Introduction:

'project Management' deals with both 'materials' as well as 'human factors' to increase the productivity.

Objectives of project:

- It should be completed in minimum time with minimum capital investment.
- It should be use available manpower and other resoures optimally.

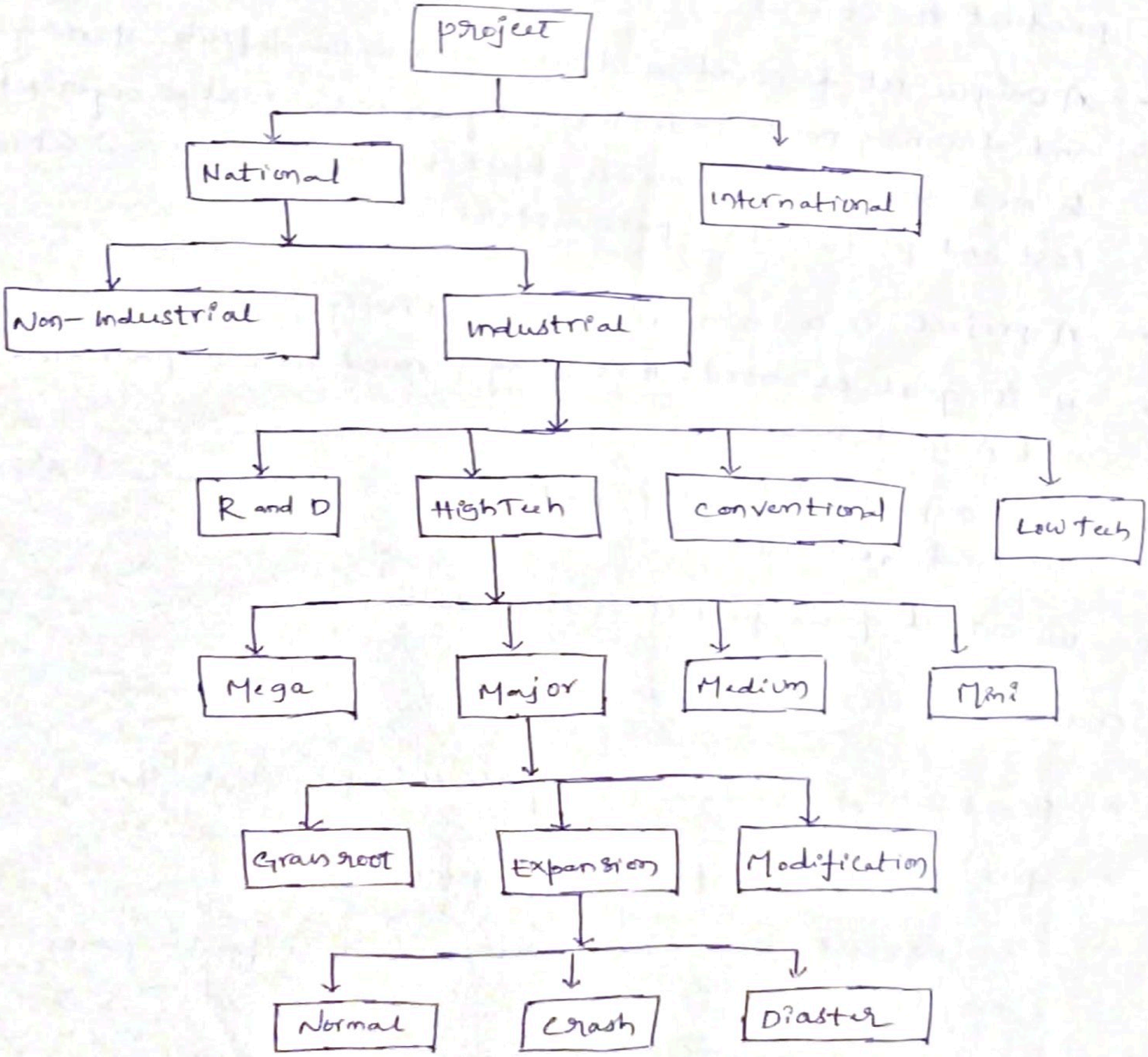
What is project:

- project is temporary endeavour undertaken to create unique product or services.
- A unique set of coordinated activities with definite starting and finishing points undertaken by an individual or organization to meet specific performance objectives with in defined schedule, cost and performance parameters.
- A project is a 'non-repetitive activity'
- It is goal oriented - it is being persued with a particular end or goal in mind.
- It has a particular set of constraints - usually centred around time and resource.
- the output of the project is measurable.

characteristics of project:

- Fixed set objectives. once they are met, project is closed.
- project has a definite life span.
- the project is a single entity, while is participants may be many.

- → Team work is absolutely essential. people from all functional groups are needed.
- → projects have definite life cycles.
- → All projects are unique, as the people and plans involved in similar projects also are different.
- → A project is subjected to a lot of change
- → Has a high level of sub contracting
- → A project is fraught with risk and uncertainty.
- → The diagram given indicates the categories of projects.



⇒ Based on the speed of execution of a project, they can be classified as:

1. Normal projects : Adequate time is provided for implementation. project will involve minimum capital cost and no sacrifice in terms of quality

2. Crash projects: Additional capital cost are incurred to gain time. in this case the quality may be compromised.

3. Disaster projects: Anything needed to gain time is allowed in this type of projects. quality short of failure level is also accepted. Round the clock work is usually done.

What is project Management:

project management is the coordinating effort to fulfill the goals of the project. the project manager, as the head of the project team, is responsible for this effort and its ultimate result. project managers use knowledge, skills, tools, and methodologies to do the following

→ Identify the goals, objectives, requirements, and limitations of the project

→ coordinate the different needs and expectations of the various project stakeholders including team members, resource managers, senior management, customers, and sponsors

→ plan, execute and control the tasks, and deliverables of the project based on the identified project goals and objectives.

→ close the project when completed and capture the knowledge accrued.

→ project management includes planning, organizing, directing, monitoring and controlling the activities and optimum allocation of resources.

Roles and Responsibilities of project Manager:

1. Co-ordinating and integrating activities across Multiple functional lines.
2. Defining and maintaining the integrity of the project
3. Development of project execution plan.
4. Organising for the execution plan.
5. Setting targets and developments of systems and procedures for accomplishment of project objectives and targets
6. Negotiations for commitments from suppliers, clients and project members.
7. Direction, co-ordination and control of project activities
8. Non-human resource management including financial matters.
9. Management of personel, that is man management.
10. Satisfy government, customer, promoters and public.
11. Achievement of cash surplus - project objectives and higher productivity.
12. Managing human inter-relationships in the project organisation.
13. Maintaining the balance between technical and Managerial project functions.

project managers are also responsible for balancing and integrating competing demands to implement all aspects of the project successfully, as follows.

→ project scope. Articulating the specific work to be done for the project

→ project time: setting the finish date of the projects as well as any interim dead lines for phases, milestones, and deliverables.

→ project cost calculating and tracking the project costs and budget.

→ project human resources: signing on the team members who will carry out the tasks of the project

→ project procurement Acquiring the material and equipment resources and obtaining any other supplies or services, needed to fulfill project tasks.

→ project communication conveying assignments, updates, reports and other information with team members and other stakeholders.

→ project quality identifying the acceptable level of quality for the project goals and objectives.

→ project risk Analyzing potential project risks and response planning.

project planning:

planning is the most important phases of project management. planning involves defining objectives of the project, listing of tasks or jobs that must be performed, determining total requirements for materials, equipment and manpower and preparing estimates of costs and durations for the various jobs or activities to complete the project. It is necessary because

- → It provides direction
- → It helps to reveal future opportunities and ~~(threat)~~ threats
- → It provides performance standards.

the following steps may be used to develop a project plan:

- → Define the scope of work, method statement, and sequence of work and objectives of project
- → Generate the work breakdown structure (WBS) to produce a complete list of activities.
- → Develop the organization breakdown structure (OBS) and link it with work breakdown structure to indentify responsibilities.
- → Determine the relationship between activities
- → Estimate activities time duration, cost expenditure, and resource requirement.
- → Develop the project network
- → Determining gross requirement for materials, equipments and manpower and preparing estimates of costs and duration for various jobs.

project scheduling:

A project has certain objectives and project is said to be completed if they are fulfilled. A series of activities ~~(are grouped into)~~ in a project are to be completed in a project with in available resources. All these activities are grouped into packages. Activities and tasks of different packages are inter related and they are assigned with resources like time with in which they are to be completed in proper logical sequence.

In other words, scheduling is the mechanical process of formalizing the planned functions, assigning the starting and completion dates to each part of the work in such a manner that the whole work (project) proceeds in a logical sequence and in an orderly manner.

steps in project Scheduling:

- identifying the tasks that needs to be carried out.
- estimating how long they will take
- allocating resources (mainly personnel)
- Scheduling when the tasks will occur.

In some cases, identifying the tasks and activities and allocation of resources to them i.e planning and scheduling takes place at the same time.

project controlling:

→ planning and scheduling are done before the actual project starts while the controlling is done during the actual project operations.

→ controlling consists of reviewing the difference between the schedule and actual performance once the project has started.

→ project control helps to determine deviations from the basic plan, to determine the effect of these deviations on the plan and to re-plan and reschedule to compensate the deviations:

→ Determination of deviations from basic plan and their effects on the project.

→ Replanning and rescheduling of activities to compensate for the deviations which is called "Updating".

→ It should be noted that planning and scheduling are accomplished before the actual project starts while controling is operative during execution of the project.

→ the method of planning and controlling that was originally developed was called project planning and scheduling (pps).
PPS was later on converted into critical path method,
so the CPM involves the deterministic approach and is used for the repetitive types of projects.

Techniques used for project management:

1. Bar chart:

Firstly introduced by Henry Gantt around 1900 AD.

Features of bar chart are:

→ It is a pictorial chart

→ It has two co-ordinates axes, the horizontal co-ordinate represents the elapsed time and vertical co-ordinate represents the job or activity to be performed.

→ the beginning and end of each bar represents starting and finishing time of a particular activity respectively.

→ the length of bar shows the time required for completion.

→ Jobs can be concurrent or can be started one after other. so some bars can run parallel or overlap each other or may run serially

Limitations of bar chart:

1. Lack of degree of details: only major activities are shown in bar chart and sub activities can not be separated out. Hence effective control over the activities in big projects can not be achieved.

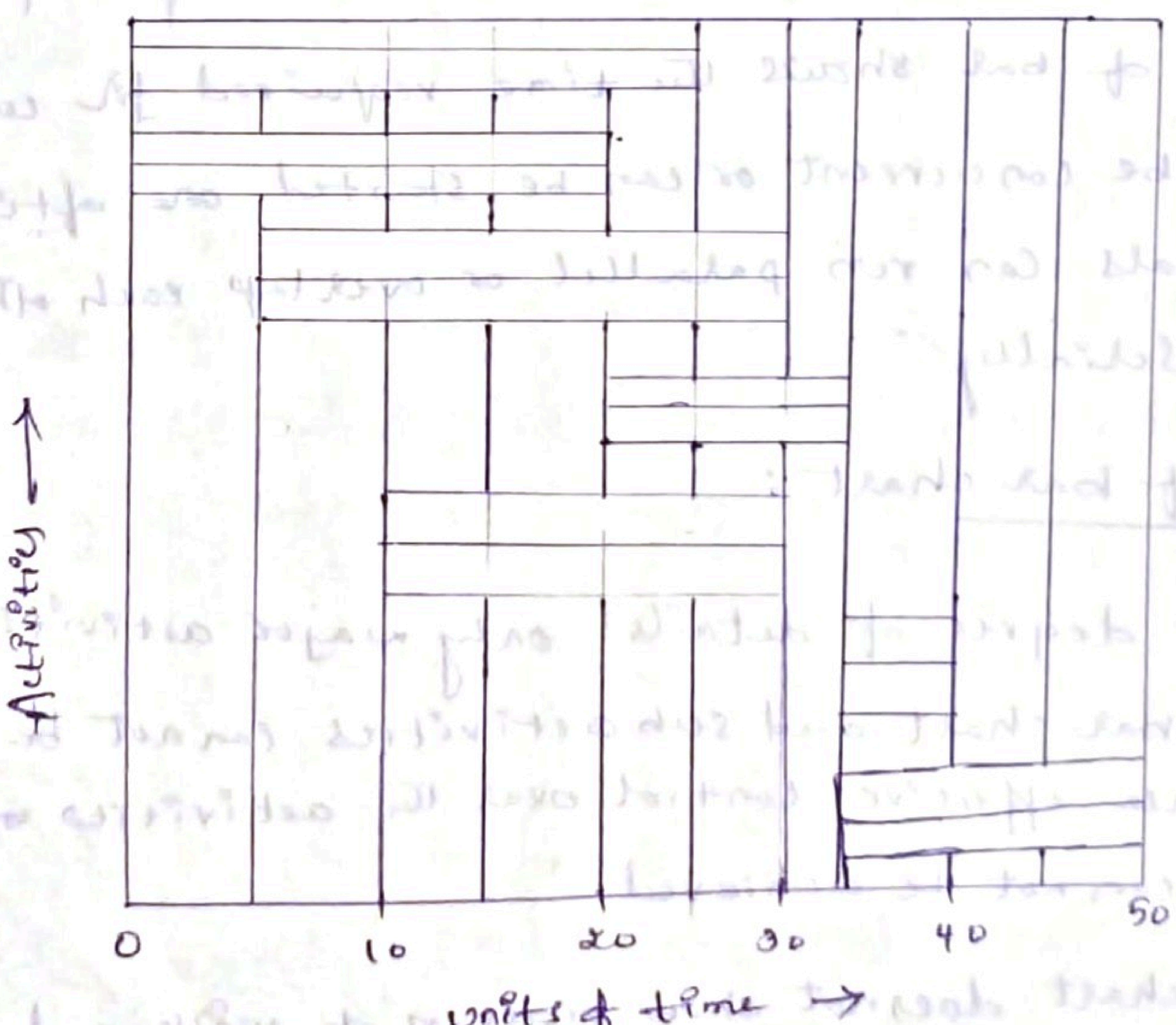
2. A bar chart does not show progress of work and hence it can not be used as a control device.

3. A bar chart is unable to depict interdependencies of various activities clearly.

4. Bar chart are not useful in the projects where there are uncertainties in determination of estimation of time required for completion of various activities such as in R&D projects.

5. Bar chart cannot distinguish between critical and non critical activities and hence resource smoothening and resource levelling can not be done.

6. Bar charts diagrams are useful for only smaller and simpler conventional projects, especially construction and manufacturing projects, in which time estimates can be made with fair degree of certainty.



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Mile stone chart:

- It is a modification over original Gantt chart.
- Milestones are key events of main activities represented by bar
- there fore they give idea about completion of sub-activities.

NOTE: Controlling can be better achieved with the help of mile stone charts, but still activity interrelationship and accountability of time uncertainty can not be depicted which can be over come in network technique

Network Methods:

- It is an outcome of the improvements in the milestone charts.
- they are called by various names such as PERT, CPM, UNETICS, LESS, TOPS and SCANS.
- However all these have emerged from the two major network systems
  1. PERT
  2. CPM

Network Diagram and techniques:

Network:

- It is the flow of diagram consisting of activities and events connected logically and sequentially.
- Network diagram are of two types
  - (i) Activity-on-Arrow Network (A-O-A)
  - (ii) Activity-on-Node Network (A-O-N)

Advantages of network method over bar chart and milestone chart

1. Interrelationships between activities and events of a project are clearly shown.

2. The project can be treated as an integrated whole with all its sub-activities clearly related with each other. It helps in controlling the project.

3. Network method is useful for very complicated projects having large number of activities.

4. It indicates the time required in between two activities in which rescheduling of a project is possible.

5. Time uncertainty is accounted for and so it also useful for research and development projects.

Elements of a Network:

1. Event:

→ An event is either start or completion of an activity.

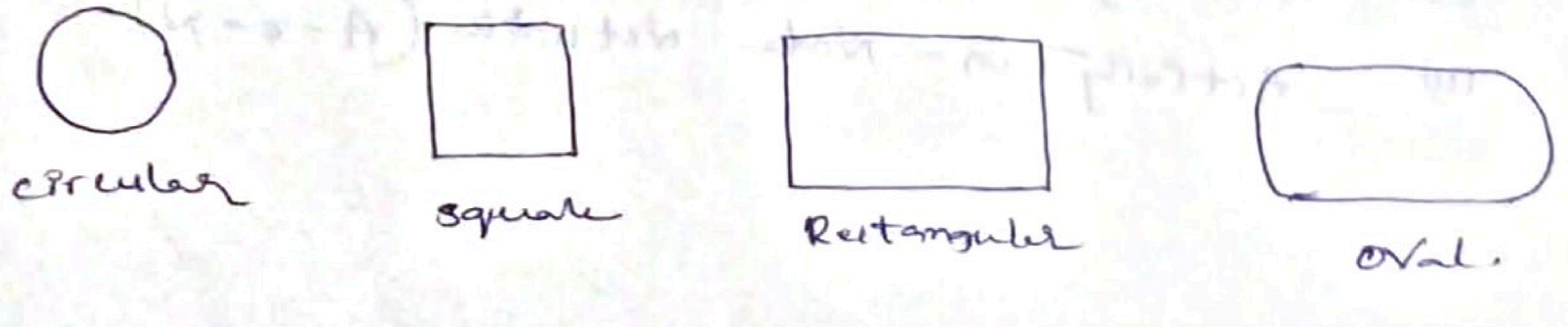
→ Events are significant points in a project which act as control points of the project.

→ An event is an instant of time and it does not require time or resources.

Examples of an event:

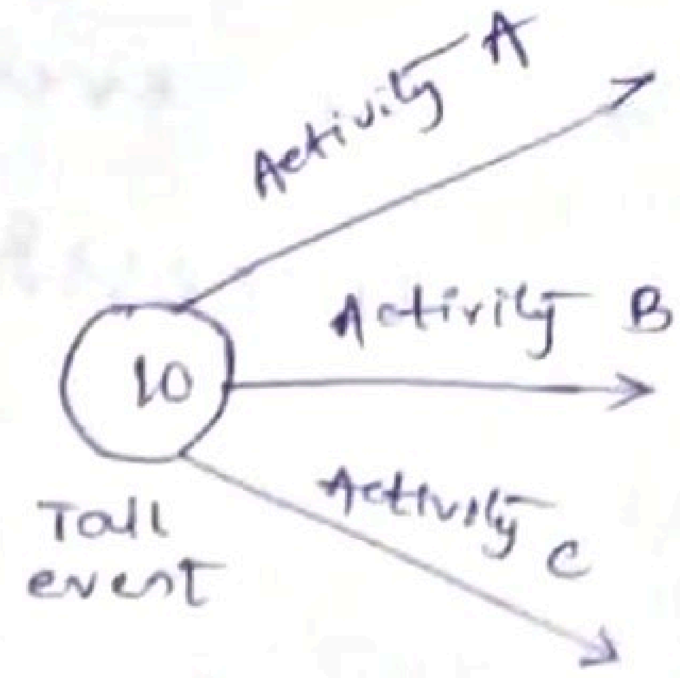
1. All parts assembled 2. A budget prepared
3. Construction completed.

→ Events are represented by nodes in a network. It may have any of the following shapes.



Tail event (or) start event:

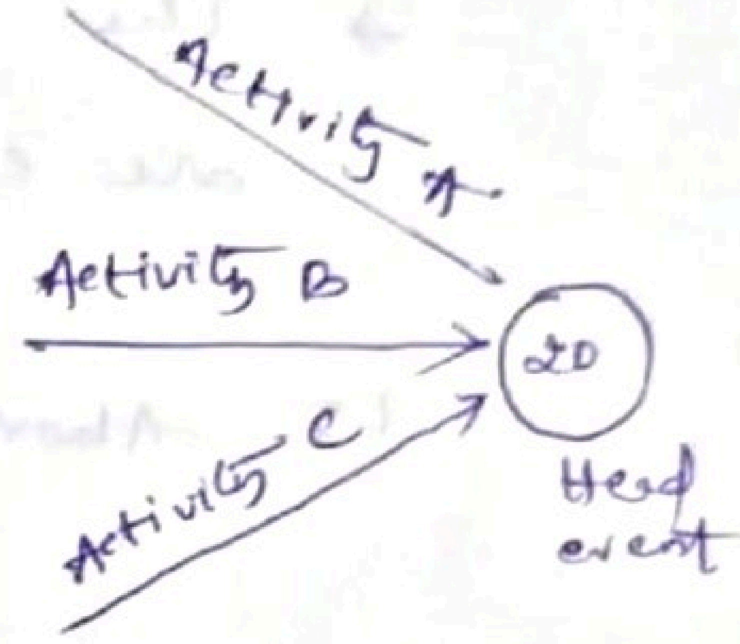
- It makes the beginning of an activity.
- If it is the first event of project then known as "initial or start event". It has only outgoing arrow



Eg: event 10 is a tail event. Arrows represent job or activity of the project.

Head event or the final event:

- The event which marks the completion of an activity known as "head event".
- If this event represents completion of entire project then it is called "Finish event".
- It has only incoming arrows

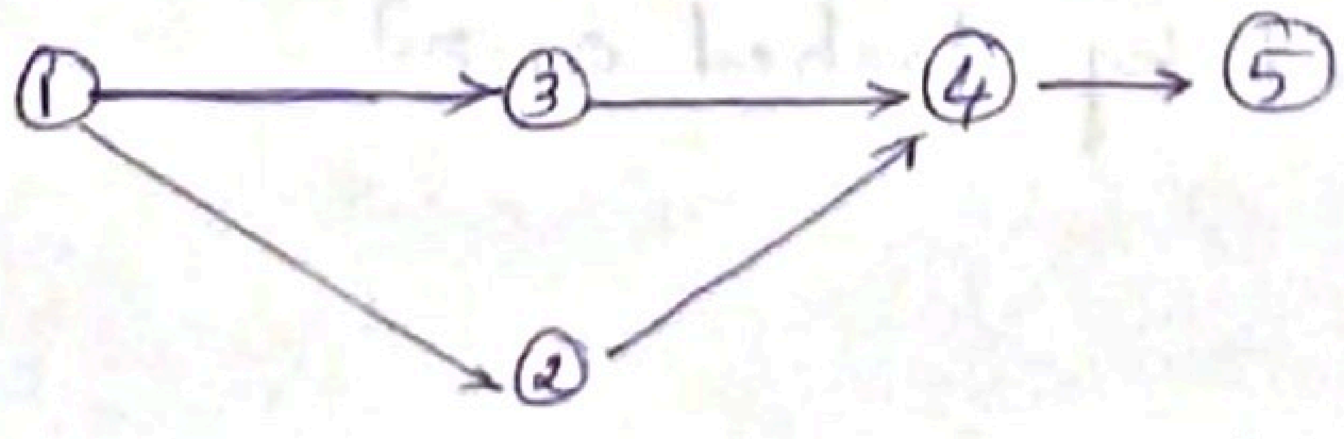


NOTE:

- When a tail event represents beginning of more than one activity, then the event is said to occur when the first activity starts from it.
- Similarly, when a head ~~hed~~ event occurs at end of more than one activity, the event is said to have occurred only when all the activities leading to it are completed.

Dual role events:

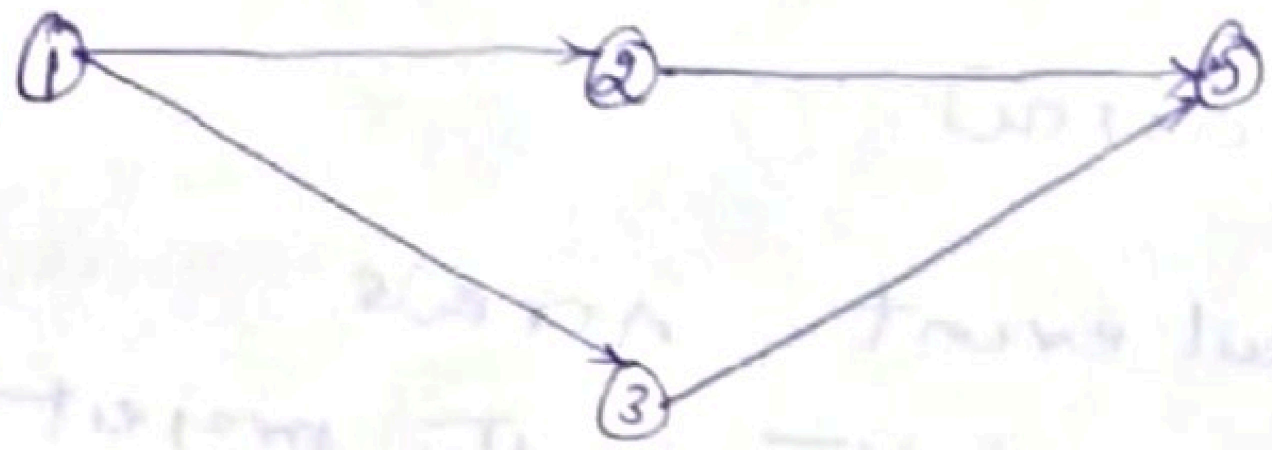
- All events except the first and the last event of a project are dual role events.
- They have both incoming and outgoing arrows.



Eg: events 2, 3, and 4 are dual role events.

successor events:

→ the events that follow another event are called successor events to that event.



Eg: Event 2 and 3 are successor events of event 1.

predecessor events:

→ the event or events that occur before another event are called predecessor event to that event.

Eg: Above fig., events 2, 3 are predecessor to event 5.

Activity:

→ Activity is actual performance of a job. It requires time and resources for its completion.

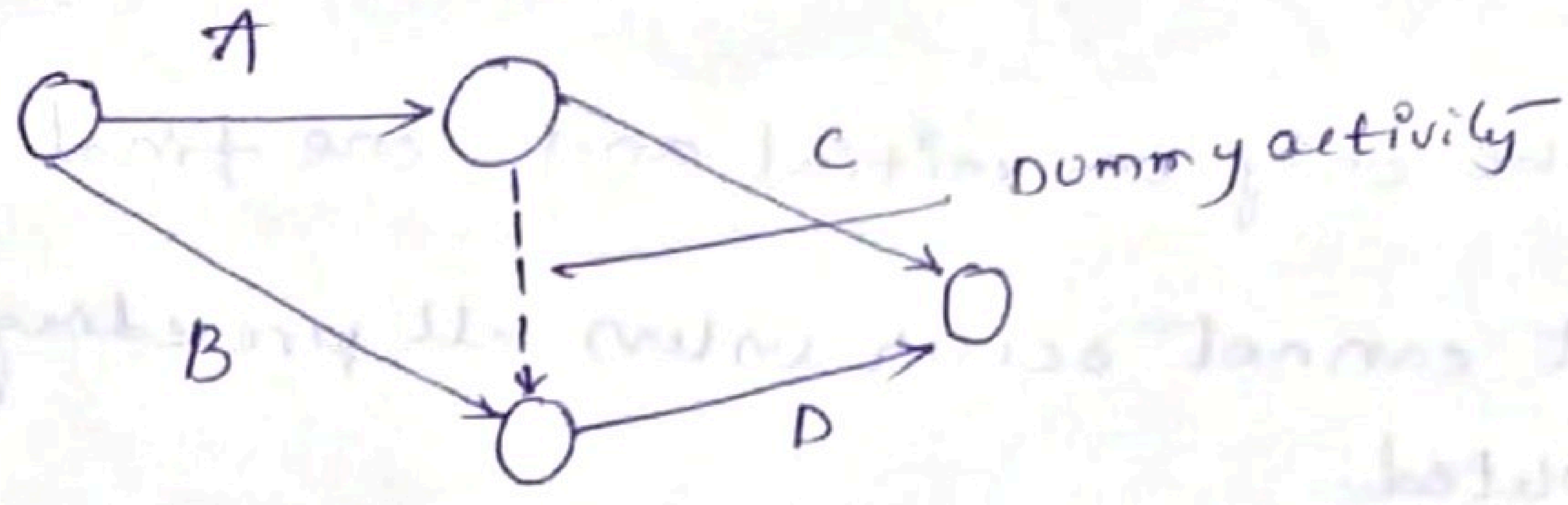
Examples of an activity:

1. Excavate trench 2. Mix concrete
3. prepare budget

Dummy:

→ A dummy is a type of operation which neither requires time nor any resource, but it donates dependency among the activities.

→ It is represented by dashed arrow

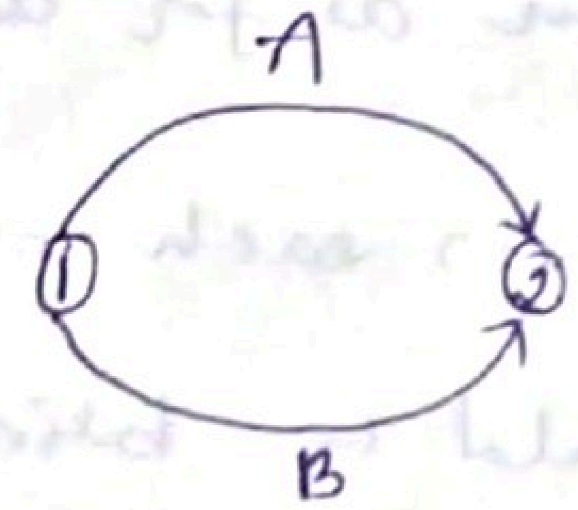


→ Fig. shows, a dummy activity.

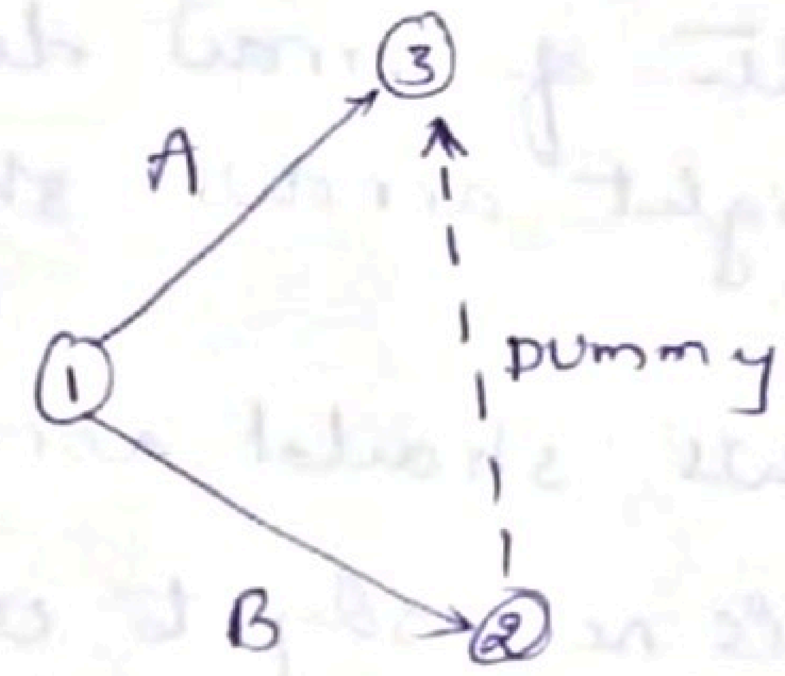
→ Dummy is used to serve following purposes:

1. Grammatical purpose:

→ To prevent two arrows having common beginning and common end.



(a) Ambiguous Representation

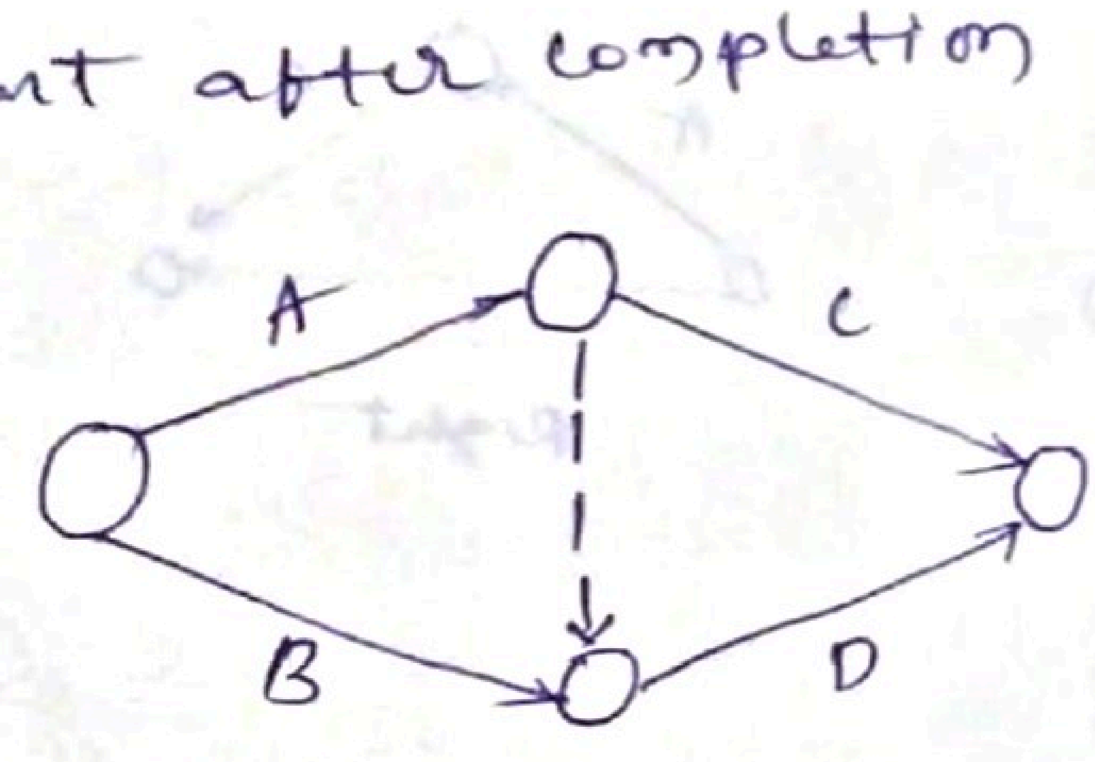


(b) Grammatically clean Representation.

2. Logical purpose:

→ To show relationship with other activities.

→ Here dummy is required to show that activity D can start after completion activities of A & B both.

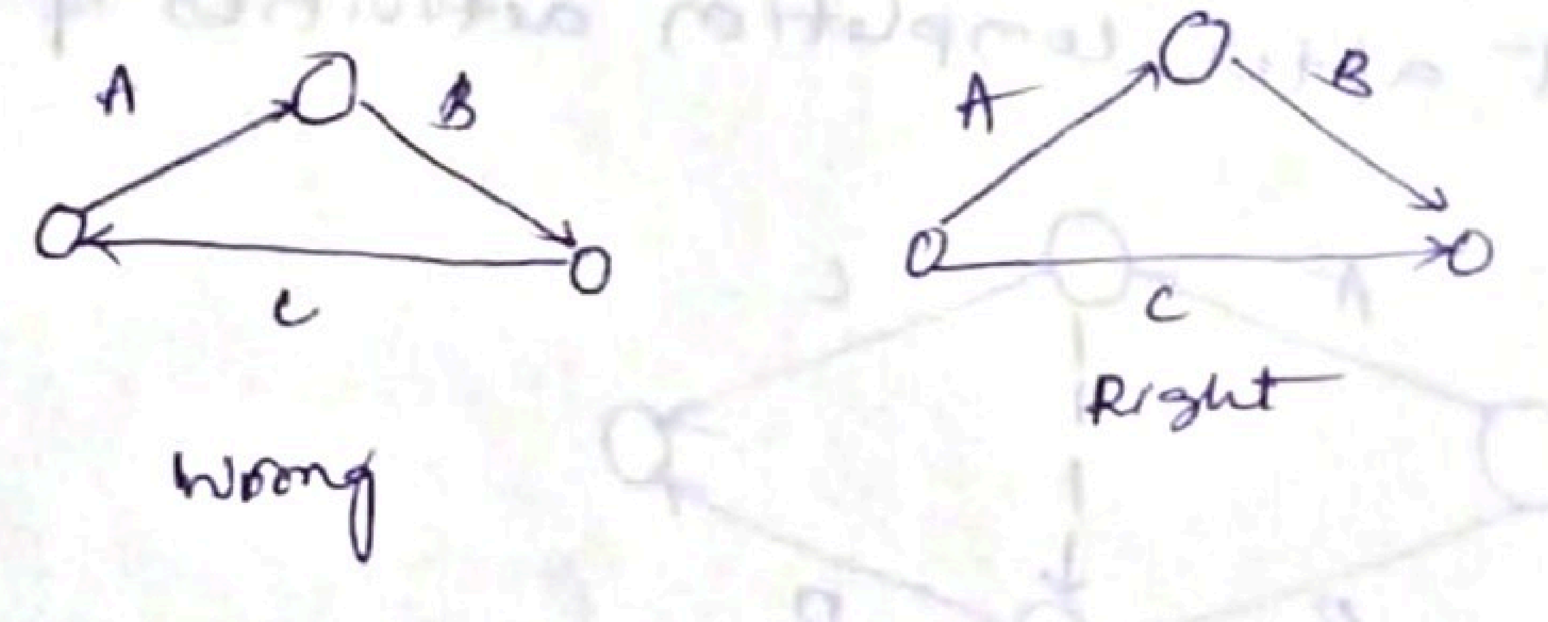


Rules of a Network:

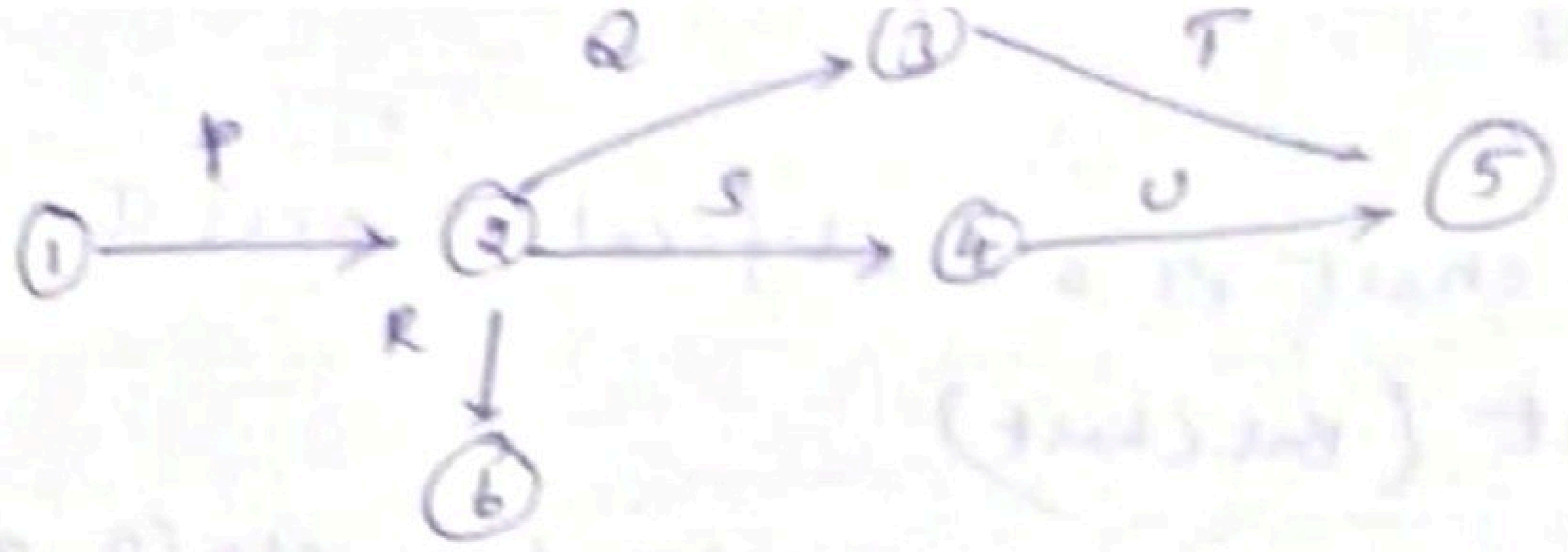
1. There can be only one initial and one final event.
2. An event cannot occur unless all preceding activities are completed.
3. An event can not occur twice
4. Number of arrows should be equal to number of activities
5. Time should always flow from left to right
6. Length of arrow does not show any magnitude straight arrows should be taken as far as possible
7. Arrows should normally not cross each other if it is necessary to cross, one should be bridged over the other.
8. No activity can start until it's tail event has occurred.

Errors in Network:

1. Looping error: Loops should not be formed.



2. Dangling error: project is complete only when all its activities are complete but the duration of activity 'R' has no effect on the project time as shown in fig (or) whenever an activity is disconnected from the network it is called dangling error.



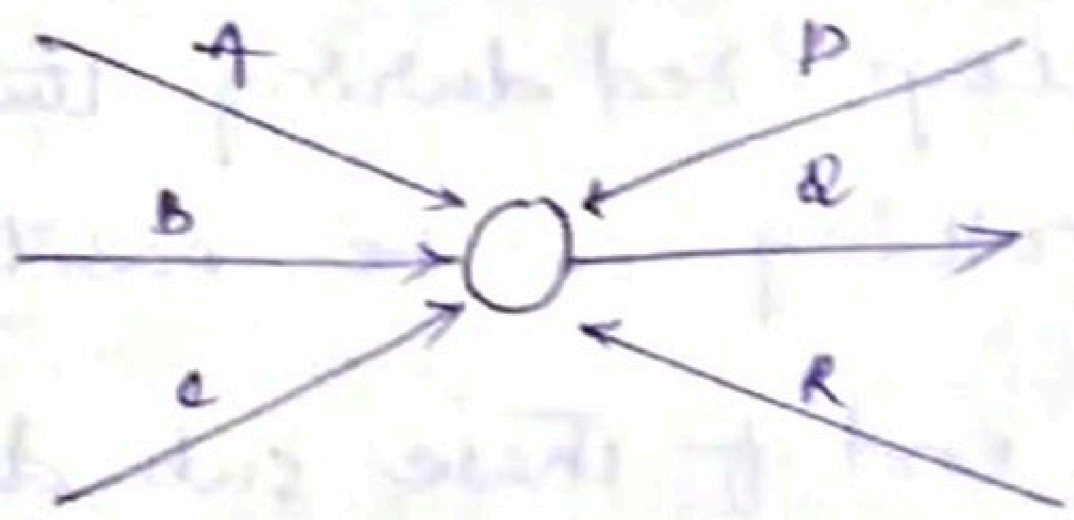
→ To avoid dangling error, the network must be examined in such a manner that all events except initial and final events must have at least one activity entering and one activity leaving them.

Wagon wheel error:

→ As shown in fig, each of the 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 but logical error has crept into it.

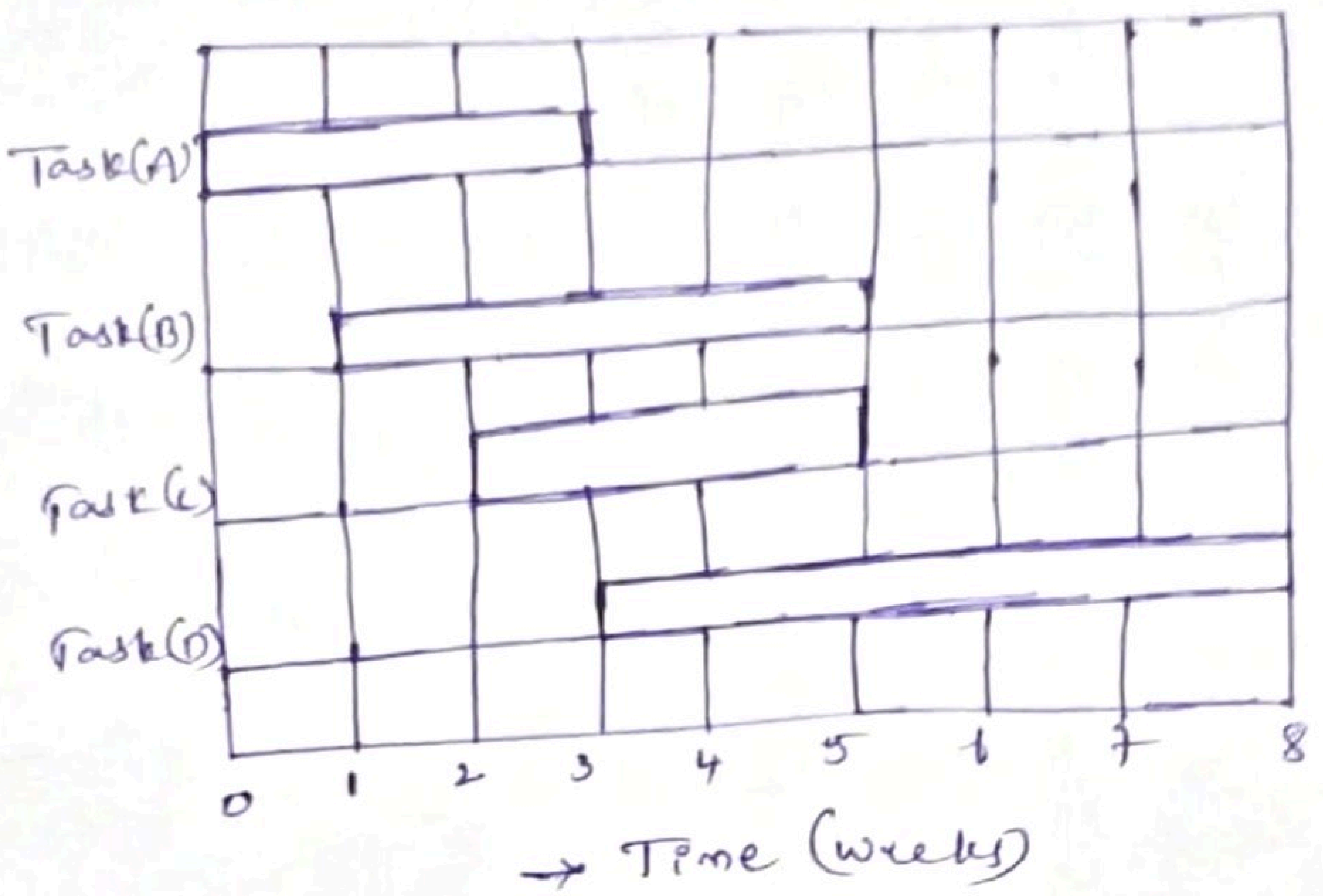


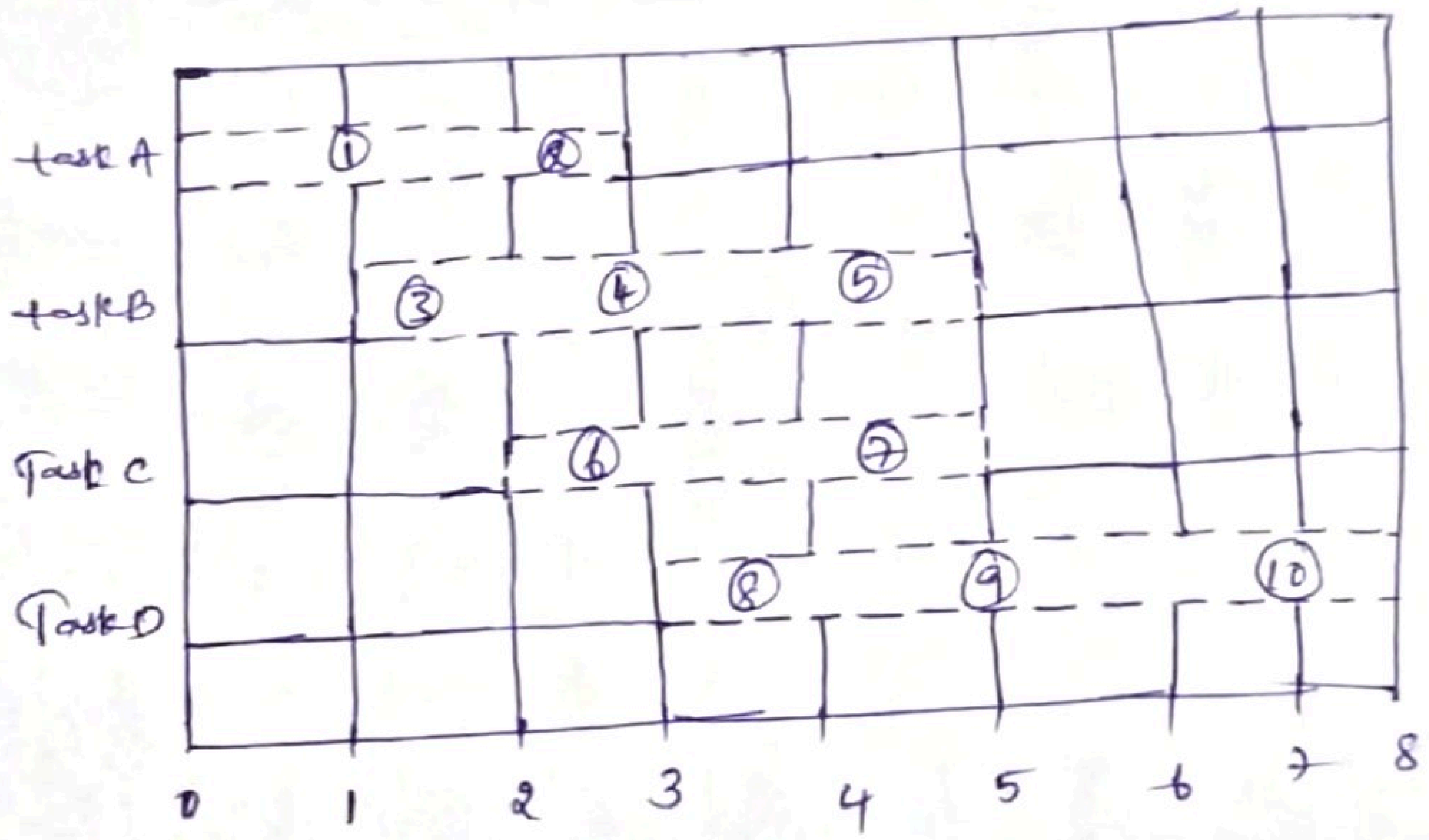
Milestone chart:

1. Milestone chart is a modification over the original Gantt chart (Bar chart)
2. Milestones are key events of a main activity represented by a bar these are specific points in time which mark the completion of certain portions of the main activity. These points are those which can be easily identified over the main bar.
3. We represents a particular activity as a bar in the chart. If the bar is long, it indicates that it is taking more time. But the fact is when a bar on a bar-charts very long, the details lack in it. If, however, the activity is broken or sub-divided into a number of sub-activities, each one of which can be easily recognized during the progress of the project, controlling can be easily done.

The beginning and end of these sub-divided activities or tasks are termed as milestones (key events).

The below figure shows the difference btw bar chart and milestone chart





→ the milestones or events in an activity are marked by circling the milestone no. The milestones indicates the completion of main events in a particular activity. therefore controlling of project becomes possible with the milestones.

→ the limitations of bar charts is similar to milestone charts except controlling. controlling is possible in milestone charts.

Project Management

Construction Project Management

Project : Converting Vision or Need to reality.

A project is composed of **activities or tasks** that are **related to one another** in some manner and all these should be **completed in order** to complete the project.

Project management: Is the **application** of knowledge, skills, tools, and techniques to project activities to meet the project requirements.

Aim: Completion of the project **on time within the budget** without compromising the **quality**.

Project Manager

Project managers have the responsibility of the **planning, procurement** and **execution** of a project.

Project managers are the first point of contact for any issues or discrepancies arising from within the heads of various departments in an organization before the problem escalates to higher authorities.

Why do we need Project Management?

- Advancing technology and increased size and complexity of projects need effective planning
- For effective Planning of project and to control cost and time over run
- To plan the project in detail. i.e. identifying the logical sequence of occurrence of the activity and inter-dependency and inter-relationship between them.
- To have proper control over project during unfavourable circumstances. (Plan –B)

Project Management Triangle

Each side represents a constraint of the project

Time constraint: Amount of time available to complete a project
Cost constraint: Amount budgeted for the project
Scope constraint: What must be done to produce the project's end result

Competing constraints

Increased scope → Increased time and increased cost,
Tight time constraint → Increased costs and reduced scope,
Tight budget → Increased time and reduced scope..

One side of the triangle cannot be changed without affecting the others

*A further refinement of the constraints separates product "quality" or "performance" from scope, and turns quality into a fourth constraint

Triple Constraint* or the *Iron Triangle

Project Management Phases

1. **Definition**
2. **Planning**
3. **Execution**
4. **Control**
5. **Closure**

Objectives of Project Management

Detailed planning of the project

Listing all the activities and their logical sequence.

Determining overall requirement of resources and their quantities .

Development of schedule

Working out time estimates for various activities based on available resources.

Preparing time schedule and calculate total project cost.

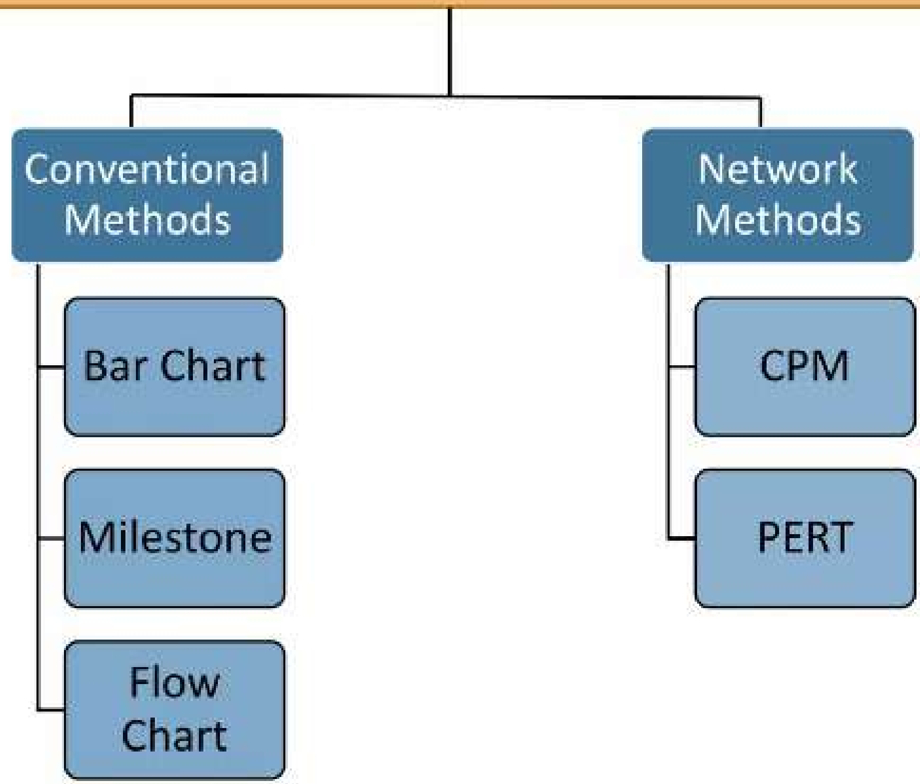
Periodic review of progress of work

Comparing the work progress with planned target whether work is as per schedule or not.

Identify corrective action to meet the lapses to achieve the target.

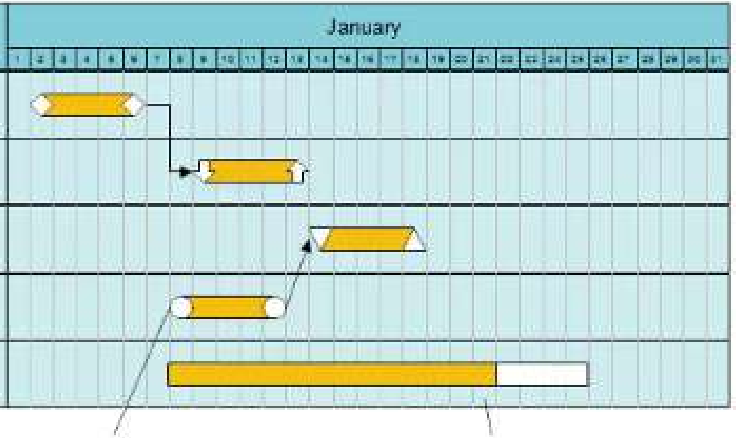
Ensure optimum use of resources such as men material money and machinery.

Tools of Planning and Scheduling

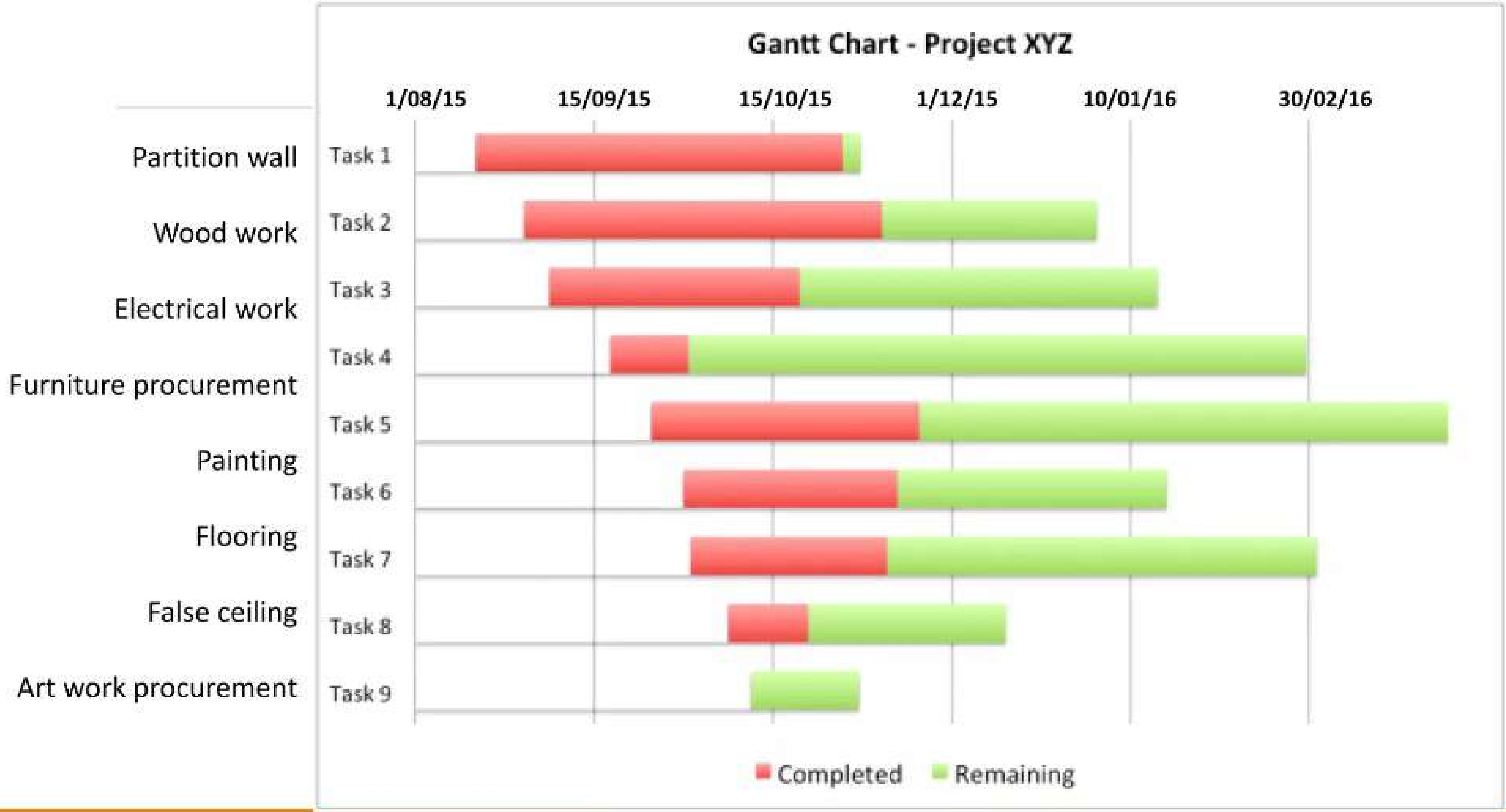


Gantt or Bar Chart

Task Name	ID	Start	Finish	Duration
Task 1	1	1/2/2002	1/6/2002	5 days
Task 2	2	1/9/2002	1/13/2002	5 days
Task 3	3	1/14/2002	1/18/2002	5 days
Task 4	4	1/8/2002	1/12/2002	5 days
Task 5	5	1/8/2002	1/25/2002	18 days

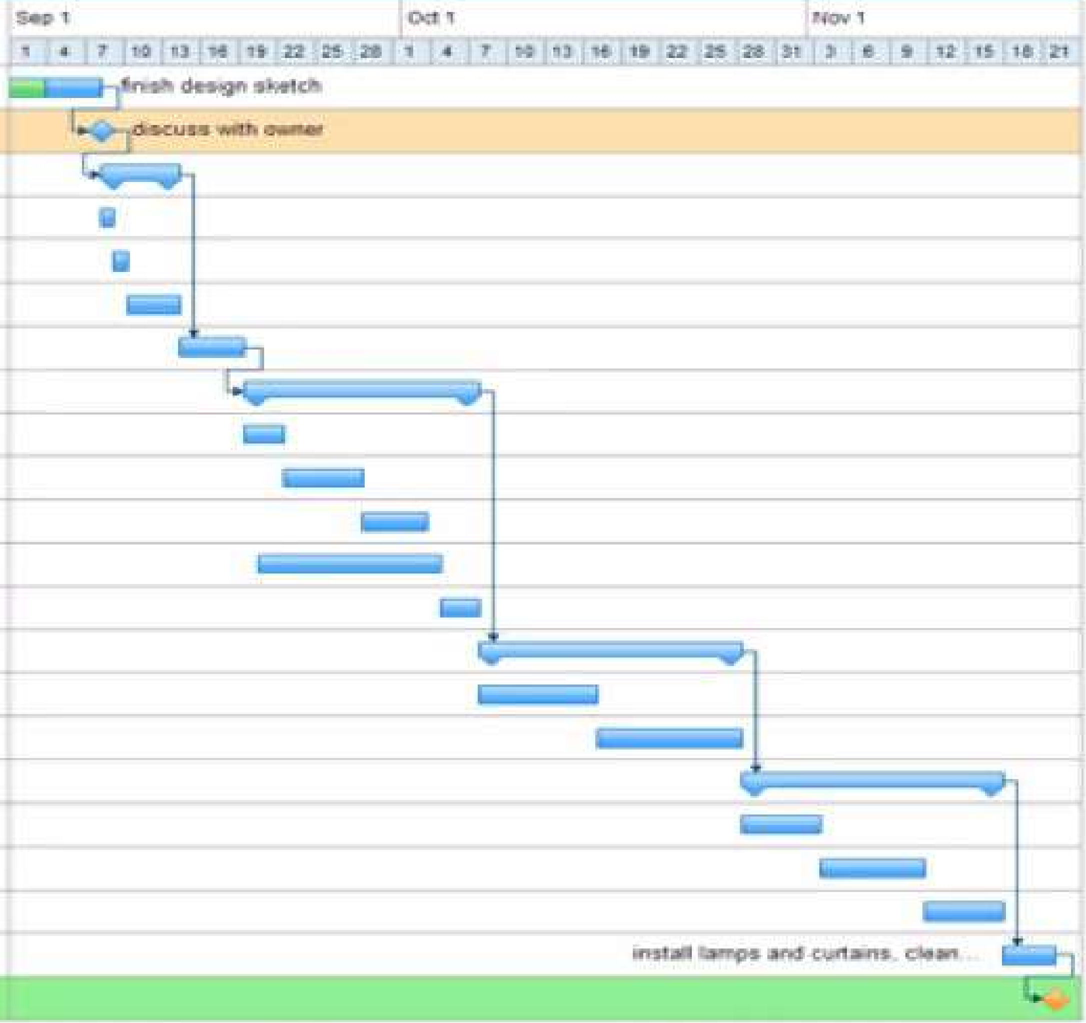


- Project is divided in to different activities represented by Horizontal bars on the Time scale
  - The beginning and the end of the bar represent the time of start and completion of the activity
  - Length of the bar represents the total time required to complete the activity.
- Reviewing progress
  - The bars are shaded to indicate the portion of the work completed.
  - Helps to identify particular activity is behind schedule, ahead of schedule or on time.


Gantt Chart - Project XYZ
1/08/15
15/09/15
15/10/15
1/12/15
10/01/16
30/02/16
Partition wall
Wood work
Electrical work
Furniture procurement
Painting
Flooring
False ceiling
Art work procurement
Task 1
Task 2
Task 3
Task 4
Task 5
Task 6
Task 7
Task 8
Task 9
Completed
Remaining

Sep 1 2011 - Nov 21 2011 — Interior Decoration Gantt Chart

No.		Task Name	Start	Finish	Duration	Completed	Manager
1		Design proposal	9/1/2011	9/8/2011	7.0 d.	40%	Mike
2		Approved by the owners	9/8/2011	9/8/2011	0.5 d.	0%	Mike
3		Construction preparation	9/8/2011	9/14/2011	6.0 d.	0%	John
4		Measure	9/8/2011	9/9/2011	1.0 d.	0%	John
5		Transportation decorate material	9/9/2011	9/10/2011	1.0 d.	0%	John
6		Removed appoint wall	9/10/2011	9/14/2011	4.0 d.	0%	John
7		Water electrician	9/14/2011	9/19/2011	5.0 d.	0%	Bill
8		Mason	9/19/2011	10/7/2011	18.0 d.	0%	Carl
9		Landfill trough	9/19/2011	9/22/2011	3.0 d.	0%	Carl
10		Bathroom	9/22/2011	9/28/2011	6.0 d.	0%	Carl
11		Kitchen	9/28/2011	10/3/2011	5.0 d.	0%	Carl
12		Building wall and wall repair	9/20/2011	10/4/2011	14.0 d.	0%	Carl
13		Floor tile laying	10/4/2011	10/7/2011	3.0 d.	0%	Carl
14		Woodwork	10/7/2011	10/27/2011	20.0 d.	0%	Ben
15		Ceiling	10/7/2011	10/16/2011	9.0 d.	0%	Ben
16		Furniture	10/16/2011	10/27/2011	11.0 d.	0%	Ben
17		Paintwork	10/27/2011	11/16/2011	20.0 d.	0%	Fred
18		Ceil	10/27/2011	11/2/2011	6.0 d.	0%	Fred
19		Wall	11/2/2011	11/10/2011	8.0 d.	0%	Fred
20		Furniture	11/10/2011	11/16/2011	6.0 d.	0%	Fred
21		Others	11/16/2011	11/20/2011	4.0 d.	0%	John
22		Owner check	11/20/2011	11/20/2011	0.0 d.	0%	John



Limitation of Gantt or Bar chart

Does not indicate the inter-relationship between various activities.

Does not indicate the effect of the activity on the overall completion of the activity.

Does not indicate which activity is critical and which has spare time.

Difficult to optimise the use of resources.

Bar charts for complex projects are complicated and not practical.

Tools of Planning and Scheduling

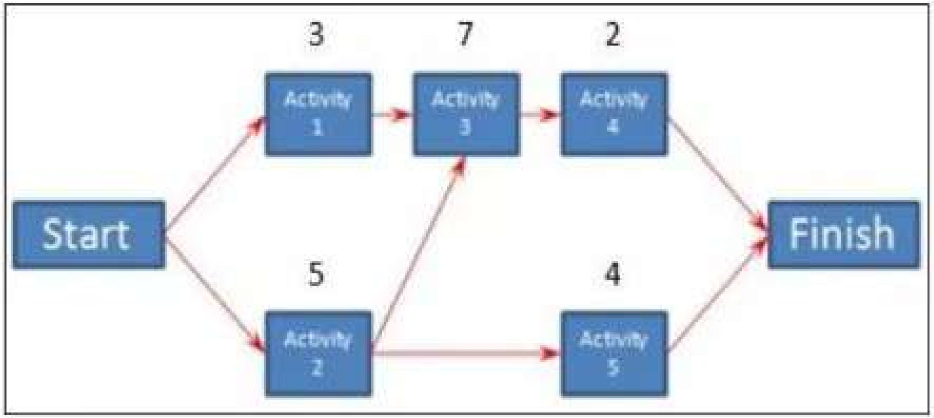
- Conventional Methods
  - Bar Chart
  - Milestone
  - Flow Chart
- Network Methods
  - CPM
  - PERT

Elements of Network

The network is a graphic plan showing jobs or activities that must be completed to achieve completion of a project.

OR

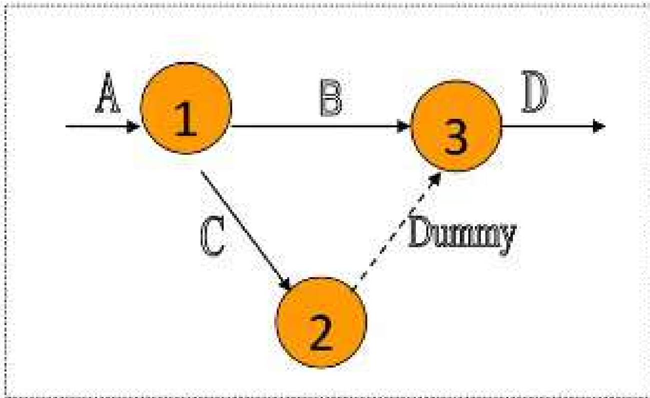
A network is also defined as an arrow diagram obtained by connecting all the activities of the project in logical sequence.



Activity: Jobs that required to be performed in executing a project.

Event: is a Point in time representing start and completion of one or more activities.

Dummy Activity: It is a zero time activity and consumes no resources. Introduced when two or more activities start and end at the same nodes



Network Method

CPM –Critical Path Method

Network are generally used for planning, scheduling and controlling of repetitive type of the projects where one can make fairly accurate assessment of the time for completion of each activity.

PERT-Program Evaluation and Review Technique

Network are generally used in research and development type of project which are non- repetitive in nature.

Also employed for the projects where it is difficult to allot definite time for performing each and every activity for want of information regarding past experience of handling similar projects

Development of Network

Steps to be followed for developing a network:

a) Note down all the activities which are required to be performed for completing the project

b) Arrange the activities in their correct logical sequence.

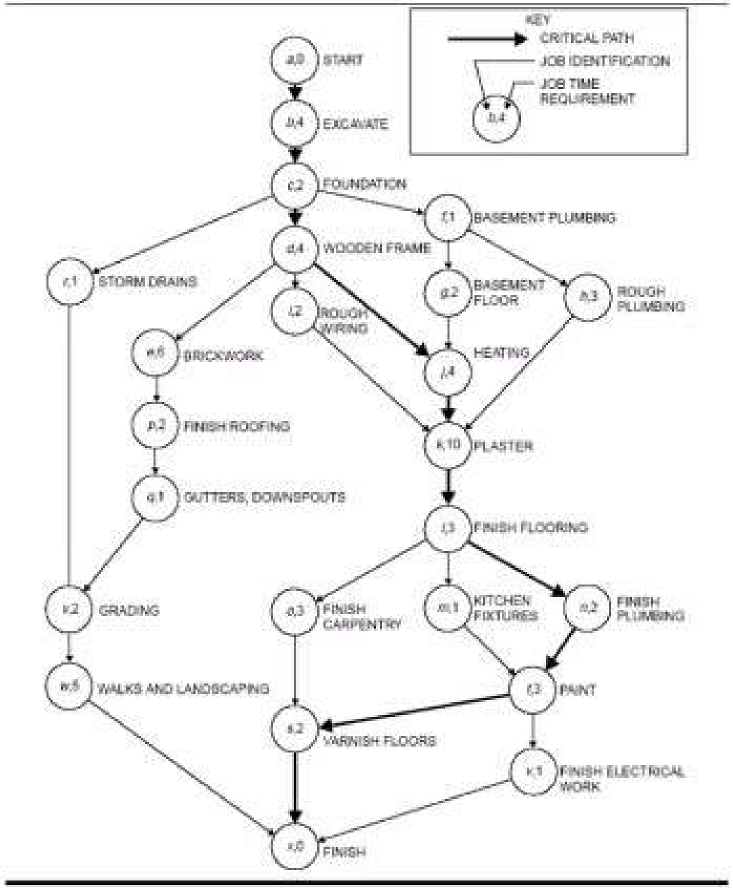
Logical sequence means:

Which activity must be completed before particular activity can be started?

Which activity can be started concurrently with other activity?

Which activity must immediately follow this activity?

a) Consider possibilities of sub-dividing different activities in phases or sections to introduce the concept of performing jobs simultaneously or concurrently. This helps in reducing overall time of completion of the project.



Network Diagram

Identify the Critical path

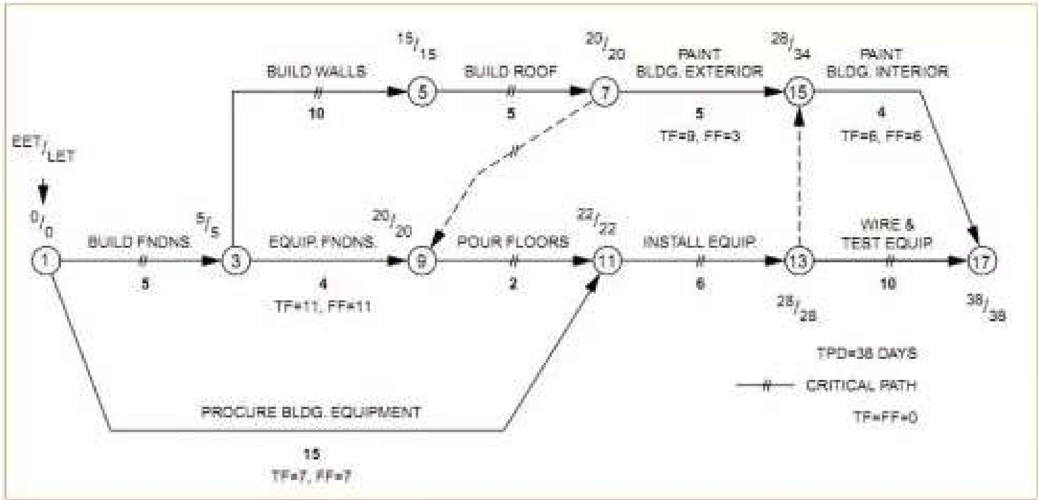
The critical path is path along the network which requires the longest time for the project from start to its completion and thus decides the time of completion of the project.

Event slack/Float is the free time available up to which occurrence of an event can be delayed without causing any delay in the completion date of the project

Zero slack → event is on schedule.

Positive slack → event is ahead of schedule

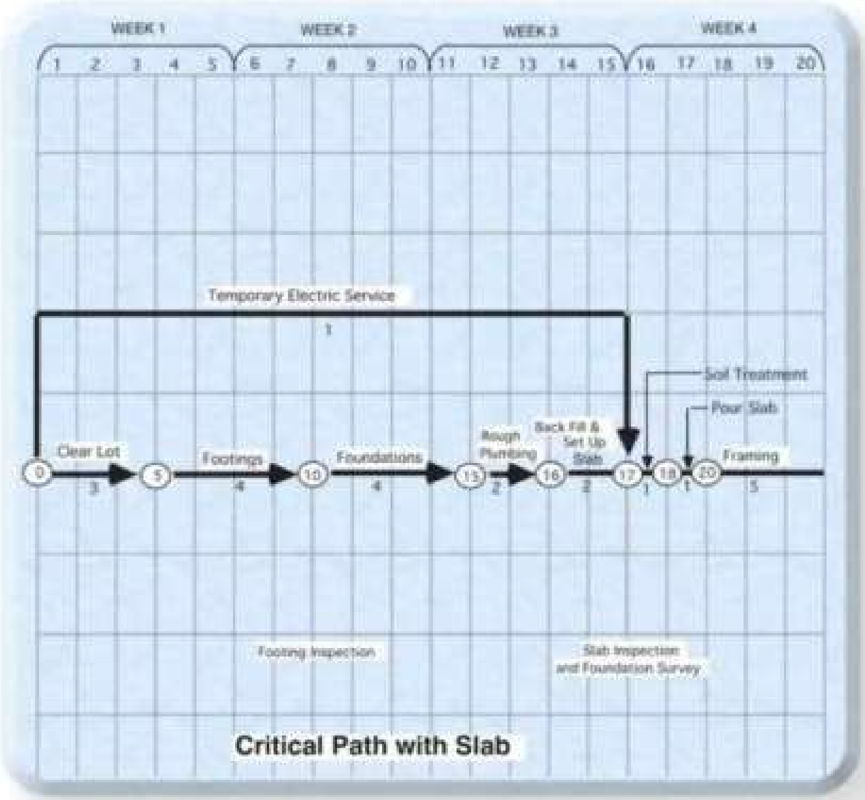
Negative slack → event is behind schedule.



To Estimate project duration

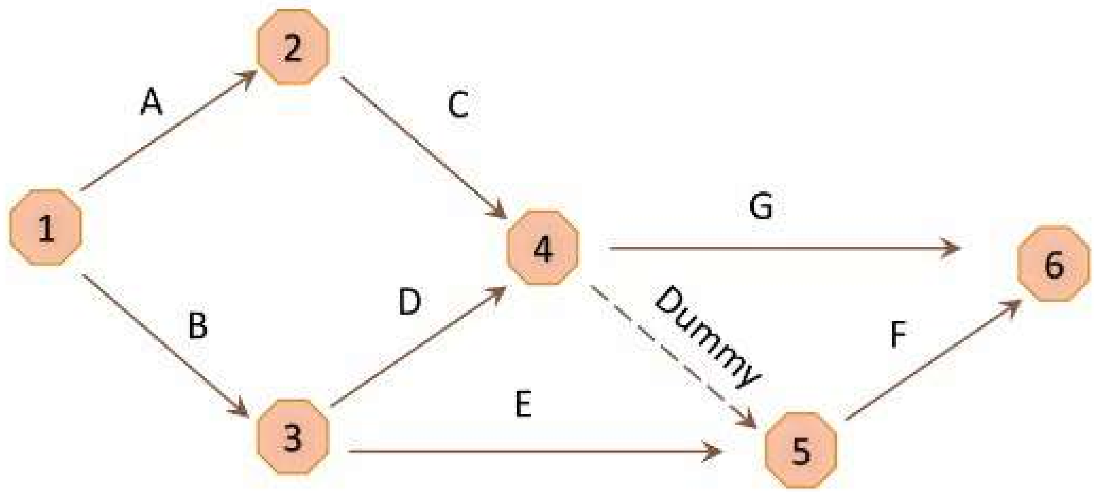
To assess the project duration 5 steps to be followed in their sequential order.

1. Estimation of activity duration time
2. Estimation of early expected even time
3. Estimation of latest allowable event time.
4. Calculation of even slack
5. Identify the Critical path.



Process of Drawing Network

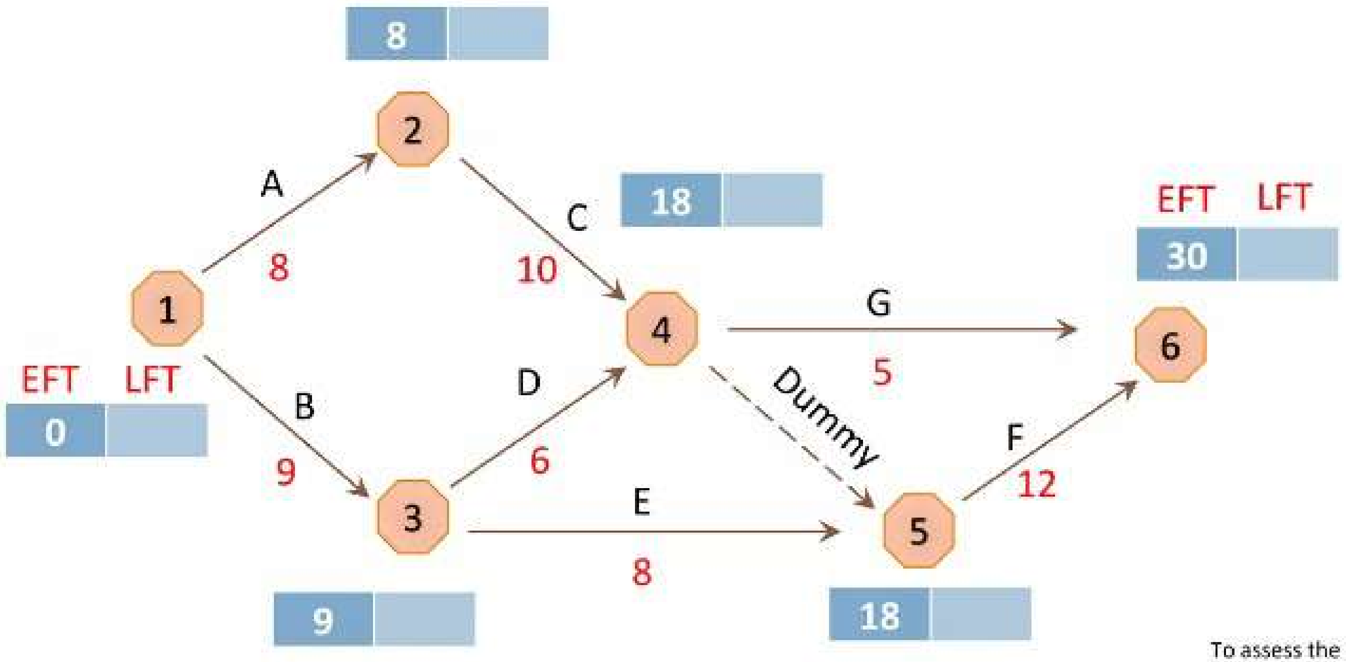
NO.	Activity
A	Partition wall
B	Electrical work
C	False Ceiling
D	Flooring
E	Painting
F	Furniture
G	Cleaning



Network diagram –First draft

Process of Drawing Network

No	Activity
A	Partition wall
B	Electrical work
C	False Ceiling
D	Flooring
E	Painting
F	Furniture
G	Cleaning



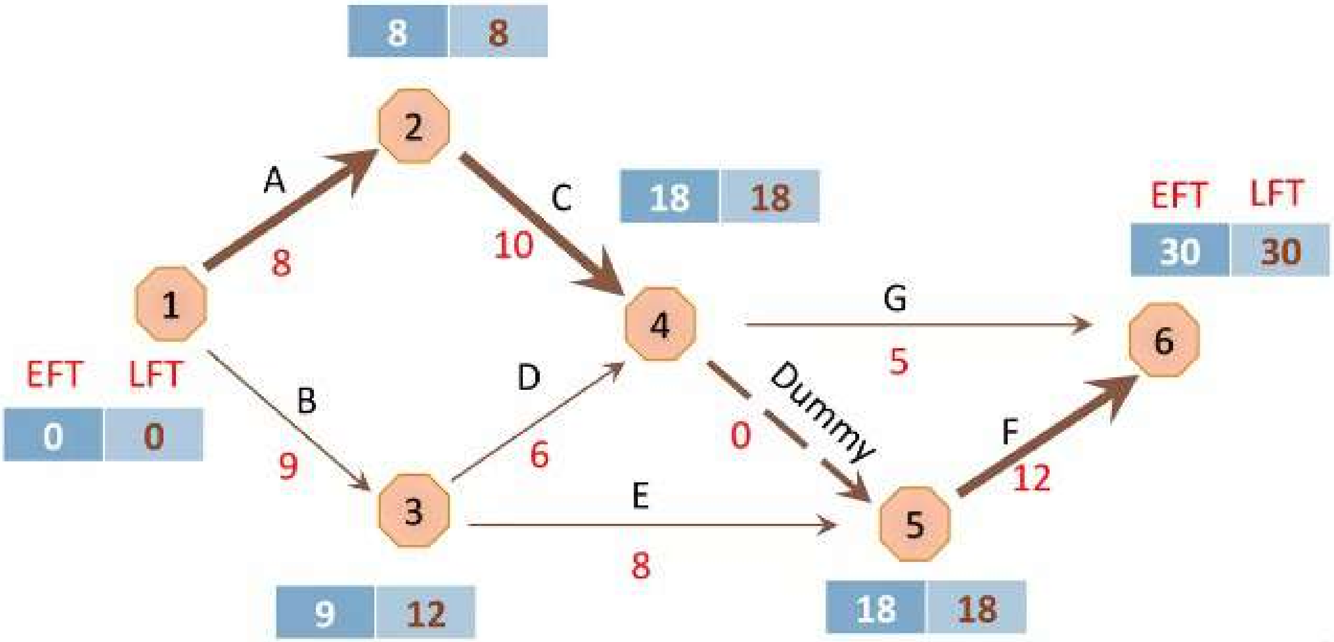
Timing the Network

To assess the project duration 5 steps to be followed in their sequential order.

1. Estimation of activity duration time
2. Estimation of early expected even time
3. Estimation of latest allowable event time.
4. Calculation of even slack
5. Identify the Critical path.

Process of Drawing Network

No	Activity
A	Partition wall
B	Electrical work
C	False Ceiling
D	Flooring
E	Painting
F	Furniture
G	Cleaning



Project Duration-30 days

Critical Path Activity – A-C-Dummy-F

To assess the project duration 5 steps to be followed in their sequential order.

1. Estimation of activity duration time
2. Estimation of early expected even time
3. Estimation of latest allowable event time.
4. Calculation of even slack
5. Identify the Critical path.

Analysing and scheduling of network

1. Calculate time estimates for each activity
2. Determine the critical path which governs the minimum project completion
3. Determine the events slack and the activity floats for Activities which are not on critical path.
4. Examine possibility of diverting unutilized resources from noncritical activity to a critical activity.
5. Analyse the network again after considering the redistribution of resources
6. Workout revised starting and completion dates of the activity.

Advantage of Network method

Easier to build a team and create human network for efficient handling of a multitasked project.

Takes into consideration the requirements well in advance to complete a project in the most efficient way possible.

Easy to determine the estimate exact time and cost of the project.

Helps to monitor human resources, and the direct and indirect costs associated with the project.

Charting in a Network makes it easier to evaluate parallel activities, handle delays and judge the outcome of a task.

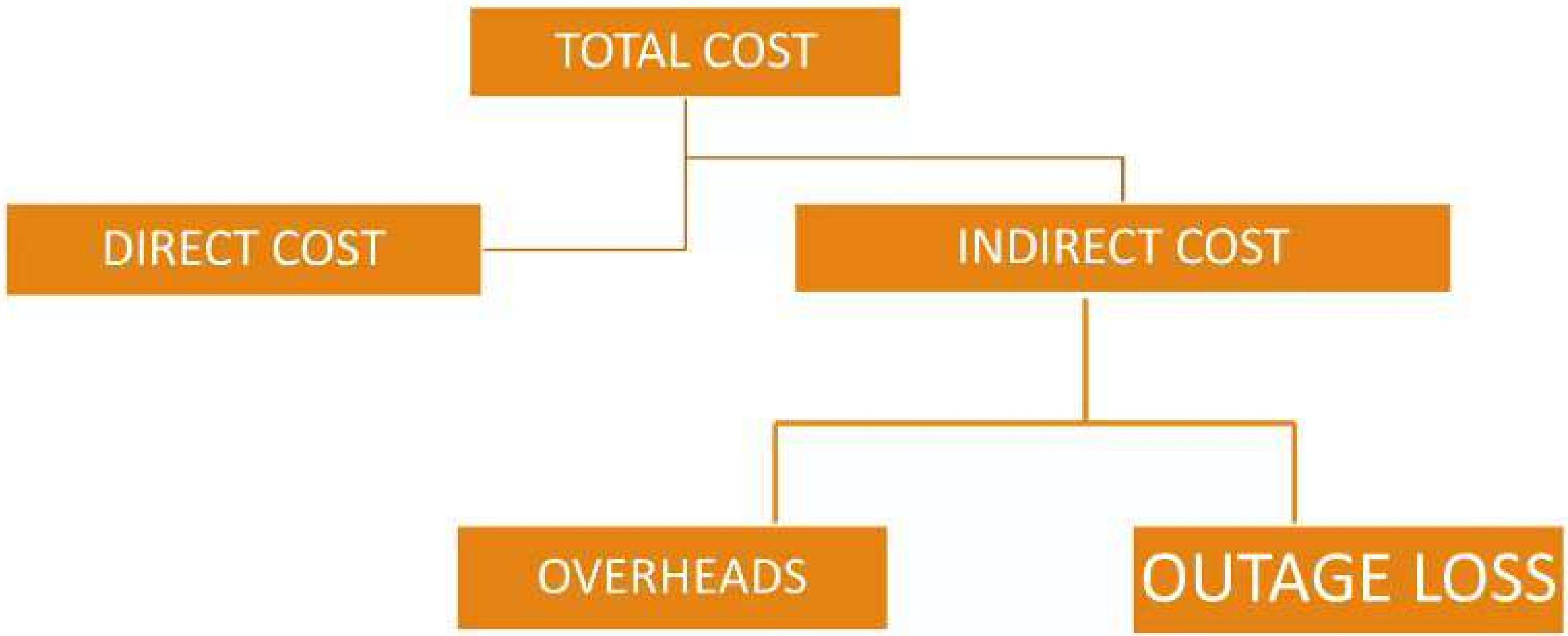
Enables the managers to minimize the project length by monitoring the critical path.

Enables the project head to determine if the task is on schedule or needs boost to accelerate the process.

Difference Between CPM and PERT

CPM	PERT
CPM uses activity oriented network.	PERT uses event oriented Network.
Durations of activity may be estimated with a fair degree of accuracy.	Estimate of time for activities are not so accurate and definite.
It is used extensively in construction projects.	It is used mostly in research and development projects, particularly projects of non-repetitive nature.
Deterministic concept is used.	Probabilistic model concept is used.
CPM can control both time and cost when planning.	PERT is basically a tool for planning.
In CPM, cost optimization is given prime importance. The time for the completion of the project depends upon cost optimization. The cost is not directly proportioned to time. Thus, cost is the controlling factor.	In PERT, it is assumed that cost varies directly with time. Attention is therefore given to minimize the time so that minimum cost results. Thus in PERT, time is the controlling factor.

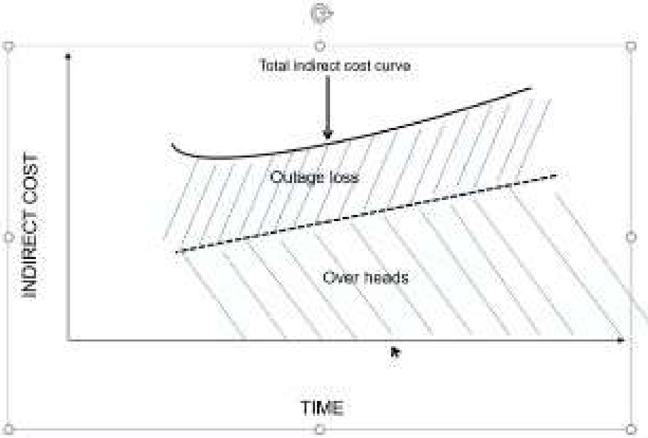
Project Cost



INDIRECT PROJECT COST

- These are those expenditures which cannot clearly allocated to the individual activities of a project, but are assessed as whole.
- It includes expenditure related to administrative and establishment charges, supervision, expenditures on central store organisation, loss of revenue, lost profit, penalty etc.
- Indirect cost rises with increased duration.
- <u>*OUTAGE LOSS :*</u> loss in profits due to inability to meet demand or penalty due to delay.

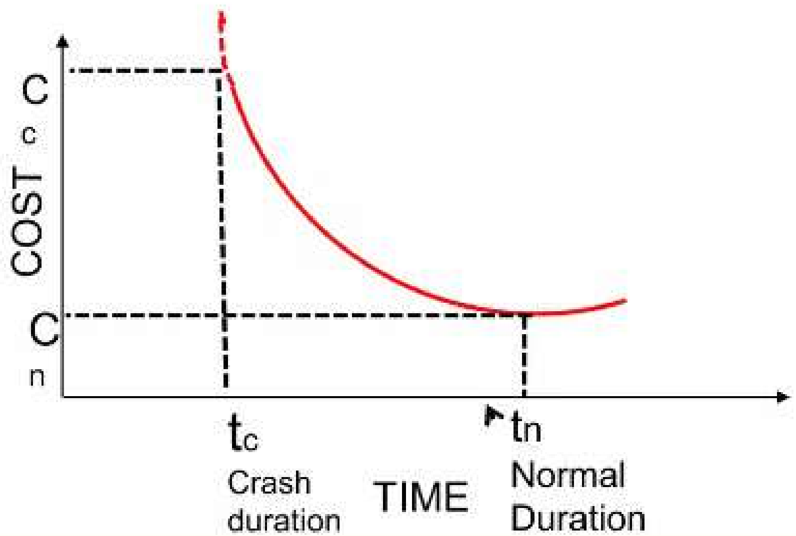
INDIRECT COST CURVE



DIRECT PROJECT COST

- Those expenditures which are directly chargeable to and can be identified specifically with the activities of the project.

- These include labour cost, material cost, equipment cost etc.



CAUSES OF PROJECT FAILURE

1. Poor planning

Although sometimes overlooked in importance, lack of planning can make a project fail. Having a successful project depends on properly defining **in detail the scope, the time frame, and each member's role**. This way, you'll have a route laid out to follow.

2. Inconsistently defined resources

Let's be clear: planning shouldn't be limited to agendas, meetings, and responsibilities. It should also include human, intellectual, financial, or structural resources. If these are not consistently determined, deadlines can't be met, which can jeopardize the project's conclusion.

3. Unclear objectives

Project objectives should be clearly defined, so as time goes by, you'll know if you're doing what's right or not. Remember that choosing **measurable goals** helps you better visualize your progress and helps you see how close you are to achieving your results.

4. Lack of detail control

Monitoring is essential for successful projects, even knowing the details of many projects simultaneously can be very challenging.

As a result, it's important **to know how your project is going**, if it is on schedule and if the budget is under control. This way, if there are any divergences from the initial plan, you can still correct them.

5. Lack of transparency

It's essential that **everyone involved in the projects have complete project visibility** so that it doesn't fail – not only the project manager, but other team members too.

This includes clear communication, good document management, and transparency about tasks' status, all of which can be achieved with centralized, all-digital files.

6. Lack of communication

Communication is the key to good project management. Without the right tools and processes to allow interaction among team members and the project manager from the beginning, efficient communication can seldom be achieved.

7. Change of direction

Among the ways projects fail, a very common one is **scope creep**. This concept refers to changes requested when the project has already started which had not been planned before. This is very common when projects are not appropriately documented and defined beforehand.

8. Unrealistic expectations

When you want to do something fast, with a limited budget, and a reduced team, it can really make your project fail. You should be realistic when it comes to your teams' capabilities, deadlines, and the resources available – only then can you obtain the results you want.

9. Lack of monitoring

Providing a schedule to the team is not enough for a project to be successful. You should also make sure everything goes as planned. This means having **frequent progress checks** or meetings, as well as making adaptations, when necessary, is essential.

10. Unrealistic due dates

Planning complex tasks for short due dates is definitely one of the causes for project failure. It is vitally important to carefully consider how long each project phase will take, in addition to **extra time for unexpected events**. This is the only way to develop a quality project.

11. Poorly assigned roles

When each team member receives their responsibilities clearly, they will know what, when, and how to perform their activities without someone needing to constantly ask for it.

Project Cost Control

- **Project cost** control includes:
  - Monitoring **cost** performance
  - Ensuring that only appropriate **project** changes are included in a revised **cost** baseline
  - Recording all appropriate changes accurately against the cost baseline
  - Preventing incorrect, inappropriate, or unapproved changes from being
  - included in the reported cost or resource usage
  - Informing **project** stakeholders of authorized changes to the **project** that will affect costs
  - Acting to bring expected cost overruns within acceptable limits

DIRECT AND INDIRECT COSTS

- **Direct costs** can be directly related to creating the products and services of the project. You can attribute direct costs to a particular project.

- For example, direct costs includes the salaries of people working full time on the project and the cost of hardware and software purchased specifically for the project.

- Project managers should focus on direct costs because they should be controlled.

- **Indirect costs** are not directly related to the products or services of the project, but are indirectly related to performing work on the project.

- For example, indirect costs would include the cost of electricity, paper towels, and other necessities in a large building that houses 1,000 employees who work on many projects.

- Indirect costs are allocated to projects, and project managers have very little control over them

Objectives of cost control

- To have a knowledge of the profit and loss of the project throughout the duration of the project.
- To have a comparison between the actual project performance and that conceived in the original project plan.
- Provides feedback data on actual project performance to future project planning

Tools and techniques of cost control

- Earned value management
- Estimate to complete
- Forecasting
- Cost variance
- Cost performance index

Earned value management

- The earned value technique uses the cost control contained in the project management plan to assess project progress and the magnitude of any variations that occur. The earned value technique involves developing these key values for each schedule activity, work package, or control account.

- It compares the amount of work that was planned with what was actually earned with what was actually spent to determine if cost and schedule performance are as planned.

- Planned value (PV)-PV is the budgeted cost for the work scheduled to be completed on an activity or WBS component up to a given point in time.

- Earned value (EV)-EV is the budgeted amount for the work actually completed on the schedule activity or WBS component during a given time period.

- Actual cost (AC)-AC is the actual cost incurred in accomplishing work on the schedule activity or WBS component during a given time period. This AC must correspond in definition and coverage to whatever was budgeted for the PV and the EV (e.g. direct hours only, direct cost only, or all costs including indirect costs).

Estimate to complete

- The PV, EV, and AC values are used in combination to provide performance measures of whether or not work is being accomplished as planned at any given point in time. The most commonly used measures are cost variance (CV) and schedule variance (SV). The amount of variance of the CV and SV values tend to decrease as the project reaches completion due to compensating effect of more work being accomplished. Predetermined acceptable completion can be established in the cost management plan.

Forecasting

- Forecasting includes making estimates or predictions of conditions in the project's future based on the information and knowledgeable available at the time of the forecast. As the project progresses, the forecasts are adjusted.
- Formula: BAC=total cumulative PV t the completion
- Forecasting technique parameters to assess the cost or the amount of work to complete schedule activities is called the EAC.

Cost variance

- CV equals earned value (EV) minus actual cost (AC). The cost variance at the end of the project will be the difference between the budget at the completion (BAC) and the actual amount spent.
- Formula: CV=EV-AC
- these two values, the CV and SV, can be converted to efficiency indicators to reflect the cost and schedule performance of any project.

Cost performance index

- A CPI value less than 1.0 indicate accost overrun of the estimates. A CPI value greater than 1 indicates a cost under-run of the estimates. CPI equals the ratio of the EV to the AC. The CPI is the most commonly used cost-efficiency indicator.
- Formula: CPI=EV/AC
- CPI is widely used to forecast project costs at completion.

SEMINAR
ON
PERT & GANTT CHART

OVERVIEW

PERT is a method of analyzing the tasks involved in completing a given project, especially the time needed to complete each task, and to identify the minimum time needed to complete the total project. PERT was developed primarily to simplify the planning and scheduling of large and complex projects.

HISTORY OF PERT/CPM

PERT

Developed by the US Navy for the planning and control of the **Polaris missile program**

The emphasis was on completing the program in the shortest possible time.

CPM

Developed by **Du Pont** to solve project scheduling problems

The emphasis was on the trade-off between the cost of the project and its overall completion time

PERT INCLUDES....

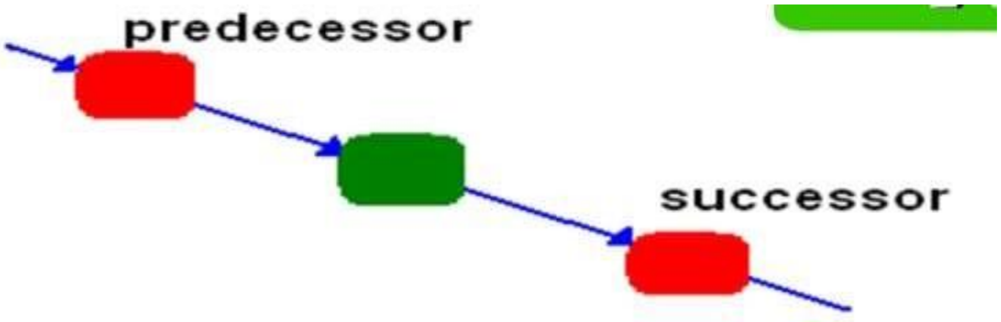
- The finished product or service desired.
- The total time and budget needed to complete the project or program.
- The starting date and completion date.
- The sequences of steps or activities.
- The estimated time and cost of each step or activity.
- Is a model for project management designed to analyze and represent the task involved in completing a given project.

COMPONENTS OF PERT MODEL

Every activity consume time and needs adequate resources such as manpower, material, space and machinery to change or move one event to other.

- **Predecessor event –** It is an event that precedes some other event, it can be single or multiple.

- **Successor events –** It is an event that immediately follows some other events, it can have single multiple successor events.



- **Optimistic Time (O)** – It is the minimum possible time required to complete the task anticipating that every event has occurred better than usually expected.

- **Pessimistic Time (P) -** This means the maximum possible time required to complete the given task, expecting or assuming everything goes wrong except the main catastrophes.

- **Most likely Time (M)** – The actual and the best time required to complete the task assuming everything goes in a usual way.

- **Expected time or the very best time (TH)** – The accurate or the actual time required to complete the task, it is the most reliable and valid time estimated to complete a task. It can be calculated using the following relation

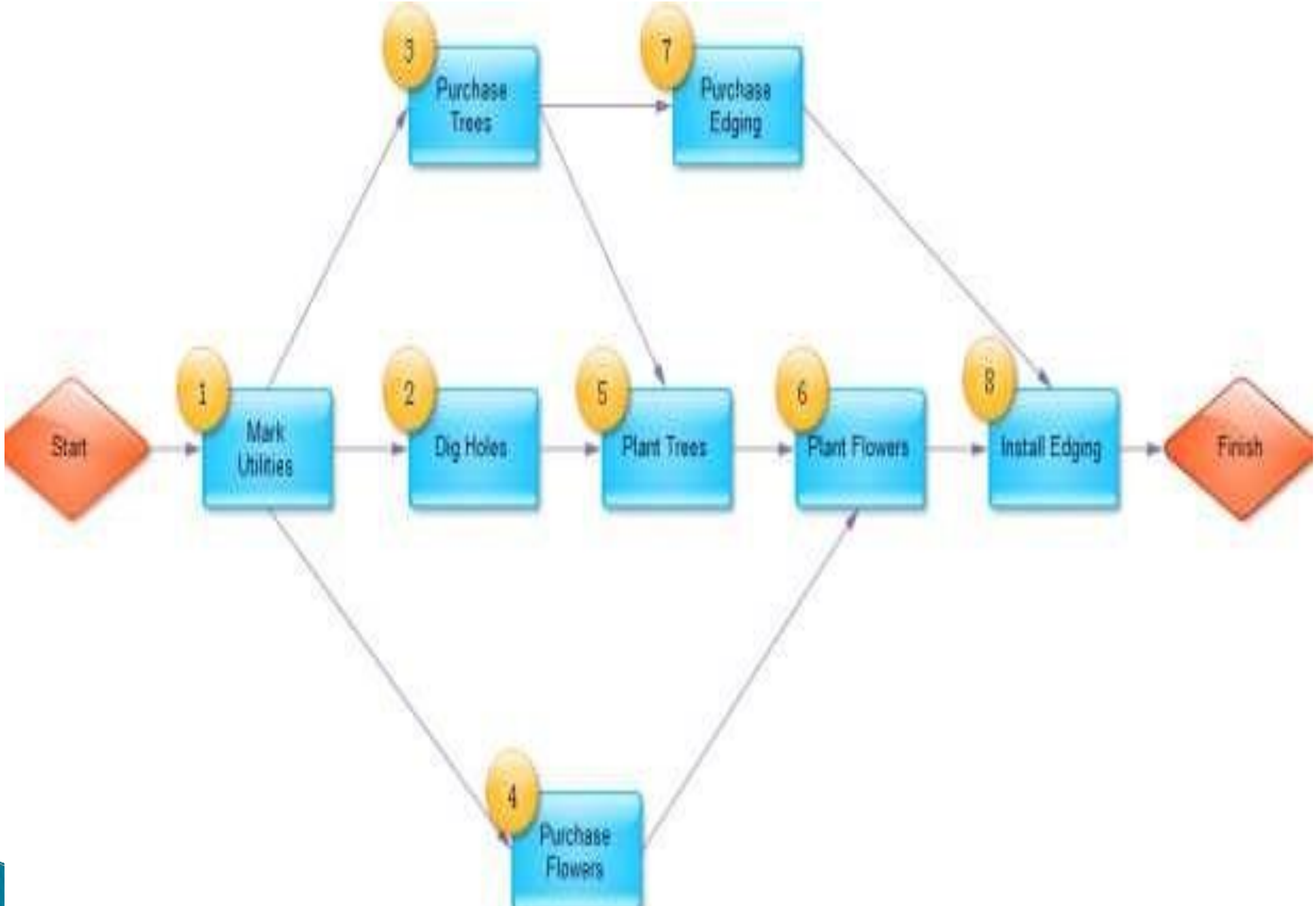
$$\mathbf{TH = (O + 4M – P) \div 6}$$

e.g. TH = (5min + 4X 10 min – 15 min) ÷ 6

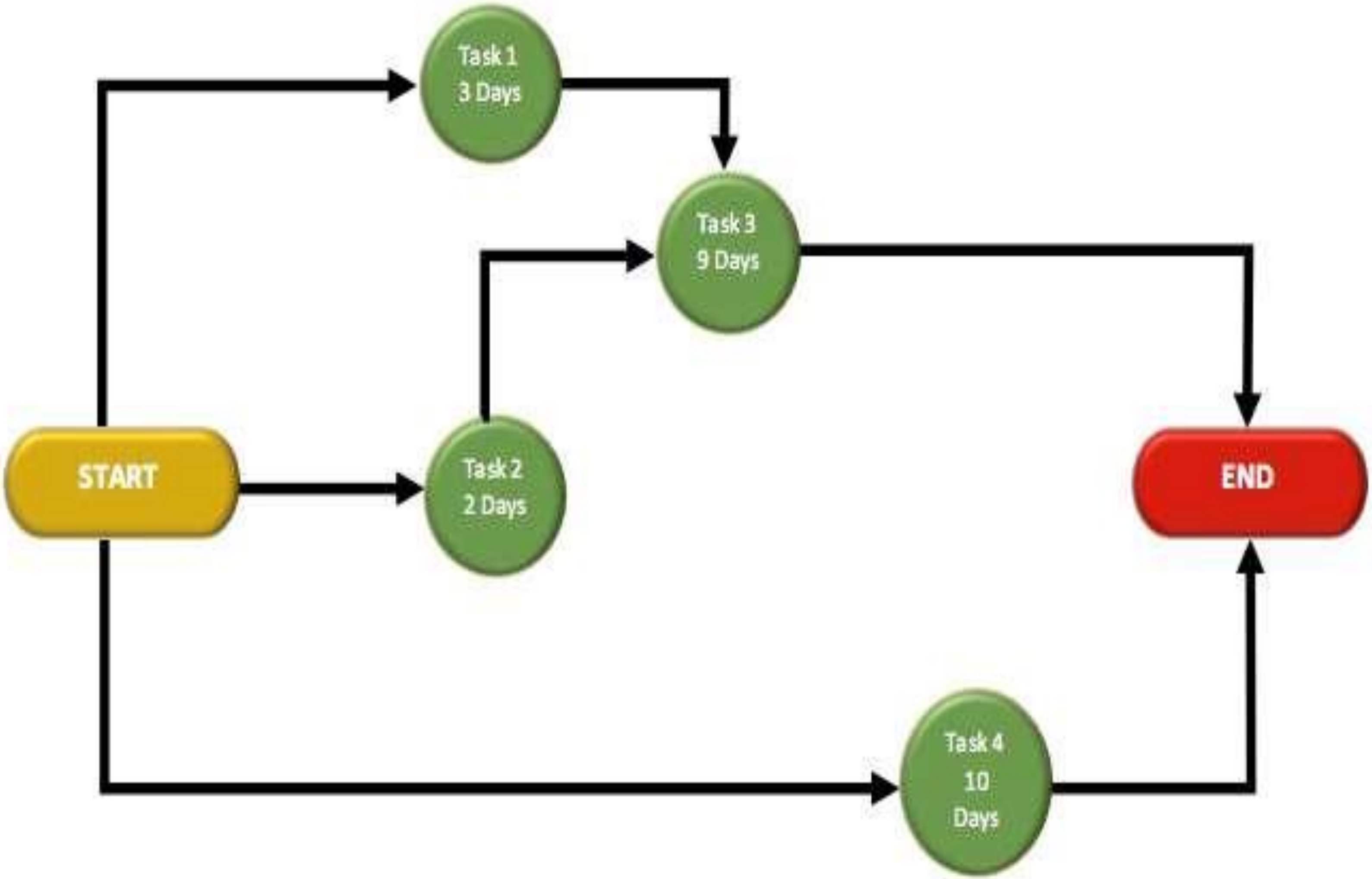
= 5 min

PERT CHART

- A PERT chart is a graphical representation of the activities of a project, showing the sequence that has to be performed continuously.
- It has the critical path of tasks that has to be finished in time.
- This chart helps to focus only the needed activity and omit the unwanted ones , therefore it saves time, energy and material.



Start
1
Mark Utilities
2
Dig Holes
3
Purchase Trees
4
Purchase Flowers
5
Plant Trees
6
Plant Flowers
7
Purchase Edging
8
Install Edging
Finish


Task 1
3 Days
Task 3
9 Days
START
Task 2
2 Days
END
Task 4
10
Days

PURPOSES

- To schedule the project.
- To organize the project.
- To coordinate the tasks.
- To manage the time.
- To analyze the work.

STEPS IN THE PERT PLANNING PROCESS

PERT involves the following steps

- Specific activities and milestones.
- Sequence of the activities.
- Network diagram.
- Estimate the time.
- Critical path.
- Update the PERT chart.

IDENTIFY THE SPECIFIC ACTIVITIES AND MILESTONES

- Activities.
- Milestones.
- It is helpful to list the tasks in a table.

Determine the proper sequence of the activities

- May be combined with the activity identification step
  - Since the activity sequence is evident for some tasks.

- Other tasks may require more analysis
  - To determine the exact order in which they must be performed.

Construct a network diagram.

- Activity sequence information
  - A network diagram can be drawn showing the sequence of the serial and parallel activities.

- **Each activity represents:** A node in the network,

- **The arrows represent:** The relation between activities.

- Software packages simplify this task
  - By automatically converting tabular activity information into a network diagram.

Estimate the time required for each activity.

- Weeks are a commonly used unit of time for activity completion.

- A distinguishing feature of PERT.
  - Its ability to deal with uncertainty in activity completion time.

- **Optimistic time(O)**
  - The shortest time in which the activity can be completed.

- To specify optimistic time to be three standards deviations from the mean.

- **Most likely time(M)**
  - The completion time having the highest probability.

- **Pessimistic time (P)**
  - the maximum possible time required to accomplish a task, assuming everything goes wrong (but excluding major catastrophes).

- PERT assumes a beta probability distribution for the time estimates.

- **Estimated Time(T_E)**
  - The best estimate of the time required to accomplish a task, accounting for the fact that things don't always proceed as normal.

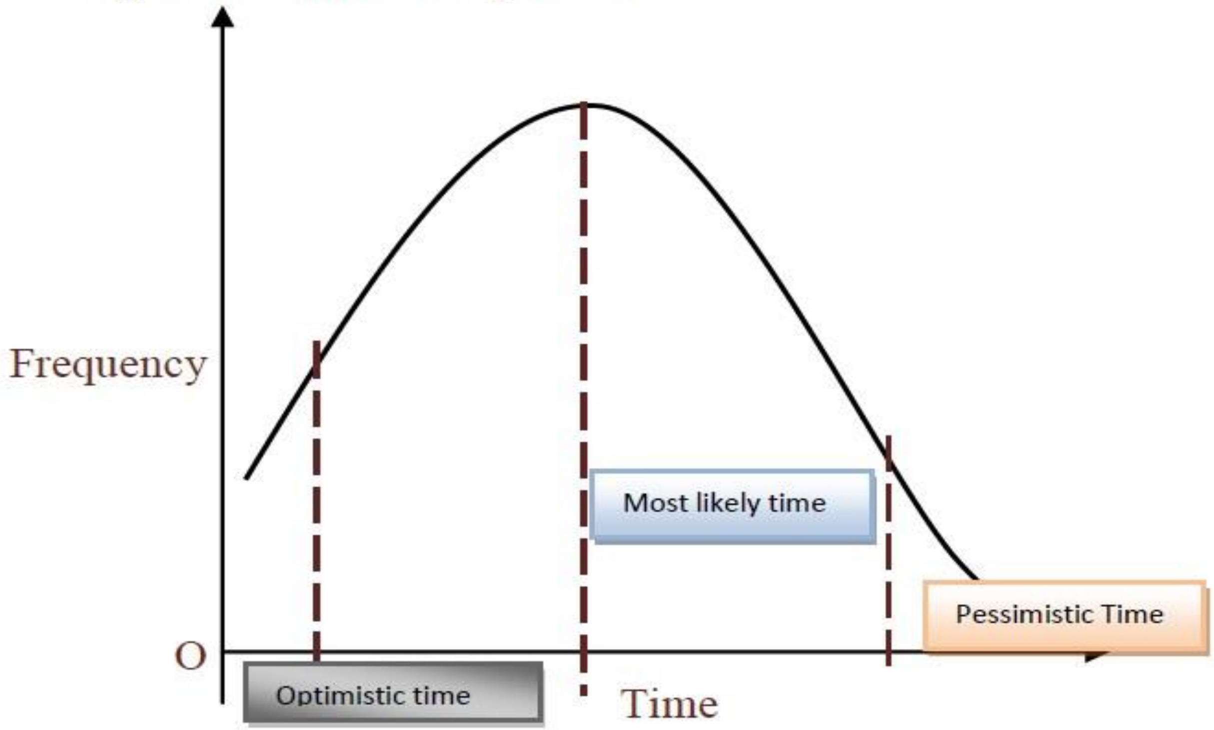
$$T_E = (O + 4M + P) \div 6$$

VARIANCE:

$$\sigma^2 = \left[\frac{(t_p - t_o)}{6}\right]^2$$

Where $t_o = the\ optimistic\ time$.
t_p = the pessimistic time.
$t_m = the\ most\ likely\ time$.

$\sigma^2 = the\ variance$
t_e =the expected time.



Problem-1: Find the expected time for each tasks from the given data:

TASK		A	B	C	D	E	F	G	H	I	J	K
LEAST TIME	t_o	4	5	8	2	4	6	8	5	3	5	6
GREATEST TIME	t_P	8	10	12	7	10	15	16	9	7	11	13
MOST LIKELY TIME	t_M	5	7	11	3	7	9	12	6	5	8	9

SOLUTION;

First we calculate the expected time 't_e 'by the formula "$t_e = (\frac{t_o+t_p+4t_m}{6})$ as follows

Task	Optimistic time(t_o)	Pessimistic time(t_p)	Most likely time (t_m)	Expected time (t_e)
A	4	8	5	$=\frac{(4+8+4(5)}{6} = 5.3$
B	5	10	7	$=\frac{(5+10+4(7)}{6} =7.2$
C	8	12	11	$=\frac{(8+12+4(11)}{6} =10.7$
D	2	7	3	$=\frac{(2+7+4(3)}{6} =3.5$
E	4	10	7	$=\frac{(4+10+4(7)}{6} =7$
F	6	15	9	$=\frac{(6+15+4(9)}{6} =9.5$
G	8	16	12	$=\frac{(8+16+4(12)}{6} =12$
H	5	9	6	$=\frac{(5+9+4(6)}{6} =6.3$
I	3	7	5	$=\frac{(3+7+4(5)}{6} =5$
J	5	11	8	$=\frac{(5+11+4(8)}{6} =8$
K	6	13	9	$=\frac{(6+13+4(9)}{6} =9.1$

Problem-2: Find the expected time and variance for each tasks from the given data:

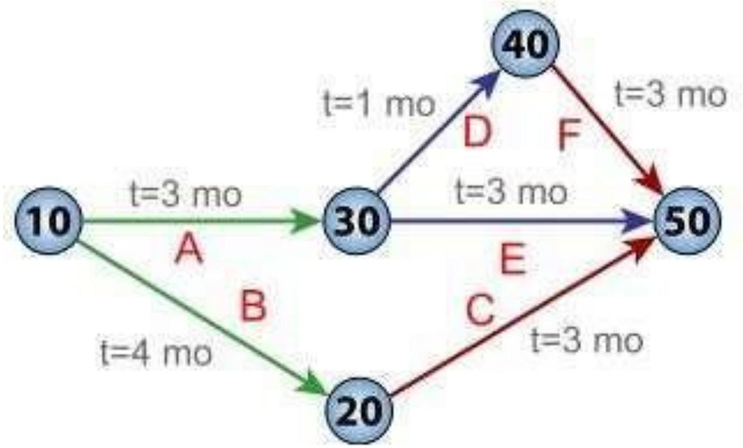
PROBLEM-2: A project has the following characteristics

ACTIVITY		**1-2**	**2-3**	**2-4**	**3-5**	**4-5**	**4-6**	**5-7**	**6-7**	**7-8**	**7-9**	**8-10**	9-10
MOST OPTEMESTI TIME(a)	t_o	1	1	1	3	2	3	4	6	2	5	1	3
MOAST PESSIMESTIC TIME(b)	t_p	5	3	5	5	4	7	6	8	6	8	3	7
MOST LIKELY TIME(m)	t_e	1.5	2	3	4	3	5	5	7	4	6	2	5

Determine the Critical Path

- The critical path is
  - Determined by adding the times for the activities in each sequence.
  - Determining the longest path in the project.

- The critical path determines the total calendar time required for the project.



- If activities outside the critical path speed up or slow down (within limits), the total project time does not change.

- The amount of time that a non – critical path activity can be delayed without the project is referred to as a slack time.

- Critical Path is helpful to determine
  - ES – Earliest Start time
  - EF - Earliest Finish time
  - LS – Latest Start time
  - LF - Latest Finish time

- The variance in the project completion time can be calculated by summing the variances in the completion times of the activities in the critical path.

- The project can be accelerated by adding the resources required to decrease the time for the activities in the critical path.

- Shortening of the project sometimes is referred to as **Project Crashing**.

Update the PERT chart as the project progresses.

- Make adjustments in the PERT chart as the project progresses.

- As the project unfolds, the estimated times can be replaced with actual times.

- In cases where
  - There are delays,
  - Additional resources may be needed to stay on schedule
  - The PERT chart may be modified to reflect the new situation.

BENEFITS OF PERT

- Expected project completion time.
- Probability of completion before a specified date.
- The critical path activities that directly impact the completion time.
- The activities that have slack time and that can lend resources to critical path activities.
- Activity start and end dates.

ADVANTAGES OF PERT (MODERN AND PHILLPS)

- It encourages logical discipline in planning, scheduling and control of project.

- It encourages more long range and detailed project planning.

- It provides a standard method of documenting and communicating project plans, schedules and time and cost – performance.

- It identifies the most critical elements in the plan, thus focusing management attention i.e. most constraining on the schedule.

- It illustrate the effects of technical procedural changes on overall schedules.

OTHER ADVANTAGES

- It explicitly defines and makes visible dependencies (precedence relationship) between the WBS elements.

- It facilitates identification of the critical path and makes this visible.

- It facilitates identification of early start, late start and slack for each activity.

- It provides for potentially reduced project duration due to better understanding of dependencies leading to improved overlapping of activities and tasking where feasible.

DISADVANTAGES

- There can be potentially hundreds or thousands of activities and individual dependency relationship.

- The network charts tend to be large and unwieldy requiring several pages to print and requiring special size paper.

- The lack of a timeframe on most PERT/CPM (Critical path method) charts makes it harder to show status although colors can help(e.g. specific color for completed nodes)

- When the PERT/CPM (Critical path method) charts become unwieldy, they are no longer used to manage the project.

LIMITATIONS

- The activity time estimates are somewhat subjective and depend on judgment. In other cases, if the person or group performing the activity estimates the time there may be bias in the estimate.

Gantt Chart

- A GANTT chart is a type of bar chart that illustrates a project schedule.

- After the PERT/CPM analysis is completed, the following phase is to construct the GANTT chart and then to re-allocate resources and re-schedule if necessary.

- GANTT charts have become a common technique for representing the phases and activities of a project work breakdown structure.
- It was introduced by Henry Gantt around 1910 – 1915.

USES OF GANNT CHART

- To show the current schedule status.
- To measure task duration in the project.
- To represent cost, time and scope of the project.
- A useful tool for planning and scheduling project.
- To plan how long a project should take.
- Lays out the order in which the tasks need to be carried out.

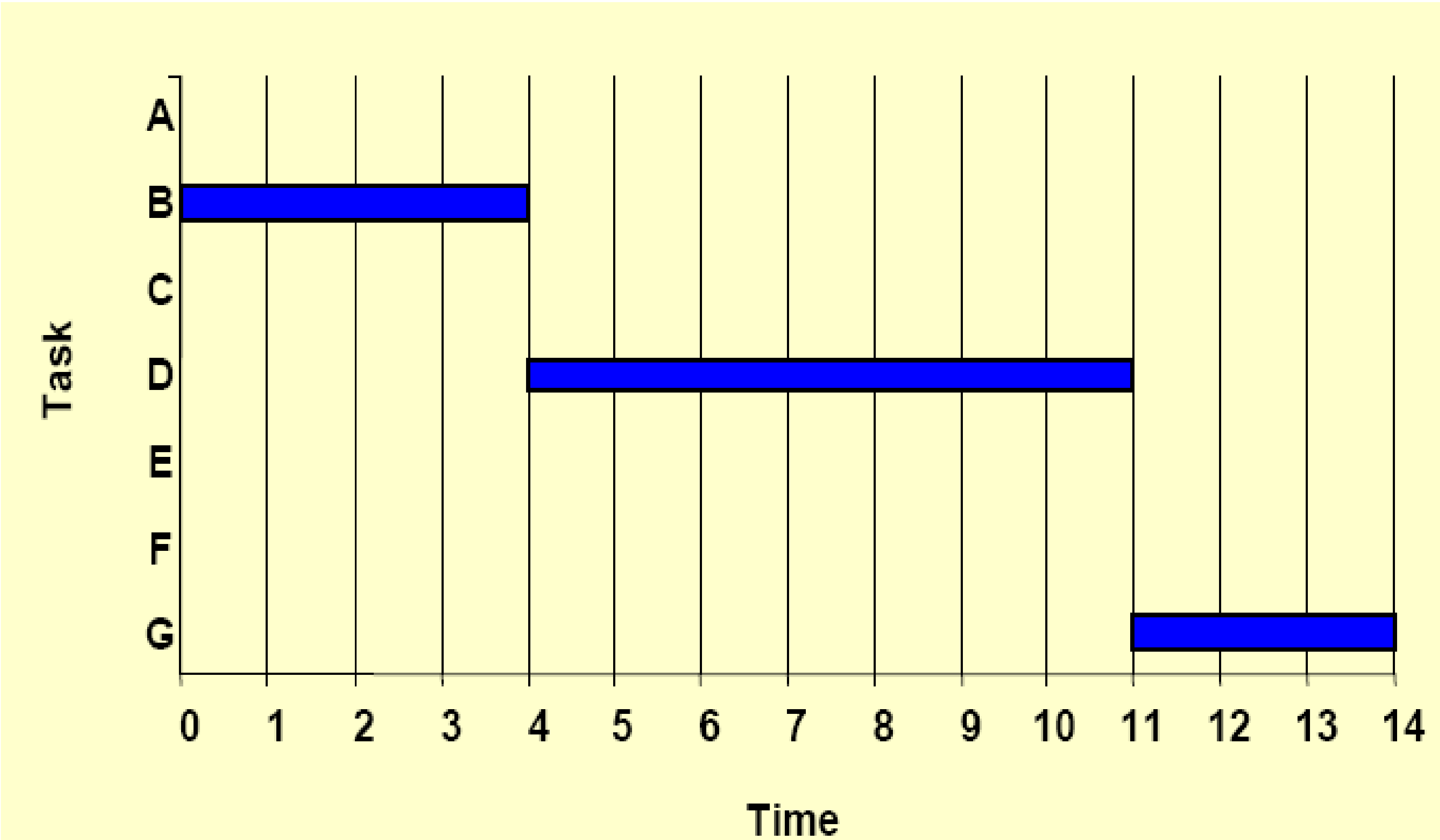
- Modern Gantt charts software provides dependencies between tasks.
- To monitor a project's progress.
- To visualize immediately what should have been achieved at any point in time.
- To assist in taking remedial action to bring the project back on course, if required.

CONSTRUCTION OF GANTT CHART

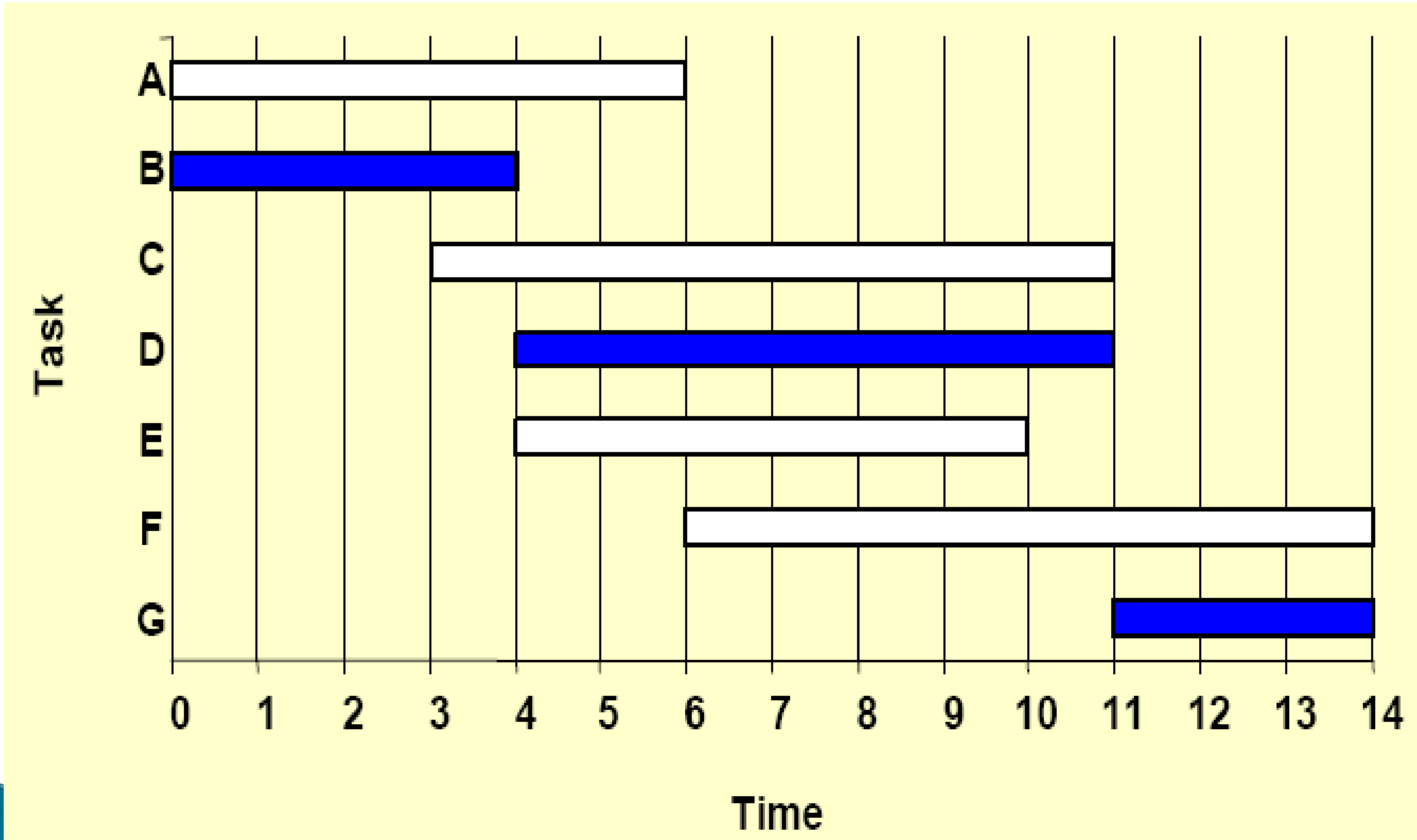
- The steps to construct a GANTT chart from the information obtained by PERT/CPM are:

1. Schedule the critical tasks in the correct position.
2. Place the time windows in which the non-critical tasks can be scheduled.
3. Schedule the non-critical tasks according to their earliest starting times.
4. Indicate precedence relationships between tasks.

Step 1. Schedule critical tasks:

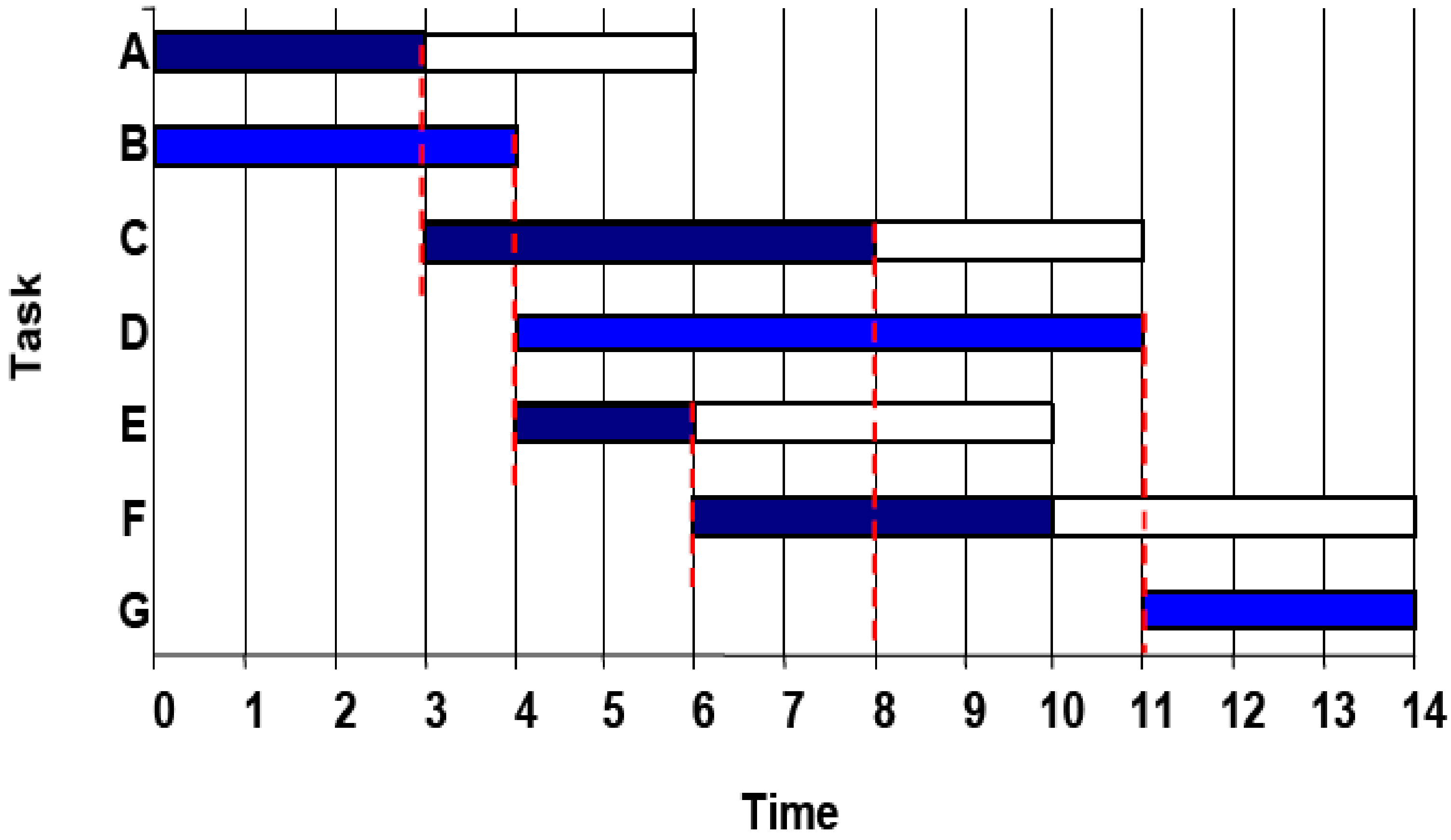


Step 2. Place time windows for non-critical tasks:



Step 3. Schedule non-critical tasks

Step 4. Indicate precedence relationships:



ADVANTAGES

- It helps in planning and monitoring the work of project.
- Time is explicitly expressed in the chart.
- All tasks are visible at a glance in relation to other.
- Deadlines are depicted in the chart.

LIMITATIONS

- Although project management software can show schedule dependencies as lines between activities, displaying a large number of dependencies may result in a cluttered or unreadable chart.

  Because the horizontal bars of a Gantt charts have a fixed height, they can misrepresent the time – phased workload (resource requirements) of a project, which may cause confusion especially in large projects.

Difference Between PERT & CPM

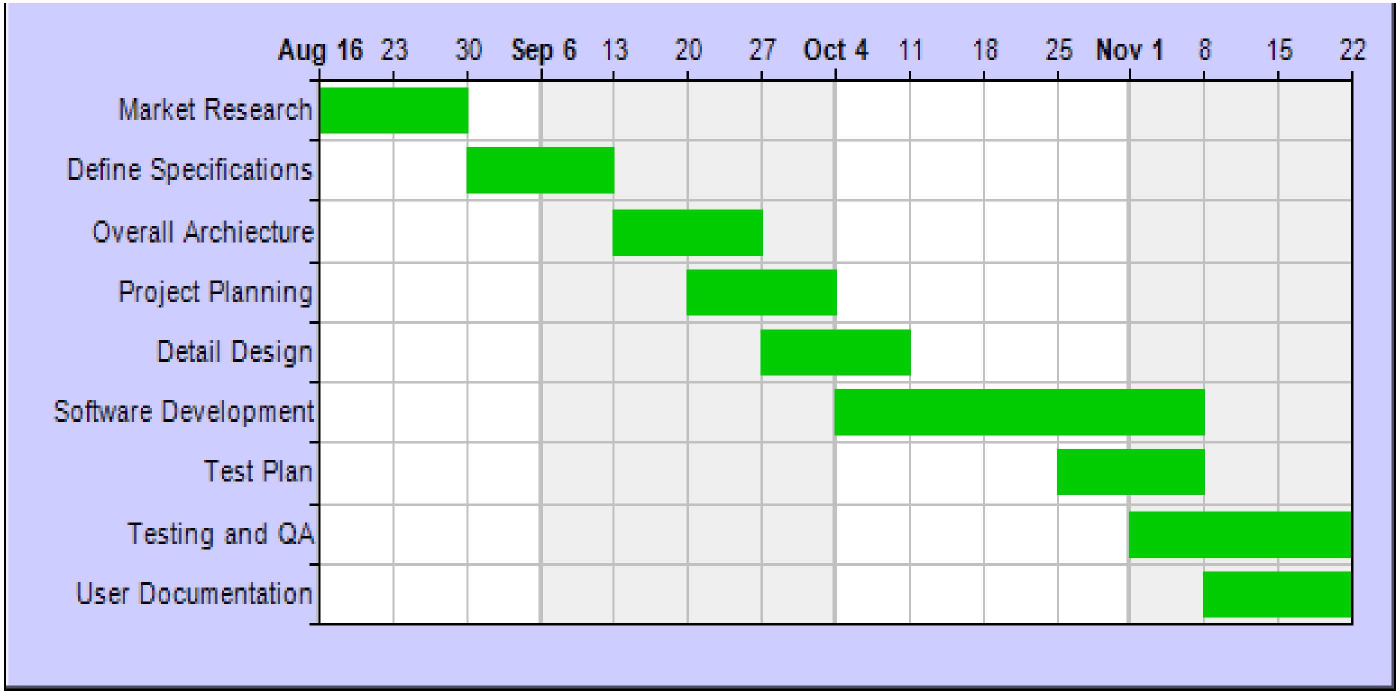
PERT	CPM
Probabilistic Model	Deterministic Model
Non-repetitive Jobs like planning & scheduling of programs	Repetitive Jobs like residential construction
Results calculated on basis of Events	Results calculated on basis of activities
Related with activities of uncertain time	Related with activities of Well Known time

CONCLUSION

PERT and Gantt chart is helpful in various project in different setting like project management, business management etc. these programs helps in reducing time from the actual time for a project, proper work, and analysis the work.

SUMMARY

- PERT
- Gantt Chart




Thank You

Project Plan Development

Project Plan Development

- Project Plan Development Approach
- Setting Up Tasks
- Planning the Transition from the Project Team to a Line Organization
- Project Documentation
- Project Plan Evaluation
- Some Guidelines

Project Plan Development Approach

- What is the purpose of the project?
  - Management
  - Technology
  - Business Process
  - Customers
  - Suppliers
- What is the scope of the project?
- What are the tangible benefits from completing the project? "If the project were not done or if it failed, what would be the impact?"

Project Plan Development Approach

- Step 1: Determine the project concept
- Step 2: Assess the project
- Step 3: Develop a strategy for the project
- Step 4: Identify major milestones and initial schedule
- Step 5: Define initial budget – using milestones.
- Step 6: Identify groups/organizations will be involved
- Step 7: Determine the methods/tools to be employed in the project
- Step 8: Identify the areas of risk and association them with milestones and tasks
- Step 9: Refine the schedule and budget
- Step 10: Identify project manager/leader
- Step 11: Identify and establish the project team
- Step 12: Develop the detailed project plan

Step 1: Determine the Project Concept

- Project Concept:
  - Purpose of the project
  - Scope of the project
  - Benefits of the project
  - General roles of the project – which organizations are going to do what
  - Basic issues that the project may face
- Evaluation of Specific Objectives & Scope
  - Do the objectives and scope fit with the organization?
  - Are the objectives too broad or too focused?
  - Are potential resources available?
  - What are the areas of risks?
  - Are the benefits reasonable given the purpose and scope?

Step 2: Assess the Project

- Perspectives:
    - Technology
    - Competition
    - Government Regulations
    - Politics
    - Cross-impacts examples
- First, determine which items can be employed in the project
- Second, determine where risks lie up front, before the project is started.
- Third, use the list to validate your objectives and scope.

Step 3: Develop a Strategy for the Project

- What should your strategy address?
  - How will you organize the project?
  - How will you select the project leader/team?
  - What will be the role of the team in project management?
  - How will you manage risk and address issues?
- First – define your approach for each of the above items (including alternatives)
- Second – refine your approach by considering political, organizational, and technological factors
- Third – evaluate each alternative

Step 4: Identify Major Milestones and Initial Schedule

- Milestones:
  - Draw up at least 10 to 20 milestones for each subprojects.
  - Logically relate the milestones between the subprojects in terms of dependences.
  - Take a piece of paper and lay it out sideways.

Step 5: Define Initial Budget

- List 4 or 5 key resources for each milestone
- Next, develop an initial budget by milestones for each subprojects (always develop your initial budget buttom-up).
- Estimate overhead and other resources as a group (including facilities, supplies, and equipments as well as personnel).

Step 6: Identify Groups/Organizations Will be Involved

- <u>Organization</u> <u>Role</u> <u>Impt. of Involvement</u>
- Create an table as above.

Step 7: Determine the Methods & Tools to be Employed in the Project

- First, determine the set of methods/tools for the actual work.
- Another set of methods and tools for the project management.

Step 8: Identify the Areas of Risk and Associate them with Milestones & Tasks

- Refine and label more detailed milestones which involve risks (smaller milestones).
- Use the list of issues that may impact the project as defined in the project concept.
- Identify any tasks (milestones) to which an issue pertains.

Step 9: Refine the Schedule and Budget

- Refine the estimates of budgets and schedule based upon the "risks" identified in the tasks.

Step 10: Identify Project Managers

- Identify several alternative project managers
- Need a backup plan for a project leader when leaves a project before completion.

Step 11: Identify and Establish the Project Team

- Identify and establish a few key people as the core of the project team.

Step 12: Develop Detailed Project Plan

- For each subproject enter the milestones and the resources that you identified.
- New define the tasks that lead up to each milestone (you now have a work breakdown structure with a list of tasks).
- Establish dependencies between tasks.
- Assign up 4 to 5 resources per task.
- Estimate the duration of each task and set the start date of the project.
- Assign the quantity of each resource for the tasks.
- Analyze the schedule and make changes by changing duration, dependencies, resources, and starting dates.

Setting Up Tasks

- Keep the task description simple – less than 30 characteristics
- If the task name is compound or complex, split the task.
- Start each task with an action verb.
- Use a field in the project database for responsibility for the task.
- Each detailed task should be from 2 to 10 days long.
- Use standard abbreviations wherever possible.
- Number all tasks in an outline form.
- Establish categories of resources (e.g., personnel, equipment, facilities, etc).

Setting Up Tasks …

- Try to avoid using the individual names of people (Put a job little abbreviated form instead).
- Keep resource names to less than 10 characteristics.
- Use a field in the software to indicate which tasks have substantial risk.
- Use task outlining and indenting.
- Group the task with appropriate milestones.
- Label milestones as such (e.g., M: Foundation completed).
- Use a field to put in the name of the person (or organization accountable for the tasks).

Planning the Transaction from the Project Team to a Line Organization

- Identify the organization that will be responsible for the results of the project.
- Work with the organization to determine several people who will be responsible for day-to-day operation.
- Plan a limited role for these individuals in the project before the transition to get them committed and involved in the project.

Project Documentation

- Depends on the size and complexity of the project
- Justify the time spent on documentation on the grounds of managing risks and for marketing.
- Recommended Items:
  - A project plan for the overall project.
  - Detailed project plans for each subproject
  - A list of initial known issues for the project
  - A description of interfaces between subprojects.
  - A description of the roles of organizations involved in the project.

Do you have a Winning Plan?

- Are the objectives and scope consistent?
- Is the scope reflected in the range of tasks?
- Is the strategy borne out in the tasks?
- Have you identified the areas of risks?
- Have you defined the key resources?
- Have you associated tasks that carry risk with the list of issues?
- If you were assigned the job of attacking the plan, what would you see as the major weakness?

Some Guidelines

- Build a plan with great detail on the near-term tasks but less detail for tasks that are further out in the future.
- Take a project and divide it into phases.
- Remain sensitive to the environment
- Understand what Not to do in a project
- Hold one person accountable for each detailed task
- Minimize documentation
- Analyze risks at the start of a project
- Use a chart to create a picture of the project

Status Check

- Does your firm follow an established sequence of steps in developing project plans?
- How are small projects handled differently from large projects in your company?
- If you were to develop a new project plan, what guideline, templates, and other support are offered in your organization?

Chapter 4: Project Planning & Scheduling

Introduction

- Planning & Scheduling are two terms that are often thought as synonymous - they are not!
- Scheduling is a part of planning effort.
- It is necessary to understand the nature of a project before planning could execute.

Introduction: Definition of a Project

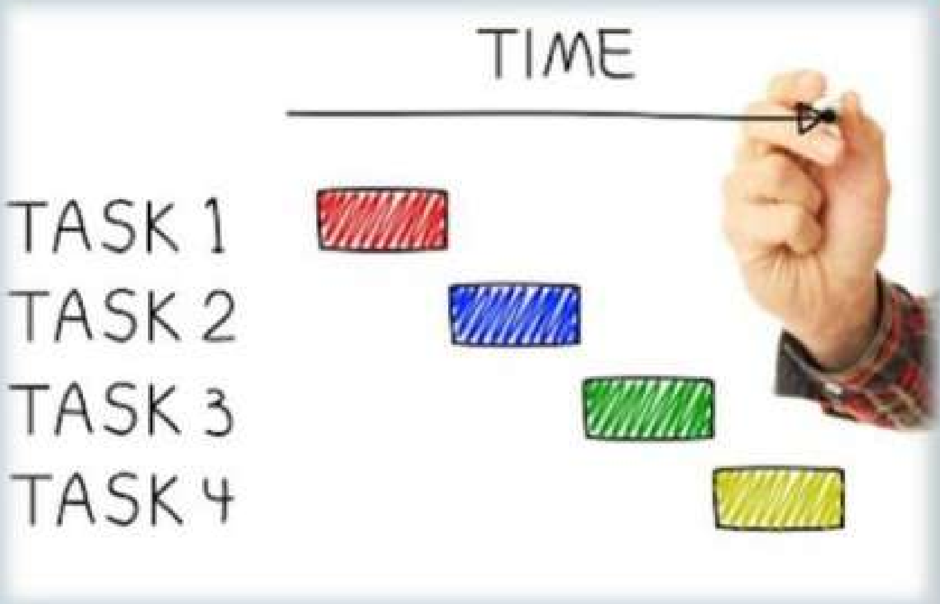
PROJECT

- The Project Management Institute (PMI, 2008) defines a project as " *a temporary endeavor undertake to create a unique product, service, or result*" p.434
- Any project must have a "*starting point*" and "*ending point*", must have a *deliverable product or service* that is *unique*.
- Project are unique. Two identical construction project might be similar but each of the project is unique and different in term of Location (soil type, weather condition, labor market, building codes, unforeseen condition, etc.), in management type and experience, and in circumstances.

Introduction: Project Planning

- Project Planning is the process of identifying all the activities necessary to successfully complete the project.
- Determining the workable work scheme to achieves project objectives.
- Identify activities involve.
- Time consuming effort and often difficult. Requires knowledge of construction methods combined with the abilities to visualize discrete work elements and to establish their mutual inter-dependencies.
- Experiences can also help.
- Effective planning – minimize the impact the unforeseen problem that could impede the progress of the project.
- Example of planning work: WBS

Introduction: Project Scheduling



- Project Scheduling is *the process of determining the sequential order of the planned activities, assigning realistic durations to each activity, and determining the start and finish date for each activity.*

Determination of the timing and sequence of operations in the project and their assembly to give the overall completion time.

Introduction: Project Scheduling

- Planning is pre-requirement to project scheduling (no way to determine the activities sequences and start/finish date of activities until they are identified).
- After the activities identify, then the sequence of start, finish and linkage between each activities can be determine.
- Project Scheduling help the managers in managing their project efficiently.
- Example of project scheduling: Gantt Chart, CPM and Network analysis

Concept of Planning and Scheduling

- Adequate attention must be given to both planning & scheduling.
- Project planning is the heart of good project management because it provides the central communications that coordinates the works of all parties.
- Desired Results of Project Planning & Scheduling are:
  I. Finish the project on time.
  II. Continuous (uninterrupted) flow of work (no delays)
  III. Reduced amount of rework (least amount of changes)
  IV. Minimized confusion on misunderstandings.
  V. Increase knowledge of status of project by everyone.
  VI. Meaningful and timely reports to management.
  VII. You run the project instead the project running you.
  VIII. Knowledge of scheduled times of key parts of the project.
  IX. Knowledge of the distributions of costs of the project
  X. Accountability of people, define responsibility/authority.
  XI. Clear understanding of who does what, when & how much.
  XII. Integration of all work to ensure a quality project for the owner.

Concept of Planning and Scheduling

- The Key Principles For Planning And Scheduling
  1. Begin planning before starting work, rather than after starting work.
  2. Involve people who will actually do the work in the planning and scheduling process.
  3. Includes all aspects of the project: scope, budget, schedule & quality.
  4. Build flexibility into the plan, include allowance for changes and time for reviews and approvals.
  5. Remember the schedule is the plan for doing the work, and it will never be precisely correct.
  6. Keep the plan simple, eliminate irrelevant details that prevent the plans from being readable.
  7. Communicating the plan to all parties; any plan is worthless unless it is known.

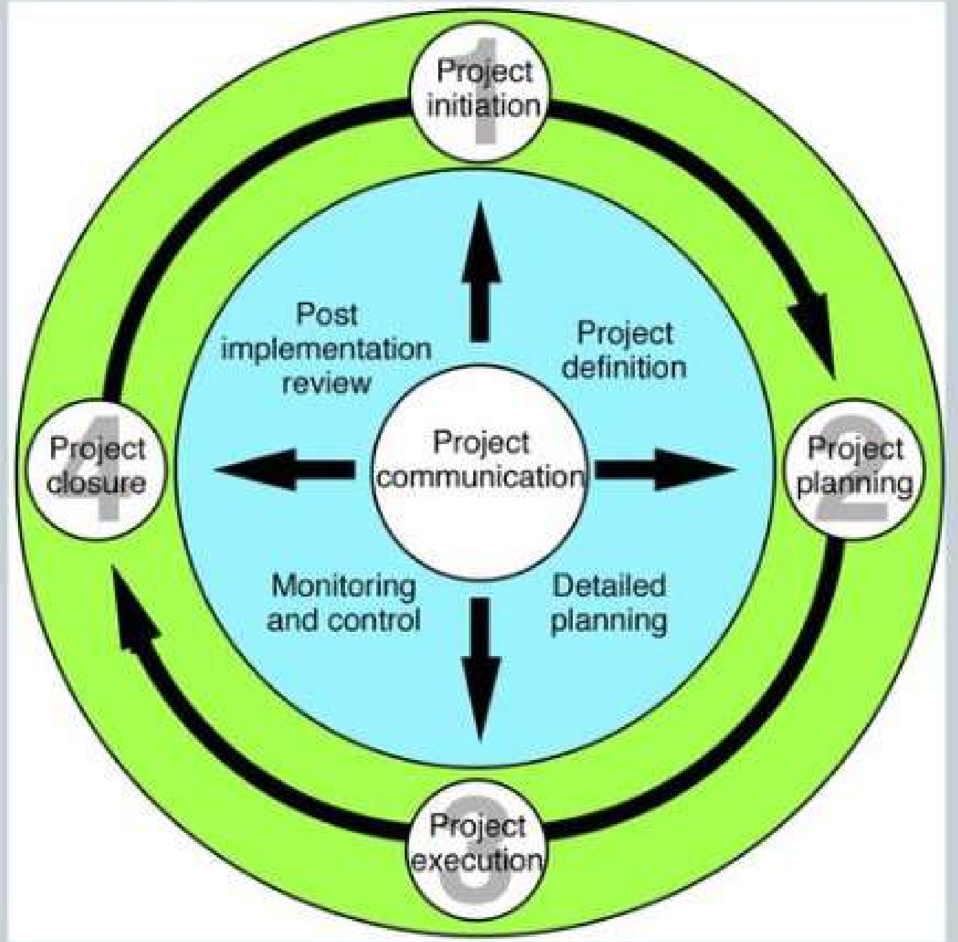
Concept of Planning and Scheduling

Techniques for Planning & Scheduling

- Varies depending upon:
  - project's size,
  - Level of complexity,
  - Duration of project,
  - Personnel involves and
  - owner requirements.
- Two (2) common methods commonly used:
  - Bar chart (Gantt Chart)
  - Critical Path Method (CPM or network analysis system)

Concept of Planning and Scheduling

- Project Life Cycle



Concept of Planning and Scheduling

- Monitor & Control

Project plan (BASELINE)

↓

Project implementation (ACTUAL)

↓

Measurement Of work performance (BASELINE-ACTUAL)

↓

Project control

↓

Project updating (REVISE PLANNING)

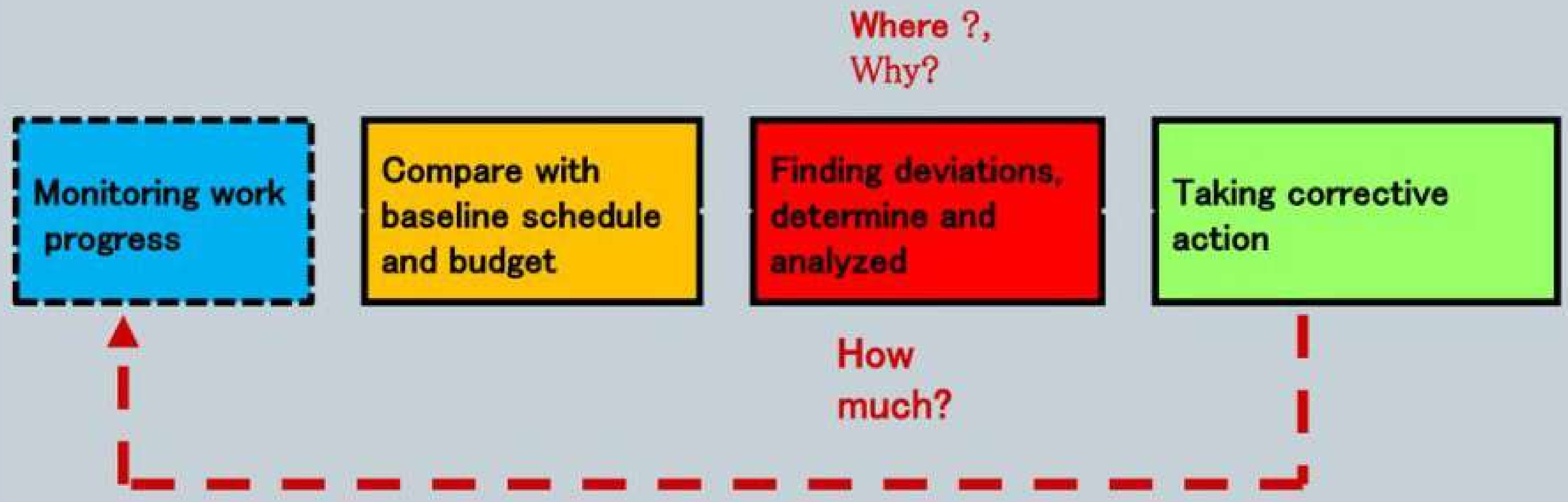
Concept of Planning and Scheduling

Monitor & Control

- Once a project starts, certain aspects can easily deviate or go astray.
- Deviation can be either:
  - Overspending
  - A schedule slippage
  - A departure from the objectives/scope
  - Etc.
- Positive deviation shows that actual performance is better than expected in the baseline file
- Negative deviation (behind schedule/over budget)- determine the reasons why?, and take corrective actions to get back on track; or at least minimize the deviations.

Concept of Planning and Scheduling

- Monitoring & Controlling Process



Work Breakdown Structure

- To achieve successful contract and corporate objectives, it needs proper planning to *identify responsibilities and element* in the construction project.
- The *FIRST STEP* in preparing planning is to develop The Work Breakdown Structures (WBS).
- WBS is a table or figure to show each steps in project.
- WBS display either in outline method or graphical method.

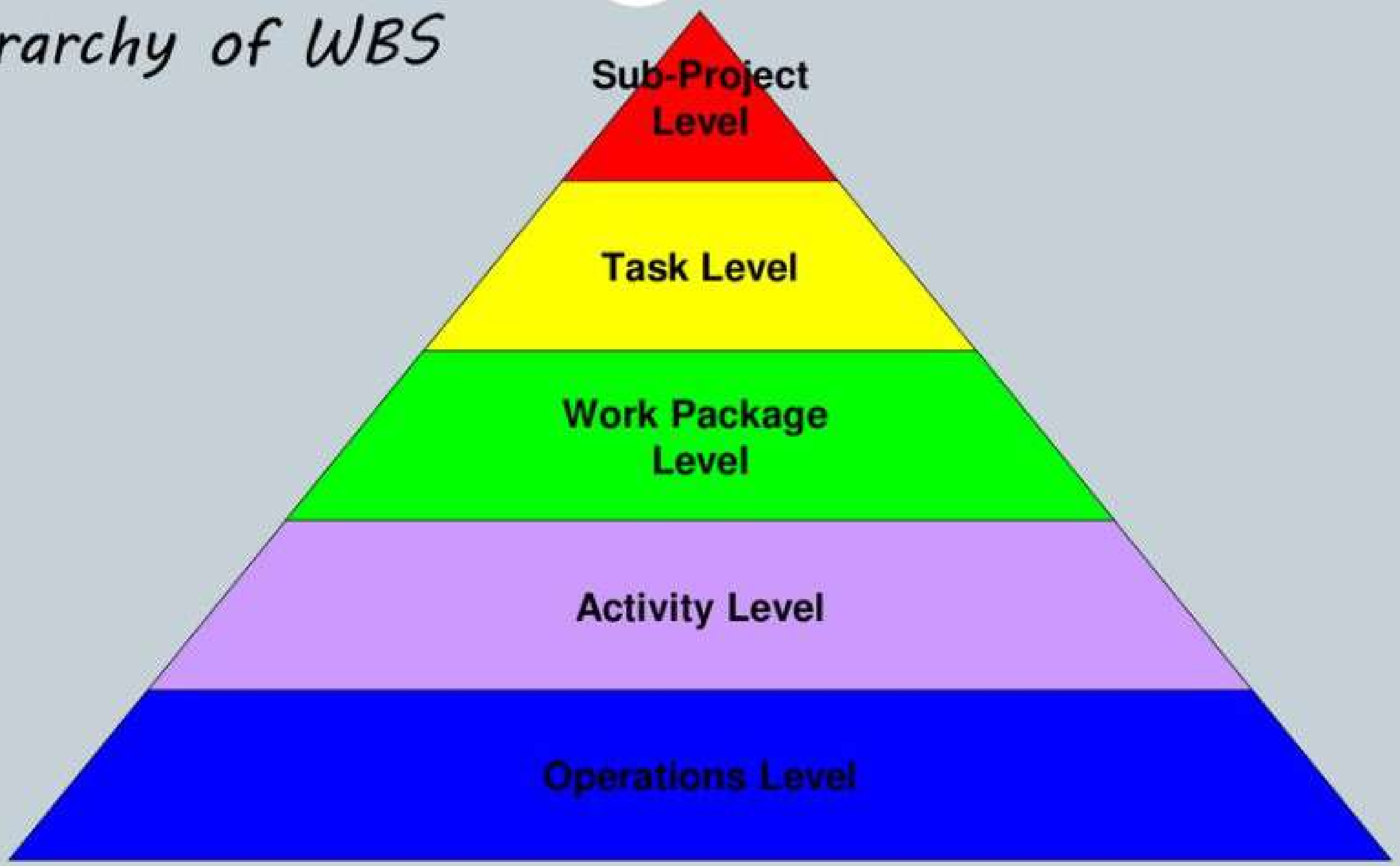
Work Breakdown Structure

- A WBS is a product-oriented family tree composed of hardware, services, and data which result from project engineering efforts during the development and production of a project which completely defines the project/program.

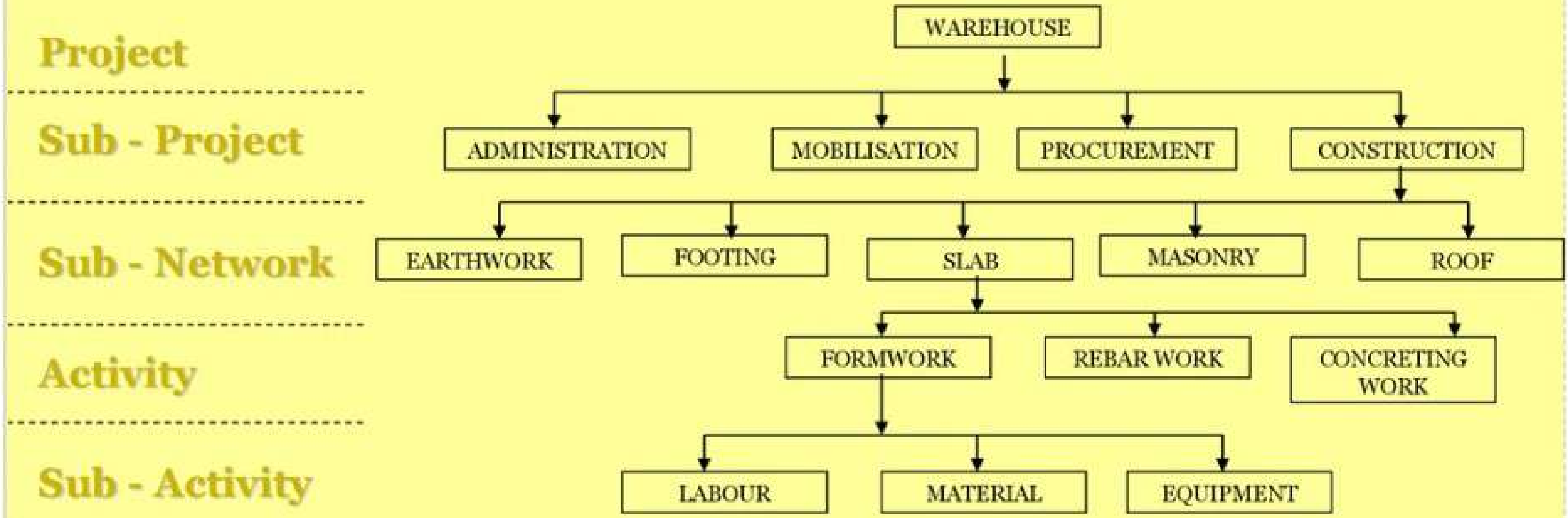
- The WBS *defines the scope of the project and breaks the work down into components* that can be scheduled and estimated, as well as easily monitored and controlled.

Work Breakdown Structure

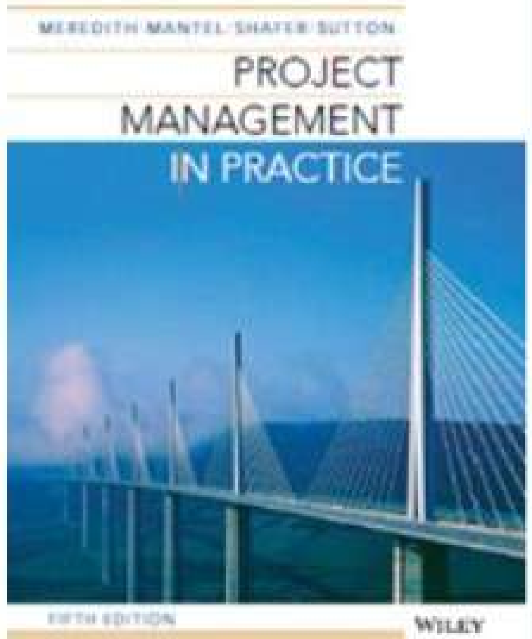
- Hierarchy of WBS



Work Breakdown Structure



Budgeting the Project



Introduction

- A budget must be developed in order to obtain the needed resources
- A budget is a plan for allocating organizational resources to the project activities
- A budget ties the project to the organization's aims and objectives through organizational policy
- A budget acts as a tool for upper management to monitor and guide the project

Methods of Budgeting

- Budgeting is forecasting what resources the project will require, what quantities of each will be needed, when they will be needed, and how much they will cost
- Most businesses employ experienced estimators who can forecast resource usage very well
- Budgeting a project is more difficult than budgeting more routine activities

Budgeting Problems

- Project are unique activities
- No history to aid estimators
- Projects may be multi-year with cost escalations
  - Changes in technology, materials, prices
- Organization tradition impacts project budgeting
  - How overhead and indirect costs are charged
  - Specific legal issues
  - Accounting idiosyncrasies
- Project managers see costs differently than accountants
  - Accounts treat costs linearly

Top-Down Budgeting

- Based on collective judgments and experiences of top and middle managers
- Overall project cost estimated by estimating the costs of major tasks
- Advantages
  - Accuracy of estimating overall budget
  - Errors in funding small tasks need not be individually identified
- Disadvantage
  - Allows budget to be controlled by people who play little role in designing and doing the work required by the project

Bottom-Up Budgeting

- Work breakdown structure (WBS) identifies elemental tasks
- Those responsible for executing these tasks estimate resource requirements
- Advantage
  - More accurate in the detailed tasks
- Disadvantage
  - Risk of overlooking tasks

Improving Estimates and Forecasts

- Forms
- Learning curves
- Tracking signals

Forms

- A form for project resource needs might include:
  - People – managers, technical and non-technical
  - Money
  - Materials – facilities, equipment, tools, space
  - Special services
- And might identify:
  - Person to contact
  - When needed
  - How many/much needed
  - Whether available

Form for Gathering Data on Project Resource Needs

Project name____________________
Date____________________
Task number____________________

RESOURCES NEEDED

Resources	Person to Contact	How Many/ Much Needed	When Needed	Check (✓) If Available
People: Managers, Supervisors				
Professional & Technical				
Nontechnical				
Money				
Materials: Facilities				
Equipment				
Tools				
Power				
Space				
Special Services: Research & Test				
Typing/clerical				
Reproduction				
Others				

Figure 4-2

Learning Curves

- Humans learn when they repeat a task
- It has been found that unit performance improves by a fixed percent each time total production doubles
- Each time the output doubles, the worker hours per unit decrease by a fixed percentage of their previous value
  - This percentage is called the learning rate

Learning Curves

$$T_n = T_1 n^r$$

where

T_n = the time required to complete the n^{th} unit

T_1 = the time required to complete the first unit

r = log(learning rate)/log(2)

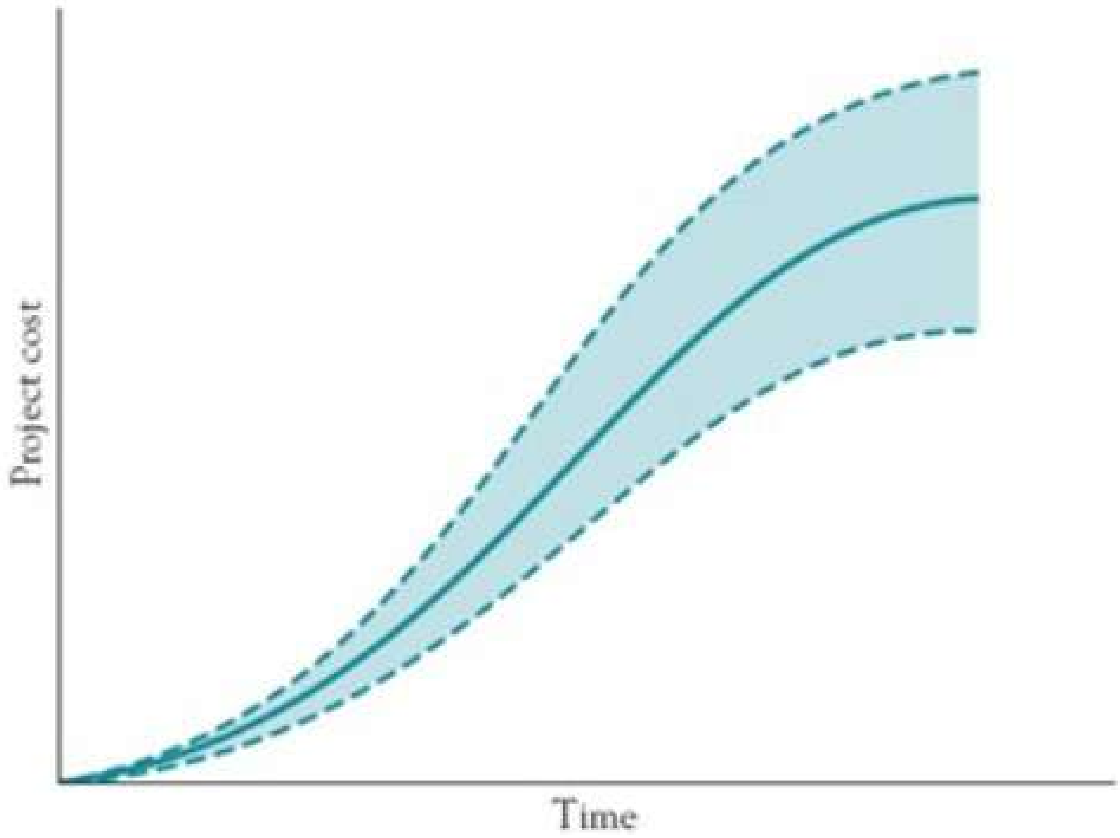
Tracking Signals

- Random error: there is a roughly equal chance that estimates are above or below the true value
  - Random errors cancel out
- Bias: if the over/under chances are not equal or the over/under errors are not the same size
- A tracking signal number can reveal if there is a systematic bias in cost and other estimates
  - And whether the bias is positive or negative
- By observing their own errors a project manager can learn to make unbiased estimates

Budget Uncertainty

- Prices may escalate
- Different resources may be required
- Project may take more or less time
  - Impacts indirect costs

Estimate of Project Costs with Uncertainty Shown



Fund Flow and Cash Flow Statement

4

Funds Flow Statement

- Based on a fundamental equation:
  - *Sources of Funds – Application of Funds = Change in Working Capital*

- *Funds Flow Statement*
  - Describes the sources from which funds were received and also the uses to which these funds were applied
  - Traces the flow of funds through the organization

Fund Flow Statement

- The statement of funds flow is usually divided into the two logical divisions
  - Sources of funds or inflows – net effect of increasing the working capital
  - Uses of funds or applications of funds – net effect of decreasing the working capital
- Gives a summary of the impacts of managerial decisions on the position of the business
- Reflects the policies of financing, investment, acquisition and retirement of fixed assets, distribution of profits and the success of operations

Factors affecting Fund Requirements

- Fund requirements vary with the *nature and type of business*
- Sales Volume growth
  - More inventories and receivables due to extended credits
- Impact of Seasonality
  - Fund requirements are restricted to a limited period
  - Providing funds on a permanent basis may lead to idle funds during most part of the year

- The contract, and contract types, overview of the construction documents.

Contract Definition

- Agreement of at least two parties with purpose of creating legal obligation between the parties and capable of being enforced by the court of law.
- Contract = offer + acceptance + consideration

Introduction tocontracts

Why Use contract in construction:

- Describe scope of work
- Establish time frame
- Establish cost and payment provision
- Set fourth obligations and relationship
- Minimize disputes
- Improve economic return of investment

Content of the contract

- Identify the parties
- Promises and responsibilities
- Scope of work
- Price and payment terms
- Commercial terms and conditions
- Project execution plan.

Major Contract Types (traditional)

Construction Contract Forms

1. Competitive Bidding	2. Negotiated Cost-Plus	3. Combination
Two Main Types: - Lump Sum (Buildings) - Unit Price (Heavy)	**Many Types:** - Cost + % of Cost - Cost + Fixed Fee - Cost + Fee + Profit Sharing - Cost + Sliding Fee - Cost + GMP Complex projects, tunnels, power plants, process plants	**New Innovative Types:** - Use a combination of contract types in a single project - Teamwork
- High risk to contractor - Low risk to owner	Risk sharing	CM administered

Lump Sum Contract

- One price for the whole contract
- Lump sum includes costs plus overheads and profits
- Higher risk to contractor
- Price quoted is a guaranteed price as per contract documents.
- Payment based on a scheduled percentage scheme (monthly progress claims)
- The contractor is free to use means and methods to complete the work and responsible for proper performance
- Work must be well defined at bid time.
- Fully developed plans and specifications

Lump Sum Contract/ advantage

- Low risk on the owner, Higher risk to the contractor
- Cost known at outset
- Contractor will assign best personnel
- Contractor selection is easy.

Lump Sum Contract/disadvantage

- Changes is difficult and costly.
- Contractor is free to use the lowest cost of material equipment, methods.

Unit Price

- Quote Rates / Prices by units
- No total final price
- Re-negotiate for rates if the quantity or work considerably exceeds the initial target
- Payment to contractor is based on the measure.
- Unbalanced bids
- Higher risk to owner
- Ideal for work where quantities can not be accurately established before construction starts.

Unit Price contract

- Require sufficient design definition to estimate quantities of units
- Contractors bid based on units of works
- Time & cost risk (shared)
  - Owner : at risk for total quantities
  - Contractor : at risk for fixed unit price.

- Large quantities changes (>15-25%) can lead to increase or decrease of unit price.

Unit Price / Requirement

- Adequate breakdown and definition of work units
- Good quantity surveying and reporting system.
- Adequate drawings.
- Experience in developing BOQ
- Payment based on the measurement of the finished works.
- Quantity sensitive analysis of unit prices to evaluate total bid price for potential quantity variation.

Unit Price /advantages

- Suitable for competitive bid
- Easy for contract selection
- Early start is possible
- Flexibility : quantities and scope can be easily adjusted

Unit Price /disadvantages

- Final cost not known from the beginning (BOQ only is estimated)
- Staff needed to measure the finished quantities and report on the units not completed.
- Unit price sometime tend to draw unbalanced bid.
  (*For Unit-Price Contracts, a balanced bid is one in which each bid is priced to carry its share of the cost of the work and also its share of the contractor's profit.*
  Contractors raise prices on certain items and make corresponding reductions of the prices on other items ,without changing the total amount of the bid)

Cost Plus

1. Actual cost plus a negotiated reimbursement to cover overheads and profit.
2. different methods of reimbursement :
    - Cost + percentage
    - Cost + fixed fee
    - Cost + fixed fee + profit-sharing clause.
3. Higher risk to owner
4. Compromise : guaranteed maximum price (GMP) reduces risk to owner while maintain advantage of cost plus contract.
5. By using this type of contract the contractor can start work without a clearly defined project scope, since all costs will be reimbursed and a profit guaranteed.

Cost + Percent of Cost

- Fee = percentage of the total project cost
  - (Cost = $500.000,Fee = 2%)

Advantages	Disadvantages
profitable for the contractor	No incentive to finish job quickly
	Owner does not know total price
	Larger the cost of the job, the higher the fee the owner pays

CONSTRUCTION DOCUMENTS

- Contract documents (graphic and written) describe the proposed construction (the 'Work') that results from performing services, furnishing labor, and supplying and incorporating materials and equipment into the construction

  A. Contract Forms

  B. Conditions of the Contract

  C. Specifications & BOQ

  D. Drawings

  E. Addenda

  F. Change Orders

A. CONTRACT FORMS

- CONTRACT FORMS
  - Agreement
  - Performance Bond
  - Payment Bond
  - Certificates

B.CONDITIONS OF CONTRACT

- CONDITIONS OF CONTRACT
- Define basic rights, responsibilities, and relationships of the parties involved in the construction project.
- 2 types: General Conditions and Supplementary Conditions
- GENERAL CONDITIONS
  - General clauses that establish how the project is to be administered.
  - Contain basic expressions of rights, duties, and limitations of the entities involved.
  - Usually in the form of published standard documents that include principles common to most construction Contracts.
  - SUPPLEMENTARY CONDITIONS
  - Modify or supplement general conditions as need to provide for requirements specific to a project. They are not standardized documents and are prepared for specific project needs.

A.1 Agreement

- The written document signed by the owner and the contractor that is the legal instrument binding the parties to the contract.
- Defines the relationship and obligations between owner and contractor.
- The agreement is quite brief and appears to consist mostly of statements of fact, whereas the general conditions section deals primarily with matters that pertain generally to be construction work and the persons involved.
- In other words, the agreement appears to consist of statements and the general conditions appear to be terms, or conditions.

Agreement (cont'd)

- The agreement should contain:
- The names of contracting parties
- A brief description of the work
- A list of contract documents, including agreement, general conditions, drawings, and specifications.
- The contract sum, or amount (lump-sum contract)
- The procedures for payment
- The contract time, or dates for start and completion
- The signatures of contracting parties and witnesses
- International construction documents are also often based on industry-prepared standard forms.

MEASUREMENT BOOK

An "**MEASUREMENT BOOK**" is a record in which measures are recorded for the work performed by the contractor for goods or services provided on the site.

So it is said to be important accounting records to maintain with accuracy and its important evidence in the court of law

DETAILS SHOULD BE MENTIONED IN M-BOOK SHEET

1. Date
2. Work Order No
3. Details reference number/boq number
4. location
5. Particulars

M-BOOK SHEET SAMPLE FOR REFERNCE

			MEASUREMENT BOOK						
CUSTOMER		Work Order No	Date:						
			Particulars						
		Job No.							
S. No	Details ref	Description of Work	Uom	Nos	Length	Breadth	Height	Qty	Total Qty

The **M-BOOK** used to record in two different sections below:

1. **Final Measurement** – Its complete measurement which should take after completion of the Project
2. **Progressive Measurement** – this type of measurement taken in different stages of project for daily wages or advance Payment

HOW TO PREPARE M-BOOK SHEET FOR MEASUREMENT?

a) First, write down the measurement date was taken.

b) BOQ no or details ref no is to understand what measurement it is and where it is taken.

c) The serial number of the new measurements is mentioned with the BOQ item number as shown in the table above. Because it tells us the new record of the same item is taken from, so the serial number of the BOQ item is useful for quick verification.

d) And before writing the measurement we should mention the unit of measurement (UOM) for your item measurement example

1) **M^3 or Cu.m**. for volumetric measurements used for excavation, concrete, etc.

2) **M^2 or Sq.m**. or M2 for area measurements for painting work & plastering etc.

3) **Running Meter or Rm** for length measurement for standard or fixed-width items like pipeline etc.

4) **No.s** for number of items used for taps & switch etc.

e) And finally, note the measurement of each item in BOQ. With least dimensions & measurement for **length 0.01 m**, for **area 0.01 m^2**, for **volume 0.01 m^3** in & for **weight 0.001 tons**

What is Muster Roll?

A muster roll is essentially a list wherein all the workers or employees of a unit are listed. A muster roll register is a register that contains the names of all the employees or workers working in a particular unit, and it is basically a roster that is used as an attendance register. It is used to keep track of all the workers who have attended work on a particular day.

Origin of the Muster Roll

Originally, a muster roll register was created for military and navy purposes. To keep track of the seamen onboard a ship, the shipmaster was required to keep a muster roll of all the officers and other workers. An official act regarding the same was passed in 1774, and it came to be known as the Act for the Relief of Disabled Seamen. These were passed on to "receivers" when a voyage ended, and the ship reached the coast. It was also used by the military for the same purpose.

What is a Muster roll Register?

A muster roll register is where the detailed list of all officers/workers/crewmembers is kept. In this register, the names and basic details of all of the workers are mentioned. Earlier on, just the names of the members were detailed in this register. Today, it is useful in maintaining a record of payments, especially for laborers who receive daily wages. As such, it is mostly used by Factories and factory workers. It is also used to keep an accurate record of progress made by employees as well as is used as employee acknowledgment upon receiving payments.

Running Account Bills (R.A. Bills)

Billing is one of the necessary documentary activities that should be sincerely administered by engineers. All measurements to be recorded on measurement sheets with needed self- instructive sketches & notes.

Billing includes a payment to be done as per the stage of work. Previous work done & advances paid up to this point unit to be kept in mind while calculating the final payable figure. Rates & mode of measurements are to be as per agreement. Also, check all necessary details are written & bills are punctually signed.

Generally, the subsequent forms of bills are made at various stages of work throughout building construction which includes,

- Advance bills
- **R.A bills**
- Cash bills
- Final bills

R.A. BILL FORMAT

Name of Company:

R.A. Bill No: _______ Name of Site:___________ Name of Contractor:____________

Date: ______ Duration: ______ Work: ______ Building:_______

Sr. No	Item	Previous Qty	Current Qty	Total Qty	Rate	Unit	Amount
	TOTAL AMOUNT BILL						
	LESS RETENTION AMOUNT						
	BALANCE AMOUNT (1-2)						
	LESS TOTAL PAYMENT UPTO PREVIOUS R.A. BILL						
	TOTAL BALANCE PAYMENTS						
	LESS DEDUCTION						
	NET PAYABLE AMOUNT						
PREPARED BY		CHECKED BY		PROJECT MANAGER			

Documents required for R.A BILL:

- Agreement of Contracts like Item rate/built-up area/space basis.
- Quality report of construction material
- Copy of material testing certificate
- Name of an existing site, Name of the contractor, R.A bill number
- Payment challans, abstract, and measurement sheets.
- Samples and company name of the material used
- Contractor’s sign and Project Engineer’s sign on the bills

Record to be maintained at the site:

- Copies of all documents related to an agreement with contractor/work
- The contractor's file and payment status to be maintained updated
- Quantity of work done as per drawing whereas as actual site execution report

Conclusion:

R.A bills are usually used by contractors to raise the invoice to the client for getting the amount. They facilitate the price for the work done, Labor, and Machines on construction sites.

Traditionally, contractors used to perform quantity takeoff by hand using printed plans, rulers, calculators, and pencils. Fortunately for modern contractors, company have created sq.feet named takeoff software to simplify and improve the process of Billing.

RESOURCE MANAGEMENT IN CONSTRUCTION PROJECTS

Introduction:

In general, construction projects are of high value, and they employ huge resources of men, materials and machines. Major works involve heavy investments- say from a hundreds of crores of rupees to a few thousands of rupees, the use of high level technology and need an open ended model for effective management of resources.

Requirements of resources were attributed to the activities based on Standard Schedule Rates (CPWD). The requisite data has been collected from the detailed drawings and prevailing site conditions. In the second phase, a Resource Constrained Analysis was carried out by Resource Leveling for various activities by decreasing resources with increased duration to study the time-cost implications.

Due to the resource-driven nature of construction management, Resource Management is really a difficult task. The construction manager must develop a plan of action for directing and controlling resources of workers, machines and materials in coordinated and timely manner in order to deliver a project within the frame of limited funding and time. Hence, aside from a technology and process focus, a resource-use focus must be adequately addressed in describing a construction method or operation in a project plan.

. Resource Management

A resource is an entity that contributes to the accomplishment of project activities such as manpower, material, money, equipment, time or space.

a) Importance of Resources in Construction Projects:

The crucial factor in successful implementation of a construction project not only depends on the quality & quantity of work, but also largely depends on availability of resources. All activities involved in the project require certain amount of resources. Each activity is allocated with a specific resource and must be completed within the time limit, otherwise it may adversely affect the overall duration of the project. The time and cost are directly dependent on the availability of resources. The time required may be determined by dividing the productivity associated with the resources used on the activity into the defined quantity of work for the activity. The best combination of resources to use for performing a construction activity is based on contractor's ability to identify the interdependencies of the various resources.

b) Methodology Adopted

There are two phases in the methodology to manage resources.

i) In the first phase, all the information and data needed to estimate resources were collected. The construction project schedule using the estimated resources was prepared in the form of Gantt chart and resources required for each activity are tabulated. The peak units required for a project day by day are shown in Resource histograms.

ii) In second phase, the actual resources available for the project were analyzed by Resource leveling with increased duration. The time-cost implications have been analyzed to alert the management.

Resource Levelling
vs
Resource Smoothing

Resource Levelling vs Resource Smoothing

What is it?

Resource optimization is used to **adjust the start and finish dates** of activities to adjust planned resource use to be equal to or less than resource availability.

Resource Levelling and Resource Smoothing are two techniques used, where Levelling focuses on moving the resources, and smoothing focuses on moving the activities.

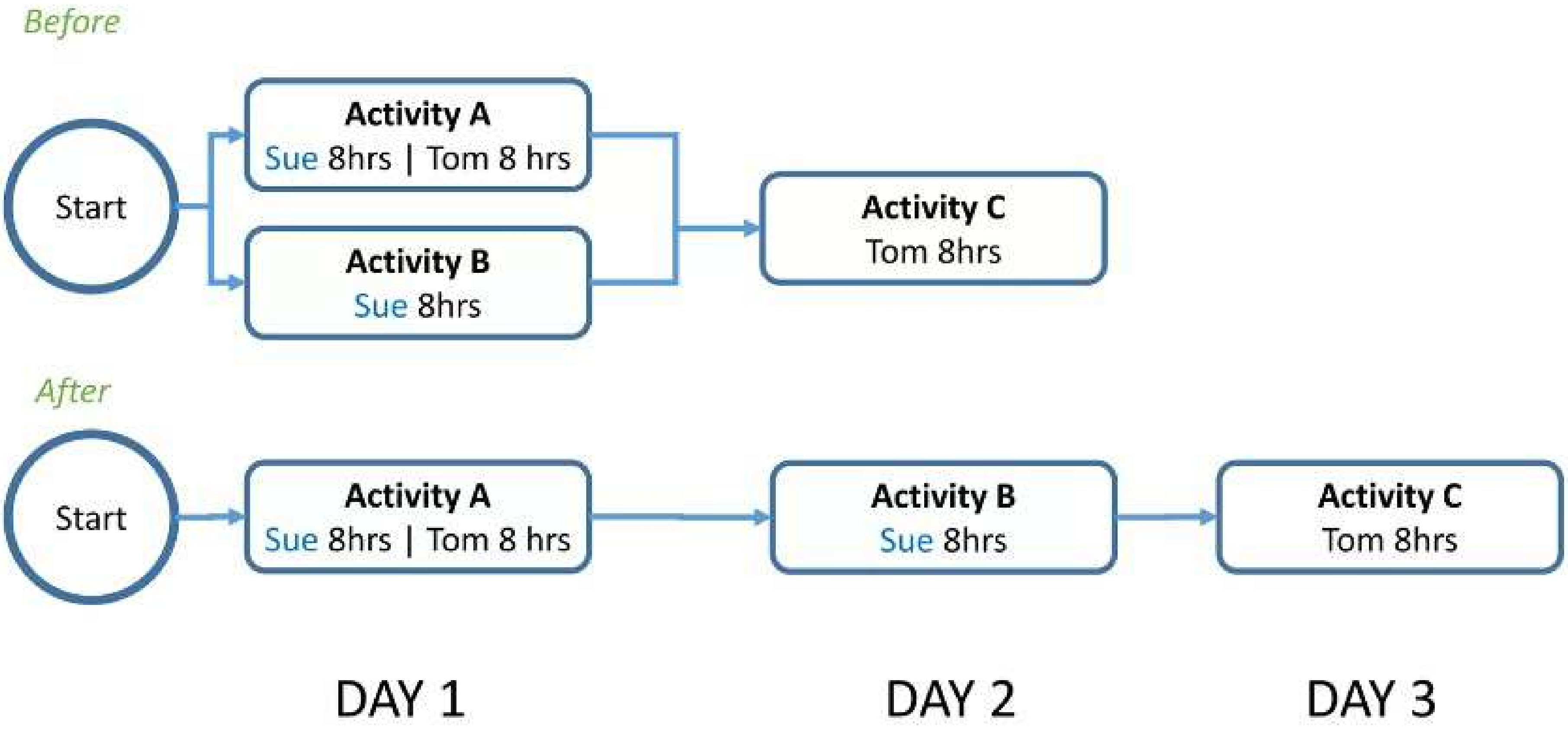
Resource Levelling vs Resource Smoothing

Resource levelling can be used when shared or critically required *resources* over-allocated, such as when a resource has been assigned to two or more activities during the same time period.

Resource levelling can often cause the original critical path to change.

Resource Levelling vs Resource Smoothing

Below – the critical path changes, as resources are allocated during the same time period and need to change.



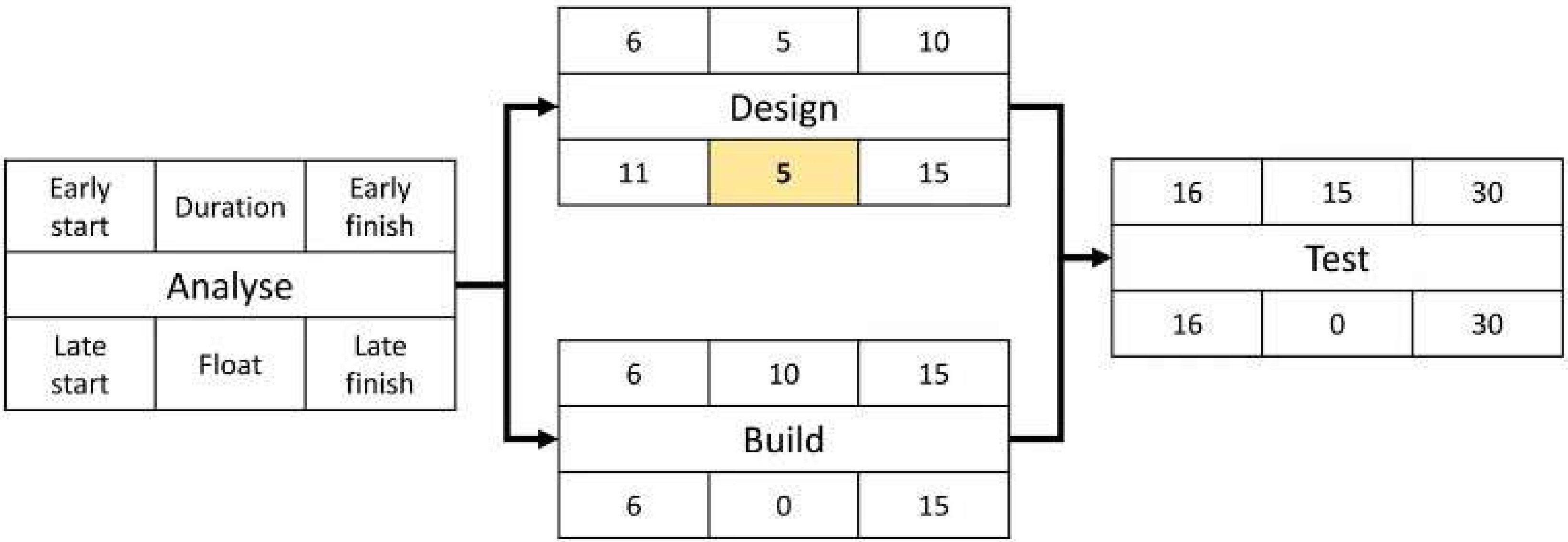
Resource Levelling vs Resource Smoothing

Resource Smoothing adjusts the *activities* of a schedule model.

In resource smoothing, activities may only be delayed within their free and total float – the critical path is not changed.

Resource Levelling vs Resource Smoothing

Below – shows the activity that could move base on Resource Smoothing (Design). The Critical Path is not changed.



Materials Management

Intro, Definition, Functions, Objectives, Stages, Factors responsible, Importance.

Material Management.

- Material includes all the things from raw material to semi-finished and finished goods.
- It has great significance as it has direct relation with the efficiency of a system.
- Generally every manufacturing unit has 25% to 75% of sales turnover investment in materials. Which makes it critical part.

Material Management.

- Expense made on Materials is invested in inventories, storage, transportation, insurance etc.
- Previously only Marketing and Manufacturing were considered as important activities of an enterprise.
- Material management has gained its importance due to costs involved and economizing the total activity.
- Material Management is basic function of business that adds directly to value of product.

Definitions.

- *Material Management is a term used to connote "controlling the kind, amount, location, movement and timing of various commodities used in production by industrial enterprises."*
- *Material Management is a basic function of the business that adds value directly to the product itself.*
- *Material management deals with controlling and regulating the flow of material in relation to changes in variables like demand, prices, availability, quality, delivery schedules etc.*

Material Management.

- MM covers various aspects of input process, like it deals with Raw-Materials, procurement of machines, other tools and necessary spares for the maintenance.
- MM is preliminary to transformation process.
- It involves planning and programming for procuring of material and quality goods of desired quality and specification at reasonable price and at right time.
- It involves being up-to-date with market information, stores and stick control, inspection and transportation of materials.

Functions of Material Management.

1. Planning and programming for materials purchased.
2. Stores and stock control
3. Receiving and issue of material.
4. Transportation and material handling.
5. Disposal of Scrap and surplus material.
6. Value engineering and value analysis.

Objectives of Material Mgt.

1. Material selection.
2. Low operating costs.
3. Receiving and controlling materials.
4. Issuance on receipt of app. authority.
5. Identification of surplus stock and take measures to reduce it.

Organization of MM department.

- The Materials manager has 4 important duties. For which he appoints managers under him, viz.

1. Purchasing.
2. Production Control.
3. Inventory and stores control.
4. Physical distribution.

Stages of Material Management.

1. Decision Stage.
2. Sourcing stage.
3. Production planning stage.
4. Stage of ordering.
5. Receiving stage.
6. Inventory control.

Importance/Advantages/Benefits

1. Regular supply is ensured, aiding for uninterrupted production process.
2. Procurement and transportation costs can be controlled and checked.
3. Efficient stock and stores control minimizes waste.
4. Pre-inspection of RM minimizes chance of rejection of final product.
5. Timely supply and other inputs is ensured.

Importance/Advantages/Benefits

6. Best utilization of labor, capital and equipment is ensured.
7. Congestion in stores and confusion can be avoided, resulting in better services.
8. Manufacturing Cycle is reduced to min.
9. Slight changes in material costs, changes the profit statement of the co.
10. Shortages can be eliminated.

A B C Classification of Materials

Introduction

ABC classification of the construction materials is based on the usage value of the construction materials for the inventory stock. The usage value refers to the product of the price and the number of construction materials.

This classification provides a scientific mechanism for the identification of the construction materials that have a significant impact on overall inventory cost as well as provides the systematic mechanism for identifying the different categories of stock that will require different policy settings and the inventory control.

The primary objective of this classification of the construction materials is to manage the different stock items that are not equal in value or order frequency.

ABC Classification of Construction Materials

1. A Classification

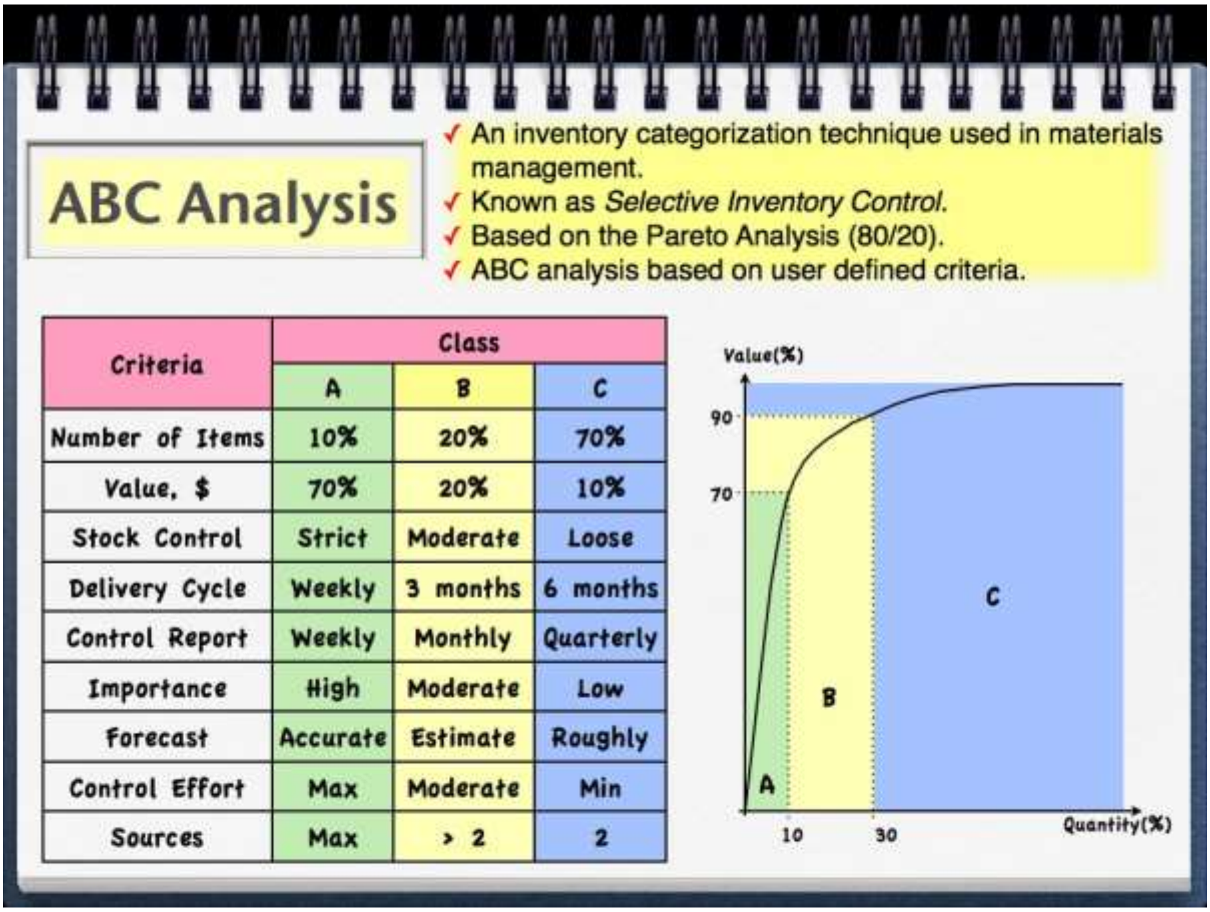
- A – classification includes the group of construction materials that have the highest inventory cost.
- These items are very important for the project.
- As the demand for these construction materials is high, frequent value analysis must be done.
- These construction materials are fast-moving and are the materials that drive the largest percentage of the target service levels and customer satisfaction rates.
- Numerically, 10% of the A items volume accounts for 70% of the total inventory value.

2. B Classification

- B classification includes the group of construction materials that have the intermediate inventory cost.
- These items are lesser important than the A group items.
- The construction materials falling under this category have mid-range inventory value and order frequency.
- Numerically, 20% of the total volume accounts for 20% of the total inventory value.

3. C Classification

- C classification includes the construction materials that have the least inventory cost.
- These construction materials are only marginally important.
- The items of this group have low order frequency and high inventory value.
- These construction materials are mostly stocked in very low quantities or not at all due to the high carrying costs associated with the stock levels.
- 70% of C items volume accounts for 10% of the total inventory value.



Criteria	Class A	Class B	Class C
Number of Items	10%	20%	70%
Value, $	70%	20%	10%
Stock Control	Strict	Moderate	Loose
Delivery Cycle	Weekly	3 months	6 months
Control Report	Weekly	Monthly	Quarterly
Importance	High	Moderate	Low
Forecast	Accurate	Estimate	Roughly
Control Effort	Max	Moderate	Min
Sources	Max	> 2	2

Introduction to Green Technology

What is Green Technology?

- Environmentally friendly technology
- Conserves natural resources
- Runs the gamut from generating power to non-toxic cleaning products
- Technology that utilizes the energy provided by renewable energy sources
- Innovative and sustainable

Goals of Green Technology

- Rethinking
- Recycling
- Renewing
- Reducing
- Responsibility

Rethinking

- Radical thinking for fundamental changes…
  - Instead of thinking, "Oh we can't do that because…" we need to think, "Oh we need to do that because…".
- What are some technologies that we could rethink the ways we design and build them?

Recycling

- Aggregates and concrete
- Paper
- Plastic
- Can
- Batteries
- Clothing
- Any thing else that we recycle?

Renewing

- Renewing (Renewable) Energy
  - Wind
  - Solar
  - Water
  - Tidal
  - Geothermal
  - Biomass (sort of)

Reducing

- Fuels – How much we use and which ones we use
- Waste – Creating less of it, especially waste that cannot be reused or recycled
- Energy Consumption – Lessening our carbon footprint

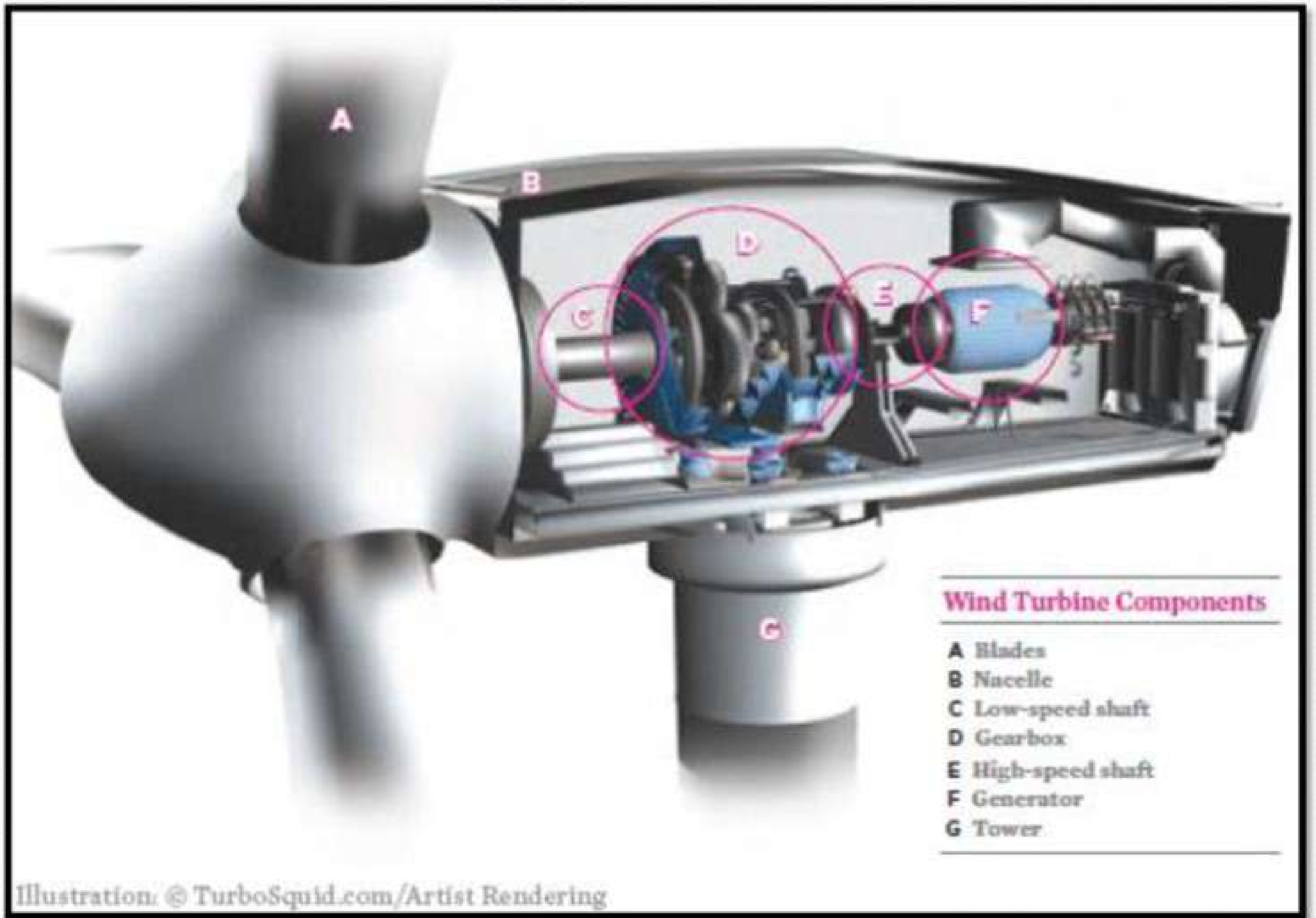
Responsibility

- Recognizing that there is only one world that we all share
- Realizing that if we can minimize the amount of damage we inflict on Earth; the longer we can live here
- Reconciling the idea that we might have to change some of our behaviours and habits

Types of Renewable Energy

- Wind Energy
  - People have been using wind for thousands of years to pump water, to mill grain and power sail boats, etc.
  - Wind turbines have a rotor that spins as the force of the wind rotates it. That rotation operates a **generator** inside the turbine which collects and produces power as the force of the wind (min. 14 kph) rotates the rotor.

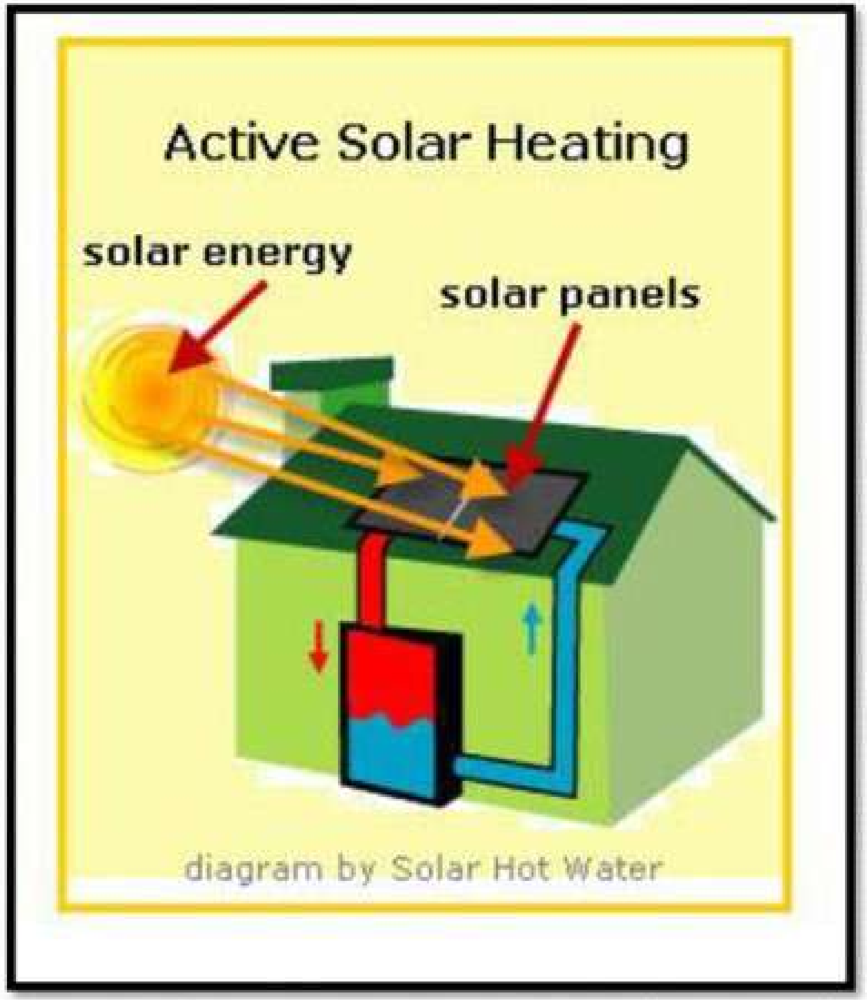
Wind Energy


A
B
C
D
E
F
G
Wind Turbine Components
A Blades
B Nacelle
C Low-speed shaft
D Gearbox
E High-speed shaft
F Generator
G Tower
Illustration: © TurboSquid.com/Artist Rendering

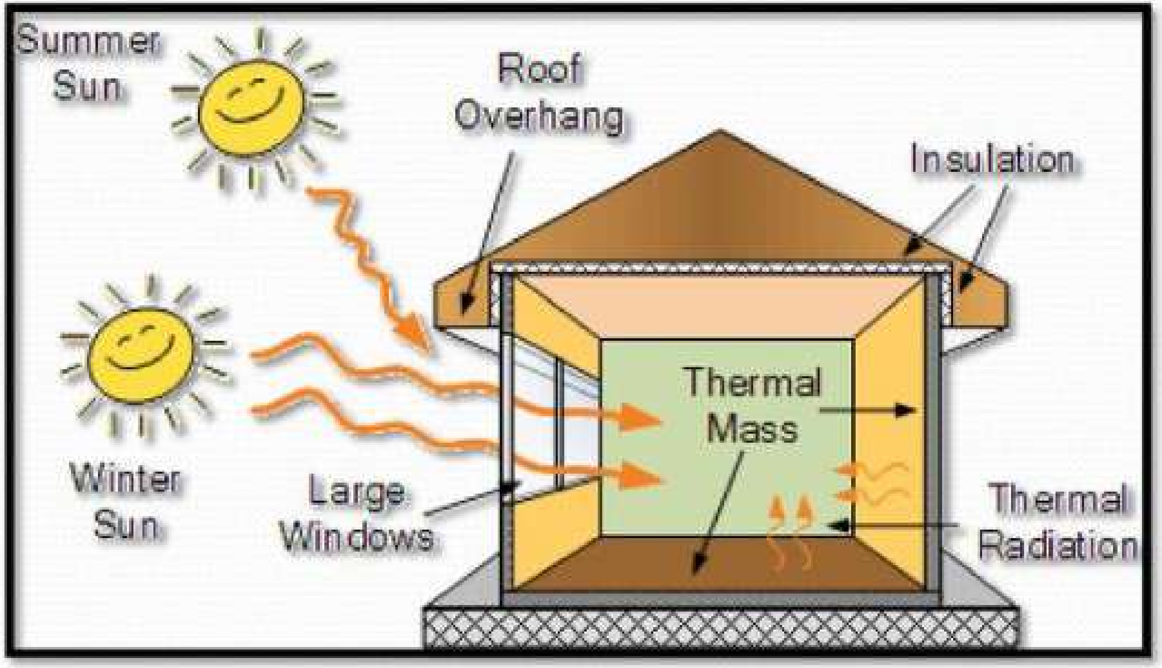
Types of Renewable Energy

- Solar Energy
  - The sun actually gives us almost all the energy we use.
  - It provides energy in two ways. We use the sun's energy **directly** to heat air and water for use in the home. We use it **indirectly** by burning fossil fuels.
  - Millions of years ago, the coal, oil and gas that we burn today were plants and trees. They stored the sun's energy using a process called photosynthesis.

Solar Energy



Passive Solar Heating

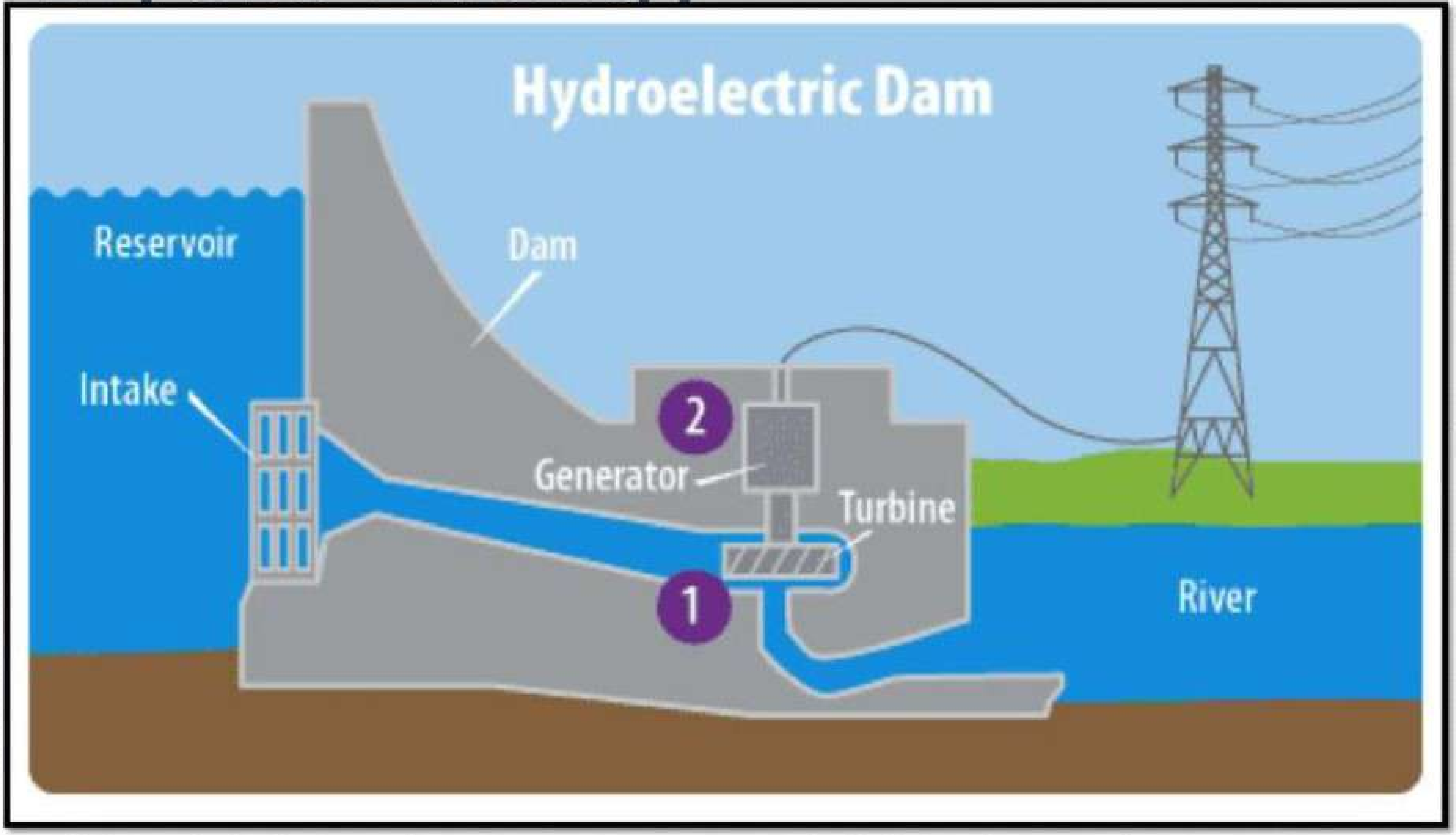


Types of Renewable Energy

Hydro Energy

- When we use the energy in flowing water to produce electricity, we call it hydroelectricity.
- Hydroelectric dams trap flowing water, then release it again under greater pressure.
- Dams depend on kinetic energy, which is the energy something possesses when it is moving.
- The bigger the height difference between the upstream and downstream water level (the 'head'), and the bigger the water flow through the turbines, the more electricity is generated.

Hydro Energy



Types of Renewable Energy

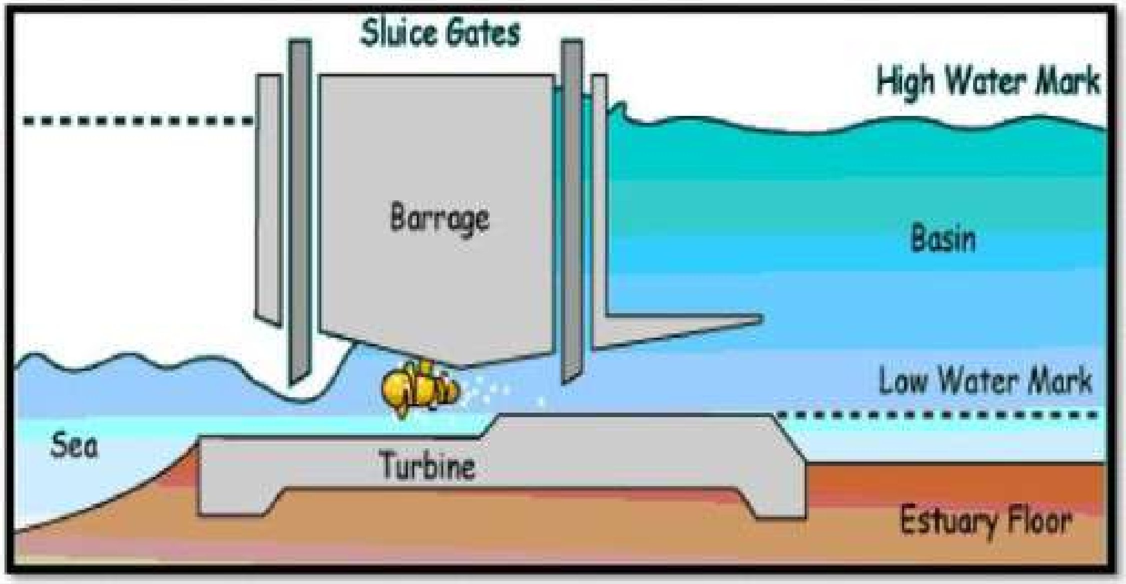
- Tidal Energy
  - Tidal energy relies on the flow and ebb of the tide, caused by the gravitational pull of the moon
  - A **tidal barrage** is a dam that is built across a river estuary or a bay on the coast.
  - The gates are opened to allow the tide to flow in, and turn the turbines, which turn the generators to produce electricity.
  - At high tide, the gates are closed and the water is held until the tide level outside the gates has dropped. Then the water is released to run through the turbines and turn the generators as it escapes.
  - So electricity is generated by water flowing both in and out of the dam.

Types of Renewable Energy

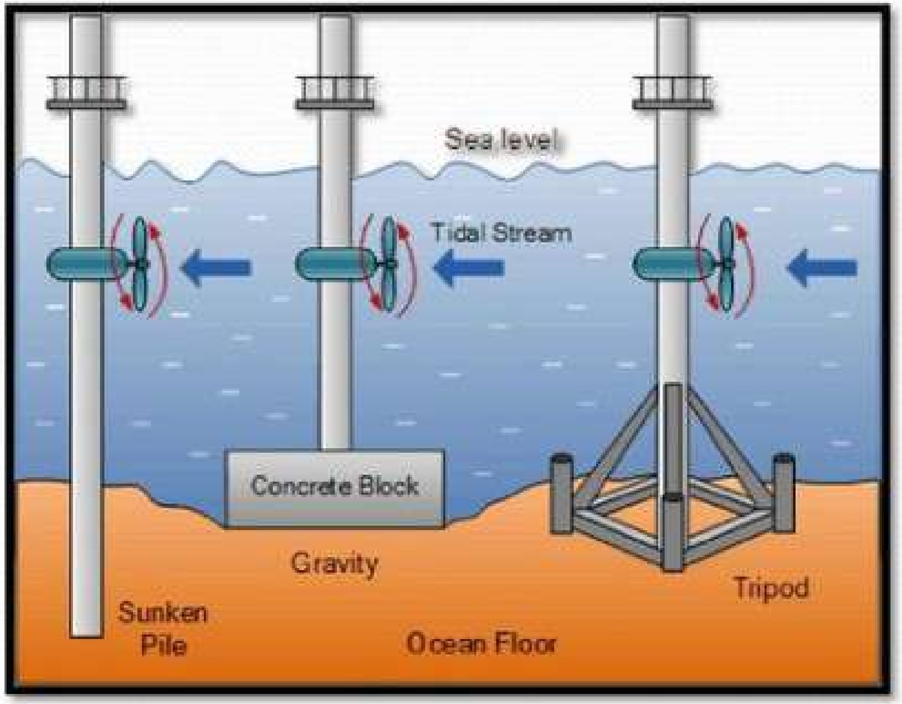
- Tidal Energy
  - A **tidal stream generator** works like an underwater wind turbine.
  - Instead of using the rising and falling movement of the tides, **tidal stream generators** make use of the fast sea currents that flow as tides move in and out.
  - Sea currents turn turbines, which turn the generators that generate electricity

Tidal Energy

Tidal Barrage



Tidal Stream Generator



GUIDE FOR USING NATIONAL BUILDING CODE OF INDIA 2016

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS

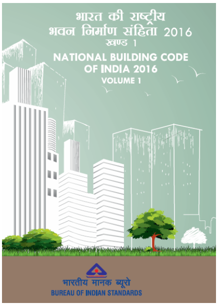
Guide for Using
National Building Code of India 2016

भारतीय मानक ब्यूरो

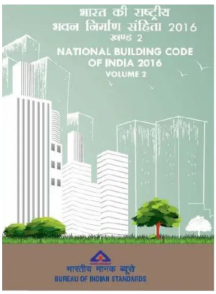
BUREAU OF INDIAN STANDARDS

About

Bureau of Indian Standards (BIS) is the National Standards Body of India established under the BIS Act 2016 for development of standards, marking and quality certification of goods and for matters connected therewith or incidental thereto. BIS has been providing traceable and tangible benefits to the national economy in a number of ways – ensuring provision of safe reliable quality goods; minimizing health hazards to consumers; promoting exports and imports substitute; control over proliferation of varieties, etc through standardization, certification and testing.



The **National Building Code of India 2016** (NBC 2016), a comprehensive building Code prepared by BIS, is a national instrument providing guidelines for regulating the building construction activities across the country. It serves as a Model Code for adoption by all agencies involved in building construction works, be the Public Works Departments, other government construction departments, local bodies or private construction agencies. The Code mainly contains administrative regulations, development control rules and general building requirements; fire safety requirements; stipulations regarding materials, structural design and construction (including safety in construction); building and plumbing services; landscaping and outdoor display structures; approach to sustainability; and asset and facility management.



Thus, the Code gives all the information required by the architect, engineer, structural engineer, construction engineer, services engineer and other professionals from the early stages of planning to translating the building on to *terra firma*. The comprehensive NBC 2016 contains 13 Parts some of which are divided into Sections and Subsections totalling 33 chapters (refer page ii).

NBC 2016 at a glance

VOLUME 1

Part 0 Integrated Approach – Prerequisite for applying provisions of the Code
Part 1 Definitions
Part 2 Administration
Part 3 Development control rules and general building requirements
Part 4 Fire and life safety
Part 5 Building materials
Part 6 Structural design
- Section 1 Loads, forces and effects
- Section 2 Soils and foundations
- Section 3 Timber and bamboo
  - 3A Timber
  - 3B Bamboo
- Section 4 Masonry
- Section 5 Concrete
  - 5A Plain and reinforced concrete
  - 5B Prestressed concrete
- Section 6 Steel
- Section 7 Prefabrication, systems building and mixed/ composite construction
  - 7A Prefabricated concrete
  - 7B Systems building and mixed/composite construction
- Section 8 Glass and glazing

VOLUME 2

Part 7 Construction management, practices and safety
Part 8 Building services
- Section 1 Lighting and natural ventilation
- Section 2 Electrical and allied installations
- Section 3 Air conditioning, heating and mechanical ventilation
- Section 4 Acoustics, sound insulation and noise control
- Section 5 Installation of lifts, escalators and moving walks
  - 5A Lifts
  - 5B Escalators and moving walks
- Section 6 Information and communication enabled installations

Part 9 Plumbing services (including solid waste management)
- Section 1 Water supply
- Section 2 Drainage and sanitation
- Section 3 Solid waste management
- Section 4 Gas supply

Part 10 Landscape development, signs and outdoor display structures
- Section 1 Landscape planning, design and development
- Section 2 Signs and outdoor display structures

Part 11 Approach to sustainability
Part 12 Asset and facility management

Introduction

The National Building Code of India (NBC 2016) is a national instrument providing guidelines for regulating the building construction activities across the country. This Guide has been prepared to help the readers of the NBC 2016 in using the Code, understanding the contents of various Parts/Sections and their connection. The key contents and concepts of each part are laid out using infographics and simplified language such that all stakeholders including officials from regulatory and other government departments, private developers, builders, contractors, professionals, academicians, and students from different backgrounds can get an understanding of the information provided within the Code.

This guide summarizes the key sections of each part of NBC. For details, please refer to NBC with latest amendments.

Part 0 Integrated Approach– Prerequisite for Applying Provisions of the Code

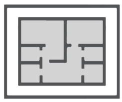
Key Content

This Part gives an overall direction for practical applications of different aspects of spatial planning, designing and construction of buildings, and laying of services. It proposes an integrated approach for utilizing appropriate knowledge and experience of qualified professionals during the entire life cycle of a development/building project.

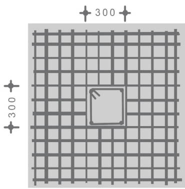
Part 0 at a glance

A development/building project and the built facility comprises 6 major stages.

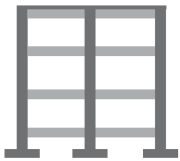
1 Location/Siting



2 Conceptualization and Planning

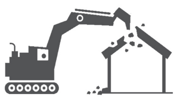


3 Designing and Detailing



4 Construction/Execution

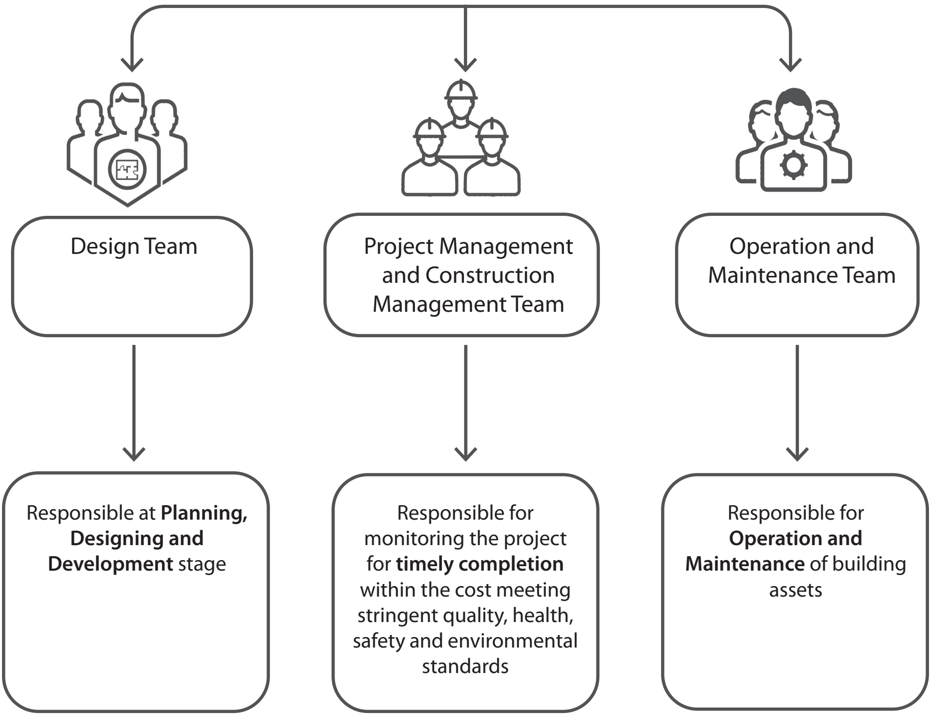
5 Operation and Maintenance



6 Decommissioning and Deconstruction

Key Teams of Multidisciplinary Professionals

Architect; Civil engineer; Structural engineer; Geotechnical engineer; Electrical engineer; Plumbing engineer; Fire protection engineer; HVAC engineer; Lift, escalator and moving walk specialist; Acoustics specialist; Information/Communication technology engineer; Health, safety and environment specialist; Environment/Sustainability specialist; Town planner; Urban designer; Landscape architect; Security system specialist; Interior designer; Quantity surveyor; Project/Construction manager; Accessibility and universal design specialist; Asset/Facility manager; and other subject specialists.



Depending on the complexity and magnitude of the project, a multidisciplinary team of professionals need to be engaged as a well–coordinated team to achieve the desired delivery in an effective manner.

For more details on Part 0, please refer to NBC 2016

Part 1 Definition

Key Content

There are approximately 1,776 terms defined in NBC 2016. Each Part or Section of the NBC gives the definitions of the important terms used in it, which may be found in the clause 'Terminology' for each Part/Section of NBC 2016.

Part 1 at a glance

Part 1 gives an index of all such definitions and directs the user to refer to the correct Part/ Section for locating the desired definition. Examples of terms whose definitions are covered in various Parts/Sections are:

Part 0 Integrated Approach– prerequisite for applying provisions of the Code	Authority having jurisdiction/Authority, Building, Owner,....
Part 2 Administration	Development, Unsafe building, Sanctioned plan, Permit, Alteration,...
Part 3 Development Control Rules and General Building Requirements	Open space, Floor Area Ratio (FAR), Building height, Chajja, Covered area, Habitable room,....
Part 4 Fire and Life Safety	Exit, High rise building, Refuge area, Evacuation Lift, Horizontal Exit,....
Part 6 Structural Design	Column, Structural timber, Curtain wall, Load bearing wall, Poisson's ratio, Prestressed concrete, Diaphragm,....
Part 7 Construction Management, Practices and Safety	Scaffold, Wall opening, Platform, Pile rig, Construction equipment,....
Part 8 Building Services	Daylight factor, Glare, Cable, Building energy simulation, Ambient noise, Lift car,....
Part 9 Plumbing Services	Service pipe, Storage tank, Water outlet, Soil pipe, Municipal solid waste,....
Part 10 Landscape Development, Signs and Outdoor Structures	Contour, Gradient, Green roof, Permeable paving, Sign, Advertising sign,....
Part 11 Approach to Sustainability	Embodied energy, Environmental impact, Indoor air quality, Renewable Source, Thermal comfort,....
Part 12 Asset and Facility Management	Building management system, Facility, End user, Housekeeping, Operational strategy,....

For more details on Part 1, please refer to NBC 2016

Part 2 Administration

Key Content

This Part describes organization of a building department for enforcement of the Code including procedure for obtaining development, building and occupancy permits; responsibility of the owner and all professionals involved in planning, design and construction of the building.

Organization and Enforcement

- Department of buildings
- Appointment of team of building officials
- Qualification of building officials
- Delegation of powers
- Powers and duties of team of building officials
- Board of appeals
- Violation and penalties
- Power to make rules

Permit and Inspection

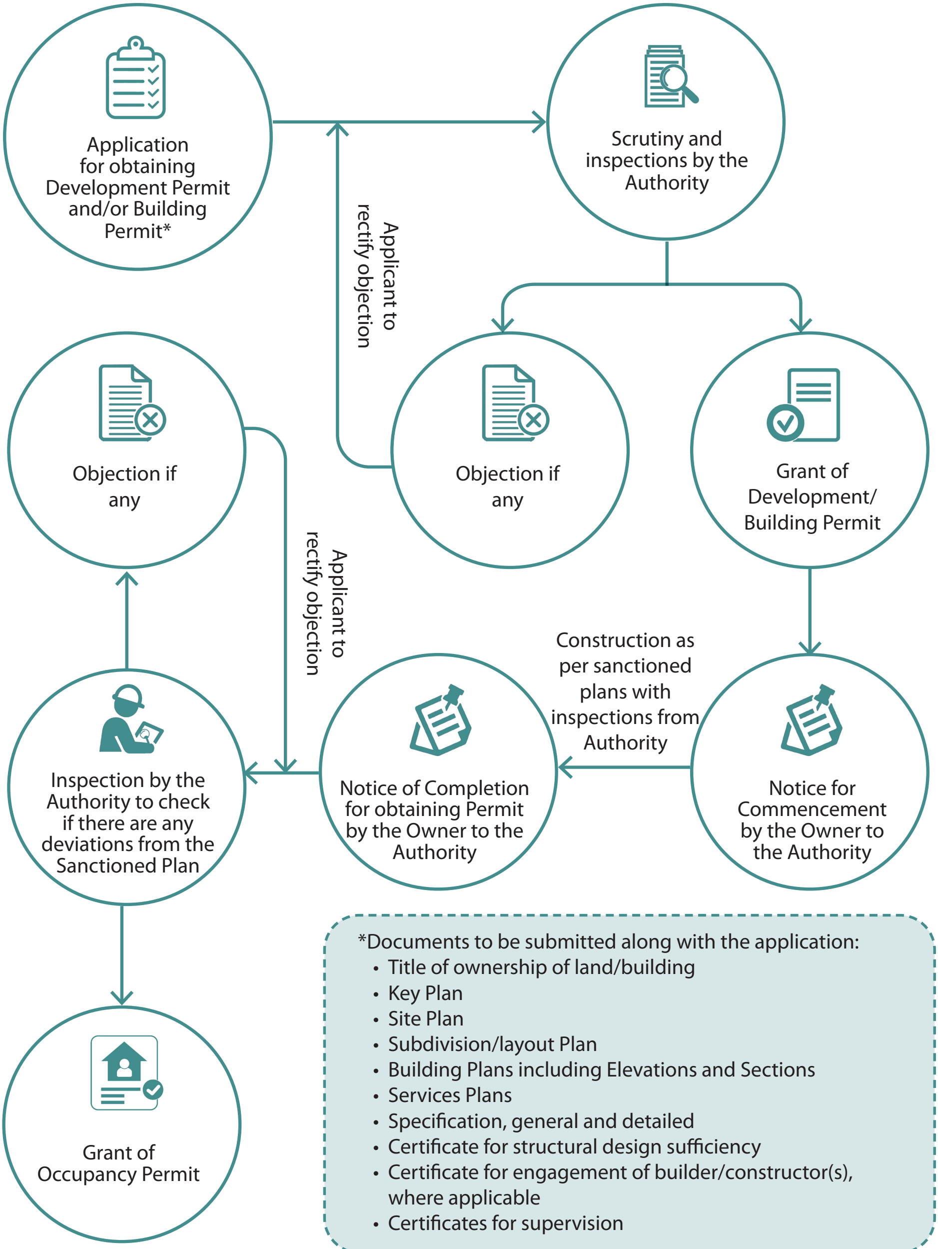
- Application for development, building permit
- Responsibilities and duties of the owner
- Validity
- Architectural control
- Inspection, occupancy permit and post–occupancy inspection
- Unsafe building
- Demolition of building

Key Stakeholders

- Owner/Developer
- Authority having jurisdiction (called Authority)
- Architect
- Civil Engineer
- Structural Engineer
- Geotechnical Engineer
- Supervisor
- Town Planner
- Landscape Architect
- Urban Designer
- Engineers for Utility Services
- Builder/Constructor

For qualifications and competencies of professionals, refer to Annex A of Part 2 of NBC 2016

Part 2 at a glance



*Documents to be submitted along with the application:

- Title of ownership of land/building
- Key Plan
- Site Plan
- Subdivision/layout Plan
- Building Plans including Elevations and Sections
- Services Plans
- Specification, general and detailed
- Certificate for structural design sufficiency
- Certificate for engagement of builder/constructor(s), where applicable
- Certificates for supervision

For more details on Part 2, please refer to NBC 2016

Part 3 Development Control Rules and General Building Requirements

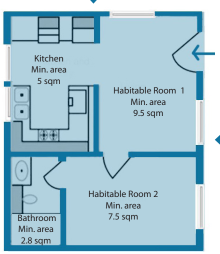
Key Content

This Part covers development control rules such as land use classification, requirements for subdivision and layout plan including means of access, open spaces, plot requirements, area and height limitations, off street parking spaces, green belts and landscaping. This Part also covers general building requirements for various parts of building and accessibility requirements in the built environment.

Hierarchy of Development

Landuse Classification

Layout/Subdivision Plan



Requirement for parts of building

- Means of access
- Fire tender movement
- Open spaces (within a plot)
- Area and height limitations
- Community open spaces and amenities
- Off street parking spaces
- Group housing
- Buildings on podium
- Green belts, landscaping

Accessibility in Public Buildings and Public Spaces

- Minimum width, gradient and specifications for walkways/ pathways and kerb ramps
- Installation of tactile ground surface indicators to aid visually impaired persons
- Adequate accessible parking spaces with signages
- Specifications of accessible approach to building, access at entrance and within the building
- Handrails and grab bars to be provided for easy movement and use of facilities
- Specifications for making level changes (stairs, ramps, lifts) accessible
- At least one accessible unisex toilet to be provided
- Accessibility to various services and their fittings such as door, windows, handles, electrical switches and taps
- In public buildings, all public areas to be made accessible
- Minimum accessibility provisions specific to different building occupancy types
- The signage requirements for universal accessibility in public buildings and public spaces are covered in Annexure B, Part 3 of NBC 2016.

Accessibility in Group Housing

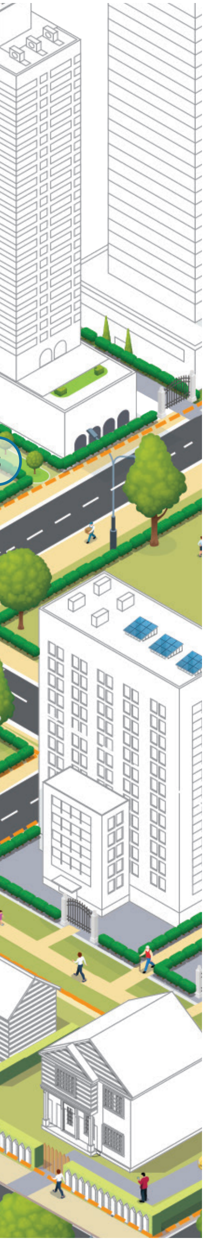
- Some ground floor Dwelling Units in group housing to be made universally accessible
- All Dwelling Units to have minimum universal design features such as minimum clear door width of main entrance, rooms, kitchen, one toilet.

This Part also covers requirements for low income housing in urban areas, cluster planning, low income habitat planning in rural areas and development planning in hilly areas.

Part 3 at a glance

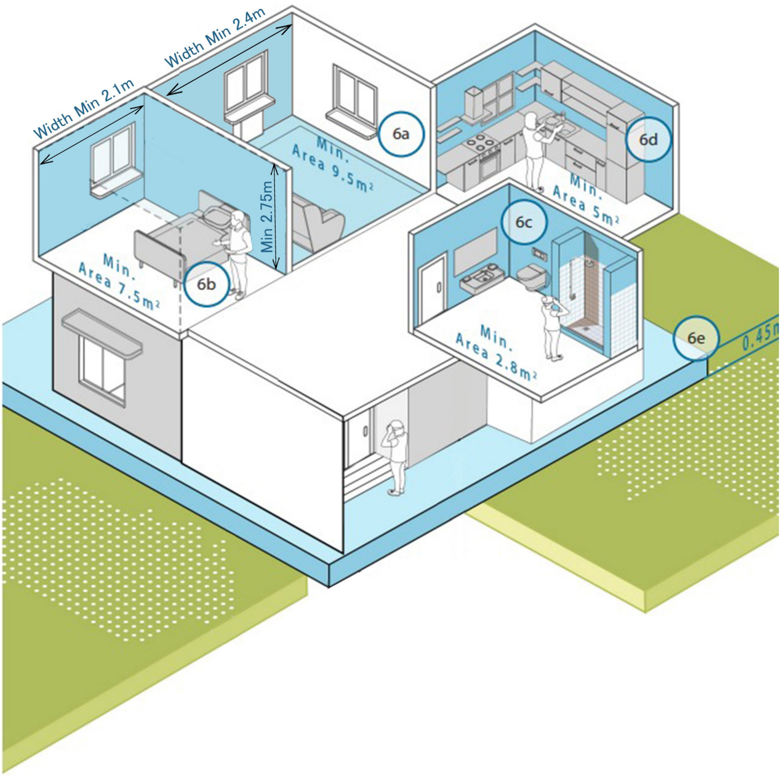
Typical Subdivision Layout

Key:
1) Open spaces (around buildings)
2) Off–street parking spaces
3) Means of access connecting different layouts
4) Greenbelts and landscaping
5) Provisions regarding plot sizes and frontage
6) General Building Requirements (Check next page for details)



Some requirements for parts of building as per Clause 12 of Part 3 of NBC 2016

6a) Habitable room 1 (Minimum area 9.5 m^2 and minimum width 2.4 m)
6b) Habitable room 2 (Minimum area 7.5 m^2 and minimum width 2.1 m)
6c) Toilet (Minimum area with W.C. 2.8 m^2)
6d) Kitchen (Minimum area 5 m^2 without dining)
6e) Plinth height (Minimum height 0.45 m for plain areas/hilly area and 0.6 m flood prone)



For more details on Part 3, please refer to NBC 2016

Part 4 Fire and Life Safety

Key Content

This Part deals with safety from fire. It specifies the demarcation of fire zones, restrictions on construction of buildings in each fire zone, classification of buildings based on occupancy, types of building construction according to fire resistance of the structural and non–structural components and other restrictions and requirements necessary to minimize danger to life from fire, smoke, fumes or panic before the buildings can be evacuated. The provisions covered in this Part are divided in three broad areas: Fire Prevention, Life Safety and Fire Protection.

Part 4 at a glance

Fire and life Safety

Fire Prevention

- Classification of buildings based on occupancy, from fire safety point of view
- Demarcation of fire zone
- Types of building construction
- Openings in fire resistant walls and floors
- Electrical installations
- Escape lighting and exit signage
- Air conditioning, ventilation and smoke control
- Heating
- Glazing
- Surface interior finishes
- Fire Command Centre (FCC)

Life Safety

- General exit requirements
- Occupant load
- Egress components
  - – Exit access
  - – Exit
  - – Exit discharge
- Compartmentation
- Smoke control
- Gas supply
- Hazardous areas, gaseous, oil storage yard, etc
- Fire Officer
- Fire drills and fire orders

Fire Protection

- Requirements for firefighting installations (refer Table 7)
- Maintenance of firefighting installation and systems

Additional occupancy wise requirements

Additional fire safety requirements for high rise building, atrium, commercial kitchen, car parking facilities, metro stations, metro trainways and measures for venting in industrial buildings, are also covered in this Part of NBC 2016.

All buildings shall satisfy minimum requirements for safety of life from fire, smoke, fumes or panic arising from these or similar causes.

FIRE PREVENTION

Classification of buildings based on occupancy.

The city or area under the jurisdiction of the Authority shall be demarcated into distinct fire zones depending upon the existing layout, types of building construction, classification of existing buildings based on occupancy and expected future development of the city or area. Intermixing of hazardous occupancies should not be allowed in other zones.

Fire Zone 1

- **Group A: Residential Buildings**
  - Subdivision A–1 Lodging and rooming houses
  - Subdivision A–2 One or two family private dwellings
  - Subdivision A–3 Dormitories
  - Subdivision A–4 Apartment houses
  - Subdivision A–5 Hotels
  - Subdivision A–6 Starred Hotels
- **Group B: Educational Buildings**
  - Subdivision B–1 Schools up to senior secondary level
  - Subdivision B–2 All others/training institutions
- **Group C: Institutional Buildings**
  - Subdivision C–1 Hospitals and sanatoria
  - Subdivision C–2 Custodial institutions
  - Subdivision C–3 Penal and mental institutions
- **Group D: Assembly Buildings**
  - Subdivision D–1 Buildings with stage and fixed seats over 1,000 persons
  - Subdivision D–2 Buildings with stage and fixed seats upto 1,000 persons
  - Subdivision D–3 Buildings without permanent stage, accommodation for 300 or more persons, and no permanent seating arrangements
  - Subdivision D–4 Buildings without permanent stage, accommodation less than 300 persons, and no permanent seating arrangements
  - Subdivision D–5 Temporary structures designed for assembly
  - Subdivision D–6 Shopping malls with multiplexes and food courts
  - Subdivision D–7 Underground and elevated mass rapid transit system
- **Group E: Business Buildings**
  - Subdivision E–1 Offices, banks, professional establishments
- **Group F: Mercantile Buildings**
  - Subdivision F–1 Shops, stores departmental stores (area upto 500 m^2)
  - Subdivision F–2 Shops, stores departmental stores (area > 500 m^2)
  - Subdivision F–3 Underground shopping centres

Fire Zone 2

- **Group E: Business Buildings**
  - Subdivision E–2 Laboratories, outpatient clinics, research establishments, libraries and test houses
  - Subdivision E–3 Electronic data processing centres, computer installations,information technology parks and call centres
  - Subdivision E–4 Telephone exchanges
  - Subdivision E–5 Broadcasting stations, T.V. stations and air traffic control towers
- **Group G: Industrial Buildings**
  - Subdivision G–1 Buildings used for low hazard industries
  - Subdivision G–2 Buildings used for moderate hazard industries

Fire Zone 3

- **Group G: Industrial Buildings**
  - Subdivision G–3 Buildings used for high hazard industries
- **Group H: Storage Buildings**
- **Group J: Hazardous Buildings**

1) Fire resistant walls, floors and compartments

- To limit the spread of fire
- No compromise for openings such as shafts, refuse chutes, vertical openings, etc.

2) Shafts

- To be provided with fire resistant rated inspection door for passage of building services such as cables, electrical wires, telephone cables, plumbing pipes, etc depending upon location.

3) Refuge area

- An area within the building for a temporary use during egress. It generally serves as a staging area which is protected from the effect of fire and smoke.

4) Fire detection and firefighting installations

- These include fire alarm, fire extinguishers, hose reels, wet riser, down comer, yard hydrants, sprinklers, deluge system, water spray, foam, water mist systems, gaseous or dry powder system, water storage tanks and pumps, etc.

All buildings shall satisfy minimum requirements, for safety of life from fire, smoke, fumes or panic arising from these or similar causes.

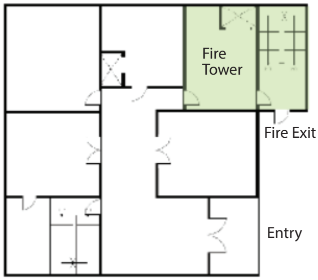
5) Means of egress

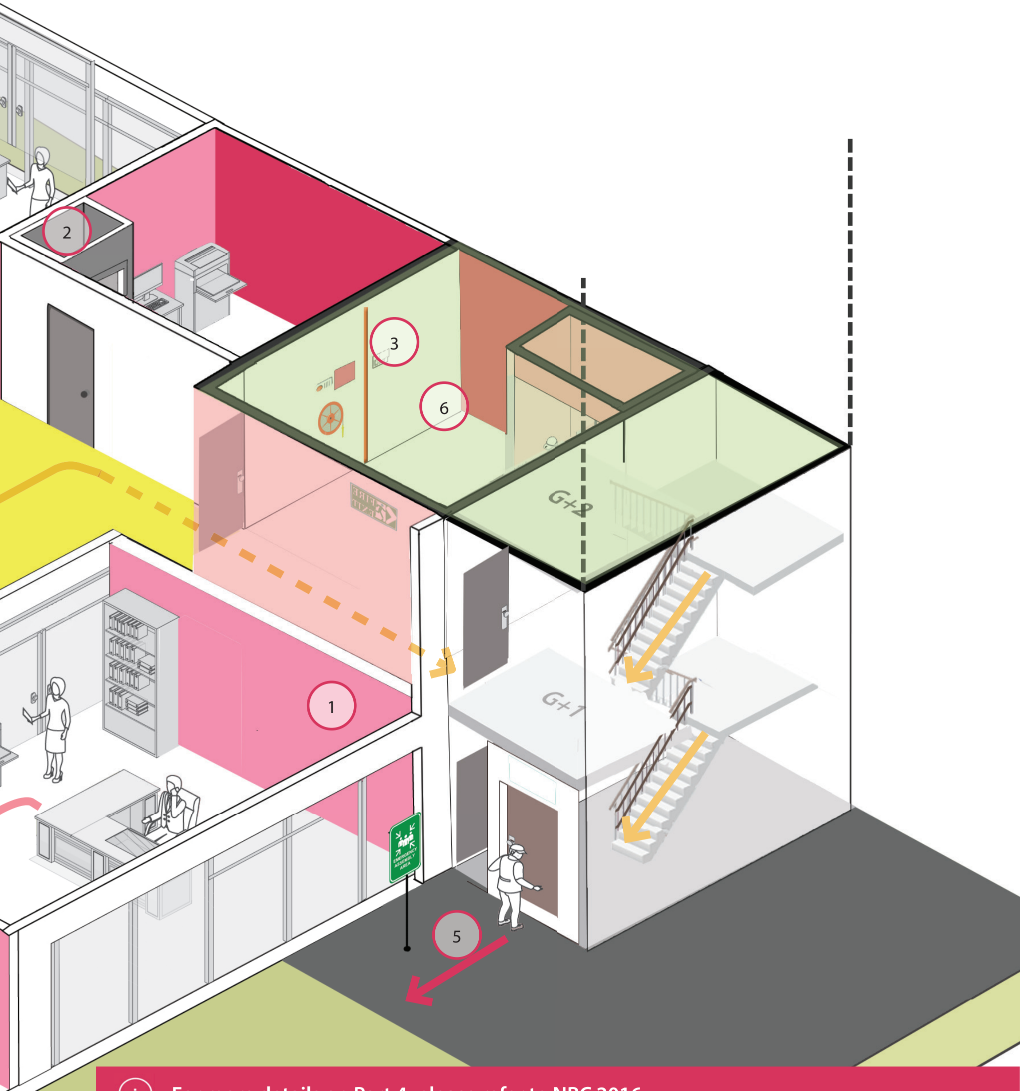
- Consists of three separate and distinct parts, that is, exit access, exit and exit discharge
- Exit access are working/functional areas
- Various types of exit access and exits are doorways, corridors and passageways, horizontal exits, internal staircases, exit passageways, external staircases and ramps.

6) Fire fighting shafts

- With fire man talk back, fire door, wet riser, hose reel, signage showing floor plan and stairways and fire man's lift

Key Plan (First Floor Plan)





For more details on Part 4, please refer to NBC 2016

Part 5 Building Materials

Key Content

This Part covers the requirements of building materials and components, criteria for accepting new or alternative building material. It details the quality and effectiveness of building materials used in the construction and of their storage, which are important aspects of building activity.

- Methods of Test
- Third Party Certification
- Materials
- Storage of Materials
- Sustainable Materials
- New or Alternative Materials

Part 5 at a glance

All building materials shall conform to relevant Indian Standards, unless otherwise specified or approved. NBC 2016 enlists around 1500 IS code specifications and methods of test under the following 30 categories of materials.

1. Aluminium and other light metals and their alloys
2. Bitumen and tar products
3. Bricks, blocks and other masonry building units
4. Builder's hardware
5. Building chemicals
6. Building lime and products
7. Clay and stabilized soil products
8. Cement and concrete
9. Composite matrix products
10. Conductors and cables
11. Doors, windows and ventilators
12. Electrical wiring, fittings and accessories
13. Fillers, stoppers and putties
14. Floor covering, roofing and other finishes
15. Glass
16. Gypsum based materials
17. Mortar (including sand for mortar)
18. Paints and allied products
19. Polymers, plastics and geosynthetics/ geotextiles
20. Sanitary appliances and water fittings
21. Steel and its alloys
22. Stones
23. Structural sections
24. Thermal insulation materials
25. Threaded fasteners, rivets and nails
26. Timber, bamboo and other lignocellulosic building materials
27. Unit weights of building materials
28. Waterproofing and damp–proofing materials
29. Welding electrodes and wires
30. Wire ropes and wire products

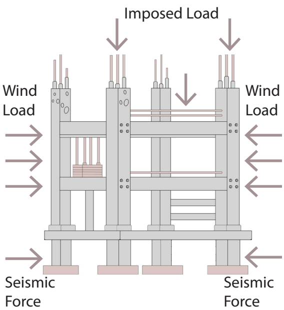
For more details on Part 5, please refer to NBC 2016

Part 6 Structural Design

Key Content

This Part provides for structural adequacy of buildings and usage of materials and technology for building design. It is divided into 8 Sections (Section 1 to Section 8).

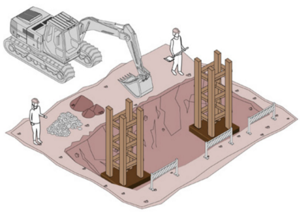
Part 6 at a glance



Section 1 Loads, forces and effects

This Section covers basic design loads to be considered for the structural design calculations of buildings. The imposed loads, wind loads, seismic forces, snow loads and other loads are minimum working loads which should be taken into consideration for purposes of design. This Section also covers:

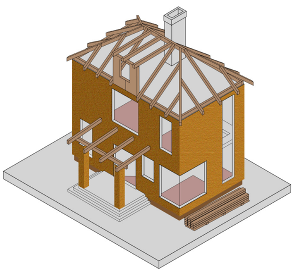
- Load calculation for rooftop helipads
- Load to be considered for parapets, balustrades, impacts and vibrations
- Imposed load due to fire tenders and emergency vehicles
- Maps on basic wind speed and seismic zones of India.



Section 2 Soil and Foundation

This Section covers geotechnical design of building foundations, such as:

- Geotechnical investigation and exploration guidance
- Geotechnical design (principles) of building foundations
- Foundation systems to ensure safety and serviceability without exceeding the permissible stresses of the materials of foundations and the bearing capacity of the supporting soil/rock
- Deep foundation including pile foundation
- Shallow foundation including raft foundation
- Ground improvement techniques.

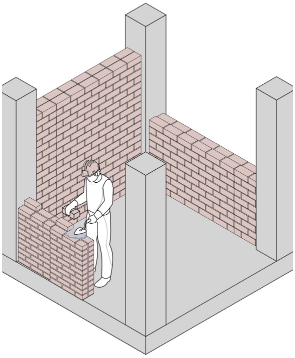


Section 3 Timber and Bamboo

- 3A Timber– This Subsection covers the general principles involved in the design of structural timber in buildings, including elements of structures connected by fasteners/ fastening techniques. It also covers the engineering properties of various species of timber.

- 3B Bamboo– This Subsection covers the design of structural bamboo in buildings with regard to mechanical resistance and durability of structures. It also covers the engineering properties of various species of bamboo.

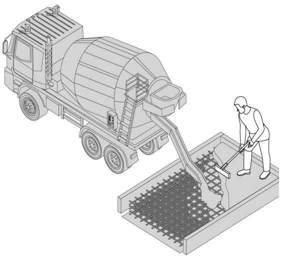
For more details on Part 6, please refer to NBC 2016



Section 4 Masonry

This Section covers the structural design of unreinforced and reinforced masonry elements in buildings. This Section also covers:

- Materials
- General requirements
- Structural design of load bearing buildings.
- Reinforced brick and reinforced brick concrete floors and Roofs
- Special consideration from earthquake point of view
- Guidelines for improving earthquake resistance of low strength masonry buildings
- Confined masonry
- Guidelines for design of non–load bearing walls/partitions
- Masonry walls using rat–trap bond technology.

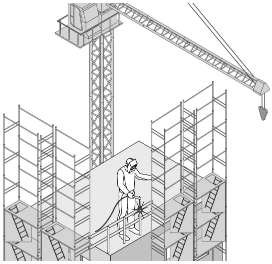


Section 5 Concrete

This Section covers structural designing of plain, reinforced concrete and prestressed concrete. The Section has been subdivided into the following Subsections:

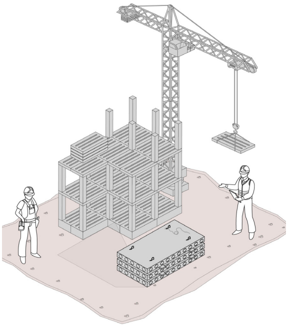
- 5A Plain and Reinforced Concrete– This Subsection covers:
  - General structural use of plain and reinforced concrete
  - Requirements of durable concrete production, fire safety and protection from environment
  - Detailed design consideration for concrete strength upto M60
  - Reinforcement requirements and detailing aspects for all type of structural elements
  - Special concretes like self–compacting concrete, high performance concrete and steel fibre reinforced concrete.

- 5B Prestressed Concrete– This Subsection covers:
  - Structural design aspects of prestressed concrete.
  - Works carried out on site and the manufacture of precast prestressed concrete units
  - Updated provisions on end–zones, ultimate shear resistance, etc.



Section 6 Steel

This Section covers the structural design aspects of steel structures in buildings. This Section applies to general construction using hot rolled steel sections and steel tubes joined using riveting, bolting and welding. This Section covers the design by limit state method and plastic theory, and also enables design by working stress method.

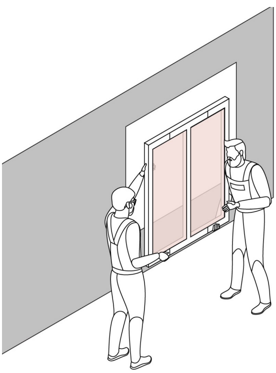


Section 7 Prefabrication, Systems Building and Mixed/ Composite Construction

The Section has been subdivided into the following Subsections:

- 7A Prefabricated Concrete– This Subsection gives:
  - Recommendations regarding modular planning, component sizes, prefabrication systems
  - Design considerations, joints & testing
  - Manufacture, storage, transportation and erection
  - Other related requirements for prefabricated concrete.

- 7B Systems Buildings and Mixed/Composite Construction– This Subsection covers:
  - Recommendations regarding modular planning, component sizes
  - Joints, manufacture, storage, transport and erection of prefabricated elements
  - Other related requirements for systems building and mixed/composite construction.



Section 8 Glass and Glazing

This Section covers:

- Selection and application of glass in buildings
- Types of glass, its requirements and associated glazing materials
- Glazing in buildings with respect to its effect on energy, visual (light) and solar environments
- Design of glass in buildings, subject to wind loading, seismic loading
- Selection, manifestation of glass in buildings, subject to safety with respect to human impact of the occupants
- Selection, design, fabrication, installation, testing and maintenance of glazing systems.

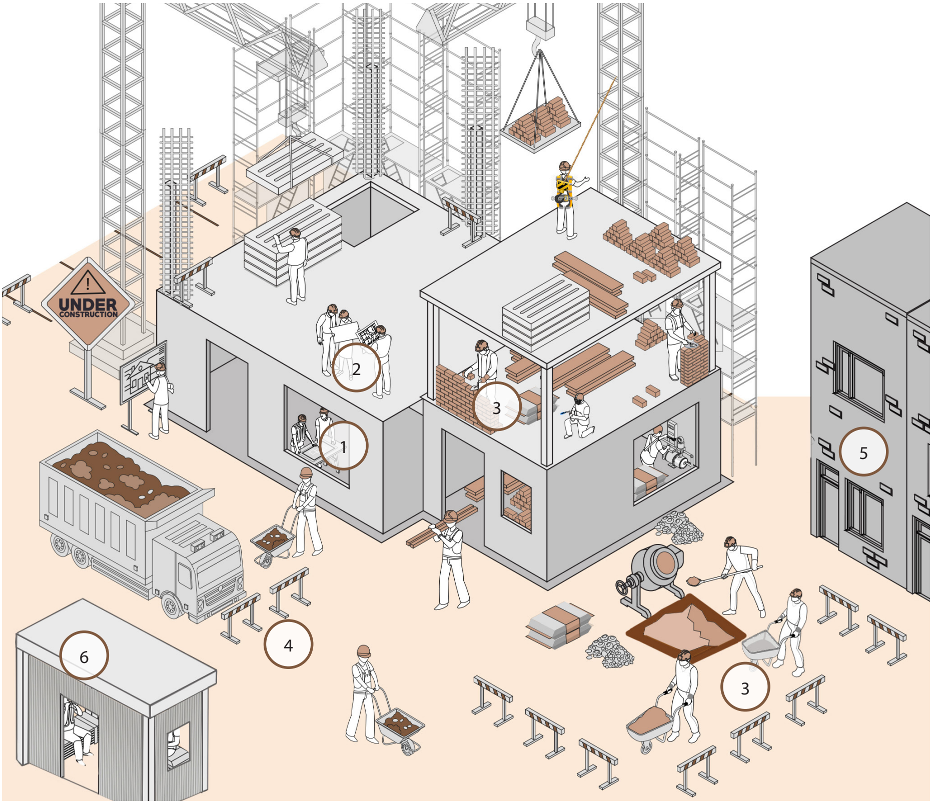
i For more details on Part 6, please refer to NBC 2016

Part 7 Construction Management, Practices and Safety

Key Content

This Part covers construction project management, construction planning, site management and building construction practices, storage, stacking and handling of materials. It also deals with safety of personnel during construction operations, demolition of buildings, habitat and welfare requirements for workers. The guidelines relating to repairs, retrofitting and strengthening of buildings are covered under this Part.

Part 7 at a glance



1) Construction management (time, cost, quality, health and safety)
2) Construction planning and site management
3) Construction practices
4) Safety in construction
5) Repairs, retrofitting and strengthening of buildings
6) Habitat and welfare requirements for workers

Standards relating to construction project management functions and construction practices are also refered in this Section.

For more details on Part 7, please refer to NBC 2016

Part 8 Building Services

Key Content

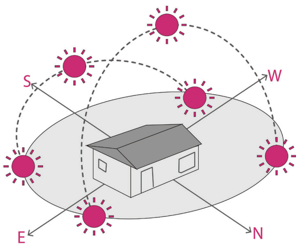
All buildings meant for human habitation must be provided with adequate building services. This Part prescribes requirements for building services, and is divided into 6 Sections.

Section 1 Lighting and Natural Ventilation	Section 2 Electrical and Allied Installations	Section 3 Air–conditioning, Heating and Mechanical Ventilation
Section 4 Acoustics, Sound Insulation and Noise Control	Section 5 Installation of Lifts, Escalators and Moving Walks	Section 6 Information and Communication Enabled Installation

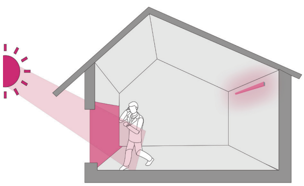
Part 8 at a glance

Section 1 Lighting and Natural Ventilation

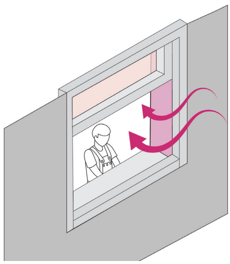
This Section covers requirements and methods for lighting and natural ventilation of buildings; design for both daylighting and artificial lighting. It also has provisions on energy conservation in lighting.



Orientation of building



Lighting



Ventilation

This Section also includes the following important aspects:

- Climatic classification map of India
- Table on solar radiation as per seasons for determining heat intake
- Recommended level of illuminance for different spaces/activities in different buildings (refer Table 4)
- Recommended values for air changes for different buildings/spaces
- Maximum allowable contaminant concentrations for fresh/ventilation air
- Optimum size/number of fans for rooms of different sizes.

Section 2 Electrical and Allied Installations

This Section covers the essential requirements for electrical installations in buildings to ensure efficient use of electricity including safety from fire and shock. It also includes general requirements relating to lightning protection of buildings and provisions on certain allied installations.

Planning of electrical installations include planning spaces for substation, switch rooms, emergency power back up system, distribution panels, overhead lines, wires and cables.

The electric and allied installations are to be carried out in conformity with the requirements of the Electricity Act, 2003 and the Central Electrical Authority (measures relating to safety and electric supply) regulations, 2010, as amended from time to time.

Key aspects covered under the Section are as follows:

Planning of electric installation

Distribution of supply and cabling

Wiring (including selection of size of conductors)

Fittings and accessories

Earthing (including maintenance free earthing)

Inspection, testing and verification of installation

Allied/ miscellaneous services

Lightning protection of buildings

Electrical installation for construction and demolition sites

Protection of human beings from electrical hazards

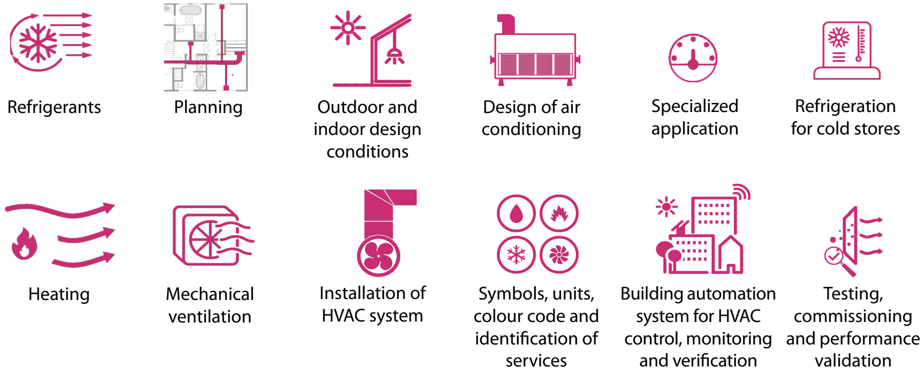
This Section also includes provisions on:

- Location of energy meters, centralized metering system and smart metering
- Requirements for electrical supply system for life and safety services
- Discrimination, cascading and limitation concepts for the coordination of protective devices in electrical circuits
- Solar photovoltaic system
- Aviation obstacle lights
- Electrical supply for electric vehicle charging and car park management system
- Typical formats for checklists for handing over and commissioning of substation equipment and earthing pit.

Section 3 Air conditioning, Heating and Mechanical Ventilation

This Section covers planning, selection, design considerations, installation, testing and commissioning of air conditioning, heating and mechanical ventilation systems for buildings. Planning includes equipment room for central AC plant , air handling units and package units, pipe shafts, supply/return air ducts and cooling tower.

Key aspects covered in the Section are as follows:



This Section also includes provisions on:

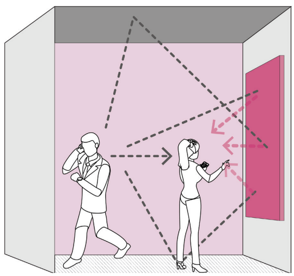
- Design of indoor conditions as per adaptive thermal comfort model
- Minimum ventilation rates in breathing zone
- Energy efficient air conditioning systems such as variable refrigerant flow system, inverter technology, district cooling system, hybrid central plant using chilled beams and radiant floor components
- Envelope utilization using energy modelling, day light simulation, solar shade analysis and wind modelling software
- Weather data of 60 cities of India
- Direct/indirect evaporative cooling units and geo–thermal cooling and heating
- HVAC systems for healthcare facilities, data centres and underground metro stations
- Energy efficient strategies for winter heating, using reverse cycle operation, solar heating systems, electric heat pump and ground source heat pump
- Modern system of mechanical ventilation for industries, commercial kitchens, underground parking and for open tunnel connecting underground metro stations
- Demand control ventilation and axial flow fans with aerofoil profile blades.

Section 4 Acoustics, Sound Insulation and Noise Control

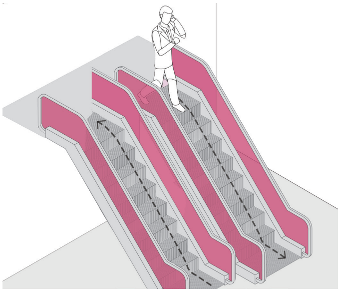
This Section covers requirements and guidelines with regards to planning against outdoor and indoor noise, acceptable noise levels and sound insulation in buildings with different occupancies, such as residential, educational, hospital, industrial, office buildings, hotels, hostels, laboratories, test houses and other miscellaneous buildings.

This Section also includes the following aspects:

- Design techniques for noise control of building services
- Guide for noise calculation, specifications for sound insulation and noise rating
- Examples of special problems requiring expert advice.



Section 5 Installation of Lifts, Escalator and Moving Walks



This Section covers requirements for planning, design, installation, operation, maintenance and inspection of lifts (passenger, goods, hospital, service, dumb waiter lifts), escalators and moving walks so as to ensure safe movement of people with satisfactory performance. This Section has been subdivided into two Subsections namely, 5A Lifts and 5B Escalators and Moving Walks.

The two Subsections include the following:

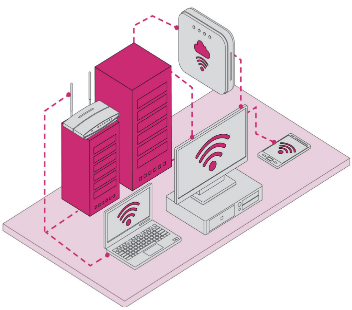
- Design arrangements and planning
- Civil and electrical requirements
- Fire protection requirements
- Minimum technical and safety requirements
- Performance requirements
- Inspection and maintenance
- Typical checklists for inspection.

Additional requirements specific to lifts include the following:

- Planning of lifts for specific building features (such as special building facilities, basement service, multiple entry levels, non smoking buildings, reserve lifts and zoning/sky lobbies in very tall buildings) and for different building types
- Specific requirements for lifts in high rise buildings and evacuation lifts
- Technical requirements for lifts in super high rise buildings
- Special lifts such as lifts without conventional machine rooms (MRL lifts), lifts used in private apartments (home lifts), hydraulic lifts, lifts with seismic resistance features.

The installation of lifts are carried out in conformity with Lift Acts and Rules, as amended from time to time.

Section 6 Information and Communication Enabled Installations



This Section covers the essential requirements for information and communication enabled installations, technology systems and cabling installations in a building. It also covers the basic design and integration requirements for telecommunication spaces within building(s) along with their cabling infrastructure, their pathway components and passive connectivity hardware.

For more details on Part 8, please refer to NBC 2016

Part 9 Plumbing Services (including Solid Waste Management)

Key Content

This Part has 4 Sections; for water supply, drainage and sanitation, solid waste management and gas supply. All buildings meant for human habitation shall be provided with potable water supply and adequate sanitary facilities.

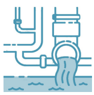
Section 1 Water Supply	Section 2 Drainage and sanitation
Section 3 Solid Waste Management	Section 4 Gas Supply

Based on local Authority's Occupancy Permit for a building, connection from the Water Supply Board and Drainage Board are obtained.

Part 9 at a glance

Section 1 Water Supply

This Section covers basic water supply requirements for different building occupancies along with provisions of plumbing, design, inspection and maintenance of water supply systems. It also includes provisions of water supply systems in high altitude and/or sub–zero temperature regions. Water supply requirements for firefighting, street cleaning and industrial plants are not included in this Section.


Basic principles for designing water supply system


Water supply requirements for different building types

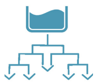

Water sources and quality

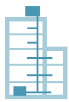

Estimate of demand load

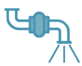

Storage of water

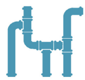

Protection of water supply


Materials, fittings and appliances

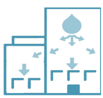

Design of distribution system

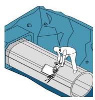

Distribution systems in multi–storeyed buildings


General requirements for pipe work


Jointing of pipes


Backflow prevention

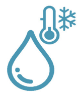

Conveyance and distribution of water within premises


Laying of mains and pipes on site


Hot water supply installations

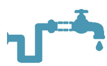

Inspection and testing


Cleaning and disinfection of supply system


Water supply system in high altitudes and/ or sub–zero temperature

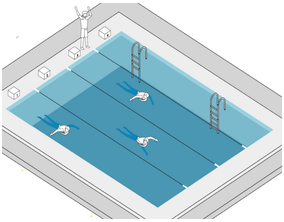

Guidelines to maintenance


Requirement for Swimming pools


Allowance for expansion

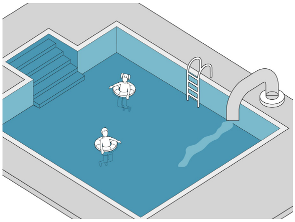
Swimming Pools

Swimming pools covered in National Building Code of India (NBC 2016) are of 3 types.



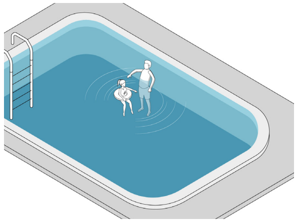
Recirculation

The Recirculation System is based on the nature of usage such as private, public, wading and competition pools. This system is provided to minimize water wastage. Disinfection shall be invariably done to ensure water of potable quality.



Flow Through

Flow Through type of pools require more water for replenishment and so cautious decision of usage of such pools should be made to ensure clear water of potable quality.



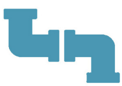
Fill and Draw

Fill and Draw type of pool is not recommended considering water conservation. Clear water of potable quality is retained till it becomes turbid or unfit for use. Thereafter, the pool is drained, cleaned and refilled with clear water.

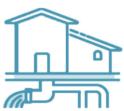
Section 2 Drainage and Sanitation

This Section covers drainage and sanitation requirements for buildings including design, layout, construction, maintenance and connection up to point of disposal such as public sewer, private sewer, individual sewerage disposal system, cesspool or any other approved point of disposal/ treatment. It also includes requirements of drainage system for high altitude and sub–zero temperature regions.

Tables 1– 15 cover drainage and sanitation requirements for different types of buildings.

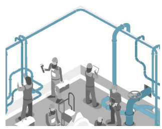


Basic principles of drainage and sanitation



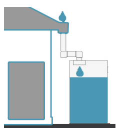
Drainage and sanitation requirements for different building occupancies

Materials, fittings and accessories



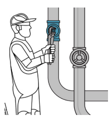
Planning and design considerations

Consideration relating to conveyance of sanitary wastes

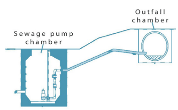


Construction relating to conveyance of rain and storm water

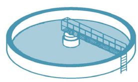
Inspection and testing



Maintenance

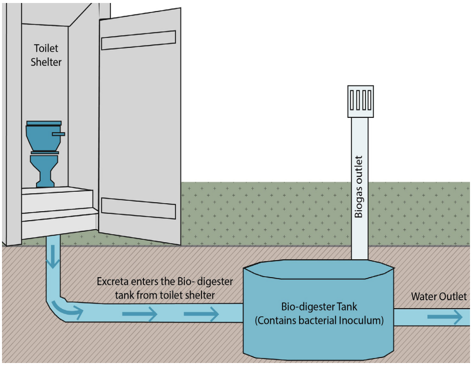


Pumping of sewage



Sewage treatment system

Bio– toilet (or Eco–toilet)



Bio–toilet involves sludge free disposal of human waste. It decomposes solid waste into water and bio–gas. It is eco–friendly, hazard free, requiring least maintenance and is capable of functioning efficiently at sub–zero temperatures.

Bio–toilet is mainly a prefabricated type structure, above the ground with a bio–digester tank below the ground.

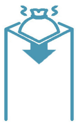
It is useful in situations where sewerage system is not available.

Section 3 Solid Waste Management

This Section comprehensively covers solid waste management system for buildings including assessment of waste generation and its treatment. Additionally, other rules and regulations in force shall be complied with for treatment and handling of solid waste. These rules and regulations are also briefly covered in this Section.

Classification of solid waste based on sources of generation, characteristics, etc.

Considerations and requirements for designing a municipal solid waste management system



Refuse chute system

Assessment of per capita waste quantities for different type of solid wastes

Methods of treatment and disposal

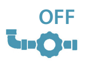
Section 4 Gas Supply

This Section prescribes safety requirements of persons and property for all piping uses and for all types of gases; for usages like fuel, lighting and medical purposes.

Requirements for safe installation of LPG, PNG and medical gas

Requirements for pressure

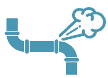
Rules for turning gas on



Rules for shutting gas off

Installation of gas pipes

Inspection of services



Leakage check

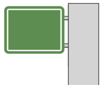
For more details on Part 9, please refer to NBC 2016

Part 10 Landscape Development, Signs and Outdoor Display Structures

Key Content

This Part covers provisions related to landscape planning, design and development and the requirements of signs and outdoor display structures with regard to public safety, structural safety and fire safety. It is divided into following two Sections:

Section 1 Landscape Planning, Design and Development

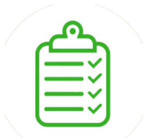


Section 2 Signs and Outdoor Display Structures

Part 10 at a glance

Section1 Landscape Planning, Design and Development

This Section covers requirements of landscape planning, design and development with the view to promoting quality of outdoor built and natural environments and the protection of land and its resources.



Statutory Approvals

Details of documents required for statutory approval of landscape development such as Landscape Master Plan, Irrigation Plan, Planting Plan, Grading Plan, etc.

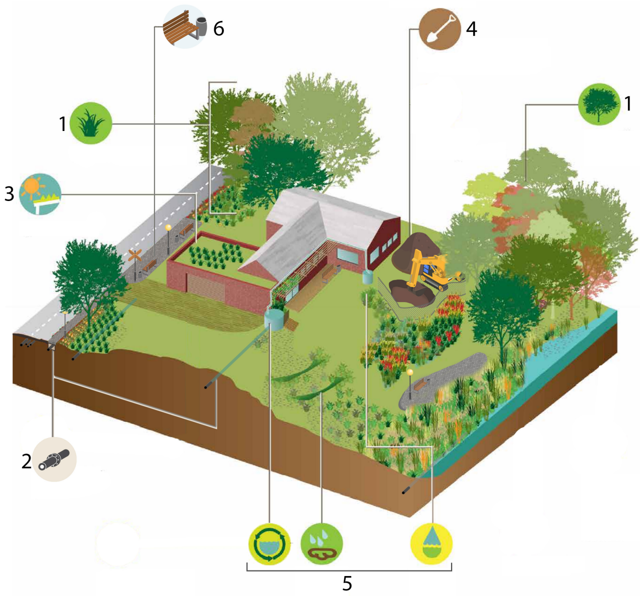
Landscape Site Planning Requirements

Assessment of the landscape requirements for the site including location, site factors, brief, user groups and landscape development for special conditions.

General Landscape Development Guidelines

Design aspects such as structural stability, waterproofing, drainage, soil fill and location of planting for landscaping roof.

Compoments of Landscape Planning, Design and Development



1. Planting Design
Aspects of planting such as ecology, botany, horticulture, aesthetic value, growth and survival patterns which would enable integrated landscape designing.

2. Service/Utilities in Landscape Development
Design integration of structures and elements related to external services (underground and overground utilities).

3. Design Guidelines for Roof Landscape
Aspects such as structural stability, waterproofing, drainage, soil fill and location of planting for landscaping roof.

4. Protection of Landscape during construction
Measures to put in place for minimum disturbance to existing soil conditions and overall micro–climatic pattern during development.

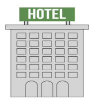
5. Soil & Water Conservation
Post construction practices to be followed with respect to vegetative measures, stormwater management, filtration techniques and conservation & reuse of water for irrigation.

6. Street Furniture
Elements for outdoor spaces such as pavement–pedestrian movement spaces, parking and vehicular movement corridor, traffic management units, public conveniences, shelter and kiosks, illumination, etc.

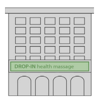
Section 2 Signs and Outdoor Display Structures
This Section covers the requirements of all signages and outdoor display structures for public safety, structural safety and fire safety.

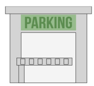
Electric & Illuminated signs


Ground signs

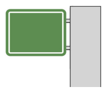


Roof signs

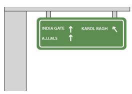

Verandah signs

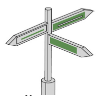


Wall signs


Projecting signs

Marquee signs


Sky signs


Miscellaneous and temporary signs

The signage requirements for Accessibility in Public Buildings and Public Spaces and, Fire safety are covered in Part 3 and Part 4 respectively of NBC 2016.

For more details on Part 10, please refer to NBC 2016

Part 11 Approach to Sustainability

Key Content

This Part covers the parameters required for planning, design, construction, operation and maintenance of buildings and those relating to land development from the point of view of sustainability.

Approach to Sustainability	Siting, Form and Design	External Development and Landscape	Materials
Waste Water Management	Building Services Optimization	Construction Practices	Commissioning, Operation, Maintenance and Building Performance Tracking

Part 11 at a glance

Approach to Sustainability

Planning level

Layout level

Building level

Planning level

- Assessment of natural resources and protected areas
- Water conservation and irrigation practices
- Integration of masterplan and transport plan
- Public and private transportation plan
- Bicycle lanes and pedestrian access
- Discourage subsidized parking in public realm
- Neighbourhood connectivity, walkability and safety
- Ecology of streets
- Planning of water and waste management system

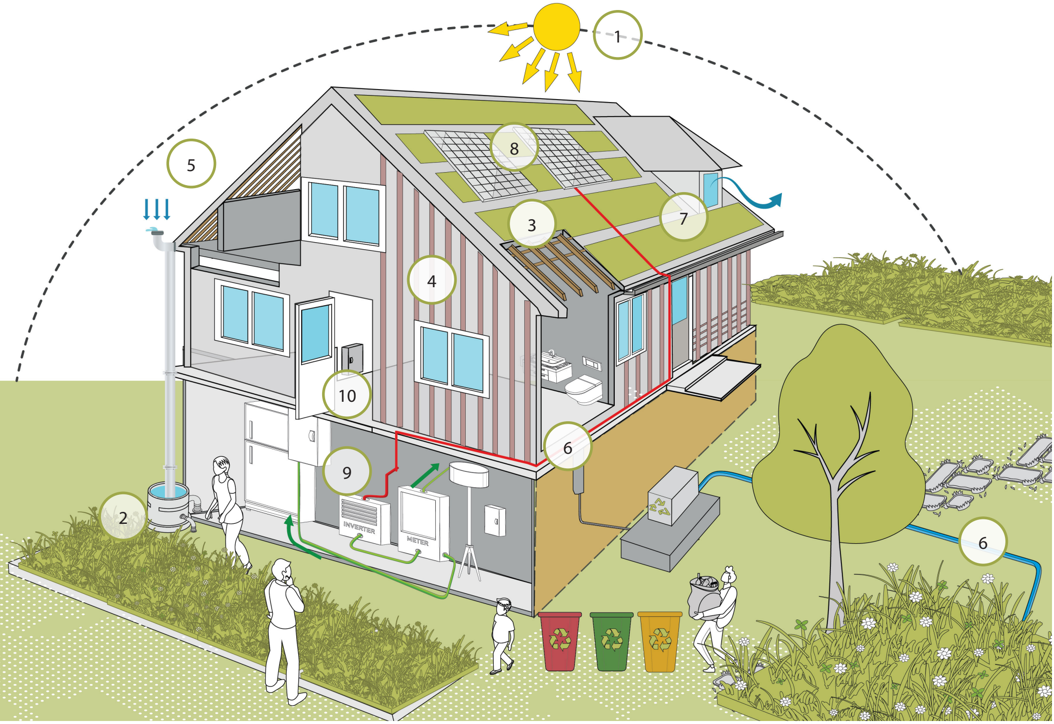
Layout level

- Topsoil preservation
- Environmental Management Plan
- Inclusion of sustainable construction through material and construction management plan
- Landscape development & drainage
- Water conservation
- Rainwater harvesting
- Wastewater management
- Solar energy utilization
- Wind energy
- Undertaking sustainable measures to curb onsite pollution

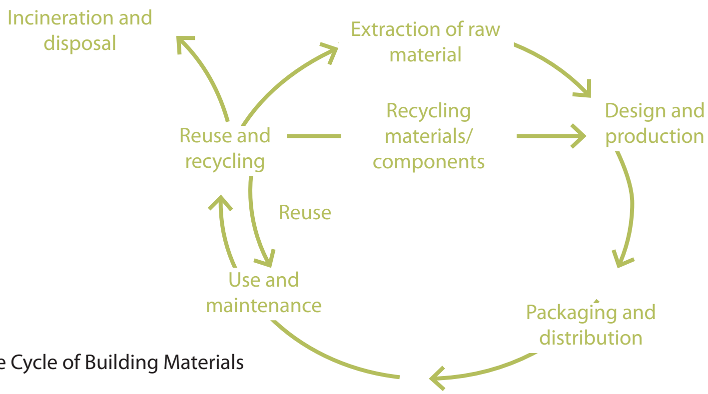
Building level

- Building siting and orientation
- Envelope optimization
- Building services optimization
- Lighting and ventilation
- Sustainable materials– use of alternate and local construction materials embodying low energy consumption
- Maintenance and safe construction
- Solar energy

Commissioning, Operation, Maintenance and Building Performance Tracking



1) Siting, form and design–building oriented optimally based on sun–path analysis
2) External development and landscape–use of vegetation that promotes a regional identity and a sense of place
3) Enhancement on thermal performance of envelope
4) Sustainable building materials
5) Rainwater harvesting
6) Waste water recyclying
7) Natural ventilation strategies
8) Passive cooling/heating techniques
9) Energy efficient electrical system
10) Building performance tracking system



Life Cycle of Building Materials

For more details on Part 11, please refer to NBC 2016

Part 12 Asset and Facility Management

Key Content

This Part covers provisions relating to management of building assets and associated facilities, such as building and building services. It also covers responsibility of facility managers and of occupants for maintenance of facilities, such as structures, equipment and exterior property.

- Asset/Facility Management
- Building Maintenance – Methods and Management
- Building Fabric Maintenance
- Systems Maintenance
- Services Maintenance

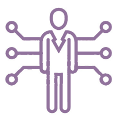
Part 12 at a glance

Asset management is integration of processes within an organization to maintain and develop the agreed services which support and improve the effectiveness of its primary activities.

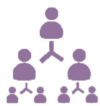
The organizational strategic plan is the starting point for development of the asset/facility management policy, strategy, objectives and plans.

Guiding factors for organizational setup of Asset/Facility Management System

Scope of Work



Competence of Staff at Various Levels

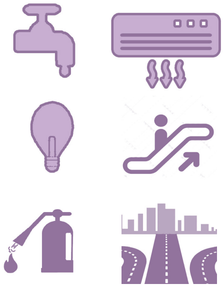


Organization Roles at Various Levels

Facility Manager

Outsourcing

Asset/Facility management can be classified under 2 services

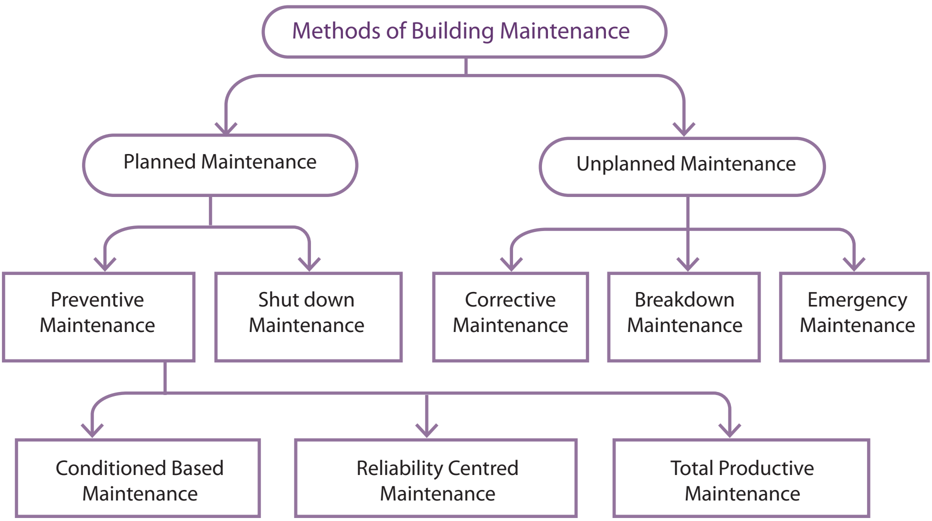


Hard Services

- Building fabric maintenance
- Building services maintenance that includes
  – Plumbing and drainage
  – Air conditioning
  – HVAC services
  – Electrical installations
  – Lifts and escalator
  – Fire fighting–detection and suppression
  – Roads and pathways.

Soft Services

- Landscaping and horticulture waste management
- Housekeeping
- Pest control
- Security management
- Solid waste management.



i For more details on Part 12, please refer to NBC 2016

Notes

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UNIT-5
Part-1
Quality Control

Structure for Discussion

- Introduction
- Concept of Quality
- Factors Affecting Quality in Construction
- Problems for Quality in Construction
- Quality and Cost
- Quality Cost in Construction
- Objectives of Quality Control
- Quality Control Procedures/System
- Quality Assurance Plan
- Conclusion
- Discussion

Introduction

- Derived from Latin word ‘Qualita’ which means what some thing is really like.

- ISO 9004 defines as “the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs”.

- Quality control is the process and mechanism by which the specified quality is achieved.

- Quality costs more, but lack of quality costs even more, so cost of repairing bad quality is high.

Introduction Contd…

- Quality is not grade. An example: Luxurious hotel with poor service or small guest house with excellent services.
- Quality standards do not demand the best quality; they establish the minimum requirements to be achieved.
- Quality control system is like human health, If one of its part is weak, the whole system will suffer.
- For Engineers quality refers “meeting the Specifications and Standards set out in full.”

Concept of Quality

Mathematically,

$$Q=P/E$$

Where, Q= Quality
P= Performance
E= Expectations

If Q>1,the customer has good feeling about the product or service.

The determination of P and E will most likely to based on perception with the organization determining performance and the customer determining expectations.

Concept of Quality Contd..

- **Quality has 9 different dimensions:**
  - Performance
  - Features
  - Conformance
  - Reliability
  - Durability
  - Service
  - Response
  - Aesthetics
  - Reputation

Factors Affecting Quality in Const.

- Quality of design
- Quality of drawings and documents
- Quality of supervision
- Quality of construction materials
- Quality of workers
- Quality of tools and equipments
- Client’s desire to pay
- Management and organization
- Qualification of contractors
- Time period available for construction
- Geographical Location of construction site
- Statutory Regulations

Problems for Quality in Const.

A. Man Related Problems

- Poor communication
- Attitude and behavior
- Training
- High Expectations
- Lack of confidence on employees

B. Material related problems

- Hi-tech desire of the client
- Invention of new materials
- Quality of construction materials supplied

Problems for Quality in Const Cond..

C. Money related problems

- Undue profit motive
- Competition in the market
- Cost of quality control

D. Method related problem

- Poor documentation

E. Minute (Time) related problems

- Pressure for design
- Pressure for contractors
- Testing and commissioning

Quality and Cost

1. **Quality Management Cost**

- Prevention cost: cost involved in activities to ensure right first time performance.
- Appraisal cost: cost involved in activities that check whether right first time is achieved.

2. **Failure Cost:** cost involved in the activities which result from not conforming to the right first time.

Quality Cost in Construction

- Price of Conformance (POC): includes the expenses incurred to ensure that products or services are provided as specified and represents about 3-4% of sales in well run companies.
- Price of Non-Conformance (PoNC): includes all expenses of doing wrong things and amount 20% or more of sales in manufacturing companies and 35% of operating cost in servicing companies.

In construction quality cost is mainly the PoNC

Quality Cost in Construction Contd..

Price of Non-Conformance (PoNC) can be minimized on major categories in general by the following means:

- Establish acceptable criteria for selection of contractors & suppliers
- Introduce the training project personnel
- Motivate site personnel to do right things first time
- Insist that the site personnel check accuracy of any setting out work

Objectives of Quality Control

- To prepare and use good quality construction materials.
- To employ appropriate construction methods.
- To enforce appropriate construction manner.
- To find out the construction defects through the appropriate field inspection/supervision.

Quality Control System

The Quality Control System comprises:

- Methods
- Procedures
- Organization for the Quality Control of the works

Responsibility of Contractor for Quality:

Conformity:

- All material incorporated and all workmanship performed strictly in conformity with the requirements of the Specifications and
- the Contractor shall be responsible for the quality of the works in the entire construction within the contract.

Quality Control System

Responsibility of Contractor for Quality Cond..

Field Laboratory Establishment:

The Contractor shall provide, use and maintain on the Site, throughout the period of execution of the contract:

- a laboratory with adequate laboratory equipment operated by competent staff for carrying out tests required for the selection and control of the quality of materials and for the control of workmanship.
- The list of laboratory equipment to be procured and laboratory facilities to be provided shall be got approved from the Engineer.
- To assume that tests shall be required on all materials to be used in the works and on all finished works or part of works.

Quality Control System

The Contractor's system for Quality Control shall include:

1. Sequence

a. Compliant testing of materials including Laboratory Trials

b. Compliant testing for methods and equipments prior to the commencement of the work , including site trials or trials sections

c. Control testing during construction

d. Acceptant testing on completed works or part of the works

(Quality Control Flow Chart)

The Contractor to carry out all necessary tests and to report to the Engineer the results of such tests before submitting materials and/or finished works or part of works to the Engineer for approval.

In certain circumstances, tests may be carried out at the place of manufacture as per the CoC.

Quality Control System

1. Sequence Contd..

- For satisfying himself about the quality of the works, quality control tests shall be conducted by the Engineer himself or by any other agencies deemed fit by the Engineer.
- Additional tests may also be conducted where in the opinion of the Engineer such tests are needed.
- Before commencement of the work, the Contractor shall demonstrate a trial run of all construction equipment for establishing their capability to achieve the laid down Specifications and tolerances to the satisfaction of the Engineer.

2 The supply and monitoring shall be in compliance with Quality Assurance Plan (QAP) as discussed below:

Quality Assurance Plan

The Contractor to submit to the Engineer for his approval, the QAP, which shall be based on the detailed Program of the Works:

The Quality Assurance Plan shall include the following:

- Quality Control Schedule
- Staff at Laboratory and Organization
- Sequence of the activities
- List of source of materials and Program and supply of materials
- List of tests and quality control procedure to be implemented by sub-contractors
- Monitoring of QAP (Natural and Man made material)

Quality Assurance Plan

Quality Control Schedule:

- The recapitulative test schedule and testing program detailing the list of tests for compliance, laboratory trials, site trials and trials Sections, construction control tests and their frequencies, tests for acceptance of the completed works with their dates.

- Recapitulative list of “critical” acceptance testing procedures, for equipment or parts of the works which corresponds to the tasks on the Critical Path according to the construction Program.

Quality Assurance Plan

Quality Control Schedule Contd…:

- Estimate of the number of tests to be carried out, list and number of appropriate equipment to conduct them, list of tests to be conducted outside the site laboratory, if any, identification of the outside laboratory where proposed to carry out the test.

- Recapitulative list of "critical" acceptance testing procedures, for equipment or parts of the works which corresponds to the tasks on the Critical Path according to the construction Program.

Quality Assurance Plan

Sequence of Activities:

- Prepare a check list for the sequences of activities to be carried for each item of Works (Sequence of activities).

Quality Assurance Plan

Staff at Laboratory and Organization:

- List of staff assigned to the laboratory, their position and responsibilities in the quality control procedures, their qualification and experience, general description and detailed organization of the laboratory activities.

Quality Assurance Plan

List of source of materials and Program and supply of materials:

- The list of sources of materials and/or of manufactured articles, their main characteristics, their identification mode as provided by the supplier when required; the program of supply and procurement of material and/or manufactured articles as per the work schedule.

- Make a location map for sources of natural material.

Quality Assurance Plan

List of tests and quality control procedure to be implemented by sub-contractors:

- The list of tests and quality control procedures to be implemented by the sub-contractors, if any, pointing out the “critical” acceptance testing procedures relating to the Sub-contracted works, which correspond to the tasks on the Critical Path included in the Sub-contracted Works.

Quality Assurance Plan

Monitoring of QAP (Natural and Man made material):

- The Contractor shall monitor and update the QAP on the basis of the decisions taken at the periodic review meetings or as directed by the Engineer and in accordance with the program of the works.

- Based on the Bill of Quantity (BoQ) of the Work item and the frequency of the tests, the required number of tests shall be calculated. The tests carried out shall be compared with the required ones, to monitor the compliance (Monitoring Chart).

Quality Assurance Plan

- The Contractor shall implement the Quality Control in compliance with the approved QAP.

- The Engineer’s approval of the QAP shall not relieve the Contractor from his responsibility of the quality of the Works.

- Nor shall the Engineer’s approval of the QAP exempt the Contractor of any procedure to inform the engineer in writing or request for the Engineer’s approval or re-approval.

Quality Assurance Plan

TESTING PROCEDURES AND SETS OF TESTS:

- For ensuring the quality of the work, the materials and the workmanship shall be subjected to testing in accordance with procedures and sets of tests.

- Frequencies are not restrictive.

- The Engineer shall direct for the tests to be carried out as frequently as deemed necessary that the materials and workmanship comply with their Specifications.

- Where no specific testing procedure is mentioned in the Specifications, the tests shall be carried out as per the prevalent accepted engineering practice or directions of the Engineer.

Conclusion

Poor quality affects:

- Sustainability
- Credibility
- Cost
- Relationship
- Time
- No funding by the Donor
- Membership of WTO

Conclusion

Therefore we should:

- Achieve quality through due effort from all with required sincerity and
- A properly designed and implementable quality assurance plan (QAP)

(Example of QAP)

(For Detail Study Section 500 of Yellow Book)


END

ISO 9000 Quality Standards in Construction

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Abdulaziz A. Bubshait
King Fahd University of Petroleum and Minerals

ISO 9000 Quality Standards in Construction

By Abdulaziz A. Bubshait,[1] Member, ASCE, and Tawfiq H. Al-Atiq[2]

Abstract: There is risk involved in any construction project. A contractor's quality assurance system is essential in preventing problems and the reoccurrence of problems. This system ensures consistent quality for the contractor's clients. An evaluation of the quality systems of 15 construction contractors in Saudi Arabia is discussed here. The evaluation was performed against the ISO 9000 standard. The contractors' quality systems vary in complexity, ranging from an informal inspection and test system to a comprehensive system. The ISO 9000 clauses most often complied with are those dealing with (1) inspection and test status; (2) inspection and testing; (3) control of nonconformance product; and (4) handling, storage, and preservation. The clauses least complied with concern (1) design control; (2) internal auditing; (3) training; and (4) statistical techniques. Documentation of a quality system is scarce for the majority of the contractors.

INTRODUCTION

Quality assurance is important in the engineering and construction industry because of the risk involved in any project. The risk involved in not completing the project on time is high, because many external factors will affect the performance of the project. It is vital that a built-in quality assurance system is developed to avoid any inefficiency that could result in poor quality of products and service being delivered to the customer. Everyone involved in the engineering and construction business has, in different ways, benefited from a common approach to quality work. Systematic quality work reduces the costs of failure in one's own work and in the final product. The standards can make quality work more efficient by creating uniformity. A contractor's in-house quality assurance system is of utmost importance; it prevents problems and their reoccurrence and allows his or her clients to relax. One of these quality system standards is the ISO 9000 standard, which has been adopted by a large number of countries around the world and is applied in various industries including engineering and construction.

Quality systems involve internal and external aspects. An internal quality system covers activities aimed at providing confidence to the management of an organization that the intended quality is being achieved. This is called a ''quality management system.'' Successful implementation of quality management systems can contribute to an increase in product quality, improvements in workmanship and efficiency, a decrease in wastage, and increased profit. An external quality system covers activities aimed at inspiring confidence in the client that the supplier's quality system will provide a product or service that will satisfy the client's quality requirements. This is called a ''quality assurance system.'' The quality system can work effectively only when the top executive responsible for engineering or production takes full responsibility for interpretation and implementation of the quality assurance program. A contractor's quality assurance system is very important to her/his clients, who will gain confidence that ''getting it right the first time'' will be the contractor's norm.

In Saudi Arabia, the large volume of construction projects, in term of numbers and size, has led giant, multinational construction contractors to the local market and created intensive competition. Although quality systems are relatively new in Saudi Arabia, especially in the construction industry, the concept is receiving the utmost attention from large construction companies who seek a competitive edge.

The quality systems of 15 major construction contractors in Saudi Arabia were assessed using the ISO 9001 standard requirements. This paper reports the findings of the assessment. The level of implementation and contractors' perceptions are also discussed.

BACKGROUND

ISO 9000 is an international standard intended to provide the generic core of a quality system standard ap-

[1]Assoc. Prof., Dept. of Constr. Engrg. and Mgmt., King Fahd Univ. of Petr. and Minerals, Dhahran 31261, Saudi Arabia. E-mail: bushait@kfupm.edu.sa

[2]Mech. Engr. and Quality Lead Assessor, Inspection Dept., Saudi Aramco, Dhahran 31311, Saudi Arabia.

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plicable to a broad range of industries and economic sectors. It outlines how a supplier can establish an effective quality system that will demonstrate commitment to quality and ability to meet customer requirements. ISO 9000 is based on, and is almost identical to, the American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME) NQA-1, Quality Assurance Program Requirements for Nuclear Facilities, 1989 (Reedy 1994).

The acceptance of ISO 9000 standards in the construction industries is not as wide as in other industries, such as manufacturing. There are special features in the construction industry that limit the implementation of the ISO 9000 standard. The following are some of these features (Phenol 1994; ''Quality'' 1992):

- A construction project is usually a unique collection of people, equipment, and materials brought together at a unique location under unique weather conditions, while most manufacturing is a system of mass production wherein all of these factors are consistent with producing typical products over and over again.
- Performance testing in construction is generally not feasible as a basis for acceptance.
- It is common to have separate contracts for design and construction.
- It is not feasible to reject the whole constructed project after completion while attached to the purchaser's land.
- Decisions to reject a defective part of a constructed project need to be taken promptly before succeeding parts are constructed or installed.
- The number of parties involved in the constructed project's procurement are more than those involved in manufacturing procurement. Achieving quality construction requires effort from all parties. This makes the interface and responsibilities of the various individuals and organizations more complicated than in manufacturing.
- The organizational structure of a construction company varies depending on the nature of the project, while the same structure in a manufacturing company is almost unchanging. This affects the smoothness of communication and interface between the responsible individuals.
- Turnover of manpower in construction is higher than in manufacturing, which affecting the precision of long-term plans.
- Construction projects are very complicated and their execution may take years.

The generic nature of the standards often leads to differences in interpretations. In turn the implementation, use, and impact of ISO 9000 standards can vary from company to company and from country to country. The concept of ISO 9000 has been viewed in various ways; as a means of improving the overall quality of operations; as the requirements of customers to be complied with; as a necessary response to competition; as a way to reduce cost; as a means to improve the flow of activities and coordination in the organization; as a strategy to have better sales through an improved quality image; as a way to maintain competitive edge in the industry, etc. (Bhuian and Al-Zamil 1996; Lamprecht 1992). Thus, the impact of ISO 9000 standards may vary depending on how it is perceived by companies.

Case Study

With the help of the Chamber of Commerce, 34 major construction contractors—located in the Eastern Province of Saudi Arabia—were identified for the study. The selected contractors were contacted and introduced to the scope of the study. Only 15 contractors agreed to participate in the study, since each has some form of a quality system. The acute sampling problems in Saudi Arabia compel researchers to adopt nonprobabilistic sampling methods in most of the surveys (Al-Meer 1989). Because this study is adopting a nonprobabilistic sample, the sampling of 15 contractors was judged sufficient for an exploratory study. Table 1 lists the contractor numbers, years of experience, number of employees, specialty, and position of the contacted person. The annual construction volume data is not listed in the table, since some con-

TABLE 1. Contractors' Background Information

Contractor number (1)	Years in business (2)	Number of employees (3)	Construction type (4)	Position of contacted person (5)
1	4	700	electrical, piping, piping mechanical, structural steel	General Manager
2	35	6,346	civil, structural steel, piping mechanical, electrical	QA Manager
3	34	1,000	mechanical, electrical civil	QA/QC Engineer
4	23	80	reinforced concrete and steel work	Projects Manager
5	40	4,000	petrochemical, refining, desalination, process control	QA/QC Manager
6	49	1,000	roads and civil	Business Manager
7	16	2,100	buildings, mechanical, electrical, and HVAC	QA Manager
8	25	1,000	mechanical, electrical, and instrumentation	QC Manager
9	5	450	mechanical, piping, and tanks	Business Manager
10	35	1,500	buildings (schools)	Operations Engineer
11	17	475	building, civil	Projects Manager
12	20	600	mechanical, electrical, civil	Projects Managers
13	8	3,000	buildings, structural steel	QC Manager
14	40+	2,500	mechanical, electrical, civil	Procurement Manager
15	29	425	roads, sewer	Projects Manager

tractors feel it is preparatory information. All of the companies are Saudi-owned companies with Westerner management staffs.

The assessment consisted of personal structured interviews with key representatives and inspection of documents. Each interview took between 2 and 4 hours. A questionnaire form was used as a checklist. The questionnaire consists of two parts, the first part being general and intended to get information about the contractors general interest in and perception towards the ISO 9000 standards. The second part asks specific questions about the ISO 9000 clauses (Table 2 lists the clauses). Contractors were asked if they have a means in their quality system that satisfies each ISO 9001 clause, and whether these means are documented and implemented. Contractors' input was evaluated and rated according to the following criteria:

- A contractor who has a system that fully complies with the respective clauses of the ISO 9001 standard was rated ''Y'' and given a value of 1.0 point.
- A contractor who has a system that partially complies with the respective clauses of the ISO 9001 standard was rated ''NF'' and given a value of 0.5 points.
- A contractor's system that did not meet the requirement of the ISO 9001 standard was rated ''N.'' It was given a value of 0 points.

For each clause, the three aspects (i.e., ''existing,'' ''documented,'' and ''implemented'') were totaled based on the above rating system. The term ''existing'' indicates the presence of the clause in the organization system either documented and/or implemented or not. The term ''documented'' indicates the knowledge and proper procedural documentation of that cause irrespective of

TABLE 2. ISO 9001 Clauses

Clause number (1)	Title of clause (2)	Remarks (3)
4.1	Management Responsibility	
4.2	Quality system	
4.3	Contract review	
4.4	Design control	
4.5	Document and data control	
4.6	Purchasing	
4.7	Purchaser supplied product	
4.8	Product identification and traceability	
4.9	Process control	
4.10	Inspection and testing	
4.11	Inspection measuring and test equipment	
4.12	Inspection and test status	
4.13	Control of nonconforming product	
4.14	Corrective and preventive action	
4.15	Handling, storage, packaging, and delivery	
4.16	Quality records	
4.17	Internal audits	
4.18	Training	
4.19	Servicing	Not included
4.20	Statistical techniques	

TABLE 3. Contractors' Compliance with ISO 9001 Clauses

ISO 9001 Clauses		Total	%	ISO 9001 Clauses		Total	%
	Exist	7.5	50		Exist	13.5	90
4.1	Documented	6.5	43	4.11	Documented	7	47
	Implemented	7.5	50		Implemented	13	87
	Exist	9	60		Exist	14.5	97
4.2	Documented	9	60	4.12	Documented	12.5	83
	Implemented	9	60		Implemented	14.5	97
	Exist	14.5	97		Exist	14	93
4.3	Documented	6	40	4.13	Documented	10.5	70
	Implemented	13.5	90		Implemented	13	87
	Exist	3.5	23		Exist	7.5	50
4.4	Documented	0	0	4.14	Documented	6	40
	Implemented	3.5	23		Implemented	6.5	43
	Exist	11	73		Exist	15	100
4.5	Documented	7	47	4.15	Documented	8.5	53
	Implemented	10	67		Implemented	15	100
	Exist	8.5	57		Exist	12.5	83
4.6	Documented	6	40	4.16	Documented	8	53
	Implemented	8	53		Implemented	12.5	83
	Exist	9.5	63		Exist	3	20
4.7	Documented	7	47	4.17	Documented	3	20
	Implemented	9.5	63		Implemented	3	20
	Exist	10	67		Exist	8.5	57
4.8	Documented	7.5	50	4.18	Documented	3	20
	Implemented	10	67		Implemented	7.5	50
	Exist	13	87				
4.9	Documented	9	60	4.19	Not included in the study		
	Implemented	12.5	83				
	Exist	14.5	97		Exist	6	40
4.10	Documented	12	80	4.20	Documented	6	40
	Implemented	14.5	97		Implemented	6	40

whether it is implemented. The term ''implemented'' indicates the knowledge and practice of that clause even though it may not be documented. For example, in the case of clause 4.17 of ISO 9001 (internal quality audit), if a contractor has a system of scheduling and performing internal quality audits, it was rated ''Y'' and a value given equal to 1. If it was found that the contractor does not have any documented procedure for internal audits, it was rated ''N'' and given a value of zero. Finally, if the contractor performed some of the scheduled internal quality audit and did not document the audit findings, it was rated as ''NF'' and given a value of 0.5. The rating of the clauses is shown in Table 3. Then the percentage of the companies complying with the ISO 9000 clauses was determined. A company was deemed to be complying with that particular clause if it had received a rating of ''Y'' in both the ''documented'' and ''implemented'' aspects of the clause. Table 4 lists the most-used and least-used clauses. As examples, the following sections given more information regarding clauses 4.3, 4.10, 4.12, 4.13, and 4.15.

Contract Review (Clause 4.3)

The standard requires that the organization has documented procedures for contract review and for the coordination of activities. Before the acceptance of the contract with the customer, the organization must review the proposed contract to ensure that (1) all requirements are adequately defined; (2) all verbal requirements are

TABLE 4. Most Complied with and Least Complied with ISO 9000 Clauses

Most complied with ISO 9000 clauses	Percentage compliance	Ranking
clause 4.12	80.0	1
clause 4.10	80.0	1
clause 4.13	60.0	3
clause 4.15	53.3	4
Least complied with clauses of ISO 9001		
clause 4.9	46.6	5
clause 4.8	46.7	5
clause 4.7	46.7	5
clause 4.11	40.0	8
clause 4.3	33.3	9
clause 4.16	33.3	9
clause 4.1	33.3	9
clause 4.2	26.7	12
clause 4.6	26.7	12
clause 4.14	26.7	12
clause 4.5	20.0	15
clause 4.20	20	15
clause 4.18	13.3	17
clause 4.17	13.3	17
clause 4.4	0	19

documented; (3) all differences are resolved; and (4) the organization is capable of meeting all contract requirements. One-third of the interviewed contractors reported that they had encountered a problem (during the execution of the projects) due to improper initial reviews of the project contracts. This inadequate contract review caused financial losses because of underestimated or overestimated bidding, and delayed project completion due to the contract's inability to plan for meeting contract requirements.

Inspection and Testing (Clause 4.10)

The main objective of the contractor's inspection and testing is to provide objective evidence that the constructed project and related components meet contract requirements. The top-ranked contractors indicated that inspection and testing activities are performed during all phases of the project—receipt, storage, field fabrication, erection, and upon completion prior to handing over to the client. The inspection and testing procedures specify the quantitative and qualitative acceptance criteria for construction workmanship and materials.

Inspection and Testing Status (Clause 4.12)

The top-ranked contractors have well-documented procedures to identify the acceptability of construction items with regard to inspection and tests performed throughout the construction process. This requirement covers all inspection and testing of materials, equipment, or construction work. The contractors use tags, marks, or routing cards to distinguish between inspected and uninspected construction items. Such procedural practice safeguards against the use of unacceptable materials and against shoddy workmanship.

Control of Nonconforming Product (Clause 4.13)

This clause is one of the most difficult aspects of the quality system because it requires the contractor's personnel to admit openly and in writing that they have done something wrong. This may cause the contractor not to notify the customer. Some of the contractors admitted that the nonconformance reports issued by the quality control personnel are either ignored or overruled by project engineers. This is due to the lack of authority given to the quality control personnel (ISO 9001, clause 4.1.2). Few stated that the nonconformances are undocumented.

One contractor relates the cost of quality to the nonconformance. Whenever a Nonconformance Report (NCR) is issued and the disposition is agreed upon, the value of the problem (i.e., the cost of rework, replacement, project delay, etc.) is calculated and documented on the NCR. Documenting the nonconformance not only serves as a tool to track the problem areas from beginning to end—it also helps in taking corrective measures to prevent reoccurrence of these problems in the future. The historical data developed through documenting the nonconformance occurring during projects can be used to reduce the costs of future projects.

Handling and Storage (Clause 4.15)

All contractors agreed that the packaging, preservation, and delivery required by clause 4.15 applies to products not for construction work. The top-ranked contractors showed evidence that the procured project materials and equipment, when received at the site or during construction, are handled properly and in such a way that their quality will not be degraded because of inappropriate handling, lifting, and rigging. Also, that materials and equipment are properly stored to ensure that they are preserved safely prior to their use or installation in the project.

Assessment Findings

Quality Systems

The quality systems of the contractors vary in complexity, ranging from an informal inspection and test system to a comprehensive system where inspection and testing is only one element among many others. Four contractors have comprehensive, corporate, documented quality systems. The systems of these four contractors are documented in quality manuals and procedures. Ten out of the 15 contractors have limited, project-wide quality control systems. In other words, the quality system in these companies covers only the activities associated with certain projects at the job site. This type of limited quality system concentrates heavily on inspection and testing. One contractor, however, has no formal system.

Registration

Of the 15 contractors, two are registered to the ISO 9002-1994 standard, four are planning to be registered in the near future, and three have hired external consultants to assist in the process of establishing formal quality systems and preparing for registration. The other four contractors are interested in being registered but not in the near future.

The registered contractors and the ones pursuing registration mentioned that the reasons for registration are top management's interest in the standard's potential to improve the quality of their projects, and the current or expected demand from customers. They believed that it is going to be compulsory in the future for public and private contracts. They wanted to be ahead of others when registration becomes a prerequisite for acceptance of bids. Some construction managers indicated that currently there are several international agents, working in Saudi Arabia, that administer registration of companies for ISO 9000. It is possible to ''shop around'' to find the certifying organization that offers the ''best deal.'' As a result, not all ISO 9000–registered companies are following the same requirements and the cost of implementing the program can very tremendously.

Applicability and Benefits

The majority of contractors believe that the ISO 9000 standards are applicable to the construction industry and will be beneficial to their companies. These contractors made no exception to any of the clauses of the standards. Two contractors have some reservations about whether or not the standards add value to the quality of construction projects.

Processes, rather than products or services, are ISO certified. The rationale is that if process management is good, then resultant products or services will also be good. It is important to recognize that some process steps add value, while other activities add cost but provide no value relative to the output of the process. These non-value-added activities include all delays in processing, temporary or permanent storage, inspections, and any rework necessary to meet customer requirements or engineering design specifications. In general, value is added in a process whenever all three of the following conditions are simultaneously met: (1) A desired physical change noticeable by the customer occurs; (2) given a chance, the customer would pay for the activity to be performed; and (3) the activity is done right the first time (Gamsby et al. 1996).

Difficulties Surrounding ISO 9000 Requirements

Six contractors reported that the ISO 9000 standards are not difficult to implement, while other six contractors reported the following difficulties:

- Voluminous amounts of required paper work associated with the documentation of the quality system and its implementation
- Difficulty in controlling the subcontractors
- Difficulty in full implementation of all the requirements, and the possibility of occasional deviation
- Difficulty in understanding the terminology of the standards
- Difficulty in sparing company personnel to undertake an additional workload in order to establish quality system and its requirements
- Lack in ability to afford full-time quality managers and specialists

Obstacles to Implementation

The contractors have identified various obstacles that discourage successful implementation of the ISO 9000 standard in their companies. These are

- High cost, especially initial cost
- Resistance to change at various levels in the organization
- Loss of productivity of the workforce due to the effort exerted in learning the new system and implementation, besides their regular duties
- Management interference
- Limited ability of personnel
- Remote job sites, making it hard to control and track the quality system implementation in all sites
- Communication problems between personnel because of language differences
- Cultural differences within the workforce

Remarks

There are several observations regarding contractor quality systems. These are highlighted below:

- There is a misconception about the objective of the ISO 9000 standards. They believe that it requires only a documented consistent level of quality, whether low or high—i.e., ''write what you do and do what you write.'' This misconception must be replaced by the correct concept, the ''plan-do-check-act,'' where the quality system is continuously monitored and updated to make sure that continuous improvement is achieved and the organization's quality policy objectives are met.

- The contractors who have just started developing quality systems in their companies do not consider setting up priorities in developing the various elements of the quality system.
- Most contractors confuse the understanding and implementation of clause 4.13 (nonconformance) and clause 4.14 (disposition and corrective action). To explain the difference, whenever a nonconforming work is constructed or wrong equipment is installed in the job site, and a decision is made to correct the problem, this is ''disposition.'' When measures are taken to prevent reoccurrence of the nonconformance in the future, this is ''corrective action.''
- Procedure effectiveness evaluations are lacking in the contractors' quality system. The objective of internal quality audits (according to ISO 9000 standards) is to verify implementation and to evaluate effectiveness. In other words, the auditor must not only check if the quality procedures are adhered to but must also check whether the procedures are adequate and effective in achieving quality and quality assurance.
- Setting up priorities is another area of concern, especially for those who have just gotten started with their new quality systems. They should consider their company operations and make a list of priorities, starting with areas needing immediate improvement. It was observed that ISO 9000 consultants look at all quality elements in the same way. It is the role of the contractor's management to identify the priorities for the consultants, and improvement progress should be followed up.

SUMMARY AND CONCLUSIONS

The quality systems of 15 construction contractors were evaluated. The quality system complexity varies from an informal inspection and test system to a registered ISO 9002 quality system. The most appealing reasons for registration are top managements interest in improving project quality and current or expected demand from customers. The ISO 9000 clauses most often complied with are (1) inspection and test status; (2) inspection and testing; (3) control of nonconformance product; and (4) handling, storage, and preservation. Misunderstandings were observed regarding the quality system documentation, method of implementation, and the difference between disposition of nonconformances and corrective actions. Setting up priorities for improvement is another area that contractors are not performing.

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TOTAL QUALITY MANAGEMENT

Contents

Introduction

Total - made up of the whole

Quality - degree of excellence a product or service provides

Management - act, art or manner of planning, controlling, directing,....

Therefore, TQM is the art of managing the whole to achieve excellence.

The concept of TQM

- Produce quality work the first time.
- Focus on the customer.
- Have a strategic approach to improvement.
- Improve continuously.
- Encourage mutual respect and teamwork.

Various Definitions

- Total quality management (TQM) has been defined as an integrated organizational effort designed to improve quality at every level.

- The process to produce a perfect product by a series of measures require an organized effort by the entire company to prevent or eliminate errors at every stage in production is called total quality management.

- According to international organization for standards defined tqm as, “TQM is a management approach for an organization, centered on quality, based on the participation of all its members and aiming at long-term success through customer satisfaction and benefits to all members of the organization and to the society.

Characteristics of TQM

- Committed management.
- Adopting and communicating about total quality management.
- Closer customer relations.
- Closer provider relations.
- Benchmarking.
- Increased training.
- Open organization
- Employee empowerment.
- Flexible production.
- Process improvements.
- Process measuring

Principles of tqm

1. Produce quality work the first time and every time.

2. Focus on the customer.

3. Have a strategic approach to improvement.

4. Improve continuously.

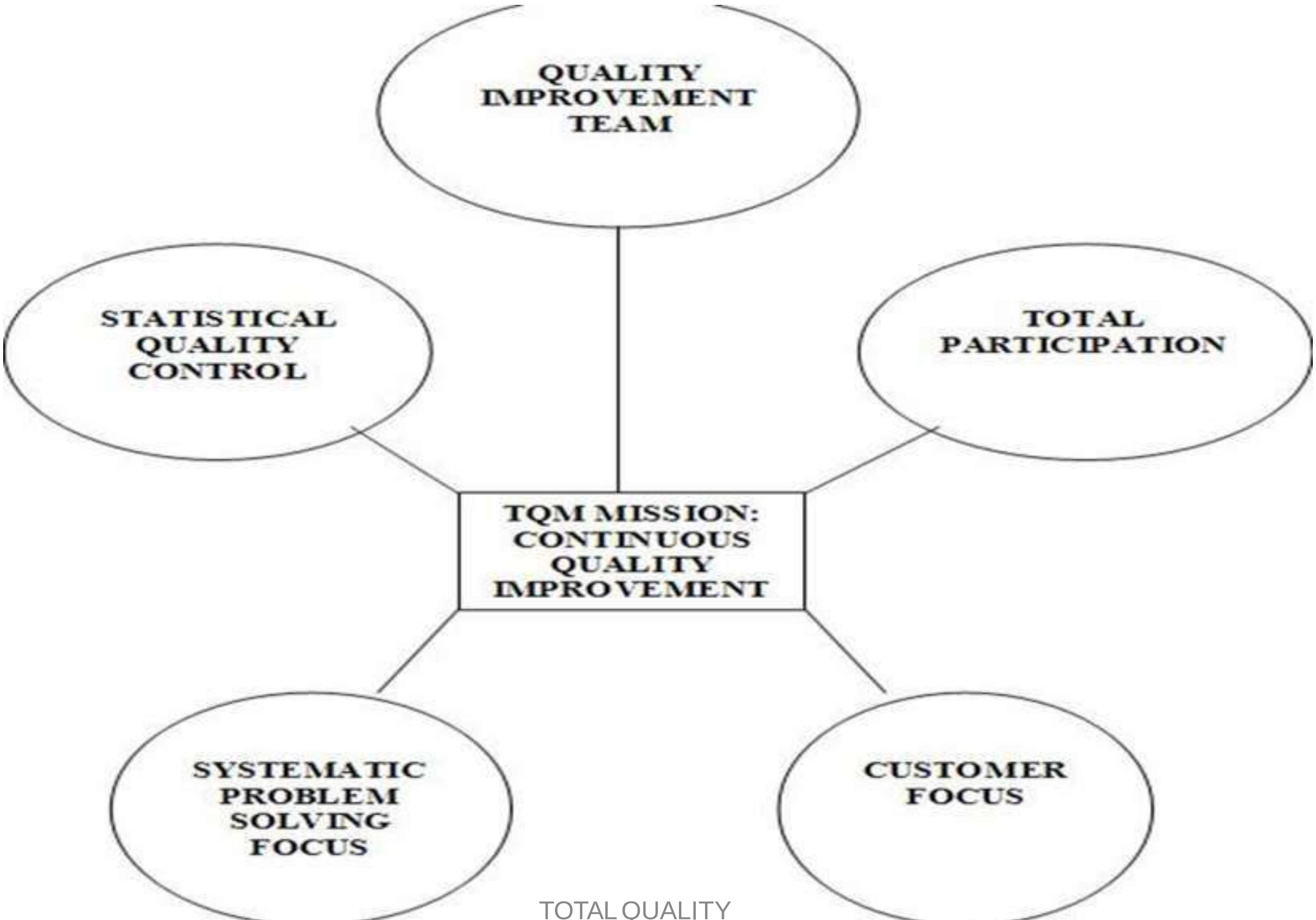
5. Encourage mutual respect and teamwork

The key elements of the TQM

- Focus on the customer.
- Employee involvement
- Continuous improvement

Continuous improvement

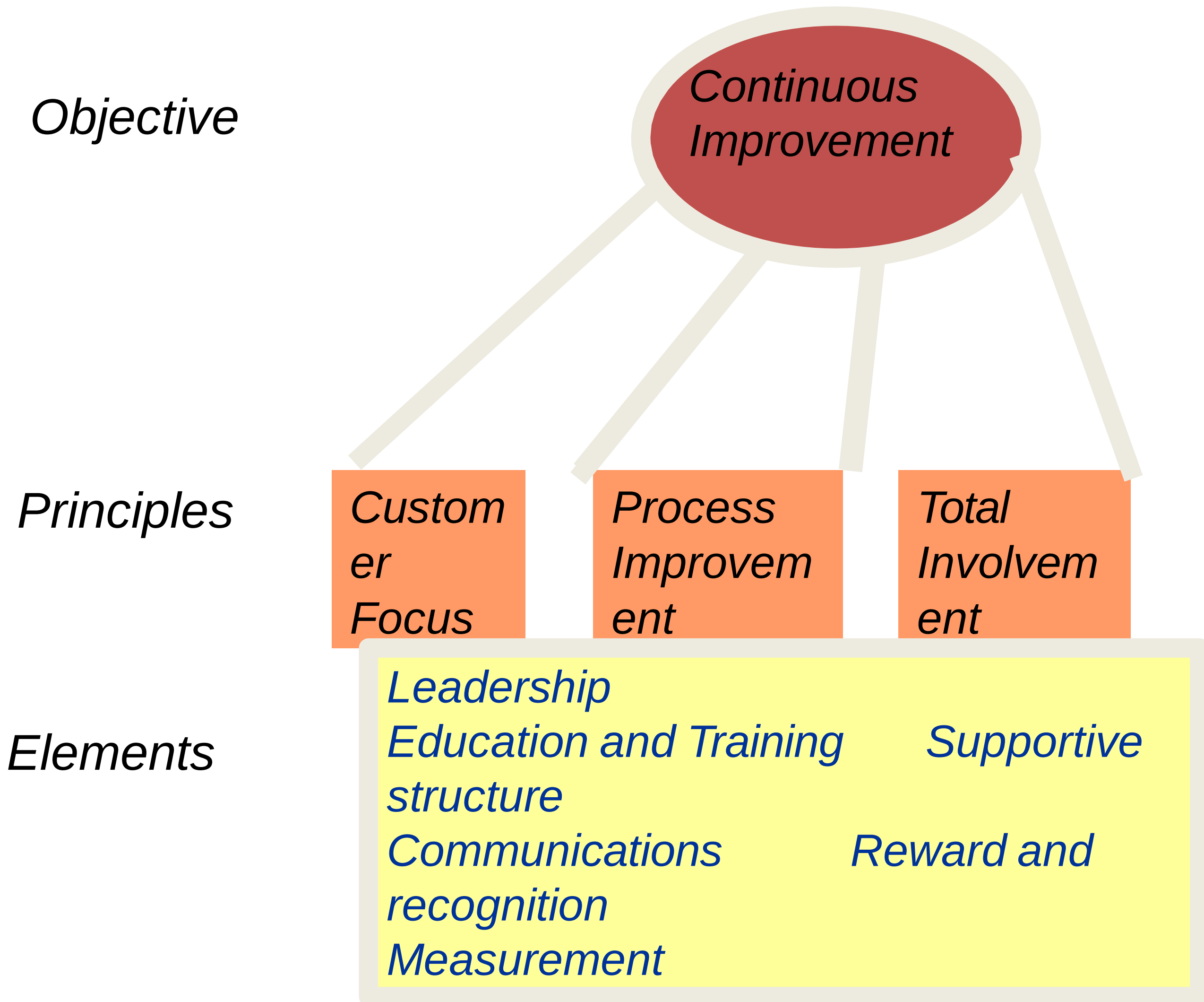
Continuous improvement



CONTINUOUS IMPROVEMENT

- The quest for quality is a never-ending process in which people are continuously working to improve the performance, speed and number of features of the product or service.
- Continuous improvement means that small, incremental improvement that occurs on a regular basis will eventually add up to vast improvement in quality.
- TQM is the management process used to make continuous improvements to all functions.
- TQM represents an ongoing, continuous commitment to improvement.
- The foundation of total quality is a management philosophy that supports meeting customer requirements through continuous improvement.

THE TQM SYSTEM



BENEFITS OF TQM:

- Improved quality.
- Employee participation.
- Team work.
- Working relationships.
- Customer satisfaction.
- Employee satisfaction.
- Productivity.
- Communication.
- Profitability.
- Market share.

Advantages of tqm

- Improves reputation- faults and problems are spotted and sorted quicker.

- Higher employee morale- workers motivated by extra responsibility ,team work and involvement indecisions of tqm.

- Lower cost.

- Decrease waste as fewer defective products and no need for separate.

Disadvantages of tqm

- Initial introduction cost.
- Benefits may not be seen for several years.
- Workers may be resistant to change.

A model for organization management.

Models of tqm

CONCLUSION:

- TQM encourages participation amongst employees, managers and organization as whole.
- Using Quality management reduces rework nearly to zero in an achievable goal .The responsibilities either its professional, social, legal one that rest with the pharmaceutical manufacturer for the assurance of quality of product are tremendous and it can only be achieved by well organised.
- Work culture and complete engagement of the employees at the work place. It should be realised that national & international regulations must be implemented systematically and process.
- Control should be practiced rigorously.
- Thus quality is critically important ingredient to organisational success today which can be achieved by TQM, an organisational approach that focusses on quality as an over achieving goals, aimed at aimed at the prevention of defects rather than detection of defects..


Thank You

Institute of Occupational Safety and Health

Safety Training Presentations

Construction Hazards & Safety Measures

Major hazards of construction

- Falls
- Electrocution
- Being struck by falling objects
- Trapped during excavation

Fall Protection

This section will discuss:

- Conditions that required use of fall protection
- Options available to protect workers

Fall Protection

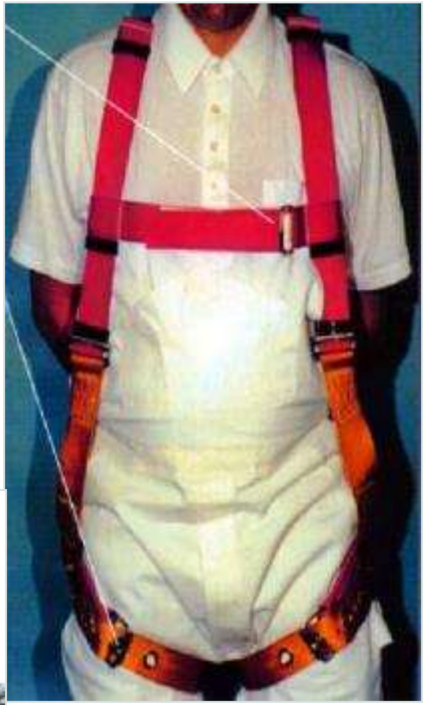
- Falls are the leading cause of fatalities in the construction industry
- Conditions that required use of fall protection
- A fall from as little as 4-6 feet
  - Can cause loss of work
  - In some cases death

When fall protection is needed?

- Walkways & ramps
- Open sides & edges
- Holes
- Concrete forms & rebar
- Excavations
- Roofs
- Wall openings
- Bricklaying
- Residential Construction

Fall protection and prevention options

- Safety Nets
- Hand Rails
- Safety Harness (PFAS)
- Equipment guards
- *Fall protection systems must be in place before work start*

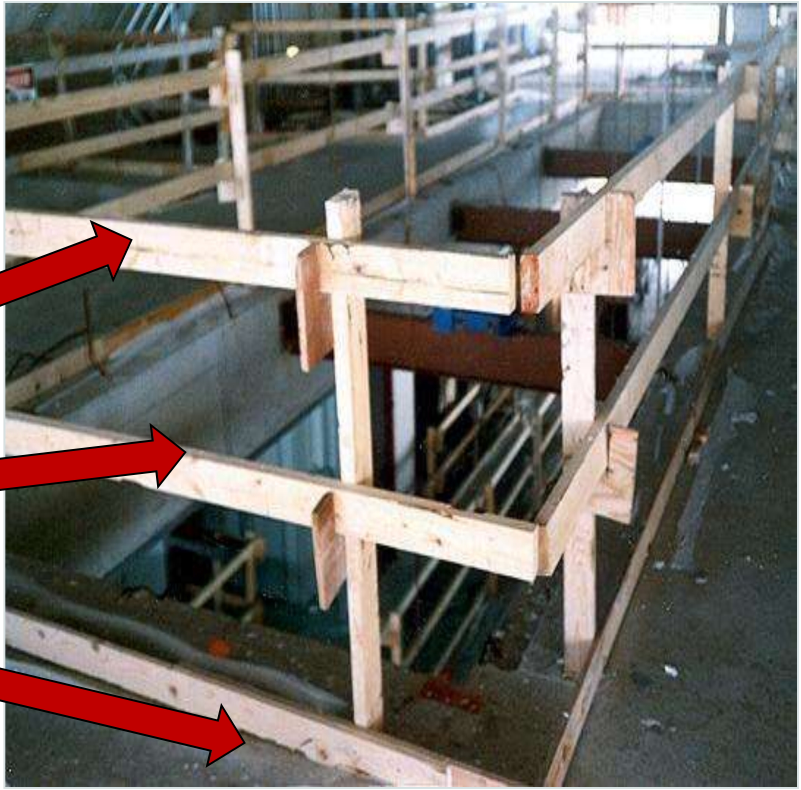


Personal Fall Arrest System, PFAS

- Must be properly trained
- Key requirements
  - No free fall more than 6 feet
  - Must be inspected prior to use
  - Safety line must be able to support 5000 lbs

Guardrails

- Top rail between 39 to 45 inches tall
- Toeboards at least 3 inches tall
  - Top rail
  - Mid Rail
  - Toe board



Safety Nets

- Used to catch falling workers
- Placed not more than 30 FT below work area
- Placed not more than 8-13 ft from edge of working area

Falling Objects

- Hardhats are required
- Use of canopies is authorized
- Barricade the area to prevent unauthorized entry

SUMMARY

- A fall of 6 ft or more protection is needed
- Use fall protection on:
- Walkways, ramps, open sides, edges, excavations,

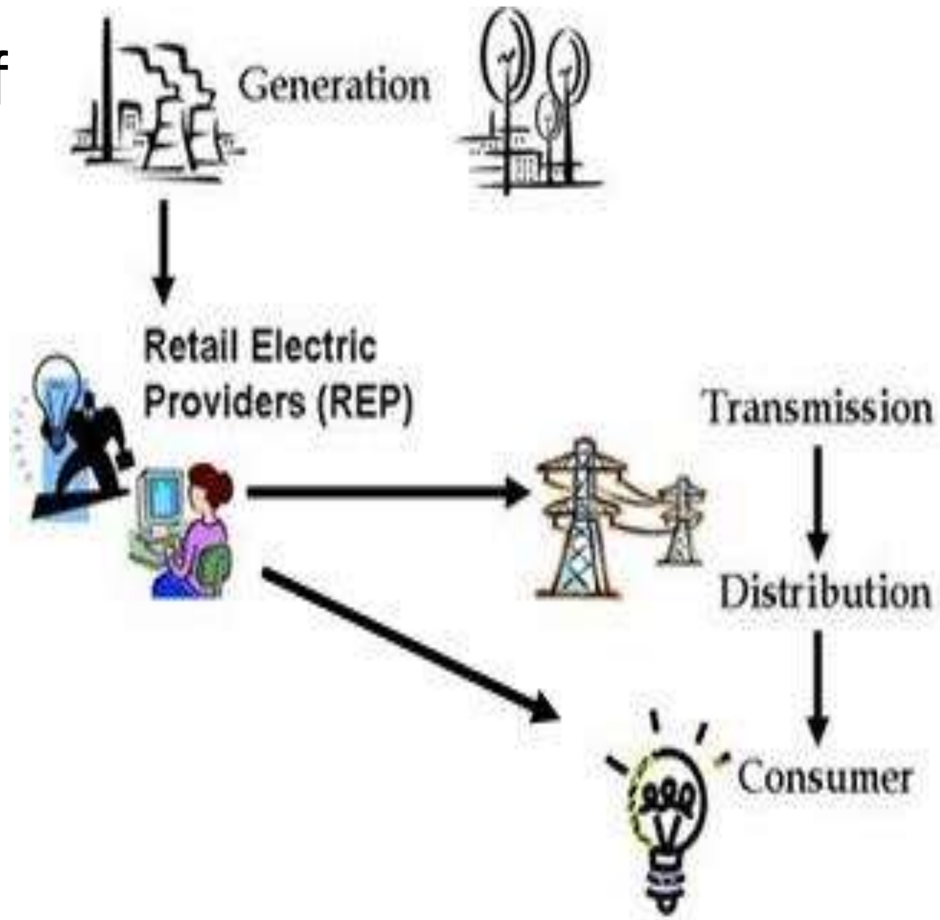
Electrical Safety

This section will discuss:

- Safety requirement
- Hazard prevention and control
- Most common injuries
- Personal Protective Equipment

How it works

- Electricity is the flow of energy from one place to another
- Requires a source of power (generating station, power station or portable generator)
- Travels in a close circuit



Electrical Safety

- Always assume that all overhead wires are energized
- Never touch a down power line
- Never operate electrical equipment while standing in water
- Coming in contact with an electrical voltage can cause current to flow through the body, resulting in electrical shock and burns. Serious injury ***or even death*** may occur.

ELECTRICAL ACCIDENTS
Most Frequent Causes

- Contact with Power Lines
- Lack of Ground Fault Protector
- Missing Ground on electric cords
- Improper use of equipment
- Improper use of electric cords

Electrical Hazards

- Electrical accidents are caused by a combination of three factors:
  - Unsafe equipment and/or installation,
  - Workplaces made unsafe by the environment, and
  - Unsafe work practices

Hazard: Exposed electrical parts

- Isolate electrical parts
- Use guards or barriers
- Replace covers

HAZARD:
Conductors entering boxes

- Shall be protected from abrasion
- All openings shall be closed to prevent access

HAZARD:
Overhead Power Lines

- Usually not insulated
- Carry extremely high voltage
- 80% of all lineman deaths were caused by contacting a live wire with a bare hand.

HAZARD:
Overhead Power Lines (Cont)

- Equipment that could contact power lines:
  - Cranes
  - Scaffolds
  - Ladders
  - Scissor lift

MOST **COMMON** INJURIES

DIRECT	INDIRECT
• Electrocution or death • Shock • Burns	• Falls

Most Common injuries Electric shock/Electrocution

- Electric shock is received when electrical current passes through the body.
  - Can cause severe damage or death.
  - You will get an electrical shock if a part of your body completes an electrical circuit by…
  - Touching a live wire and an electrical ground,
  - Touching a live wire and another wire at a different voltage.

Most Common injuries: Burns

- Most common shock-related injury
- *Electrical Burns, Arc or Flash Burns, Thermal Burns
- Occurs when you touch electrical wiring or equipment that is improperly used or maintained
- Very serious injury that needs Immediate attention

Most Common injuries Falls

- Caused by involuntary electric shock
- Occurs on personnel working in elevated locations (ladder, scaffolds, etc)
- May result in serious injury or death

PERSONAL PROTECTIVE: EQUIPMENT

- PPE should always be first line of defense
- Rubber gloves
- Rubber Insulated work boots,

  Hoods, sleeves or blankets

SAFETY WORK PRACTICES

- Only qualify person should work on electrical equipment
- Use special insulated tools when working on fuses with energized terminals
- Don’t use worn or frayed cords and cables
- Don’t fasten extension cords with staples, hang from nails, or suspend by wire.

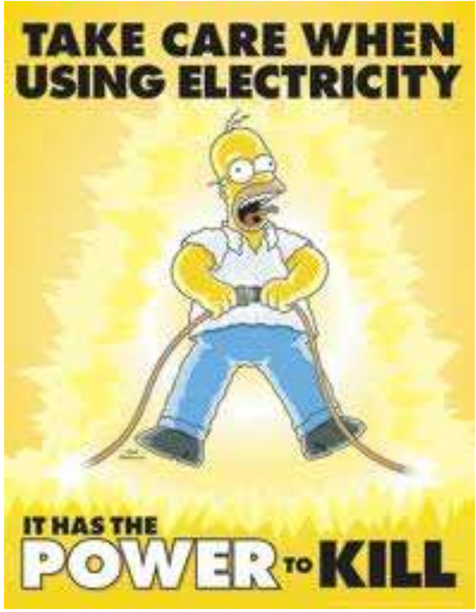
SAFETY WORK PRACTICES

- De-energize live parts before commencing work
- Lock or Tag out circuits (or both)
- Inspect extension cords
- Avoid contact with overhead lines
- Avoid wet conditions
- Check switches and insulation

SUMMARY

Electrical equipment must be:

- Listed and labeled
- Free from hazards
- Used in the proper manner



If you use electrical tools you must be:

- Protected from electrical shock
- Provided necessary safety equipment

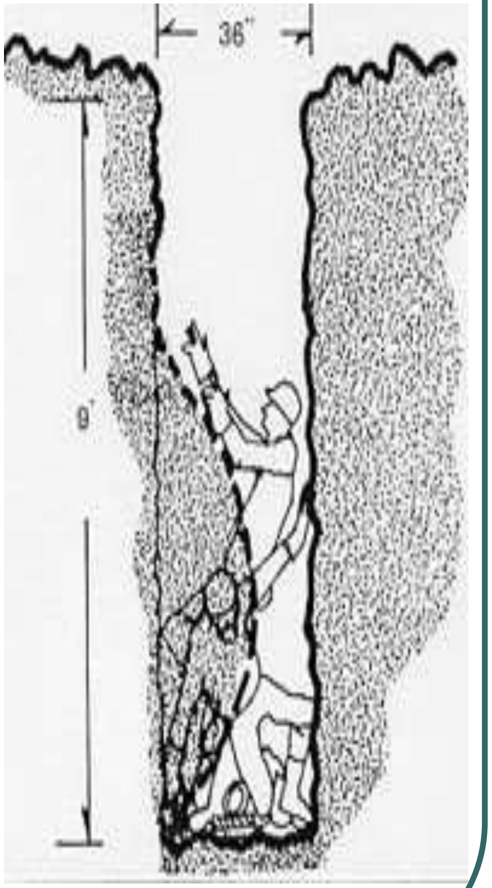
ARE YOU WORKING ON A TRENCH OR DIGGING YOUR GRAVE?

TRENCHING & EXCAVATION HAZARDS

- Risks of excavation
- How to protect employees from cave-ins
- Factors that pose a hazard to employees working in excavation
- Role of competent person

EXCAVATION HAZARDS
Risks

- Most hazardous construction operation
- Cave-ins are the greatest risk
- Most accidents occurred in 5-15 ft deep



EXCAVATION HAZARDS
Employee Protection

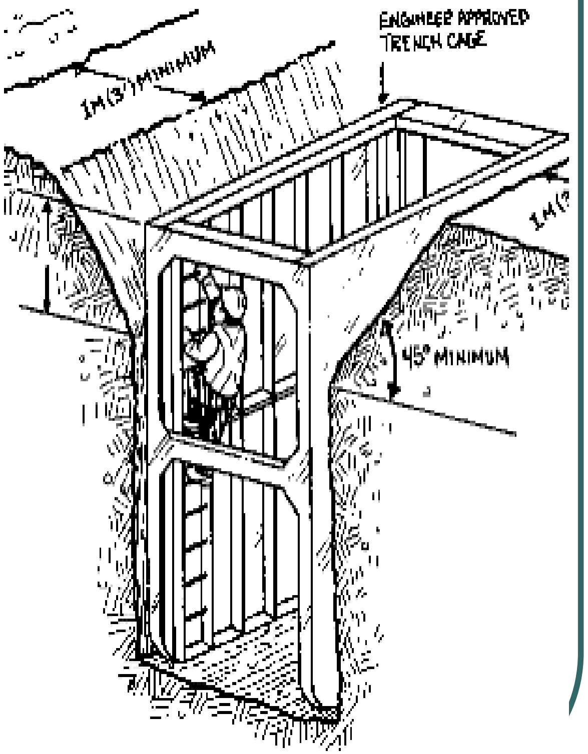
- Employees should be protected from caves-in by using a well designed protective system
- Systems must be able to support expected loads to the system

EXCAVATION HAZARDS Protective System Design

- A well designed system will have a correct design of sloping and benching systems
- Correct design of support systems
- Handle materials and equipment

EXCAVATION HAZARDS
Employee Protection

- Protect employees from potential cave-ins
- Slope or bench sides of excavation
- Place shields between the side of the excavation and work area



Inadequate Worker Protection

Factors that pose hazards to employees

- Soil classification
- Depth of cut
- Water content of soil
- Changes due to weather and climate
- Other operations in the vicinity

Types of Protection Trench Shield

A trench shield was built around this work area

Hydraulic Jacks

Hydraulic Jacks

- Easily dropped in place and adjusted
- Trench pins installed in case of hydraulic failure

Egress Systems

- A stairway, ladder, or ramp must be present in excavations that are 4 or more feet deep, and within 25 feet of the employees
- Must extend 3FT above excavation

EXCAVATION HAZARDS
Competent Person

- Must have had specific training in and be knowledgeable about:
  - Soils classification
  - The use of protective systems
  - The requirements of the standard
- Must be capable of identifying hazards, and authorized to immediately eliminate hazards

EXCAVATION HAZARDS Competent Person

- A competent person must make daily inspections of excavations, areas around them and protective systems:
  - Before work starts and as needed
  - After rainstorms, high winds or other occurrence which may increase hazards
  - When you can reasonably anticipate an employee will be exposed to hazards.

SUMMARY

- The greatest risk in an excavation is a cave-in.
- Employees can be protected through sloping, shielding, and shoring the excavation.
- A competent person is responsible to inspect the excavation.
- Other excavation hazards include water accumulation, oxygen deficiency, toxic fumes, falls, and mobile equipment

References

- 29 CFR 1926 Safety and Health Regulations for construction
- 29 CFR 1926.Subpart E- Personal Protective Equipment
- 29 CFR 1926 Subpart K – Electrical
- 29 CFR 1926 Subpart L – Scaffold
- 29 CFR 1926 Subpart M – Fall Protection
- 29 CFR 1926 Subpart P – Excavations
- 29 CFR 1926 Subpart T - Demolition

A SEMINAR

ON

"SAFETY MANAGEMENT IN CONSTRUCTION INDUSTRY"

- ✓ Introduction
- ✓ Economic Reasons in Construction Industry
- ✓ Major causes of Accidents
- ✓ Approaches to improve construction safety
- ✓ Safety Measures followed L&T Construction industry
- ✓ Conclusion

INTRODUCTION

- Accidents are playing a major role regarding health concern and destroying a life, resulting in an estimated approx. 1.2 million deaths and 50 million injuries worldwide each year.

- Construction industry is high hazardous as compared to other industries. Comparing construction to the other industries , the rate of accidents is higher and is upto six times more.

- construction industry have suffered human and financial losses as a result of the poor safety record and also due to human which can be prevented by Safety Management

Economic Reasons in Construction Industry

Economic reasons may be due direct or indirect costs.

With the help of safety management we can minimize the costs.

Major causes of Accidents

- Electrocutions
- Falls
- Trenching and evacuation
- Struck by

Minor Causes Of Accidents

- Human Behavior
- Difficult Work Site Conditions
- Poor Safety Management practices
- Unsafe Work Methods, Equipment, and Procedures
- Unskilled, Semi skilled workers
- Communication problems
- Speedy jobs, long working hours

Approaches to improve construction Safety

- Rules and recommendations of OSHA
- Learn how to be safe
- Get Visibly Involved
- Provididng Incentives
- Formal Inspections
- Safety meetings regularly
- Safety education
- Research findings
- Regular safety meetings
- Awareness should be stressed by management

SAFETY MANAGEMENT BY L&T CONSTRUCTION COMPANY

- At the greater heights safety nets are provided along the walls for greater safety of the workers.
- It prevents the workers from falling down .

Safety Nets

- Strong scaffolding and centering done to support the workers such that it can take the load of the workers and materials while at work.
- Lacing and bracing are to hold the position of the scaffold
- the type of scaffold selected depends on the strength of the soil.

Scaffolding

Shuttering is employed at the site with at most care to prevent the materials from falling down , thus avoiding any damage or loss .

Shuttering

Electrical safety at the site

- Safety belts are tied to the workers which prevents falling down of the workers.
- It is tied to the life line which in turn is supported either by the hand rail or the scaffold beside.

Safety belts

Handrails satisfy two purposes:

1. To prevent the workers from falling down
2. Life line is tied to the hand rails

Handrails

Sign boards :


నిదానముగా వెళ్లండి
L&T Construction
Stack Materials only with in Barricaded areas.
COMPULSORY KEEP RIGHT

Indicators and alarms should be used while reversing the vehicles.

Indicators and Alarms

- Cranes should be provided with load indicators
- signal man must be employed for

1. Guiding the driver
2. Alerting the workers

Signal man

Cranes

- Bariccation provided for pits below 3m
- placed 2m away from the pit

sign boards are displayed

Excavated grounds

First aid room

Initial treatment is given to the injured persons

Induction room

Workers are given initial training for safety before entering into the site

First aid measures

Safety symbols

Safety Equipments

CONCLUSION

- Produce higher morale
- Improve the company's public image
- Accidents in the construction industry are costly in terms of human life and economy
- Safety management reduce cost and increase productivity
- Reduction in accidents and associated costs are direct benefits to the construction industry.

ACCIDENT PREVENTION

Why do accidents happen?

- Accidents happen because of one or both of the following:

Unsafe acts

Unsafe conditions

Unsafe Acts

- Unsafe acts are actions by people that directly cause or contribute to an accident. Examples are:
  - Horseplay, running
  - Drug or alcohol use
  - Not following procedures – taking shortcuts
  - Unauthorized use of equipment or tools
  - Using damaged equipment
  - Not using personal protective equipment

Unsafe Conditions

- Examples of unsafe conditions are:
  - Damaged equipment
  - Poor lighting
  - Missing machine guards
  - Unsafe atmosphere
  - Slippery floors
  - Lack of proper equipment

Controls prevent accidents

- There are 3 basic types of controls we use to prevent accidents:
  - Engineering Controls
  - Administrative Controls
  - Training Controls

Engineering Controls

- Engineering controls include:
  - Building and equipment design
  - Location and types of machinery controls
  - Machine guards
  - Equipment location and access

Administrative Controls

- Administrative controls include:
  - Hazard identification and analysis
  - Identification of personal protective equipment
  - Specific safety procedures
  - Proper storage of material and equipment
  - Controlled access to hazardous areas
  - Authorization requirements for hazardous operations

Training Controls

- Training is necessary so you know
  - how to recognize, report, avoid and control hazards
  - how to safely use equipment, tools and chemicals
  - how to select, use and store personal protective equipment

Report!

- Any unsafe acts
- Any unsafe conditions
- Any accidents or injuries
- Any near-misses

Inspect!

- Do a daily safety check of
  - your work area
  - your equipment
  - your tools
  - yourself

Be Alert!

- Think about your actions
- Watch out for others
- Know the hazards of your surroundings
- Watch where you walk

Be Accountable!

- Don’t create unsafe conditions
- Clean up spills immediately
- Put things back when you are done
- Keep your work area safe for others

Fire Protection in Construction

INTRODUCTION

- Fire safety can be ensured if flammable materials are kept away from heat and oxygen.
- 3 ingredients of fire are fuel, oxygen and source of ignition.
- If any of them is removed no fire will occur.
- Precautionary measures should be planned before starting any construction work.

Precautionary measures:

- Less use of flammable materials like timber, bamboo, coal, paints etc.
- Quantities of flammable materials should be kept to minimum at work sites.
- Flammable solids, liquids and gases must be stored away from oxygen and oxidizing materials.
- Smoking should be prohibited at fire risk areas of work place.
- Precautions must be taken in transporting, storing, handling and using flammable materials.

- Electrical fires occur due to insulation failure, overloaded conductors and poor connections. Hence, proper care must be taken.
- Fire extinguishers should be kept at strategically convenient points.
- Personnel should be trained to use them.
- Fire tender should remain parked at site round the clock.
- Adequate water should be available for fighting the fire.
- Buckets filled with sand should be kept at appropriate places for smothering the fire.

Fire Detection and Alarm System

- Fire detection cum alarm system detects fire at the earliest stage and alerts the people, hence life and property could be saved.
- A fire detector is designed to detect one of the 3 characteristics of fire i.e., heat, smoke and radiation (flame).
- The type of detector to be installed at a place depends on nature of construction and type of hazard that might take place.

Fire Detection and Alarm System

- Heat detectors:
  - Fixed heat detectors respond when the ambient temperature reaches a high value (like 58 deg etc.)
  - Rate of rise heat detector measures rate of increase in ambient temperature and responds when increase in rate is above normal or when temp reaches 58 deg whichever is earlier.
- Smoke detectors:
  - Ionization smoke detectors respond when smoke enters detector and causes a change in ionization currents in the detector.
  - Optical smoke detector contains a light source and photo electrical cell responds when light is scattered by smoke particles.

- Flame detectors:
  - It is detector that looks over a given area and responds when it detects UV or IR radiation.
  - Because of its inability to detect smouldering fire it is used in specialized applications to supplement heat and smoke detectors.

TEN COMMANDMENTS

Confederation of Indian Industry (CII), Eastern Region concluded the chapter on fire safety by issuing 10 commandments which are as follows:

1. Have a written down fire prevention plan for your company and ensure it is sincerely implemented.
2. Identify and eliminate fire risks or reduce them to the maximum extent possible.
3. Train and retrain your employees in fire prevention and fire fighting.

4. Install suitable fire protection equipment and make sure your employees know how to use it in case of fire.
5. Regularly inspect your fire safety equipment so that it doesn't fail in an emergency.
6. Establish an emergency plan in close connection with the public fire department.
7. Take utmost care while handling flammable materials.
8. Follow good house keeping practices, because a clean house is a safe house.

9. Protect plant against hazards within and outside by having suitable construction.
10. Never violate any fire safety laws.

NBC, Part IV issued by BIS is a comprehensive document covering all aspects of fire safety.

BIS plays a major role in formulating the general standards related to fire safety and fire fighting.

SOME SAFETY RELATED CODES:

- IS:933 – specification for portable chemical foam fire extinguisher
- IS:934 - specification for portable water type fire extinguisher
- IS:2878 - specification for fire extinguisher (carbon dioxide type – portable, trolley mounted)
- IS:8758 – recommendations for fire precautionary measures in the construction of temporary structures and pandals (fabricated structure).