S. No.	Topic	Page No.	Date	Grade/ Marks	Signature

Construction Project Management

Objective:-

After completion of this course, students will be able to

- Describe the fundamental concepts of project
- Handle construction project management &
- Plan, monitor and control construction projects by choosing appropriate tools.

Syllabus: (45 hours)

1. Introduction - 2hrs
2. Project planning, Monitoring & Control - 8 hrs
3. Contract Administration - 6 hrs
4. Construction plant & Equipment - 8 hrs
5. Quality Control / Assurance - 4 hrs
6. Material Management - 3 hrs
7. Construction Site Preparation - 2 hrs
8. Environmental Health & Safety at construction site - 4 hrs
9. Project Maintenance - 2 hrs
10. Organization & Management - 6 hrs

Tutorials:-

1) Prepare a work schedule of a given project by using Gantt Chart and CPM Network.
2) Prepare a quality control procedure by using PPMO conditions of contract.
3) Use standard specifications for civil works (yellow book) to prepare list of IS & BS codes that is required in quality control proces
4) Prepare a site layout plan for the construction of 100m long RCC Bridge.
5) Prepare a Quality Assurance Plan (QAP) for a given project.

Chapter-1, Introduction

Outline:

→ Project & Program Definition
→ Characteristics of projects and programs.
→ Project Life Cycle
→ Phases in construction Project Lifecycle:

※ Construction Project Management:

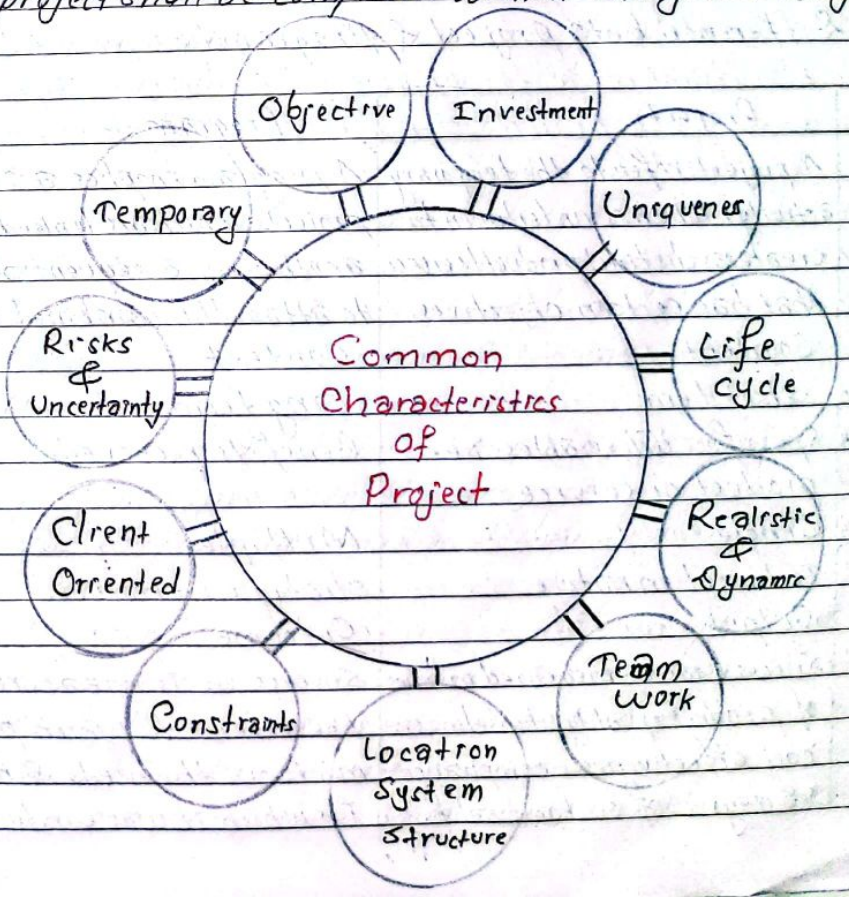
→ Construction: Action of building something, typically a large structure like building, bridge, road etc.
→ Project: Series of activities & tasks that have a specific objective, defined start and end dates, funding limits & consume resources.
→ Management: Sort of administration whose function is to plan, organize, control & coordinate the use of other resources to achieve the desired goal.

→ Thus, CPM can be defined as planning, organizing, directing & controlling of projects and its resources to achieve specific objectives that has been established to complete specific goals.

※ Project & its characteristics:

→ Project is a series of activities & tasks that have a specific objective, defined start & end dates, funding limits & consume resources.
→ The major characteristics of project are
1) The project should have specified target
2) The project should be unique and cannot be replicated with the same task & resources giving the same results.
3) Should satisfy owners requirement & expectations from project.

4) The construction project shall consists of a number of associated activities contributing to the project as a whole.
5) The time limit for completion of project shall be defined.
6) The construction project is complex & it involves a number of individuals from different departments. so, right coordination shall be setup within departments.
7) The project manager must be flexible to accomodate any change that might occur during the project.
8) The total cost of construction project shall be defined & project shall be completed within the given budget.



✻ Program & its characteristics

→ A bundle of projects which are linked to one another, rationally to attain the combined benefits is called program.
→ Focus on context
→ Have long term time horizon
→ Concerned with benefit received.
→ Strategic in nature.
→ It consists of various projects which are started to reach organizational goals.

✻ Difference bet^n project & Program

Basis	Project	Program
Meaning	A project refers to the temporary activity, which is undertaken to create a distinct product/service that has certain objectives.	A program implies a set of projects which are linked to one another, in a sequential manner to attain the combined benefits.
Focus on	Content	Context
Time Horizon	Short term	Long term
Concerned with	Specific deliverables i.e. product or service.	Benefits received.
Functional Units	Single	Multiple
Tasks	Technical in nature	strategic in nature.
Produces	Output	Outcome
Success	Success can be measured in terms of product quality, timeliness, cost effectiveness, compliance & degree of customer satisfaction	Success is measured by the extent to which program meets out the needs & benefits for which it was conducted.

✻ Scope of Construction Management

- Government Organization
  - Irrigation
  - Highway (DOR, LRBP, DOLIDAR)
  - Building
  - Hydropower
  - Water supply & sanitation
  - Alternative Energy
  - Municipality
  - Other organization
- Consultants
- Contractors
- Input Suppliers
  - Material supplier
  - Equipment supplier
- Valuation
  - Banks & financial institutions

✻ Project Life Cycle :-

→ Each project has a predetermined duration with a definite beginning and an identifiable end.
→ Its starting point is the time when the idea is conceived by the client & its end marks the time when mission is accomplished.
→ The timespan between the start & completion of a project represents the project life cycle, which varies from few months to few years.

→ Although construction projects differ in many ways, the life span of a project follows a similar pattern. After conception there is a gradual buildup in the use of resources it is followed by a long duration plateau & towards the end, there is a rapid run down till completion (Fig 1)

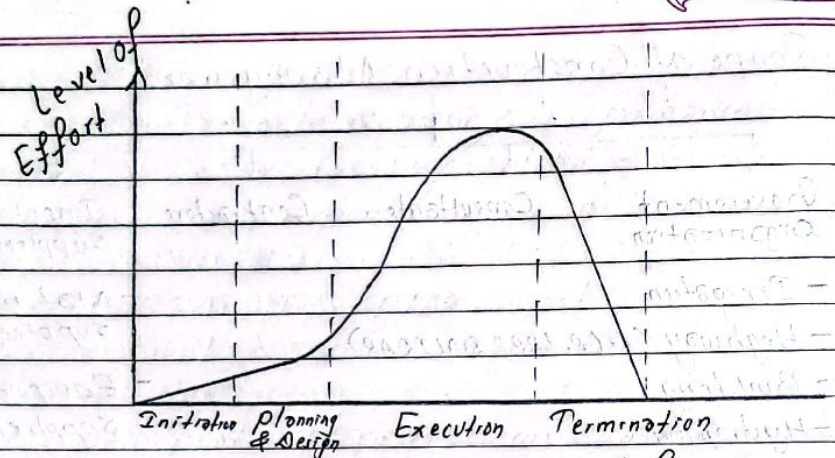


Fig: Typical construction project life cycle.

→ The breakdown of whole project into different phases is also considered as the project phases. After breaking down the whole project, it will be easier to plan, monitor, update, fund and also to success the project within time, cost & quality.

→ Generally, the projects are divided into 4 phases.
(a) Conceptual phase / Initiation / Formulation phase
(b) Planning phase
(c) Implementation / Construction phase
(d) Termination phase.

(a) Conceptual phase / Initiation phase / Formulation phase
→ Project Identification / project screening
→ Project Formulation
→ Pre-feasibility of the project
- Technical Analysis
- Market Analysis
- Financial Analysis
- Socio-economic analysis
- Environmental analysis.

→ Project identification
→ Performance of existing industries
→ Availability of raw materials
→ Availability of skilled labour
→ Import / Export statistics
→ Price Trend
→ Data from various sources
→ Government policy / Guideline
→ Analysis of economic & social trends.

→ Setting of Project Objective & Goals:
- ~~Gaol~~ Goals are the end results to be achieved. They serves as focal point in organization for using resources.
- Setting of objective is to meet the goal.
- Objectives are to be workable & achievable with the involvement of given resources under normal circumstances.
- Consideration while selecting objectives:
(a) S → Specific
(b) M → Measurable
(c) A → Achievable
(d) R → Realistic
(e) T → Timeliness

(b) Planning phase:
→ Detail feasibility study
→ Project appraisal
→ Project approval
→ Detailed Engineering & Design
- Analyzing & designing the structure & its elements

- A set of explicit drawings & specification
- Setting standards of safety & performance
- Technology (construction method)
- Consultation of experts like geologists, economists & environmental scientists.
- Detail estimation of the project.

→ Procurement

(c) Implementation / Construction phase:-

→ In this phase, the project plan is put into motion & the work of the project is performed practically on site. It is essential to maintain control & communicate as needed during each implementation stages.

→ site handover
→ Setup the project organization
→ Project Execution
→ It involves the organization & coordination of all the resources for the project.
→ Labor
→ Construction Equipment supplies & utilities
→ Money, technology & Methods
→ Construction planning & scheduling.
→ Cost & Quality control
→ Quality Assurance Testing

(d) Termination phase:-

→ Final project evaluation
→ Project handover
→ Transition between the construction & final taking over of the structure.
→ Also called commissioning stage.
→ In this stage, it involves the following activities.

1) Records are prepared of the actual construction work finally carried out at site.
2) Changes are recorded for reason of technical performance & financial implications
3) To inspect the construction work thoroughly and have any defects removed (Defect liability period)
4) Issue of project completion Certificate
5) To prepare operating instructions & maintenance manual

※ Functions of Management:-

- planning (what to do?, when to do?, How to do?)
- Organizing (creation of organization)
- Staffing (selection of right persons for different jobs)
- Directing (Motivation, Guidance, supervision & leading the employees of organization)
- Controlling (cost, resource, quality & monitor progress)
- Coordination (Proper coordination from top level to achieve the specified goal)

※ Project classification:-

1) General classification
(a) Building Construction
(b) Infrastructure construction
(c) Industrial Construction
(d) Special purpose projects.

2) Time basis classification:-
- Long duration projects (over 10 years)
- Medium duration projects (3 to 10 yrs)
- Short duration projects (1 to 3 yrs)
- Special short term projects (less than 1 year)

3) Project Value basis classification
- Mega value projects (over $1000 Million)
- Large value projects ($100 million to $1000 Million)
- Medium value projects ($10 Million to $100 Million)
- Small value projects (Less than $10 Million)

※ Note:-
→ The project manager aims to achieve mission by
→ Managing
- Time & progress
- Cost & Cash flow
- Quality & performance
- Organization behavior

With
- Organization resources

By
- ~~organizing~~, planning resources
- Scheduling resources
- Organizing resources
- Directing resources
- Monitoring & controlling resources

Within
- Quality Constraints
- Time constraints
- Cost constraints
- Environment Constraints

※ Resources in Construction Industry (5 Ms)
1) Manpower
2) Money
3) Materials
4) Machines
5) Minute or Methodology

※ Six M's of Management
(a) Manpower:- Managerial & non-managerial persons
(b) Machines:- Used to convert raw materials into finished produ
(c) Materials:- Raw material required for production of goods
(d) Methods:- Systems & procedures used for performing various operations.
(e) Money:- Means for conducting all activities
(f) Markets:- Both products & services need marketing to increase firms financial return.

Chapter-2, Project planning, Monitoring & Control

Outline:-

→ Introduction to planning, monitoring & control.
→ Introduction to project planning tools- Gantt chart, milestone chart, linked-bar chart, CPM, PERT, line of balance.
→ Use of Grant chart & CPM network for project planning & Monitoring.
→ Resource planning & leveling by using Gantt chart
→ Preparing construction schedule, labour schedule, material schedule & equipment schedule by using Gantt chart
→ Earned Value Analysis (EVA)
→ Time cost tradeoff
→ Introduction to cost control & technical auditing.

※ Construction Planning:

→ It is the most important step in any project, without plan nothing will happen. It is the mental process, deciding about the future line of action of the construction project.
→ In planning, there will be many alternatives and among them most efficient plan can be selected for design & construction.
→ Deciding,
  - What to do?
  - How to do?
  - When to do?
→ Objective of planning
1) Proper design of each element
2) Proper selection of machinery & equipment.
3) Proper arrangement of repair & maintenance of them.
4) Procurement of required materials.

5) To ensure trained & capable workers & to provide welfare schemes incentives of them.
6) To manage continuous flow of fund.
7) To provide proper safety measure of workers.
8) Proper arrangement of communication etc.

※ Steps for effective planning:-

Identify the problems to be encountered
↓
Obtain different alternatives for execution
↓
Fixing the start time, end time & duration of project
↓
Decision regarding material, labors, equipments etc.
↓
Estimation of Budget needed
↓
Evaluation of Effectiveness of plan.

※ Work Breakdown Structure (WBS)

→ For effective planning and scheduling, it is necessary to breakdown the total project into subsections & activities.
→ Each activity or job may further be subdivided into smaller jobs for planning at various levels.
→ The functional elements of a project & their interrelationship are determined by a technique known as work breakdown structure.
→ Such a technique establishes the hierarchical order in a

system by breaking the project into recognizable systems, sub-systems & discrete activities.

→ The objective of WBS is to identify discrete activities or tasks that can be planned, estimated, scheduled, executed & controlled for completion.

Program (set of projects)
↓
Project (sum of all tasks)
↓
Task (sum of all subtasks)
↓
Sub-task (Sum of work packages)
↓
Work Package (sum of work units)

Eg: Level of WBS

✱ Advantages of WBS

→ planning can be easily performed
→ Easy for resource allocation
→ Risk Analysis can be done
→ Cost & budgets can be optimized
→ Coordination can be established
→ Network Analysis can be done
→ Schedules can be established.
→ When summed up total program can be described.

✱ Scheduling:-

→ Process of fitting the workplan to a time frame showing sequential relationships among various activities
→ Schedules are prepared for construction resources such as labour, materials, machinery & money required at various stages of the work.
→ The actual progress of each activity can be monitored with reference to the planned schedule.
→ The construction schedule serves the following purposes
a) Making available a time table showing the schedule & sequence of each activity.
b) Providing a schedule for monitoring the progress of work & taking corrective measures, if required.
c) Providing a means for establishing & maintaining time goals & prioritizing activities.

✱ Factors Affecting Scheduling:-

→ location
→ Geographical Condition
→ Weather
→ Market Area
→ skills/Experience of Project Manager
→ Attitude of project manager
→ Capacity of the contractor
→ Project Environment
→ Relation of Project Teams
→ Nature of the project/Size of the project

* Steps on preparing a schedule:-
1) Assess total quantity of the activity.
2) Ascertain the sequence of operation.
3) Decide on the method of Execution
4) Determine the rate of executing the activity
5) Calculate theoretical time required to complete the activity.
6) Allocate relaxation allowance & contingency allowance
7) Fix the date to start the activity
8) Consider independence of other activities
9) Determine the rate of completion of the activity.
10) Determine the final completion date of project by adding duration along the critical path.

** Advantages of Scheduling:-
→ It gives the clear picture about the quantity & type of materials needed at different stages of execution of work.
→ The time of starting of each activity is known.
→ The resource utilization is optimized.
→ The actual progress of each activity can be monitored.
→ The interrelationship of various activities & their relative importance of each stage of construction is known.
→ The effect of any change can be reduced.
→ Total time to complete the project is known.
→ The work can be executed in a most efficient way without wastage of time and any inputs, resulting in maximum possible economy.

** Preparation of Material, Equipment & Labour Schedule
→ For any given work, the resources required are materials manpower, machinery/plant (Equipment & Money.
→ These resources have to be utilized in a planned & efficient manner in order to derive the maximum benefit
→ The right type of labour or equipment may not be available at the required time due to labour shortage or breakdown of machinery.
→ Thus, to execute the construction work in an efficient manner and without wastage of any of the inputs, schedules for various project resources need to be prepared.

** Preparation of Material Schedule:-
A typical material schedule prepared weekly for the construction of a temporary shed (8m x 20m)

Materials	Units	Weeks				
		1	2	3	4	5
Cement Bags	No.	110	100	115	120	135
Bricks	No.	4500	4000	5500	3000	2600
Sand	Cum.	20	20	35	25	15
Aggregate	Cum.	20	35	30	25	30
Steel	kg	-	-	-	-	-

* Preparation of Labour Schedule:-
→ A typical labour schedule prepared weekly for the construction of a temporary shed (8m x 20m).

Manpower (labour)	Weeks				
	1	2	3	4	5
Foreman	1	1	1	1	1
Carpenters	–	–	–	1	1
Welders	–	–	3	2	1
Mixer Operator	–	–	–	–	–
Masons	1	1	2	2	1
Bar benders	–	2	1	–	–
Labourers	3	3	10	6	3

* Preparation of Equipment Schedule:-
A typical equipment schedule prepared weekly for the construction of a temporary shed (8m x 20m)

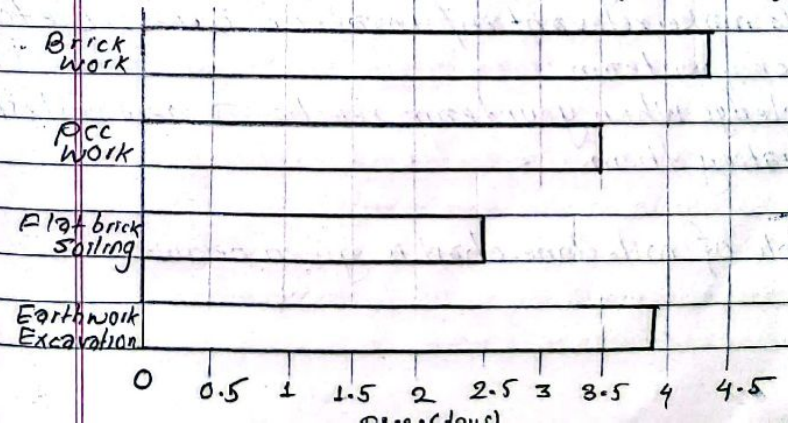
Equipment	Weeks				
	1	2	3	4	5
Concrete Mixer	–	–	1	–	–
Vibrator	–	–	1	–	–
Welding Set	–	–	1	–	–
Truck	–	1	1	1	1
Equipment for erecting trusses	–	–	–	1	–

* Classification of Schedule:-
- Construction Schedule
- Materials Schedule
- Labour Schedule
- Equipment Schedule
- Financial Schedule.
- Control Schedule
- Organization Schedule
- Summary Schedule.

* Methods / Techniques of Scheduling:-

- Scheduling by Chart
  - Bar charts
  - Milestone chart
  - Linked Bar Chart
- Network Techniques
  - CPM
  - PERT

* Scheduling by Gantt Bar Charts:-
→ The conventional method of scheduling used in the construction industry is the bar chart. It is also known as Gantt Bar Chart after Henry Gantt, who developed this technique around 1919.
→ A bar chart consists of two coordinate axes, one showing the time and other showing jobs or activities to be performed.
→ Each job is shown in the form of horizontal line or bar and the length of bar indicates duration of the job or activity.
→ In a project, some jobs are taken up concurrently and some are required to be completed before others can begin.



Eg: Gantt chart

* Limitation/ Disadvantages of bar chart
a) Interdependencies of activities cannot be clearly depicted.
b) Donot show project progress
c) Critical activities cannot be identified.

Milestone Chart:-

→ A milestone chart is a visual representation of the most important tasks your team needs to complete throughout a project.
→ Milestones are checkpoints. They show your team when an activity or phase has been completed.

→ Steps to create Milestone chart
1) Create a rough timeline & define your project goals & objectives.
2) Write down all task in chronological order
3) Identify tasks that impact your deadline (milestone)
4) Create your timeline
5) Ask your team for feedback & adjust the timeline to prevent issues later on.
6) Add documents to your timeline during the project lifecycle to make relevant information accessible to everyone on your team.
7) Acknowledge when your team reaches a new milestone by celebrating them.

→ The sample of milestone chart is given below.

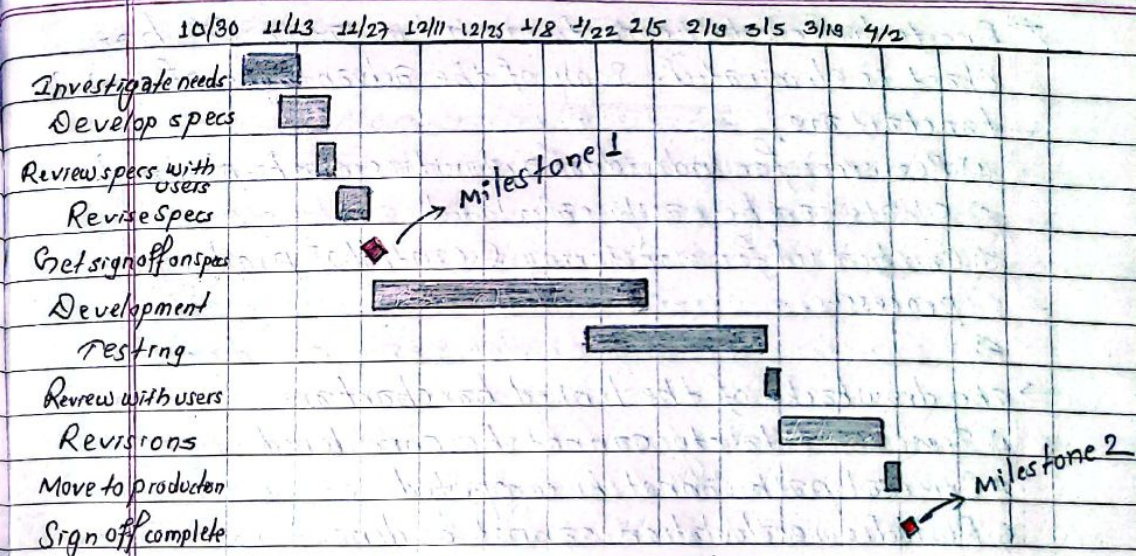
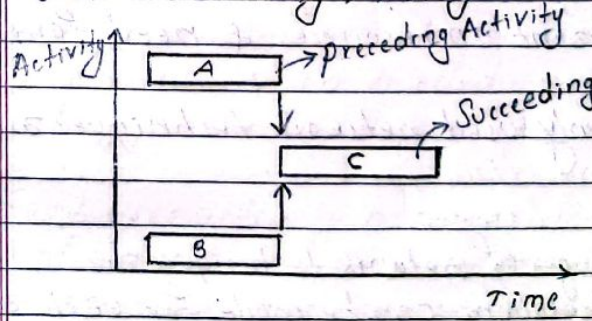


Fig: Milestone Bar Chart

Linked Bar Chart:-

→ This is an improvement over Gantt chart or milestone chart.
→ Activities are linked with arrows and lines specifying the sequence of these activities.
→ It provides clear picture of activity relationship.
→ The end of preceding activity is connected to the start of the succeeding activity.



→ Due to linked bar chart, main limitation of bar chart is eliminated. Some of the advantages of linked bar chart are
1) Resources for individual activities can be planned.
2) Floats can be easily calculated.
3) Can be used for monitoring & control of production processes.

→ The drawbacks of the linked bar chart are
1) Time uncertainty cannot be considered
2) Critical path cannot be computed.
3) Periodic recalculation cannot be done.

✻ Network Techniques:-

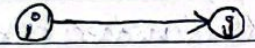
→ A network is the graphical representation of the project activities arrange in a logical sequence & depicting all the interrelationship among them.
→ A network consists of activities & events.
→ Network technique provides a rational approach to the planning, scheduling & controlling of construction works.
→ The application of such techniques is inevitable where there is a constraint on resources & need for higher productivity.
→ The two commonly used network techniques are
a) CPM
b) PERT
→ The major advantages of network techniques are
1) The time calculations can be made for each activity and for the project as a whole.
2) Activity interrelationship can be established.
3) Critical / Non-critical activities can be identified hence slack & float for each activity can be calculated.
4) It can be used for monitoring & control of project.
5) The complex / large projects can be graphically represented
6) Cost optimization can be done.
7) Project progress can be obtained.
8) Time uncertainties can be accounted having probabilistic approach.

✻ Critical Path Method (CPM)

→ CPM was developed in 1956, in the USA
→ The method was successfully tried for the construction of chemical plant in USA.
→ Presently this method is used worldwide in business and industry also.
→ Use of CPM provides meaningful answers to such questions
1) What will be the completion time of project?
2) If there is a delay in one activity, will the entire project be delayed? If so, by how much?
3) What is the most economical way to speed the project?
4) How to schedule material deliveries so as to have materials when needed and avoid costly storage for long periods?

→ It uses activity oriented network which consists of a number of well recognized tasks or activities. Each activity is represented by arrow & the activities

are joined together by events.



→ CPM is generally used for simple, repetitive types of projects for which activity times and costs are certainly & precisely known.
→ It is deterministic model.
→ Eg: Construction of a bridge, road, building etc.

※ Programme Evaluation & Review Technique (PERT)

→ PERT was developed by engineers of the united States Navy while working on the polaris missile program during 1957-58.
→ PERT has been in use for various research & development projects which are non repetitive in nature. Such projects are characterized by an extreme degree of uncertainty both in the development of the system and in the time duration of various activities.

→ Three time estimates are used to determine the expected or average time of each activity.

(a) Optimistic time estimate (to)
It is the shortest possible time for completing an activity.

(b) Most likely time estimate (tm):-
It is the maximum time for completing an activity under normal conditions.

(c) Pessimistic time estimate (tp):-
It is the maximum time required to complete an

activity under abnormal or extremely adverse conditions.

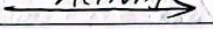
→ It uses event oriented network in which successive events are joined by arrows.
→ It is preferred for those projects whose time for various activities cannot be precisely pre-determined.
→ It is a probabilistic model.
→ Example: Launching of Satellite, research & development of new product.

※ Difference between CPM & PERT:-

CPM	PERT
1) CPM is activity oriented.	1) PERT is event oriented.
2) Single time estimates are used for various activities	2) The time estimates for activities are probabilistic. • Optimistic time (to) • Pessimistic time (tp) • Most likely time (tm)
3) CPM is used for repetitive types of projects.	3) PERT is used for research type of projects.
4) CPM places emphasis upon optimizing allocation of resources & minimizing overall project cost.	4) PERT lays emphasis on reducing project completion time without cost constraint.
5) It is deterministic model.	5) It is probabilistic model.
6) CPM manages the predictable activities.	6) PERT manages unpredictable activities.
7) Critical path Method	7)

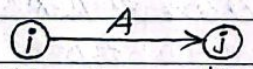
✳ Terminologies used in Network Diagram:-

1) Activity:-
→ It is the task that requires time & resources for its execution.
→ An activity is represented by an arrow, the tail represents the start & the head represents the finish of the activity.



→ The length, shape, direction of arrows has no relation to the size of activity.

2) Events or nodes:-
→ It is the beginning and end points of an activity.
→ It is a point in time.
→ The event has no resources and is represented by a circle.
→ The i^{th} event & j^{th} event are the tail event & head event respectively.



3) path:-
→ It is an unbroken chain of activity arrows connecting initial event to some other event.

4) Network:-
→ Arrow Diagram.
→ Graphical representation of sequentially connected arrows and nodes representing activities & events of a project.

5) Dummy Activity:-
→ Dummy is an imaginary activity which do not consume resources.
→ It is represented by dotted arrow.
→ It serves two purposes.
- Logical purpose
- Grammetical purpose

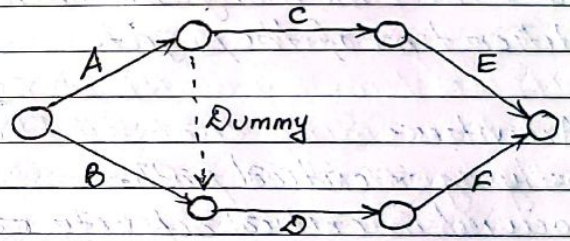
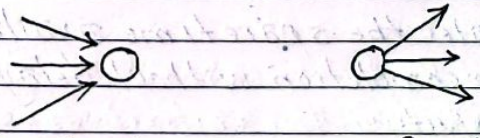
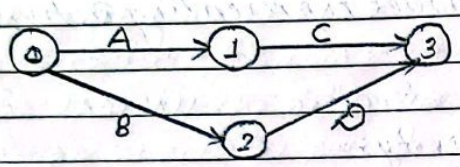


Fig:- Representation of Network using dummy activity

6) Merge & Burst Events:-
→ One or more activities can start and end simultaneously on an event.



7) Preceding & Succeeding Activities:-
→ Activities performed before given events are known as preceding activities & activities performed after given event are known as succeeding activities.



Activities A & B precede activities C & D respectively.

8) Critical Path:-
→ It is the path in a network diagram which takes maximum time (i.e the longest duration) among the alternative paths through which the project can be completed & the time along this path determines the completion time of the project.

9) Critical Activities:-
→ Activities lying on critical path.
→ If delay occured in critical activity causes delay in completion of entire project.
→ Activities which have zero total float are called critical activities.
→

10) Float:-
→ It indicates the spare time available for the activities for their completion without delaying a completion of a project.

11) Total float:-
→ It is the difference betn LFT & EFT or LST & EST

12) Free Float:-
→ It is an obliged float within which an activity can move without affecting the succeeding activities.
Free float = Total Float − slack of head event.

13) Independent Float:-
→ It is the excess of minimum available time over the activity duration.
Independent float = Free Float − slack of tail event.

14) Interfering Float:-
→ It is the difference between total float & free float.

15) Earliest Event Time (EET)
→ It is the earliest ~~event~~ time an event can take place, assuming that all the events prior to it also occur at their earliest time.

16) Latest Event Time (LET)
→ It is the latest time by which an event can occur, if the project is to be completed within the specified time.

17) Slack:-
→ The difference between LET & EET of an event is called slack or event slack.
→ It gives the range of time available within which the event must take place if the project is to be completed on schedule.

18) Earliest start time (EST):-
→ This is the earliest time an activity can be started, assuming that all the activities prior to it have taken place as early as possible.

19) latest start time (LST):-
→ This is the latest time an activity can start consistent with the completion of the project in the stipulated time.

$$LST = LFT - Duration$$

20) Earlrest Finish Time (EFT):-
→ It is the ~~latest~~ earlrest time by which an activity ~~must~~ can be completed assuming that all the activities prior to it begin at their ESTs.

$$EFT = EST + Duration$$

21) latest Finish Time (LFT):-
→ It is the latest time by which an activity must be completed to ensure the completion of project within the stipulated time.

22) Forward Pass:-
For calculating the earliest event times (T_E), computations are made in a forward direction (left to right). This process is called forward pass.

23) Backward Pass:-
For calculating the latest event times (T_L), computations

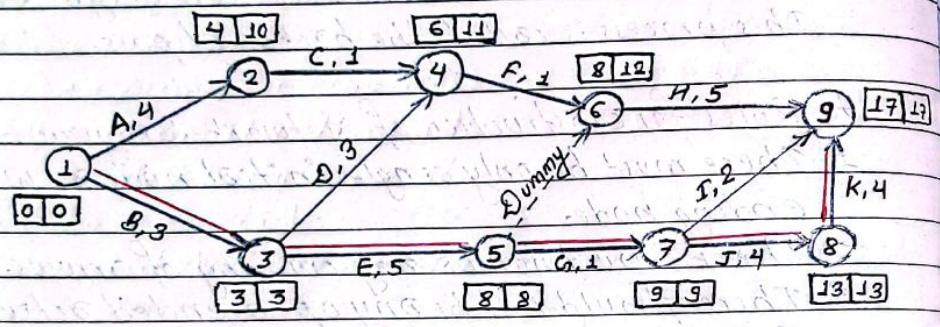
are made in a backward direction (right to left). This process is called the backward pass.

* Rules for construction of Network Diagram:-
1) There must be only single initial node as well as ending node.
2) There should not be any crossing of arrows.
3) There should not be any open ended activity (dangling error)
4) There cannot be any network path looping back (looping error)
5) An event cannot occur more than once.
6) Dummy activities shall be introduced only when it is absolutely necessary
7) There should be only one arrow for an activity.
8) Two conventions used for developing NWD are,
   - Activity on Arrow (AOA)
   - Activity on Node (AON)

Q. Draw a CPM Network, Find the critical path, critical activities, project duration, EST, EFT, LST, LFT, TF, FF, IF & INF

SN	1	2	3	4	5	6	7	8	9	10	11
Activity	A	B	C	D	E	F	G	H	I	J	K
Duration (weeks) (D)	4	3	1	3	5	1	1	5	2	4	4
Preceding	-	-	A	B	B	C,D	E	E,F	G	G	J
Succeeding	C	D,E	F	F	G,H	H	I,J	-	-	K	-

→



Forward pass computations

$E_1 = 0$

$E_2 = 0+4 = 4$

$E_3 = 0+3 = 3$

$E_4 = \max^m(4+1, 3+3) = 6$

$E_5 = 3+5 = 8$

$E_6 = \max^m(6+1, 8+0) = 8$

$E_7 = 8+1 = 9$

$E_8 = 9+4 = 13$

$E_9 = \max^m(8+5, 9+2, 13+4) = 17$

Backward Pass Computations

$L_9 = 17$

$L_8 = 17-4 = 13$

$L_7 = \min^m(13-4, 17-2) = 9$

$L_6 = 17-5 = 12$

$L_5 = \min^m(12, 9-1) = 8$

$L_4 = 12-1 = 11$

$L_3 = \min^m(8-5, 11-3) = 3$

$L_2 = 11-1 = 10$

$L_1 = \min^m(10-4, 3-3) = 0$

For critical path, following conditions must be followed

(i) $E = L$ for head event

(ii) $E = L$ for tail event

(iii) $E_j - E_i = L_j - L_i$ = Duration of Activity

→ Critical Activity ⇒ B-E-G-J-K

Critical Path ⇒ 1-3-5-7-8-9 (Represented by double line in network diagram)

SN	Activity	Duration	EST	EFT	LST	LFT	TF (LFT−EFT)	FF	IF	InF
1	A	4	0	4	6	10	6	0	0	6
2	B	3	0	3	0	3	0	0	0	0
3	C	1	4	5	10	11	6	1	-5	5
4	D	3	3	6	8	11	5	0	0	5
5	E	5	3	8	3	8	0	0	0	0
6	F	1	6	7	11	12	5	1	-4	4
7	G	1	8	9	8	9	0	0	0	0
8	H	5	8	13	12	17	4	4	0	0
9	I	2	9	11	15	17	6	6	6	0
10	J	4	9	13	9	13	0	0	0	0
11	K	4	13	17	13	17	0	0	0	0

Total float (TF) = LFT − EFT or LST − EST

Free float = TF − slack of head event

Independent float = FF − slack of tail event

Interfering float = TF − Free float (FF)

→ Project Duration = 17 weeks

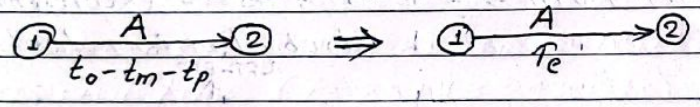
✱ Programme Evaluation & Review Technique:- (PERT)

→ Time Estimates,

- Optimistic time (t_o)
- Pessimistic time (t_p)
- Most likely time (t_m)

$[t_p > t_m > t_o]$

→ Expected Activity Duration $(T_e) = \frac{t_o + 4t_m + t_p}{6}$



→ Standard Deviation, $\sigma = \frac{t_p - t_o}{6}$

→ Varrance, $\sigma^2 = \left(\frac{t_p - t_o}{6}\right)^2$

→ Standard Deviation of critical path,

$$\sigma_{cp} = \sqrt{\Sigma\sigma^2} = \sqrt{\sigma_1^2 + \sigma_2^2 + \cdots}$$

→ Normal Deviate $(z) = \frac{T - T_{cp}}{\sigma_{cp}}$

Where, T = Given number of days,

T_{cp} = Expected Project Duration

Q Following are the activities & corresponding duration of the project & find

(a) Find the standard deviation of the project.

(b) Find the risk of completing the project by 4 weeks after the expected project completion period.

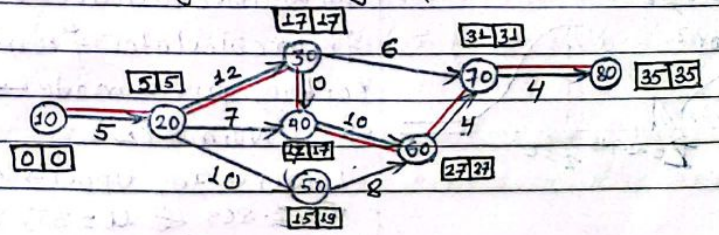
(c) Find the risks of completing the project by 5 weeks before the expected project completion period.

Activity	t_o (weeks)	t_m (weeks)	t_p (weeks)
10-20	2	5	8
20-30	8	11	20
30-40	0	0	0
20-40	4	7	10
20-50	4	9	20
40-60	7	10	13
50-60	3	7	17
30-70	3	5	13
60-70	2	3	10
70-80	2	4	6

→ Solution,

Activity	t_o	t_m	t_p	$\sigma^2 = \left(\frac{t_p - t_o}{6}\right)^2$	$T_e = \frac{t_o + 4t_m + t_p}{6}$
10-20	2	5	8	1	5
20-30	8	11	20	4	12
30-40	0	0	0	0	0
20-40	4	7	10	1	7
20-50	4	9	20	7.111	10
40-60	7	10	13	1	10
50-60	3	7	17	5.44	8
30-70	3	5	13	2.77	6
60-70	2	3	10	1.77	4
70-80	2	4	6	0.44	4

Network Diagram using expected time (T_e)



Critical path ⇒ 10-20-30-40-60-70-80

Expected project duration (T_{cp}) = 35 weeks

variance, $\sigma^2 = 1 + 4 + 0 + 1 + 1.77 + 0.44 = 8.21$

(a) standard deviation of project = $\sqrt{\sigma^2}$

$= \sqrt{8.21}$

$= 2.865$

Normal Deviate (z) = $\frac{T - T_{cp}}{\sigma}$ $\left[z = \frac{x - \mu}{\sigma}\right]$

(b) Risk of completing the project 4 weeks after the expected time ($T = 35 + 4 = 39$ weeks)

$= P\left(z \leq \frac{39 - 35}{2.865}\right)$

$= P(z \leq 1.396)$

$= 0.9177$ [From standard Normal chart]

$= 91.77\%$

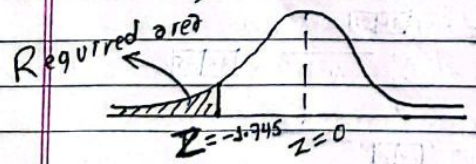
(c) Probability of completing the project 5 weeks before the expected time ($T = 35 - 5 = 30$)

$= P\left(z \leq \frac{30 - 35}{2.865}\right)$

$= P(z \leq -1.745)$

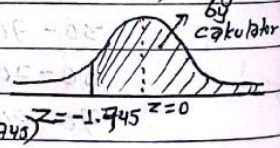
$= 0.0409$

$= 4.09\%$



Direct Calculation of probability in Calculator,

[calculator gives probability value of $p(z > -1.745)$



so, we have to deduct value coming from calculator from 1.

For this, press mode → 7 (dist^{b})

→ 2 (Normal (D)

Lower → 30, upper → 9×10^{99} ($\approx \infty$)

$\sigma \rightarrow 2.865$ & $\mu = 35$, Then, $p = 0.959$

$P(z \leq -1.745) = 1 - 0.959 = 0.041$

✱ Earned Value Analysis :- (EVA)

→ Earned Value Analysis is a method that allows the project manager to measure the amount of work actually performed on a project beyond the basic review of cost & schedule reports.

→ EVA provides a method that permits the project to be measured by progress achieved.

→ It compares the actual work completed at any time to the original budget & schedule.

✱ Eight steps for performing EVA :-

1) Determine the percent complete of each task.

2) Determine planned value (PV)

Planned value, also known as Budgeted ~~work~~ cost of Work scheduled (BCWS), is defined as the amount of task that is supposed to have been completed.

3) Determine Earned Value (EV)

Earned value, also known as Budgeted Cost of Work Performed (BCWP), is the amount of task that is actually complete.

4) Obtain Actual Cost (AC)

Actual cost, also known as Actual Cost of Work Performed (ACWP), is the actual cost of the work. To calculate actual cost, all project costs such as labour cost, materials cost, equipment costs, fixed costs etc.

At this step, information gathering phase is complete. The following calculation represent the application of

earned value analysis to keep your project on schedule and budget.

5) Calculate schedule Variance (SV)
The schedule variance represents the schedule status of the project.

$$SV = EV - PV$$

A negative SV means the task is behind schedule.
A positive SV means it is ahead of schedule.

6) Calculate Cost Variance (CV)
The cost variance represent the cost status of the project.

$$CV = EV - AC$$

A negative cost variance means the task is over budget. A positive cost variance means it is under budget.

7) Calculate Other status Indicator,
a) ~~Scheduled~~ Schedule Performance Index (SPI)

$$SPI = \frac{EV}{PV}$$

SPI = 0.8 means the project 20% beyond the schedule.

b) Cost performance Index (CPI)

$$CPI = \frac{EV}{AC}$$

CPI = 0.9 means, the project is 10% over budget.

c) Estimate at completion (EAC)

$$EAC = AC + BAC - EV$$

d) Estimate to complete (ETC)

$$ETC = EAC - AC$$

e) To Complete performance Index (TCPI)

$$TCPI = \frac{BAC - EV}{BAC - AC}$$

8) Compile the results & Interpreting the results.

For Example,
Let's say, the task budget is $5000. Task start date is Jan1 & finish date is Jan10.
→ If it's Jan6 today, the task is supposed to be 60% complete,

$$PV = 0.6 \times \$5000 = \$3000$$

→ Let's say, the actual percent complete of task is 40%

$$EV = 0.4 \times \$5000 = \$2000$$

→ Let's say, the actual cost of task is $1500
→ Schedule Variance, (SV) = EV - PV
= 2000 - 3000 = -$1000
[-ve SV means task is behind schedule]
→ Cost variance (CV) = EV - AC = 2000 - 1500
= $500
[+ve cost variance means it is under budget]
→ SPI = 2000/3000 = 0.67
CPI = 2000/1500 = 1.33
Budget at Completion (BAC) = $5000 [only one task]
EAC = 1500 + 5000 - 2000 = $4500
ETC = 4500 - 1500 = $3000

$$TCPI = \frac{5000 - 2000}{5000 - 1500} = 0.857$$

Q. A construction company is planned to fix 100 units of precast windows in 20 days with a budget of 25 lakhs. The progress status was reviewed on 10 days from the date of start of fixing & only 40 units were fixed with the expense of 9 lakhs. Find out all parameters of Earned Value Analysis & comment on its performance.

→ Given,

Actual Cost (AC) / ACWP = 9,00,000

Earned Value (EV) / BCWP = $\frac{40}{100} \times 25,00,000 = 10,00,000$

Planned Value (PV) / BCWS = $\frac{10}{20} \times 25,00,000 = 12,50,000$

- Schedule Varrance (SV) = EV − PV
  = 10,00,000 − 12,50,000
  = −2,50,000

−ve SV means the work is behind the schedule.

- Cost Varrance (CV) = EV − AC
  = 10,00,000 − 9,00,000
  = ₹1,00,000

+ve CV means the work is under budget.

- Schedule Performance Index,

$$SPI = \frac{EV}{PV} = \frac{10,00,000}{12,50,000} = 0.8$$

It means project is 20% beyond the schedule.

- Cost performance Index,

$$CPI = EV/AC = \frac{10,00,000}{9,00,000} = 1.11$$

It means project is 11% under budget.

✻ Time Cost Trade off

→ Time and cost are such two elements that cannot be both reduced at a time to optimize the resources.

→ When cost is reduced, certainly time will to some extent increase & when time is shortened, certainly cost will increase.

→ Any project cost comprises of the following two components.
a) Direct cost that decreases with time increase &
b) Indirect cost that increases with time increase.

→ The judicious balance between time & cost is called time-cost trade off. The time cost trade off can be obtained by studying the availability of those two resources and the demand for those two resources for a given project.

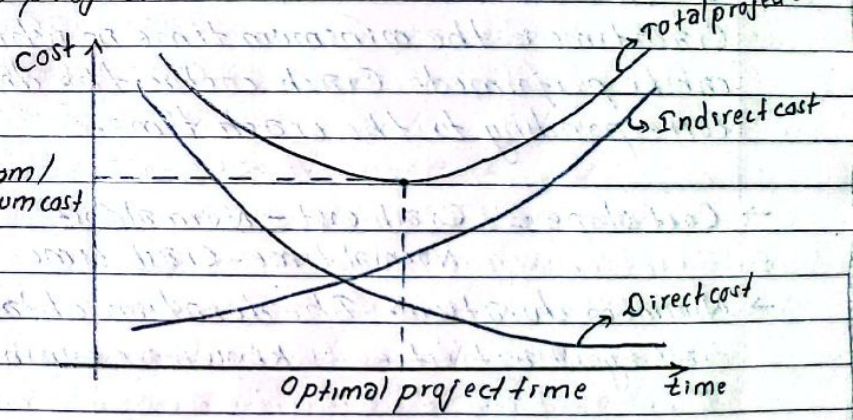


Fig: Relationship bet^n cost & time.

✻ Project Crashing:-

→ Spending more money to get something done more quickly is called crashing (Compressing).

→ The objective of project crashing is to reduce project duration while minimizing the cost of crashing.

→ Compressing or crashing the project schedule refers to the acceleration of the project activities in order to complete the project sooner. The time required to complete a project is determined by the critical path, so to compress a project schedule one must focus on critical path activities.

→ Normal time & Normal Cost:-
Normal time is the time for performing an activity with the normally available resources. Normal cost is the minimum direct cost when the activity is performed in normal time duration.

→ Crash time & Crash Cost:-
Crash time is the minimum time in which an activity can be performed. Crash cost is the direct cost corresponding to the crash time.

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

→ Minimum duration:- The duration obtained after crashing all activities is known as minimum duration.

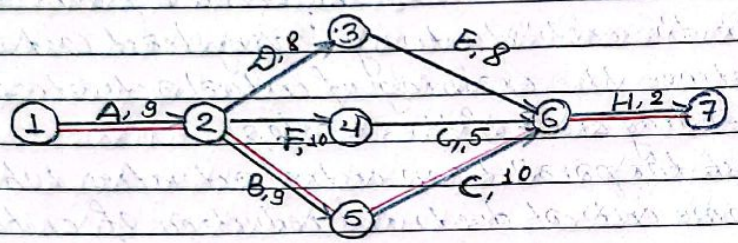
* Procedure for optimization of time cost trade off:-
1) Draw CPM Network
2) Obtain project duration, critical path & critical activity
3) Determine the cost slope for various activities & arrange them in ascending order of cost slope.
4) Compute the direct cost for the network with normal duration of activities.

5) Crash the activities in the critical path, starting with the critical activity having least cost slope.
6) Continue the crashing of critical activities in the ascending order of the cost slope.
7) Crash the parallel non critical activities which have become critical due to the reduction of critical path duration by steps of 5 & 6.
8) The crashing of activities is continued till a stage is reached beyond which no further crashing is possible.
9) At every stage of crashing, determine the total cost of the project by adding indirect & direct cost.
10) Draw the total cost duration curve.
11) The optimum duration corresponding to the minimum total cost of project is obtained from the curve.

Note:- Crash cost > Normal Cost
Crash time < Normal time

Q) A project consists of eight activities. The indirect cost of the project may be taken as Rs 250 per day. Determine the normal, optimum and min^m duration of the project from the data given below.

Activity	A	B	C	D	E	F	G	H
i node	1	2	5	2	3	2	4	6
j node	2	5	6	3	6	4	6	7
Normal Duration	9	9	10	8	8	10	5	2
Crash duration	6	5	9	7	6	5	3	1
Normal Cost	2500	3500	5500	2700	5800	3400	6500	7600
Crash Cost	3130	3700	5680	2800	6040	3650	6860	7900



$\frac{C_c - C_n}{t_n - t_c}$ ← Cost slope

Activity	Normal Duration	Crash Duration	Normal cost	Crash cost	Cost slope
A	9	6	2500	3130	210
B	9	5	3500	3700	50
C	10	9	5500	5680	180
D	8	7	2700	2800	100
E	8	6	5800	6040	120
F	10	5	3400	~~3650~~	~~250~~ 50
G	5	3	6500	6860	180
H	2	1	7600	7900	300
			Σ=37,500		

Critical path is along 1-2-5-6-7.

Normal Duration of project = 9+9+10+2 = 30 days

Direct Normal cost of all activities = Rs 37,500

Now crashing the activity having lowest cost slope, thus crashing the activity B say for 3 days.

Extra cost will increase by 50×3 = 150

Direct project cost after crashing activity B for 3 days
= 37,500 + 150 = 37,650

Now, duration of project = 30-3 = 27 days.

Now, B is left by 1 day to be crashed. Let us crash B & D by 1 day each having least cost slope.

Extra cost will increase by 50×1 + 100×1 = 150

Duration of project = 27-1 = 26 days

Total direct cost after crashing B & D by 1 day
= 37650 + 150
= 37,800

Crashing A by 3 days, extra cost of crashing = 3×210 = 630

Direct cost of project = 37800 + 630 = 38430

Duration of project = ~~26~~ 26-3 = 23 days

Now, crashing E, F, C simultaneously by 1 day,

Extra cost of project = 180×1 + 120×1 + ~~250×1~~ 50×1
= ~~370~~ 350

Duration of project = 23-1 = 22 days

Total direct cost of project = 38430 + 350 = 38780

Now crashing remaining activities G & H simultaneously by one day,

Increase in cost will be, = 180 + 300 = 480

Total direct cost of project = 38780 + 480 = 39260

Duration of project = 22-1 = 21 days.

→ The results are tabulated below,

Duration of project	30	27	26	23	22	21
Direct Cost	37500	37650	37800	38430	38780	39260
Indirect Cost	7500	6750	6500	5750	5500	5250
Total Cost	45000	44400	44300	44180	44280	44510

Normal Time = 30 days

Optimum Time = 23 days

Minimum Time = 21 days.

(After crashing all activities)

* Resource Management:-

→ Men, material, money are three resources required for any activity. If there is shortage of resources, the activity cannot completed in time.

→ The job of the project manager is to plan resources for the different activities so that the resource utilization is optimized.

→ Project activities have therefore to be scheduled in such a manner that demand for various resources is fairly uniform over the entire project duration.

→ The project manager will develop a schedule as per considering the following major factors.

a) Stock Ability

b) Required Resources
- Uniform requirement
- Non-uniform requirement

c) Resource complexity.

* Resource Aggregation:-

→ Resource Aggregation is a method of calculating needed resources at the project or multiproject level for each time unit to enable implementation of the plan.

→ During this process, no limitation on available resources is considered.

* Resource Allocation:-

→ Resource allocation is the distribution of available resources to different activities on different dates and in different quantities.

→ It is usual in planning a project, a planner has to consider not only the activity precedence relationships but also the availability of the resources.

→ While allocating resources, the planner tries to distribute (allocate) the resources from critical activities to non-critical activities so that important activities (having no floats) can be continued without affecting the project completion date.

* Resource Levelling:-

→ Resource leveling is the method of scheduling activities within their available float so as to minimize fluctuation in day to day resource requirements.

→ By resource leveling, we try to optimize the use of resources required to complete a project.

→ Resource leveling helps in obtaining uniformity in resource ~~management~~ requirement throughout the life of a project. The benefit of resource leveling is to ease resource management so that cost involved in managing resources can be minimized.

→ When the project is to be completed at any cost by the due date, a project manager often comes across mis-match that there are surplus resources available on some days and there is shortage of resources on some other days.

→ The main objective of project manger in such situation is to level resources as far as possible throughout the project execution time keeping in view time constraint.

* Resource Smoothing

→ It is a part of resource leveling process.

→ It is the process that attempts to determine a resources requirements that is smooth & where peaks are eliminated.

→ Example,

Week →	1	2	3	4	5	6	7	8	9
Activity ↓									
A	12	8							
B		5	8	6					
C				2	6				
D				2	6	10	10	6	
E								4	5
Total	12	13	8	10	12	10	10	10	5

$$\text{Average} = \frac{90}{9} = 10$$

* Difference between Resource Leveling & Smoothing

Resource Levelling	Resource Smoothing
1) Aim is to adjust start & end dates of a project with resource constraints while balancing resource requirements & resource availability.	1) Aim is to achieve optimal resource usage by avoiding peaks & valleys in the resource usage profile. Hence the name smoothing.
2) Used in resource constraint scheduling.	2) Used in time constrained scheduling.
3) Critical path of project will be affected, & usually the length of critical path will increase.	3) Critical path of the project won't change.
4) Can be applied to resources on critical path.	4) Doesnot apply to resources on critical path.
5) Free and total float (or slack) may be used.	5) Free & total float (or slack) may be used.
6) Will optimize all the resources & may change the duration of the project.	6) May not be able to optimize all the resources if sufficient slack (or float) isn't available but doesnot change the duration of the project.
7) Risk: May change the critical path & hence the duration.	7) Risk: loss of flexibility due to reduction in slack. Hence chances of increase in number of near critical activities.

* Monitoring, Evaluation & Control:-

→ Monitoring, evaluation & control are vital tools of project management.

→ It helps the project team to make a rational & improved decision about the project performance.

→ Monitoring is ongoing & continuous activity throughout the entire life of the project.

→ Evaluation is an examination & appraisal of how things are going on in the project. It is conducted at periodic interval.

→ Project control may be defined as a continuous process of verifying whether action are being taken as planned and taking corrective action to ensure that events confirm to plans as closely as possible.

* Project Monitoring:-
→ This simply means to maintain tradeoff and to check systematically & scientifically all project activities.
→ It is gathering of information to review & implement project work.
→ Conducted to know whether the project activities & action are moving according to the objectives set at the beginning.
→ Carried out mostly during project implementation phase.
→ It is done to trade the progress of the project, identify the problem & deviations, corrective actions are carried out & response is generated.

* Project Evaluation:-
→ It is an examination & appraisal of how things are going on in the project.
→ The basic purpose of evaluation is to help in achieving the project's goals as a contributor to parent organizations goals.
→ It is undertaken to identify problem, clarify performance, cost & relationship, improve project performance, identify opportunities, reduce cost & provide feedback to client of the project.
→ Types of project Evaluation
(a) Pre-project Evaluation:-
It is done to determine whether it fits the objectives & overall strategy of organization or not.

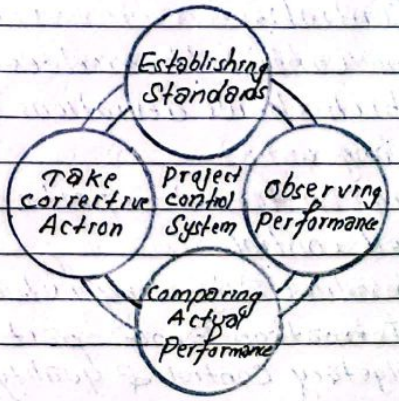
(b) Ongoing project Evaluation:- It is conducted to

measure the status of the project during its life cycle.

(c) Project completed Evaluation: It is carried out for an immediate assessment of the success upon project completion.

(d) Post Project Evaluation:- It is undertaken to find out the impact of project in society on long term basis.

* Project Controlling:-
→ Project control may be defined as a continuous process of verifying whether action are being taken as planned and taking corrective action to ensure that events confirm to plans as closely as possible.
→ The purpose of control system is to predict what may happen in the physical system and take necessary steps before hand, so that the system can maintain equilibrium despite various interruptions from both inside & outside the project.



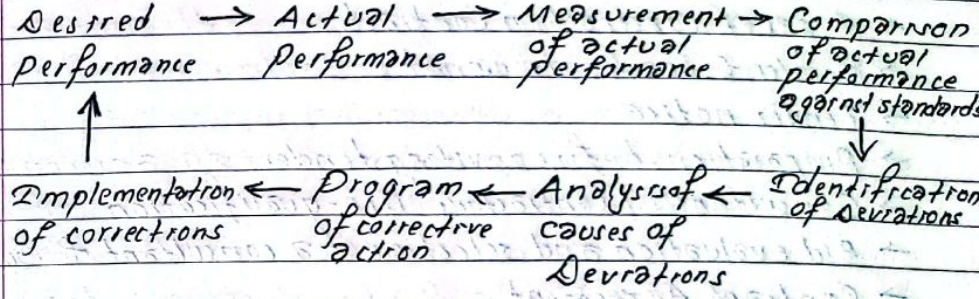
→ Types of Control:-

(a) Concurrent Control:-
→ Yes/no control
→ Real time or steering control
→ It involved the adjustment of project performance before any serious damage is done.
→ Done while an activity is still taking place.
→ Example:- Inventory & Quality control chart.

(b) Pre-control:-
→ It is also called feed forward control, predictive control or preventive control.
→ It anticipates the problems that project are likely to confront.
→ It is more aggressive approach to control because correction can be made before the system output is affected.
→ It overcomes the time lag in taking corrective action. However, it is costly control.

(c) Feedback Control:-
→ Many systems control themselves through information feedback, which shows deviations from standards & initiates changes.
→ It is also called historical or post control. It is output based control.
→ It simply involves adjusting future action on the basis of information about past performance.
→ Example:- Budgetary Control & quality inspection

* Feedback Loop of Control System:-



** Line of Balance (LOB):-
→ Line of balance is a management control process for collecting, measuring and presenting facts related to time and cost accomplishment.
→ It shows the process, status, background, timing and phasing of the project activities, thus providing management with measuring tools that help
1) Comparing actual progress with a formal objective plan
2) Examining only the deviations from established plans and gauging their degree of severity with respect to the remainder of the project.
3) Reserving timely information concerning trouble areas where appropriate corrective action is required.
4) Forecasting future performance.

→ A conventional network technique applied to develop & control a single batch.

Chapter-3, Contract Administration

Outline:-

- Method of work execution
- Contract definition
- Types of construction Contract
- Tender & tender document
- Tender notice
- Preparation before inviting tender
- Consultant's / Contractor's pre-qualification
- Bid evaluation and selection of a consultant & contractor
- Contract Agreement
- Conditions of Contract (PPMO & FIDIC)
- Public Procurement Act & Public Procurement Regulation
- Duties & responsibilities of a site supervisor
- Supervising work of a contractor.
- Site order books
- Procedure to prepare bill - running bill & final bill
- Muster roll, Measurement books
- Progress reporting

* Method of Work Execution:-

- Work execution is the procurement of goods or services.
- Prior to procuring, organization shall have to prepare design, drawing, specification, special & other description.
- There are two methods of construction work execution are
  - (i) Through Amanat
  - (ii) Through Contract

* Work Execution by Amanat:-

- Work are executed directly by the department or owner.

- All the required men, materials, tools and equipment etc. are managed by the owner.
- This method is followed only if
  - a) The estimated amount of work is not more than Rs. 1,00,000 as per PPA, 2063.
  - b) The work is of smaller size and the expenses are minimum
  - c) Government rules and regulations permit.
  - d) The work is of special nature.

* Construction Work through Contract:-

SN	Procurement Method	Contract size	Contractor
1)	Sealed Bidding		
	ICB (International Competitive Bidding)	> 5 Arab	International
	NCB (National Competitive Bidding)	> 20 lakh	International + Nepali JV
2	Sealed Quotation	upto 20 lakhs	All
3	Direct procurement	upto 5 lakhs	All
4	Procurement under special circumstances.	Emergency circumstances	Depends on contract amount
5.	User's committee	upto 1 crore	Contractor can't be used.

* Contract:-

- According to contract act 2056, "Contract is an agreement between two or more than two persons to do or not to do something, which can be enforceable by law".
- It is legal written document, its main purpose is to define exactly the rights & obligations of each party to do something for the other for a certain considerations.
- It usually contains clauses that specify

i) Completion time of project
ii) Liquidated damages
iii) Particulars concerning payments to the contractor.
iv) Scope & nature of work to be done.

→ All contracts are agreement but all agreements are not contract.

→ Elements of the contract:-
1) Offer and acceptance
2) Consideration
3) Capacity to contract
4) lawful purpose
5) Free consent
6) Possibility of performance
7) Certainty
8) Two or more competent parties
9) Written

✻ Classification / Types of Contract

(a) Based on payment

1) Unit Price (BOQ) Contract:-
→ It may be entered into where the quantity of a construction work is difficult to be ascertained

2) Lumpsum Contract:-
→ Construction work is carried out as per drawing & specification given by a client within a specified time in fixed amount. On completion of work, taking

detailed measurement will also not be necessary, whole work is checked/compared with drawing & specifications and contractor is paid lumpsum amount.

3) Cost plus Contract:
→ It may be entered into for procuring a construction work involving high risks & unpredictable conditions.
→ Four types of fee structure are common in cost plus contract.
(a) Cost + percent of cost
(b) Cost + fixed fee
(c) Cost + fixed fee + Profit sharing
(d) Cost + Sliding fee

(b) Based on technical & Administrative Responsibility:-

1) Traditional Approach:-
→ client appoint the design team before contractor is selected. Construction itself is the responsibility of single general contractor under contract to the owner.
→ Example:- Lumpsum contract, Unit price contract, cost plus contract etc.

2) Owner - Builder Approach / Force Account Approach.
→ Owners perform both their own design work and some or all of the actual construction with their own forces.

3) Design & Build Contract / Turn key Contract
→ In this contract, the owner enters into a single agreement by which the design & build contractor agrees to perform both the design & construction of the project.

→ A turn key is a type of project that is constructed so that it could be sold to any buyer as a completed product.
→ Heading defines just turn a key, open the door.

4) Time & Material Contract:-
→ A time and material contract may be used only when it is not possible at the time of placing the contract to estimate accurately the extent or duration of the work or to anticipate costs with any reasonable degree of confidence.

5) Engineering Procurement & Construction Contract (EPC)
→ Type of construction contract between parties where the contractor is responsible for all the engineering, procurement & construction activities to deliver the completed project to the employer or owner within a predefined time and cost.

6) Build Own Operate Transfer (BOOT) contract:-
→ BOOT is a public private partnership (PPP) project model in which a private organization conducts a large development project under contract to public sector partner, such as a government agency.
→ Government retains strategic control over the project.
→ The majority of construction & long term operating risk can be transferred onto the Boot provider.

(c) Classification on the basis of method of selecting the contractor:-
1) Competitively Tendered Contracts:-
Contractor is selected based on the competition among the bidders.

2) Negotiated Contract:- Contract is awarded through negotiation with the contractor.

(d) Classification as per enforceability:-
1) Void Contract:-
→ An agreement not enforceable at law is a void contract.
→ It is a valid contract but due to certain reasons it becomes void after its formation.
→ A void contract cannot be enforced by either party.
→ Example:- Sachin & Isha contract to marry on next sunday. Isha dies before the sunday. The contract becomes void.

2) Voidable Contract:-
→ An agreement which is enforceable by law at the option of one or more of the parties, there to but not at the option of the other or others is a voidable contract.
→ Contracts caused by fraud, undue influence, misrepresentation or by coercion are voidable contracts.
→ Example:- Mr. Sanjeeb threatens to shoot Mr. Shah to purchase a car for one million. Mr. Shah agrees the contract was made by coercion and is voidable at the option of Mr. Shah.

3) Valid Contract:-

→ Valid contract is that contract which is enforceable at law. It creates legal obligations between the parties.

→ It enables one party to compel another party to do something or not to do something.

Contracting Procedure:-

→ Contracting procedure is more or less the same as procurement procedure. The usual steps in contracting are as follows,

1) Work package
2) Preparation of tender document
3) Determination of the contractor's qualifications to undertake the work package.
4) Prequalification of contractors, if that is included in the approach.
5) Tender invitation
6) Tender Submission
7) Tender Opening
8) Evaluation & recommendation
9) Approval
10) Award of contract
11) Signing of agreement with detailed contract conditions.

Prequalification & Postqualification works of contractors.

→ The owner is the key party who pays for the construction work. So, owner usually has a wish to hire a capable, reliable & trustworthy contractor so that his investment doesnot go in vain.

→ For this reason, the owner floats notice containing the type and class of the bidders for that particular work. Also for reducing unnecessary sorting of mass bids for the work, the owner wants to apply only from the capable and reliable bidders. This is called pre-qualification.

→ The bidders are sorted prior to bidding by class or type so that the unnecessary load of work doesnot accumulate.

→ Open bidding to all type and class of bidders is called postqualification. All the bidders bid for the work and later the office will sort out the most suitable bidders based on certain criteria.

→ When there are many capable bidders of the same class and type, the owner wants to be ensured of their expertise in the performance of the work & hence pre-sets an examination into their expertise.

→ The owner asks the potential bidders to submit their past experience certificates, availability of resources like manpower, equipment & other relevant to the work.

→ When the tender notice is published, only those listed bidders are asked to prepare and submit the tenders. Completion in the bidding will take place among them only. Others who have not been prequalified will not be allowed to bid.

Conditions of Contract:-

→ Construction involves owner, contractor and consultant.

→ Thus, in the agreement, there must be clauses or conditions which shall define the duties & responsibilities

of the owner, contractor & consultants

→ Conditions of contract depends upon the nature of work, type of contract & the situation.

→ Special type of work or special situation usually demand special conditions. Some of the common conditions of contract are discussed here,

1) Contract Duration:-
Time is very important part in a contract. Work shall be completed within a specified time. If the execution of work is delayed, contractor may be levied compensation by the owner.

2) Engineer's duties and authority:
The duties and authority given to the contractor shall be clearly specified.

3) Payment Procedure:-
Contractors shall be paid regularly for the work completed. Generally, 10% of the total billing amount is retained as retention money.

4) Security Deposit:-
When the contract is awarded, contractor has to deposit some money, 5% of the estimated or tendering amount as a security deposit. If contractor is able to perform the duties assigned as per terms and conditions, security deposit is refunded otherwise whole or part of it will be forfeited.

5) Additions and Alterations:-
To adjust additions, ommissions, modifications and alterations without difficulty, a clause should be there in conditions of contract.

6) Price Escalation:-
Construction contract having longer duration should have price escalation clause. In the absence of this clause, contractor's incentive (profit) is likely to be affected due to rise in market price.

7) Defective Work:-
→ The work executed shall be as per drawings and specifications or the instructions given by the authorized person, which must be in writing.
→ If the work is found defective, owner can ask the contractor to reexecute it. Sometimes, contractor is levied compensation for the defective work.

8) Arbitration:-
→ Arbitration is an alternative method of dispute settlement. It takes less time & less money than for the normal court procedure.

Tender:-
→ Tender is a written offer presented before an owner showing interest to perform the specified works within the specified times under agreed conditions.
→ To invite contractors, a notice is published which is called a tender notice.

→ Tender notice is a means of an expression through which contractors know where they have to bid a tender. Tender notice shall be published in such a way that all the concerned parties can get the information well in time.

Necessity of Tendering :-
→ To seled best contractor
→ To get quality work
→ To get work at competitive price.
→ To maintain transparency.
→ To encourage public private partnership.

* Tender Notice:-
→ Tender notice shall be published in a widely read newspaper from where the notification could reach to the concerned parties.
→ A tender notice shall contain the following information:
1) Name of the authority
2) Sources of fund
3) Date, time & place
4) Nature of the work
5) Cost of tender documents
6) Earnest money - (bid bond) to be deposited.
7) Security Money - (performance bond) to be deposited.
8) Estimated cost of work (if applicable)
9) Date, time & place - where and when the tender will be open.
10) Other relevant informations.

** Earnest Money :-
→ Earnest Money provides guarantee of the party's willingness of carrying out the work if that is awarded to him.
→ It is also called bid bond.
→ This money is deposited while bidding a tender.
→ Generally, 2.5 to 3% of the estimated amount is demanded as an earnest money.
→ The earnest money deposited by the successful bidder is returned and the deposits of the unsuccessful bidders will be returned back.

** Performance Security :-
→ In the earnest money retained, the successful bidders has to add another 2.5% of the bidding amount before signing contract agreement. This types of deposit is called security deposit which is also called performance bond.
→ This security deposit will be retained in the owner's account until the contractor successfully execute the contract. If the contractor did not perform well as per the contract or leave the work, the security deposit will be forfeited.
→ Generally, security deposit & other retained earnings of a contractor are released after the defect liability period is over.
→ As per PWD, within 14 days after receipt of the letter of acceptance, the successful bidder shall deliver to the employers a performance security.

Preparation before inviting tender:-

a) Project Formulation :-
The necessity of the project is identified and cost benefit analysis is done.

b) Detail Design & Cost Estimation:-
At this stage, detail design of the project is done and based on the design, a detail cost estimate of the project is prepared.

c) Approval of Cost Estimation:-
The concerned authority will approve estimated cost of the project and allocate budget for the project.

d) Tender Document Preparation:-
In order to notify publicly, a tender document that fulfilling all the requirements is to be prepared before inviting tender. Approval of tender document by the concerned authority is essential.

e) Tender invitation:-
After fulfilling all the requirements, a tender notice is published.

Evaluation of tenders & selection of Contractor:-

→ After the submission of tenders by the potential bidders, the next step is to evaluate those submitted bids.
→ The criteria on which the bids have to be evaluated are included in the tender documents.

→ The usual criteria are as follows
1) Registration validity and renewal of the firm.
2) Evidences of experiences in the past five to two years.
3) Successful completion of projects in the past years.
4) Heavy equipment, material transport vehicles & construction machines.
5) Technical manpower, their qualification & experiences.
6) The rates of items of works and total amount of the work.
7) Financial Capability.

Submission of tenders:-

→ In order to keep secrecy till the opening of the tender, they should be submitted under sealed cover latest by the closing time.
→ For the purpose of identity, the name of work and its due date should be clearly written on the top of the envelop.
→ Tender may be sent either by post or can be put in the letter box kept for the purpose in the premises of the owner, before closing time.
→ The closing time for receipt of tenders should be kept after the normal time of delivery of the post.
→ Tenders received after the due date & time are rejected.

Opening of tenders:-

→ The valid tenders are opened at the notified time in the presence of tenders or their representatives, who may choose to be present there.

→ A record of tenders received is also kept.
→ The earnest money, if any must be deposited along with the tender in the manner prescribed.
→ Tenders submitted without earnest money are rejected.
→ The amount is refundable if tender is not accepted and usually adjusted against contractor's security, if bid is accepted.
→ In case, the contractor whose tender is accepted fails to undertake the work, the earnest money deposited by him is forfeited.

※ Site Order Book:-

→ Site order book shall be maintained at site because senior officials frequently visit the site where they make some decisions or give some instructions.
→ In some cases, the superior officials give instructions to the subordinates at site.
→ In short, at site, senior officials may instruct or direct for the effective & efficient performance of the work. Such instructions or directions given at shall be recorded in a book & signature of concerned authority need to be taken on it.
→ The book keeping at site for such purpose is called site order book.

※ Procedure to prepare a bill:-

→ Before preparing the bill of a contractor, the entries in the MB about quantities and description of work or supplies are scrutinized by the subdivisional officer and

calculations of areas or contents are checked arithmetically.
→ The bill is then prepared on appropriate form of the measurement entries. The rates allowed are entered either in the abstract of measurement or bill itself by the sub-divisional officer.
→ The full rates as per agreement are allowed if the quality of work done or supplies made are upto the stipulated specifications.
→ Extraordinary payments such as bonus or compensation to contractors are not permissible except with the written order from finance department of the concerned government.
→ At an agreed interval usually every month, contractor is paid for the work executed. For such intermediate payments, a statement for the work done shall be prepared, which is called running bill.

※ Running Bill:-

→ In order to take an intermediate payment at agreed interval (usually every month) for the contractor, a bill is prepared on the basis of MB's record of the work executed.
→ A detailed estimate & abstract of cost is prepared. then only contractor is paid.
→ Usually 5% of money is retained as retention money. This money will be refundable as mentioned in the contract.

※ Final Bill:-

→ For final payment, on the completion of a project or

termination of the contract, final bill is prepared & contractor is paid.
→ The entire work is evaluated while preparing final bill.
→ Higher authority may visit & check all the works executed for final approval (Taanch Pass)
→ All the retention money is adjusted (for taxes, advances, fines etc.) before making payment to the contractor.

First and Final Bill:-
→ The single payment made for a work or contract on its completion is called first & final payment.

Work Accounts:-
→ The main objective of keeping works accounts is to exhibit simply but accurately, the expenditure incurred on various works.
→ It is desirable to record the details of accounts for large works due to following reasons.
1) To get information on various aspects of the work from statistical point of view, if necessary.
2) To analyze the cost of various items of work, classes of work etc.
3) It facilitates efficient control transactions in large works specially, if the period of construction is prolonged.

→ The account of works are based on following two initial records.
- Muster Roll (MR)
- Measurement Book (MB)

Muster Roll (MR)
→ A MR is a record, in which names, particulars and attendence of daily labours, amount payable to them and the workdone by them are recorded.
→ The advance for payment to labour is issued on the basis of MR and after disbursement of wages and recording necessary certificates of disbursement, it is kept as a voucher.
→ MRs are prepared on prescribed format. This format maintains the records of the attendance of labors, payments and workdone by them.
→ This form consists of three parts.
1) Part I of the MR is a nominal roll meant for recording the attendance & absence of the labours and fine imposed upon them.
2) In part II, the details of unpaid items are recorded. The unpaid wages of the previous MRs are also carried over. Payments made out of the arrears (पिछले पैसे बाकी) are also recorded in this part.
3) Part III of the MR is used for recording the amount of workdone by the labour employed as per the nominal roll.

Rules for preparing Muster Roll:-
1) One or more MRs can be used for the same work.
2) MRs should never be prepared in duplicate for the same work.
3) The presence of labour should be marked with a cross mark (X) and the absence with letter A, just at the start of work or day on each day.

4) Labours may be paid more than once a month depending upon local conditions, but after each payment, separate or new MB has to be opened.
5) The daily record of attendance and fines should be recorded in such a way that
- The calculation of the net wages of each labour for the purpose of payment becomes easy.
- It may be difficult to tamper with the original entries.
- It may be easy to classify the expenditure by subheads of works.

Measurement Book :-

→ Measurement Book (MB) is an important book where all the works executed are recorded regularly.
→ On the basis of MB, contractor is paid regularly.
→ MB is the initial record of all kinds of works which are susceptible to measurement. This MBs are the basis of all accounts of quantities of work done by contract labour employed departmentally and the materials purchased for specific works.
→ MBs should be kept & maintained in such a way that the transactions are readily traceable in the accounts of the department.
→ MBs are very important records and should be kept in safe custody. They must be maintained in accurate and kept carefully so that they may be produced in a court of law as evidence.
→ All MBs belonging to a division should be numbered

serially and a register should be maintained in the divisional office showing the serial number of each measurement book.
→ Measurement books are of three types
1) Ordinary Measurement Book
2) Standard Measurement Book
3) Check Measurement Book

Ordinary Measurement Book :-

→ It is an initial record of all kind of works which are susceptible to measurements. In this book, entries regarding the work done, supplies made are recorded for the purpose of making payments to the contractors.
→ At the top of this book, following items are written,
1) Name of work
2) Location of the work site.
3) Name of agency executing the work
4) Date of written orders for commencement of work.
5) Date of completion of work
6) Date of measurement of work
7) Date of agreement & its number
8) Name of subordinate officer - in charge of labour
9) Reference of previous management.

Standard Measurement Book :-

→ The measurement book where standard measurements are recorded is known as standard measurement book.
→ For example : Some buildings which are repaired periodically and the quantities of various items of work remain unchanged from year to year.

In such cases of repair works to save the trouble of measuring them everytime, it is convenient to maintain standard measurement book.

※ Check measurement book:-

→ In order to check the measurements made by the sectional officer or junior engineer/overseer, a check measurement book is kept by the subdivisional officer.

→ To avoid double payment no measurement is recorded for the purpose of payment in a check-book.

→ It is solely kept for checking purposes.

→ At the end of the measurement in the MB of the sectional officer following certificate is recorded by the subdivisional officer.

→ "Check measurement was made by me in the check measurement book No..... on page..... The sectional officer concerned was/was not present at the time of check measurement."

* FIDIC conditions of Contract:-

→ FIDIC:- International Federation of Consulting Engineers

→ Construction industry needs alternative dispute settlement mechanisms which are able to solve rapidly the dispute relating to especially international construction projects, even in the construction site as far as they emerge.

→ A modern tender system shall begin with an

efficient evaluation of the prequalification of applicants and proceed with a tender procedure based on high quality tender documents and carry on with the balanced conditions of contract which fairly distributes possible risks of future among the employer & contractor.

→ FIDIC is the international standard contract & conditions of contract in detail and also a model for general contracting contract for international construction works.

→ In FIDIC, the scopes and nature of construction works is clearly defined in technical conditions of contracts and drawings, constitute the legal basis for construction work for the completion of construction project at the desired time and within the budget, how to perform each stage, what the risks & responsibilities are clearly and precisely defined.

→ The main objective of the FIDIC is to intend to establish a balance or even to prevent the oppression of the contractors against the employer.

※ PPMO Conditions of Contract:-

→ Public Procurement Monitoring Office

(Why)→ To serve as guiding body responsible for procurement policy formulation and the implementation & monitoring of effective public procurement System.

→ To establish & maintain transparency, accountability, effectiveness, efficiency & economy along with non-discrimination and equality in public procurement proceedings of Nepal.

→ To acheive maximum benefits from the public expenditure through economy & rational judgement.

✻ Award of Contract:

→ The lowest responsive bid is identified and recommended for award of job by bid evaluation committe. A decision is taken for award of contract.
→ A letter of acceptance (LOA) is issued requesting the selected bidder to submit performance security & to sign the contract.
→ Once the contract is signed, bid security of all other bidders will be returned.
→ Letter of intent is issued within 7 days of bid selection and information should be given to other bidders also.
→ If there is no complaint from other bidders within seven days, letter of acceptance is issued to notify the successful bidder to come with performance security for contract agreement within 15 days.
→ If successful bidder fails to furnish the performance guarantee and to sign contract within 15 days, then his bid security shall be forfeited and bid of next lowest responsive bidder is accepted & called for agreement.

✻ Selection of Consultants:

→ Consultation service can be procured by following methods

1) Quality & Cost based Selection (QCBS)
   Technical proposal ⇒ 70-90%
   Financial Proposal ⇒ 30-10%

2) Quality based Selection (QBS)
→ For consulting services of exceptionally complex or such services are likely to have considerable impact on national economy or future project, the selection of proposals may be made exclusively on the basis of QBS.

3) Fixed Budget Selection (FBS)
→ Incase of FBS, while inviting proposal for selection of consultant, available budget shall be indicated in the proposal.

4) Least Cost Selection (LCS)
→ Among the technically qualified consultant, job is awarded to the consultant with lowest financial proposal.

✻ Prebid Meeting

→ For big and complex project works, pre tender meeting should be conducted to cause appraisal of the project, appreciate the views of prospective bidders, comments & suggestions are given to organization.
→ Pre-bid meeting are gatherings scheduled after an invitation for bids or request for proposal is advertised.

✻ Duties & Responsibilities of Site Supervisor:

→ Supervising workers, subcontractors & Work Activities.
→ Preparing & presenting site inductions, safety briefings and toolbox talks.
→ Assessing and managing safety hazards.
→ Ensuring appropriate site rules and welfare facilities are in place.

→ Carrying out regular inspections.
→ Helping project managers to plan the work programme.
→ Helping coordinate deliveries of materials, plants and equipments.
→ Completing records for site reports.
→ Attending site management meetings.
→ Carrying out regular inspections to ensure compliance with relevant legal requirements, processes & procedures.
→ Raising safety concerns at the appropriate level
→ Resolving problems & implementing improvements.
→ Organizing & overseeing external inspections such as with a health & safety inspector.
→ Providing emergency first aid if required.

Chapter-4, Construction plant & Equipment:-

Outline

→ Introduction to construction tools, machines, plants & equipments
→ Advantages of using construction equipment
→ Equipment for excavation, transportation & Compaction
→ Aggregate Handling Equipment
→ Concrete batching, mixing & compacting equipment
→ Pile foundation Construction equipment.
→ Equipment for construction of caisson foundation
→ Equipment for lifting of materials & parts
→ Tunneling Equipment
→ Equipment for hydraulic construction
→ Equipment for highway pavement construction
→ Criteria for selection of equipment.

✻ Construction tools, machines, plants and machines:-

→ A construction tool is any instrument or simple piece of equipment that you hold in your hands and use to do a particular kind of work. Eg:- Spades, hammers & knives etc.

→ A construction machine (or mechanical device) is a mechanical structure that uses power to apply forces & control movement to perform an intended action. Eg:- Vibrator, Chain saw etc.

→ A construction equipment is a relatively heavy machines which perform specific construction functions under power. Eg:- Excavators, dozers, graders, scrapers etc.

→ A construction plant refers to heavy machinery & equipment used during construction works. Eg: Batching plant, aggregate production plant etc.

Advantages of using construction equipment

→ Tasks which are too heavy or too delicate for human muscles to do can be done easily by a machine.
→ Speedy Construction
→ More accurate work
→ Works of labour becomes much lighter. He has simply to press a knob and then the equipment starts working.
→ Cheap goods:- The use of equipment has resulted in large scale production & has reduce costs.
→ Mobility of labour
→ More employment:- In long run, machinery creates more employment than displacing labour immediately.
→ Equipment can work in adverse weather, climatic condition & topography.
→ Equipment is free from social & emotional factor.

Selection of Appropriate Equipment:-

Since it is not possible to by all types & sizes of equipment. It becomes essential to select the most owing equipment by considering following factors.
→ Type of equipment that the project requires: standard equipment or special equipment.
→ Operating cost of equipment
→ Cost of repair and maintenance
→ Availability of spare parts & skilled manpower
→ Opportunity available to optimize the use of equipment
→ Economic life of construction equipment
→ Geological Condition
→ Weather Condition

→ Site Condition
→ Transport facilities
→ Availability of fuel
→ Suitability of equipment
→ Experience & reputation of equipment manufacture
→ Noise criteria
→ Life span of structure
→ Energy benefits (energy efficiency)
→ Environmental health attributes
→ Safety
→ Quantity of work & time allowed for completion
→ Interference expected and interdependence with other operations
→ Structural design
→ Accessibility to location:

Equipment for excavation:-

1) Excavators (consists of boom, dipper, bucket & cabs)
2) Dozer/ Bulldozer:- (Crawler with metal plate to push large quantities of soil, sand & other)
3) Back Hoes Loader:- (used to increase depth of digging & no shoring is required)
4) Power shovel:- Excavate earth & load in transport equipment or deposit it in levees, dams & spoil banks near the pit.
5) Drag lines:- For very deep excavations which is not possible by power shovel (pit containing water)
6) Grader:- Leveling & grading / finishing
7) Clamshells:- consists of bucket with two halves, hinged at top & provided with teeth at bottom.

8) Trenching machines:- used in water pipelines, gas pipeline, cable trenches & sewer ditches.
9) Scrappers:- Cut, haul & discharge materials
10) Powerjack hammer:- Used to drill holes in hard rock
11) Pneumatic rock drills:- Drilling by compressed air
12) Air Compressor:- drive drilling machine to drill holes in rock.

Transportation Equipments:-

1) Trucks or Trippers (equipped with hydraulic piston)
2) Mini-dumpers:- loading & unloading, small capacity
3) Rail Wagons:- large quantity of materials to be transported in long distance. (Tunnel construction)
4) Loaders:- Excavate soft soil & transported it to short distance.
5) Belt Conveyor:- used in gravel & sand quarries
6) Bucket Conveyors:- Transport loose material in vertical dir^{n}
7) Rope-way:- Material is transported between two points through rope.

Earth Compaction Equipment:-

1) Smooth Wheel Roller:- user for compaction of cohesive soil
2) Sheep Foot Rollers:- Consists of hollow drum & pads or projections on periphery of drum
3) Grid rollers:- Rollers formed by network of steel bars
4) Tamping rollers:- High speed, self propelled & non vibrating rollers
5) Pneumatic tired rollers:- two tandem axles with four to five wheels on each axle.
6) Rammer:- Heavy iron weight with wooden hammer
7) Frog Rammer:- Rammers with smaller ramming plate (30ϕ)

Aggregate Handling Equipment:-

1) Crusher:- Reduce size of aggregate
   - Primary Crusher
   - Secondary Crusher
   - Tertiary Crusher
2) Screening plants (Separation of oversize crushed stone & washing of aggregate)
   - Revolving screens
   - Vibrating screens
3) Conveyor belt

Concrete Construction Equipment:-

steps 1) Proportioning
2) Batching:- Volume/weight batching, Manual, semi automatic and fully automatic batching plant
3) Mixing:-
   - Hand mixing
   - Machine mixing
     - Batch mixer → Tilting type mixers
     - Batch mixer → Non-tilting type mixers
     - Continuous mixer
   - Pan mixing (lab)
4) Transportation
   - Pan method
   - Transportation by dampers & trucks
   - Bucket Conveyors
   - Chutes
   - Belt conveyors
   - Concrete pumps
   - Builders Hoist
   - Transported by Crane

5) Compaction of Concrete
- Internal vibrators (Needle vibrator)
- Surface Vibrators
  - ↳ Vibrating screed
  - ↳ Pan type vibrator
  - ↳ Plate type tamper
  - ↳ Vibratary rolling screed.
- Form Vibrators
- plate vibrators (slab construction)
- Concrete rollers (dam construction)

6) Finishing of Concrete:-

7) Curing

※ Cranes for Lifting:-

1) Stationary crane:- large working radius, almost any lifting capacity.
2) Overhead or Grantry Cranes:- (factory or workshops)
3) Mobile Cranes:- mounted on mobile units.
4) Tower Crane:- Used in construction of industrial & multi-storeyed buildings.
5) Heavy Lifting Cranes:

※ Equipments for tunnel construction:-

a) Equipment required for tunnel construction by conventional method
- Drilling machine
- Ventilating arrangement
- Electric Arrangement
- Wheel borrow, trucks, loaders etc.

- Pumps if required to drain water
- Formwork & supports
- Concreting machine / Batching plant / Concrete pumps

b) Tunnel Boring Machine (TBM):-
→ Recently developed technigues to drive tunnel through both hard rock & soft soil.
→ Very fast & efficient
→ These machines can work in fixed coordinates x, y & z.
→ Available in different size & Capacity.

※ Equipment for hydraulic construction:-
→ Construction in deep sea harbors, large lake, construction of off shore oils rigs
→ In shallow water area, construction is done using coffer dam
→ For dewatering from construction sides, pumps are used.
→ Types of pumps
- Displacement pump
  - ↳ Reciprocating pump
  - ↳ Diaphram
- Centrifugal pumps
  - ↳ Conventional
  - ↳ self priming
  - ↳ Air-operated.

※ Equipment for highway & Pavement Construction

1) Air track drill:- for quarry blasting
2) Chip Spreader:- Lays down the aggregate on top of bituminous binder which is then rolled by a compactor.

3) Compactors
4) Concrete plant / batch plant
5) Curb machine: A curb machine takes concrete & creates a continuous curb and gutter.
6) Crushing Machines
7) Motor grader: Machine with long blade used to create flat surface
8) Oil distributor: Application of prime or tackcoat by it.
9) Paver: Used to lay asphalt on roadway
10) Paving plant: Used for manufacture of asphalt, macadam, blacktop etc.
11) Ready Mix Truck: Typical concrete mixer uses a revolving drum to mix the components.
12) Sweeper: equipped with water tanks & sprayers. Used to loosen particles & reduce cost.
13) Water Truck: For compaction & dust control

* Equipment for bituminous pavement work
→ Bitumen Boiler
→ Bitumen Distributor
→ Aggregate Spreader
→ Asphalt distributor
→ Asphalt Concrete plant
→ Asphalt Concrete pavers
→ Rollers
→ Water tanker.

** Pile Driving Equipments:-
1) Piling Rigs:- fixed on crane base composed of series of leaders support the hammer and pile and guide them when pile is forced into ground.
2) piling Winches:- Used to hoist the object vertically.
3) Hanging Leaders:- designed to be hanged from jib of crane.
4) Hammer Guides:- Guides the pile
5) Piling Hammer:-
• Single acting steam or compressed air hammer
• Double acting pile hammer
• Diesel pile hammer
• Hydraulic operated hammer
• Drop Hammer
6) Helmet, Driving Cap, Dolly & Packing
Helmet is cast steel that is placed over pile to hold the dolly bet' pile & hammer. packing is placed in order to protect the former from the hammer blow.

** Equipments for construction of Caisson Foundation
1) Boring Machine
2) Crane
3) Motor, pump, air compressor.
4) Air shaft
5) Concrete batching plant
6) Cutting edge, Curb, steering wall
7) Reinforcement bar cutting & bending equipments etc.

Chapter-5, Quality Control / Assurance

Outline:-

- Introduction to quality control / Assurance
- Objectives of QC/QA
- Factors affecting quality of construction.
- Quality Control Technique
- Preparing QC plan, approval of material source, material sampling and testing at on site laboratory and off site laboratory
- Quality control of Works - Checking, setting out, earthwork, formwork, reinforcement, concrete construction, masonry construction, curing
- Preparing Quality Assurance Plan (QAP)
- Quality Control tools:- checklists for checking various activities at worksite.
- Role of Specification.

Why we study quality?

- To provide basic concept concept of quality & procedures to be used.
- To attain the required quality in the job performance.
- To increase understanding of problems associated with management of quality at construction site and also understand the remedial actions required to overcome them.
- To provide concept of quality management System.

Quality:-

- Quality is defined as
  - Degree of goodness
  - Conformance to requirements
  - Fitness for purpose.

- Other define quality as,
  - Zero defect
  - Consistent conformance to expectation
  - Doing things right the first time
  - Quality is not grade.
- Quality costs more, but lack of quality costs even more.
- Quality is a means of acheiving project success. It is not the goal itself.
- Process quality is more essential than product quality.
- Quality standards donot demand the best quality, they establish the minimum requirements to be acheived.
- Quality must be customer focused.
- It includes quality of design, quality of construction, quality of inspection, quality of usage and quality of maintenance.

Quality Control:-

- The operational techniques & activities that are used to fulfill requirements of quality.
- It is the progress of regulating or directing an activity to verify its conformance to a standard and to take corrective action required.
- This explains more about quality monitoring.
- The control process in fact is the corrective steps taken to eliminate or reduce the variance observed during monitoring process.
- It may be understood as all the measures taken to maintain or satisfy the quality of performance.

Quality ~~Cont~~ Assurance:-

→ All those planned and systematic actions necessary to provide adequate confidence that a product or services will satisfy given requirements for quality

→ Quality assurance is predetermined logical, procedural approach to work.

→ Quality assurance is concerned with attainment of quality during every stage of the construction project whereas quality control is only concerned with activities such as inspection, sampling & testing.

Objective of Quality Control / Quality assurance:-

→ To fulfill requirement of regulatory bodies by meeting quality standards concerned with the public health, safety and environment.

→ Designer Oriented Objective

1) Contribute to better design by serving as a source of feedback upon which to base the future project designs.
2) Permit use of less stringent design standards & reduction of safety factors with resulting savings in cost in those areas where quality can be assured.
3) Provide tight quality control of areas using new materials and techniques, thereby encouraging use of new design and construction methods which results in savings in cost.

→ Contractor Oriented Objectives

1) Reduce rework due to rejected or unacceptable material or work by developing and following procedures having a maximum probability of success.

2) Ensure that the quality level of the constructed product conforms to that required by the plans, specifications & contract documents.

→ To fulfill owners requirements by achieving safe, reliable & durable outputs:

Difference between Quality Control & Quality Assurance:-

Quality Assurance	Quality Control
1) Aims to prevent defect.	1) Aims to identify & fix defects
2) Preventive technique	2) Corrective technique.
3) Defines standards & procedures that need to be adhered to in order to meet customer requirements.	3) Ensures that standards are followed while working on the products.
4) Helps build processes	4) Helps implement the existing process.
5) It is the duty of complete project team.	5) It is only the duty of the testing team.
6) Process Oriented Exercise	6) Product oriented Exercise
7) Is generally not a time consuming activity.	7) Is generally a time consuming activity.
8) Does not involve executing the program or code.	8) Involves executing the program or code.
9) Done before quality control	9) Done after Quality Assurance
10) Makes sure quality team is doing the right things in the right way.	10) Makes sure that whatever the quality team has done is as per the requirements.
11) QA is all about planning or finalising the quality targets for a project & showing the ways of achieving same clearly.	11) QC includes all those tasks or activities performed in ground as per the quality guidelines or framework.

Factors affecting construction quality

- Design
- Drawings
- Specifications
- Bid preparation & selection of contractor
- Socio-economic factors
- Environmental factors
- Weather
- Scheduling
- Monitoring & Controlling Systems
- Political Situations
- Managerial skill of project manager
- Attitude of team members / contractors

Total Quality Management (TQM):-

- TQM is an operating philosophy that seeks to make continuous improvements throughout an organization or business by improving & motivating staff at all levels.
- Continuous improvement is a fundamental principle of the TQM philosophy.
- TQM emphasizes quality at the source.
- Each employee should be responsible for the quality of his or her works.
- The product, process, organization, leadership and commitment are considered as five pillars of TQM.
- Stages of Quality Control in TQM

(a) Design stage Quality Control

- A bad design can not produce a good project.
- Therefore enough care should be taken for quality control of design itself.

(b) Document Stage Quality Control:-

- Careful consideration has to be given while preparing contract documents.
- Since the documents are most important to control the quality of construction projects, the quality of document itself is important. Very much careful study is essential while preparing the tender documents.

(c) Implementation / Construction stage:-

- This is the most important stage in construction projects
- Actual quality steps are taken at the construction site in this stage.
- This stage is also important because all the deficiencies of previous stages can be identified and corrective measures are taken during this stage.
- Therefore, the role of engineer for construction supervision is vital & serious.

Quality Circle:-

- Quality Circle is a small group of employees in the same work area or doing a similar type of work who voluntarily meet regularly for about an hour every week to identify, analyze and resolve work related problems, leading to improvement in their total performance and enrichment of their work life.
- Quality circle is a technique of participative management for continuously improving quality, quantity, efficiency & safety.
- Quality circle is a work team of employees who meet regularly to discuss their quality problems, investigate causes recommend solutions and take corrective actions.

Impacts of Quality Circle:-

→ Tangible Impacts

1) Better Quality (25-35%) of the problem is usually dealt by quality circle)
2) Productivity Improvement
3) Higher Safety
4) Greater cost effectiveness
5) Better house keeping
6) Increased profitability
7) Waste Reduction
8) Reduced absenteeism and grievances

→ Intangible Impacts:-

1) Harmony & mutual trust
2) Better communication
3) Participative Culture
4) Enrichment of job

Dimensions of Quality:-

1) Performance, Eg: Brightness of picture
2) Features:- Eg: Remote Control
3) Conformance, Eg: Workmanship
4) Reliability, Eg:- Consistency of performance
5) Durability, Eg: long useful life
6) Service, Eg:- Resolution of problem & complaints i.e timely providing repair & servicing
7) Response:- Eg: human to human interference, closely interactions
8) Reputation:- Eg:- Ranked first.

Quality Assurance plan:-

→ QAP is a critical part of any project, as it enables to agree a set of quality targets with the customers.
→ It helps in monitoring & controlling the level of quality, which further indicates the level of adherence to the targets.
→ The purpose of QAP is to direct & facilitate the establishment of quality assurance activities with a processes used to deliver right products & services to the client.
→ This also makes sure of the quality of the goods delivered.
→ Quality Assurance plan describes the principles, processes and procedures used to support the regular delivery of high quality products and competitive services.
→ Quality assurance activities concentrate on the prevention of problems through the continuous improvement of processes.

Quality Assurance Team:-

→ Team dedicated for good quality products & services.
→ The roles & responsibilities of quality assurance team are,

1) To guide the technical staff to gradually improves the standards relating to Quality.
2) To develop & maintain QAP.
3) To conduct the audits & reviews
4) To ensure the quality assurance processes and procedures adequately control processes.
5) To review & approve specifies deliverables.
6) To promptly report the results of audits to management.
7) To implement task level quality control based on quality assurance standards.
8) To manage defects, errors & corrections.

Quality Control Techniques:-

→ Start with right workers → Define Acceptance Criteria
→ Invest in Technology → Create Inspection plan
→ Use of right materials.
→ Ensure Safety & Compliance
→ Check & check again (use checklists to conduct inspections)
→ protect Completed Work
→ Avoid Scope creep
→ Audit & Test
→ Repair Deficiencies Immediately
→ Have supplier and vendor Expectation from the starts.
→ Prevent future deficiencies.

Quality Control measures at Site:-

1) Study duties, responsibilities, tender specification, standards, codes of practice and work instruction.
2) Evolve effective acceptance/rejection procedures for construction materials in coordination with project purchase department.
3) Do proper sampling & testing of steel, cement, concrete, aggregates, water etc & verify test results in view of standards and work specifications prior to their use in construction. Also control quality of electrodes to their use in welding.
4) Set procedures to control quality at the points of storage for raw materials, mixing & placing of concrete.
5) Follow the prescribed curing & de-shuttering schedules.
6) Observe procedures to control quality of welded joints of structural steel members.

7) Evolve a system to check quality of workmanship in all construction activities.
8) Keep all revised Indian standards and codes of practice available in QC laboratory and have them handy during discussion with client/Consultant
9) Maintain sequence of construction required under any activity.
10) Discuss QA/QC issues as a separate agenda during site review meetings with staff.
11) Observe regular schedule for maintenance, repairs & calibration of plants & equipments.
12) Keep laboratory equipments such as weigh batchers, batching plant, vibrator & spare parts ready at site.
13) Carry out instruction cards in pocket while supervising/ inspecting works.
14) Regularly maintain the formats prescribed under ISO 9002 Quality Assurance System

Specification:-

→ It describes the nature and class of work, materials to be used in the work, workmanship etc.
→ Important for execution of work
→ Cost of work depends on specifications.
→ Specification should be clear and there should not be any ambiguity anywhere.
→ Thus, the combination of drawings & specifications define completely the structure. Drawings & specification form important part of contract document.
→ Types, General, Detailed & Standard Specification

Importance of Specification:-

1) Without specification, contract document / agreement is incomplete, invalid & baseless.
2) Any changes in the specification changes the contract cost.
3) The cost of unit quantity of work is governed by its specification.
4) To verify & check the strength of materials
5) It helps to bring up the expected and envisaged qualities in the design stage of all materials, workmanship and products.
6) It helps to ensure the expected quality of materials, procedures, outputs by testing samples at different stages of construction.
7) To specify the equipment, tools & plants to be employed for a works and thus enables to procure or hire.
8) It serves as guide for site engineer.
9) To procure the material required for project as well as the owner can check the quality of materials confirming the specifications avoiding dispute with the contractor.
10) It serves as an evidence & resolves dispute concerning the work if arise due to misunderstanding about the quality, process or maintenance of the work.
11) Details which are not clearly shown in the drawing can be obtained through specification.

Specification Writing

→ Description of material
→ Workmanship
→ Tools and plants
→ New work protection
→ Expression (Clear, short, complete, easy to understand)
→ clauses of Specification

Preparing Quality Assurance Plan:-

→ Identifies the organization, roles & responsibilities of individuals who will be participating in the project during construction.
→ provides a preliminary construction schedule with a summary of planned construction activities, their sequence, interrelationships, durations & terminations
→ Briefly summarizes the minimum qualifications of lead project participants from the engineers & contractors organizations
→ Provides a description of construction inspection program that includes inspection responsibility, anticipated inspection frequency, deficiency resolution & inspector qualifications
→ Describes key activities that will take place & processes that will be used to meet the quality standards, including communications, technical records handling, review & observation functions, sampling & testing requirements, acceptance/rejection criteria that will be followed and corrective measures to be used when deficiencies are found.
→ Includes a summary of documentation procedures for work clarification and changes to the work.

Material Testing & Site Inspections:-

→ To examine & analyze performance of materials prior to & during construction, materials like soil, concrete, rebar, structure steel, masonry etc. are tested.

→ Material Testing & Site Inspections are necessary throughout the construction process to ensure a quality project upon completion.

→ Construction material testing can be divided into two categories: field testing, which occurs at the project site and laboratory testing which involves taking samples from the project site back to an offsite location for further analysis.

→ The outcome of each is to ensure construction materials are safe & reliable, easily maintained & sustainable, donot damage the project site, nor endanges anyone or anything within the perimeter of the project.

Field Testing:-

→ Field testing is done by certified professionals at project site.

→ It includes

a) Soil & Aggregate Sampling & testing
- Compaction & density
- Bearing Ratio
- Permeability Testing
- Vane shear Test

b) Aggregate Sampling & Testing:-
- Air entrainment testing
2 Slump Testing
- Temperatures
- Unit Weight etc.

Laboratory Testing:-

→ For detailed analysis on material, samples are taken back to lab and different tests are carried out as per requirements.

→ Lab tests can be performed if the field testing results prove inconclusive or more detailed analysis is needed.

→ It includes

a) Soil Testing:-
Moisture content, Specific gravity test, dry density test, atterberg limits test, sieve analysis, Modified / Standard proctor, bearing ratio test etc.

b) Asphalt Testing
Mix Evaluation, stability, flow, Bulk Specific Gravity, Extraction

c) Masonry / Concrete Testing
Flexural strength testing, Compression strength testing, Unit weight, tensile testing, absorption, efflorescence testing, Mix design, structural Masonry testing etc.

Quality Control Tools:-

(a) Tools for collecting & understanding project data
- Check sheet
- Scatter diagram
- Graphs
- Histogram
- Pareto chart

(b) Tools for understanding project processes
- Run charts
- Control charts

(c) Tools for analyzing project processes.
- Cause & effect diagram / Fishbone diagram / Ishikawa Diagram

(d) Tools for solving project problems
- Brainstorming
- Force Field Analysis

(www.researchgate.net/publication/Quality-Tools-in-Project-Management)

※ Construction checklist:-

→ A checklist is a list of items you need to verify, check or inspect. It helps to ensure consistency & completeness in carrying out a task.

→ The common types of construction checklists are,
1) General Safety Checklists
2) Equipment Checklists
3) Tools Checklists
4) Quality & Certification checklists
5) Prework Checklists
6) Safety Checklists

For details, www.tutorialstipscivil.com/civil-topics/what-is-checklist-for-different-type-construction-work-at-site/

Chapter:6, Material Management

Outline:-

→ Importance of material management
→ classification of materials
→ Purchase Management
→ Inventory Management
→ Construction Garbage
→ Surplus Materials.

※ Material Management:-

→ It is the process of uniting the activities involved in the acquisition and use of materials employed in the production of finished goods products.

→ It is the planning, directing, controlling and coordinating those activities which are concerned with materials and inventory requirements.

※ Objectives of Material Management:-

→ Finding and selecting the materials and components with correct specification
→ To minimize the operation cost and increasing profit without making compromise in quality.
→ Receiving material safely in good condition
→ Issue material upon receipt of appropriate authority.
→ Identification of surplus stocks and taking appropriate measures to reduce it.
→ Regular supply of raw materials to ensure continuity of production.
→ To minimize storage and stock control costs.
→ To purchase items of best quality at the most competitive price.

Function of Material Management:-

→ Planning for material purchase
→ Stores & stock control
→ Receiving & issue of the material.
→ Transportation and handling of materials
→ Disposal of scrap and surplus materials.

Duties & Responsibilities of Material Manager:-

(a) Purchase Management (Procurement)
→ Selection of suppliers and issue of purchase order.
→ Timely delivery of material from the suppliers.
→ To look for new products, materials & suppliers.

(b) Production Control
→ Determining requirements of materials and parts to be purchased and manufactures.
→ Schedule of production & purchasing
→ Issue work order to manufacturing departments and purchase order to suppliers.

(c) Inventory and stores Control:-
→ To keep detail and up to date record of inventory.

(d) Traffic
→ Selection of Carriers
→ Developing & using techniques to optimize the transportation costs.

(e) Physical Distribution
→ Finished goods are moved from the production line to the warehouse & finally to the customer.

Material Procurement:-

→ Procurement is the process of purchasing of equipment, materials, supplies, labors and services required for construction and implementation of a project.
→ Procurement is normally performed at several levels. Certain long lead items may be procured by the owner, others by the manager and less critical items by each of the contractors involved in the project.
→ Procurement involves two types of activities
(i) Contracting & subcontracting
(ii) Material & equipment management

Procedure for Material Purchasing:-

(a) Prime Contract:-
A prime contract is one let by the owner to a contractor who is in turn responsible for performing the work according to contract specifications.

(b) Purchase Order: A purchase order is a short form of contract normally issued for procurement of materials, permanent equipment and Supplies.

(c) Subcontract:-
A subcontract is a form of lower-tier contract for procurement of work and services to be performed by other than a prime contractor at construction site.

(d) Agreement & Lease: Agreement & leases are form of contracts often used for procurement of technical services and for rental or lease of automobiles, construction or office

equipment or other temporary items that are not consumed or donot become part of the finished work.

(e) Control of Material Procurement:-

→ In material procurement, the main sources of information are requisitions, bids and quotations, purchase orders & subcontractors, shipping documents, receiving documents & invoices.

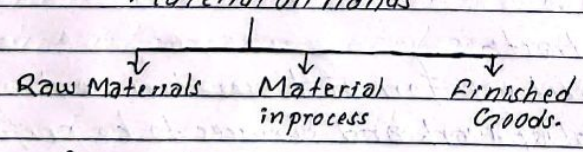
→ In most cases, these provide enough feedback for control. Other important opportunities for control of material costs on large projects are,

- Requisition procedures
- Minimization of rehandling & shortages
- Inventory procedures & policies.

Inventory:-

→ Inventory is the quantity of goods or materials on hand.

→ It is the sum of costs of all supplies of ficial & non official, whenever they may be stored & that have not yet been used.



→ Types of Inventory

(a) Official Inventory:-

→ Consumable products found in central Service & other storerooms, warehouses and satellite storage areas.

→ Canbe counted as an asset on the facility's balance Sheet.

(b) Unofficial Inventory:-

Consumable products found in user areas such as surgical locations and labs. These items have usually been expensed to the user departments are stored in unofficial location.

Inventory Management:-

→ Inventory Management means stocking adequate number and kind of materials and stores so that the materials are available whenever required & wherever required.

→ It is a tool of management which is used to maintain an economic investment in materials and products for the purpose of obtaining a maximum financial return.

→ objective of inventory management

1) To redvce the financial investment in inventories
2) To minimize idle time by avoiding stock outs and shortage
3) To avoid losses from inventory obsolescence.
4) To improve quality of ~~store~~ care.

→ Terminology

a) Lead time:

Average duration of time in days betn the placing of order & receipt of materials.

b) Internal lead time:

Time between placing of demand and receipt of materials from one department to other department.

c) External lead Time:-

Time between the placing of order and receipt of materials from the suppliers.

d) Buffer stock:-
It is the quantity of stock/stores set apart as a safeguard against the variation in demand and procurement period. This quantity should be used only at the time of emergency for unforeseen demand.

e) Recorder Level:-
→ Stock level at which fresh order has to be placed.

f) LIFO & FIFO
→ Last in First out & First in First out

g) Shortage Cost:-
This is cost of non-availability of an item & it includes
- Cost of lost goodwill
- Overtime Special effort to obtain an item.
- Lost Revenue.

h) Inventory Carrying Cost:
→ Cost associated with keeping the materials in the stores.
→ It includes storage, handling cost, cost of insurance, physical deterioration & obsolence.

(i) Inventory acquisition cost/ Replacement Cost
→ Cost incurred in placing order. (ordering cost)
→ It includes salaries and wages of staff working in purchase department, rent for the space, electricity, depreciation in the equipment & furniture etc.

* Inventory Control Techniques:-
→ Intuitive Method / Want book method
→ Perpetual Inventory method
→ ABC Method
→ JIT (Just in Time) Method

* Purchasing Procedure:-
→ Material Selection
→ Inquiry to venders
→ Vender competition & Comparison
→ Vender Selection & Negotiation
→ Purchase Order
→ Vender Evaluation

** Classification of Materials:-
(a) Based on value of consumption:- (ABC classification)

Group or class	Total items of stock	Inventory cost
A	10%	70%
B	20%	20%
C	70%	30%

(b) Based on use of Materials
1) Uniform Required Materials
2) Non-uniform Required Materials
3) Raw materials & finished materials
4) High value, Medium value & low value material.
6) Fast moving, Slow moving & Dormant stock.

✻ Construction Wastage/Waste:-

→ Construction waste is any substance, matter or thing that is produced as a result of construction work and is abandoned. This waste can be a mixture of surplus materials resulting from site clearance, construction, excavation, renovation, refurbishment, demolition & even road works.

→ Construction waste includes a huge variety of materials. Few of which can be recycled and few cannot, in addition to this there are some waste which are hazardous in nature.

→ Major Construction waste are

1) Dredging materials
2) Insulation & Asbestos Materials
3) Concrete, brick, tiles & ceramics
4) Wood, Glass & plastic
5) Metallic Waste
6) Masonry & Drywall
7) Cement
8) Paints, varnishes, adhesives, sealants.
9) Bituminous mixtures, coal tar & tar.

✻ Ways to reduce waste & save construction cost

1) Train employees & subcontractors in the reasons for operating sustainably. Employee knowledge and commitment are essential pre-requisites for high performance in waste reduction.
2) Only use suppliers which will accept back your unused materials. Over 10% of materials delivered to construction sites are never used.

3) Use excess earthworks materials to contour & landscape your sites.
4) Use a site crusher to reprocess existing concrete & stone
5) Waste reduction - think creatively.
6) Efficiently Separate waste types & keep materials clean for maximum recycling value.
7) Recycle building materials which can't be reused without processing.
8) Select the ecofriendly materials for construction.

✻ Surplus Materials:-

→ A surplus materials is the excess/unused materials in construction site after completion of construction work.

→ The surplus material is generated by the applied wrong specification or design changes after purchasing or over-purchased.

→ Ways to use surplus material

1) Donate/give the construction material to some local or needful people.
2) Reuse of Construction Surplus material by themselves for other works.
3) Return the material back to your suppliers.
4) Ask the contractor for reuse in another site.

Chapter-7, Construction Site Preparation

Outline:-

- Factors affecting construction site planning
- Layout of site office, material storage, pol storage & garbage storage
- layout of fabrication yard
- Fencing & barricading
- Access to workplace
- Labor Camp & Resting Area.

Construction site planning:-

- Before execution of works in the field/site, there should be detail site plan or master plan of the project.
- As per site plan, the layout of any structure/building will be done.
- All the facilities required for the project activities will be arranged like access road, storage area for materials, accomodation for engineers, staffs & workers, yard for the storage for reinforcement, bricks, aggregates, sands and workshops for repair & maintainance of equipment etc.
- If the preparation of all the ~~activities~~ facilities can be done as per site plan, it will very easier to work and it helps to reduce the management costs.
- It also helps to increase the efficiency of works and also increases the profit by completing the project within the time & quality.

Factors affecting the construction Site planning

- Nature of the project
- location of the project

- Topographical Condition of the project
- Capacity of the contractor to stock the materials.
- Availability of the markets
- Access/transportation facility
- Uniform required materials
- Non uniform required materials
- Weather/external factor

Layout of Site office, Material storage, pol storage & Garbage Storage:-

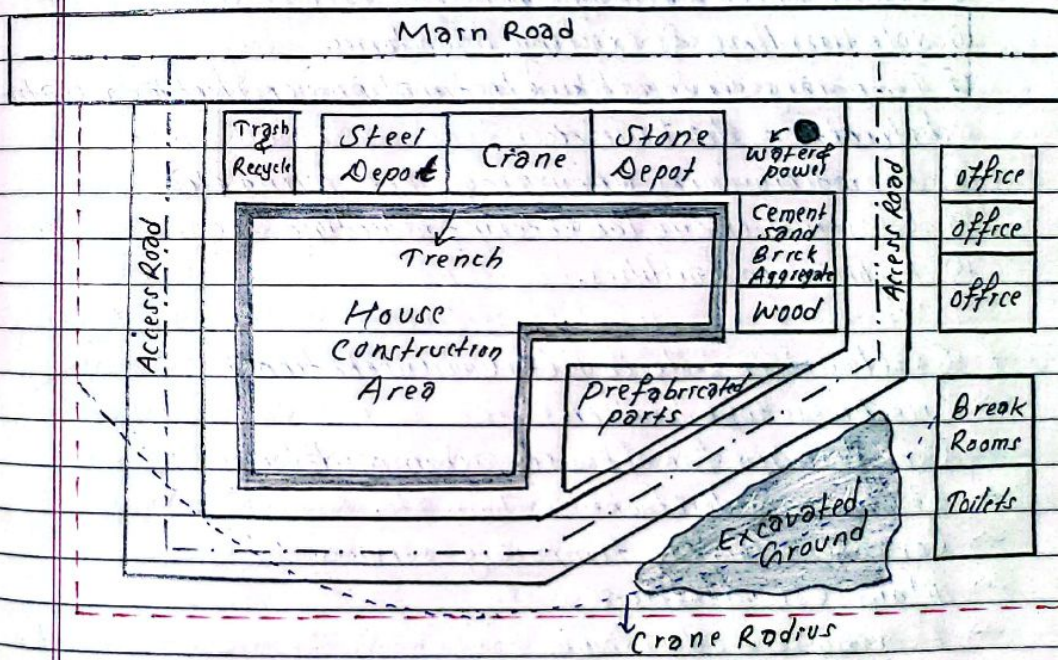


Fig: Layout of Site

→ Site layout plan includes
1) Zones for particular activities
2) Cranes (including radii & capacities)
3) Site offices
4) Welfare facilities
5) Offloading, temporary storage & storage areas
6) Sub-contractor facilities, Car parking
7) Emergency routes & muster points
8) Access, entrances, security & access controls, temporary roads and separate pedestrian routes.
9) Waste management & recycling areas
10) Vehicle wheel washing facilities.
11) Site hoardings & existing boundaries.
12) Temporary services like electrical power, lighting, water distribution, drainage etc.
13) Temporary works (propping, sheet piling etc)
14) Construction site laboratory for testing
15) Fabrication facilities.

* Construction Site layout Considerations:-
→ Site Access Consideration
→ Consideration for offices & accommodations
→ Storage considerations
→ Consideration for temporary services
→ plant Consideration
→ Fencing Considerations
→ Safety & Health Considerations
→ Consideration of radii & capabilities of Cranes etc.

* Fencing and Barricades:-
→ Construction fencing will be designed and erected around jobsites where there is a possibility of injury to employees, students, or the public. Special precautions must be taken to protect all persons.
→ The following guidelines are applicable to all types of construction sites:-
1) The contractor shall install and maintain temporary concrete, asphalt or wood ramps to provide a safe path of travel for mobility-impaired pedestrians at all locations where ramps have been temporarily removed or are needed to route pedestrians.
2) All fences must be minimum height of 4'2" and capable of withstanding 200lbs of force indicated by OSHA regulations
3) The contractor who erects the fence shall take care to see that no construction equipment, material, fencing & / or construction debris are outside of the fence area.
4) The fence must be maintained in good conditions with a good apperance, rigid, plumb and safe throughout the construction period.
5) The contractor shall maintain an accessible corridor that provides at least one safe path of travel for all pedestrians at all times.
6) If the portion of the pedestrian way is rerouted due to construction, the path of the travel shall be clearly defined.

* Construction Camp:-
→ The size and type of construction camp depends upon the following factors.
- Type of Work
- Amount of Work involved
- Duration of construction

→ Planning of Camp should be done keeping certain basic principles of planning in view, for a suitable layout such as
- There should be minimum disturbance, where night workers can sleep in day time.
- Stores should be made close to access road & place of delivery of material
- Hospitals should be located at a quiet place having good air circulation & quick access from the work for emergencies.

→ Following facilities are generally arranged in Camp.
1) Permanent houses - for job officials, supervisors or residential operators
2) Temporary houses - for workers
3) Staff Houses - for engineers, foreman & officials
4) Dining hall & kitchen - for feeding labours & workers
5) Guest House - For visiting officers
6) Community Hall - For common function, recreation for all habitants
7) Schools:- Educational facilities for worker's children
8) Office:- For design & clerical work
9) Garage, shops, repair shops, petrol station etc.
10) Various shops - Carpentor's shop, electrician's shop, mechanical shops, cable shops etc.

Access to Workplace:-

→ It is necessary to examine roads on & off the construction site. Ease of accessibility would minimize the chance of accidents, decrease the time needed to arrive at project site, decrease in material transportation cost. Easy to carry equipments, machines and cranes etc.

Outline

→ Introduction to EHS at construction site
→ Causes of accidents in construction projects
→ Minimizing the construction accidents
→ Safety planning
→ PPE as a safety measures at site
→ Training to improve safety standard at construction site - induction, toolbox talk, skill training
→ Role of safety engineer and safety steward.

Introduction to EHS at construction site

→ Environmental health is the branch of public health that is concerned with all aspects of the natural and built environment that may affect human health.

→ Environmental health is the study of how environmental factors can harm human health and how to identify, prevent & control such effects.

→ Environmental health professionals work to
a) Maintain a safe supply of food & drinking water.
b) Discover mechanisms of diseases caused by environmental exposures.
c) Treat & dispose of solid and toxic wastes
d) Reduce air, water, food & noise pollution
e) Control workplace hazards.

→ EHS management system aims to: Identify hazards & control risks related to worker's health & safety for all their activities; promote the reduction of work injuries; reduce the impact of activities on the working environment; improve productivity.

Safety:-

→ Safety may be defined as act of being safe from the materials, substance & the process at construction site.
→ Safety basically is concerned with no loss of life and property at the work place.
→ Where safety ends, accident starts.
→ Construction sites are often dangerous because they
1) carried out at dangerous place
2) Use dangerous materials like blasting materials.
3) Use dangerous methods like underwater drilling & blasting, tunneling etc.
4) Use heavy machines which often becomes the cause of accident.
5) Defective condition of equipment, tools, floors, stairs etc.
6) Unsafe design & construction
7) Unsafe process, operation or arrangement.
8) Unsafe dress eg: loose clothing, no gloves, no apron and shoes etc.

Accident:-

→ An accident can be defined as an unplanned, unintended, unexpected, unwanted occurrence which upsets the planned sequence of events and actions resulting in the loss of production, injury to the persons & damage to the plants & equipment.
→ Accident prevention saves the following.
a) Human Life
b) Temporary or permanent injury of workers
c) Loss of worker's willingness, encouragement

"Follow NBC 114:1994, Construction Safety" for more details.

d) Damage to plant or equipment or material
e) Loss of compensation to the workers
f) Loss of time and investment
g) Loss of Works

Causes of Accidents:-

a) Physical Cause:-
→ The physical cause is related to the machines, tools, materials & physical environment etc.
→ Accident due to machine being unsuitable for job, due to wear and tear, due to constant use, due to brittleness nature of used tools, due to explosive and petroleum products etc.

b) Physiological Cause:-
→ Accidents due to the poor eye sight, poor health, intoxication are the physiological causes.
→ These are the causes of accident because of the beyond control of the human. These causes are related to human anatomy.

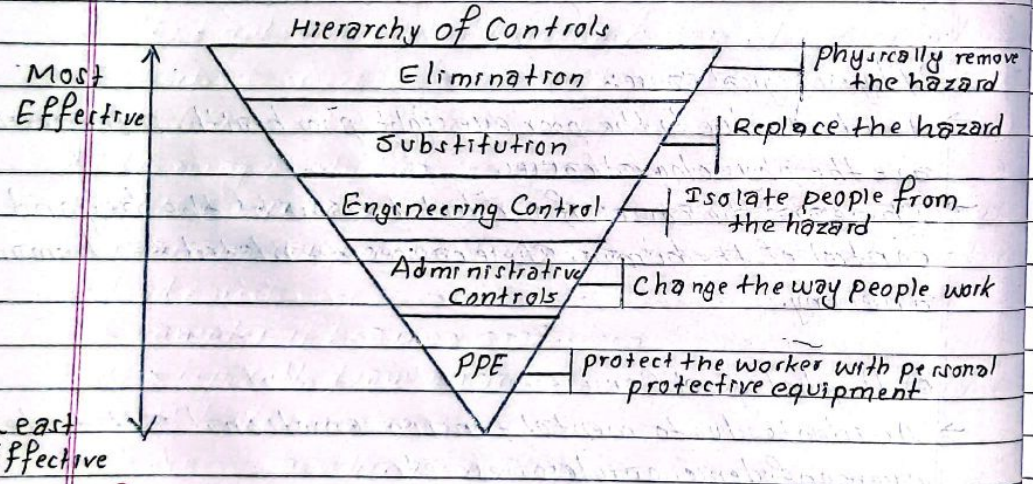
c) Psychological Cause:-
→ Accidents due to mental tension, emotional attitude, overconfidence, carelessness etc.

Accident Prevention and Control:-

a) Use of safety sign, signals & instructions
- Mandatory sign & signals
- Danger sign & signals
- Caution sign & signals

- Informative sign and signals
- Safe condition sign & signals

b) Provide safety training for all employees.
c) Hold frequent crew safety meetings.
d) Use protective clothing & wear (Hard hat, goggles, gloves, steel toed shoes or protective suits)
e) Keep the workplace clean.
f) Use & maintain equipment & tools properly.
g) Prevent falls (Use guardrails, toe boards, screens, canopy)
h) Recognize the hazards & make the plan
i) Be careful with vehicles.



** Personal Protective Equipment:-

→ PPE is equipment that will protect the user against health or safety risks at work.
→ It can include items such as safety helmets and hard hats, gloves, eye protection, high visibility clothing, safety footwear, safety harnesses.

→ PPE are supplied to all the personnel's working on site & even for the personal who are temporarily visiting to the site.
→ Minimum PPE requirements for safety at construction site
1) Hard Hat or Helmet
2) Safety Glasses
3) Hand protection gloves
4) Safety Vests
5) Proper clothing
→ Additional PPE requirements for safety at construction site.
1) Hearing protection
2) Respiratory protection
3) Face shields
4) Safety Harness
5) Material storage etc.

* Eye and Face protection:-

→ Safety glasses or face shields are worn anytime work operations can cause foreign objects getting into the eye such as during welding, cutting, grinding, nailing etc.
→ Eye and face protectors are selected based on anticipated hazards.
→ Safety glasses or face shields are worn when exposed to any electrical hazards including work or energized electrical systems.

* Foot protection:-

→ Construction workers should wear shoes or boots with slip-resistant & puncture-resistant soles.
→ Safety toed footwear is worn to prevent crushed toes when working around heavy equipment or falling objects.

* Hand protection:-
→ Gloves should fit snugly.
→ Workers wear the right gloves for the job. For example: heavy duty rubber gloves for concrete work, welding gloves for welding, insulated gloves & sleeves when exposed to electrical hazards.

* Head protections:-
→ Workers shall wear hard hats where there is potential for objects falling from above, bumps to their heads from fixed objects, or of accidental head contact with electrical hazards.
→ Hard hats are replaced after a heavy blow or electrical shock.

* Hearing protection:
→ It is compulsory to wear hearing protection equipment near any equipment, tool or machinery which makes loud noises.
→ Examples of hearing protection
i) Disposable foam plugs
ii) Molded ear plugs
iii) Noise cancelling ear plugs
iv) Ear muffs

* Body protection:-
→ Provide protective clothing for those parts of the body exposed to possible injuries.
→ Use laboratory coats, coveralls, vests, jackets, aprons, surgical gowns, full body suits.

* Respiratory Protection:-
→ Sometimes as voluntary respiration policy dust mask is supplied, any employee looking for additional comfort or safety while working with fiber glass, fire proofing, cleaning the floors or handling debris.

** Role of Safety Engineer:-
→ The role of safety engineer is to lead the effort in preparing the safety plan for their specific project assignments and then to follow them into the field for execution.
→ Safety engineer is also responsible for approving & monitoring the safety programs for subcontractors operating on the site.
→ The primary duty is to ensure that the work performed on the site is done within the safety program laid out for that project.
→ Safety engineer must be proactive in reviewing the field operations to ensure that the proposed construction methods and technologies have been analyzed from the safety and health standpoint.
→ Responsible for all on-site safety trainings for supervisors, skilled labours & workers.
→ Responsible for ordering the necessary safety supplies and equipment for the project.
→ Safety engineer should conduct periodic field inspections & emergency drills to see that the safety equipment and systems are being used & functioning properly.
→ To monitor the safety incentives and reward programs set up to improve the site's safety records.

Roles of Supervisor for safety at construction Site:-

→ The supervisor must be properly trained in delivering the correct safety message to the people working under their direction.
→ Supervisor also need to continuously monitor their areas to ensure that proper safety procedures are practiced.
→ When they are planning the execution of their work they have to keep safety in mind to ensure that trained workers using safe equipment are available to safety perform the tasks as planned.
→ They are responsible for delivering the site safety procedures to the workers through the general & foremen.
→ Safety procedures are a two way street, the supervisors also get feedback from the workers about unsafe working conditions. The feedback may be in the form of worker complaints about unsafe practices.

Training to Workers:-

→ Safety engineer is responsible for all on-site safety training for supervisors, skilled labour & workers. He should monitor the training and safety follow up done by the site supervisors.
→ They should be trained about safety measures.
→ They have to know the knowledge about safety procedures.
→ They need to follow clear safety rules to prevent from the injuries.
→ They need to be prepared with well dress; gloves, aprons, shoes etc. during the construction work.
→ They need to work in proper and adequate lighting & ventilated working conditions.

→ They need to be aware about tool box. Tool box is a primary safety tool which helps the workers at work site.
→ Training should be given frequently to the workers.

→ Types of Training:-

(a) Induction Training:-

→ Induction training is a form of introduction for new employees in order to enable them to do their work in a new profession or job role within an organization.

(b) Tool Box Talk Training:-

→ It focuses on improving foremen's planning & communications skills. Topics include leadership, conflict management and cross-cultural communication.

(c) Skill Training:-

→ It is a process that has been designed to offer specific training to the employee so that he can fulfill a particular job requirement.
→ It is for newly hired recruits & is also used to retrain & reeducate existing employees in a new process and technology.

Safety Code of Practice:-

→ The occupational Safety & Health Association (OSHA), Act of USA
→ The Health & Safety at Work Act 1974 (UK)
→ ILO convention & recommendation 1981
→ Labour Act 2074 (Nepal) → IS Code → National Building Code
→ Workers Compensation Act → Fire Regulation Act

Chapter-9. Project Maintenance

Outline:-

- Meaning & importance of maintenance
- Objective of maintenance management
- Types of maintenance
- Maintenance planning
- Issues of project maintenance with special reference to projects/systems under operation in Nepal.

* Project Maintenance:-

- Maintenance is an activity to acquire full life utilization of a facility or equipment at its normally running condition.
- Project maintenance helps to ensure the continue and smooth operation of any plants, machines or systems.
- The maintenance at the beginning may be less required but as the utilization goes on, it requires frequent maintenance to complete its service life.

* Objectives of Maintenance Management

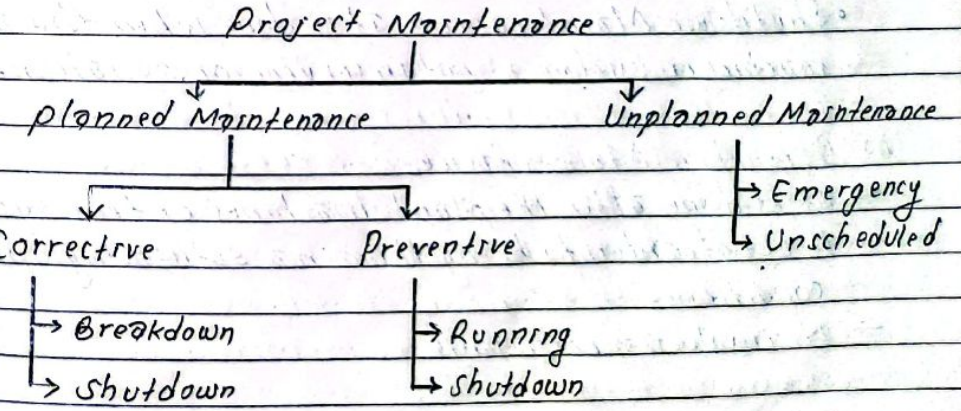
- To maximize and to ensure the availability of plants, machines or systems for operation, generation & distribution of the product facilities or services
- To maximize the useful life of the plant, machines or systems.
- To minimize wear & tear & deterioration of plants.
- To provide safe work/operation environment for the workers using plants, machines or systems.
- To maximize the return or invest by efficient operation of the plants, machines or systems.
- To minimize the loss due to production stoppages.
- To improve quality of products & to improve the productivity of plant.

- To minimize the total maintenance cost
- To improve reliability, availability & maintainability.

* Importance of Maintenance Management

- Preserve the owner's investment and prolong the lives of aspects to increase the time over which investment provides service.
- To minimize the loss of productive time & cost because of malfunctioning of equipment
- Acquire full life utilization of a facility or equipment as its normally running conditions.
- Increase the higher productivity by providing the smoothly operations of the equipment, plant & machines.
- Save life of equipment, machine & plants by providing the regular maintenance.
- Minimize the accidents caused by the machines, equipment, plants & other factors.

* Classification of Project maintenance:-



1) Planned Maintenance:-
→ maintenance carried out on a regular basis.
→ It improves uptime and quality of output & reduces repair maintenance costs through the continuous quality improvent.

(a) Preventive Maintenance:-
→ Carried out in order to keep something in working order or extend its life, such as replacing cracked roofing tiles before inclement weather.
→ It is the regular maintenance which is done to prevent breakdown / failure of the plant, machinery or systems.
→ It involves inspection, lubrication, adjustment, repair or overhauling of the plant, machines or systems.

- Running Maintenance: It means the maintenance work is carried out when the plant, machines or system is in service or in operation.

- Shutdown Maintenance:- It is done when the plant, machine or system is not in service or operation.

(b) Corrective Maintenance:-
→ It is done after the plant, machines or the system is out of order to bring them in a satisfactory operating conditions.
→ It involves minor repairs.

- Breakdown Maintenance:- It is done when plant, machine

or a system is out of order, i.e failure of the system.

- Shutdown Maintenance:- It is done when the plant, machine or system is shutdown & can be brought into satisfactory operating conditions on minor repairs.

2) Unplanned Maintenance:-
→ Any maintenance task that occurs unexpectedly.
→ It happens when there is no formal strategy in place to address a repair, replacement or inspection before it's needed.

* Emergency Maintenance:- Nobody knows when to do repair and maintenance work. If the system stops to work suddenly, this type of maintenance is done. In this type of maintenance, there may be a lot of expenses for the maintenance as well as schedule works may be disturbed.

* Unscheduled Maintenance:- Unscheduled maintenance is a maintenance that is not scheduled for specific time & has not been assigned to a technician.

** Difference between Preventive & Corrective Maintenance:-

Corrective Maintenance	Preventive Maintenance
1) It is carried out after recognition with the intention of returning an item to a state in which it can perform a required function.	1) It comprises the replacement of components or overhauling of assets at a fixed interval.
2) It is less complex and simple process because it does not involve any planning to prevent assets from failure.	2) It is more complex as compared to CM because it involves planning to prevent assets from failure.

3) It can be more expensive than PM as some equipment failure causes greater damage to system.	3) It is quite cheaper than CM & also prevent assets from failure.
4) Performed at random interval as it is performed when failure occurs.	4) Performed at regular intervals.
5) It is not better for safety of employees and working environment as it increases risk of injury.	5) It is better for safety of employees & working environment as it reduces risk of injury.
6) It requires greater number of employees or technicians to perform.	6) It requires a smaller number of employees or technicians to perform PM.
7) It increase work load for technicians.	7) It decreases work load for technicians.

** Maintenance planning:-

→ planning decides what, how and time ~~study~~ estimate for a job.

→ Thus, maintenance planning is the process of identifying the parts, tools, procedures and standard specification required for effective maintenance work.

→ Objectives of maintenance planning:

1) To provide the right information for the technician to more easily to perform the job.
2) To ensure right priority maintenance work is accomplished based on business needs.
3) To maximize the efficient use of worktime, material & equipment.
4) To interface with the operations partner to ensure the equipment is available for the maintenance at specified time.
5) To have identified the right parts and materials, having the stage & kitted.

* Steps for effective maintenance plan:-

→ Identify activities that require maintenance.
→ Prioritize them in sequence
→ Make the team and educate the team.
→ Develop the chart for maintenance
→ Develop guiding principle for maintenance planning
→ Define planning process
→ Prioritize work to be done.
→ Develop effective procedures
→ Measure effectiveness.

** Issues of project maintenance under operation in Nepal:-

→ Inadequate maintenance
→ poor design
→ Untimely maintenance
→ Limited construction materials
→ Limited capacity and number of qualified HR resource
→ Weak governance
→ Lack of funding
→ Transparency
→ Lack of qualified contractors
→ Natural disaster
→ War & Conflict

Chapter 10 - Organization & Management

Outline:-

- Definition of organization & management
- Principles of management
- Types of Organization - line organization, line & staff organization, functional organization and project organization
- Leadership & Motivation
- Project Communication
- Meaning & importance of HRM
- Recruitment & Selection
- Training
- Trade union in Nepal

Meaning of Organization:-

- Systematic arrangement of people brought together to accomplish some specific purpose/task.
- Social system composed of people, structure & technology for acheiving common goals.
- Organization is the framework by which a company communicates, develop goals & then works on achieving those goals.
- Organizations are important at every level of human life. Organization need people & People need organization.
- The major characteristics of Organization are
  a) Goal Oriented
  b) Collection of people
  c) Structure
  d) Technology
  e) Continuity
  f) Environment

Principles of Organization

- Unity of Objectives
- Division of work & Specialization
- Definition of job
- Separation of line & staff functions
- Chain of Command and Scalar principle
- Principle of Correspondence
- Unity of Command
- Unity of Direction
- Exception principle → Communication
- Span of Supervision → Flexibility
- Principle of Balance → Continuity

Classification of Organization:-

(a) On the basis of relation
- Formal Organization
- Informal Organization

(b) On the basis of organizational design
- Line Organization
- Line & staff Organization
- Functional Organization
- Matrix Organization

Formal Organization:-

- Created by management to accomplish goals of organization
- Defined by Organization Structure
- Depicted by the organization chart.
- Based on division of Work job specialization
- Authority-responsibility of every position is clearly defined.

→ Members are guided by formal policies, plans, rules, procedures.
→ Communication channel is through scalar chain.
→ Focusing on goals & efficient perform of jobs.
→ Long life in terms of continuity.
→ Slow in adapting to environmental change.

* Informal Organization:-
→ Not defined by organization structure.
→ Unplanned & Spontaneous
→ Results from human interactions/social relationships.
→ Based on common interests, attitudes & work related needs.
→ No written policies, plans, rules, procedures
→ Guided by customs, culture, group norms, values & beliefs
→ Quickly adapts to environmental changes.
→ The communication is through informal channel.
→ Primary focus is person
→ Co-exist with the formal organization.

* Line Organization:-
→ It is traditional organization structure
→ It is called as military or departmental or scalar type of organization.
→ Under this system, authority flows directly & vertically from the top of the managerial hierarchy down to different levels of managers & subordinates & down to operative level of workers.

→ Line organization clearly identifies authority, responsibility and accountability at each level.
→ The personnel in line organization are directly involved in achieving the objectives of the organization.

* Advantages:
→ It is simple to design & easy to understand.
→ Authority-responsibility relationships are clear & definite.
→ Members are clear about superior-subordinates relationships.
→ Accountability is also clearly defined.
→ Employees have strong sense of discipline.
→ Conflicts are few.
→ Communication is easy & quick
→ The structure is less expensive and also flexible to suit changing conditions.

* Disadvantages:-
→ Centralization of authority at the top can lead to autocratic behavior, dictators may emerge.
→ Lack of Specialist
→ Lead to nepotism or favoritism.
→ Kills initiative of lower levels due to one way communication from top to bottom.
→ Inefficiency due to lack of expert advice.

* Line and staff Organization:-
→ This type of organization structure is in large enterprises. The functional specialists are added to the line in line & staff organization.

→ Staff is basically advisory in nature and usually does not posses any command authority over line managers.
→ In the line and staff organization, staff assists the line managers in their duties in order to achieve the high performance.
→ Types of staff :- personal, specialized & general

* Advantages:-
→ Expert advice
→ Discipline
→ Balance workload
→ Advancement Opportunity
→ Flexibility

* Disadvantages:-
→ Conflicts - tend to interfere with line authority
→ Confusion - Lack of coordination between line & staff members
→ Overdependence - line members may depend on staff members for decision making
→ Carelessness: Staff members may lack of practical knowledge
→ Inefficiency: Expensive because two sets of employees are needed.

Functional Organization:-
→ It was evolved by Taylor while he was working as a foreman
→ He suggested eight foreman, four in factory & four in planning division as under.

1) Factory division
(i) The gang boss (ii) The speed boss
(iii) The inspector (iii) The maintenance & repair boss

2) Planning division
(i) Route clerk (ii) Instruction Card clerk
(iii) Time & cost clerk (iv) The shop disciplinarian
→ Each worker receives instructions not only from one superior but also from a group of specialists.
→ Three types of authority relationships are in the functional organization such as line authority, staff authority & functional authority.
→ Organizational members are grouped into functional departments.

* Advantages
→ Work specialization
→ Coordination
→ Efficiency
→ Direction & Control
→ Career progress

* Disadvantages:-
→ Lack of environmental adaptation
→ Poor coordination across functional department
→ Decision delays
→ Myopic focus - Self centered narrow departmental focus
→ Lack of unity of command.

Matrix Organization:-
→ Also called project organization
→ This organizational structure are temporarily formed for specific projects for a specific period of time, for the project of achieving the goal of developing new product.

→ The specialists from different functional departments such as production, engineering, quality Control, marketing research etc. will be drawn to work together. These specialists go back to their respective duties as soon as the project is completed.
→ Really, the project organization is setup with the object of overcoming the major weakness of the functional organization, such as absence of unity of command, delay in decision making & lack of coordination.

* Advantages:-
→ Environmental adaptation - able to adopt to changes in the environment
→ Efficiency
→ Motivation & Commitment
→ Free time for top management
→ Job Security
→ Employees Development.

* Disadvantages:-
→ Multiple Command structure - more than one boss
→ Power struggle - Power struggle between functional managers & project managers for allocation of resources.
→ Duplication - Project group can operate as mini department.
→ Costly to implement & maintain.

Management
→ Management is the process of planning, organizing, leading & controlling the resources of an organization

in the efficient & effective manner to achieve the specified organizational goals.
→ The functions of the management are,
1) Planning
2) Organizing
3) Staffing
4) Directing
5) Controlling
6) Coordinating
7) Communicating

1) Planning:-
→ Predetermining future
→ Involves selecting goals and the actions to achieve them.
→ Chooses alternatives/future best course of actions from among alternatives.
→ Deciding in advance about what to do, how to do, when to do, & who is to do it?

2) Organizing:-
→ Establishing a structure of roles
→ To assign the people who can do bet in his/her positions.
→ Define activities/tasks required to achieve goals.
→ Grouping the activities in departments.
→ Establishing authority & responsibility for each position
→ Coordinating activities to achieve harmony of efforts.

3) Staffing:-
→ Filling and keeping filled position in the organizations Structure.
→ Human resource management functions
→ Determining job description & job specifications
→ Recruiting, selecting, placing, developing, promoting, remunerating & retiring people.

4) Directing:-
→ Communicating, influencing & motivating people to perform tasks
→ It consists of
- Communication - flow of information from top to bottom, bottom to top
- Leading - Guiding & influencing the work of subordinates
- Motivation - Act of simulating or energizing people to contribute at some higher rate.

5) Controlling:-
→ The measurement & correction of performance to achieve planned targets.
→ Cyclical process of monitoring, comparing & correcting
→ The steps of controlling are,
- Establishing Standards
- Measuring actual performance
- Finding & analyzing deviation
- Corrective actions

6) Coordinating:-
→ Process of achieving unity of command
→ Individual actions need to synchronize in sequence.
→ Others must go on at the same time and in the same direction to finish together & achieve the overall task.

7) Reporting:-
→ Important function of management.

→ It communicates the actual work progress of an employee to the senior
→ Decision are made based on available information.
→ Daily, monthly, weekly, quarterly reporting.

8) Budgeting:-
→ A statement of future expenditure and revenues for planning and controlling financial & other resources.
→ Variable / Fixed budget
→ Sets strategies, goals, resource limits & premises for budget

✻ Principles of Management
→ Division of work - Specialization for all kinds of works
→ Authority & Responsibility - Authority flows from responsibility
→ Discipline
→ Unity of direction - one plan and one head for a group of activities having one objective.
→ Unity of Command - One employee, one boss
→ Subordination of individual interests to general interest
→ Remuneration - fair & equitable pay to employees
→ Centralization - Highly centralized power structure
→ Scalar chain - all employees are linked with each other in a hierarchy or superior subordinates relationship
→ Order - a place for everything & everything in its proper place.
→ Equity - Sense of kindliness and justice throughout all level of scalar chain.
→ Stability of tenure of personnel - job security
→ Initiative - encourages subordinate's initiatives
→ Esprit de Corps - Union is strength, cohesiveness and team sprit.

※ Leader:-

→ The person who guides & influences the activities of followers.
→ Leader influences the followers mainly through
a) power
b) Reason - use of facts and data
c) Assertiveness - use of direct & forceful approach
d) Friendliness - Use of goodwill & support
e) Bargaining - use of benefits/favors
f) Inspiration - a ability to inspire subordinates
g) Motivate - Use of motivational technique to energize people
→ Leader must be visionary, proactive, persistent, purposeful, people oriented, technology oriented & Socially Conscious.

※ Leadership:-

→ leadership is the effort to influence/change the behavior of others in order to accomplish organizational/individual or personal goals.
→ It is the art of influencing people so that they will make efforts willingly & enthusiastically for the achievement of tasks/for changing their behaviors.
→ Effective leadership is vital for the survival & success of all organization.
→ There are three elements of leadership.
a) Leader
b) Follower
c) Situation

* Functions of Leadership

→ Goal Determination

→ Environmental adaptation
→ Task focus (problem-centered function)
→ People focus (Social function)
→ Representation
→ Define Organization climate

* Leadership styles:

→ Leadership styles deals with the way, leaders influence the followers.
→ The widely recognized leadership styles are
a) Autocratic, democratic & free rein style
b) Managerial Grid style
c) Four Systems of management style
d) Situation style

※ Motivation:-

→ Motivation is an important management tool to harmonize & achieve goals of individuals & organizations.
→ Motivation energies, directs & sustains human behavior: a force that causes people to behave in certain ways & that is goal directed.
→ Types of motivation
• Intrinsic Motivation (self motivated, no need of external thing to motivate)
• Extrinsic Motivation (Need of external thing to motivate)
→ Theories of motivation
• Hierarchy of needs theory (Abraham Maslow)
• Duel Factor Theory (Frederick Herzberg)
• The expectancy theory (The vroom theory)
• Theory 'x' & Theory 'y'

* Techniques of Employee Motivation:-
→ Motivation is the key for effective work performance. It is the act of emerging people to achieve goals through higher productivity.
→ Managers can use the following techniques for employee motivation
1) Money
2) Participation
3) Quality of Working Life (QWL)
QWL is system approach to job design. Techniques of job design can be job simplification, job rotation, job enlargement, greater participation of subordinates etc.
4) Modified Work Schedules (flexible time, job sharing)
5) Behavioral Modification
→ Rewards should be based on performance
→ Never punish in front of others.
→ Be fair at all times.
→ Rewards can be in term of incentives, praise, promotion etc.
6) Management by Objectives (MBO)
→ MBO is used as motivational technique for self control of performance.

** Incentives:-
→ An incentive can be anything that attracts a worker's attention & stimulates him to work.
→ An incentive scheme is a plan/program to motivate individual/group performance.
→ This program may be of monetary rewards or variety of non-monetary rewards/prizes.

→ The timing & frequency of incentives are the basis of a successful incentive plans.
→ The plan requires proper communication to the employees & encourage individual performance.
→ Incentives can be classified into,
(a) Direct Compensation
→ Basic salary/wage, overtime work, holiday, bonus based on performance, profit sharing
(b) Indirect Compensation:-
→ Insurance, pension, provident fund

** Project Communication:-
→ Communication is the process of transmission of information between two or more persons.
→ Communication has no meaning unless it has been clearly understand by the receiver.
→ It is the transmission of understanding through the use of symbols.
→ Barrier to communication are often present when
1) Message is not clear.
2) Faulty transmission
3) loss of Interest
4) Unclear assumption
5) Trust
6) Fear
7) Semantic problems (Same words may mean entirely different things to different people)
8) Use of jargons (use special word to common word)
9) Discored Perceptron.

→ The basic elements of communication are
1) Sender
2) Encoding
3) Message Channel
4) Decoding
5) Receiver
6) Feedback
7) Noise

→ Importance of Communication:-
1) It facilitates all the functions of management
2) It is a vital skill for managerial effectiveness
3) It facilitates effective job performance
4) It links people together
5) It facilitates emotional expression of facing.
6) Communication is a critical management tool
7) Poor communication is the source of interpersonal conflict.
8) Information is made productive & goals are achieved.

✻ Human Resource Management (HRM)

→ HRM is a management function that helps managers recruiting, selecting, training & developing members for an organization.
→ HRM is concerned with people in organization.
→ HRM functions are not confined to business establishments only, they are applicable to no-business organization too, such as education, healthcare, recreation etc.
→ HRM refers to a set of programs, functions & activities designed & carried out in order to maximize both employee as well as organization.

✻ Importance of Human Resource Management:-

→ Attracting talent through effective HRP.
→ Developing necessary skills & attitude with training.
→ Securing cooperation through motivation.
→ Opportunities for personal development
→ Motivating work environment
→ Proper allocation of work
→ Good employment opportunities.
→ Development of human capital
→ Generation of income & consumption
→ Better lifestyles
→ Development of a country
→ Deliver economic growth.

✻ Recruitment & Selection:-

→ Recruitment is the process of attracting qualified candidates for a job role & selection is the process of identifying & selecting the right candidate for that job.
→ Right selection creates
i) Human Capital
ii) Improves employer, employee relations
iii) Increases productivity and commitment of employees &
iv) Facilitates environmental turnover.
→ Poor selection leads to
i) Increased employee turnover
ii) Absenteeism
iii) Accidents
iv) Job dissatisfaction
v) High cost of training &
vi) Productivity losses.

* Difference between recruitment & selection Process

Recruitment	Selection
1) It is the process of locating & encouraging potential applicants to apply for existing & anticipated job openings.	1) It is the process of picking those individuals who have the relevant qualifications to fill the jobs.
2) The objective is to invite more & more applications for the vacancy.	2) The objective is to select the employees who is suitable according to the skills, qualifications
3) It is done before selection	3) It is done after recruitment
4) It is positive approach	4) It is negative approach
5) In this process, vacancies are advertised on various portal websites & offline mediums by which applicants get notified.	5) It includes various steps from screening interview to various selection tests, medical examination etc.
6) It requires less time	6) It involves more time.
7) Economical Method	7) Expensive Method.

** Steps in Recruitment & Selection Process:-
→ Identify job vacancies
→ Prepare Job preparation & Job Specification
→ Advertising the job vacancy
→ Managing the response
→ Arranging the interviews
→ Reception
→ Screening Interview
→ Application Blank

→ Selection Test
- Intelligence test
- Aptitude Test
- Personality Test
- PIP Test (Protective, Interest, Preference Test)

→ Selection Interview
→ Medical Examination
→ Reference Check
→ Hiring decision
→ Appointment Letter

** Training:-
→ Training is the act of increasing the knowledge & skills in an employee for doing a particular job.
→ Training enhances capabilities required to improve performance in the present job. It involves positive changes in knowledge, skills and attitudes of employees to increase their efficiencies & effectiveness on the job.
→ Objectives of training
1) To achieve change in behavior of those trained and do the job in a better way.
2) It gives individual new skill, technical knowledge, problem solving ability.
3) To get people oriented with their present job. It changes attitude and ideas of human resources management in development aspects.

※ Methods of Training:-

(a) Induction Training:-
→ Initial phase training in which the new employee learns what to do? Where to go? And what are the important rules, policies & procedures?

(b) Training for promotion:-
→ Training to fit for higher jobs & create incentives.

- On the job training
→ Learning with working
→ It is learning by doing under the supervisor of an experienced employee.

- Off the job training
→ Training takes place outside the work situation.
→ It is mostly class room based.
→ It includes lecture/conference, simulation exercise, experimental exercise etc.

(c) Apprentic Training
→ Employees learn by working with those already skilled in their jobs.
→ Examples:- plumbers, Electricians, Accountants etc.

(d) Vestibule Training
→ This training pertains to the trainees of employees separately before they are placed on the jobs.
→ These days, separate training schools are opened to train the new employees.

(e) Internship Training:-
→ Training is organized by mutual understanding & agreement with technical institutions & vocational schools.
→ This training is conducted for training skilled & managerial personnel.

(f) Simulation Training:-
→ This training is conducted on a model either in class or in laboratory.

※ Benefits of Training:-

→ Improve knowledge, skills & attitudes.
→ Aids productivity & quality improvements
→ Heightens employee morale & job satisfaction
→ Improves labor management relations
→ Helps keep costs down, betters safety.
→ Fosters openness & trust, improves communication
→ Helps plan change & manage conflict
→ Improves Organizational climate.

※ Trade Union:-

→ It is an association formed by workers to secure economic welfare of the workers to bargain with their management for the welfare of the workers.
→ In construction works, workers are less organized due to the nature of the work.
→ In democratic system, trade unions are allowed to play their role freely.

→ In autocratic system, trade unions are hardly existed or non-existed.
→ At the outside, in England, in 1824, workers were allowed to unit in unions.
→ In Nepal, in 1947, Nepal Majdoor Sang was established.
→ In 1952, Nepal Majdoor Sarthan was established.
→ In 1961, when Panchayat System is introduced, this type of trade unions were banned.
→ After the restoration of the democracy in the country, many trade unions are functioning like: General Federation of Nepalese Trade Union (GEFONT), Nepal Trade Union Congress (NTUC), All Nepal Trade Union Congress (ANTUC), Nepal Revolutionary Workers union, Democratic Confederation of Nepalese Trade Union.

→ Principles of Trade Union
1) Unity is strength & no exploitation
2) Equal pay for equal job for male & female workers
3) Security of service.

→ Objectives of Trade Union
1) To work for the workers economic & social upliftment by improving working conditions of the workers.
2) To try to maintain good relationship between the workers & the management.
3) To assist for the development of the enterprise by enhancing productivity.

4) To work to make the workers dutiful & disciplined.

→ Functions of Trade Union
a) To demand adequate wages for the workers to improve their living standards.
b) To work for improving working conditions - safe, secured & healthy environment.
c) To participate in management for controlling purposes & for taking workers demand or voice to the management.
d) To provide financial helps to workers at the time of need by establishing a welfare fund.
e) To help workers at the period of strike employment, lock-outs etc.

※ Difference between Leader & Manager:-

Leader	Manager
1) Leaders create a vision.	1) Manager create goals.
2) Leaders are change agents.	2) Manager maintain the status quo.
3) Leaders are unique.	3) Managers are copied.
4) Leaders take risks.	4) Managers control risk.
5) Leaders are in it for the long haul.	5) Managers think short term.
6) Leaders grow personally.	6) Managers rely on existing, proven skills.
7) Leaders build relationships	7) Managers build systems & processes
8) Leaders coach	8) Managers direct.
9) Leaders create fans	9) Managers have employees.