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 resources 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.

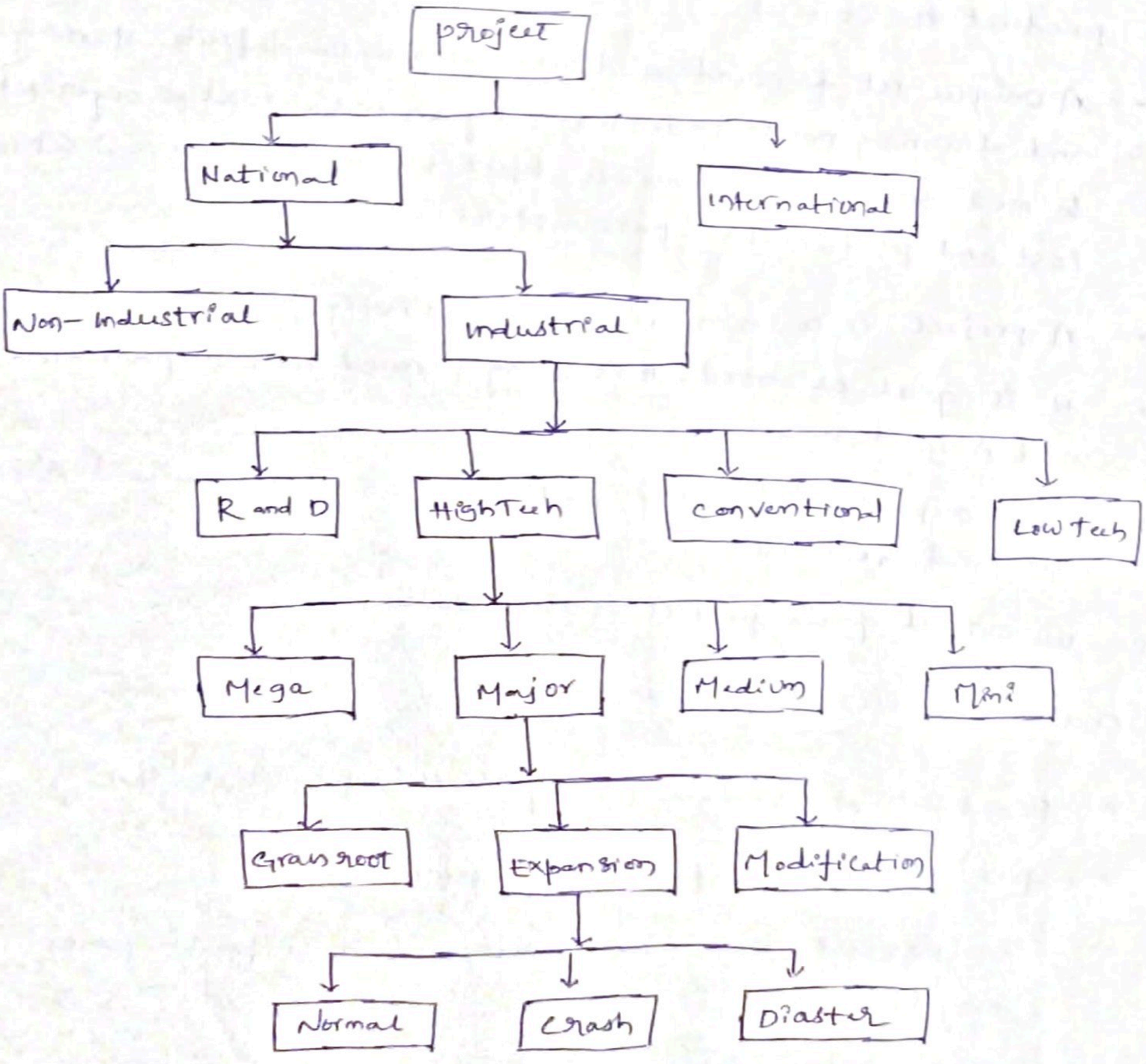
→ All projects are unique, as the people and plans involved in similar projects also are different.

→ 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 cast 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 shat 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 & 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 works 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 identify 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 within which they are to be completed in proper logical sequence

In other words, scheduling is the mechanical proces 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 A.D.

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:

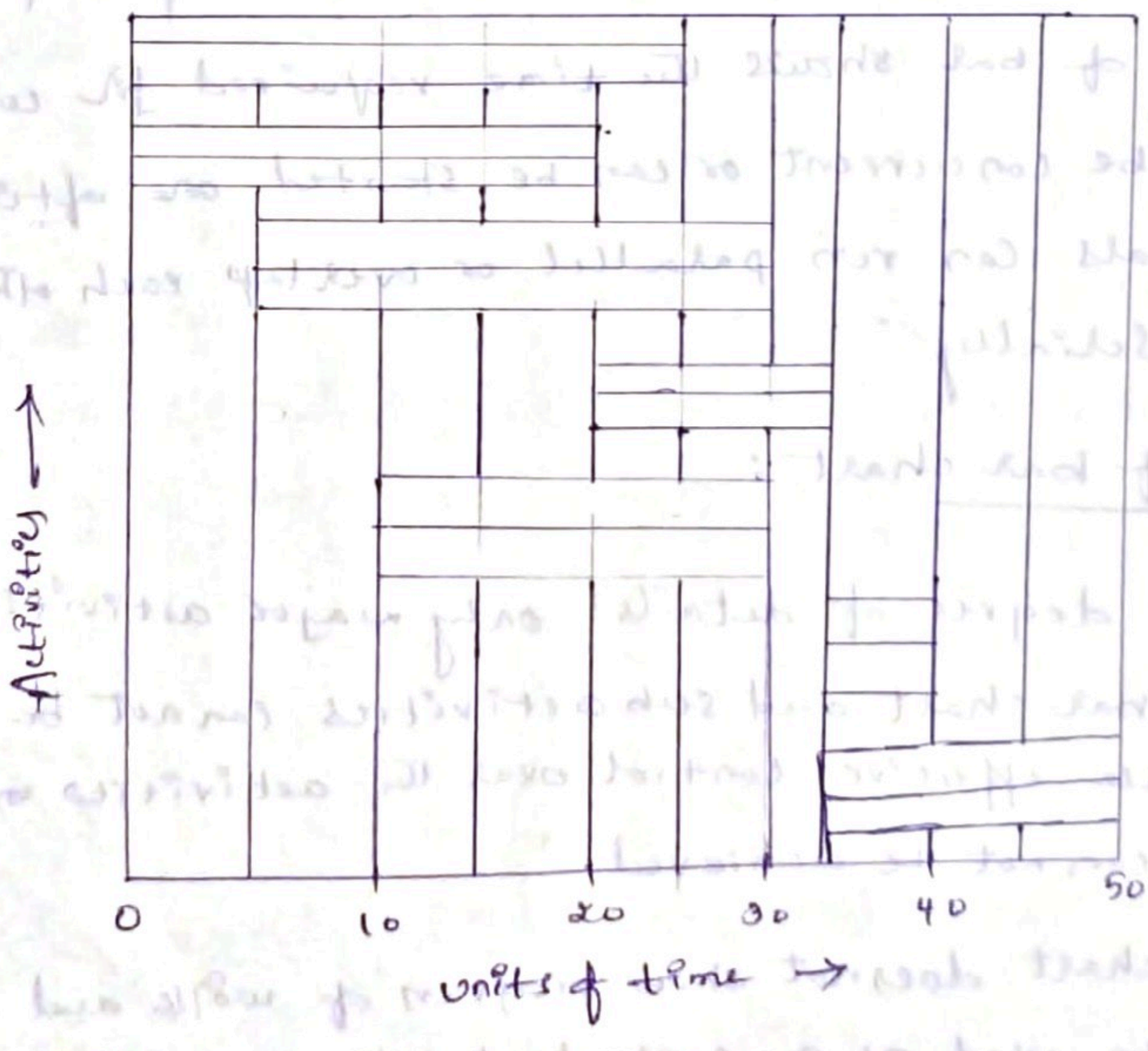
1. Lack of degree of details: only major activities are shown in bar chart and sub activities can not be separated out. Hence effective control over the activities in big projects can not be achieved.
2. A bar chart doesnot show progress of work and hence it can not be used as a control device.

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 cannot 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.



Milestone chart :

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

NOTE: Controlling can be better achieved with the help of milestone charts, but still activity interrelationship and accountability of time uncertainty can not be depicted which can be overcome 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, ONETICS, 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 [07]

1. Inter relationships 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.

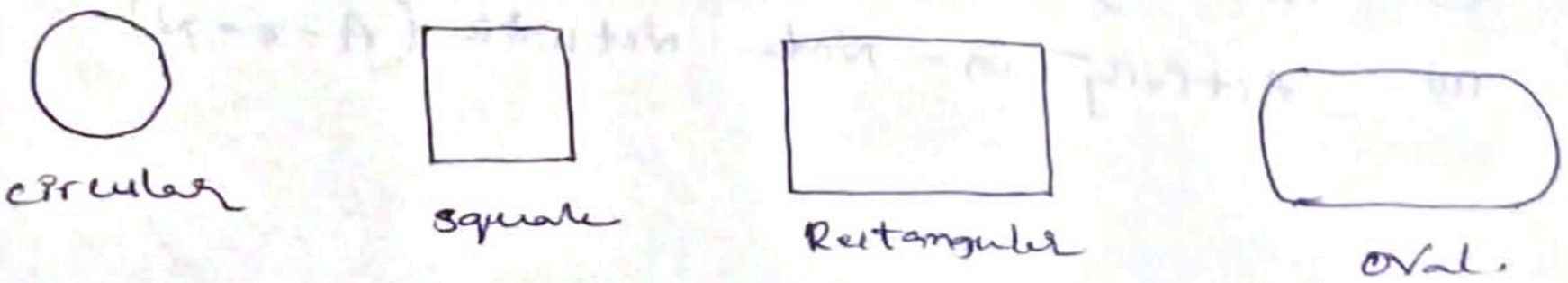
Elements of a Network:

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.

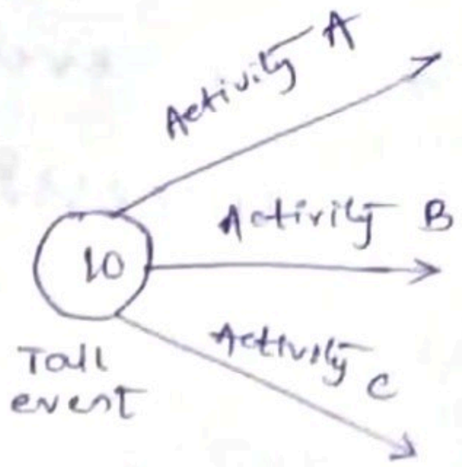


Tail event (or) start event:

→ 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



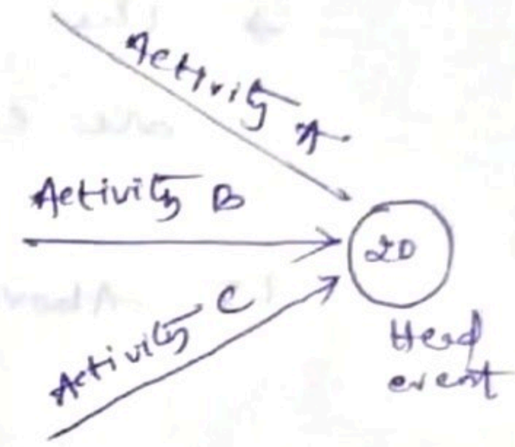
Eg: event 10 is a tail event. Arrows represent job or activity of the project.

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:

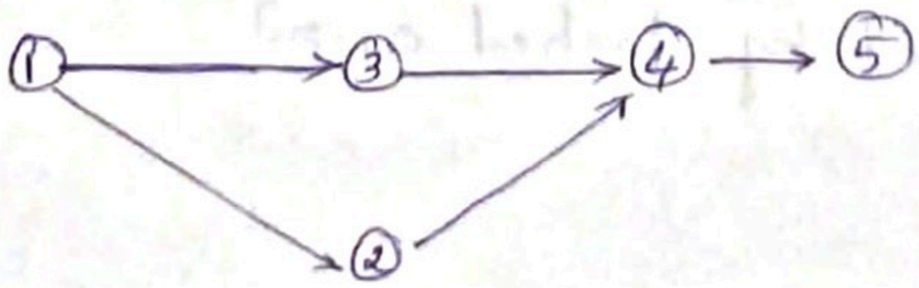
→ When a tail event represents beginning of more than one activity, then the event is said to occur when the first activity starts from it.

→ Similarly, when a head 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.

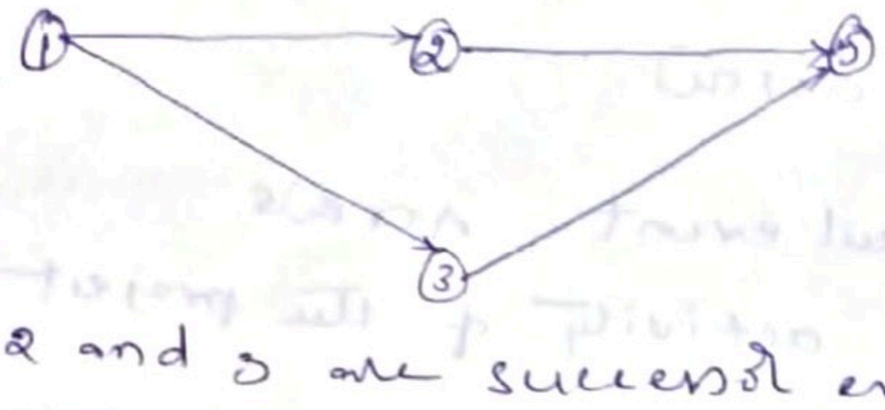
→ They have both incoming and outgoing arrows.



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.

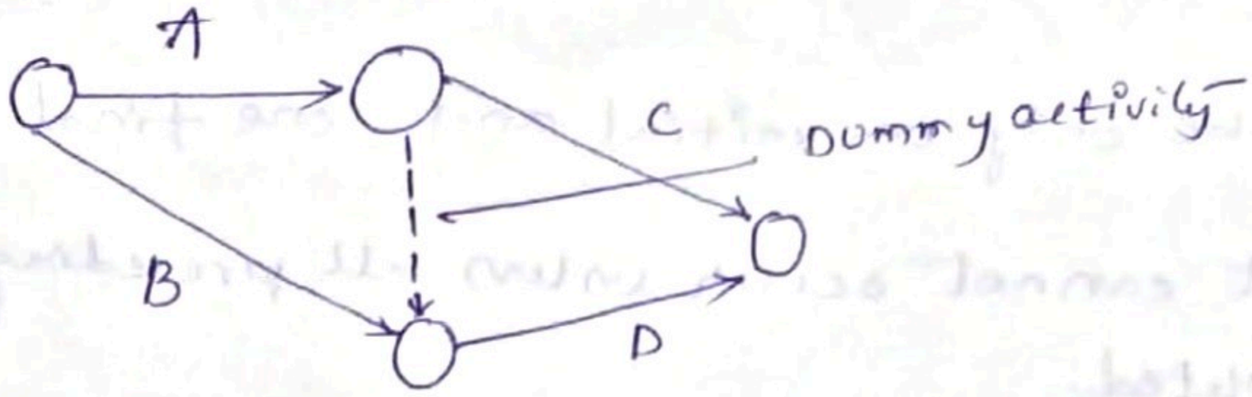
examples of an activity:

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

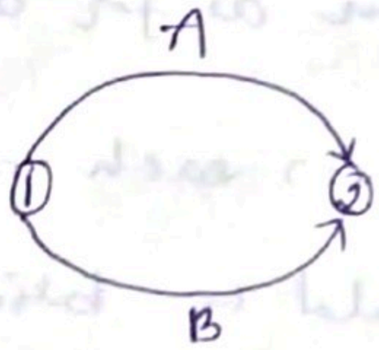


→ Fig. shows, a dummy activity.

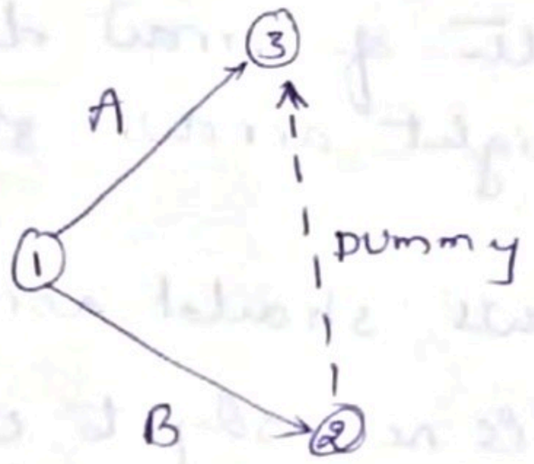
→ Dummy is used to serve following purposes:

↳ Grammatical purpose:

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



(a) Ambiguous Representation

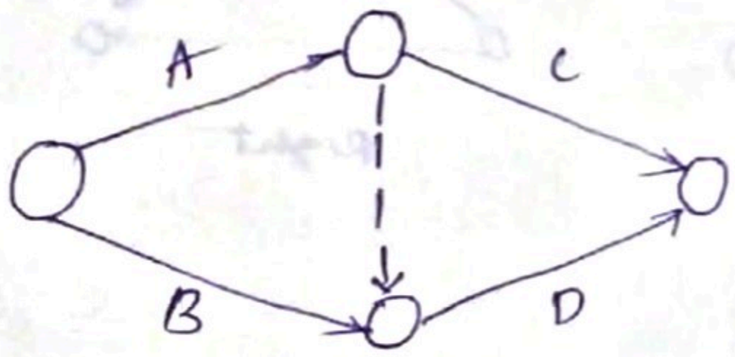


(b) Grammatically clean Representation.

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.

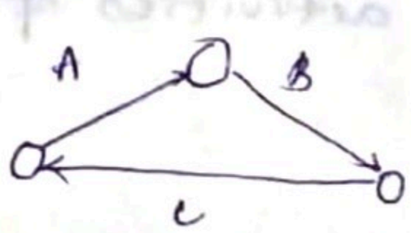


Rules of a Network:

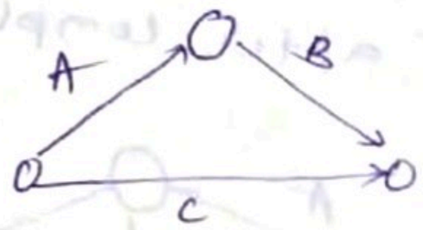
1. There can be only one initial and one final event.
2. An event cannot occur unless all preceding activities are completed.
3. An event can not occur twice
4. Number of arrows should be equal to number of activities
5. Time should always flow from left to right
6. Length of arrow does not show any 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.

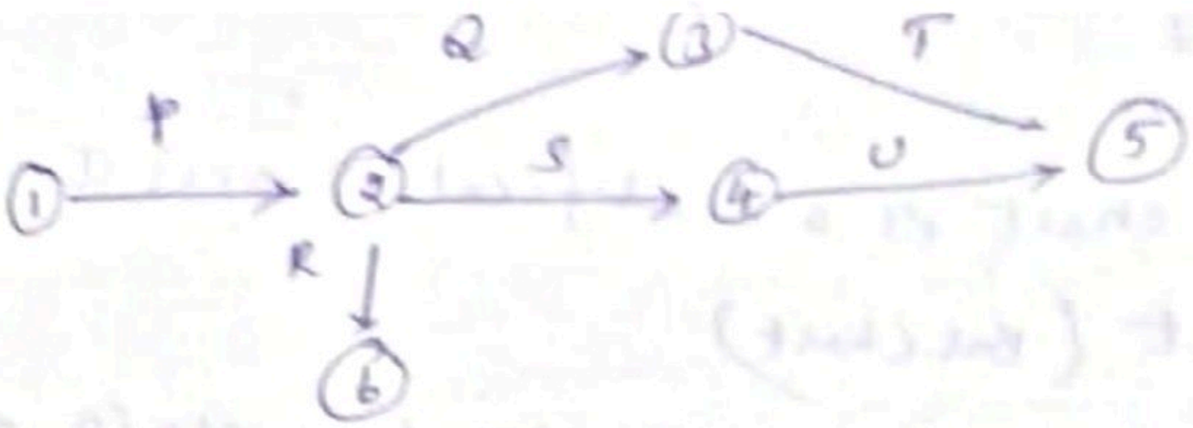


Wrong



Right

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.



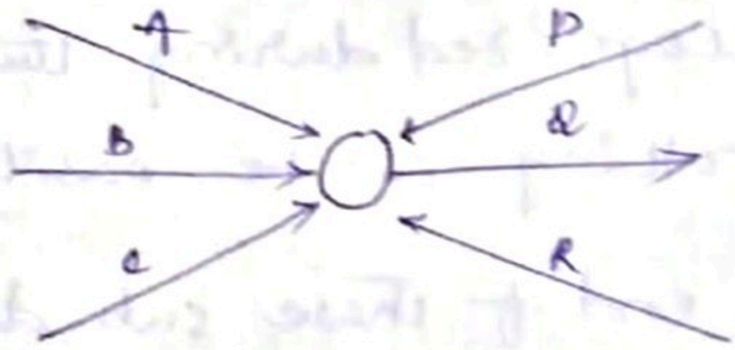
→ To avoid dangling error, the network must be examined in such a manner that all events except initial and final events must have at least one activity entering and one activity leaving them.

Nagon 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.

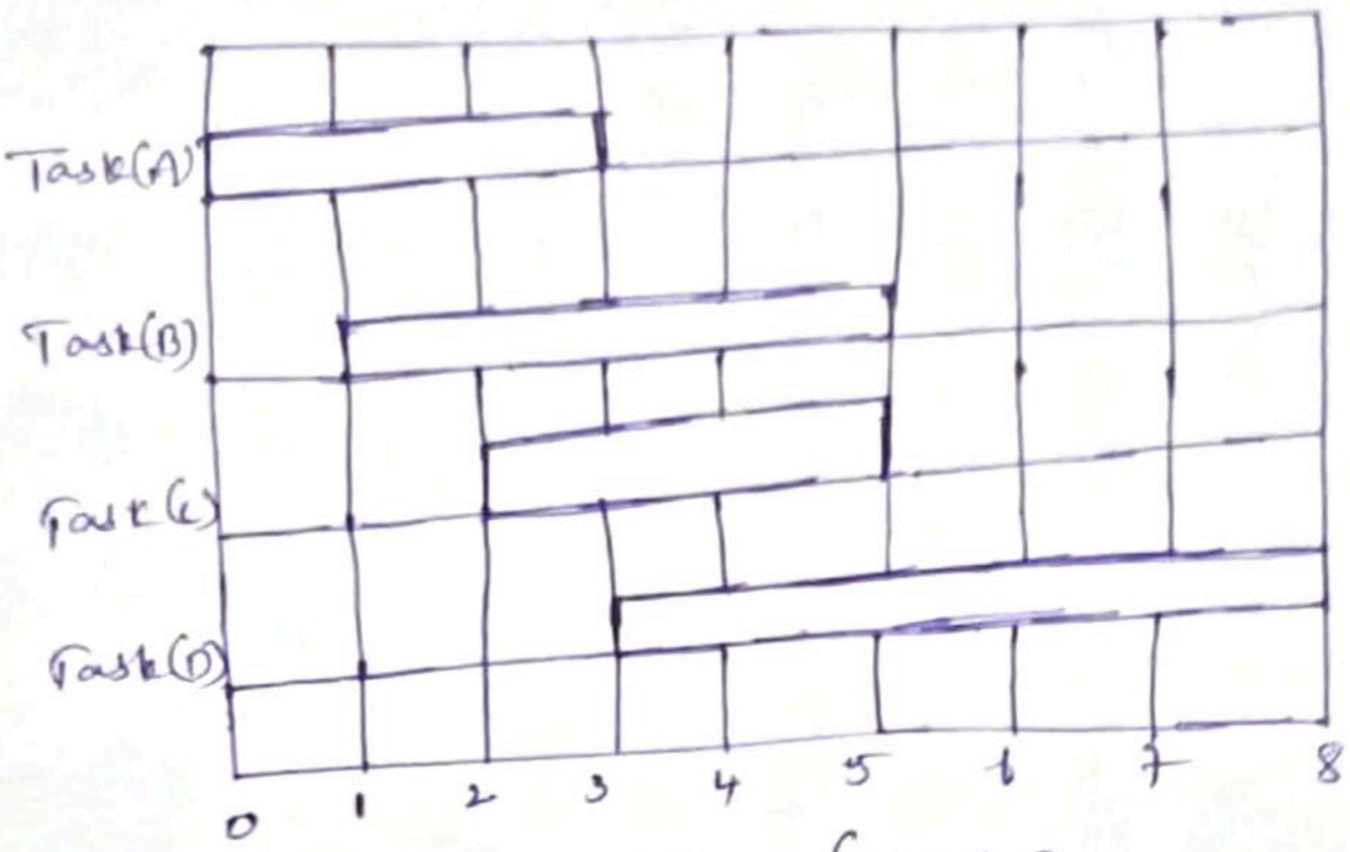
→ There is no error visible in the construction of diagram but logical error has crept into it

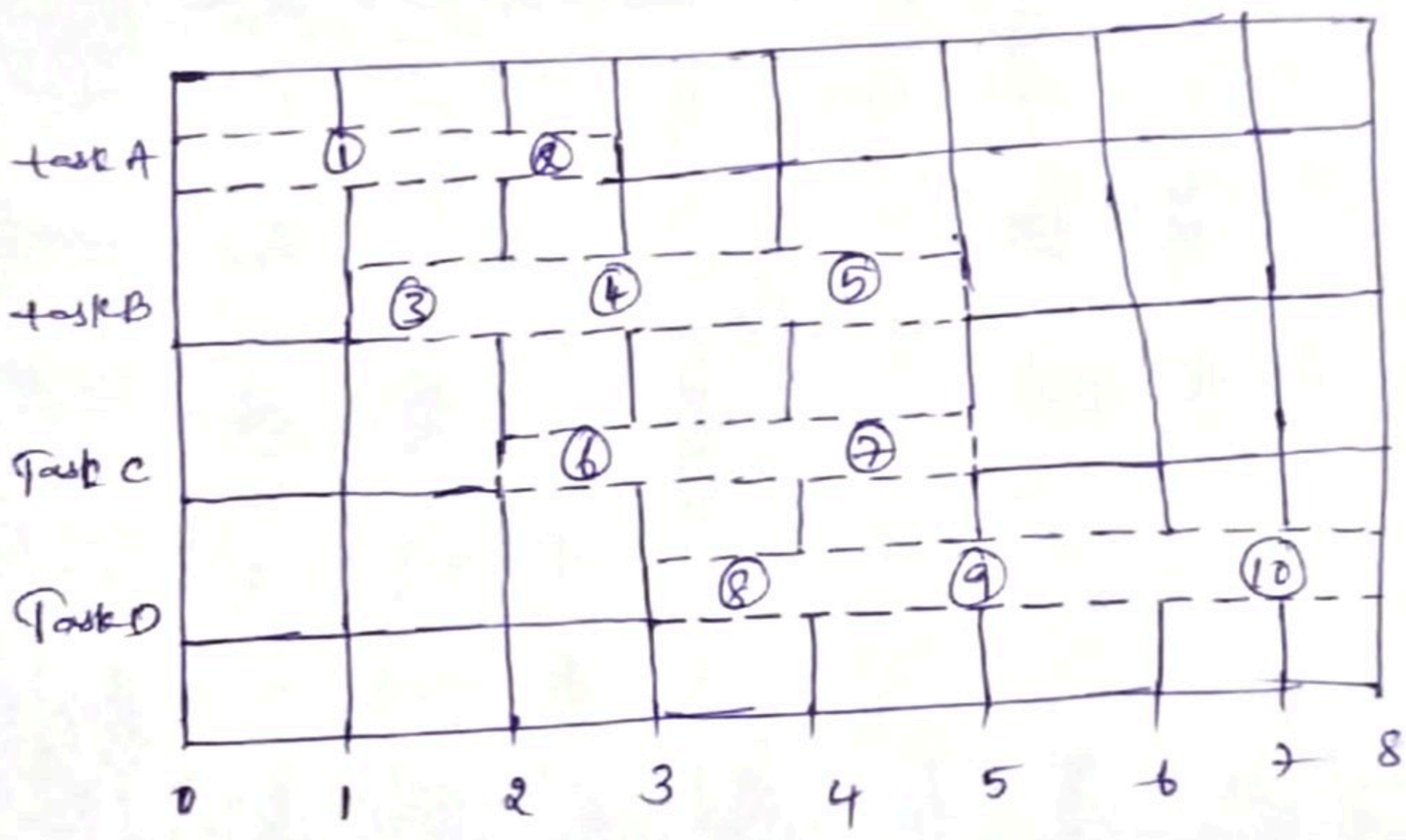


Milestone chart :

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 Evaluation and Review Technique (PERT):

→ PERT stands for "project/programme Evaluation and Review Technique".

→ PERT involves uncertainty into the project completion time.

→ It is a numerical technique used in the projects in which time cannot be estimated accurately such as research and development projects.

→ It is an event oriented network. cost is assumed to be directly proportional to time

Three time estimates are made in PERT:

1. optimistic time (t_o): this is the minimum possible time in which an activity can be completed under the most ideal conditions.

2. pessimistic time (t_p): this is the maximum time required to complete an activity under the worst possible conditions.

3. Most likely time (t_m): this is the time required to complete an activity under normal working conditions. Its value lies between t_o and t_p. It is near to the expected time.

Note: the most likely time (t_m) is based on experience and judgement being based on the time required if the activity is repeated a number of times under

essentially the same conditions

→ this time signifies the most frequently occuring time
it reflects a situation "things are as usual nothing exciting".

Mean Time, Standard Deviation and Variance of an Activity:

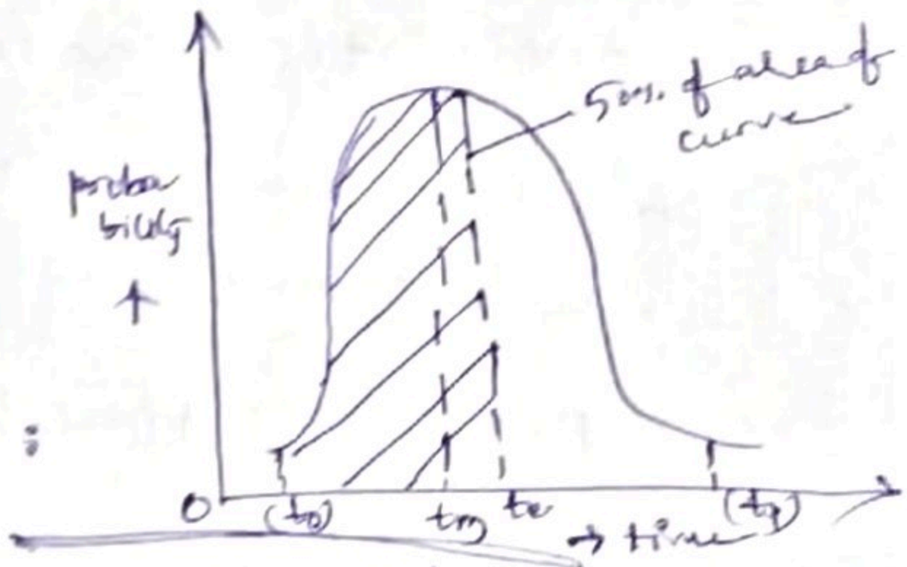
Mean Time (or) expected Time (or) Average Time:

→ in PERT each activity is assumed to follow β-distribution curve of time

→ this is calculated from β-distribution curve of time at which probability of activity is just 50%.
Time taken by various activities follow β-distribution.

→ Hence value of expected time is calculated by weighted average as,

$$te = \frac{to + 4tm + tp}{6}$$



Standard deviation of an activity (σ):

→ this is the measurement of uncertainty, which is approximately one sixth of time range i.e

$$\sigma = \frac{tp - to}{6}$$

→ It can be seen above that 'σ' is affected by relative distance from the most optimistic estimates to the most pessimistic estimates.

→ therefore, wide range in time estimates represents greater uncertainty.

NOTE: In a limiting case, certainty of an activity duration occurs only when the three time estimates coincide, so that the standard deviations and the variance both vanish. consequently the activity duration becomes certain which is the case of CPM. Hence, a PERT is a general case whereas CPM is the particular case of PERT.

Variance of an Activity (σ^2):

→ square of standard deviation is variance of an activity.

→ It is to be noted that higher the uncertainty about a process, greater is the standard deviation and hence greater is the variance of a project.

Central limit theorem:

→ The Theorem states that a project consists of a large number of activities, where each activity has its own mean time (t_e), standard deviation (σ), variance (σ^2) and also its own β-distribution curve.

→ the distribution of time for the project as a whole will approximately be a normal distribution, i.e mean time ∑ expected time of a project is

$t_e = t_{e_1} + t_{e_2} + t_{e_3} + \cdots$ along critical path and the variance is,

$\sigma^2 = \sigma_1^2 + \sigma_2^2 + \sigma_3^2 + \cdots$ along critical path.

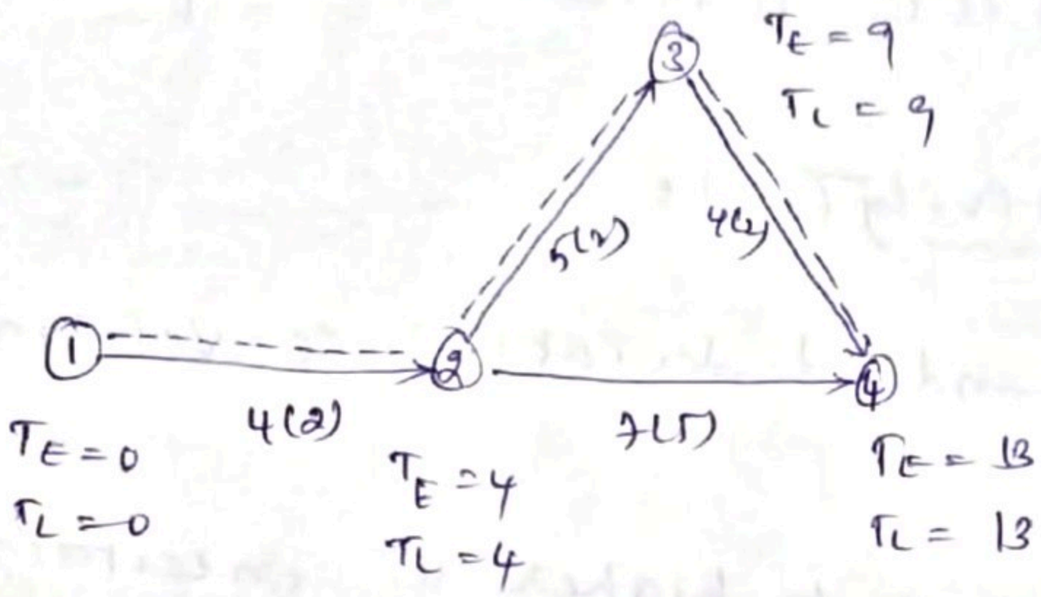
→ Hence standard deviation of the project as a whole

$\sigma = \sqrt{\sigma_1^2 + \sigma_2^2 + \sigma_3^2 + \cdots}$ along critical path.

Critical path:

→ The time wise longest path is the critical path.

→ In this path, any type of delay in any event will cause delay in the project. These are shown by double lines or dark lines in a network



→ 1-2-3-4 is the critical path of following network

Time computation of events:

1. Earliest expected occurrence time (EOT):

→ The time at which an event is expected to occur earliest.

→ The time at which an event can be expected to occur earliest.

→ An event occurs when all the activities leading to it are completed.

→ It is generally denoted by T_E. It is calculated by forward path.

$$T_E^j = T_E^i + t_{ij}$$ (when there is only one path)

$$T_E^j = (T_E^i + t_{ij})_{max}$$ (when there are more than one path)

Here T_E^i = EOT of event j

T_E^i = EOT of event i

t_{ij} = expected time of activity.

2. Latest Allowable occurrence Time (LOT):

→ the latest allowable time at which an event must occur to keep the project on schedule.

→ It is generally denoted by T_L. This is calculated through backward path.

$$T_L^i = T_L^j - t_{ij} \quad \text{- when there is only one path.}$$

$$T_L^i = \left(T_L^j - t_{ij}\right)_{min} \quad \text{- when there are more than one path.}$$

where T_L^j = LOT of event j

T_L^i = LOT of event i

t_{ij} = expected time of activity i-j

Note: the latest allowable occurrence time of the finish event is equal to the schedule completion time of the project.

Slack:

→ slack is defined as the difference between latest allowable time (T_L) and earliest expected time (T_E) of an event.

slack for any event $j = T_L^j - T_E^j$

slack for any event $i = T_L^i - T_E^i$

→ slack may be positive, zero or negative

→ when 'slack is greater than zero'. it indicates project is ahead of schedule and availability of excess resources. such events are sub-critical.

→ if slack is zero, it indicates work is on schedule and events are critical. Resources are just adequate.

→ If slack is negative, it indicates work is behind schedule and may cause delay in project completion. events are super critical. extra resources are required.

→ the path having minimum or zero value is the 'critical path' which is also time wise longest path.

Critical path method : (CPM)

→ This is based on deterministic approach in which only one time estimate is made for activity completion.

→ Network diagram in CPM is activity oriented.

→ It is activity oriented network

→ Each activity is represented by arrow and the junctions between the activities represents events.

→ used for repetitive type of project - accurate time and cost estimate for completion of each activity can be made with fair degree of accuracy - deterministic model.

→ Trade of between time & cost

→ used in construction projects like bridges, buildings, dams, canals, etc.

Event Times in CPM :

1. Earliest occurrence time (T_E) :

→ Time at which an event may occur as early as possible

2. Latest allowable time (T_L) :

→ Time at which event may occur as late as possible without delaying the overall project completion time

→ These are similar to PERT and are calculated in the same fashion.

Activity Times in CPM:

1. Earliest start time (EST):

→ It is the earliest possible time at which an activity can be started.

→ for an activity i- j, earliest event time of event i

i.e T_E^i is EST of activity i- j

2. Earliest finish time (EFT):

→ It is the earliest possible time by which an activity can be completed

→ for an activity i-j

$$EFT = EST + t_{ij} = T_E^i + t_{ij}$$

t_{ij} = Activity duration

3. Latest start time (LST):

→ this is the latest possible time at which an activity can be started without delaying the overall project.

$$LST = LFT - \text{Activity duration}$$

$$LST = T_L^j - t_{ij}$$

LFT = latest finish time of activity $i-j = T_L^j$

4. Latest finish time (LFT):

→ this is the latest time by which an operation or activity must be completed without delaying the project.

→ for an activity $i-j$, latest allowable time of head event j

i.e T_{Lj} is LFT of activity $i-j$

Float:

→ It is associated with activity times

→ it is analogous to slack of events in PERT

→ it is the range within which start or finish time of an activity may fluctuate without affecting the project completion time

→ Floats are of following types

1. Total float:

→ the time span by which starting or finishing of an activity can be delayed without delaying the completion of the project

→ It is the maximum available time in excess of the activity completion time.

→ total float is given by f_T.

$$f_T = (T_L^j - T_E^i) - t_{ij}$$

→ total float is given by F_T.

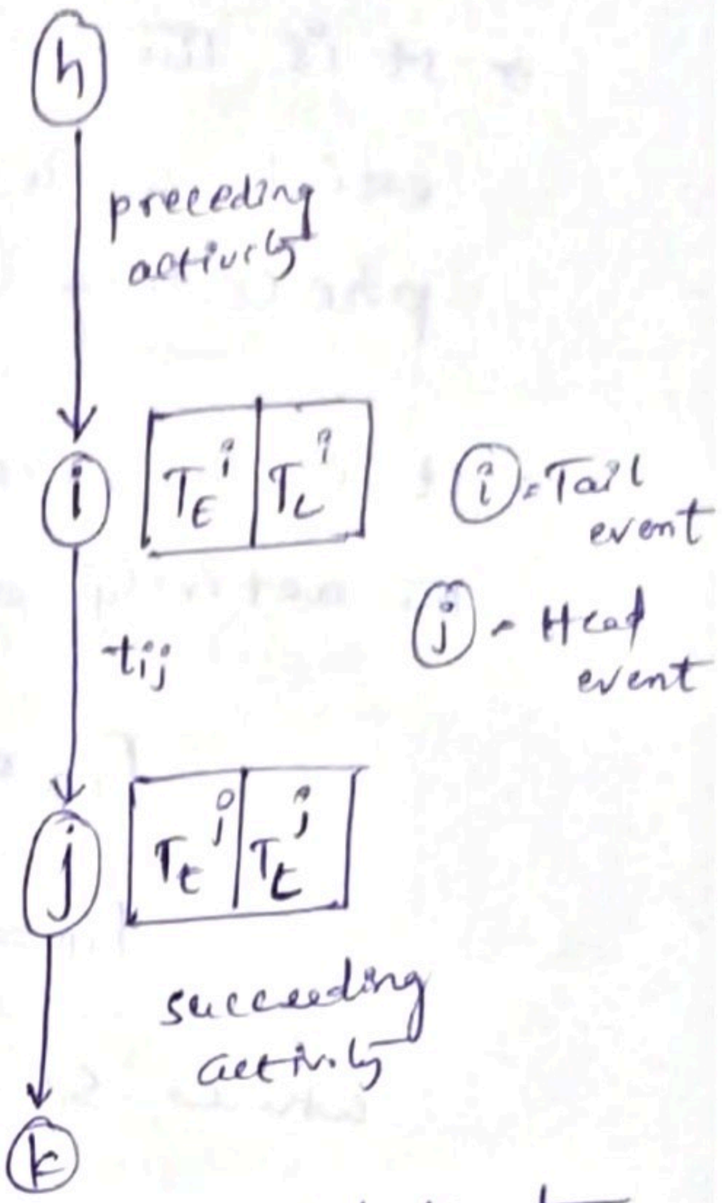
$$f_T = (T_L^j) - (T_E^i + t_{ij})$$

$$f_T = (T_L^j) - (T_E^i + t_{ij})$$

$$F_T = LFT - EFT \quad (or)$$

$$f_T = (T_L^j - t_{ij}) - T_E^i$$

$$f_T = LST - EST$$



→ total float

→ Total float of an activity affects total float of succeeding as well as preceding activities.

2. Free float (F_F):

→ the delay which can be made without delaying succeeding activities. It affects only preceding activities.

→ it is denoted by F_F. It is assumed that all activities start as early as possible

→ Free float is given by

$$F_F = (T_E^j - T_E^i) - t_{ij}$$

$$f_F = f_T - S_j$$

where S_j is head event slack

3. Independent float (F_{ID}):

→ It is the minimum excess available time which exists without affecting any of succeeding & preceding activities. It is denoted by F_{ID}.

→ It is the excess of minimum available time over the activity duration.

$$F_{ID} = (T_E^j - T_E^i) - t_{ij}$$

$$F_{ID} = F_F - S_i$$

where S_i is tail event slack

4. Interfering float (F_{INT}): It is smaller to head event slack

$$F_{INT} = S_j = F_T = F_F.$$

Critical path:

→ In CPM analysis, the path along which total floats are zero & minimum is called as critical path. all activities on this path are critical. There can be more than one critical paths.

Subcritical path:

→ It is the path joining all sub critical activities. for a sub critical activity total float is greater than zero i.e

$$F_T > 0$$

Super critical path:

→ It is the path joining all super critical activities.

For a super critical activities total float is less than zero.

$$F_T < 0$$

CPM systems:

→ Mainly two systems are used in CPM analyses.

1. A-O-A system (Activity on arrow system)

→ An activity is graphically represented by an arrow.

→ The tail end and head end of arrow represent start and finish of an activity respectively.

2. A-O-N system (Activity on node system (or) precedence dia)

→ Activity is represented by a circle or a node.
events have no places.

→ Arrows are used only to show the dependency relationship between activity nodes.

→ When two or more activities start parallely then an activity called DEBUT (D_0) is provided at the beginning.

→ Like wise a finish activity (F_0) is provided at the end when more than one activities finish parallely.
Activities D & F has zero duration.

Advantages of A-O-N system

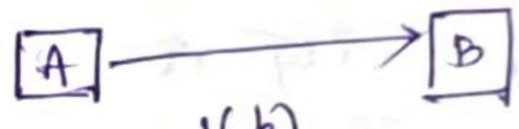
1. A-o-N system eliminates the use of dummy activities
2. It is more helpful for projects having more overlapping activities
3. It is a self sufficient and self-explanatory. All activity times (EST, EFT, LST, LFT) are represented on the diagram.
4. Revisions and modifications are easier
5. pre-operations and post-operations of activities under consideration are distinctly visible.

Examples:

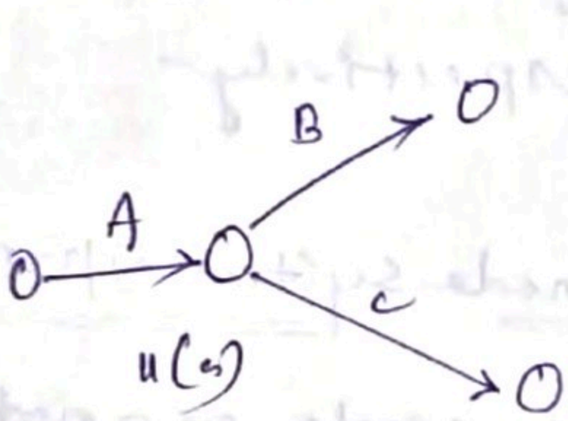
A-o-A

I(a)

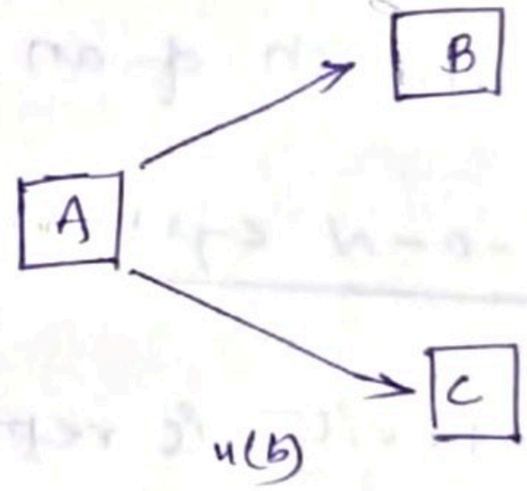
A-O-N



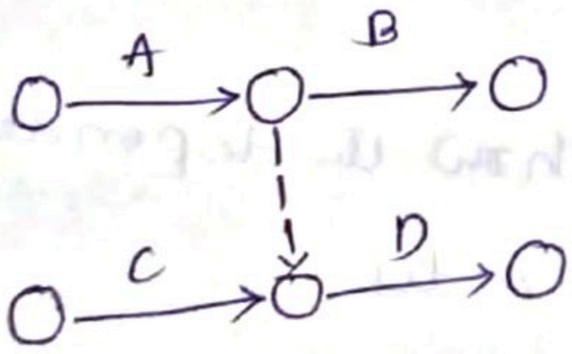
I(b)



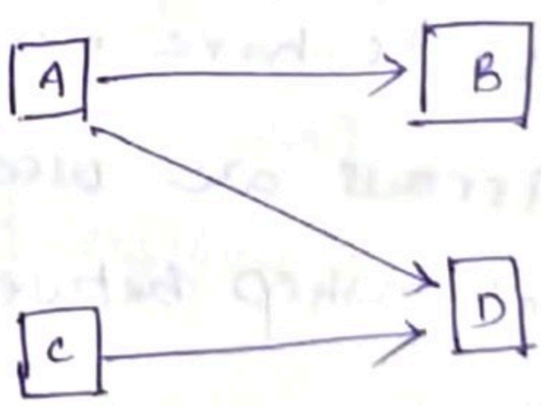
II(a)



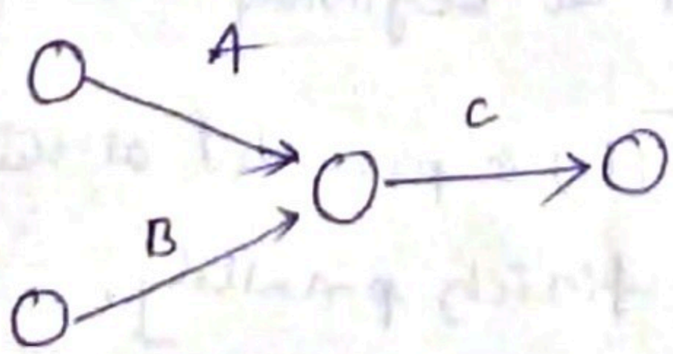
II(b)

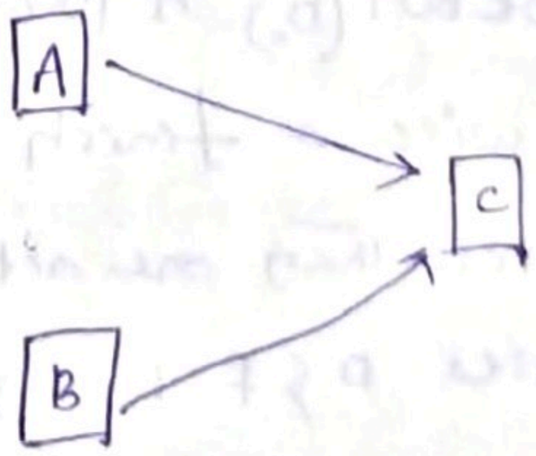


III(a)



III(b)





→ In CPM, time is related to cost and the object is to develop an optimum time - cost relationship.

→ CPM makes use of the cost estimates along with the time estimates and provides a schedule for completing the activities at minimum total cost.

→ the ultimate object of the network technique is not only to bring improvement in planning, scheduling, and control of project but also to asses the possibility of arriving at feasible and desirable time - cost relationship.

→ the overall project duration can be reduced by reducing the duration of only the critical activities in the project network.

→ the duration of such activities may be reduced in two ways.

(a) By deploying more resources for the early completion of such activities.

(b) By relaxing the technical specifications for such activities.

→ In whole of CPM cost model, we will be assuming that project duration is reduced by deploying more resources on critical activities.

→ the optimum duration will be one which gives the most economic cost for completing the project.

→ PCPM, there are two time and cost estimates for each activity. normal estimate and crash estimate.

→ in normal estimate, the emphasis is on cost with time being associated with minimum cost

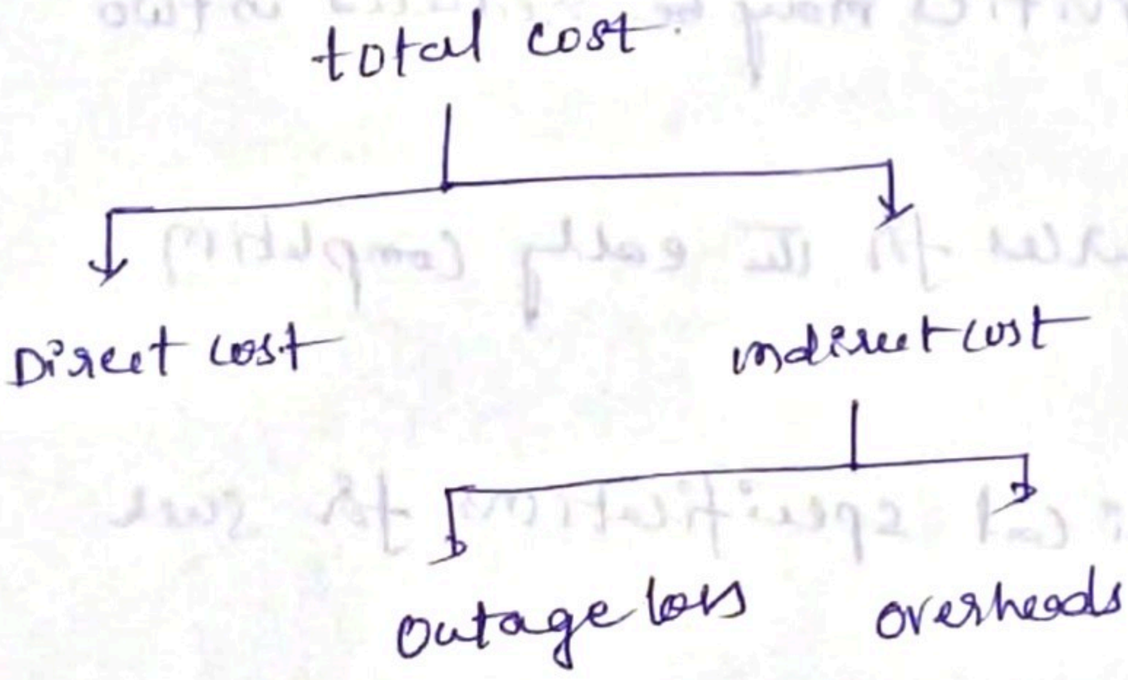
→ the crash estimate involves the absolute minimum time required for the job and the cost necessary to achieve it. Here emphasis is on time

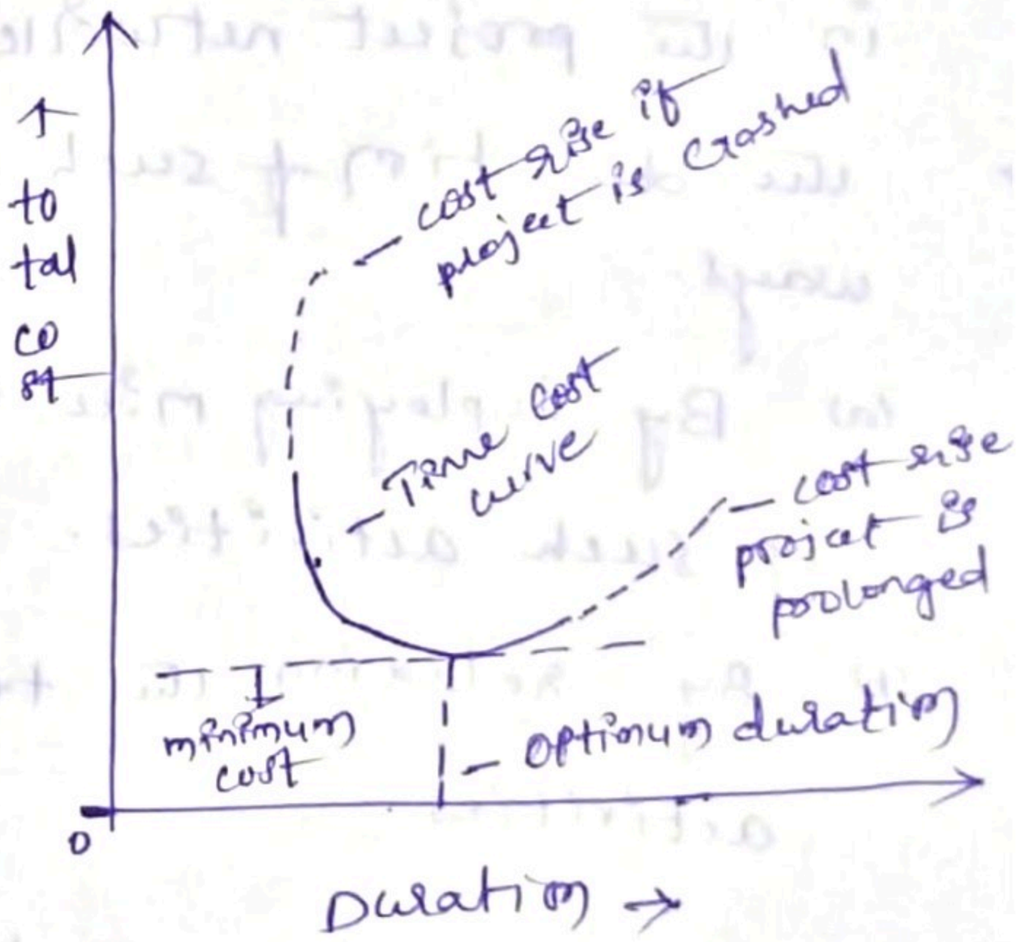
project cost:

→ total project cost is the sum of two separate costs.

(a) the direct cost for accomplishing the work

(b) the indirect cost related to the control & direction of that work, financial overhead, lost production, and the like etc.





→ From graph

(i) if a project goes on indefinitely, the cost will increase.

(ii) the cost will increase if the project is extended.

(iii) cost is minimum at some optimum project duration

components of project cost:

Indirect project cost:

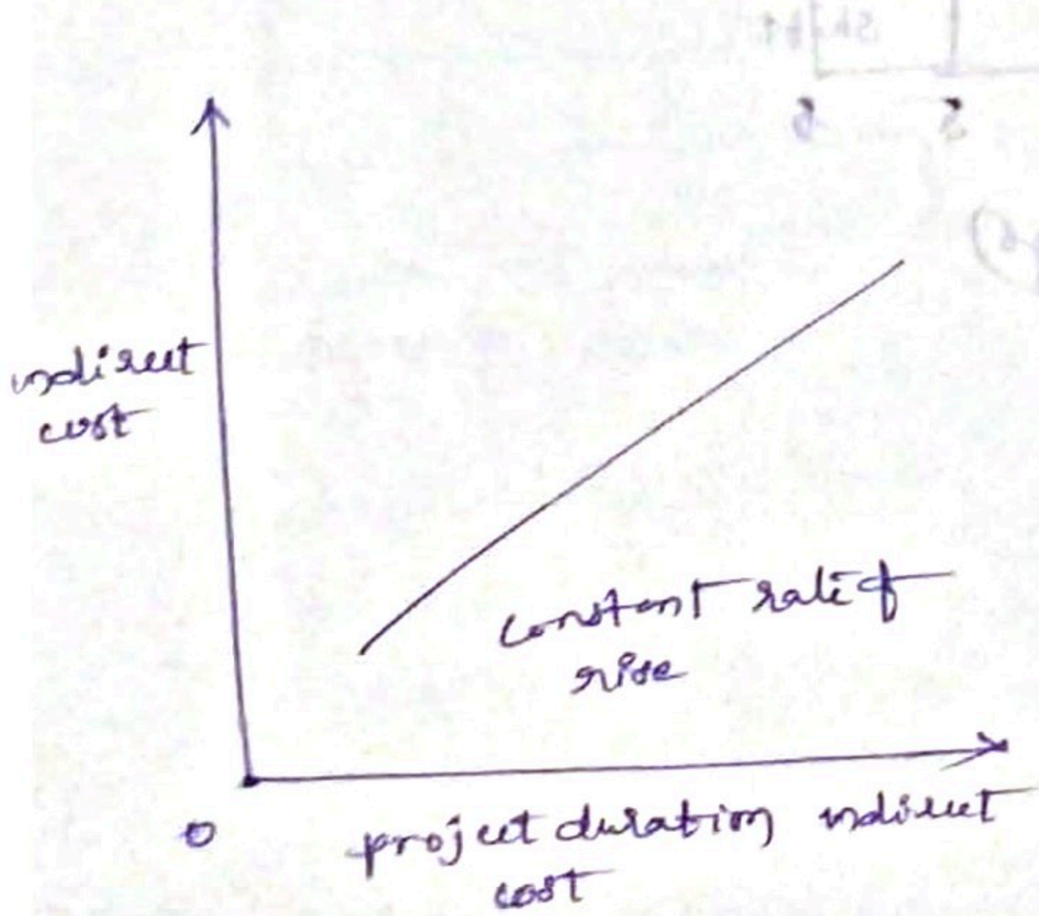
→ Indirect costs on a project are those expenditures which cannot be apportioned (or) clearly allocated to the individual activities of a project, but are assessed as a whole

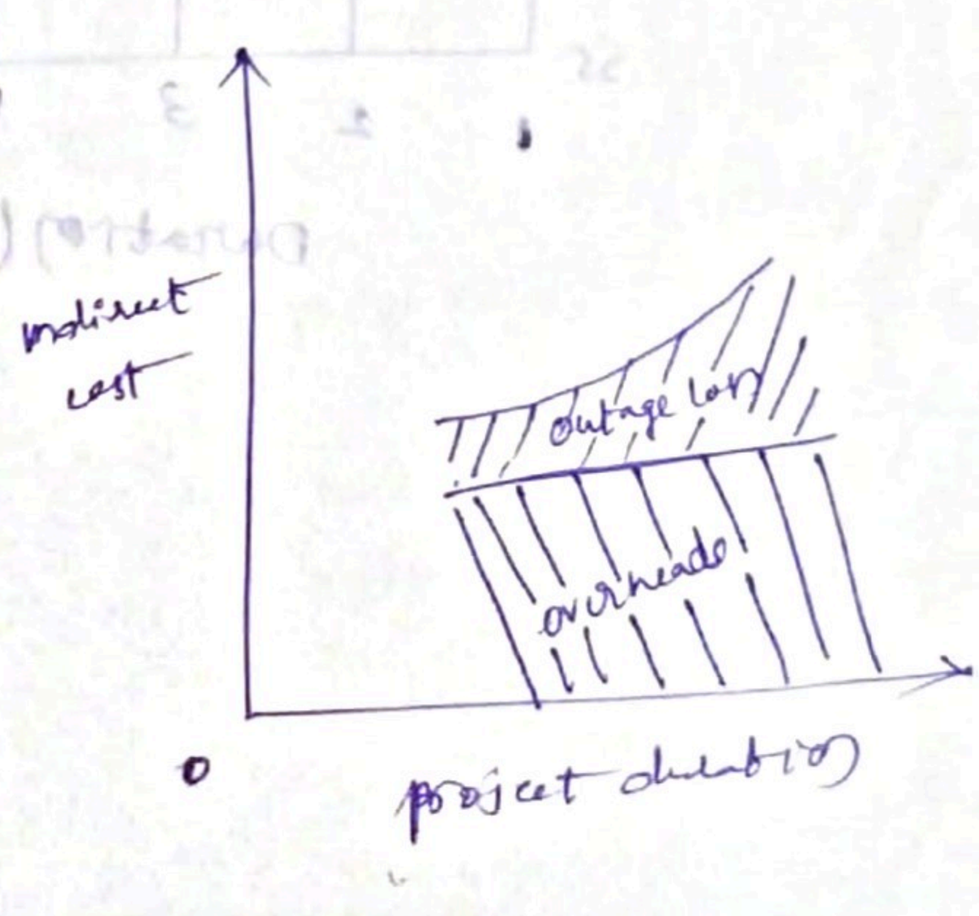
→ The indirect cost includes the expenditure related to administrative and establishement charges, overhead, supervision, expenditure on a central store organization, loss of revenue, lost profits, penalty etc.

→ Indirect cost rises with increased duration, considering only overhead and supervision. It is represented by a straight line, with a slope equal to daily overhead.

→ But when there is a loss in profits, due to inability to meet demands (or) due to some penalty, due to delay, a corresponding cost increase must be added to the cost of overheads, producing the curve. such a loss is called outage loss.

→ The total indirect cost curve will then be curved.





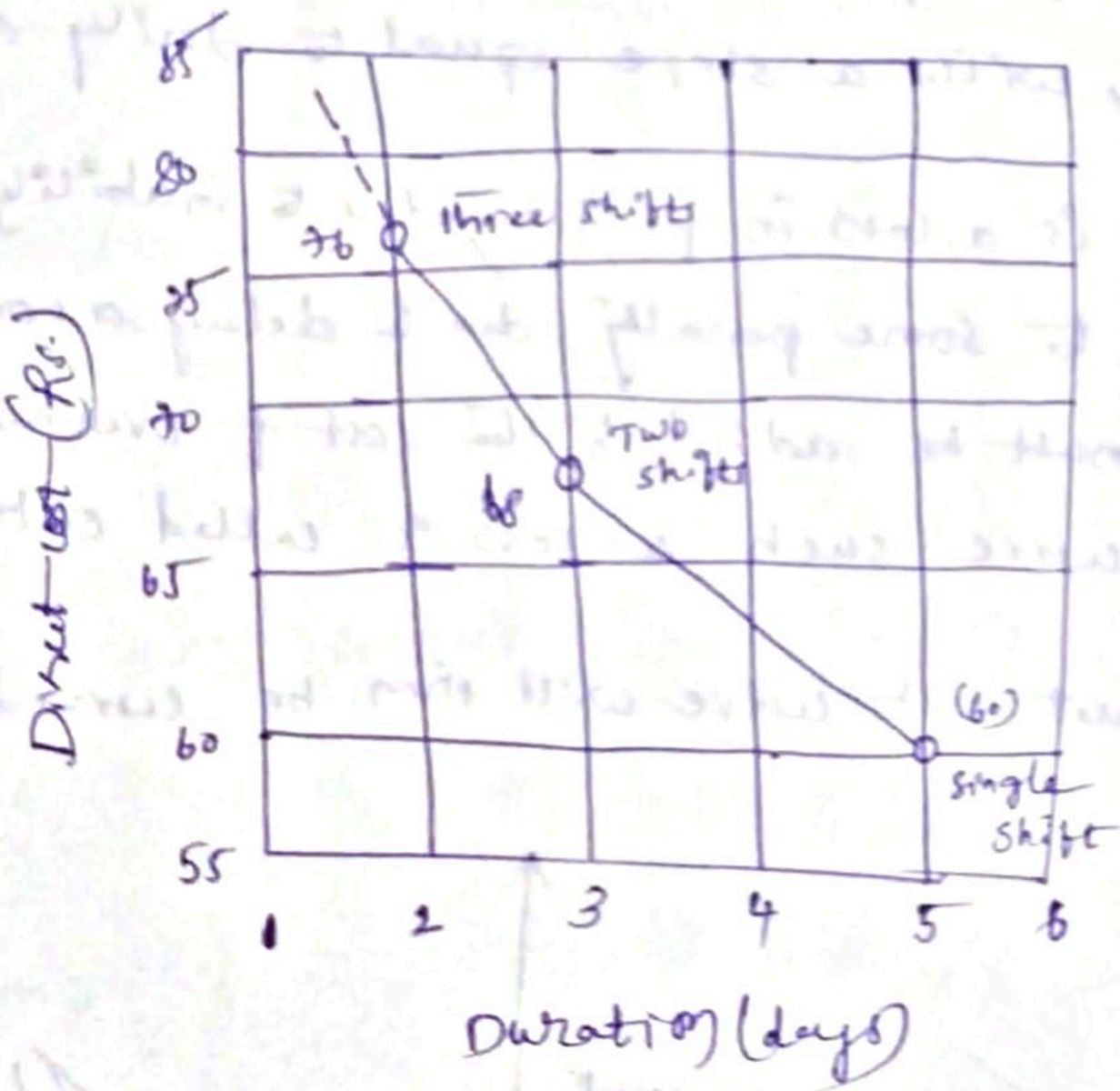
Direct project cost:

→ It is the cost which is directly dependent on the amount of resources involved for completion of activities.

→ It includes labour, material, plants and machining etc

→ To get the same work done in less time we have to increase amount of labour, equipment and time saving material that to at extra charges which simply means increase in direct cost

→ The project has the highest cost corresponding to the crash duration, and has normal cost corresponding to the normal duration.



Normal time (t_n):

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

Crash time (t_c):

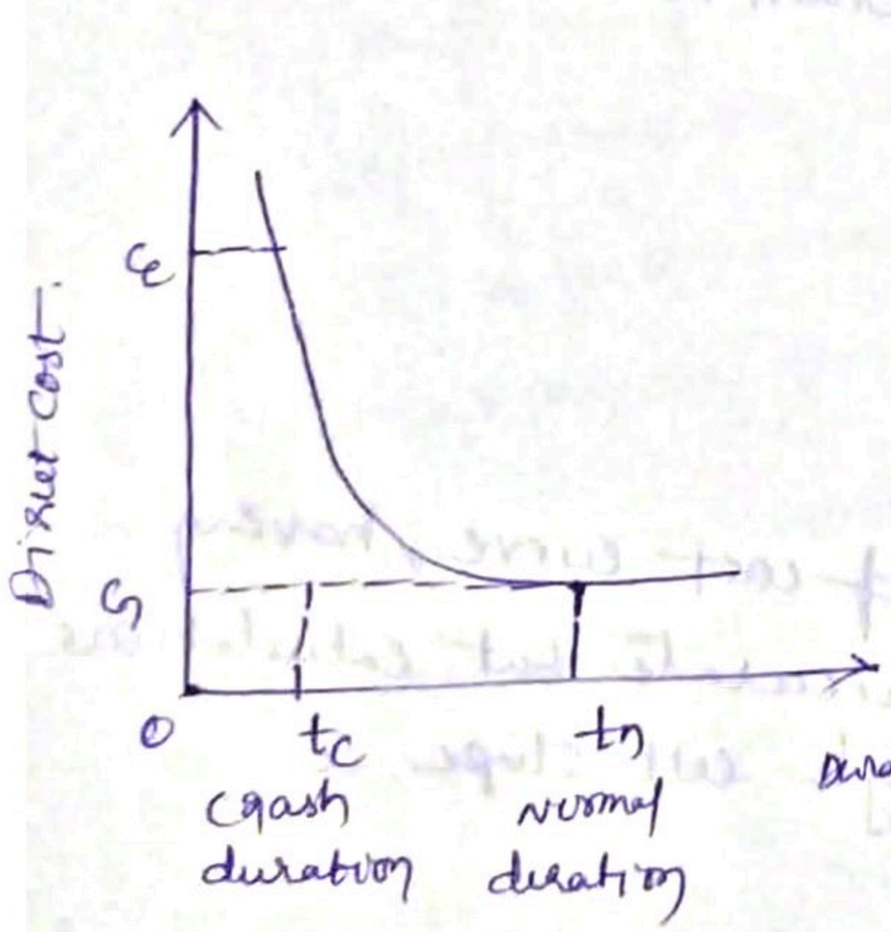
Crash time is the minimum possible time in which an activity can be completed, by employing extra resources. Crash time is that time, beyond which the activity cannot be shortended by any amount of increase in the resources

Normal cost (C_n):

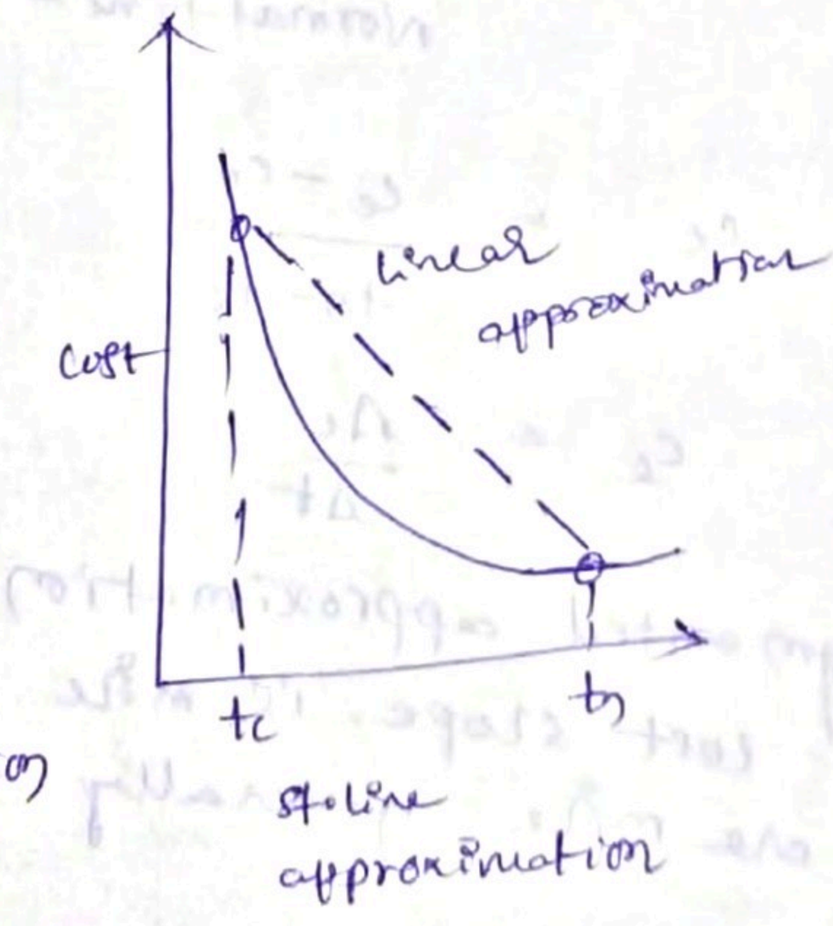
This is direct cost required to complete the activity in normal time duration.

crash cost (C_c):

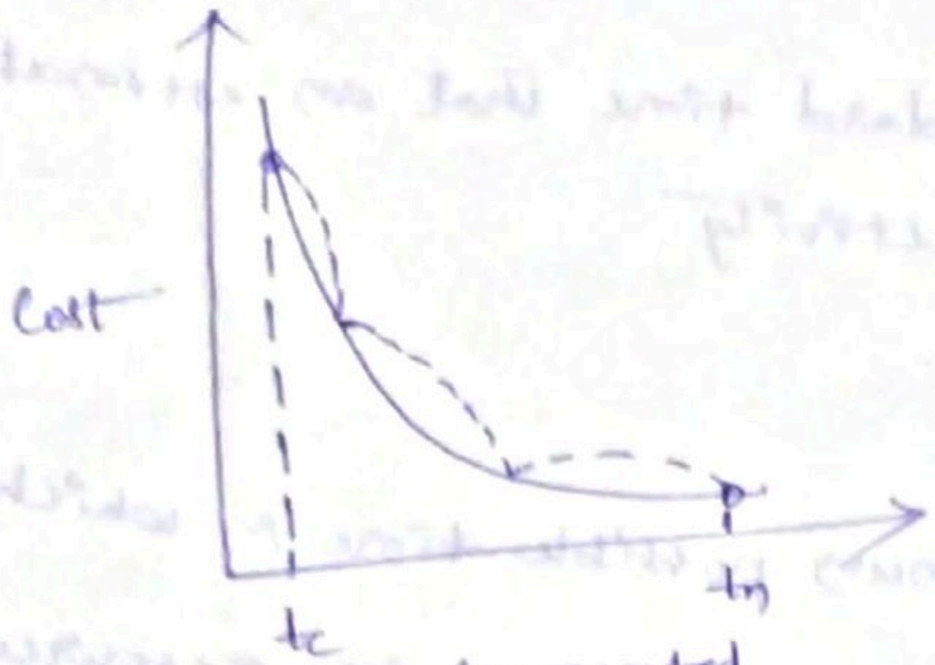
This is the direct cost corresponding to the completion of the activity with in crash time.



Generalized direct cost-time curve



Direct cost curve approximation.



→ st. line (or) segmented approximation of the direct cost curve is helpful in carrying out the cost/project analysis. In such analysis, the cost slope is used.

Cost slope:

→ The cost slope is the slope of the direct cost curve, approximated as st. line.

It is defined as

$$\text{cost slope} = \frac{\text{Crash cost} - \text{Normal cost}}{\text{Normal time} - \text{Crash time}}$$

$$C_s = \frac{C_e - C_n}{t_n - t_c}$$

$$C_s = \frac{\Delta c}{\Delta t}$$

→ The segmented approximation of cost curve, having multiple cost slope, is more accurate but calculations involved are more, generally single cost slope is assumed.

Resource allocation:

→ All the necessary resources are not available in unlimited quantities

→ Availability of some of the resources may be restricted

→ Availability of manpower and material etc. may be restricted.

→ Availability of funds, credit, capital investment and heavy equipment may be restricted.

→ supervisory, technical and skilled manpower, space and equipment are usually the most important resources that need to be allocated carefully

→ the various activities of the project are to be scheduled in such away that the demand of various resources is more or less uniform all along the project duration.

→ In a network, various activities are involved, and each activity requires some resources to perform it.

→ There may be activities which are to be performed simultaneously, and may require common resources.

→ the requirement of resources to execute these simultaneous activities may exceed the available resources.

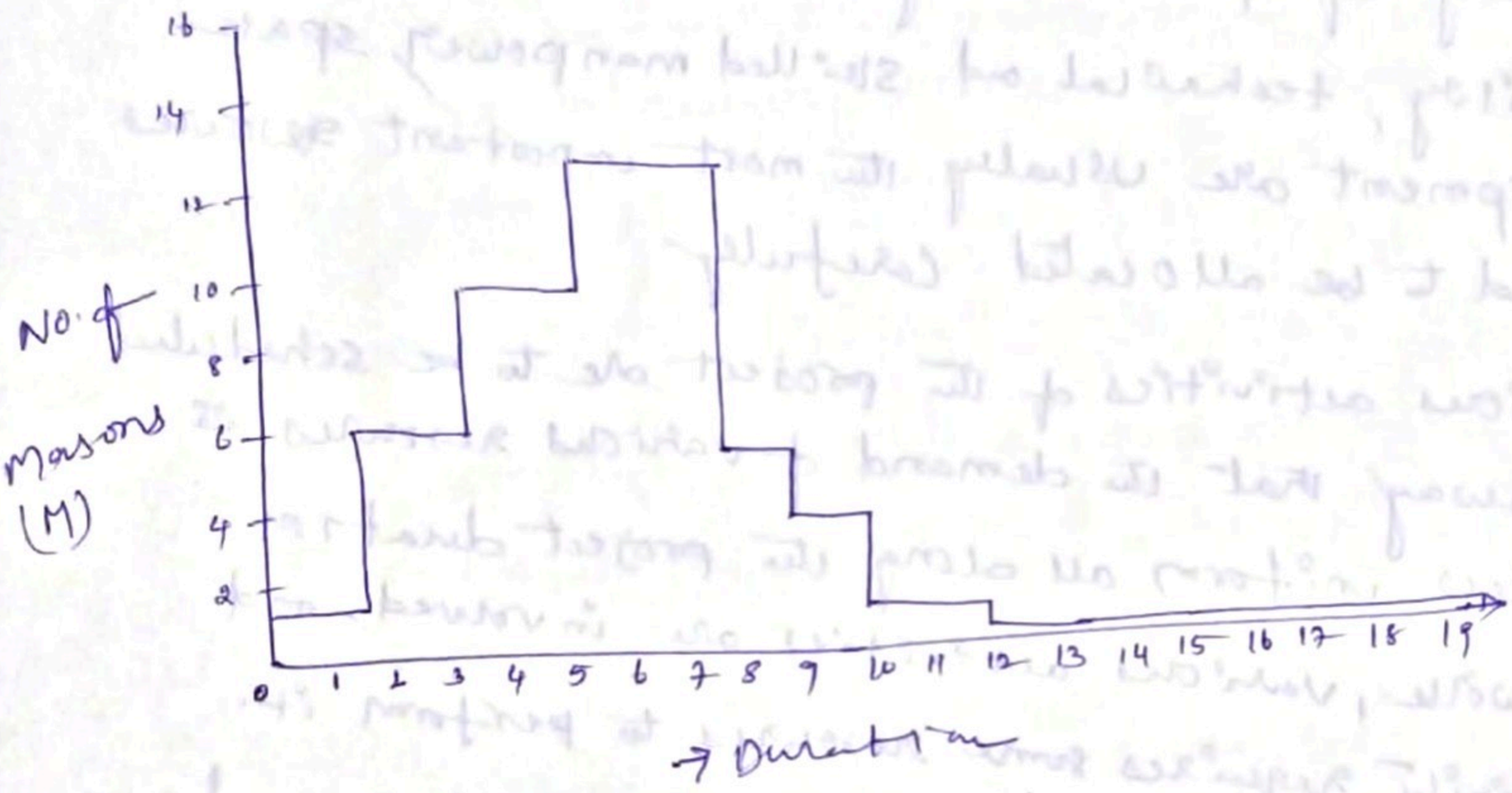
→ However at some other period of the execution of the same project, there may be very few activities which may require these resources.

→ Hence the requirement of particular type of resources may not be uniform during the project duration.

→ This can be best known by plotting the resource usage profiles or histograms.

→ the diagram which shows variation in the requirement of resources with time is called resource usage profile(s) histogram.

→ Resource allocation can be achieved by following two processes.



Resource smoothening:

→ Here resources are considered unlimited.
→ project duration is maintained and critical activities remain unchanged.
→ start time of some of non critical activities are shifted with in their available floats to create uniform demand through out

Resource levelling:

→ Here resources are considered limited. project duration may be changed.
→ Activities are rescheduled to cut down the peak requirement of resources so that it does not cross the limit of resources.

7. Available resources should never be less than the maximum quantity required for any activity of project.

→ Firstly, available floats are used then if needed duration of some activities is increased (or) decreased as per the resource requirement

CPM Updating:

→ the process of reviewing the progress of project execution and redrafting the network according to latest requirement is called 'updating'.

→ During redrafting, scheduled dates are revised. new critical path may emerge and hence project priorities may change.

→ crashing of new critical activities may be required to make project on schedule

→ updating is necessary to compensate for deviations in actual execution of works and original plans.

→ During the process of updating, neither activities are deleted nor new activities added.

When to update:

1- updating should be more frequent for shorter duration projects

2. For larger duration projects, frequency should be increased as project is nearing completion.

3. Whenever major change in the duration of any of activity occurs updating should be done

UNIT 3

1

Trucks and Hauling Equipment :

→ In transporting excavated material, processed aggregates and construction materials and for moving other pieces of construction equipment.

→ Trucks serve one purpose, they are hauling units that, because of their high travel speeds, provide relatively low hauling costs.

→ the use of trucks as the primary hauling unit provides a high degree of flexibility.

→ Most trucks can be operated over any haul road for which the surface is sufficiently firm and smooth, on which the grades are not excessively steep.

→ Some units are designated as off-highway trucks because their size and weight are greater than that permitted on public highways.

→ Off-highway trucks are used for hauling material in quarries and on large projects involving the movement of substantial amounts of earth and rock.

→ On such projects, the size and costs of these large trucks are easily justified because of the increased production capability they provide.

→ Trucks can be classified by many factors, including

1. the method of dumping the load - rear dump, bottom dump, side dump.
2. the type of frame - rigid frame (or) articulated
3. the size and type of engine - gasoline, diesel, butane (or) propane
4. the kind of drive - two-wheel, four-wheel, (or) six wheel.
5. the number of wheels and axles, and the arrangement of driving wheels
6. the class of material hauled - earth, rock, coal (or) ore
7. the capacity - gravimetric (tons) (or) volumetric (cubic yards)

→ If trucks are to be purchased for general material hauling, the purchaser should select units adaptable to the multipurposes for which they will be employed.

→ On the other hand, if trucks are to be used on a given project for a single purpose, they should be selected specifically to fit the requirements of the project.

Rigid Dump trucks:

→ In the Rigid dump trucks (RDT), there is one immensely strong main frame on which are mounted both axles, the body and the cab.

→ the main frame assures long life of equipment

Articulated dump trucks:

→ In the articulated dump trucks (ADT), rear frame and front frame are connected by articulated coupling.

→ ADTs have the following distinct advantages over RDTs for the construction and earth moving industries

(a) Low turning radius

(b) Higher tractive effect

(c) Better operator comfort

(D) Faster cycle time

Rear dump trucks:

→ Rear dump trucks are heavy duty trucks with a strongly built body which is hinged at the back and is fitted with a hydraulic pump on the underside to lift the front of the body and tilt it backwards into a dumping position.

→ They can haul free-flowing material such as earth, sand, gravel, blasted rocks, ore, shale, coal etc.

Rear Dump trucks are used when:

(a) the material to be hauled is large rock and the maximum flexibility is required for hauling a variety of materials under variable job conditions

(b) Maximum gradability and rapid spotting in restricted area is required.

(c) the hauling unit is subjected to severe loading impact when under a large shovel & dragline.

(d) Dumping is restricted in hoppers or fill.

→ In cold climate countries, the body is designed to prevent material from freeting.

→ Exhaust gases from the engine are carried through ducts which heat the body of the truck and it helps considerably when hauling wet, adhesive and sticky materials.

Bottom Dump trucks:

→ In Bottom Dump Trucks, the body always remains in position and the discharge of material takes place through the bottom by the opening of two longitudinal gates.

Bottom Dump trucks are used when:

(a) the material to be hauled is easy flowing like sand, gravel, dry earth etc

(b) the load is to be spread in layers as on fill of a dam.

(c) the material is discharged while the unit is moving and the rapid and controlled rate of discharge gives these units a time advantage over rear dump trucks.

(d) Because of limited openings these donot find application when the material is of big size or it is wet and sticky.

(e) Long adverse grades should not exceed 5% for the best performance.

Dump trucks:

→ Side dump trucks have the body hinged on both sides such that they can dump the material in a long narrow length or one one & both sides of a road.

→ the dump trucks are built with a strong chassis to withstand rough road conditions at construction sites the dumper can handle both free flowing material and the rock

Capacities of trucks and hauling equipment:

→ There are at least three methods of rating the capacities of trucks and wagons:

1. Gravimetric - the load it will carry, expressed as a weight
2. struck volume - the volumetric amount it will carry, if the load is water level in the body.
3. Heaped volume - the volumetric amount it will carry, if the load is heaped on a 2:1 slope above the body.

→ the gravimetric rating is usually expressed in pounds & kilograms and the latter two rating in cubic yards (a) cubic meters.

→ the struck capacity of a truck is the volume of material that it will haul when it is filled level to the top of the body sides.

→ the heaped capacity is the volume of material that it will haul when the load is heaped above the sides.

→ the standard for rated heaped capacity uses an assumed 2:1 slope

→ the actual heaped capacity will vary with the material that is being hauled.

→ Wet earth or sandy clay can be hauled with a slope of about 1:1, while dry sand or gravel may not permit a slope greater than about 3:1

→ To determine the heaped capacity of a unit, it is necessary to know the struck capacity, the length and width of the body, and the slope at which the material will remain stable while the unit is moving.

→ Smooth haul roads will permit a larger heaped capacity than the rough haul rods.

→ the truck's weight capacity may limit the volumetric load a unit can carry

→ this happens when hauling a material having high unit weight such as iron (or) even wet sand.

→ However, when the unit weight of the materials is such that the safe load is not exceeded, a unit can be filled to its heaped capacity.

→ Always checks to ensure that the volumetric load doesnot cause a condition where the load weight exceeds the gravimetric capacity of the truck.

5. Truck size Affects productivity:

→ the productivity of a truck depends on the size of its load and the number of trips it can make in a unit of time.

→ the no. of trips completed per hour is a function of cycle time.

→ Truck cycle time has four components.

① load time ② haul time
③ dump time ④ return time

→ Examining a match between truck body size and excavator bucket size yields the size of the load and load time

→ the haul and return cycle times will depend of the weight of the truck, the horsepower of the engine, the haul and return distances and return ~~Cycle times will depend on~~ distances, and the condition of the roads traversed.

→ Dump time is a function of the type of equipment and conditions in the dump area.

→ when an excavator is used to load material into trucks, the size of the truck cargo body introduces several factors, which affect the production rate and the cost of handling the material.

Small trucks - Advantages.

1. More flexibility, which may be an advantage in restricted work sites
2. Higher speed, can achieve higher haul and return speeds.
3. production, little impact if one truck breaks down
4. Balance of fleet, easy to match no. of trucks to excavator production

Small trucks - Disadvantages:

1. Number, more trucks increases operational dangers in the pit, along the haul road and the dump.
2. More drivers required, more needed for a given output
3. Loading impediment, small target for excavator bucket
4. positioning time, total spotting time greater because of the number required.

Large trucks - Advantages:

1. Number, fewer needed for a given output
2. Drivers required, fewer needed for a given output
3. Loading advantage, larger target for the excavator bucket.
4. positioning time, frequency of spotting trucks is reduced.

3 rge trucks – Disadvantages:

1. cost of truck time at loading greater, especially with small excavators.
2. Loads heavier, possible damage to the haul roads thus increasing the cost for maintenance of the haul road.
3. Balance of fleet, difficult to match number of trucks to excavator production.
4. Size, may not be permitted to haul on highways.

CALCULATING TRUCK PRODUCTION:

→ the most important consideration when matching excavators and trucks is finding equipment having compatible capacities.

→ Matched capacities yield maximum loading efficiency.

→ the following is a format that can be used to calculate truck production

① Number of Bucket loads:

→ the first important step in analyzing truck production is to determine the number of excavator bucket loads it takes to load the truck.

$$\text{Balanced number of bucket loads} = \frac{\text{Truck capacity (lcy)}}{\text{Bucket capacity (lcy)}}$$

(2) Load Time and Truck load volume:

→ the actual number of bucket loads placed on the truck must be an integer number.

→ It is possible to not completely fill the bucket (light load) to match the bucket volume to the truck volume, but that practice is usually inefficient as it result in wasted loading time.

→ if one less bucket load is placed on the truck, the loading time will be reduced. but the load on the truck is also reduced.

→ Sometimes job conditions will dictate that a lesser number of bucket loads be placed on the truck i.e, the load size is adjusted if haul roads are in poor condition & if the trucks must traverse steep grades.

→ The truck load volume in such cases will equal the bucket volume multiplied by the no. of bucket loads.

Next Lower integer: For the case where the number of bucket loads is rounded down to an integer lower than the balance number of loads are reduced because of job conditions.

Load time = Number of bucket loads × Bucket cycle time

Truck load (volumetric) = Number of bucket loads × Bucket Volume
LI

Higher integer: If the division of truck cargo body volume by the bucket volume is rounded to the next integer and that higher number of bucket loads is placed on the truck, excess material will spill off the truck

→ In such case, the loading duration equals the bucket cycle time multiplied by the number of bucket swings.

→ But the volume of the load on the truck equals the truck capacity, not the number of bucket swings multiplied by the bucket volume.

Load time = Number of bucket loads x Bucket cycle time

Truck load (volumetric) = Truck Volumetric capacity.

HI

Gravimetric check:

→ Always check the load weight against the gravimetric capacity of the truck.

Truck load (gravimetric) = Volumetric load (cy) x Unit weight (loose vol. lb/cy)

Truck load (gravimetric) < Rated gravimetric payload.

③ Haul time

→ Hauling should be at the highest safe speed and in the proper gear.

→ To increase efficiency, use one-way traffic patterns.

fpm = feet per minute
mph = miles per hour

$$\text{Haul time} = \frac{\text{Haul distance (ft)}}{88 \text{ fpm/mph} \times \text{Haul speed (mph)}}$$

→ Based on the gross weight of the truck with load, and considering the rolling and grade resistance from the loading area to dump point, haul travel speeds can be estimated using the truck manufacturer's performance chart.

→ The truck's performance chart should be used to determine the maximum speed for each section of haul road having a significant difference in grade or rolling resistance

④ Return time :

→ Based on the empty vehicle weight and the rolling and grade resistance from the dump point to the loading area, return travel speeds can be estimated using the truck manufacturers performance chart.

$$\text{Return time (min)} = \frac{\text{Return distance (ft)}}{88 \text{ fpm/mph} \times \text{Haul speed (mph)}}$$

⑤ Dump time :

→ Dump time will depend on the type of hauling unit and congestion in the dump area.

→ Consider that the dumping area is usually crowded with support equipment.

dozers are spreading the dumped material, and multiple pieces of compaction equipment may be working in the area.

→ Rear dumps must be spotted before dumping
→ This usually means that the truck must come to a complete stop and then backup some distance
→ total dumping time in such cases can exceed 2 min.
→ Bottom dumps will customarily dump while moving.
→ After dumping, the truck normally turns and returns to the loading area.
→ Under favorable conditions, a rear dump can dump and turn in 0.7 min but an average unfavorable time is about 1.5 min.
→ Bottom-dumps can dump in 0.3 min under favorable conditions, but they too may average 1.5 min when conditions are unfavorable.
→ Always try to visualize the conditions in the dump area when estimating dump time

(6) Truck cycle time:

→ the cycle time of a truck is the sum of the load time, the haul time, the dump time, and return time

$$\text{Truck cycle time} = \underset{\text{time}}{\text{Load}} + \underset{\text{time}}{\text{Haul}} + \underset{\text{time}}{\text{Dump}} + \underset{\text{time}}{\text{Return}}$$

(7) Number of trucks required:

→ the no. of trucks required to keep the loading equipment working at capacity is

$$\text{Balanced no. of trucks} = \frac{\text{Truck cycle time (min)}}{\text{Excavator cycle time (min)}}$$

production:

→ the number of trucks must be an integer number

Integer lower than Balance number:

→ if an integer number of trucks lower than the result in above equation is choosen, then the trucks will control production.

$$\text{production (cy/hr)} = \text{Truck load (cy)} \times \text{No. of trucks} \times \frac{60 \text{ min}}{\text{Truck cycle time (min)}} \quad \text{— (A)}$$

Integer Greater than Balance number:

→ When an integer number of trucks greater than the result in above equation is selected production is controlled by the loading equipment

$$\text{production (cy/hr)} = \text{Truck load (cy)} \times \frac{60 \text{ min}}{\text{Excavator cycle time (min)}} \quad \text{— (B)}$$

→ As a rule, it is better to never keep the loading equipment waiting.

→ If there is not a sufficient number of haul trucks, there will be a loss in production.

→ Truck bunching (or) queuing will reduce production 10 to 20% even when there is a perfect match between excavator capacity and the no. of trucks.

→ If there are extra haul units, the queuing effect is reduced.

→ Therefore, it is usually best to have more trucks that is with above equation roundup to the next integer.

⑧ Efficiency:

→ the production calculated with either equation (A) & equation (B) is based on a 60-min working hour.

→ that production should be adjusted by an efficiency factor

→ Longer hauling distances usually result in better driver efficiency.

→ Driver efficiency increased as haul distance increases out to about 8000 ft, after which efficiency remain constant.

→ Other critical elements affecting efficiency are bunching equipment condition.

$$\text{Adjusted production} = \text{production} \times \frac{\text{Working time (min/hr)}}{60 \text{ min}}.$$

Types of compaction equipment:

→ Applying energy to a soil by one & more of the following methods will cause compaction.

1. Impact - sharp blow
2. pressure - static weight
3. Vibration - shaking
4. kneading - Manipulation (or) rearranging.

UNIT - IV

Introduction :- In order to have proper quality construction projects the use of mechanical equipments has become an important and essential future. Use of construction equipment became unavoidable for execution of large and complex and projects with stringent shedules and critical performence standards. It has been estimated that about 20-30% of the total project cost has been accounted towards equipment and machinary.

① Common construction equipments :-

* Equipment for excavation
* Equipment for hauling.
* Equipment for compaction of earth
* Drilling and Blasting Equipment.
* Rock crushing equipment.
* Concrete producing equipment
* Pile Driving equipment
* Hoisting equipment. e.t.c.

Equipment for Excavation :-

1. Hoists
2. Cranes
3. Tractors
4. Bulldozers
5. Graders

7. Drag lines
8. Calmshell buckett.

1. HOISTING EQUIPMENT

Hoisting is the operation of lifting the load Hence equipments used for Hoisting purpose lift the load from the place, hold it in suspension during trans-fer from one location to the another and finally plac it on the desired location.

It should be strong enough to negotiate the load presser and should consume minimum time possible in the operation and it must be quite safe while handling.

Types of Hoisting equipment :-

Mainly we have 4 types of hoisting equipments

Those are
1. pulley
2. chain hoists
3. Jacks
4. Winch.

Pulley :-

Pulley and sheave are used for lifting rough surface and heavy objects. Both chains and wire ropes are used for this purpose.

Chain Hoists :- It is used for lifting loads upto 50 tonnes. The system consists of hand chain and the

and the load chain the pull applied through the hand

chain is transmitted to the load chain with a multiplica-tion factor over 20.

Jacks :- It is based on the principle of inclined planes. It is the shortname of screwjack. The smallest Jack may have a capacity of 5 tonnes and is generally used for lifting an automobile wheel, while the bigger variety may be of 100 tonnes capacity.

They are primarily of two types.

1. Mechanical
2. Hydraulic.

In the mechanical system, load is mounted on platform which is attached with spirally Threaded spindle. The platform is rotated and load is lifted.

The hydraulic type, pressure is exerted by a liquied on the surface.

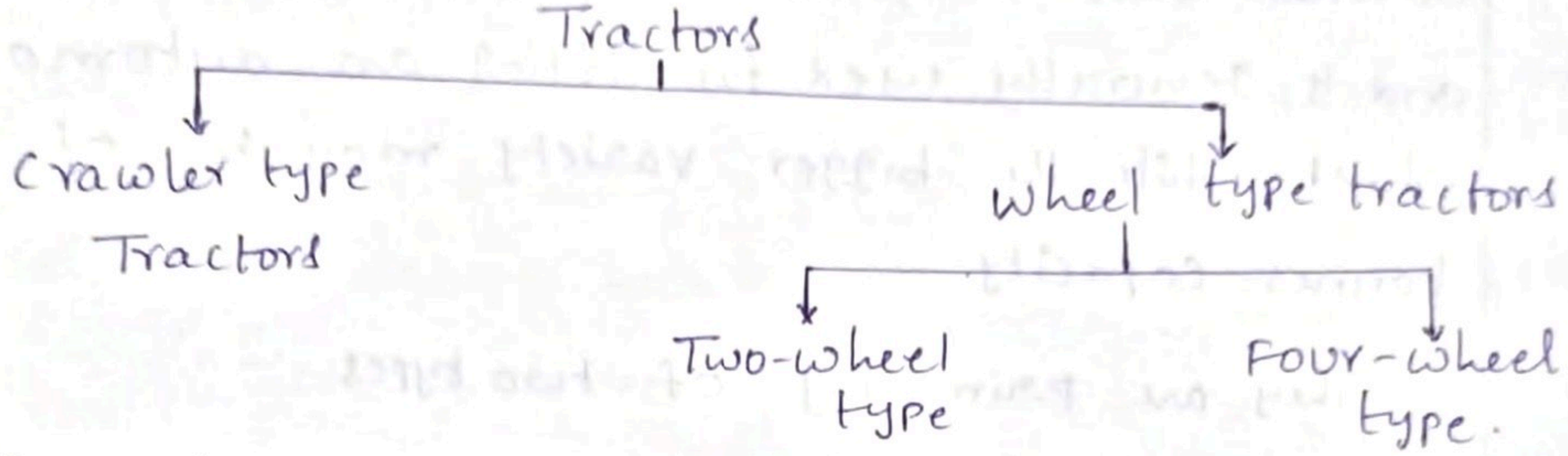
Winch :-

A winch is a combination of gears (spur and Pinion) clutches and brake. The operation is controlled through a series of levers.

It is commonly used in lifting the Railway Gates.

(2) Tractors

These are multi-purpose machines used mainly for pulling and pushing the other equipments or heavy loads. They are also used for agricultural purposes. Tractors may be classified as:



(i) Crawler type tractors :-

It is a versatile equipment used to move bull dozers, scrapers and wagons on rough roads. The crawler has a chain by which these tractors can be very effective even in the case of loose or moddy soils.

Maximum speed is generally 11.2 kmph average is about 4.8 to 5.6 kmph. Therefore best suited for short hauls say 60 to 150m, through are used for long distence too. Special advantage of crawler type tractors is their ability to travel over very rough surfaces and to climb steep grades upto 25 to 29%. at speed of 3 kmph.

(ii) Wheel type Tractors :- The travel with high speeds than crawel type tractor. These type of tractors are generally employed for light but speedy JObs. maximum speed is generally more than 50 kmph.

Wheel type tractors are of two types.

(a) Two-wheel type tractors
(b) Four-wheel type tractors.

Advantage of Two-wheel tractors :-

*. Fewer tyres to provide and maintain
*. Increased maneuverability
*. Decreased rolling resistence, because of the elimi
-nation of extra axle.

Advantages of Four-wheel type Tractors:

*. Greater confidence of operator, due to better steer
-ing properties.
*. Less tendency to bump over rough haul roads.
* Greater speed due to better steering properties and
less tendency to bump over rough haul roads.

Gradability of Tractors :- It is the mimum slope, express
-ed as percentage, upto which a crawler or wheel type
Tractors may move at a uniform speed

$$K = \frac{972 \times T \times G_1}{R \times W} - \frac{N}{20}$$

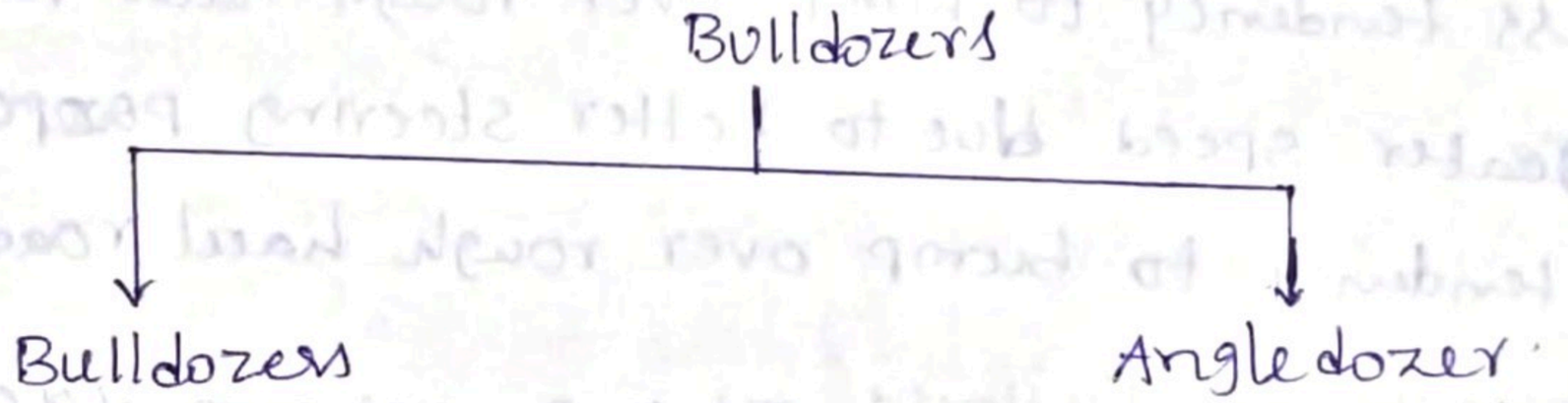
Where K = gradability, %
T = Rated engine torque lbs.ft
G_1 = Total gear reduction for a particular gear selected
R = Rolling radius
W = Gross weight of complete units in lbs
N = Rolling resistance in lbs per ton.

(3) BULLDOZER

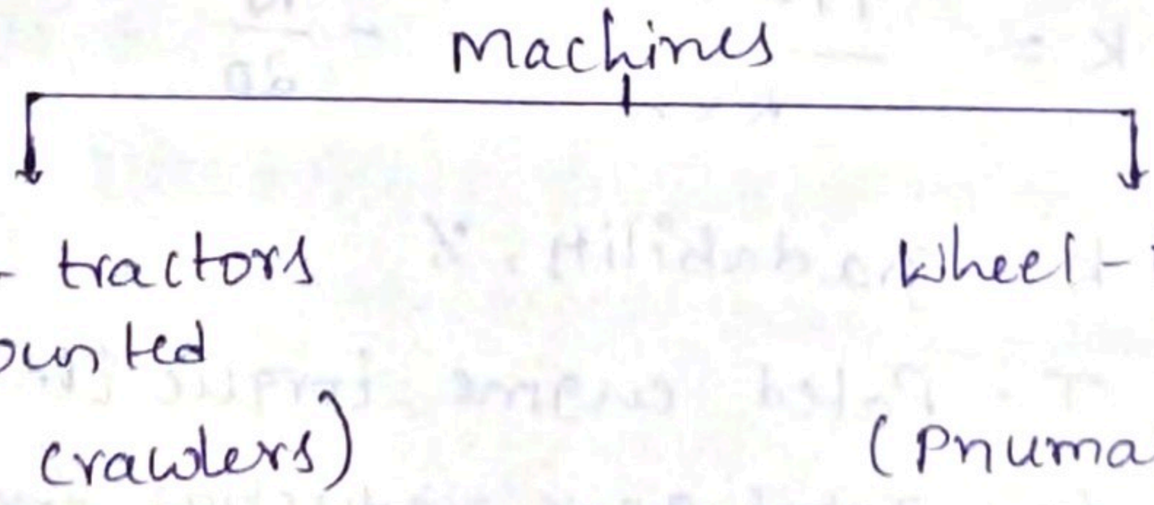
Bull dozer are very popular earth moving equip-ent which can be used for the following JOBS:

1. Site clearence
2. Cutting in mountaneous and rocky terrain
3. Moving earth for haulages upto 100 meters.
4. Loading tractor pulled scapers
5. Spreading earth fill
6. Back filling trenches
7. Earth road maintenance.

They are two types of bulldozers.



In some, blades may be adjusted to permit use a Bulldozer or angledozer. These machines may be divide on the basis of their mounting as.



Based on method of raising and lowering the blades bulldozers may be clanified as

(a) cable controlled

(b) Hydraulic controlled

The cables controlled operation has the following advantages

1. Simple to operate
2. Easier repair
3. Less danger of damage to the machine

The hydraulic controlled operation has the following advantages.

1. Ability to provide high down pressure on the blades.
2. More precise setting can be maintained

Crawler tractor mounted	Wheel Tractor Mounted.
1. Higher tractive effort	1. High Travel speed
2. Can operate in rough & muddy surface	2. No hauling equipments is req for transporting the dozer from one job to the other.
3. Can work in rocky area	3. Greater output
4. Can travel over rough Surface	4. Less operator fatigue
5. Can push large blade Loads	5. Ability to travel over paved highway without damaging the surface.

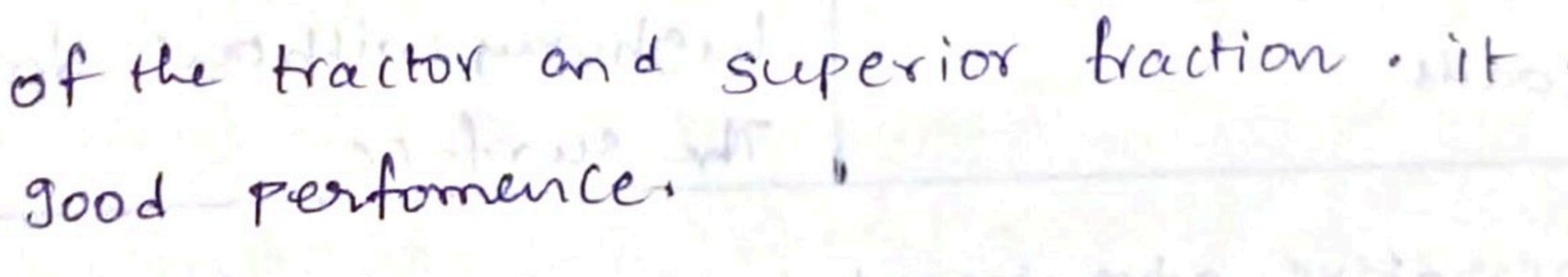
Comparative advantages between Crawler tractor & Wheel tractor mounted.

(4) Scraper

The scraper are the devices that can load itself, can carry the material and discharage at the other en- scrapers are another ex of combination of an exca- -tor and a mover. They are not suited for

1. Wet or muddy material
2. Hard rocks.

The self loading scrapers are available upto 40cu suitable hauling distence is 150 to 300m in some case upto 1500m. Depending upon type of the tractor used Scraper can be clanified as.



Crawler - Tractor Scraper :- The equipment consits of crawle Tractor pulling a pnumatic self loading scraper. even on rough and poor roads because of the high drawbar Pull of the tractor and superior fraction. it gives the good performence.

Wheel Tractor Scraper :- When the haul distence is long this type of tractor is better suited for the JOb. it is more economical than crawler type.

Motor Scraper :- Motor scraper are those having their own engine and motoring arrangment.

Operation of scrapers: A scraper is loaded by moving the front end of the bowl till the cutting edge, enters the ground and at the same time, raising the front apron to provide an open slot, through which the earth flows into the bowl. As the scraper is pulled forward, a strip of earth is forced into the bowl. The cutting edge is raised and the apron is lowered to prevent spillage during hauling.

The dumping operation consits of lowering the cutting edge to the desired height, above the fill, raising the apron, and forcing the earth out. Scrapers are availa-ble with either cable or hydraulic control for operations

(5) Draglines

Draglines are used to excavate earth and load it into hauling units such as trucks, tractor pulled wagons e.t.c or deposit on banks, dams etc.

Powershovel up to capacity of 1.9 cu.m can be conv-erted into draglines by replacing the boom of the shovel with a crane boom and substituting the dragline bucket for the shovel dipper.

Although shovel and dragline can be used on some project for the same job, in many projects draglines would have advantages over shovel.

Advantages:-

* Useful when earth is to be removed from a ditch or canal or pit containing water, as trucks won't have to go into mud
* Draglines with long booms are helpful when earth is to be deposited on banks or dams, eliminating need of hauling unit

* Draglines are excellent for excavating below without shoring.

Disadvantage

Disadvantage of a dragline is lesser output as compared to a shovel of same capacity

Operation of a Dragline :-

The bucket is lowered in fully dumped position, releasing both the hoist and drag cable, till it rests on the ground with the teeth digging into the earth. The hoist cable is slackened slightly and then the drag pull is applied. this action fill in the earth and the bucket takes a horizontal position. it is then hoisted. when the rq dumping height is attained, the boom is swung to the position of dumping and the drag brake is released. This will dump the load off the bucket. The boom is then swung back to the digging position and the same cycle of operation are repeated.

Applications :-

*. It is the most suitable machine for digging softer material and below it's track level.

*. It is very useful for excavating trenches when the sides are permitted to establish their angle of response without shoring.

*. It has long trenches

* It is mostly used in the excavation for canals and depositing on the embankment without hauling units

(6) Clamshells.

This machine is so named due to the resemblance of its bucket to a clam which is like a shell-fish a hinged double shell. The front end is essentially a crane boom with a specially designed buckets loosely attached at the end through cables as in a drag line.

The capacity of the clam shell bucket is usually given in cubic meters. There are 3 methods to express capacity.

Water level capacity:- Water level capacity is the capacity of the bucket if it was hung level and filled with water.

Plate line capacity:- Plate line capacity indicates the capacity of bucket following a line along the top of the clams.

Heaped capacity:- Heaped capacity is the capacity of bucket when it is filled to the maximum angle of responce for the given material.

For specially heaped capacity angle of responce is assumed as 45°

Operation:- The calmshell bucket is brought over the location where the material is to be dug. The bucket is lowered with the shells open till a good contact is made with the ground. Now the bucket shells are closed-in-through the closing line. As the two shells

close in, the weight of the bucket enables it to
into the material, thereby filling it. it is then hoisted and
swung to the position of dumping and the contents are
dumped. The boom is then swung back to the digging
position and the same cycle of operations are repeated
The operations are performed by manipulating the cables
suitably.

Applications :-

* · clamshells are commonly used for handling loose mater
-ials such as crushed stone, sand, gravel, coal, etc

* · The main feature of calmshell is the vertical lifting
of material from one location to another.

* · clamshells are mainly used for removing from
cofferdams, sewer manholes, well foundations e.t.c

(7) Cranes

A crane is a machine which is having a hoist with a longitudanal and cross movement. The hoist of a crane consits of wire rope and hook. The crane is used both for lifting and lowering materials, and to move them haizentally, cranes uses one or more simple machines to create mecha -nical advantage and thus move heavy loads. many factors are taken into considerations while selecting a crane. These factors include lifting capacity, crane use and application and the number of work cycles

Types of Cranes :-

Cranes are of many type Some of them are given below.

a. overhead or Gantry cranes
b. Mobile cranes
c. Tower cranes
d. Stationary cranes

Gantry cranes :-

These types of cranes due to its large service area, freedom from floor obstruction and Three-way-mobi-lity, are widely used in erection, foundry, steel plants storage yards and different types of industrial works These type of cranes consits of two main parts

i.e The bridge and
The Crab

The bridge consist of two main gerders fixed at their ends to the end carriage which are supported on tram wheels and capables of moving on gantry rails. The crab consits of the hoisting gear mounted on a frame. The frame itself is mounted on another set of wheels and capable of travelling across the main gerder.

Mobile Cranes:

Mobile crane is mounted on a carrier usually a truck which provides the mobility for this type of crane. This crane has two parts namely.

(i) A carrier which is often reffered to as the lower and

(ii) A lifting component which includes the boom also reffered to as the upper.

These are mated together through a turnable which allows the upper to swing from side to side. modern hydraulic truck cranes are usually single engine machines, with the same engine powering the undercarriage and the crane. The upper is usually powerd via hydraulics run through the turntable from the pump mounted on the lower. older hydraulic Jack truck cranes had 2 engines. one in the lower is used for the cran to travel on the road and second one, ran a hydraulic pump for the outriggers and Jacks. The second in the upper ran the upper through a hydraulic pump of its own. Generally, these cranes are able to travel on highways, eliminating the need for special equipment to transport the crane. when working on the job site, outriggers are extended harizantally from the chassis then vertically to level and stabilize the crane while stationary and hoisting.

TOWER CRANES :-

It is usually fixed to the ground on a concrete this crane often gives the best combination of height and lifting capacity and is used in the construction of tall buildings. The base of the crane is attached to a mast which gives the crane its height. further the mast is attached to the slewing unit that allows the Cranes to rotate. On top of the slewing unit there are Three 3 main parts

Those are

1. The long horizontal Jib (working arm)
2. Shorter counter Jib
3. operator's cab.

Stationary cranes :- These are also known as DERRICK cranes. These are consits of a mast, a boom and a bull wheel on which the boom rotates about a vertical axis and guys or supporting members. These cranes are either electrically operated, diesel operated or diesel-electrically operated.

A derrick crane can be classified into 2 types.

Those are.

1. Guy derrick type
2. stiff leg derrick type.

8) GRADERS :-

Graders are multipurpose machines used for finish-ing, shaping, bank sloping and ditching. They are also used for mixing, spreading, side casting, leveling and crowning, light stripping operations, general construction and dirt road maintenence. A grader's primary purpose is cutting and moving material with the mold board. These machines are restricted to making shallow cuts in medium-hard materials; They should not be used for heavy excavation. A gradar can move shallow amounts of material but cannot perform dozer-type work beacuse of the structural strength and location of it's moldboard.

Graders are capable of progressively cutting ditches to a depth of 3ft and for working on slopes as at steep as 3:1 However, it is not advisable to run graders parallel with such step slopes beacuse they have a comparatively high center of gravity and the righ pressure at a critical point on the mold board could cause the machine to roll over.

The components of the grader that actually do the work are the mold board (blade) and the ~~scrape~~ Scarifier. Graders may also be equipped with lightweight rear-mounted rippers.

Mold board :-

The moldboard, commonly referred to as the blade, is the working member of the grader. A rotating circle carries the moldboard. Through intricate hydraulics The moldboard can be placed into many positions, either under the grader or to the side. it can be side-shifted horizontally for increased reach outside of the tires

Moldboard Angle :-

The moldboard can be angled (positioned) at almost any angle to the line of travel, parallel to the direction of travel, shifted to either side, or raised into vertical position.

Scarifier :-

Material too hard to cut with the moldboard should be broken up with the scarifier. A scarifier is an attachment hung between the front axle and the moldboard. it is composed of a scarifier log with removable teeth.

The teeth can be adjusted to cut to a depth of 12 in. When operating in hard material, it may be necessary to remove some of the teeth from the scarifier log. A maximum of 5 teeth may be removed from the log.

Spreading :-

Graders are often used to spread and mix dumped loads. Because of their mechanical structure and operating characteristics, gradars can only be effective Spreading and mixing free-flowing materials. A general formula for figuring grader spreading and mixing Production is

Production (bcy) Per hr = 3.0 x hp

Where hp = Engine flywheel-brake horsepower of The grader and efficiency is assumed to be a 50 min working hour.

PRO: A large grader is rated at 220hp. What is its expected production, in bcy when used for spread dumped from haul trucks?

Sand is free-flowing material, Therefore it can be used to calculate The production.

production (bcy) Per hr = 3.0x220

= 660 bcy/hr.

TIME ESTIMATES :-

The following formula can be used to prepare estimates of The total time required to complete a grader operation.

UNIT-V

CONCRETING EQUIPMENT

CRUSHERS:-

Crushers are Sometimes classified according to the Stage of Crushing that they accomplish, such as Primary, Secondary, and tertiary. A primary Crusher receives the stone directly From the Excavation after blasting and produces the First reduction in stone Size.

They are Three types of Crushers

* Jaw Crushers
* gyratory Crushers
* Impact Crushers

Jaw Crushers:-

Machines operate by allowing stone to Flow into the Space b/n two Jaws. One of which is Stationary While the other in Movable. the Space b/n the Jaws diminishes as the stone travels downward under the effect of gravity and the motion of the Movable Jaw. Until the Stone Ultimately passes through the Lower Opening. the Movable Jaw is Capable of Exerting a pressure Sufficiently high to Crush the hardest rock. Jaw Crushers are Usually designed with the toggle as the Weakest Part. the toggle will break if the Crusher

Encounters an uncrushable object or is subjected to overload. This limits damage to the crusher.

Double toggle:-

A double-toggle jaw crusher. The Blake type has a movable jaw suspended from a shaft mounted on the crusher frame. The rotation of a second shaft, which is eccentric and is located behind the movable jaw. Raises and lowers the pitman, actuating two toggle, and these produce the crushing action. As the pitman raises the two toggles, a high pressure is exerted near the bottom of the swing jaw that partially closes the opening at the bottom of the two jaws. This operation is repeated as the eccentric shaft is rotated. The jaw plates are replaceable. The jaws may be smooth or in the event the stone tends to breaks into slabs. Corrugated jaws may be used to reduce the slabbing.

Single toggle:-

When the eccentric shaft of the single-toggle crusher, as illustrated is rotated. it gives the movable jaw both a vertical and horizontal motion. This type of crusher is used quite frequently in portable rock-crushing plants because of its compact size lighter weight, and reasonably sturdy construction.

Gyratory Crushers :-

Gyratories are the most Efficient of all primary type Crushers. A gyrating mantle mounted within deep bowl characterizes these Crushers. they provides Continuous Crushing action and are used for both primary and Secondary Crushing of hard, tough, abrasive rock.

True gyratory :-

A Section through a gyratory Crusher. the Crusher Until Consists of a heavy Cast-iron or steel frame, with an Eccentric shaft and driving gears in the lower Part of the Unit. in the upper part there is a Cone-shaped Crushing Chamber, lined with hard-steel or manganese-steel plates called the "Concaves". The Crushing member includes a hard-steel Crushing head mounted on a Vertical steel Shaft. This shaft and head are Suspended from the Spider at the top of the frame that is so Constructed that Some Vertical adjustment of the shaft is possible.

The size of a gyratory Crusher is the width of the receiving Opening. measured b/n the Concaves and the Crusher head. the Setting is the width of the bottom opening and may be the Open or closed dimension.

Normally the Capacity of a "true gyrator" Crusher is based on an Open-size Setting.

The size selected may be dictated by of the rock from the blasting operation. or it may inctaled by a desired Capacity.

Impact Crushers :-

Impact Crusher fracture the feed Stone by the application of high-speed impact forces. Advantage is taken of the rebound b/n the individual stones and against the machine surfaces to fully explot the initial impact energy. the design of some impact Crushers also Utilizes Sheeur and Compression. in addition to impact action to fracture the stones. this is accomplished by forcing the stone b/n the revolving and stationary parts of the Crusher. Speed of rotation is important to the Effective Operation of these Crushers as the energy available for impact varies as the square of the rotational speed.

→ Single Rotor :-

The Single rotor-type impact Crushers breaks the stone both by the impact action of the impellears striking the feed material and by the impact that result when the impeller-driven material strikes against the aprons within the Crusher Unit. these Crushers produce a cubical product but are Economical only for Low-abrasion feeds.

Double rotor :- These Units are similer or the Single rotor models and accomplish aggregate - Size reduction the same mechanical mechanisms. They will produce some what higher proportion of fines.

→ Hammer mills :- The hammer mill, which is the most widely used impact Crusher. Can be used for primary or Secandary Crushing the basic parts of a unit includes a housing frame. a horizontal shaft Extending through the housing a number of arms and hammers attached to a housing a number of arms and hammers attached to a spool, which is mounted on the shaft: One or more manganese - steel or other hard - steel breaker plates and a Series of grate bars, whose Spacing can be adjusted to regulate the width of openings through which the Crushed stone flows

* Selection of Crushing Equipment :-

In Selecting Crushing equipment. it is essential that Certain information be known prior to making the Selection. The information needed includes, but is not necessarily limited to, these items.

1. The kind of stone to be Crushed.
2. The required Capacity of the plant - needed.

Output production

3. The Maximum Size of the Feed Stones (Concerning size)
   The size range of the feed is a helpfull)
4. The method of Feeding the Crushers.
5. The Specified size range of the product.

* Screening of Aggregate:-

The Screening process is based upon the simple premise that particle size smaller than the screen cloth opening size will pass through the screen and that oversized particles will be retained.

Screen opening can be described by either of two terms:

1. Mesh
2. Clear Opening

1. Mesh:-

The Mesh refer to the number of openings per linear inch to count the number of openings to an inch. Measure from the center of the screen wire to a point 1-in distance.

2. Clear Opening:-

Clear opening "or" "space" is a term that refers to the distance b/n the inside edges of two parallel wires.

Types of Screenings :-

The Screenings are following three types

1. Revolving Screens
2. Vibrating Screens
3. Horizontal Screens

1. **Revolving Screens :-** Revolving screens have several advantages over other types of screens, especially when they are used to wash and screen sand and gravel. the Operating action is slow and simple, and the maintenance and repairs costs are Low. if the aggregates to be Washed contains silt and clay. a scrubber can be installed near the Entrance of a screens to agitate the Material in Water. At the same time streams of Water can be sprayed on the aggregate as it moves through the screen.

2. **Vibrating Screens :-** Vibrating screens consist of one or more layer or "decks" of open mesh wire cloth mounted one above the other in a rectangular Metal box. These are the most Widely used aggregate production screens. The vibration is Obtained by means of an Eccentric shaft. a Counter Weight shaft, or Electromagnets attached

to the frame or to the screens

A unit may be horizontal or inclined high Slope (20° or less) from the receiving to the large end. The vibration, 850 to 1,250 strokes per causes the aggrega to flow over the surface of the screen. Normally, large amplitude and slower speed one necessary for large scre Openings, and the opposite is necessary for small screen Openings.

3. Horizontal Screens :-

Horizontal Screens, the throw of the vibrations must move the material both forward and up-ward. For that reason. its line of action of 45° relative to the horizontal.

Most of the particles that are smaller than the Openings in a screen at will drop through the screen while the oversize particles will flow off the screen at the discharge end. For a multiple - deck unit. the size of the Openings will be progressively smaller for each lower deck.

A screen will not pass all material whose size are equal to or less than the dimensions of the Openings in the screen. Some of this material may be retained on and carried over the discharge end of a screen. the efficiency of a screen can be defined as the ratio of the amount of material passing through a

-2/5. Mixers of all types and sizes are either free fall mixers or power mixers. Free Fall Mixers termed "gravity mixers". Mix Concrete by lifting the ingredients with the aid of fixed blades inside a rotating drum and then dropping the material by over coming the friction bln the mixture and blades.

power mixture blend Concrete by rapid rotary motion of paddles inside the mixing drum. The size of a mixer is measured by volume manufactures commonly Categorize mixers by normal volume or drum size rather than by the "total volume" or the "dry charge" the nominal volume is the maximum batch Capacity the output of mixer.

mixer output is measured in "cf or cy" per hour depending on mixer size and is determined by the mixer's Cycle time. mixer Cycle Composed are

1. loading time
2. Mixing time
3. Discharging time

the Estimation of Mixer Output for Self-loading freefall mixers is Commonly based on 40 cycle/hr or 1.5 min of total cycle time for mixer of up to 15 cf & 30 cycle/hr. 2 min of total cycle time for large mixer.

Cf means Cubic feet
Cy means Cubic yard.

Screen divided by the total amount that is small pass Through, with the ratio expressed as a percent. The Efficiency is obtained with a single-deck screening use amounting to 90 to 95%. As additional are installed. Efficiencies of these decks with ease, being above 85% for the second deck and 75% for the third deck.

* Concrete Mixers:- There are two types of Concrete-mixing Operation is use:

1. transit Mixed
2. Central Mixed

Today, unless the project is in a remote location or is relatively large. The Concrete is batched in a Central batch plant and transported to the job site in transit-mix trucks, often referred to as ready Mixed Concrete trucks, or truck Mixers.

When discussing Concrete mixing and Mixers, batch mixing should be distinguished from Continous or "Flow-type" Mixing. Whether on the job site or at the ready-Mixed plant. Concrete is Usually mixed by batches Only for Specific applications is Mixing Continous, namely, with continuous flow of Concrete ingradient Charged into one end of the Mixer and Continues Flow of Concrete discharge at the other end.

Types of concrete mixers

They are 6 type of Concrete mixers.

1. Free fall mixer
2. Tilting mixer
3. Reversible mixer
4. power mixer
5. pan mixer
6. Trough mixer

1. **Free Fall Mixers :-** The drum of a free fall mixer can be filled and emptied by changing its direction of rotation. Opening it, or tipping it up. Rotation speed must carefully follow machine - specific instruction and should not be too fast so that the free fall of the mixture is not interrupted by the centrifugal force. Free Fall mixing suits concretes that are not too stiff. Usually with a 2-in. minimum slump. as commonly used on construction sites, truck mixers, discussed later, also use free fall mixing. Two common types of free fall mixers are tilting mixers and reversible mixers.

2. **Tilting mixers :-** These are commonly trailer-mounted or otherwise portable small to mid size mixers. Used either as main concrete mixing equipment

Sites or as ancillary equipment on sites served by ready - mixed Concrete plant. The drum has two a one around which the drum rotates and another serves to Change drum loading and mixing position (drum opening up) to discharge position (drum opening down). this position Change is done manually by a dump wheel (or handle, in the smaller mixers) While drum rotation is electric. gasoline, or diesel powered.

Common outputs are in the range of 2 to 10 cy/hr. Large mixers. in the range of 5 to 15 cy. are used on central-Mixed Concrete plants.

3. Reversible Mixers:- The drum on a Reversible mixers has one horizontal axis around which it rotates. There are two openings. One at each end of the drum: one for feeding the ingredients, the other for discharging the Mixtures. In mixing position the drum rotates in the one direction. While for discharge rotation is reversed. Commonly Self-loading Reversible Mixtures are midsize to large - size units Mounted on a two - or Four-Wheel tailer for transportation between sites.

4. power Mixers:-

power Mixers, also termed puddle M Mixers, forced Mixers, or Compulsory mixers, Mix Concrete.

rapid rotary motion of paddles (or mixers heads) moving in centric or eccentric courses inside the drum. To prevent the concrete from sticking the drum side and bottom. Some of the paddles must constantly clean the concrete off the side and bottom and redirect it to drum's Centre. the paddles are spring - connected to the drum to prevent them from breaking under the intensive mixing action. The intensive mixing also causes excessive wear to the drum's inner surface. Which is not present in dredal Mixers. to withstand this wear, the inside of the drum is lined with small, easily replace able plants that are produced of specialized abrasion - resistant material.

The mixing output of a power mixer is about 50 to 100% higher than that of a same - size free - fall Mixer.

5. Pan Mixers :- The paddles of a pan Mixer are connected to a vertical shaft inside the pan-shaped drum. In turbomixers the vertical shaft is fixed and located in the centre of the drum.

1. Bothe the drum and paddles rotate in counter directions.
2. The drum is stationary while all the paddles rotate In the same direction.

3. The drum is stationary but paddles rotated in the counted direction.

6. Trough Mixers:- These are power Mixer that have a through shaped drum (resembling a horizontally placed barrel cut by half). The single-shaft Mixer has a horizontal shaft onto which the paddles are connected in a spiral like arrangement: in some models wave-shaped mixing arms replace the paddle The combination of radial (rotary and axial (horizontal) movements obtained produces a three-dimensional circulation path that further increases mixing intensity and therefore results in shortened mixing times.

Placing Concrete :-

1. Buckets:- Normally, properly designed bottom dump Bucket enable Concrete placement at the lowest practical slump Care should be exercised to prevent the Concrete from segregation as a result of discharging from too high above the surface or allowing the fresh Concrete to fall past obstruction (such as the forms themselves in the case of column) gates should be designed so that they can be opened and closed at any time during the discharge of the concrete.

mual OR Motor propelled Buggies :-

Hand buggies and Wheel barrows are usually Capable of Carrying from 4 to 9 cf concrete and this are Suitable on many projects, Either as the sole or main concre placing equipment for small or as a Complementary means of projects Utilizing Canes or pumps as the Major Concrete-placir Equipment When Considering the use of buggies and Wheel barrows, the Expense of building ramps, ramways, and Simil Setups should be taken into account, as buggies and wheel barrows can only Operate on smooth and rigid surfaces Hon buggies are Safe than wheel barrows they have two wheels Rather than one.

3. Chutes and Drop pipes :-

Chutes are often used to transfer Concrete from a higher elevation to a lower elevation they should have a rou bottom. and the slope should be steep enough for the concret to flow Continuously Without segregation. Truck Mixers ar normally equipped with built in Swing Cand often extend Chutes. These chutes are hydraulically Operated for direct Placing of the mix When the Concreting location is Within Chutes reach. Drop pipes are used to transfer the concrete Vertically down.

4. Belt Conveyors :- Belt Conveyors can be classified into types they are :-

1. portable or self - Contained Conveyors.
2. Feeders or Series Conveyors.
3. Side - discharge or Spreader Conveyors.

All types provide for the rapid movements of fresh Concrete but must have proper belt size and speed to achieve the desired rate of transportation. particular attention must be given to points where the concrete leaves one Conveyor and either continues on the another conveyor or is discharged as segregation can occur at these points. the optimum Concrete slump for Conveyed Concrete is from 2 1/2 to 3. A belt Conveyor mounted on a track Carrier being used to Place low - slump was roller Compacted concrete.

5. Concrete pumps :- pump require a steady supply of pumpable concrete to be effective today there are Three types of pumps being manufactured.

1. piston pumps.
2. Pneumatic pumps
3. squeeze pressure pumps

Most Piston pumps currently contain two pistons, with one retracting during the forward stroke

are others to give a more continuous flow of concrete. The pneumatic pumps normally use a reblend discharge box at the discharge end to bleed off air and to prevent segregation and spraying.

* Pump with a pipeline :-

In this configuration, also termed a line pump. The pipeline is a separate system that must be assembled and connected to the pump before pumping operations begin. the pipe line is laid from the location of the pump to the concrete casting area.

In terms of pump mobility. three types can be distinguished.

1. Stationary pump :- The pump is mounted on a steel frame and stationed in a fixed location throughout construction. This configuration is suitable for limited-area sites with large and frequent concreting operations.

2. Trailer pump :-

The pump is mounted on a one-or-two axle trailer to enable easy on-site relocation as well as movement b/n sites. it suitable mainly for spread-out sites. ~~It is so~~ one pump can also serve several adjacent site as it can be moved b/n them according to concreting schedule.

3. Truck pump :- Not to be confused with truck-mou by tr pump and bottom. Combination this quick setup pump is moved b/n sites and Operated on a standard truck Chassis.

*CONSOLIDATING AND FINISHING :-

Consolidating Concrete :- Concrete, a heterogeneous mixture of Water and solid particles in a stiff condition, will normally contain a large quantity of voids when placed the purpose of Consolidation is to remove these Entrapped air voids & to ensure complete filling of the forms. The importance of proper Consolidation cannot be overemphasized. as the entrapped air can render the Concrete totally Unsatisfactory Entrapped air can be reduced in two Ways - Use more Water or Consolidate the Concrete.

Consolidation is normally achieved through the Use of Mechanical vibrators. only in case a Extremely Small/thin elements and particularly Wit concrete Mixture is Consolidation by hand tools, such as a plastic - head hammer, allowed, properly vibrated Concrete is higher-quality Concrete, mainly in terms of Strength but also in terms of reinforcement protection, resistance to aggressive agents, and Overall appearance. Vibrators and

The vibrat action are characterized and distinguished by the wing properties.

1 Frequency :- The number of vibrations per unit time (Commonly minutes).

2. Amplitude :- The Magnitude of the motion in Each vibration.

3. Orientation :- There are vibrators with random motion at all directions. While others have Unidirectional motion only.

Surface vibrators exert their effects at the top Surface of the Concrete and Consolidate the concrete from the top down. They are used mainly is slab construction. and there are four general types:

They are :- 1. The vibrating Screend.

2. The pan-type vibration.

3. The plate-or grid vibratery tamper.

4. The vibratary rolling Screend.

These Surface vibrators Operate in the range from 3000 to 6000 vibration/min.

* Finishing and Curing Concrete :-

The Finishing process provides the decired fina Concrete surface. Unformed surfaces may require only "Screeding" to proper Contour and elevation or a broom Floated, or troweled finish may be specified.

Furthermore, Each step in the finishing Operation, from first "Floating" to the Final Floating or troweling Should be delayed as long as possible.

this duration is limited by the necessity to finish the Concrete to the decired grade and surface smoothness While it can still be Worked (still in a plastic state).

Floating has three purposes :-

1. To Embed aggregate particles just beneth the surface.
2. To remove slight imperfections, high spots, and fill spots; and.
3. To Compact the Concrete at the surface in preparation for other finishing Operations.