

Management



- (1) ~~cost~~ Time
- (2) cost
- (3) Material/ Resources
- (4) Man Power — Labour
Team

Construction Management :-

Construction management may be defined as an "art of planning", co-ordinating & controlling various construction activities of a project to produce qualitative & economical product with the available resources.

Objectives of construction Management :-

The main objective of construction management are :-

- i) completing the work within estimated budget & specified time.
- ii) Evolving high quality workmanship.
- iii) Providing safe working conditions for all.
- iv) Taking sound decision at the lowest practical management level through delegation of authority.
- v) Motivating people to give their best within their capacity.
- vi) Creating an organisation that works as a team.

→ Construction management is the overall planning, co-ordinating & controlling of a project from inspection to completion aimed as meeting our requirements in order to produce a functionally and financially project.

Q.1 Functions of Construction Management :-

The functions of construction management are :-

- i) Planning and scheduling
- ii) Organising
- iii) Staffing
- iv) Directing
- v) Controlling
- vi) Co-ordinating

Planning and scheduling :-

- i) It is essentially covers the aspects of "What to do" "How to do it".
- ii) Planning involves formulation of number of alternative realistic work plan for achieving specified objectives with based suitable available resources.

Scheduling :-

- i) Scheduling is the fitting of final work plan to a time scale.
- ii) It shows the duration and order of various construction activities.
- iii) It deals with the aspect of "When to do it".

Organising :-

- i) Organisation is concerned with division of the total construction work into manageable department or sections.
- ii) Systematically arranging various operations.
- iii) The relation betⁿ various personnel are established.

Staffing :-

- (i) Staffing is the provision of people to fulfill the positions to be created.
- (ii) Staffing functions include :-
 - (a) Recruiting the right people
 - (b) Arranging staff training courses
 - (c) Carrying out proper staff assessment.

Directing :-

Dt - 22/3/22

The directing function is concerned with training subordinates to carry out assigned task, supervising their work and guiding them there where needed.

Controlling :-

- (i) Controlling is necessary for ensuring effective and efficient work.
- (ii) It involves a constant review of the work plan to check ~~actual~~ ^{actual} achievement.
- (iii) Comparison of actual and planned performance.

Co-ordinating :-

- (i) It is necessary to bring together & co-ordinate the work.
- (ii) Regular meetings of departmental heads with top management.
- (iii) Plans, problems and control technique are discussed for determining best solution.

Team work
Regular meetings
Decision making } Co-ordinating

Resources

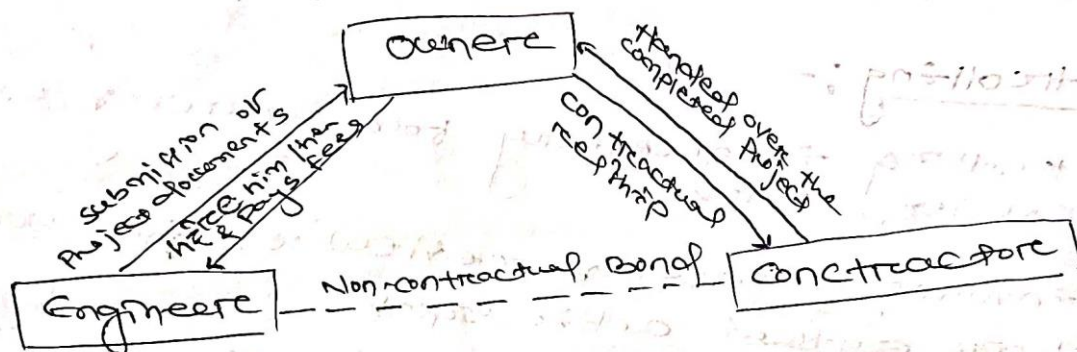
Resources for construction industry :-

Resources -

1. Land / space - Govt / Private land
2. Cost - State Govt / Central Govt / company / individual
3. Materials - cement, sand, aggregate, water, reinforcement, soil etc.
4. Man power - skilled / unskilled / Engineer / contractor / Manager.
5. Machine - Roller / Tamping machine / Excavator / Mixer / etc.

Construction Team :-

1. Owner - Govt / Private
2. Engineers - JE / AEE / Designer etc.
3. Contractors - Labourer, Manager, supervisor etc.



Construction planning :-

Systematic arrangement of all the construction activities before starting actual construction work on a project.

Stages of construction planning

Pre-Tender stage

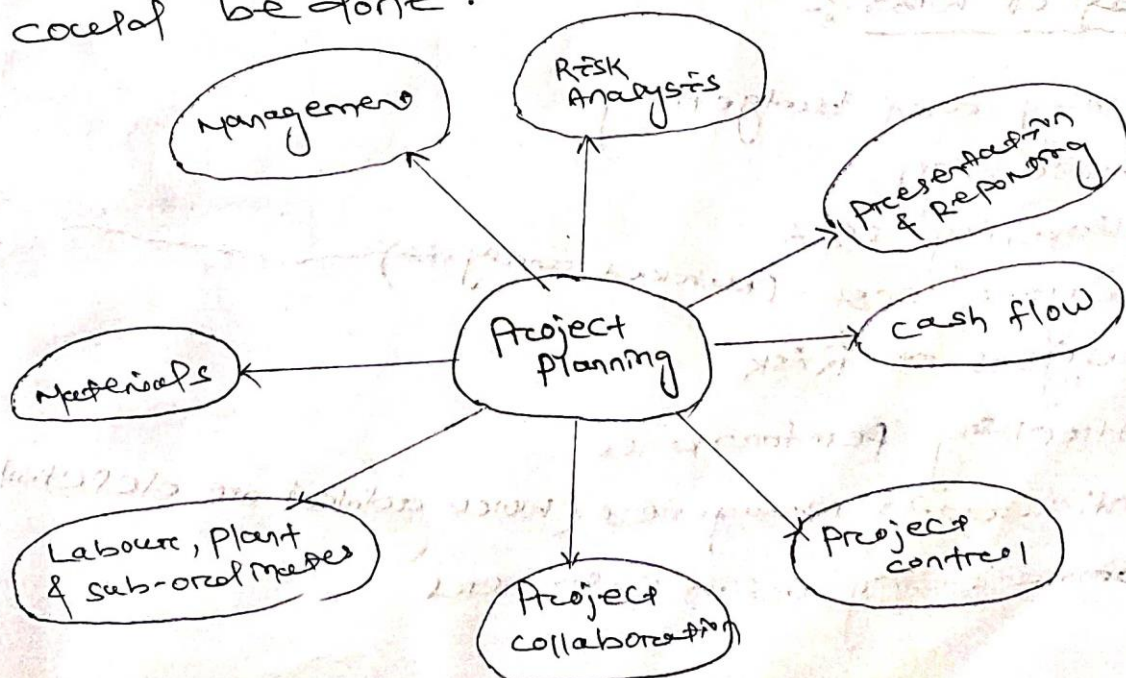
→ Various construction activities required before the notification inviting tenders & submission of bid by the contractor.

Post-Tender stage / construction stage

Planning required by the contractor after the acceptance of his tender by the authority & award of contract to him.

Project Planning :-

It is the process of selecting a particular method and the order of work to be adopted for a project from all the possible ways and sequentially in which it could be done.



Importance of Project Planning :-

- (i) Planning helps to minimize the cost by optimum utilisation of available resources.
- (ii) Planning resolves inter departmental conflicts.
- (iii) Planning encourage innovation & creativity.
- (iv) Planning imparts competitive strength to the enterprises.

Dt = 25/3/22

WORK BREAKDOWN STRUCTURE (WBS) :-

Breakdown - whole to part

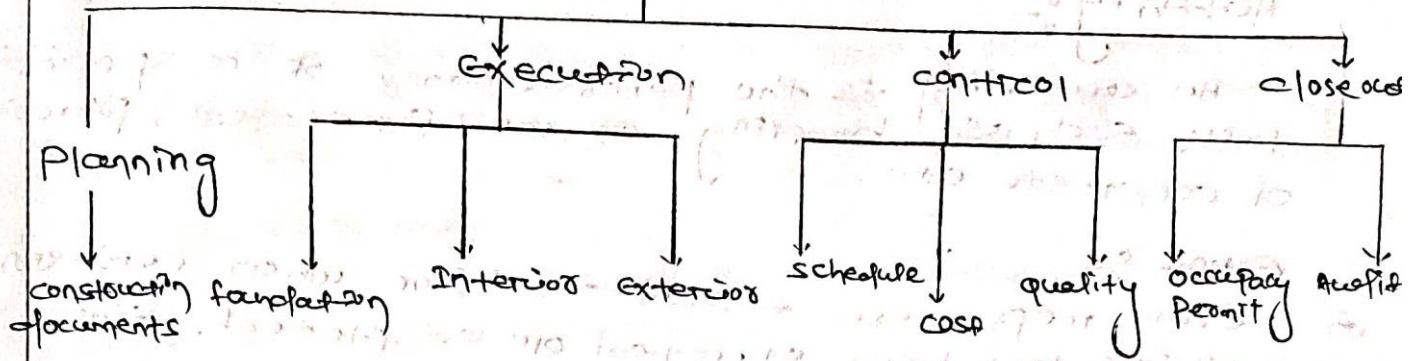
Definition :-

- (i) Work breakdown structure is the most important project management tool.
- (ii) WBS captures the entire project scope of work in a very object fashion.
- (iii) WBS guides the project team to do project planning, project execution & project control effectively.

Usage of WBS :-

- (i) Planning and budgeting
- (ii) Scheduling
- (iii) Estimating cost
- (iv) Analysis cost (Market analysis)
- (v) Analysis of Risk
- (vi) Controlling performance
- (vii) Configuration Management (work added or deleted)
- (viii) Communicating with customers.

Work Breakdown Structure



Construction scheduling by Bar charts :-

- i) A bar chart is termed with a list of activities, specifying the start date, duration of the activity and completion date on each activity and then plotted on a project time scale.
- ii) The detailed level of the bar chart depends on your project complexity and use of the schedule.

Activities

Site clearance

Excavation

Stacking of Material

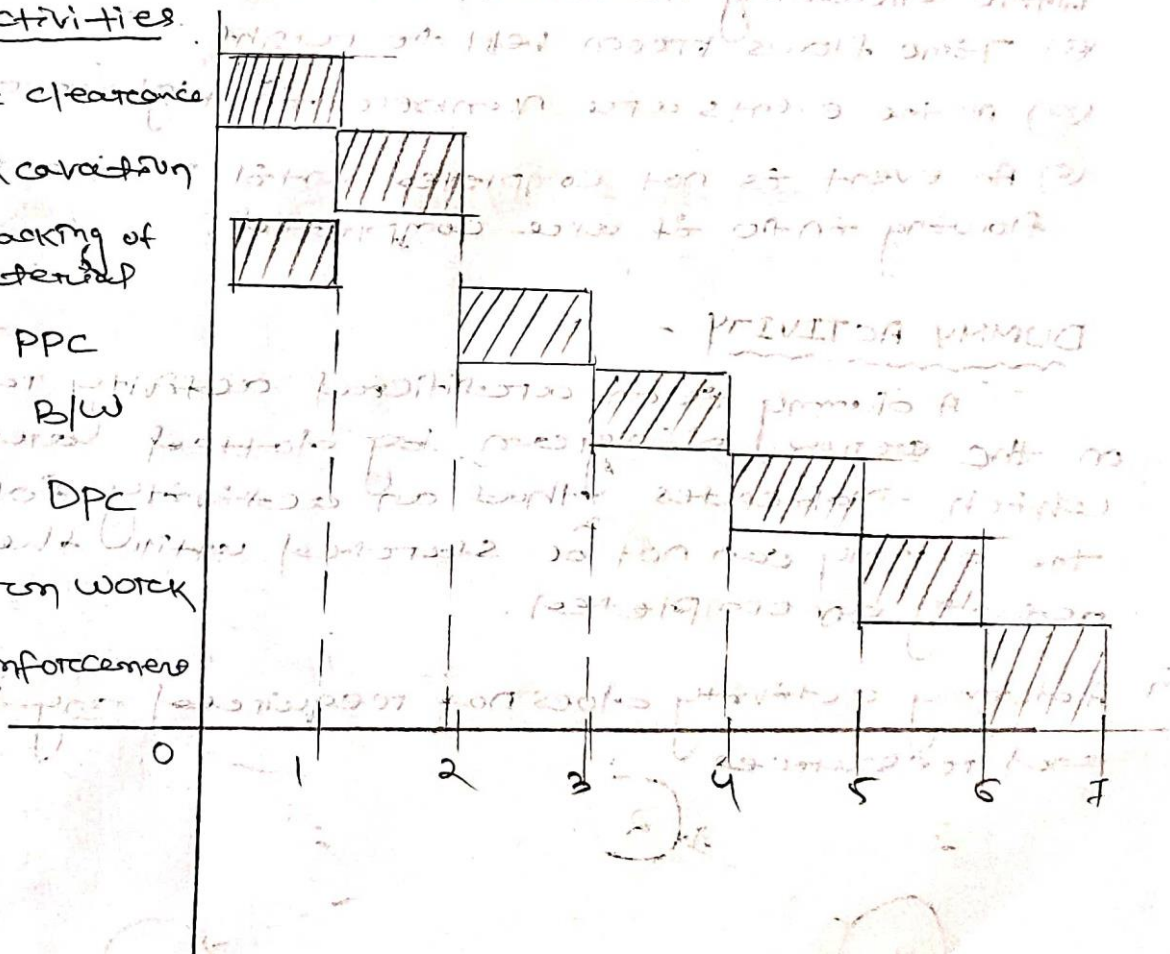
PPC

B/W

DPC

Form work

Reinforcement



CPM & PERT

Elements of Networking :-

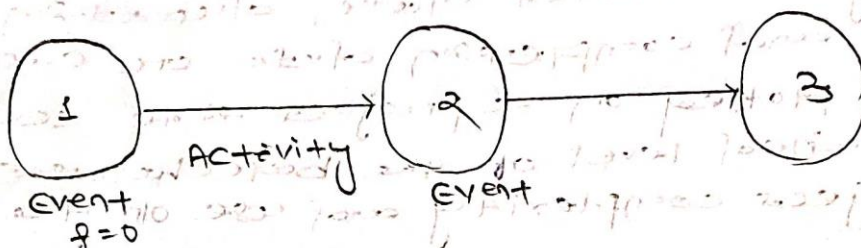
Activity :-

An activity is the performance of a specific task such as bearing or reinforcement, placing of concrete etc.

Event :-

(i) Event represents instant in time when certain activity has been started or completed. Event is also called NODE.

(ii) It is represented by a circle.



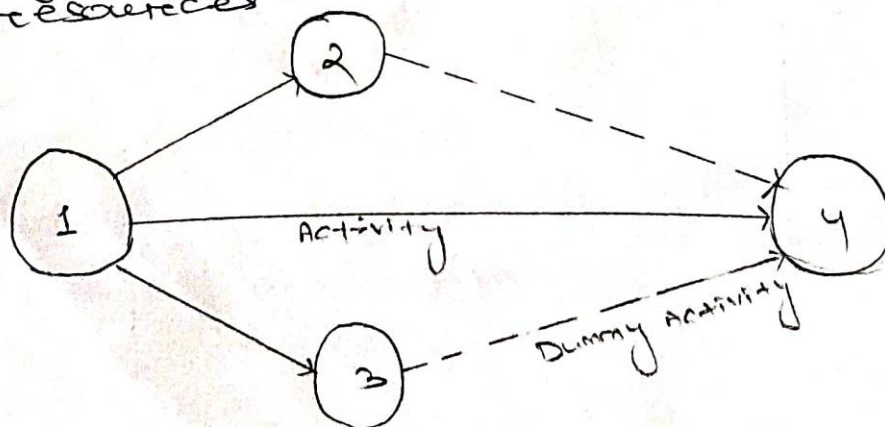
While drawing network, it is assumed that -

- (a) Time flows from left to right.
- (b) All the events are numbered in higher order.
- (c) An event is not completed until all the activities flowing into it are completed.

DUMMY ACTIVITY -

A dummy is an artificial activity represented on the arrow diagram by dotted arrow, which indicates that an activity following the dummy can not be started until the preceding activity is completed.

(i) A dummy activity does not require any time and resources



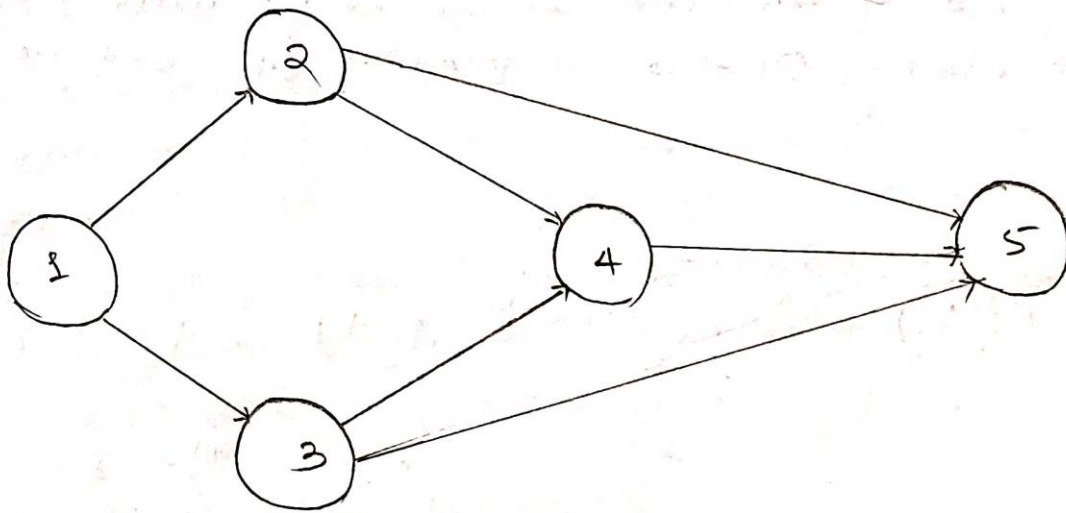
Predecessor :-

Predecessor Event :-

The Event or Events that happen before another event are called predecessor Event or Events.

Successor Event :-

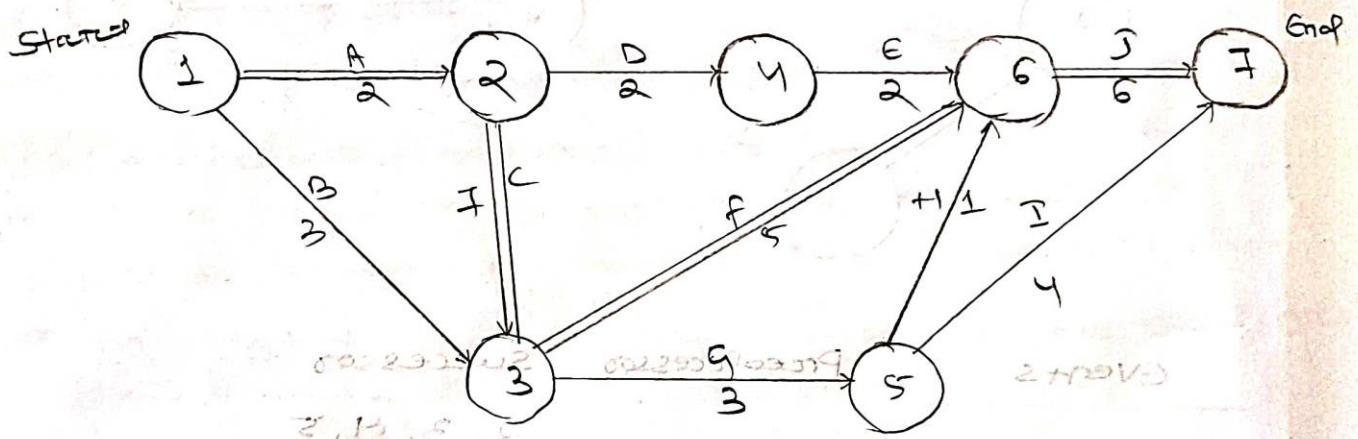
The Event or Events that follows another Event are called successor Events.



Events	Predecessor	Successor
1	—	2, 3, 4, 5
2	1	4, 5
3	1	4, 5
4	1, 2, 3	5
5	1, 2, 3, 4	—

Critical Path Method :-

- (i) The total project time is the maximum of the time amongst all paths originating from initial event and terminating at the final event, indicating the completion of the project.
- (ii) The path of longest duration is defined as critical path & the activities in this path are called critical activities.
- (iii) Any delay in critical activity will result a ~~the~~ delay in the completion of entire project.



- 1-2-4-6-7 = 12
- 1-2-3-5-7 = 16
- 1-3-5-6-7 = 13
- 1-2-3-6-7 = 20
- 1-2-3-5-6-7 = 19
- 1-3-5-7 = 10
- 1-3-6-7 = 14

PERT AND THREE TIME ESTIMATES

Dt. 30/3/2

PERT - Pert stands for project / programme evaluation and review technique.

- (i) The prime function of the management is selecting making under such uncertainty conditions and balancing the risk associated with a particular problem.
- (ii) In order to reflect this uncertainty, the modeling of network is resorted.
- (iii) Pert introduces uncertainty into the account by three types of time estimate of activity duration which are as follows -
 1. Optimistic Time estimate (t_o)
 2. Pessimistic Time estimate (t_p)
 3. Most Likely Time estimate (t_m)

1. Optimistic Time estimate :-

- (i) The optimistic time estimate is an estimate of minimum time required for an activity, if nothing goes ~~wrong~~ wrong.

~~Pessimistic~~

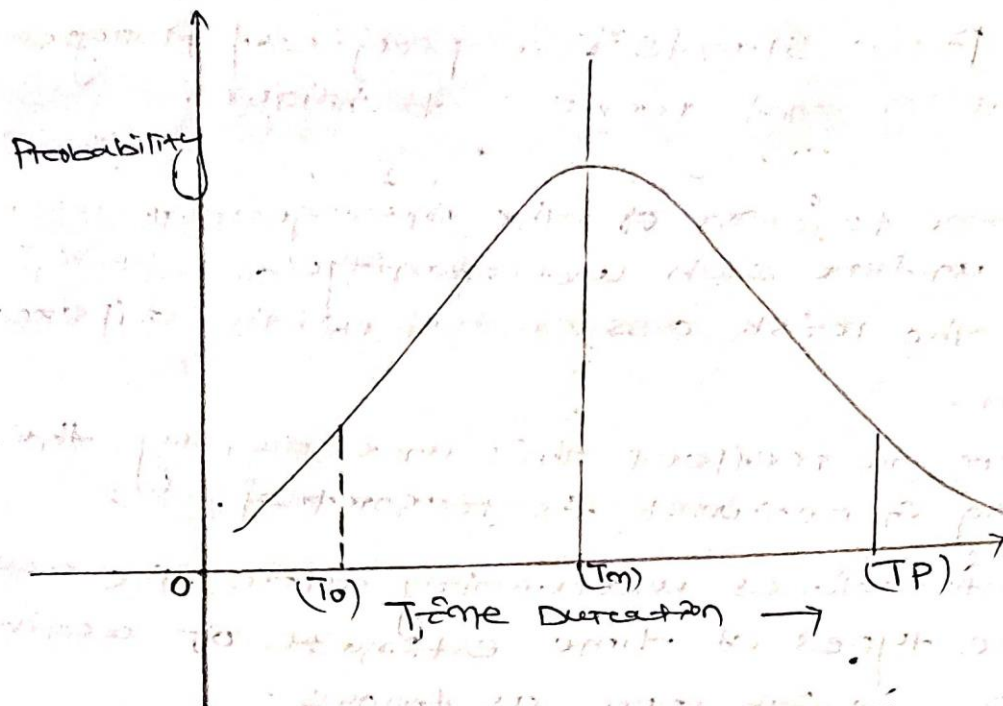
- (i) Ideal conditions are assumed during the execution of the activity.

2. Pessimistic Time estimate :-

- (i) The pessimistic time is an estimate of the maxⁿ time required for an activity, if everything goes wrong.

3. Most Likely Time estimate :-

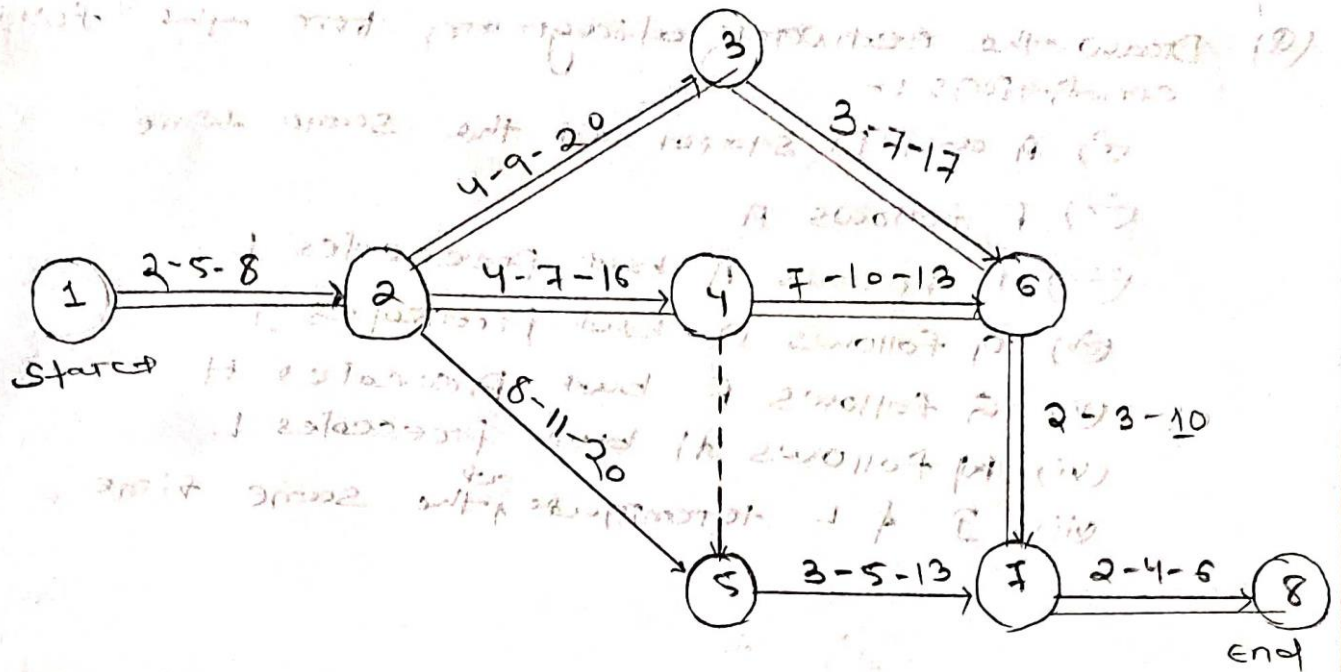
The most likely time is based on experience and judgement of the activity is repeated a number of times under essentially the same condition.



EXPECTED MEAN TIME :-

- (i) Expected mean time of an activity is denoted by (T_e)
- (ii) Expected mean time of an activity can be calculated

$$T_e = \frac{T_o + 4T_m + T_p}{6}$$



Event	t_o	t_m	t_p	$t_e = \frac{t_o + 4t_m + t_p}{6}$
1-2	2	5	8	5
2-3	4	9	20	10
2-4	4	7	16	8
2-5	8	11	20	12
4-6	7	10	13	10
3-6	7	7	17	8
5-7	3	5	13	6
6-7	2	3	10	4
7-8	2	4	6	4

$$1-2-3-6-7-8 = 5 + 10 + 8 + 4 + 4 = 31$$

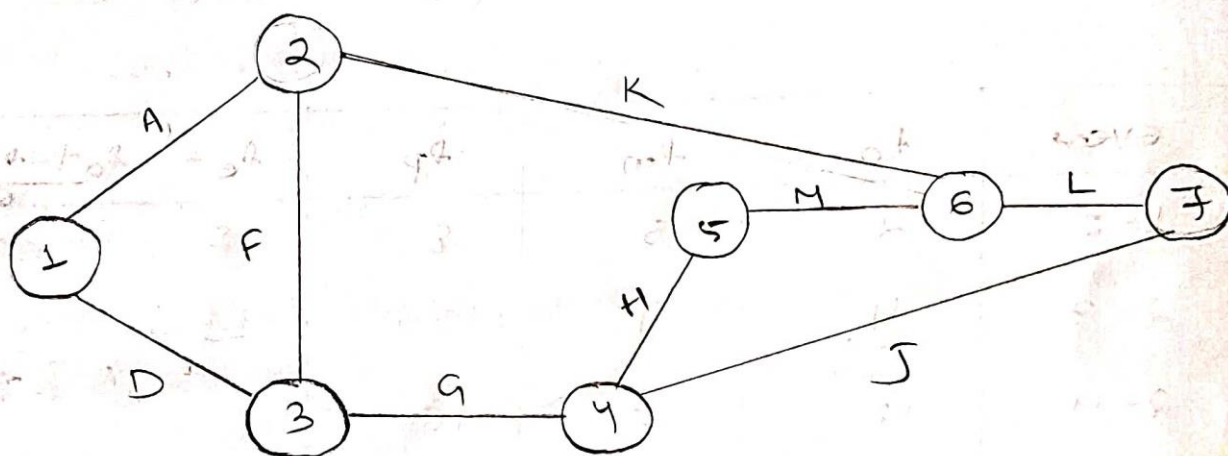
$$1-2-5-7-8 = 5 + 12 + 6 + 4 = 27$$

$$1-2-4-6-7-8 = 5 + 8 + 10 + 4 + 4 = 31$$

$$1-2-4-5-7-8 = 5 + 8 + 0 + 6 + 4 = 23$$

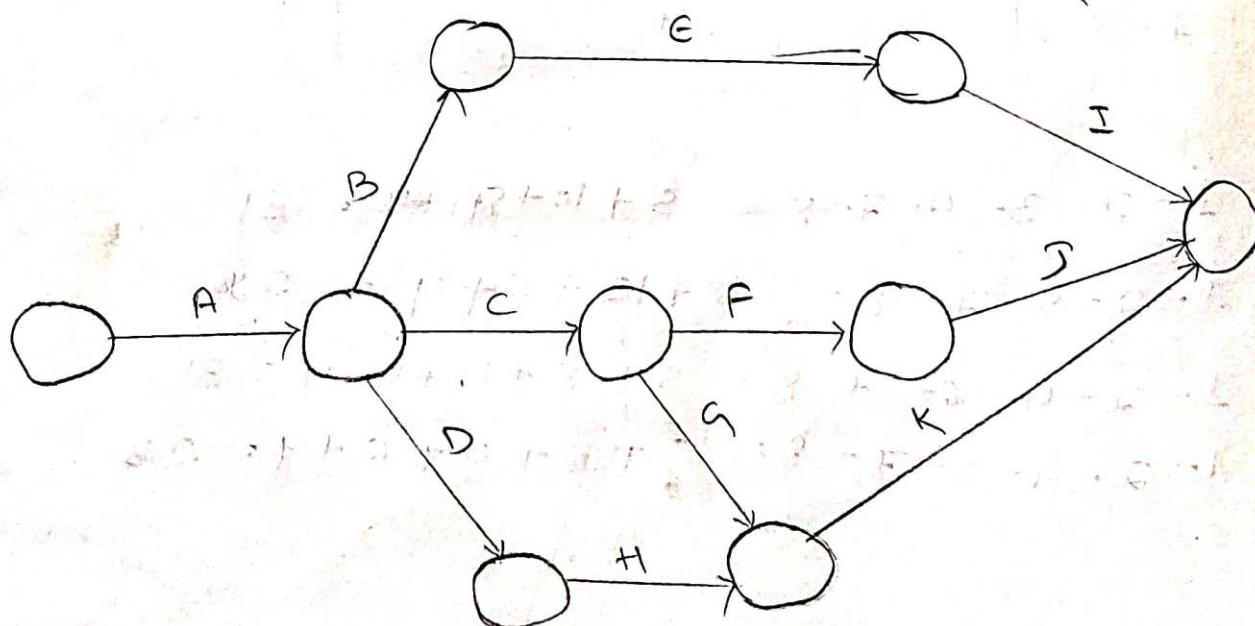
(Q) Draw the network diagram for the following conditions:-

- (i) A and D start at the same time
- (ii) F follows A
- (iii) K follows A but precedes L
- (iv) G follows D but precedes J
- (v) G follows F but precedes H
- (vi) M follows H but precedes L
- (vii) J & L terminate at the same time



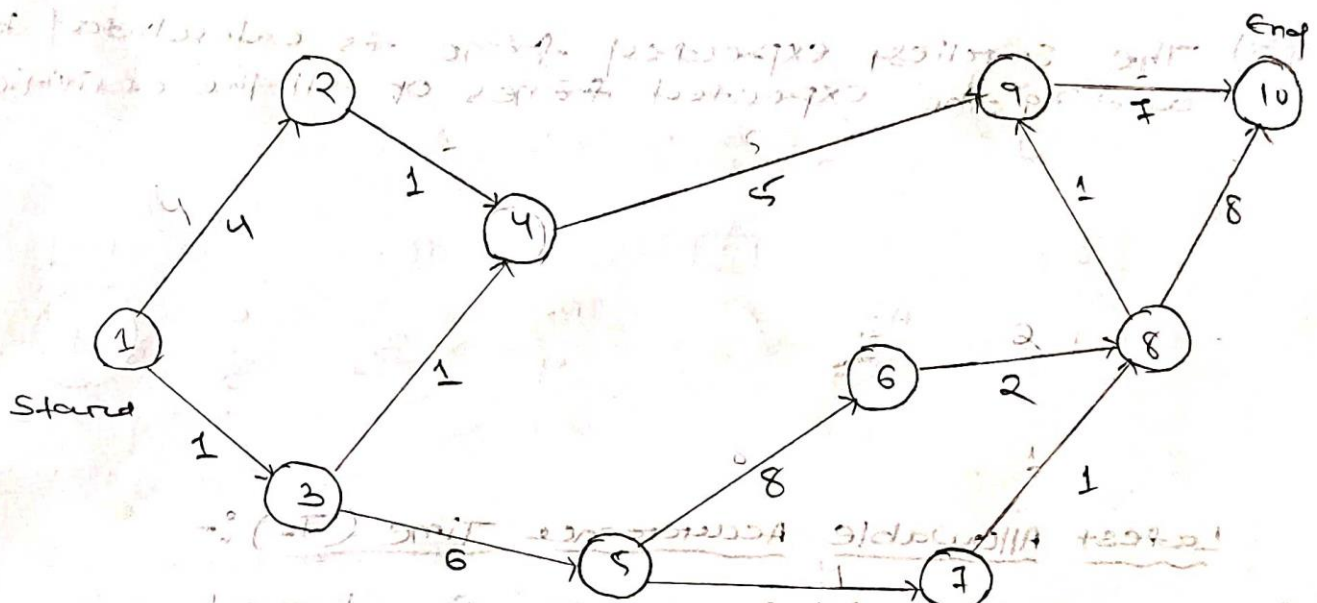
(Q) In a project consisting of 11 activities, the directions are given below:-

- | | | | |
|-------------------------|-------------------|-------------------|-------------------|
| (i) $A \rightarrow B$ | $B \rightarrow E$ | $D \rightarrow H$ | $H \rightarrow K$ |
| (ii) $A \rightarrow C$ | $C \rightarrow F$ | $E \rightarrow I$ | |
| (iii) $A \rightarrow D$ | $C \rightarrow G$ | $F \rightarrow J$ | |
| | | $G \rightarrow K$ | |



A Project schedule has the following characteristics:

Activity	Time (Weeks)	Activity	Time (Weeks)
1-2	4	5-6	4
1-3	1	5-7	8
2-4	1	6-8	1
3-4	1	7-8	2
3-5	6	8-9	1
4-9	5	8-10	8
		9-10	7



critical paths -

$$1-2-4-9-10 = 4+1+5+7 = 17$$

$$1-3-4-9-10 = 1+1+5+7 = 14$$

$$1-3-5-7-8-10 = 1+6+4+1+8 = 20$$

$$1-3-5-7-8-9-10 = 1+6+4+1+1+7 = 20$$

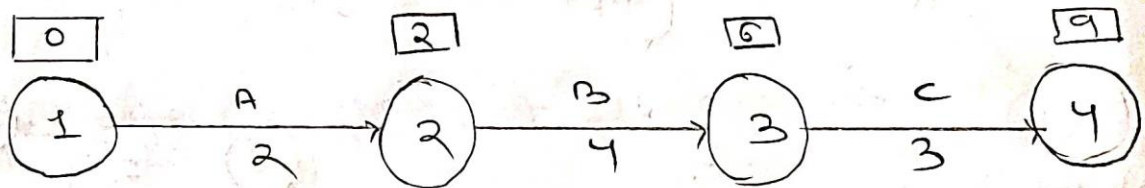
$$1-3-5-6-8-10 = 1+6+8+2+8 = 25$$

$$1-3-5-6-8-9-10 = 1+6+8+2+1+7 = 25$$

- Dt - 4/9/20
- (i) PERT is an event oriented network and the important is time occurrence for events.
 - (ii) Hence, we will loop in to duration associated with the occurrence of events.
 - (iii) The two times estimates are:-
 - (1) earliest expected time (T_E)
 - (2) Latest allowable occurrence time (T_L)

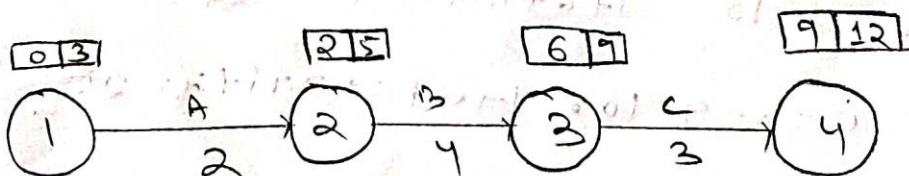
Earliest Expected Time (T_E) :-

- (i) The earliest expected time is the time when an event can be expected to occur.
- (ii) It is usually put above or below that particular event.
- (iii) The earliest expected time is calculated by adding the expected times of all the activities.



Latest Allowable Occurrence Time (T_L) :-

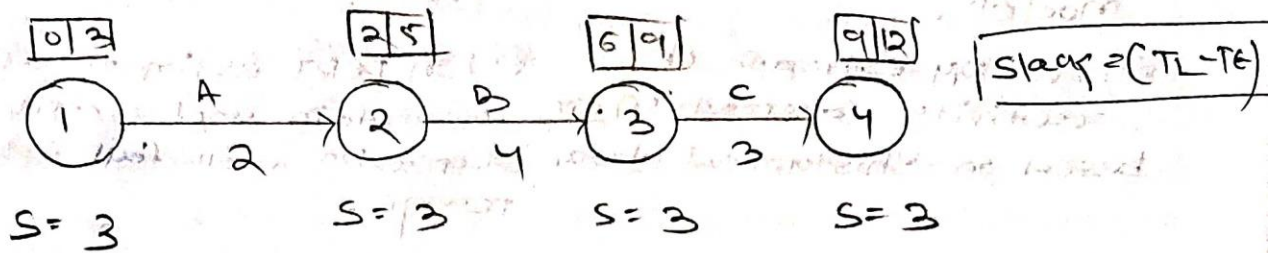
- (i) Almost all the projects are time bound.
- (ii) For each event, some time limit is allotted by which that event must occur.
- (iii) The latest time by which an event must occur to keep the project on schedule is called latest allowable occurrence time.



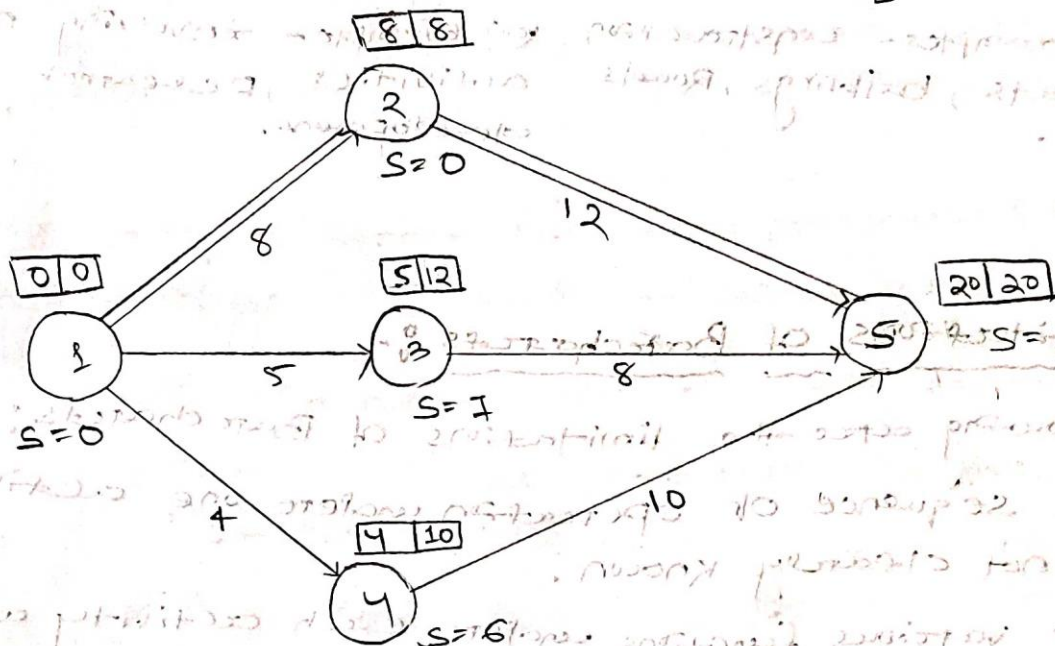
subtract / minus

SLACK :-

The difference betⁿ earliest expected time and latest allowable occurrence time of an event is called the slack of that event.



Date:- 5/4/22



forwarded (+) max^m

backward (-) min^m

When T_L is not given then assume $T_L = T_E$

→ A critical path is the one which connects the event having (0) or minimum slack time.

Differentiate betⁿ CPM & PERT :-

9.m.p

CPM	PERT
(i) It is a deterministic model. (ii) In CPM estimate of activity duration are based on historical data. (iii) It is used for repetitive job like residential construction. (iv) Examples - construction Projects, buildings, Roads etc.	(i) It is a probabilistic model. (ii) In PERT estimate are uncertain and activity duration will fall into a range. (iii) It is known for nonrepetitive job like research & development programme. (iv) Example - involving new activities, Research & development.

9.m.p

Limitations of Bar charts :-

following are the limitations of Bar charts :-

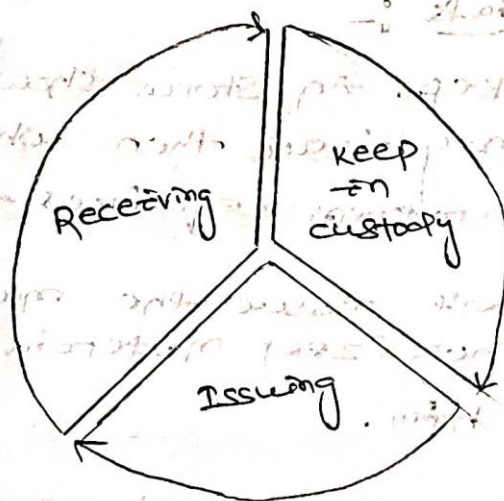
- (i) The sequence of operation where one activity is not clearly known.
- (ii) The various functions where each activity are shown by one bar, that why the interlinking is not clearly known.
- (iii) One fails to know the delay in completion of the project due to uncertainty.
- (iv) This is not given an idea as to what is completed & what is left because the bar representing any activity does not show any event in it.
- (v) Difficult to read just length of bar & ^{position} of bar, so time schedule is change.

MATERIALS AND STORE MANAGEMENTIntroduction :-

- (i) Store is an important component of material management, since it is a place that keeps the material in a way by which the materials are well accounted for, are maintained safe & are available at the time of requirements.
- (ii) Literally store refers to the place where materials are kept under custody.
- (iii) Storage is an essential and most vital part of the economic cycle of store management.

Typically a store has few processes & a space for storage. The main processes are -

- (i) To ^{receive} ~~create~~ the incoming material
- (ii) To keep the materials under the custody.
- (iii) To move them out of the store for use.



Process of a store

CLASSIFICATIONS OF STORES:-

- (i) Stores can be temporary nature which means that it has a limited life.
- (ii) Stores can also be permanent nature.
- (iii) Stores are classified as under -
 - (1) functional store
 - (2) Physical store

Dt- 8/4/22

functional store:-

- (i) functional stores are named based on the function of material store.
- (ii) Examples are - fuels store, spare parts store, Electric store, Explosive store & finished goods store, etc.

Physical store:-

- (i) Physical stores can be centralised stores or decentralised stores.
- (ii) Examples are - central store, sub store, department store, site store, receipt store, open yards & etc.

Issue of materials :-

- (i) Materials are kept in store show that the store keeper may issue them, whenever the production department requires these.
- (ii) A store keeper can't issue the materials unless a properly authorized material requisition is presented to him.

- Preparation of material requisition form
- Pricing of materials

X/YZ Company Limited

Material Requisition

Department :

No :

Job No :

Date :

To

The storekeeper

Please issue the material stated here

SINO	Description	Quantity	Rate	Amount	Bin card No	Remarks
------	-------------	----------	------	--------	----------------	---------

Authorized By:

Issued By:

Received By:

Checked By:

P.M.P

Bin Card :-

- (i) Bin card is the record maintained under the perpetual inventory system by the store department.
- (ii) It shows the quantities of material receive, issued & balance in hand after each receipt & issue.
- (iii) It is also known as stock card.
- (iv) It is kept inside the store department.
- (v) It records only quantities of material not the value.

Signature

B-En card

Material code :
 Material Description :
 Location :
 Unit of Measurement :

Maximum Level :
 Minimum Level :
 Record Level :

Date	Received from/ Issue to	Receipts	Issue	Balance	Verification with SL & Date by

Dt-9/4/22

Indent :-

(i) Purchase indent is an internal document use by companies to authorize the requisition of purchase of raw materials, capital items, machineries & etc.

Machines - Drilling

Capital items - excavator / Required hire budget

(ii) It is usually prepared by the store-in-charge for the department.

(iii) It provides detailed information about

a. Item name with the make

b. Technical description

c. Required quantity

d. Estimated price may be mentioned

I.N.P

Invoice :-

(i) An invoice ^{or} bill is a commercial document issued by a seller to a buyer, ~~refer~~ relating to a transaction & indicating the products, quantities and product service has provided in the bill.

Invoice

Bill No:

From :

BILL TO :

Name/ company :

client/ company :

Address :

SL No	Description	quantity	Rate	Amount	Remarks

Thank You for your Business:

Total =

Prepared By -

Tax & GST =

Invoice Total =

Construction OrganizationIntroduction :-

- A construction organization consists of the management, administration, field controls, engineers, supervisors, safety officers, quality control, precommissioning team and hand-over team.
- The construction management organization is normally a project task force (PTF) organization and full time assignment.

Precommissioning - To check the profit

Functions of organization :-

- (i) Long term planning.
- (ii) To prepare a structure of organization.
- (iii) To maintain good relationship.
- (iv) To prepare wage policy.
- (v) Coordinate of various department.
- (vi) To monitor various activities & progress.
- (vii) To fulfill management aims.
- (viii) To establish good relationship with workers and management.

Structure of construction organization :-

- (i) The organizational structure indicates the arrangements of different departments & the division of labour.
 - (ii) It refers to the organization of administrative patterns.
 - (iii) It is about how to use one of the basic resource, people and how to overcome the communication barriers.
- administrative pattern - prepare the paper work

I.M.P Types of structure of construction organization :-

- (i) Depending upon the manner in which the authority and responsibilities in an organization are distributed in to two categories -
 - 1) Line organization
 - 2) Line & Staff organization

Line organization :-

- (i) This is the earliest, simplest & most important form of organization.
- (ii) In this type of organization, the authority in the top of the structure will take the decision & it will be pass level step by step, through a downward direction.
- (iii) All major decisions are taken by the top authority and passed on ^{to} subordinates for necessary action at their level. (Ex - military organization)
- (iv) This type of organization is based upon military formation.

- (v) As in Army, commander in chief has full control over the entire Army.

Advantages :-

- (i) It is simple to work & easy to understand.
- (ii) It permits quick decision.
- (iii) It provides strong discipline.
- (iv) Responsibility is fixed & everybody knows to whom he is responsible.

Disadvantages :-

- (i) The organization is rigid & inflexible.
- (ii) Generally there is inadequacy of communication from lower level to higher level.
- (iii) The loss of one or two capable person may affect the organization badly.

Date:- 16/4/22

Importance

(b) Line and Staff organization :-

- (i) The line organization is not suitable for large & complex industry, where key man needs advice from experts in different fields.

Experts - High knowledge on that field / Best

- (ii) These specialists who constitute the staff in the organization are experts with long experience.
- (iii) They don't have the authority to command anybody.
- (iv) Their role is purely advisory & not directly involved in carrying out the main objectives of the organization.
- (v) The combination of line organization with expert staff is known as line & staff organization.

- (vi) The line executes the work, the staff carries on the research planning, scheduling & recording the performance.

Staff - Expert

Advantages :-

- (i) Advice of expert specialist is available.
- (ii) The project can be executed with better quality product.
- (iii) It provides more job opportunities.
- (iv) Discipline problem are resolve by line authority.
- (v) It gives increased economy and efficiency through expert staffs.

Disadvantages :-

- (i) Possibilities of conflict betⁿ line person & staff.
- (ii) The overhead cost of the production will increase due to high salaries of experts.
- (iii) The slackness of any section will affect the whole system.

EQUIPMENT MANAGEMENT

D-1 - 214/20

IDENTIFICATION OF DIFFERENT ALTERNATIVE EQUIPMENT :-

Generally 4 factors are considered for identification of alternative equipment

- (i) Equipment productivity
- (ii) Product features and attachments
- (iii) Suppliers support
- (iv) Cost

EQUIPMENT PRODUCTIVITY :-

- (i) For some types of operations, the required production is a known quantity. The best size of equipment can be chosen for the known production at the least cost.
- (ii) Past experience is a major factor to assess the size the equipment that will give the best production rate. The buyer's own experience can be supplemented by that of the equipment suppliers.
- (iii) Primary usage should be distinguished from secondary usage. Suppose a crawler tractor is under consideration it is being purchased primarily for bulldozing, and clearing, ripping or loading? Primary usage is an important consideration in determining the size of equipment and its attachments, while some compromise can be made in secondary usage.
- (iv) Equipment production is also affected by operating conditions.
- (v) For large equipment, transportation being work sites become an important consideration. Legal restriction on the movement of roads should be determined.

i) operator's wages is also a factor in considering equipment size.

2. Product features & attachments:-

i) construction equipment are available with a wide variety of features & attachments that offers greater productivity, broader applications, increased operating safety and improve operator convenience. These features should be properly evaluated.

ii) Equipment productivity can be increased in many ways some of them as follows:-

- a) By choosing the right equipment with the right attachment.
- b) By ^{adding} ~~releasing~~ special attachments such as a retarder for speed control on graders. It can enable an equipment to do work that ordinary ~~it will not~~ able to perform economically.
- c) By reducing equipment downtime i.e the ability to correct malfunctions quickly.
- iii) Safety features deserves particular attention.
- iv) selecting type of wheel type equipment & track for crawler equipment is a critical process.

3. Suppliers support:-

- i) From the time of purchase to the final resale, the equipment supplier plays an important role in determining whether a particular equipment can become an efficient part of an economical system.
- ii) The availability of spare parts, service facilities & qualified personnel for training the operators must be considered.

(ii) supplier support can take many forms, agreements are offered that support regular machine inspection, service, guaranteed availability & predetermined prices when the equipment ~~is returned~~ is returned for ~~hire~~. Long & short term lease agreements can be negotiated to guarantee availability, allow for purchase, or guarantee a total cost for equipment hire.

4 COST:-

(i) The cost of an equipment is the final factor of consideration. The cost of purchase should be just one part of overall selection criteria, resale cost should also be considered, along with maintenance & repair cost.

(ii) A low initial cost is a worry while considering only when coupled with satisfactory performance & supplier's support for parts & services.

Importance of owning and operating costs in making decisions for hiring & purchase of equipment :-

There are several methods of determining the probable cost of owning & operating construction equipment should provide information that may be useful for the purchase equipment.

- factors that affect the cost of owning & operating construction equipment include

- (i) The cost of the equipment to the owner.
- (ii) the severity of the job condition
- (iii) The no of working hours in a year
- (iv) the no of years the equipment is used.
- (v) the cost with which the owner maintains and repairs it.
- (vi) the demand for used equipment when it is disposed of, which will affect the salvage value.

When the cost of owning and operating of construction equipment is to be estimated before it is purchased, the cost records based on past experience will generally not be available. The cost which should be considered include capital investments & depreciation (the ownership cost, maintenance, repairs, petrol, oil & lubrication charges (operating cost)).

When the contractor requires additional equipment to carry out the work under the contract, he should decide whether

(a) to purchase or

(b) take it on rent with option to purchase

c) To take it on rent with ^{own} ~~option~~ to purchase option but under a lease agreement.

under certain conditions it is financially beneficial to purchase, while under other conditions it is more economical & satisfactory to take it on rent. The methods selected should be one that will provide the use of the equipment at the lowest total cost, consistent with the use that the contractor will make of the equipment.

Each method has its own advantages & disadvantages which should be considered before making a decision.

The advantages of purchasing the equipment as compared to renting -

(i) It is more economical if the equipment is used sufficiently.

(ii) It is more likely to be available for use when necessary.

(iii) Because of ownership it should assure better maintenance & care, purchased equipment should be kept in better maintained condition.

Disadvantage of purchasing & owning equipment -
It may be more expensive than hiring.

(i) The purchase of the equipment, may require a considerable investment of money and may be needed for other purposes.

(ii) The ownership of equipment may influence a contractor to continue to use obsolete equipment even after superior equipment has been introduced & available in the market.

(v) The ownership of equipment design, properly fore a given type of work may ^{induced} ~~influence~~ a contractor to continue along that type of work.

(iv) The ownership of equipment might influence a contractor to continue using the equipment beyond its economic life, thereby by increasing the cost of production.

(vi) The most important factor in deciding whether to purchase or hire, is its expected long term utilization. Renting of equipment charged a profit & thus the hourly rate would be higher than the comparable cost to the owner, if he used the equipment consistently. If the expected use is for a short period, then renting is usually cheaper.

Inspection and testing of equipment :-

Regular inspection of equipment is an important part of field maintenance. Regular inspection means periodic investigation of the condition of all the components like engine, transmission, drive train, hydraulics, structural members & wearing components, such as undercarriages, tires & cutting edges.

A maintenance programme should be prepared for implementation. Coordinating between maintenance programme & construction operations is the most important responsibility. In a large organisation, maintenance inspection personnel would handle only inspections & adjustments.

The areas of responsibilities of maintenance inspection personnel are as follows :-

- (i) Regular inspecting & adjusting
- (ii) scheduling machines for maintenance check
- (iii) advising the equipment managers of the service needs.
- (iv) keeping records of their works on machines.

Job layout for different construction site :-

A job layout is prepared by the superintendent at the start of a project. On this layout, drawn to the scale, the area available for offices, equipment, storage of materials & warehouses, construction forms & fabricating reinforcement of structural

steel members. In preparing the site layout all areas are arranged so as to reduce the time consume in carrying materials from the storage areas to the project & moving the equipment from the workshop to the site of work.

Equipment & materials that are similar in use should be stored close together where possible. When storing cement the stacking of cement bags should be so made that the first bag in is the first bag in to be taken out.

Materials handling or hoisting equipment has to perform a large variety of functions in building a different structured & the selected layout must be able to do all that is required of it. The functions include shifting formwork, welding sets & lifting equipment from block to block, reinforcement bars, resting equipment & so on.

It is desirable to make a layout which, as the work goes on, tends to systemize itself. It is a very expensive job to teach 2000-2004 persons about keeping their work growing in the most economical way for the project as a whole.

Once the plan layout of the equipment have design & selected, the entire job is practically fixed.

Quite often, a small model of a layout ~~with~~ will serve as a ^{valuable} check or a paper study, one will often bring out elements

that have previously been overlooked. Models of special equipment will provide variable information of assurance before any large expenditures are made on full scale operating that the proposed ~~plan~~^{scheme} will work satisfactorily.

Equipment maintenance and minor repairs.