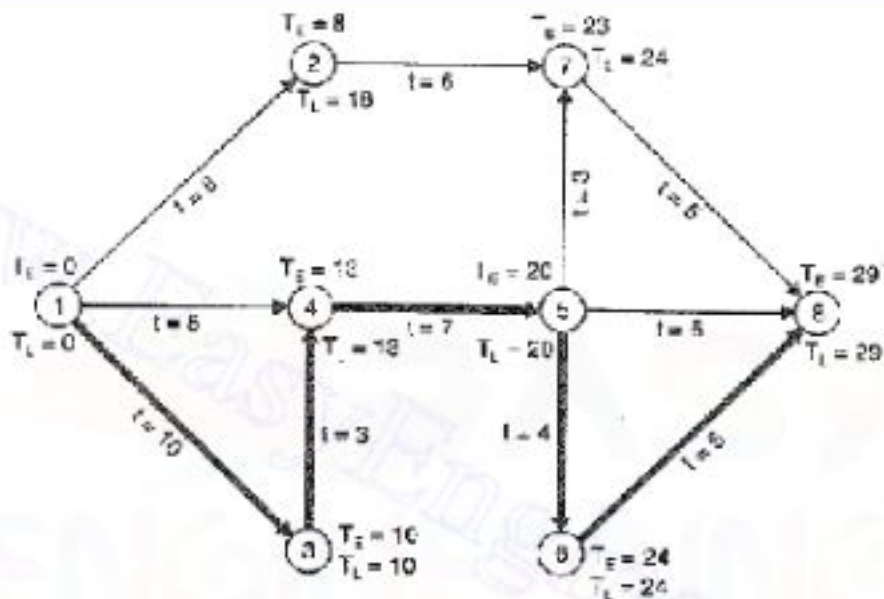
7. The time required to perform activity 5-8 has been revised, based on the experience on the project, gained to this point. It now requires 10 days in the place of 6 days originally estimated.

8. No other activities have been started, and the original time estimates for those activities will appear to be accurate.

Update the network, and determine the revised critical path.



RESOURCE UPDATING:



RESOURCE UPDATING:

Table 10.2
Review after 12 days

Activity	Whether completed or not		Additional time required for activities in progress (days)	Completion time required for activities yet to begin (days)
	Yes/No	If yes, time taken (days)		
(1)	(2)	(3)	(4)	(5)
1-3	No	—	10	—
1-8	Yes	6	—	—
1-4	Yes	6	—	—
2-7	No	—	—	0
3-4	Yes	3	—	—
4-5	No	—	6	—
5-8	No	—	—	4
5-7	No	—	—	8
5-9	No	—	—	10
6-8	No	—	—	6
7-8	No	—	—	6

RESOURCE UPDATING:

Solution. Fig. 10.2 shows the original network, with T_E and T_L marked. The critical path, shown by dark lines is along activities 1-3, 3-4, 4-5, 4-6 and 6-8.

Table 10.2 gives the details of execution of the various activities at the end of 12 days.

The updated network can now be drawn on the basis of data of columns (1), (2), (4) and (5) of the above table. For those activities, which have already been completed, completion time t is taken to be zero, since they require zero time after the 12th day. Also the earliest event time (T_E) and leasted occurrence time (T_L) of each event is computed *with reference* to the original starting date of the project. This can be best achieved by taking T_E for event 1 as equal to 12.

RESOURCE UPDATING:

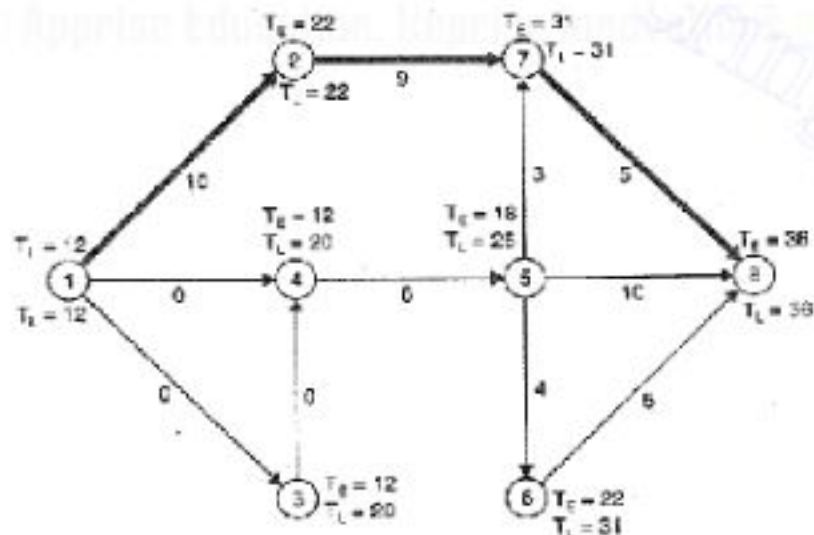


FIG. 10.3. UPDATED NETWORK.

RESOURCE UPDATING:

After having determined the updated T_E for each event, corresponding T_L can be computed by the *backward pass*. The updated network is shown in Fig. 10.3. The critical path of the updated network has now changed ; it is now along activities 1-2, 2-7, 7-8, shown by dark lines. According to the updated network, the project will take a total time of 36 days, instead to 29 days originally planned. On the day of updating, the remaining duration of project = $86 - 13 = 24$ days.

UNIT IV -
COMPUTERIZED
PROJECT MANAGEMENT

CONTENTS

- Introduction: Creating a New project, building task. Creating resources and assessing costs, Refining your project.
- Project Tracking-Understanding tracking, recording actual.
- Reporting on progress.
- Analyzing financial progress.



INTRODUCTION

- Modern construction management has fast evolved into an independent field of study to include a gamut of issues including financing of large infrastructure projects, construction equipment, planning and scheduling, and tender and contract management.
 - The emergence of computers and their widespread use in the construction industry for data storage, retrieval and analysis have on the one hand made the job of the construction manager easier, and on the other hand made it more complex. Off-the-shelf software tailor-made for use in the construction industry is now commercially available.
 - The following sections briefly discuss some of the programmes that are readily available to the manager for planning, scheduling, leveling, monitoring and reporting functions. Once the basic data has been entered into the software, it is possible to schedule, reschedule and monitor at frequent intervals without much effort.
 - Although the advantages of the project management software may not be remarkably visible for a small project, it really pays off when used in management of large projects. In fact, in most of the large projects these days, it is contractually mandatory to use software for project scheduling and monitoring. This is perhaps the area that has caught the imagination of programmers to the largest extent, and a wide range of project management software is available in the market, varying in the degree of sophistication and features, and in the price.
-

INTRODUCTION

- Software is helpful at both planning and execution phases of the project. In the former, software helps to create a well-thought-out plan and, at times, also a more creative solution, based on logical sequencing of events, besides helping a planner to foresee problems. During the execution of a project, software is helpful for promoting effective coordination and better resource allocation. Some of the advantages associated with project management software are:
- Speed and accuracy have greatly improved.

It is not a very costly proposition and even medium and small companies can afford these software.

- Most of the software are user-friendly and one can use them quite easily.
- The software can handle complex problems involving multiple stakeholders as well as a number of constraints.
- It is easy to modify the inputs, and maintaining the records has also become easier.
- Decision-making has become easier. It is possible to try different possible alternatives and select the best alternative with the assistance of 'what if' analysis in project management software.

INTRODUCTION

- ► Nevertheless, it should be borne in mind that the use of (any) software does not make a project manager more effective—it is only a tool to make the manager more efficient. It is only the time required for carrying out calculations that can be reduced, and the basic models, etc., have still to be developed by a manager. Simply put, project management software does not help define the scope of work, or communicate to the client, or to carry out resource allocation. It only facilitates these processes and eliminates the possibility of computational errors, though judgmental errors can still be made.
- ► The initial few steps are common to both manual planning and software based planning. For example, in software-based management of projects, we need to think about the objectives of the project, the constraints, and the assumption on which the overall plan is based. There has to be clear and measurable objectives, and the plan should include a list of deliverables and milestones or dates of delivery. Due to the presence of unknown factors in the beginning of a project, the software-based plan also
- utilizes the planner's previous knowledge and experience to come up with 'educated guesses' for many of the input parameters.

INTRODUCTION

- ► At the initial stage, often there are many unknown factors—for example, the resource requirement of key activities and the overall available resources for different stages of the project. Experienced planners can rely on their previous knowledge and come up with 'educated guesses'. The accuracy of these assumptions will determine the quality of the plan. Constraints on a project are factors that are likely to limit the project manager's options. Typically, the three major constraints are schedule, resources and scope. Any change in one of these constraints usually affects the other two, and also affects the quality of the overall plan.

POPULAR PROJECT MANAGEMENT SOFTWARE

- Given the unknown factors and potential changes in constraints, the planner needs to define a scope management plan to deal with the same during execution of a project.
- ▶ The history of project management software is perhaps as old as the history of the computer. While the early project management software were limited in features, their modern counterparts are very powerful. Artemis, Can Plan, Hard Hat Manager, Microsoft Project, Primavera Project Planner, Primavera Suretrak Project Kick Start and Scitor's Business Solutions—PC Suite are some of the project management software available in the market, besides Microsoft Excel, which is also used by managers.

POPULAR PROJECT MANAGEMENT SOFTWARE

- PRIMAVERA

- ► Primavera Systems, Inc. is the world's leading provider of project, program and portfolio management software solutions. It provides the software foundation that enables all types of businesses to excel in managing their portfolios, programs, projects and resources.
- Primavera helps companies make better portfolio investment decisions, improve governance, prioritize their project investments and resources, and deliver tangible results back to the business. Primavera has product solutions specific to certain industries like construction, aerospace, manufacturing and power.

POPULAR PROJECT MANAGEMENT SOFTWARE

- MILESTONE PROFESSIONAL

- It is a fast and easy software to schedule, manage and report projects. It has Gantt chart software for creating presentation-ready project management charts and also works with Microsoft Project. It can function as an add-on tool for Microsoft Project. It can create presentation reports, combine cost and schedule, manage large projects, create reports from Microsoft Office Project, calculate earned value, and distribute schedules via print, email and Internet.

POPULAR PROJECT MANAGEMENT SOFTWARE -

“CANDY”—Construction Project Modelling and Project Control

- ‘Candy’—Construction Project Modelling and Project Control is a single package, project control system designed by construction professionals specifically for the construction industry. Estimations, valuations, planning, cash flow and forecasting components can be integrated.
- The operation in candy is similar to manual methods. One of Candy’s most powerful features is the unique facility to dynamically link money and time, i.e., linking the bill of quantities to the programme of work.

POPULAR PROJECT MANAGEMENT SOFTWARE

- **AMS REALTIME PROJECTS**

- This is a powerful, easy-to-use tool that provides integrated project, resource scheduling and cost management. It supports the needs of individual project managers and provides consolidation, aggregation, analysis and management through powerful multi-project facilities.

- **PROJECT KICKSTART**

- Project KickStart helps save time and money by organizing thoughts quickly with easy user interface. It has straightforward task management and progress tracking, both of which are essential for efficient, successful projects. Its other features include basic budgeting and cost tracking. It also supports Gantt chart to keep the project on time—or better still, ahead of schedule—and helps in keeping the project organized with centralized document repository.

POPULAR PROJECT MANAGEMENT SOFTWARE

- MS Project
- MS Project is a popular software offering a number of functions such as scheduling, resource levelling, tracking and reporting, in a user-friendly manner. In appearance, it is almost like a spreadsheet. Preparation of schedule and identification of critical path are easily achievable in MS Project.
- MS Project distinguishes between work resources and material resources. Tracking is possible by entering the information on percent completion of task. The newer versions are equipped with work breakdownstructure tools, risk analysis tools and multiple project-planning tools.

FUNCTIONS OF PROJECT MANAGEMENT SOFTWARE

- While the features of different software may differ, all project management software make an effort to address the following key areas:
 - ▶ Scheduling function
 - ▶ Resource management including labour, equipment and materials management
 - ▶ Monitoring of a project during execution to assess compliance with schedules and estimates prepared prior to commencement
 - ▶ Generation of appropriate progress reports, which could be different depending upon the target reader (audience)—reports for internal circulation within a contractor's organization could be quite different from those submitted to the client. Similarly, the issues of interest for a financier could be quite different from those for an end user.

QUESTION BANK:

- Previous Year Questions:
- Write down some critical points to follow in choosing the software for a project.
- Illustrate in detail about Computerized Project Management in construction.
- Discuss how computerized project management be done for a new project with its limitations.
- Write the procedure of analyzing the project in Computerized Project Management.
- Explain how to create resources and assign costs in Computerized Project Management.
- Explain how project tracking process can be done by computerizing the project management.
- Write down the objective and limitation of analyzing the financial status of a project.

PRECEDENCE RELATIONSHIPS IN YOUR SCHEDULE

- **Finish-to-Start**

- This means that Activity B cannot start until Activity A has completed. This is by far the most common relationship between multiple activities. In most schedules, all relationships will be finish-to-start. Example:

- Activity A is "Create the Project Charter."

- Activity B is "Obtain Project Charter approval from the Project Sponsor."

- This finish-to-start relationship would say that we must create the Project Charter before we obtain Project Charter approval from the Project Sponsor.

PRECEDENCE RELATIONSHIPS IN YOUR SCHEDULE

- **Start-to-Finish**

- Start-to-finish means that Activity A must start before Activity B can finish. This is a very rare relationship.
 - Example: Let's assume that you want to fertilize your garden, but the plants must all be wet when the fertilizer is applied.
- Activity A is to "fertilize the garden."
- Activity B is to "water the garden."
- The start-to-finish relationship says we need to start watering the garden (activity B) first to get the plants wet. This activity must continue until the fertilizing starts (activity A). This will ensure the plants remain wet until the fertilizer is ready to be applied. Note that you can start watering at any time and you can finish fertilizing at any time. The relationship only ties the start of activity A to the completion of activity B.

PRECEDENCE RELATIONSHIPS IN YOUR SCHEDULE

- **Start-to-Start**

- This means Activity A must start before Activity B can start.

- Example: Assume that you are having your walls painted in one room and wallpaper is being hung in another room. You want to minimize the total disruption and so you want to make sure both activities happen at the same time.

- Activity A is "Paint the walls."

- Activity B is "Hang the wallpaper."

- The wallpaper hangers may be ready to go (activity B). However, the start-to-start relationship says that they cannot start until the painting starts (activity A). This relationship is based on the activity start times. The end times of each activity are not related and, in fact, one activity could end at a much later time than the other.

PRECEDENCE RELATIONSHIPS IN YOUR SCHEDULE

- Finish-to-Finish
- This means Activity A must finish before Activity B can finish.
- Example: Assume you're cooking dinner and you want the turkey to finish cooking before the potatoes.
- Activity A is "Cook turkey."
- Activity B is "Cook potatoes."
- The finish-to-finish relationship says that the turkey must finish cooking (activity A) before the potatoes finish cooking (activity B). This relationship is based on the end times. They can each start whenever they need to, as long as they finish in this order.

Introduction to BIM

- ► *Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition.*

BIM in construction management

- Participants in the building process are constantly challenged to deliver successful projects despite tight budgets, limited resources, accelerated schedules, and limited or conflicting information. The significant disciplines such as architectural, structural and MEP design should be well coordinated, as few things don't take place at the same place and time. Building Information Modeling aids in collision detection at the initial stage, identifying the exact location of discrepancies.
- The BIM concept envisages virtual construction of a facility prior to its actual physical construction, in order to reduce uncertainty, improve safety, work out problems, and simulate and analyse potential impacts. Sub-contractors from every trade can input critical information into the model before beginning construction, with opportunities to pre-fabricate or pre-assemble some systems off-site. Waste can be minimised on-site and products delivered on a just-in-time basis rather than being stock-piled on-site.
- Quantities and stored properties of materials can be extracted easily. Scopes of work can be isolated and defined. Systems, assemblies and sequences can be shown in a relative scale with the entire facility or group of facilities. BIM also prevents errors by enabling conflict or 'clash detection' whereby the computer model visually highlights to the team where parts of the building (e.g. structural frame and building services pipes or ducts) may wrongly intersect.



KEY CONCEPTS IN BIM

**Keep reading to find out more
about the following 6 key terms:**

1. Smart digital model or intelligent design
2. Model data
3. Clash detection
4. BIM levels & BIM dimensions
5. Parametric design / modelling
6. Computational design or algorithmic modeling

SMART DIGITAL MODELS

are independent, flexible, and interoperable. They are designed to be used in a variety of ways, from design to construction and operation.



MODEL DATA

Provides information about the model, including its purpose, scope, and the data sources used to create it.



CLASH DETECTION

Identifies and resolves conflicts between different building systems, such as structural, mechanical, and electrical, before construction begins.



COMMON TERMS IN THE BIM WORLD

BIM LEVELS & BIM DIMENSIONS

Refers to the different levels of detail and information used in BIM, ranging from conceptual design to construction and operation. It also refers to the different dimensions of BIM, such as 3D, 4D, and 5D.



PARAMETRIC DESIGN

Uses algorithms and rules to generate design options and optimize building performance. It allows designers to explore different design scenarios and make data-driven decisions.



COMPUTATIONAL DESIGN

Uses computational methods to optimize building design and performance. It involves using algorithms and simulation to explore different design options and make data-driven decisions.



3D

- Existing Conditions Models
- Safety & Logistics Model
- Animation Renderings Walkthroughs
- BIM driven prefabrication Laser accurate BIM driven field layouts

4D

SCHEDULING

- Project Phasing Simulations
- Detailed Simulation Installation
- Visual Validation for Payment Approval

6D

SUSTAINABILITY

- Conceptual Energy Analysis
- Detailed Energy Analysis
- Sustainable element tracking
- LEED tracking

5D

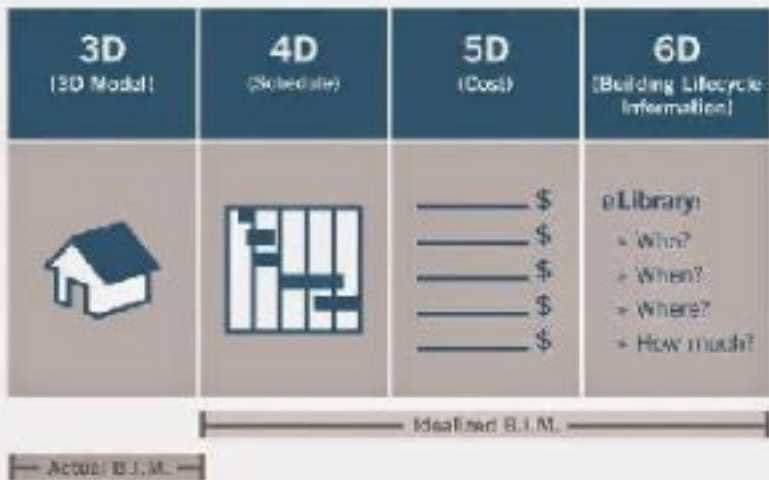
ESTIMATION

- Quantity Extraction to support cost Estimates
- Trade Verification from Fabrication Models:
 - Structural Steel - Rebar
 - MEP
- Value Engineering
 - What-if-scenarios
 - Visualizations
 - Quantity Extractions
- Prefabrication Solutions

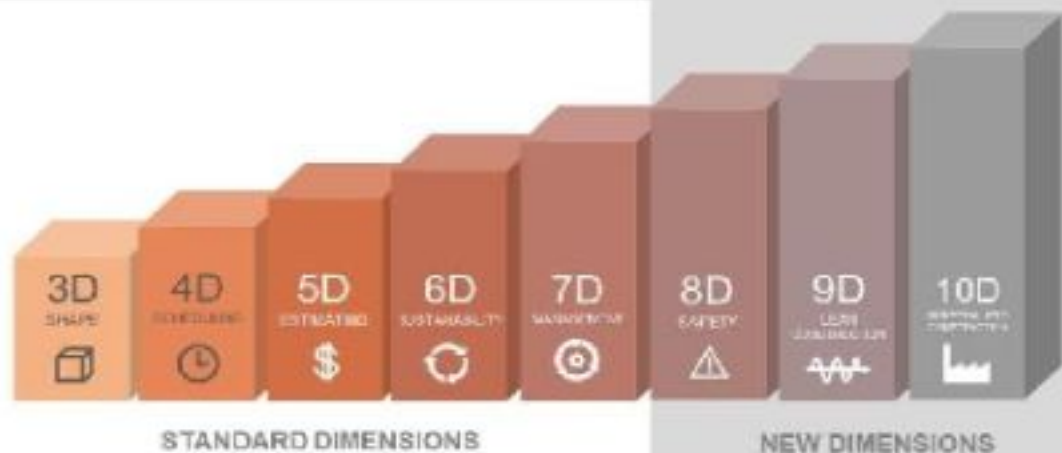
7D

FACILITY MANAGEMENT APPLICATIONS

- Life Cycle BIM Strategies
- BIM As-Builts
- BIM embedded Q&M manuals
- BIM Maintenance Plans & Technical Support



DIMENSIONS OF BIM



PROJECT FEASIBILITY STUDY

Naaz Iqbal, Navya A.M, Nuwera Tabassum, Reshman Mashuda,
Thakreem Seema, Shainaz Begum, Sharon Infanshia.

WHAT IS PROJECT FEASIBILITY STUDY?

- A project feasibility study examines all of a project's pertinent aspects including
 - economic,
 - operational
 - technical,
 - legal, and
 - schedulingto determine the possibility of the project's successful completion.

- Prior to commencing the project and investing funds, time, and efforts into it, managers conduct a feasibility study of the project.

- Feasibility is done to check whether a project will be successful and how to overcome potential obstacles for the project. It will help us to evaluate the project from start to the end



WHY DO WE CONDUCT A PROJECT FEASIBILITY STUDY

- Understand all aspects of the project feasibility
- Find potential problems during the project's implementation
- Determine the viability of the project
- Define alternative solutions to obstacles
- Enhance project success by analyzing data from multiple sources
- Identify obstacles and challenges





KEY ELEMENTS OF PROJECT FEASIBILITY STUDY

In project management, a **project feasibility study** evaluates the following areas:

1. **Technical Capability:** Is the organization equipped with the necessary technical resources to complete the project
2. **Budget:** Does the organization have the financial resources to carry out the project, and does the cost-benefit analysis justify moving forward?
3. **Legality:** What are the project's legal requirements, and can the company meet them?
4. **Risk:** What are the risks involved in completing this project? Is the risk worth the company's money and time based on the expected benefits?
5. **Operational feasibility:** Does the project, in its intended scope, address the organization's needs through fixing problems and/or seizing opportunities?
6. **Time:** How much time would it take for completion?



Market Study

- Market study/research is the **systematic gathering, recording and analysis of data** about problems relating to the marketing of goods and services.
- Market research is the means by which those who provide goods and services **keep themselves informed** of the needs and desires of the buyers and distributors of the goods and services.
- The market study aims to address the following questions :
 - **What is the market?**
 - **Who are the competitors?**
 - **Who is the target audience?**
 - **What do customers want?**
 - **What to competitors offer?**
 - **What is your USP (Unique Selling Proposition)?**
 - **What do customers think you offer them?**

Market Study

Methods of Market Research :

- FIELD RESEARCH
- DESK RESEARCH

FIELD RESEARCH :

It consists of conducting personal interviews, telephone or online interviews and conducting surveys - either through offline or online modes. Analysing the purchase and usage of the targeted product within the market is the ultimate goal.



Market Study

DESK RESEARCH :

Consists of consulting :

Internal sources :

- Sales figures
- Accounting records
- Customers' comments and complaints
- Sales representatives' reports

Online research :

- Search Engines
- Newsletters, articles and blogs

Printed Research :

- Business Directories
- Business statistics
- Industrial market research reports

How to do a desk research



Identify or select the topic you need to research



Identify the sources of information with the most relevant data



Check if previous data related to the topic is available



Compare and compare the collected data to an available forecast



Analyze the data and identify if all the questions have been answered



If there are missing questions, report the outcomes and objectives



Financial analysis

-make sure whether the proposed project will be financially viable

- servicing debt
- satisfy the return expectations of those who provide the capital.

The aspects which have to be looked into while conducting financial appraisal are:

1. Investment outlay & cost of project.
2. Means of financing
3. Project profitability
4. Break-even-point
5. Cash flows of the project
6. Investment worthwhileness judged in terms of various criteria of merit
7. Projected financial position



1. **Investment outlay**

refers to the financial resources committed to an investment.

2. **cost of project**

represents the total of all items of outlay associated with a project which are supported by long-term funds.

3. **Means of financing**

Means by which a budget deficit is financed or a surplus is used. Means of financing are not included in the budget totals.

To meet the cost of project the following means of finance are available;

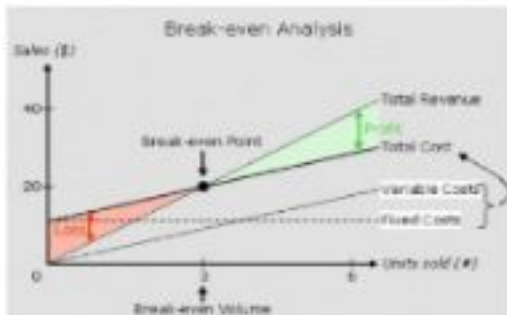
- Share capital
- Term loans
- Debenture capital
- Deferred credit
- Incentive sources

Project profitability

The Project Profitability report is used to monitor the planned and real cost related to a project.

Break even point

The break even point is the point where the gains equal the losses.





Cash flow of the project

When beginning capital-budgeting analysis, it is important to determine a project's cash flows.

These cash flows can be segmented as follows:

- Initial Investment Outlay
- Operating Cash Flow over a Project's Life
- Terminal-Year Cash Flow

Projected financial position

Projected Financial Statements is summary of various component projections of revenues and expenses for the budget period. They indicate the expected net income for the period.



Economic analysis

Economic feasibility is where Analysis of a project's costs and revenues in an effort to determine whether or not it is logical and possible to complete.

Benefits of economic feasibility

Tangible benefits

- Reduce and avoid cost
- Reduce error
- More flexible
- Faster activities

Intangible benefits

- Maintaining competitiveness
- Increase organisation flexibility
- Promote learning and understanding
- Timely information

Project cost of economic feasibility

Tangible cost

- System development
- Hardware and software procurement
- Users and staff training
- Site preparation
- Date or system conversion

Intangible cost

- Maintenance and support
- Incremental data storage
- Incremental communication
- New software and hardware leases
- consumables

How do we estimate economical benefits

1. Historical information of similar projects
2. Future taxation and inflation estimates
3. Scale and scope of the project
4. Anticipation and other competing projects

Technical Study

To assist businesses in determining whether

- a) **Technical resources** are sufficient for the job.
- b) **Technical team** is capable of executing planned concepts.

Technical study factors

1. Site Location
2. Plant Size
3. Layout
4. Machinery and equipment
5. Environment Impact Assessment EIA
6. Inputs
7. Infrastructure facilities
8. Manpower





Technical Study factors

- **Site Location:**
 - The **accessibility & availability** of raw materials
 - The cost of transport and proximity
- **Plant Size (Production capacity - volume manufactured in a given time):**
 - **Optimum plant size** is critical to the success of a project.
 - A plant represents **sunk costs** and any under utilisation of its capacity means either reduced profits or levels below **Break Even Point**.
- **Layout:**
 - Good layout with minimum material handling, effective space utilization, smooth workflow, safety facilities and **Flexibility of arrangements**.
- **Machinery equipment:**
 - **What type** of equipment and technology will the construction need ?
 - **What costs** are involved to purchase and set up the equipment ?
 - **How long** will it take to acquire the equipment and begin operations ?



Technical Study factors

- **Environmental Impact Assessment:**
 - This study - **identifies the environment** in which a project is to be implemented, assesses the short and long term impacts.
 - Surface water quality, air quality, land quality and etc.
- **Inputs:**
 - **Operation phase** of the project.
 - Classification of the inputs:
 - Raw Materials, Processed materials, Water & steam, Gas, fuels and electricity
- **Infrastructure facilities:**
 - Availability and characteristics of roads, bridges, railway facilities, ports, etc. depending upon their relevance to the assessed requirements of the project at both implementation and operation stages need to be studied.
- **Manpower:**
 - The availability in needed numbers, of manpower of requisite skills where and when required, has to be studied.
 - Manpower covers both the **project implementation and the operation phases.**



Operational feasibility

- **KEY ELEMENT:** Does the project, in its intended scope, address the organization's needs through fixing problems and/or seizing opportunities?
- This assessment entails researching to evaluate whether and to what extent — the project can meet the organization's needs.
- Operational feasibility studies also look at how a project plan meets the requirements specified during the requirement analysis phase.



- Operational feasibility determines if the human resources are available to operate the system once it has been installed.
- Users that do not want a new system may prevent it from becoming operationally feasible.
- Is a measure of how well a proposed system solves the problems, and takes advantages of the opportunities identified during scope definition and how it satisfies the requirements identified in the requirements analysis phase of system development.



Ecological Analysis

- Characterized by the interdependence of living organisms in an environment; an ecological. Anything ecological relates to the science of ecology, which is the study of how **living things** and **the environment** do their thing.
- Issues like **preserving** rainforests, **saving** endangered species, and keeping drinking water safe.
- Ecological things have to do with how **plants** and **animals** relate to each other, in good and bad ways, in specific environments — from the impact of floods on river insects to how smog harms humans.
- Just about anything people do has an ecological impact — for better or worse.



Legal Feasibility

- This assessment looks into if any component of the proposed project violates any regulations, such as zoning laws, data protection legislation, or social media laws.
- Let us take an example that a company that desires to build a new office building at a particular location. A feasibility study may discover that the desired location for the company is not designated for that sort of business.
- To establish the legal feasibility of a project a due diligence process is undertaken. It ensures that the project can be performed in accordance with current legal requirements and that key aspects of the project have been analysed from a legal perspective.
- In this stage, issues like planning permission, land ownership/leases and taxation are all considered by the project team.



Legal Feasibility

- Financial aspects
- Commercial feasibility
- Land and property assets issues
- Foreign investment and currency exchange
- Employment issues
- Taxation and accountancy
- Environmental issues



Administrative Feasibility

- Administrative feasibility refers to the likelihood that a department or agency can implement the policy or deliver the program well. It entails an assessment of a department's or agency's capacity, a projection of available resources and agency behavior that may be difficult to estimate.
- This part of the feasibility study formula is concerned with whether the various parties involved in the project are capable of completing it successfully. Even if a project involves just a single contractor, they'll need to make sure their own workers will be available.
- This is where having a well-thought-out construction workforce plan centered around dedicated software comes in handy.

Steps in conducting project feasibility

- **Preliminary Analysis:** The purpose of the preliminary analysis is to identify insurmountable barriers that would render a feasibility study ineffective.
- **Define the scope:** The scope of the project will also take into consideration its impact on internal stakeholders as well as external clients or consumers.
- **Market research:** There is no such thing as a project that is performed in a vacuum. Those performing the feasibility assessment will look at the current competitive landscape to see if the project has a place in it.
- **Financial analysis:** The project's feasibility study will look at the project's economic costs, such as equipment or other resources, man-hours, the project's expected benefits, the break-even date, financial risks, and, most crucially, the financial impact of the project's failure.
- **Roadblocks and alternative solutions:** If any potential obstacles arise during the study, it will investigate options to ensure the project's success.
- **Results re-evaluation:** It's critical to take a fresh look at the feasibility study, especially if a large amount of time has passed after it was completed.
- **The last decision:** Whether the project should proceed or not—is the final part of a feasibility study.



Best Practices to Conduct Project Feasibility study

- Obtain feedback from the right stakeholders on the new concept.
- Analyze and challenge your data to ensure that it is reliable.
- To assist in data collection, conduct a market survey or market research.
- Make business, organizational, or operational plans.
- Make forecasted income statement.
- Prepare forecast of balance sheet.
- Make a preliminary decision whether to proceed or not regarding carrying out the strategy.

THANK YOU

The background is a solid teal color. In the upper right quadrant, there is a large, faint donut chart with three segments. To its right and below are several smaller, faint circular icons, some resembling pie charts. In the bottom right corner, there is a faint bar chart with four vertical bars of increasing height.

Real Estate And Regulatory Strategies

Aditya
Akshaya
Eliana
Jasraj
Vishal
Vatsal

What is real estate?

Real estate is the land along with any permanent improvements attached to the land, whether natural or man-made—including water, trees, minerals, buildings, homes, fences, and bridges. Real estate is a form of real property.



INTRODUCTION

An Act to establish the Real Estate Regulatory Authority for regulation and promotion of the real estate sector and to ensure sale of plot, apartment or building, as the case may be, or sale of real estate project, in an efficient and transparent manner and to protect the interest of consumers in the real estate sector and to establish an adjudicating mechanism for speedy dispute redressal and also to establish the Appellate Tribunal to hear appeals from the decisions, directions or orders of the Real Estate Regulatory Authority and the adjudicating officer and for matters connected therewith or incidental thereto.

OBJECTIVES:

- ensure accountability towards allottees and protect their interest
- ensure fair-play and reduce frauds & delays
- introduce professionalism and pan India standardization
- establish symmetry of information between the promoter and allottee
- imposing certain responsibilities on both promoter and allottees
- establish regulatory mechanism to enforce contracts
- promote good governance in the sector which in turn would create investor confidence

Real Estate Laws and Regulations



Real Estate (Regulation and Development) Act, 2016

- The Real Estate (Regulation and Development) Act, 2016 is an Act of the Parliament of India which seeks to protect home-buyers as well as help boost investments in the real estate industry.
- The bill was passed by the Rajya Sabha on 10th March, 2016 and by the Lok Sabha on 15 March 2016.
- The Act came into force from 1 May 2016 with 69 of 92 sections notified.
-
- The Central and state governments are liable to notify the Rules under the Act within a statutory Period of six months.
-
- Applicable to whole of India except Jammu and Kashmir

Real estate regulatory authority (RERA) is the governing authority.



SALIENT FEATURES

- Establishes the **State Real Estate Regulatory Authority** for that particular state as the **government body** to be approached for redressal of **grievances against any builder**.
- Vests authority on the real estate regulator to **govern both residential and commercial real estate transactions**.
- It is mandatory for developers to post **all information** on issues such as project plan, layout, government approvals, land title status, sub-contractors to the project, schedule for completion with the State Real Estate Regulatory Authority (RERA) and then in effect pass this information on to the consumers.
- The current practice of selling on the basis of ambiguous **super built-up area** for a real estate project is **declared illegal**.
- Carpet area has been **clearly defined**.
- Punishment for developer who violates the order of the appellate tribunal of the RERA is **three years imprisonment with or without a fine**.

SALIENT FEATURES

- Currently, if a **project is delayed**, then the developer does not suffer in any way. Now, **the law ensures** that any delay in project completion will make the developer liable to pay the same interest as the EMI being paid by the consumer to the bank back to the consumer
- The developer cannot make any changes to the plan that had been sold without the written consent of the buyer.
- This puts paid to a common and unpopular practice by developers to increase the cost of projects.
- Every project measuring more than 500 square metres or more than eight apartments will have to be registered with the RERA.
- The law mandates every builder to keep 70% of collection from every project in Separate Bank Account.

REGISTRATION

Who is liable to get Registration from RERA?

- All commercial real estate projects where the land is over 500 square metres.
- All residential real estate projects where the land is over 500 square meters or eight apartments, to register with the Real Estate Regulatory Authority (RERA) for launching a project.
- For on-going projects which have not received completion certificate on the date of commencement of the Act, will have to seek registration within 3 months.
- Real estate agents who facilitate selling or purchase of properties must take prior registration from RERA. Such agents will be issued a single registration number for each State or Union Territory, which must be quoted by the agent in every sale facilitated by him.

What is the Process of Registration?

- Applicant has to file an application for registration with RERA in prescribed form along with prescribed fees and documents.
- Application for registration must be either approved or rejected within a period of 30 days from the date of application by the RERA. On successful registration, the promoter of the project will be provided with a registration number, a login id and password for the applicants to fill up essential details on the website of the RERA.

What is the penalty for failure to get register?

- A penalty of up to 10 percent of the project cost or three years' imprisonment may be imposed.

PRIOR REGISTRATION OF REAL ESTATE PROJECT WITH REAL ESTATE REGULATORY AUTHORITY

(1) No promoter shall advertise, market, book, sell or offer for sale, or invite persons to purchase in any manner any plot, apartment or building, as the case may be, in any real estate project or part of it, in any planning area, without registering the real estate project with the Real Estate Regulatory Authority established under this Act.

- Provided that projects that are ongoing on the date of commencement of this Act and for which the completion certificate has not been issued, the promoter shall make an application to the Authority for registration of the said project within a period of three months from the date of commencement of this Act
- Provided further that if the Authority thinks necessary, in the interest of allottees, for projects which are developed beyond the planning area but with the requisite permission of the local authority, it may, by order, direct the promoter of such project to register with the Authority, and the provisions of this Act or the rules and regulations made thereunder, shall apply to such projects from that stage of registration.

PRIOR REGISTRATION OF REAL ESTATE PROJECT WITH REAL ESTATE REGULATORY AUTHORITY

2) No registration of the real estate project shall be required if:

Area of land does not exceed 500 sq Mts
No. of apartments does not 8 in a phase
In case of Renovation/Repair/Redevelopment
Promoter has received completion certificate for a real estate project prior to commencement of this act

APPLICATION FOR REGISTRATION OF REAL ESTATE PROJECTS.

f) A declaration, supported by an affidavit, which shall be signed by the promoter or any person authorised by the promoter, stating:—

(a) They should have legal title to the land on which the development is proposed along with legally valid documents with authentication of such title.

(b) The land is free from all encumbrances, or as the case may be details of the encumbrances on such land including any rights, title, interest or name of any party in or over such land along with details

(c) 70% of the amounts, for the real estate project from the allottees, from time to time, shall be deposited in a separate account to be maintained in a scheduled bank to cover the cost of construction and the land cost and shall be used only for that purpose.

d) The promoter shall withdraw the amounts from the separate account, to cover the cost of the project, in proportion to the percentage of completion of the project

e) the promoter shall get his accounts audited within six months after the end of every financial year by a chartered accountant in practice.

Regulatory Strategies

The establishment of a statutory regulatory authority for real estate regulation is a relatively recent phenomenon. The Real Estate (Regulation and Development) Act, 2016 requires each state to establish a Real Estate Regulatory Authority. As of July 2021, 20 States and Union Territories have established their own regulatory authorities. States are also mandated to set up a Real Estate Appellate Tribunal by this Act.

The real estate sector is subject to several types of regulation and control, such as building and planning regulations, environment law and labour law.

Moreover, land itself is subject to a legal and administrative regime that controls its ownership and transfer. However, as the real estate sector grew in the decades of the 2000s, there were concerns about the risky financial practices and mis-selling by promoter companies, the prevalence of black money and shady dealing, and the imbalance of market power between buyers and sellers. This gap was sought to be filled through the establishment of the real estate regulatory authorities.

Applicability of the Bill: The proposed initial Bill was applicable for residential real estate. It is now proposed to cover both residential and commercial real estate.

Establishment of Real Estate Regulatory Authority: Establishment of one or more 'Real Estate Regulatory Authority' in each State/ Union Territory (UT), or one Authority for two or more States/UT, by the Appropriate Government for oversight of real estate transactions.

To appoint one or more adjudicating officers to settle disputes and impose compensation and interest.

Registration of Real Estate Projects and Registration of Real Estate Agents: Mandatory registration of real estate projects and real estate agents who intend to sell any plot, apartment or building, with the Real Estate Regulatory Authority.

Regulatory Strategies

Mandatory Public Disclosure of all project details: Mandatory public disclosure norms for all registered projects such as details of promoters, project, layout plan, plan of development works, land status, status of statutory approvals and disclosure of proforma agreements, names and addresses of real estate agents, contractors, architect, structural engineer etc.;

Functions and Duties of Promoter

- Disclosure of all relevant information of project;
- Adherence to approved plans and project specifications;
- Obligations regarding veracity of the advertisement for sale or prospectus;

Compulsory deposit of 50 percent: To compulsorily deposit 50 percent (or such lesser percent as notified by the Appropriate Government) of the amounts realized for the real estate project from the allottees in a separate account in a scheduled bank within a period of fifteen days to cover the cost of construction to be used for that purpose.

Adherence to declared plans: To bar the promoter from altering plans, structural designs and specifications of the plot, apartment or building without the consent of two-third allottees after disclosure. However, minor additions or alterations permissible due to architectural and structural reasons;

Regulatory Strategies

Functions of Real Estate Agents: Real estate agents to sell properties registered with the Authority;
Maintain books of accounts, records and documents;
· Not to involve in any unfair trade practices;

Rights and Duties of Allottees: Right to obtain stage-wise time schedule of project;
· Claim possession as per promoter declaration and refund with interest and compensation for default by the promoter; · Allottees to make payments and fulfil responsibilities as per agreement;

Functions of Real Estate Regulatory Authority: The Authority to act as the nodal agency to co-ordinate efforts regarding development of the real estate sector and render necessary advice to the appropriate Government to ensure the growth and promotion of a transparent, efficient and competitive real estate sector.

Fast Track Dispute Settlement Mechanism:

· Fast track dispute resolution through adjudicating officers (District Judge); · Appellate Tribunal to hear appeals;

PROTECTION OF BUYERS

The Act prohibits unaccounted money from being pumped into the sector. As now, 70 per cent of the money has to be deposited in bank accounts through cheques. A major benefit for consumers included in the Act is that builders will have to quote prices based on carpet area and not super built-up area. Carpet area has been clearly defined in the Act to include usable spaces like kitchen and toilets.

(The Act defines carpet area as the whole floor area that can be used within the apartment walls. This excludes spaces such as open terraces, shafts, and balconies, among others.)

The Bill ensures mandatory disclosure by promoters to customers through registration of real estate projects as well as real estate agents with the Real Estate Regulatory Authority. The Bill aims at restoring confidence of the general public in the real estate sector

ESTABLISHMENT OF REAL ESTATE APPELLATE TRIBUNAL

Establishment of State-level Real Estate Regulatory Authorities (RERAs) to regulate transactions related to both residential and commercial projects. RERAs will ensure timely completion and handover of projects. Appellate Tribunals will now be required to adjudicate cases in 60 days as against the earlier provision of 90 days. Regulatory Authorities has to dispose of complaints in 60 days while no time frame was indicated in earlier Bill.

The appropriate Government shall, within a period of one year from the date of coming into force of this Act, by notification, establish an Appellate Tribunal to be known as the — (name of the State/Union territory) Real Estate Appellate Tribunal.

- Every bench of the Appellate Tribunal shall consist of at least one Judicial Member and one Administrative to Technical Member

APPLICATION FOR SETTLEMENT OF DISPUTES AND APPEALS TO APPELLATE TRIBUNAL.

- Every appeal made shall be preferred within a period of sixty days from the date on which a copy of the direction or order or decision made by the Authority or the adjudicating officer is received
- On receipt of an appeal, the Appellate Tribunal may after giving the parties an opportunity of being heard, pass such orders, including interim orders, as it thinks fit.
- The Appellate Tribunal shall send a copy of every order made by it to the parties and to the Authority or the adjudicating officer
- The appeal preferred, shall be dealt with by it as expeditiously as possible and endeavor shall be made by it to dispose of the appeal within a period of sixty days from the date of receipt of appeal. Appellate Tribunals will now be required to adjudicate cases in 60 days as against the earlier provision of 90 days. Regulatory Authorities has to dispose of complaints in 60 days while no time frame was indicated in earlier Bill.

OFFENCES, PENALTIES AND ADJUDICATION

SECTION 59-72

Penalty for nonregistration under section 3.	<ul style="list-style-type: none">• He shall be liable to a penalty which may extend up to 10% of the estimated cost of the real estate project.• If any promoter does not comply with the orders, he shall be punishable with imprisonment for a term which may extend up to 3 years or with fine which may extend up to a further 10% of the estimated cost of the real estate project, or with both.
Penalty for contravention of section 4.	He shall be liable to a penalty which may extend up to 5% of the estimated cost of the real estate project.
Penalty for contravention of other provisions of this Act.	He shall be liable to a penalty which may extend up to 5% of the estimated cost of the real estate project.
Penalty for nonregistration and contravention under sections 9 and 10.	He shall be liable to a penalty of Rs10000 for every day during which such default continues, which may cumulatively extend up to 5% of the cost of building.
Penalty for failure to comply with orders of Authority by promoter.	He shall be liable to a penalty for every day during which such default continues, which may cumulatively extend up to 5% of the estimated cost of the real estate project.
Penalty for failure to comply with orders of Appellate Tribunal by promoter.	He shall be punishable with imprisonment for a term which may extend up to 3 years or with fine for every day during which such default continues, which may cumulatively extend up to 10% of the estimated cost of the real estate project, or with both.
Penalty for failure to comply with orders of Authority by real estate agent.	He shall be liable to a penalty for every day during which such default continues, which may cumulatively extend up to 5% of the estimated cost of building.
Penalty for failure to comply with orders of Appellate Tribunal by real estate agent.	He shall be punishable with imprisonment for a term which may extend up to 1 year or with fine for every day during which such default continues, which may cumulatively extend up to 10% of the estimated cost of building.

Benefits of Real estate Regulatory act:

1. **Standardized carpet area:** The carpet area on which the builder calculates the price of the property was not defined. Every builder/developer had his own method of calculation of the Carpet Area. For the same flat, the builder would calculate the carpet area as 1500 sq ft and the other would calculate the carpet area of 1400 sq ft. This used to happen as there was no standard formula for the computation of the Carpet Area. However, this has now been clearly defined by the RERA Act and the same formula would be applied by all builders/developers for calculation of the carpet area.

Cost of Property = Carpet Area x Rate per sq ft

2. **Rate of interest on default:** In case of default in payment by the buyer or default in completion of the project by the builder, the rate of interest to be paid shall be the same for both parties. Earlier what used to happen was that in case the builder delays the possession of property – the interest paid by builder to the home buyer was less whereas in case the buyer defaulted – the interest to be paid by the buyer to builder was higher. There was no parity in the interest to be paid by both the parties. The RERA Act has now clearly specified that the interest rate shall be the same for both the parties.

Benefits of Rera

3.Right of the buyer in case of Defect after possession:

In case of any structural defect or any defect in workmanship, quality, provision or service is discovered within 5 years after the possession of the apartment, such defect will be rectified by the builder at no extra cost within 30 days.

4.Right to information:

The buyer shall be entitled to all the information related to the project, be it the plan layout, execution plan, stage wise completion status etc.The builder fails to do so, the buyer shall be entitled to claim compensation for the same.

5.Right of the Buyer in case of False promises:

In case there is a mismatch in the commitments made by the builder and the actual project, the buyer has the option to withdraw from the project, wherein he is **entitled to full refund** of the amount paid as advance or otherwise along with interest and claim compensation.

FACILITY PROGRAMMING AND PLANNING

- Hyroon Nisha, Prasanna, Saif, Sahith Akeel Razak, Farhan, Shamayila, Samyuktha

What is facility?

Facilities are something designed, built, installed, etc., to serve a specific function affording a **convenience or service**: transportation facilities; educational facilities; a new research facility.

What is facility Planning?

Facility planning is **concerned with the design, layout, and accommodation of people, machines and activities of a system or enterprise within a physical spatial environment**. Facility planning is very important in a manufacturing process due to their effect in achieving an efficient product flow.

The design components of a facility layout consists of the

- Facility Systems
- The Plant Layout
- The Material Handling System .

- **The facilities systems** consist of the structural systems, the atmospheric systems, the enclosure systems, the lighting/electrical/communication systems, the life safety systems, and sanitation systems (like a hardware)
- **The plant design or layout** consists of all equipment, machinery, and furnishings within the building envelope.
- **The material handling system** consists of the mechanisms needed to satisfy the required facility interactions

Facilities can be broadly defined as buildings where people, material, and machines come together for a stated purpose - typically to make a tangible product or provide a service.

- The facility must be properly managed to achieve its stated purpose while satisfying several objectives.
- Such objectives include producing a product or producing a service at lower cost, at higher quality.
- or using the least amount of resources.

Levels of decisions

- Strategic or Design or Long-term
- Planning or Intermediate
- Operational or short-term

Importance of Facilities Planning & Design

- Manufacturing and Service companies spend a significant amount of time and money to design or redesign their facilities. This is an extremely important issue and must be addressed before products are produced or services are rendered.

A poor facility design can be costly and may result in:

- poor quality products,
- low employee morale,
- customer dissatisfaction.

What is facility programming?

Facility programming is an information-processing activity.

Second, the organizational setting or culture of the campus is the general context both in which programming takes place and in which the boundaries are set.

Third, facility programming is more than simply an inventory of needs or a computation of allowed space—it is a process that helps guide and potentially anticipate subsequent steps in facility development.

Objectives of facility Programming?

Making Choices and Decisions

Programming provides a campus with information to make decisions and choices about space. In so doing, programming helps reduce anxiety about a proposed project. Because it is a process, programming provides a systematic way of assessing and evaluating need.

A program is a method to organize:

- Ideas
- Wants
- Assumptions

A program should evaluate:

- Needs
- Requirements

Last, a program needs to communicate:

- Results
- Agreements

• Issues of Budget, Scope, and Quality

• The overriding issue affecting campuses in programming is to understand and balance the relationship between budget, scope, and quality.

• Budget or project cost is the total amount available for the project. Project scope is the quantity or the summation of all proposed project areas as measured in gross square feet. Project quality is the estimated cost to construct the building using an approximation measured in dollars per square foot and based on building materials, finishes, and means of construction. If any two of these three items—budget, scope, or quality—are fixed, the third item is automatically determined.

• One purpose of the programming activity is to test the major project needs, then refine and recycle them until they are in balance in terms of project budget, scope, and quality.



Steps in Programming

Programming generally consists of the following steps:

1. Establish a user (building) committee.
2. Review existing campus documents.
3. Determine the functional needs of the project.
4. Illustrate relationships between activities.
5. Determine growth patterns as exactly as possible.
6. Translate functional needs into planning guidelines.
7. Identify occupying units, functions, and support facilities.
8. Determine general and specific space requirements for each.
9. Diagram building component sizes and shapes (including height, width, and bulk).
10. Prepare specific room data sheets for each individual and distinct space.
11. Assist the User Committee in preparing the project documentation.

1. Establish a User (Building) Committee

The programming process should begin with the appointment of a program planning or oversight committee. For academic facilities, this committee can include faculty and other users representing the programs involved, representative(s) from other departments, and representatives of the dean's office and student leaders, as well as campus planning and budget staff and campus architects and engineers.

2. Review Existing Campus Documents

The context for the facility program is the campus organization for the project. If the following are available, they should be identified or referenced. If these background materials are not available, a list of planning assumptions that will serve as the basis for the program should be developed and agreed upon.

- Instructional or use plans
- Descriptive information about users
- Design goals and objectives
- Relationships between disciplines or activities.

3. Determine the Functional Needs of the Project

Clearly, the identified user needs are the backbone of the facility program. The most important components are:

- Project justification based on existing or projected conditions
- Functions
- Activities
- Internal environments that allow the users to best carry out their activities. This could include privacy, shared meeting spaces, etc.

4. Illustrate Relationships between Activities

Buildings do not stand alone. They are linked or tethered to other campus activities, including support needs such as safety, security, maintenance, delivery, and communication links. There are often other related campus requirements that need to be considered if new space is added. These requirements could pertain to site improvements, utilities, communications, system capacity and location, and the capabilities of these systems to serve the project. Linkages to other programs and their location on the campus need to be identified.

5. Determine Growth Patterns as Exactly as Possible

Because programs change and evolve, space should be flexible to meet these changes. It is useful to consider meeting future needs as well as solving unmet current needs.

- Carefully review university enrollments, by campus, for the immediate past three years and the projected next 10 years.
- List facility components of both fixed and variable size that should occur in particular phases of the project.
- Refine phases of facility construction.

6. Translate Functional Needs into Planning Guidelines

The following need to be included in the program.

- Define room size dimensions for activities that have clearly defined sizes.
- Define optimal areas consistent with campus program needs and enrollment projections for areas that are more flexible in configuration.

7. Identify Occupying Units, Functions, and Support Facilities

Based on interviews, workshops, campus-prepared materials, and programmer knowledge, it should now be possible to pinpoint the following:

- Space factors and space needed in relationship to this project
- Functional relationships with other units
- Functional relationships within and between administrative, student, faculty, and staff activities

8. Determine General and Specific Space Requirements for Each

With the knowledge gained in the discovery process, it is now possible to develop a precise building facility program using the following methodology:

- Identify activities for which space is needed.
- Provide a distinct name for each required room or space.
- Develop an estimate of net assignable square footage (NASF) for each space or room based on population and enrollment information.
- Summarize these needs by major user and occupancy group.
- Estimate total building area.
- Identify general area requirements for Non assignable spaces.
- Estimate total building area (GSF).

9. Diagram Building Component Sizes and Shapes

Because it is often easier to understand the components of a facility program in graphic format, it is useful to create diagrams. These need not be elaborate, although they often are, even including suggested furniture layouts.

10. Prepare Specific Room Data Sheets for Each Individual and Distinct Space

Room or space data sheets are important components of a facility program because they provide a unique way to communicate baseline information about every space in a building program. The data sheets contain information that could influence the design of the facilities as classified by architectural, systems, and furniture criteria.

- Architectural criteria include ceiling height of rooms; floor, wall, and ceiling finishes; special acoustical needs; special lighting; security; lecture capture and webcam technology; and other.
- Systems controls include telephone; data; computer; audiovisual; electrical; HVAC; plumbing; fire protection; and other.
- Furniture criteria include fixed equipment; loose equipment; and miscellaneous equipment, installed by either the contractor or the owner.
- List minimum ceiling heights where applicable.
- Note any special floor, wall, or ceiling conditions.
- Note any special storage or equipment needs related to the activity.

11. Assist the User Committee in Preparing the Project Documentation

In addition to assembling the products of the steps above, the product, or facility program, has many components. First is an executive summary so that a person on the periphery of the proposed project does not have to read the detail. The summary is followed by specific campus planning and building needs.

OBJECTIVES OF FACILITY PLANNING

- Improve customer satisfaction by doing easy to do business.
- Increase return on assets (ROA) by maximizing inventory turns.
- Maximize speed for quick customer response.
- Reduce costs and grow the supply chain profitability.
- Support the organization's vision through improved material handling, material control, and good housekeeping.
- Effectively utilize people, equipment, space, and energy.
- Maximize return on investment (ROI) on all capital expenditures.
- Be adaptable and promote ease of maintenance.
- Provide for employee safety, job satisfaction, energy efficiency, and environmental responsibility.
- Assure sustainability and resilience.

Applications of Facilities Planning (FP)

Facilities Planning (FP) determines how activities tangible fixed assets best support achieving the activity's objectives.

- what is the objective of the facility?
- how the facility achieves that objective?

In the case of a manufacturing firm:

Facilities Planning (FP) involves the determination of how the manufacturing facility best supports production.

In the case of an airport:

Facilities Planning (FP) involves determining how the airport facility is to support the passenger-airplane interface.

In the case of a hospital:

Facilities Planning (FP) for a hospital determines how the hospital facility supports providing medical care to patients.

Disciplines involved in Facility Planning (FP)

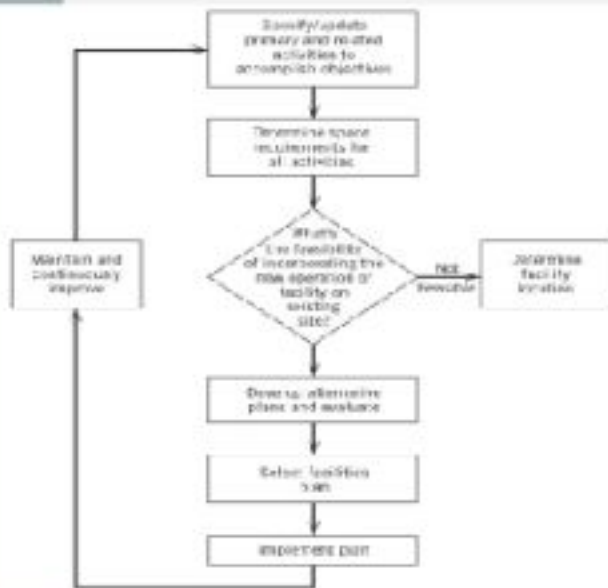
Within the engineering profession:

- Civil engineers,
- Electrical engineers,
- Industrial engineers,
- Mechanical engineers,
- Architects,
- Consultants,
- General contractors,
- Managers,
- Real estate brokers, and
- Urban planners are involved in FP.

FACILITY PLANNING CYCLE

Facilities Planner considers the facility as a dynamic entity.

Therefore continuous improvement is an integral element of FP cycle.



4 STEPS PROCESS OF FACILITY PLANNING

I. UNDERSTANDING

- Thoroughly understand the organization's mission, vision, values, and goals.
- The strategic plan focuses on the longer-term, big-picture needs, and **vision of the organization**. It is critical for success.
- Facility managers must begin the development of the SFP by thoroughly understanding the needs of the organization.
- Then a business-driven approach is taken to analyze the organization's facilities and to **set tangible goals and plan targets**.
- Often, organizations take a strictly cost-driven approach to their facilities.



4 STEPS PROCESS OF FACILITY PLANNING

1. ANALYZING

- Exploration of the range of possible futures and triggers is needed to analyze your organization's facility needs using analytical techniques — such as systematic layout planning (SLP), SWOT analysis, strategic creative analysis (SCAN), or scenario planning.
- These needs and issues may include workforce demographics, manufacturing processes, **organizational structure** and culture, community and government/regulatory requirements, market position, and capacity rates and volumes.
- All of these combine to define the individual elements of the SFR.



4 STEPS PROCESS OF FACILITY PLANNING

III. PLANNING

- Once the analysis is completed, plans for potential responses and periodic updates to existing plans in response to changes in the market need to be developed to meet the long-range needs of your specific organization.
- As a result of the analyses performed, decisions will become apparent, or recommended courses of action can be supported by the completed analysis.
- These recommendations will become the essence of the SFP.
- It is important to note that once approved, and the SFP may continue to evolve and adapt to changing conditions within and outside the organization. The flexibility of a good SFP will accommodate the minor adjustments.



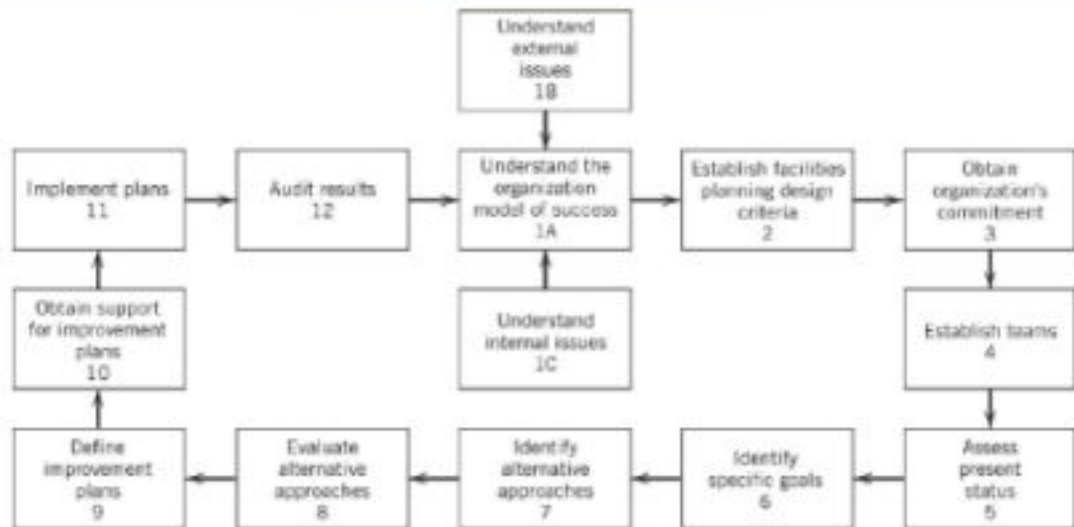
4 STEPS PROCESS OF FACILITY PLANNING

IV. ACTING

- Take action as planned to implement the strategic facility planning successfully.
- Feedback from actions taken can be incorporated into the next plan and/or project to provide continuous improvement to future SFPs.
- Implementation of an SFP typically requires the development of a specific project or project to deliver new, altered, or reconfigured space to meet the organizational need. This specific project is a unique process that is supplemental to the SFR.
- While implementation is in progress, flexibility to adapt to changed conditions may be required.



FACILITY PLANNING PROCESS:





Ex: Facilities Planning Process for General and Manufacturing Facilities

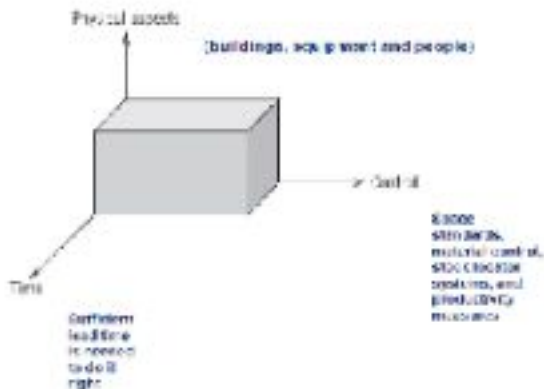


Ex: Facilities Planning Process for Hospital Facilities

**COMPARISON OF
DESIGN PROCESS AND
FACILITY PLANNING
PROCESS**

Phase	The Engineering Design Process	The Facilities Planning Process
Phase I	Define problem.	<ol style="list-style-type: none"> 1. Define or redefine objective of the facility. 2. Specify primary and support activities.
Phase II	<p>Analyze the problem.</p> <p>Generate alternatives.</p> <p>Evaluate the alternatives.</p> <p>Select the preferred design.</p>	<ol style="list-style-type: none"> 3. Determine the interrelationships. 4. Determine space requirements. 5. Generate alternative facilities plan. 6. Evaluate alternative facilities plan. 7. Select a facilities plan.
Phase III	Implement the design.	<ol style="list-style-type: none"> 8. Implement the plan. 9. Maintain and adopt the facilities plan. 10. Redefine the objective of the facility.

DEVELOPING FACILITY PLANNING STRATEGIES



There are 3 dimensions which are used to improve the facility planning process:

- I. Physical aspects
- II. Control
- III. Time

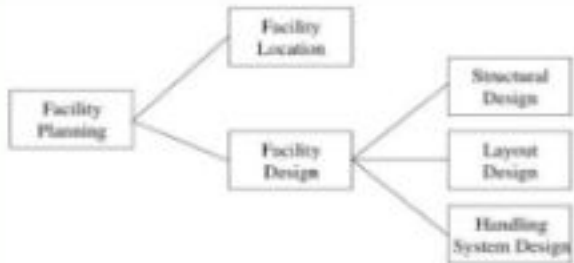
HIERARCHY OF FACILITY PLANNING

Location: is the placement of a facility with respect to customers, suppliers, and other facilities with which it interfaces.

Structure: consists of the building and services (e.g., gas, water, power, heat, light, air, sewage).

Layout: consists of all equipment, machinery, and furnishings within the structure.

Handling System: consists of the mechanism by which all interactions required by the layout are satisfied (e.g., materials, personnel, information, and equipment handling systems).



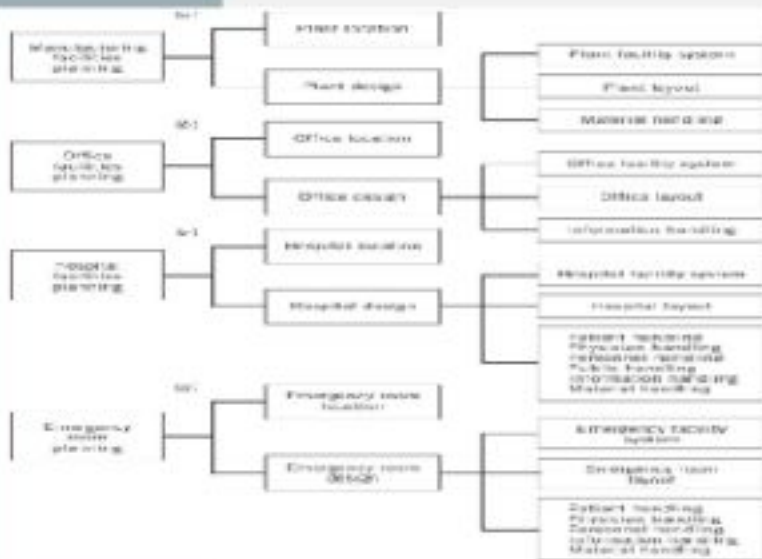
EXAMPLE FOR FACILITY PLANNING

(GENERAL
CONCEPT):



Example facilities
Planning for specific
types of facilities:

- a) manufacturing plant
- b) Office
- c) Hospital
- d) Emergency room



Ten Essentials of Facilities Planning and Design

Facilities planning and design

1. Understand the phases in the development of a facility and know the parties involved in the development of a building.
2. Recognize that the organization's strategic plan drives the need for facilities. The facility master plan should be aligned with the strategic plan.
3. Understand the responsibilities of the Owner's representative during planning and design. Learn how to manage the selection process for design consultants.
4. Recognize how occupants and their activities impact the size and design of a space. Learn about universal design, area definitions and space standards.
5. Learn the process for programming building spaces and how to select a site for development.

Campus planning and design

6. Learn about the process of master planning so that the Longterm phased development of a facility's campus is optimized.
7. Understand the environmental impacts of development and learn the key aspects of the environmental impact assessment process.
8. Learn the key aspects of the capital improvement planning process and how to put together a capital improvement plan for a large facility.

Workplace planning and design

9. Understand the considerations in the planning and design of workplaces.
10. Learn the principles of managing space in a large facility with a space management policy and software.

DESIGN MANAGEMENT

CONSTRUCTION AND PROJECT MANAGEMENT

SEMESTER : X

MEASI ACADEMY OF ARCHITECTURE

WHAT IS DESIGN MANAGEMENT ?

Design is the **process of creating a solution** to a project brief and then preparing instructions allowing that **solution to be constructed**.

In order that project budgets can be satisfied, programmes achieved, and designs properly co-ordinated and communicated, the design process needs to be planned and controlled. Problems can occur where there is missing information, poorly communicated information, inconsistencies between documentation, poor resource allocation, poor decision making due to inadequate information, and so on.

These difficulties have become more prevalent as buildings have become more technical, the range of products and materials has increased, standards and regulations have become more strict, and there are a greater number of specialist designers, particularly in the early stages of the design process.



WHY DO WE NEED TO MANAGE THE DESIGN

PROCESS?

Inefficiency, budget overrun, failure to deliver on time, a large amount of waste, collisions at a construction site, conflicts between the parties on the project – many of these things are caused directly or indirectly by poor management of the design process.

In addition, there are other challenges, such as:

- Each project is unique and every time more complex.
- Multiple parties/stakeholders involved.
- More and more frequent design and build contracts.
- There is a high level of technical knowledge and a relatively low level of management and leadership-related knowledge in the construction industry.

Through the proper design management,

2. We are able to achieve the client's and project's goals,
3. Improve cooperation by streamlining the communication process and
4. Deliver documentation on time, with the agreed quality and in accordance with the budget.



DESIGN MANAGER

Design managers initially emerged in contractor organisations as they started undertaking a portion of design, which involved their specialist sub-contractors. They can also be known as design co-ordinators.

This new role favours individuals with training in design as well as an understanding of the contracting processes.

DESIGN MANAGER IS NOT THE LEAD DESIGNER.

The design manager has an enabling and co-ordinating role, but is not acting as a designer themselves. The role should not be confused with the lead designer, who heads the decision making and co-ordination of the actual design, or with the lead consultant, who directs the work of the entire consultant team.



In short, design management is all about organizing, planning, and directing people, their knowledge, and the flow of information to achieve the goals of a project.

Selected specific tasks of the design manager are:

- Coordination between multiple project participants.
- Ensuring that the design process is within the assumed time, quality and budget.
- Signing and supervising the contract with the designer.
- Establishing information exchange systems and processes.
- Control of what has been designed against what is to be done in real life ("buildability").
- Checking whether the conditions and requirements of the contract, standards, specifications, etc. are met during the design process.
- Searching for optimization opportunities.
- Engaging contractor's representatives in the design process.



THE MAIN TASKS OF THE DESIGN MANAGER ARE TO:

- Establish a platform for good communication and collaboration between relevant parties and thereby an effective flow of design and production information.
- De-risk design problems by finding solutions before they materialise.
- Contribute to planning and co-ordination in a way that adds value to the processes.
- Prepare, manage and secure all-party ownership of an integrated design programme.



THE ROLE REQUIRES VARIOUS CAPABILITIES, INCLUDING:

- An all round basic knowledge of the construction and property industry.
 - A good grasp of the technical aspects of design and construction matters, systems and processes.
 - An understanding of planning applications, building regulations, codes of practice, environmental and health and safety regulations.
 - Planning and programming skills.
 - Legal, commercial and contractual knowledge.
 - Negotiating and people skills.
 - Presentation skills.
- All this means that design managers require considerable experience and so tend to come from the ranks of the professions or from design and build contracting organizations and will have experience on a wide number of projects.

Collaborative practices for building design and construction

1 Introduction

2 Working practices

2.1 Procurement

2.2 Organization

2.3 Roles and responsibilities

3 Information management

4 Building information modelling (BIM)



•INTRODUCTION

•Establishing collaborative practices is of particular importance on building design and construction projects, as they are likely to involve bringing together large number of diverse disciplines, many of whom will not have worked together before. They are also likely to involve the co-ordination and integration of a great deal of complex information, procedures and systems.

•This has become increasingly true as project structures have evolved from straight-forward client - consultant - contractor relationships to more integrated structures with complex financing arrangements, early engagement of the supply chain and the introduction of sub-contractor and supplier design.

2. WORKING PRACTICES

2.1 PROCUREMENT

- Establish the **broad principles of collaborative practice as early as possible** in a project, even if some specific details are left unresolved until later stages.
- A decision to adopt a collaborative approach should be taken at the outset by the client** so that a requirement to follow appropriate procedures can be included in appointment documents and can be a consideration in the selection of procurement route, form of contract and preparation of tender documentation. **The implementation of collaborative practices should then be discussed in detail during consultant team start-up meetings, specialist contractor start-up meetings and pre-contract meetings.**



- The Government Construction Strategy recommends that **public projects adopt design and build, private finance initiative or prime-type contract procurement routes**, as these are considered to be more collaborative

Other forms of **collaborative procurement include partnering** (sometimes referred to as alliancing), which is a broad term used to describe a management approach that encourages openness and trust between the parties to a contract. The parties become dependant on one another for success and this requires a change in culture, attitudes, behaviours and procedures throughout the supply chain. It is most commonly used on large, long-term or high-risk contracts. Where a partnering relationship is for a specific project, it is known as **'project partnering'**. Where it is a multi-project relationship it is known as **'strategic partnering'**.

2.2 ORGANISATION

- **Evaluation of the behaviours** and collaborative competence of individuals in teams during the procurement process.
- **Clear lines of communication and authority.**
- **Protocols for the preparation and dissemination of information.**
- **Co-location of team members.**
- **Financial motivation** (such as tying the consultant team and the contractor into a common target cost for which there is joint 'gain' or 'gain').
- **Rewarding initiative.** Regular workshops and team meetings.
- **Problem resolution procedures,** which should be based on solutions, not blame.
- **Procedures to ensure continuous improvement.** This might require continual benchmarking, target setting, assessment, feeding back and adaptation.
- **Early warning procedures.**
- **Social activities.**

2.3 ROLES AND RESPONSIBILITY

Clarity of responsibility and co-ordination can be improved by the appointment of:

- A project sponsor or client representative.
- Client champions for different aspects of the project.
- A project manager.
- A lead consultant.
- A lead designer.
- A design co-ordinator (for the co-ordination and integration of designs prepared by specialist contractors).
- An information manager for computer-aided design (CAD) or building information modelling (BIM).



INFORMATION MANAGEMENT

Ensuring that consultants sign up to the use of compatible systems and agreed document and drawing standards will help facilitate collaboration.

Systems might include:

- Computer Aided Design (CAD).
- Building Information Modelling (BIM).
- Common document management systems.
- Common E document management systems



Drawing standards might include:

- Layering standards.
- Zoning strategy.
- Grid strategy.
- Origin and orientation.
- Naming protocols.
- Agreed standards for dimensions, abbreviations and symbols.
- Standard templates (for example drawing titles).
- Standard page sizes and scales.
- Distribution protocols.
- Change control procedures.

Building Information modelling (BIM)

Building Information Modelling (BIM) is seen increasingly as a means facilitating collaborative working. BIM is a very broad term that describes the process of creating a digital model of a building.

The range of levels of this type of modelling are categorised as:

- Level 0: Unmanaged CAD.
- Level 1: Managed CAD in 2D or 3D.
- Level 2: Managed 3D environment with data attached, but created in separate discipline models.
- Level 3: Single, collaborative, online, project model with construction sequencing, cost and lifecycle management information



CLIENT ENGAGEMENT AND CONTROL

The client must be properly engaged in the design process with consistent and timely information delivered to and received from the design team.

At its most basic level, design can be seen as an iterative process, where, at each iteration, there are

- a design process
- inputs - resources used in the production of a product or creation of a service
- outputs - the amount of output chargeable to customers for building and civil engineering work done in the relevant period



At the end of each iteration the outputs are reviewed and then the process begins again. Typically, this is structured by establishing a series of 'gateways', at which the client assesses the state of development of the project and considers the following –

- a. whether it satisfies their strategic objectives,
- b. that it is affordable,
- c. that value is being delivered,
- d. and that risks are acceptable.

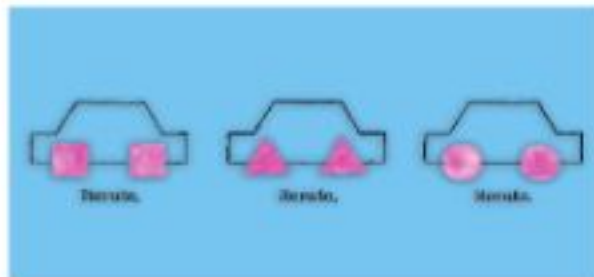
They can then decide whether to progress to the next stage. Allowing the client to make this decision requires the preparation and submission of relevant information by the consultant team and contractors. As the project develops, this might include:

- a. Strategic brief
- b. Preliminary business case
- c. Project execution plan
- d. Project brief
- e. Concept design report
- f. Detailed design report
- g. Production information report
- h. Tender report
- i. Construction stage report
- j. Final report
- k. Assessment and lessons learned report



It is possible that the client will decide not to proceed, or will ask for further work to be carried out, whether this is revision of the design, or undertaking value management exercises to re-align proposals with the available budget. Value management is a team-based approach used to define the client's objectives and ensure that best value, whole-life solutions are selected to satisfy those objectives.

Decisions to proceed may be accompanied by the introduction of change control procedures, freezing certain aspects of the project. This ensures that approved aspects of the project are not changed without the permission of the client. Changes to a project may have impacts on time, cost or quality. Broadly, the later in the development of a project that changes occur, the greater those impacts are likely to be.



Examples of stages where change control procedures might be introduced include:

- At the end of the concept design stage if the project is tendered at this stage (for example on a design and build project).
- At the end of the concept design stage, when the project brief might be frozen.
- During the detailed design stage when the detailed design, technical design and specification are finalized.
- During the tender stage when the tender documentation has been prepared.
- When the contractor is appointed and any further changes may qualify as variations.

It is important that the need for changes is minimised. This can be done by:

- Undertaking thorough site investigations and condition surveys.
- Ensuring that the project brief is comprehensive and is supported by stakeholders.
- Ensuring that legislative requirements are properly integrated into the project.
- Ensuring that risks are properly identified.
- Ensuring that designs are properly co-ordinated before tender.



This control process can be refined further by processes such as building information modelling (BIM). BIM identifies explicitly the decisions and information deliverables required at each stage of the project. This ensures that appropriate information is created and shared in a suitable format at the right time so that better decisions can be made throughout the design, construction and operation of built assets. It is not about creating a 3D model for its own sake, and it is not an add-on process. BIM is fundamental to the way a project is set up and run.



A holistic approach to the design management

The design manager can have different roles in different phases, companies, and different types of contract. In addition, he should be competent in three main areas- management ,Leadership and administration



Design management is being done by construction companies because of the failure of other existing systems to achieve proper integration of the design and construction processes. Initial results from a three-year empirical study of the practice of design management in an international construction company have been compared to conceptions devised from literature in order to describe design management practices.

1.Design Management as Integrators of Design and Construction

Design management personnel were observed dealing with many of the issues required to integrate design and construction. Overcoming or moderating the issues between design and construction was seen as a necessary role in the construction industry. When these issues were not addressed properly confusion over construction techniques arose, design intent was lost in the final constructed product, unnecessary delays took place and poor project satisfaction was observed. Incorporating design and construction as co-developers or codesigners is one way in which integration of design and construction is dealt with.



2. Design Management as Managers

(i) Design Management as a Division of Project Management :

tactics for developing a project culture; defining the tasks; managing information production; evaluation of information; and planning, monitoring and control.

(ii) Design Management as Managing Design :

- 1) developing a matrix for managing design, because it involves a number of organisational levels and activities;
- 2) planning design, which involves including design in organisational goals, strategies and policies for design, and putting process in place for using design;
- 3) organising for design, which means having the right structure, choosing the right teams, using training and development programs and investing in design;
- 4) implementing and monitoring design, which involves implementing and monitoring design programmes and projects; and
- 5) evaluating design including evaluating the management of design and design projects.

(iii) Design Management as Task, Flow and Value Management:

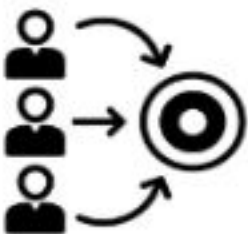
- 1) as a process of converting inputs into outputs (Task management)
- 2) as a flow of materials and information through time and space (Flow management)
- 3) as a process of generating value for customers (Value management)



3. Design Management as Meta Designers

Tasks being done that did not fall under the "management" conception and were perhaps in the domain of designers on smaller design projects.

Meta designers, which are used in the IT industry design things so that the users become the designers and as such they design the design system rather than design a system. That then incorporates users as co-developers or co-designers . The definition used here is that "meta design" is about incorporating others such as stakeholders, consultancies and sub-contractors as co-developers or co-designers, designing the design system and doing tasks which were perhaps in the domain of designers on smaller projects.



Tasks that designers have in smaller projects, which design management in larger projects may take on in order to maintain a comprehensive overview:

Integration of the various demands of the project's stakeholders; interaction with groups of people that have different ways of looking at the design problem; determining design strategies; balancing design risk; and taking into account the larger whole.



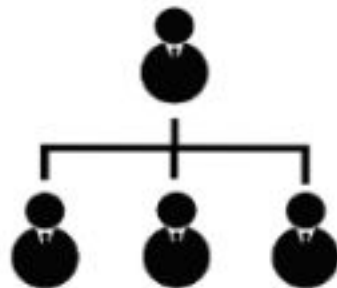
Organisation

It is important the scope of work for each member of the design team is clearly defined, documented and communicated to the rest of the team prior to any design work starting.

Typically, one member of the design team is appointed as 'lead designer' to direct and co-ordinate other designers in the consultant team as well as any specialist designers that are appointed. The lead designer will often be the architect, however this is not necessarily the case and appointment documents for other consultants will generally offer provision for them to be nominated lead designer.

The role of lead designer might include:

Co-ordinating site surveys.
Co-ordinate the preparation of information for the project brief.
Co-ordinating the preparation of designs and specifications.
Integrating different aspects of the design and their interfaces into the overall design.
Co-ordinating internal and external consultations and design reviews.
Defining the form and content of design information to be prepared.
Reporting to the client on design matters and seeking approvals.
Co-ordinating the preparation of schedules of inspections, tests, mock ups and samples.
Co-ordinating consultations, negotiations and submissions to planning authorities and other statutory and non-statutory authorities.
Co-ordinating the preparation of tender documentation and reviewing submissions.
Co-ordinating quality control systems.
Co-ordinating the issue of production information to contractors and the review of designs prepared by contractors.



Team leadership is essential for ensuring the effective performance of the design team. Each team member will have their own strengths and weaknesses, specialist knowledge and experience.

The way that the team works collaboratively and independently will influence the efficiency of the design process.

Other appointments might include:

A design co-ordinator for the co-ordination and integration of design prepared by specialist contractors.

A design manager

An information manager for computer aided design (CAD) or building information modelling (BIM).

A lead consultant who directs the work of the consultant team and is the main point of contact for communication between the client and the consultant team, other than on significant design issues where the lead designer may become the main point of contact.

A project manager responsible for the day-to-day management of the overall project.

DESIGN MANAGEMENT PLAN

A design management plan can be used to co-ordinate design activities, and might include:

- A design responsibility matrix.
- Schedules of drawings and other information to be produced by each discipline/specialist.
- A design programme.
- Standard methods and procedures.
- Estimates of staff hours to be spent by designers on each element or drawing.
- Change control procedures.
- Monitoring and reporting procedures.



- Design programme, including key dates for reviews and information exchanges.
- Schedules of information required/release dates.
- The size and format of drawing types.
- Procedures for CAD / BIM (see BIM execution plan).
- Estimates of staff hours to be spent by designers on each element or drawing.
- Monitoring of design resources expended compared to planned estimates.
- Initiating procedures for design changes.
- Requirements for collateral warranties.
- Incorporation within the design schedule of key dates for review of design performance to check:

Compliance with brief.
 Cost acceptance.
 Value engineering analysis.
 Health and safety issues.
 Completeness for tender



DESIGN RESPONSIBILITY MATRIX

Roles and Responsibilities Matrix

<i>Responsibility Assignment Matrix</i>						
Task Name	Name					
	Name Here	Name Here	Name Here	Name Here	Name Here	Name Here
Market Research	R	C	C	A	I	
Advertising	R	A	C	I	I	
Storyboarding	A	R		C	I	C
Funding		C	R	I		I
Design		R	A	C	I	C
Production			A	R	I	
Distribution	C		C		R	A

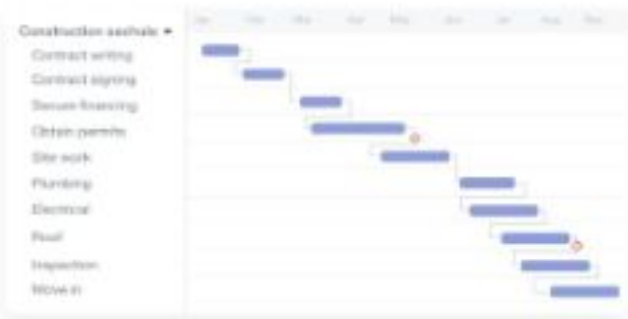
R - Responsible **A** - Accountable **C** - Consulted **I** - Informed

Preparation of a design responsibility matrix should begin early in the development of the project. It may start with a simple, strategic overview of design responsibility for the main design elements. As the project progresses, however, it should increase in detail to allocate responsibility for specific elements, systems and products, setting out the level of detail and format of design information to be produced and any requirement for collateral warranties.

It is important that design responsibilities are clearly defined and properly understood before tender documentation is prepared or appointments made.

DESIGN PROGRAMME

A design programme (or design schedule) describes the sequence of design tasks from the initial appointment of the design team to the completion of the design. For straight-forward projects this might be a simple gantt chart showing each consultants' planned resources for each stage. For more complex projects it may be a very detailed document showing interrelated and interdependent design inputs from consultants, sub-consultants, the contractor, sub-contractors and suppliers



The design programme should be aligned to the main project programme, and may work backwards from key completion or delivery dates. It should indicate procurement periods for major items and reasonable durations for design approval procedures. Without such information, design programmes can be unrealistic or unachievable.



On projects where BIM has been adopted, a Master Information Delivery Plan (MIDP) may be prepared, setting out when project information is to be prepared, by whom and using what protocols and procedures. The preparation of this information might be managed by a BIM Information Manager.

The RIBA Plan of Work 2013 defines the design programme as: 'A programme setting out the strategic dates in relation to the design process. It is aligned with the Project Programme but is strategic in its nature, due to the iterative nature of the design process, particularly in the early stages.'