CHAPTER THREE

PLANNING AND PROJECT APPRAISAL

Construction project planning and Scheduling

Introduction

Planning is one of the four main functions of management. Together with organizing, control and leading, it forms the foundation pillars of effective management (Robbins et al. 2000). In simple terms, planning is a process of forecasting future outcomes that may be uncertain or even unknown. It means assessing the future and making provision for it by gathering facts and opinions in order to formulate an appropriate course of action. Planning thus develops a strategy and defines expected outcomes (objectives) for undertaking a specific task before committing to such a task.

A project can be said to be a particular and unique form of organization with a limited lifespan. It exists for a finite period only: the achievement of its objective means that it comes to an end. An important characteristic of projects is that they are driven by objectives that are defined at the start. The project manager assumes overall responsibility for the project and leads the project team.

Although the terms ‘planning’, ‘programming’ and ‘scheduling’ are generally used indiscriminately, they are fundamentally different from each other. Using a top-down hierarchical approach, ‘planning’ sits at the top. It is the overall approach to predicting a future course of action. ‘Programming’ is placed in the middle. It is the name given to the task of identifying activities, establishing relationships, and developing logical sequences among such activities that would depict their order of execution. ‘Scheduling’ sits at the bottom. It is a process of quantifying the program. This involves, for example determining times and costs of activities, and the efficiency of allocated resources.

Construction planning’ may refer to a range of tasks concerned with determining the manner in which a job is to be carried out: budgeting, forecasting, preparing feasibility studies, or creating construction schedules. Construction scheduling is a mechanical process for setting in sequential order various operations in a construction project by the dates of starting and completing each operation of the work in such a manner so that the whole work should be done in an orderly and systematic way.

Construction project Planning

Construction planning is a fundamental and challenging activity in the management and execution of construction projects. It involves the choice of technology, the definition of work tasks, cost budgeting, the estimation of the required resources and durations for individual tasks, and the identification of any interactions among the different work tasks. A good construction plan is the basis for developing the budget and the schedule for work. Developing the construction plan is a critical task in the management of construction, even if the plan is not written or otherwise formally recorded. In addition to these technical aspects of construction planning, it may also be necessary to make organizational decisions about the relationships between project participants and even which organizations to include in a project

In developing a construction plan, it is common to adopt a primary emphasis on either cost control or on schedule control as illustrated in Fig. 6.1 Some projects are primarily divided into expense categories with associated costs. In these cases, construction planning is cost or expense oriented. Within the categories of expenditure, a distinction is made between costs incurred directly in the performance of an activity and indirectly for the accomplishment of the project. On the other hand, in some projects scheduling of work activities over time is critical and is emphasized in the planning process. In this case, the planner insures that the proper precedence among activities is maintained and that efficient scheduling of the available resources prevails. However, most complex projects require consideration of both, cost and scheduling over time, so that planning, monitoring and record keeping must consider both dimensions. In these cases, the combination of schedule and budget information is a major concern.

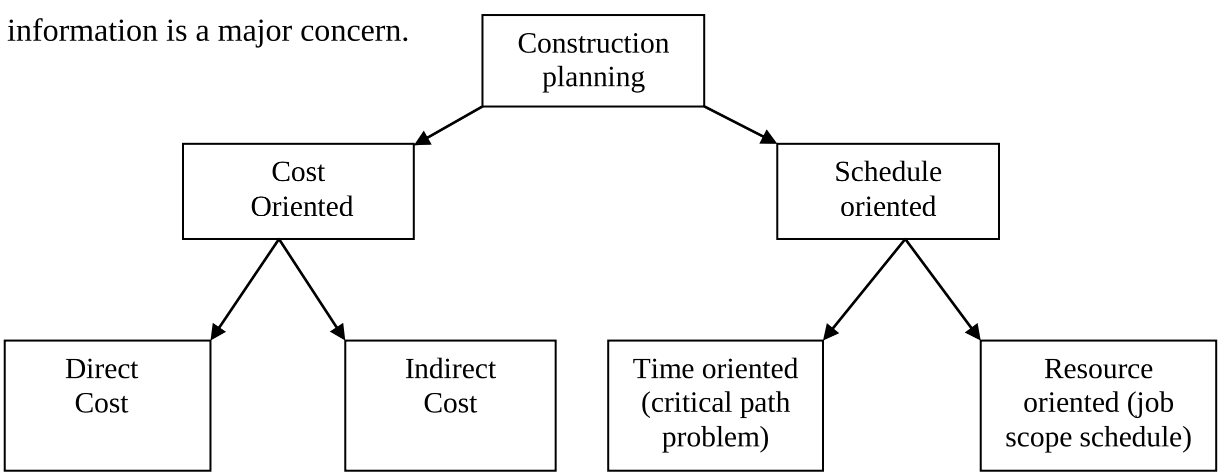


Figure 1 Alternative Emphases in Construction Planning

Functional Requirements of Construction Planning

Construction planning should have the following functional requirements these are technology choice, work breakdown, and budgeting.

Choice of Technology and Construction Method

The choices of appropriate technology and methods of construction are critical factors for the success of a project, even though in most cases less attention is given to these factors. For example, a decision whether to pump or to transport concrete in buckets will directly affect the cost and duration of tasks involved in building construction. A decision between these two alternatives should consider the relative costs, reliabilities, and availability of equipment for the two transport methods. Unfortunately, the exact implications of different methods depend upon numerous considerations for which information may be sketchy during the planning phase, such as the experience and expertise of workers or the particular underground condition at a site.

In selecting among alternative methods and technologies, it may be necessary to formulate a number of construction plans based on alternative methods or assumptions. Once the full plan is available, then the cost, time and reliability impacts of the alternative approaches can be reviewed. This examination of several alternatives is often made explicit in bidding competitions in which several alternative designs may be proposed or *value engineering* for alternative construction methods may be permitted. In this case, potential constructors may wish to prepare plans for each alternative design using the suggested construction method as well as to prepare plans for alternative construction methods which would be proposed as part of the value engineering process.

Defining Work Tasks

At the same time that the choice of technology and general method are considered, a parallel step in the planning process is to define the various work tasks that must be accomplished. These work tasks represent the necessary framework to permit *scheduling* of construction activities, along with estimating the *resources* required by the individual work tasks, and any necessary *precedences* or required sequence among the tasks. *Scheduling is* to determine an appropriate set of activity start time, resource allocations and completion times that will result in completion of the project in a timely and efficient manner.

The definition of appropriate work tasks can be a tedious process, yet it represents the necessary information for application of formal scheduling procedures. Since construction projects can involve thousands of individual work tasks, this definition phase can also be expensive and time consuming. Fortunately, many tasks may be repeated in different parts of the facility or past facility construction plans can be used as general models for new projects. For example, the tasks involved in the construction of a building floor may be repeated with only minor differences for each of the floors in the building.

More formally, an *activity* is any subdivision of project tasks. The set of activities defined for a project should be *comprehensive* or completely *exhaustive* so that all necessary work tasks are included in one or more activities. Typically, each design element in the planned facility will have one or more associated project activities. Execution of an activity requires time and resources, including manpower and equipment.

The extent of work involved in any one activity can vary greatly in construction project plans. Indeed, it is common to begin with fairly coarse definitions of activities and then to further sub-divide tasks as the plan becomes better defined. For this reason, this process is a natural *hierarchy* of activities with large, abstract functional activities repeatedly sub-divided into more and more specific sub-tasks. For example, the problem of placing concrete on site would have sub-activities associated with placing forms, installing reinforcing steel, pouring concrete, finishing the concrete, removing forms and others. Even more specifically, sub-tasks such as removal and cleaning of forms after concrete placement can be defined. Even further, the sub-task "clean concrete forms" could be subdivided into the various operations:

- Transport forms from on-site storage and unload onto the cleaning station.
- Position forms on the cleaning station.
- Wash forms with water.
- Clean concrete debris from the form's surface.
- Coat the form surface with an oil release agent for the next use.
- Unload the form from the cleaning station and transport to the storage location.

It is generally advantageous to introduce an explicit hierarchy of work activities for the purpose of simplifying the presentation and development of a schedule. More formally, a hierarchical approach to work task definition decomposes the work activity into component parts in the form of a tree.

Higher levels in the tree represent decision nodes or summary activities, while branches in the tree lead to smaller components and work activities.

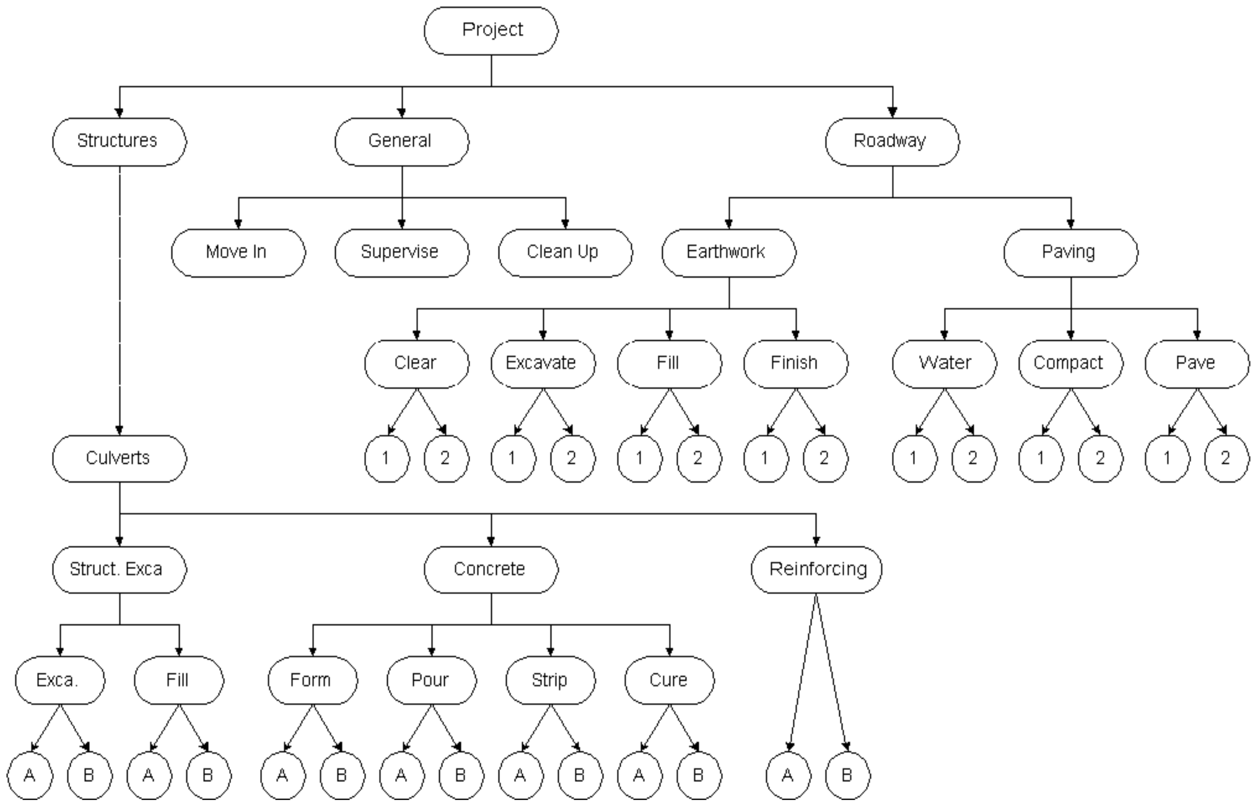


Figure 2 Illustrative Hierarchical Activity Divisions for a Roadway Project

Defining Precedence Relationships among Activities

Once work activities have been defined, the relationships among the activities can be specified. *Precedence* relations between activities signify that the activities must take place in a particular sequence. Numerous natural sequences exist for construction activities due to requirements for structural integrity, regulations, and other technical requirements. For example, design drawings cannot be checked before they are drawn. Diagrammatically, precedence relationships can be illustrated by a *network* or *graph* in which the activities are represented by arrows. The arrows are called *branches* or *links* in the *activity network*, while the circles marking the beginning or end of each arrow are called *nodes* or *events*.

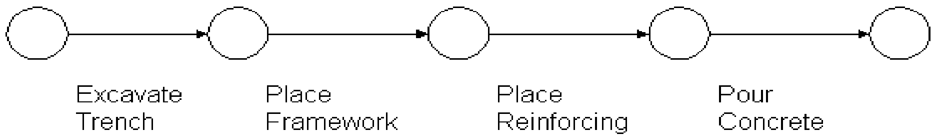


Figure 3 Illustrative Set of Four Activities with Precedence's

In the above figure 3, links represent particular activities, while the nodes represent target events.

Finally, it is important to realize that different types of precedence relationships can be defined and that each has different implications for the schedule of activities:

- Some activities have a necessary technical or physical relationship that cannot be superseded. For example, concrete pours cannot proceed before formwork and reinforcement are in place.
- Some activities have a necessary precedence relationship over a continuous space rather than as separate work task relationships. For example, formwork may be placed in the first part of an excavation trench even as the excavation equipment continues to work further along in the trench. Formwork placement cannot proceed further than the excavation, but the two activities can be started and stopped independently within this constraint.
- Some "precedence relationships" are not technically necessary but are imposed due to implicit decisions within the construction plan. For example, two activities may require the same piece of equipment so a precedence relationship might be defined between the two to insure that they are not scheduled for the same time period. Which activity is scheduled first is arbitrary. Reversing the sequence of two activities may be technically possible. In this case, the precedence relationship is not physically necessary but only applied to reduce costs as perceived at the time of scheduling.

Activity duration estimation

One of the most difficult tasks in planning is establishing the duration of activities. To do that, the planner needs to know:

- The quantity of the work
- The resources needed for its execution
- Productivity rates of the required resources
- The specific contractual requirements imposed on the project
- The presence of risk.

Determining time duration of activities from labor productivity rates

The quantity of work is commonly measured and compiled by quantity surveyor in a document called a 'bill of quantities'. When a bill of quantities for a particular project is available to the contractor, the contractor's planner can easily determine the volume of work for each activity in the project. One of the familiar formula for determining the duration of an activity used in most construction is :

$$Dij = \frac{Aij}{Pij * Nij}$$

Where:

Dij= duration of an activity ij

Aij= quantity of work

Pij= the average productivity of a standard crew in the task ij

Nij= the number of crews/person assigned to the task

The planner may vary the activity duration by either increasing or decreasing the labour crew size, provided this is possible or practicable.

Determining time duration of activities from daily output rates of resources

Duration of activities can also be calculated from the volume of work and the daily output rates of resources. The Output rates per day for plant/equipment and labour may be obtained from published cost data catalogues. The calculation process to determine activity duration in days is:

Activity duration in days = quantity of work/resource output rate per day

For example, assume that an excavator will be used to excavate $60m^3$ trenches. The output rate of the selected excavator is say 80 m^3 per day. It is also possible to calculate. The duration to excavate 60 m^3 trenches will be calculated as follows:

Activity duration = 60/80 = 0.75 day

Although it takes less than one day to excavate the trench, the planner will probably round the duration to the nearest day, in this case one day. More complex tasks performed by plant or equipment may require the allocation of additional labour to assist with and supervise such tasks.

Construction Project Scheduling

The scheduling of a construction project is often confused with Planning, which is an entirely different and separate function. Although the planning function may never be accomplished in a total manner, it can be accomplished in a broad and practical sense. Planning must be done before the project can be intelligently scheduled. Scheduling is a mechanical process for formalizing the planning function, assigning time boundaries for each part of the work in such a manner that the work proceeds in logical sequence and in an orderly and systematic manner.

Thus, a construction project scheduling is a projected time table of construction operations that will serve as the principal guide line for project evaluation.

Preparation of schedules:

Preparation of schedules involves the following three steps:

1. Determination of activities or job steps. Breaking the works into smaller units or activities.
2. Determining of the activity durations.
3. Determining the sequential relationships among the activities or preparing the Job Logic.
4. Establishment of a plan network i.e. developing a bar chart or network diagram.

Construction Activities:

Most projects are divided into construction activities to facilitate job planning. It is a portion of a project, which may be performed by a classification of laborers (CREW) or perhaps by a single type of equipment.

Construction/Job Activity: – is thus a segment of work in the construction project that has a recognizable beginning and end, implying that it requires time to accomplish the task.

Scheduling Techniques:

There are two common methods of scheduling used in the construction industry. This are:

A. Bar chart (Gantt chart) Scheduling method.

B. Network scheduling method: which include the Critical Path Method (CPM) and the Project Evaluation and Review Technique (PERT).

A. Bar Chart (Gantt chart) Method: -

The bar chart is probably the best known of all the planning techniques. It basically features a plan of a project split into a logically related individual activities each represented graphically by scaled lines. Bar charts present the project schedule plotted to a horizontal line scale. The bar lines represent the time period allocated to each operation and the relationship between the commencement and completion of each can be readily observed. The bar chart has been the traditional management device for planning and scheduling construction projects. Bar charts are particularly helpful for communicating the current state and schedule of activities on a project. As such, they have found wide acceptance as a project representation tool in the field. For planning purposes, bar charts are not as useful since they do not indicate the precedence relationships among activities. Thus, a planner must remember or record separately that a change in one activity's schedule may require changes to successor activities.

There have been various schemes for mechanically linking activity bars to represent precedence, but it is now easier to use computer based tools to represent such relationships.

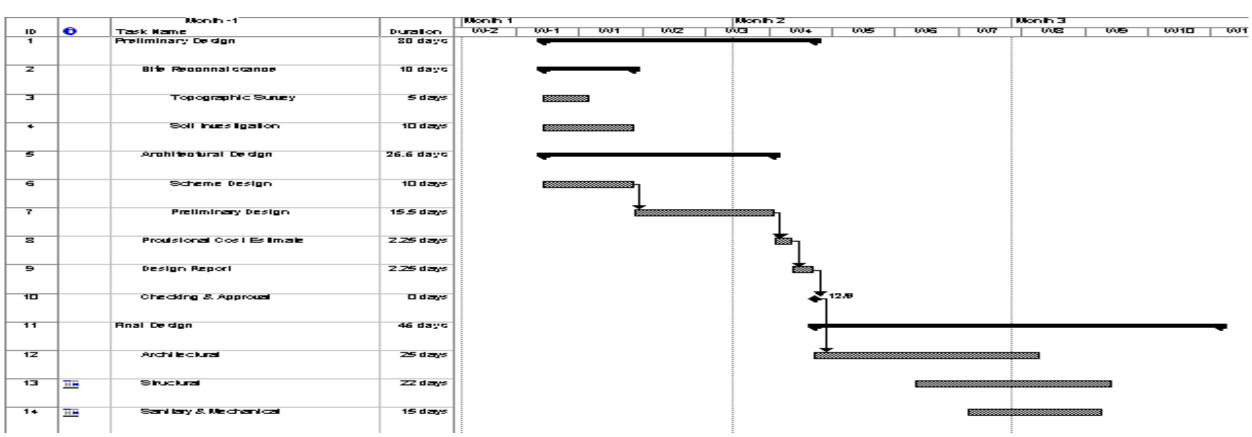
Advantages of Bar chart:

- Useful to report information to people who are concerned about a project but may not be involved in day-to- day management.
- A simple format and readily understood at all levels of management,
- It can provide a quick, visual overview of a project in convenient way to monitor job progresses, schedule equipment and crews and record project advancement.

Disadvantages:

- Interdependencies among activities are difficult to show. The bar chart itself doesn't provide a basis for ascertaining which activities are critical and which are floaters.
- It is not an adequate planning and scheduling tool because it doesn't portray a detailed, integrated and complete plan of operations.
- Can't tell what will be the effect of a delay today will have on the timing of future activities.

Example of schedule using bar chart:



B. NETWORK SCEHDULING: -

Network Scheduling: - is a method of scheduling activities by joining them in a series of interconnected links, which reflect relationships of activities by the planner.

Basic Assumptions:

1. The project can be broken down into a group of activities.
2. Each activities can be assigned a duration.
3. The logical relationship among activities are known and fixed in the network chains.

Rules for Preparing the Network Diagram:

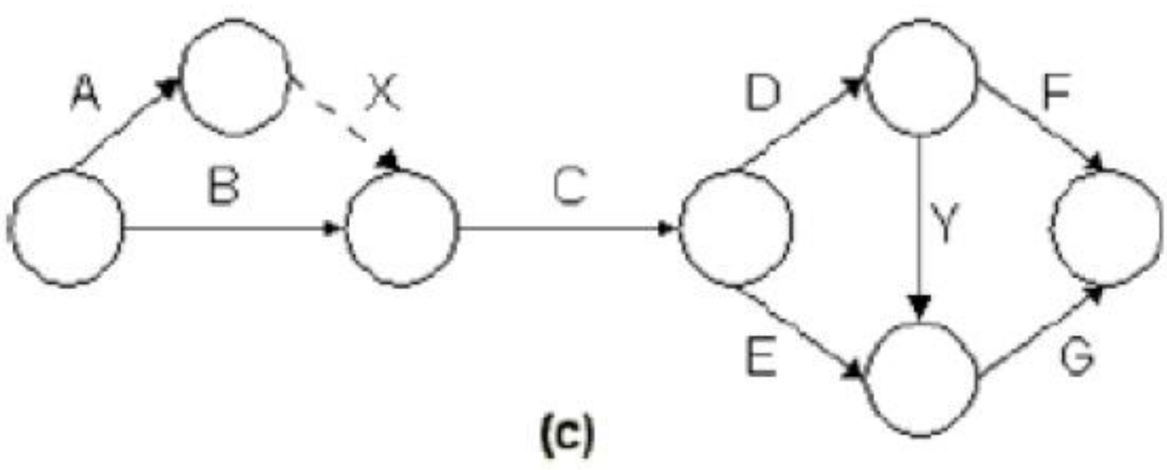
1. No activity can start before the preceding activity is finalized.
2. There is only one start and finish for an activity.
3. No activity leads back and forms a loop.
4. The logical precedence, concurrent and subsequent activities must be clearly developed.
5. A Dummy activity is established only to show relationship. A dummy activity is assumed to have duration of ZERO time units and it is introduced on the network when it is necessary.

Presentation of Networks: -

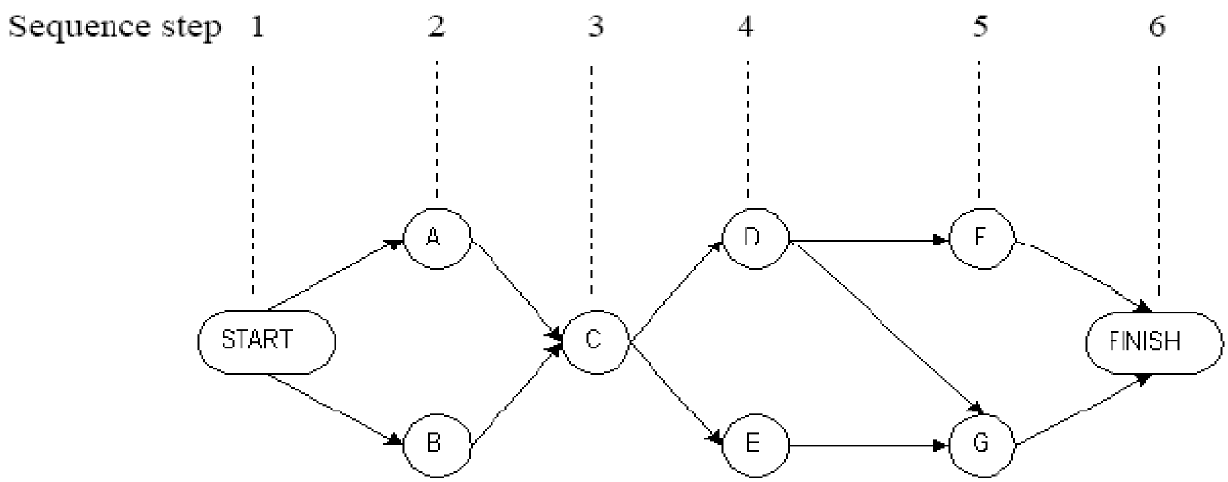
Showing the job activities and their order of sequence (logic) in pictorial form produces the project network. This network is a graphical display of the proposed plan.

There are two methods. These are: -

i. Arrow or Activity on Arrow Diagram



ii. Node or Activity on Node Diagram



Types of Network Schedules

The two common types of network schedules used in the construction industry are the Critical Path Method (CPM) and the Program Review and Evaluation Technique (PERT).

A, Critical Path Method (CPM)

The most widely used scheduling technique is the critical path method (CPM) for scheduling, often referred to as critical path scheduling. This method calculates the minimum completion time for a project along with the possible start and finish times for the project activities. Indeed, many texts and managers regard critical path scheduling as the only usable and practical scheduling procedure. Computer programs and algorithms for critical path scheduling are widely available and can efficiently handle projects with thousands of activities.

The critical path itself represents the set or sequence of predecessor/successor activities which will take the longest time to complete. The duration of the critical path is the sum of the activities' durations along the path. Thus, the critical path can be defined as the longest possible path through the "network" of project activities. The duration of the critical path represents the minimum time required to complete a project. Any delays along the critical path would imply that additional time would be required to complete the project. Formally, critical path scheduling assumes that a project has been divided into activities of fixed duration and well defined predecessor relationships. A predecessor relationship implies that one activity must come before another in the schedule. No resource constraints other than those implied by precedence relationships are recognized in the simplest form of critical path scheduling.

Calculation of Event Times:

Basically the two event times are the one that starts in the earliest possible time and the other on the latest possible time. The method used to calculate them is different from each as shown below:

A. Earliest Event Time (TE)

- Earliest event time is the earliest possible time, when all activities leading to the event will or are completed.
- It is written above the node or the activity line.
- At each node, the TE is found as TE of the preceding event plus the activity duration of the activity connecting the two events. This method of calculation is called Forward Pass.
- If there are more than one TE at a given node the maximum of earliest event time should be taken as the governing one.

B. Latest Event Time (TL)

- Latest event time is the latest possible occurrence of an event without delaying the project completion time.
- It is written below the node or the activity line.
- At each node, the TL is found as TL of the subsequent or succeeding event minus the activity duration of the activity connecting the two events. This method of calculation is called the Backward Pass.
- If there are more than one TL at a given node the minimum of latest event times should be taken as the governing one.

Important Definitions

A. Earliest Start Time (EST = TE)

This is the earliest time that an activity can start. It represents the earliest event time of the preceding activity.

B. Earliest Finish Time (EFT)

It is the earliest time, when an activity can be finished:

EFT = EST + Activity Duration

C. Latest Finish Time(LFT)

This is the latest time, when an activity may be completed without affecting the project completion time. It represents the late event tine of the succeeding event.

D. Latest Start Time (LST)

It is the latest possible time that an activity can start without affecting the project completion time.

LST = TL – Activity Duration

E. Total Float Time (TF)

Total float time is the amount of time that an activity can be delayed without affecting the total project completion time.

TF = LFT – EFT

F. Free Float Time (FFT)

Free float time is the time that an activity can be delayed without affecting the early start of the following activity.

TFF = T E,j - (T E,i + D i – j) , where T E,j - earliest event time of event j,

T E,i - earliest event time of event i,

D i – j - duartion of activity i – j.

The total float time that can't be exceeded as it will cause a delay in the project. Meanwhile the free float of an activity can be exceeded.

Example for the project indicated below,

A. Develop a clear logic network for the activities.

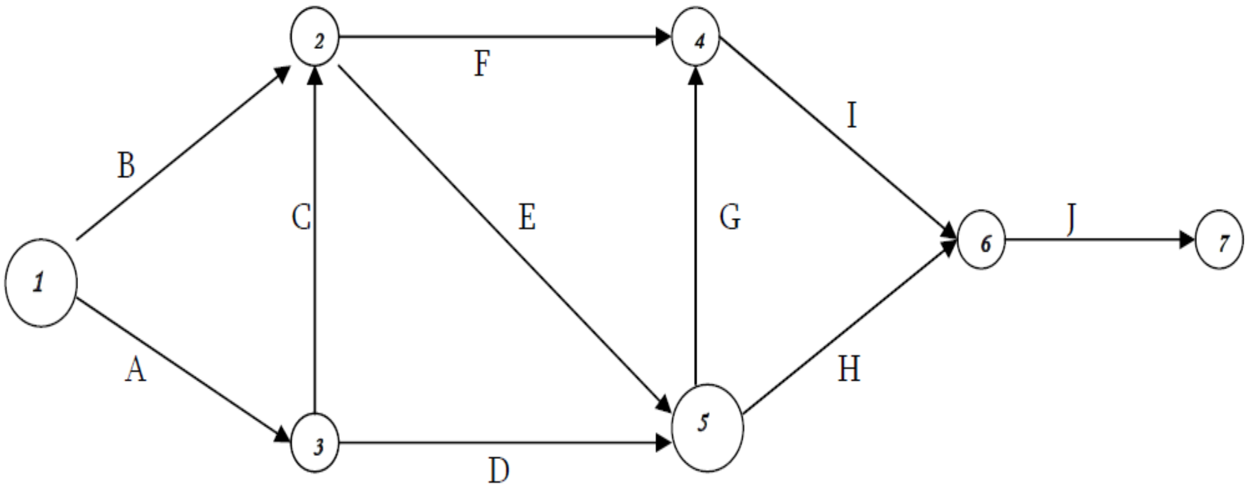
B. Show the critical path.

C. Using tabular format calculate the event, activity, total and free float times.

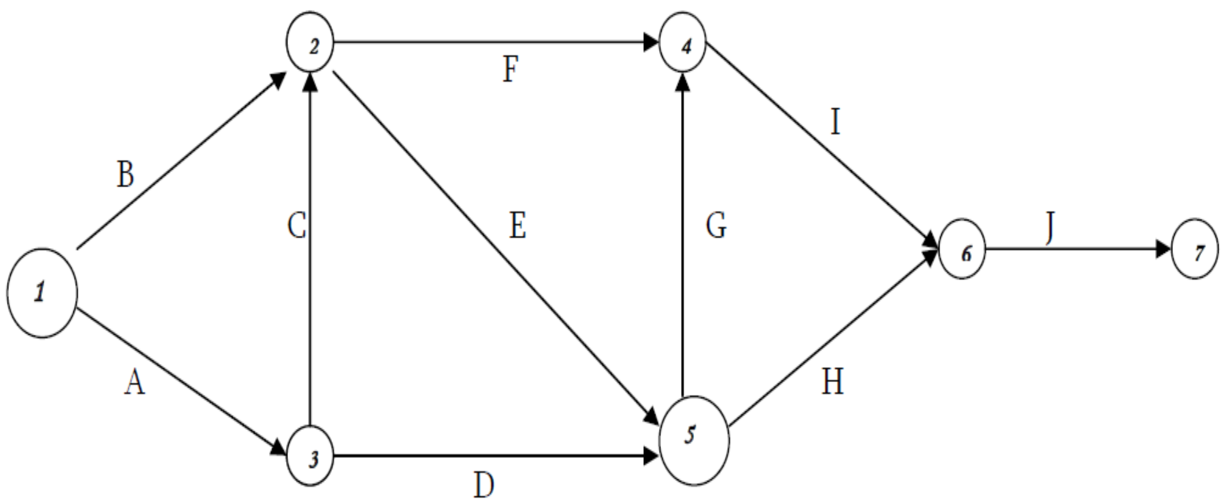
Activity	Duration, Days	Preceding Activity
A	3	. - - -
B	2	- - -
C	5	A
D	4	A
E	6	B, C
F	2	B, C
G	3	D, E
H	2	D, E
I	7	F, G

J	5	H, I

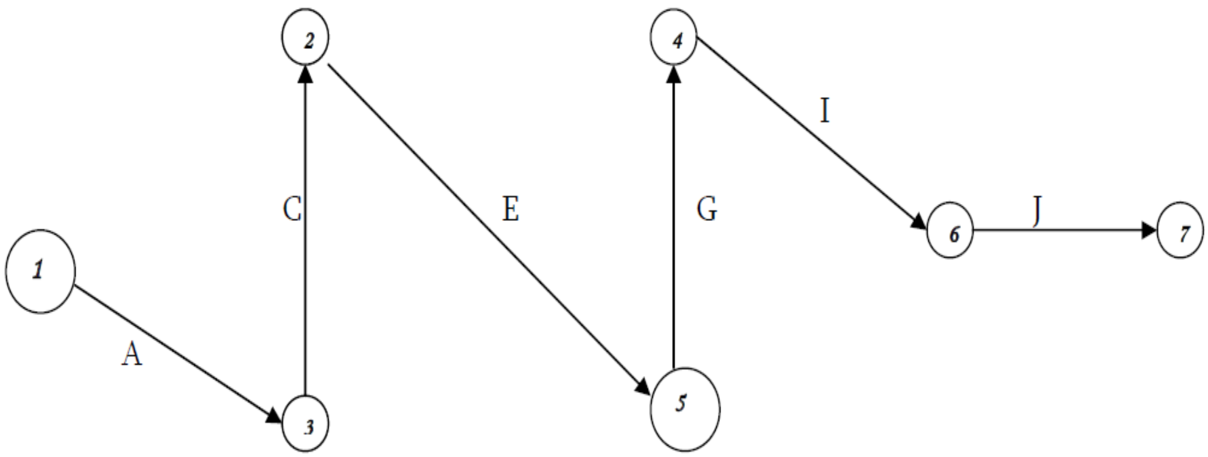
A. Network Logic:



B. Critical Path - Duration Calculation



Critical path



Activity	Duration	EST	EFT	LFT	LST	TF	FF
A	3	0	3	3	0	0	0
B	2	0	8	8	6	6	6
C	5	3	8	8	3	0	0
D	4	3	14	14	10	7	7
E	6	8	14	14	8	0	0
F	2	8	17	17	15	7	7
G	3	14	17	17	14	0	0
H	2	14	24	24	22	8	8
I	7	17	24	24	17	0	0
J	5	24	29	29	24	0	0

Program Review and Evaluation Technique (PERT)

The two commonly used network methods for project planning and scheduling are the program evaluation and review technique (PERT) and the critical path method (CPM). Both PERT and CPM are termed critical path methods because both use the critical path to complete expected project duration, early and late times, and slack. The two are frequently described under one term, PERT/CPM. Despite their similarities, PERT and CPM were developed independently in different problem environments and industries. PERT was developed for application in projects where there is uncertainty associated with the nature and duration of activities. It originated in the late 1950s during the U.S. Navy's Polaris Missile System Program. In complex research and development programs, there are questions about the kind of research to be done, how long it will take, what stages of development are necessary, and how fast they can be completed- largely because of the uncertainty about the exact nature of the final outcomes. Such projects are contracted as new developments unfold and before problems in technology, materials, and processes can be identified and resolved. Thus, the duration of the project is uncertain and there is considerable risk that the project will overrun the target completion time.

Three Time Estimates:

PERT addresses uncertainty in the duration by using three time estimates: Optimistic, most likely, and pessimistic. These estimates then are used to calculate the expected time for an activity. The range between the estimates provides a measure of variability, which permits statistical inferences to be made about the likelihood of project events happening at particular times. As seen in the figure, the optimistic time 'a' is the minimum time an activity could take- the situation where everything goes well; there will be little hope of finishing earlier.

The most likely time 'm' is the normal time to complete the activity. It is the time that would occur most frequently if the activity could be repeated. Finally, the pessimistic time 'b' is the maximum time an activity could take- the situation where bad luck is encountered at every step. The pessimistic time includes likely internal problems in development, but not force majors such as strikes, power shortages, and bankruptcy, fire or naturals disasters. The three estimates are obtained from the people most knowledgeable about difficulties likely to be encountered and about the potential variability in time- expert estimators or those who will actually perform or manage the activity.

The three estimates are related in the form of a Beta Probability distribution, Figure 4 with parameters ‘a’ and ‘b’ as the end points, and ‘m’ the modal, or most frequent value. The PERT originates chose the Beta distribution because it is not necessarily symmetrical- properties that seem desirable for a distribution of activity times.

Based on this distribution, the mean or expected time, te, and the variance, V, of each activity are computed with the three time estimates using the following formulas.

$$t_e = \frac{a + 4m + b}{6}$$

$$V = \left(\frac{b - a}{6}\right)^2$$

The expected time, te, represents the point in the normal distribution where there is 50-50 chance that the activity will be completed earlier or later than it.

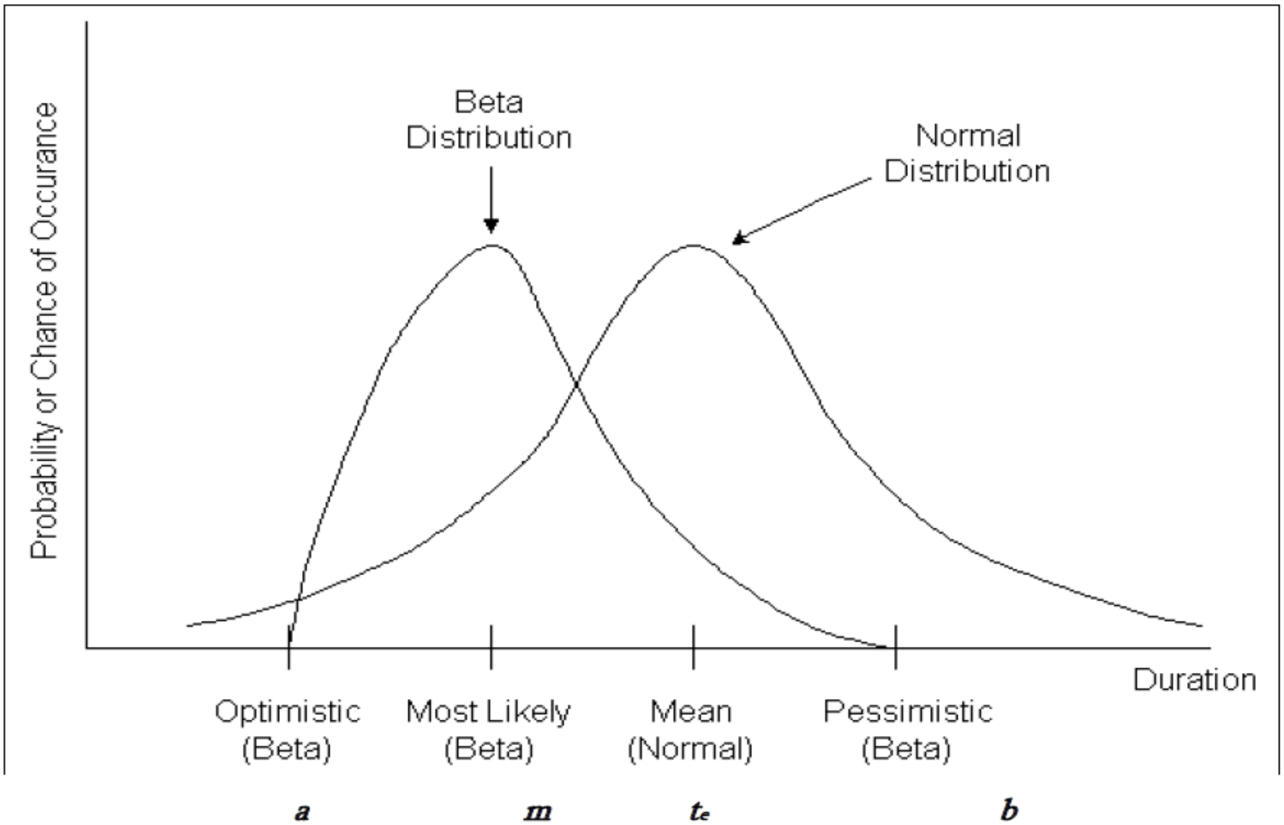


Figure 4: Beta and Normally Distributed Activity Durations

Probability of Finishing a Project by a Target Completion Date:

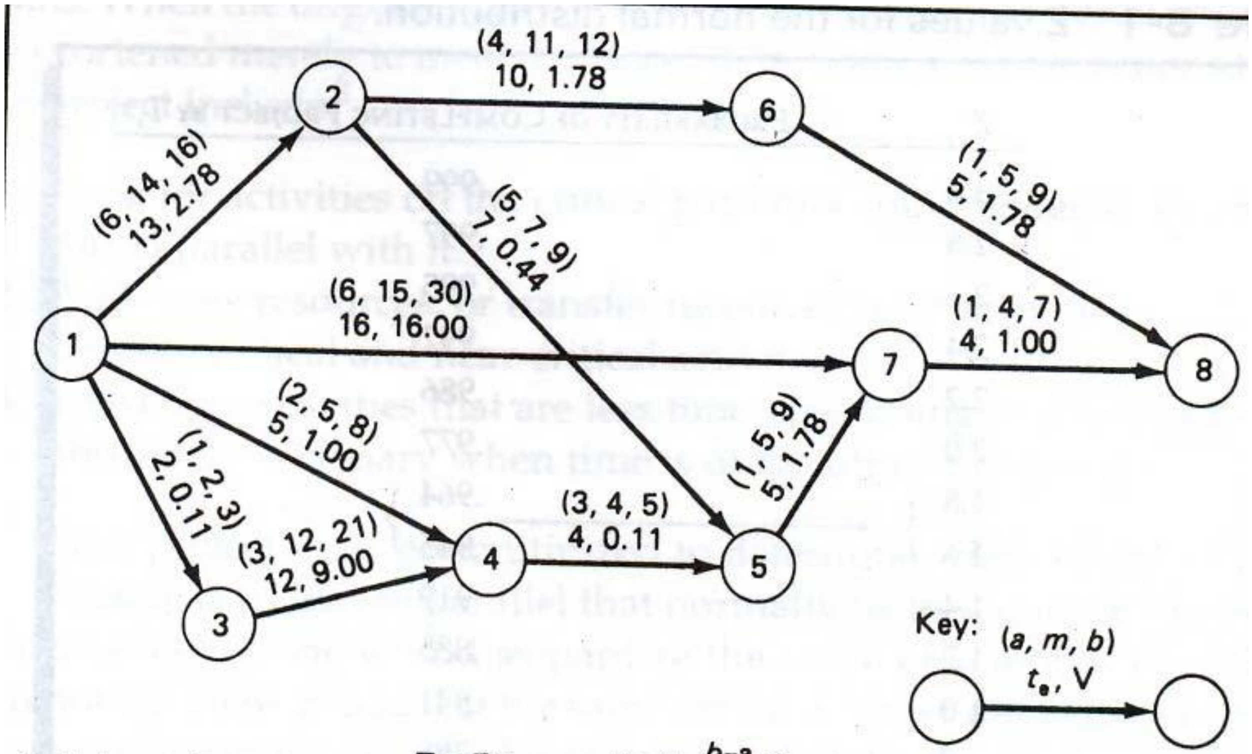
Statistically the expected time of a sequence of independent activities is the sum of their individual expected times. Hence the expected time of the project, Te, is the sum of the expected activity times along the critical path.

$$T_e = \sum_{CP} t_e$$

Where, te, are expected times of the activities along the critical path.

In PERT, the project duration is not considered a single point estimate contrary to CPM, but an estimate subject to uncertainty owing to the uncertainties of the activity times along the critical path. Because the project duration; Te, is computed as the sum of average activity times along the critical path, it follows that, Te, is an average time. Thus the project duration can be thought of as a probability distribution with an average of Te. So the probability of completing the project prior to Te is 50 percent, and the probability of completing it later than Te is 50 percent.

As an example, consider the following questions about the project shown in the network.



Path (events)	$T = \sum_{path} t_e$	$V = \sum_{path} \left(\frac{b-a}{6}\right)^2$
a) 1-2-6-8	28**	6.34
b) 1-7-8	20	17.00
c) 1-2-5-7-8	T_e = 29*	V_p = 6.00
d) 1-4-5-7-8	18	3.89
e) 1-3-4-5-7-8	27**	12.00

*Critical path
**"Near" critical paths

i) What is the probability of completing the project in 27 days?

ii) What is the latest (95% probable) likely date by which the project will be completed?

i) Given , Ts= 27 days

Te = 29 days; Vp = 6.0 ; Find F(Z)

According to the Z values of normal distribution,

$$Z = \frac{T_S - T_E}{\sqrt{V_P}}$$

; Z = -0.82

The probability of completing the project within 27 days is equal to the area under the normal curve to the left of Z =-0.82. Referring to the table, F(-Z) = 1- F(Z);

= 1- F (0.82)

= 1-0.7939

= 21%

ii) Given, F(Z) = 0.95, Te= 29 days, Vp= 6.0

Find, Ts

From the normal distribution table, the Z values for 95% probability is approximately 1.645

$$1.645 = \frac{T_s - 29}{\sqrt{6.0}}$$

Ts =33.03 days

In other words, it is highly likely (95% probability) that the project will be completed within 33 days.

Project appraisal

Finance is a specialized functional field of business administration. The term finance can be defined as the management of the flows of money through an organization, whether it to be a corporation or non-corporate business or government agency. Finance concerns itself with the actual flow of money as well as any claims against money. The flow of funds within a corporation is basically a continuous process, particularly if the corporation has been in business for a period of time. Fig 1-1 illustrates a typical cash flow diagram with the focal point being the reservoir of cash. One could see the following as inflow and outflow of cash.

- Cash is raised through equity, debt or through investment by other corporations,
- Cash inflow includes net credit sales, net cash sales and sales of assets,
- Cash is disbursed through purchase of materials, fixed assets, expenses as wages and salaries to workmen,
- Cash is repaid to stockholders in form of dividends, creditors in the form of loan repayment and also to other corporations stocks or bonds.

If total cash inflow exceeds all costs (including depreciations) for a given period, then there is a profit for that particular period, if not there is a loss.

Finance is also a concern to the other organizations involved in a project such as the general contractor and material suppliers.

Based on the conceptual plan, the cost estimate and the construction plan, the cash flow of costs and receipts for a project can be estimated. Normally, this cash flow will involve expenditures in early periods. Covering this negative cash balance in the most beneficial or cost effective fashion is the project finance problem.

Construction Works Financing Requirements

The procurement process for a construction project by a contractor for tendering, contracting, resource allocating, supervision and other costs entirely depends on the availability of finance. The major source of finance for the contractor’s construction project is advance payment and progress payments, but in addition sources from his own reserve or other important ready made sources of finance should be available in different forms.

Access to finance is one of the major constraints for the market entry and growth of construction companies tendering for projects in developing countries. There must be different alternative financial mechanisms for the contractor to choose for the procurement of these basic resources in facilitating construction projects, mainly for the three most significant and basic resources (i.e. material, equipment, and labor).

Construction works require the following major financial demands from the proposal of the project at the tender stage to the final completion of the project from the contractor's perspective.

- Financial demand for tender
- Financial demand for contracting
- Financial demand for inputs (Resources)
- Financial demand for supervision
- Financial demand for payment processing

Construction Economics and Finance is important because:

- It clearly indicates the financial health of an organization / a company based on one of its most important resource; Finance
- It enables to plan and monitor this most important resource through well developed, acknowledged and enforced for use financial accounting system; Financial Statement, Balance Sheet, Cash flow, Ledgers, Journals, Budgeting, Financial ratios, etc.
- It enables the determinations of costs, expenses and profits on the one hand; assets, liabilities and equities on the other hand which are the bases for formulating the financial accounting system.

Basic Economics Principles

Owners generally wish to:

- lower costs and completion times of their construction projects; and
- Increase the benefits such as quality, life time, profit or serviceability etc of their construction projects.

As a result they want their construction projects are optimally designed, constructed and operated in order to make their business objective viable.

Construction Economics is useful in order to ensure such demands of Owners.

As a result; the following decisions need to be made in order to fulfil such requirements:

- Deciding whether to accept a project or not;
- Choosing how to allocate risks and responsibilities to carry out the project (Delivery Methods and Contract Type);
- Selecting optimal design, construction and operation technologies: methods, materials, machineries, etc.
- Prioritizing projects to supply – demand principles and use scarce resources

Therefore the following basic economics principles are vital to support such decisions:

- Supply and Demand
- Interest, Profit and Cash flow
- Time Value of Money & Cash Flow Diagrams
- Treatments of Price Changes
- Setting the Study Period
- Selecting a discount rate
- Economies of Scale (External and Internal)
- Decision Support Methods, Processes & Tools

Major Functions of Construction Finance

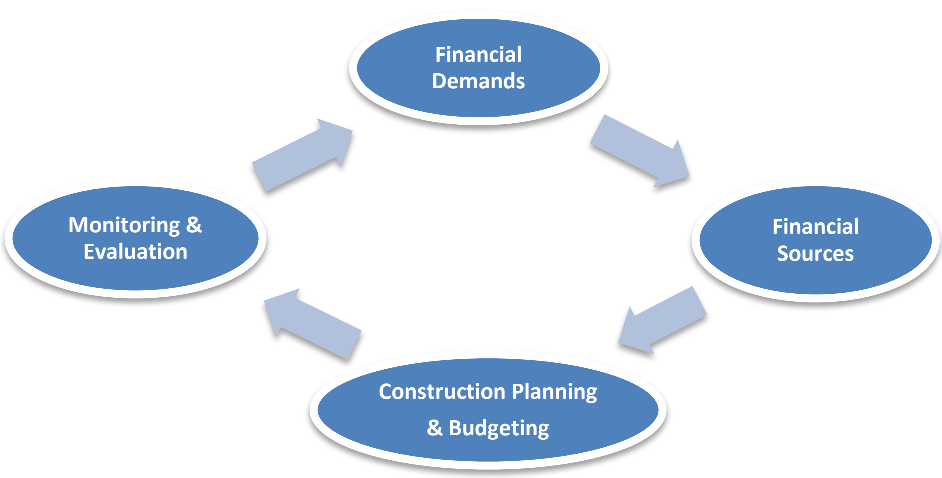


Figure Major Functions of Construction Finance

The Time Value of Money

Money has time value. If one is given the choice to receive 100 birr today or 100 birr next year. The individual will definitely choose 100 birr today. This is because money has value.

- Individuals in general prefer current consumption to future,
- To account for opportunity cost and inflation of money through time. Opportunity cost is a cost foregone by not using resources at their best possible option.

Financial investments involve cash flows occurring at different points in the time series. These cash flows have to be brought to the same point of time for purposes of comparison and aggregation.

Simple interest: no interest is earned on the interest. Interest is accounted only for the principal.

FV = PV (1+ nr)

Present and Future Value of a Single Amount

Compound Interest: refers to the case where interest payment is reinvested to earn further interest in future periods. The relationship is given by:

$FVn = PV (1+r)^n$

Where, FV: Future Value

PV: Present Value

n: number of years over which the cash flows occurs

r: Interest rate or discount rate.

Eg. If the firm is due to receive Birr 550,000 in 2 years at a time when money is worth 10 percent compounded annually. What is the present value?

PV = FV / (1+r)n ‘ r’ here designates a discount rate.

PV= Birr 454,545

Present Value of an Uneven Series

In financial analysis, one often comes across uneven cash flow streams. The present value of cash flow stream –uneven or even- may be calculated as follows:

$$\mathrm{PV} = \sum_{t=1}^{n} \frac{\mathrm{At}}{(1+\mathrm{r})\mathrm{n}}$$

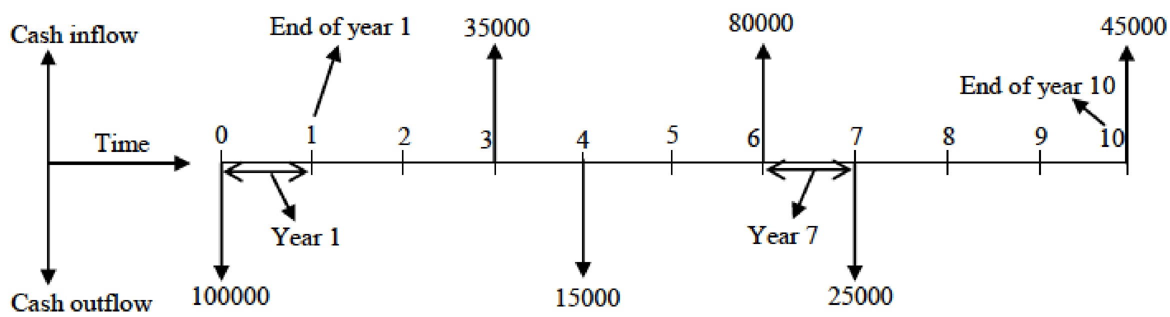
At = cash flow occurring at the end of year t

Cash flows

It is the stream of monetary values, costs and benefits - resulting from a project investment

Cash-Flow Diagrams – pictures showing:

1. A time interval divided into an appropriate number of equal periods
2. All cash outflows (withdrawals, expenditures, etc.) in each period
3. All cash inflows (deposits, income, etc.) for each period



Cash-Flow Diagram

Interest Factors

- ✓ Multiplicative numbers calculated from interest formulas for given interest rates and periods
- ✓ Used to convert cash flows occurring at different times to a common time

Compound Amount Factor

The mathematical expression $(1 + i)^n$ is referred to as the ***compound amount factor***, represented by the functional format (F/P, i, n). Thus, F = P(F/P, i, n).

Investment Appraisal

The decision making processes of determining the economic analysis and financial viability of capital investments under conditions of certainty. Financial viability analysis values investment proposals toward meeting the profitability and/or wealth maximization targets of firms or individuals. However economic analysis in addition, values social and economical costs and benefits of an investment proposal pursuant with local or national development plan. Often firms and governments have more investment opportunities than financial resources. Investment analysts should look to the available evaluation methods to distinguish among the competing proposals and develop a ranking procedure that will determine the method of allocation of capital funds.

A wide range of methodology has been suggested to judge the worthwhileness of investment projects. The important investment evaluations from simple to more complex methods are the following.

- ✓ Payback Period,
- ✓ Net Present Value (NPV)
- ✓ Internal Rate of Return (IRR)
- ✓ Cost-Benefit Analysis
- ✓ Cost-effective analysis
- ✓ Multi-Criteria analysis
- ✓ Linear Programming (e.g. Simplex Methods)
- ✓ Dynamic Programming (e.g. Combinatorial Problems).

Under this section, we deal only the top four evaluation techniques

The Payback Period

The payback period is the length of time required to recover the initial cash outlay on the project. According to the payback criterion, the shorter payback period, the more desirable the project would be. Firms using this criterion generally specify the maximum acceptable payback period. If this is 'n' years, projects with a payback period of 'n' years or less are deemed worthwhile and projects with a payback period exceeding 'n' years are considered unworthy.

e.g

Year	Cash Flow(Birr)	Discounting Factor(10%)	Present Value	Cumulative net cash
0	-10,000	1.000	-10,000	-10,000
1	3000	0.909	2,727	- 7,273
2	3000	0.826	2,478	-4,795
3	4000	0.751	3,004	-1,791
4	4000	0.683	2,732	941
5	5000	0.621	3,105	
6	2000	0.565	3,130	

Looking to the above simple example, the payback period is between 3 and 4 years

The Net Present Value (NPV)

The net present value of a project is the sum of the present values of all the cash flows both positive and negative that are expected to occur over the life of the project.

$$NPV=\sum_{t=1}^{n} B_t (1+r)^{-t}-\sum_{t=1}^{n} C_t (1+r)^{-t}$$

Where, B_t = the benefit or return at the end of year t

C_t = the cash outlay or investment at the end of year t

r = the required return

Series present worth factor: As with the other factors, there is a corresponding inverse to the capital recovery factor. The *series present worth* factor is found by solving the capital recovery equation for P.

$$P = A\frac{[(1+i)^N - 1]}{[i(1+i)^N]}$$

or, symbolically

$$P = A(P/A, i, N)$$

With the NPV method, the cash flows are discounted using the required return as discount rate. If the net present value is positive, the proposals' forecast return exceeds the required return and the proposal is acceptable. If the net present value is negative, the forecast return is less than the required return and hence the proposal is not acceptable.

To illustrate the net present value assessment of projects, consider the following cash flow streams.

Year	Benefit (Birr)	Cost (Birr)
0	--	-- 1,000,000
1	200,000	--
2	200,000	--
3	300,000	--
4	300,000	--
5	350,000	--

$$NPV=-\frac{1,000,000}{(1.1)^0}+\frac{350,000}{(1.1)^5}+\frac{300,000}{(1.1)^4}+\frac{300,000}{(1.1)^3}+\frac{200,000}{(1.1)^2}+\frac{200,000}{(1.1)^1}$$

NPV = Birr 5,273. The net present value is shown positive with firm's required return accounted 10% to compensate for time and risk.

Application:

For investments of large size with longer project life whose future conditions are certain or future potential risks associated with the project market and finance are predictable. It is useful for comparing mutually exclusive projects of equivalent size when potentially higher return or profitability is a concern.

The Internal Rate of Return (IRR)

The internal rate of return method calculates the actual rate of return provided by a specific stream of net cash benefits compared to a specific net cash outlay. It uses a trial-and-error approach to find the discount factor that equates the original investment to the net cash benefits. In other words, it is the internal discount rate which equates NPV with zero.

$$IRR= \sum_{t=1} B_t (1+r)^{-t} = \sum_{t=1} C_t (1+r)^{-t}$$

The idea is to find 'r' that equates benefits with cost outlay. Investment projects that yield higher internal rate of return as compared with the required rate return by the firm will be accepted and those that fail to meet this acceptance criterion would be rejected.

Year	Benefit (Birr)	Cost (Birr)
0	--	-- 1,000,000
1	30,000	--
2	30,000	--
3	40,000	--
4	45,000	--

Example for IRR:

Consider the following cash flow stream

$$1{,}000{,}000=\frac{30{,}000}{(1+r)^1}+\frac{30{,}000}{(1+r)^2}+\frac{40{,}000}{(1+r)^3}+\frac{45{,}000}{(1+r)^4}$$

The calculation 'r' involves a process of trial and error. Let's begin with r=15%:

The right hand side provides net present value of Birr 100,802. Since this is higher than the cost, we require higher discount rate to arrive at the value of 100,000. Try with 16% of discount rate. The value drops to Birr 98,641. We can conclude that the IRR is between 15 and 16%.

Application

Very similar application with NVP except that it is not effective for ranking of competing proposals. Managers and financial analysts prefer to think of return of projects in terms of IRR to required return. Because this can easily be related with the expected inflation, current borrowing interest rates, the opportunity cost and so on.

Further more in the absence of required return rate, it is still possible to determine the IRR and analyze the acceptance range of the project.

The Cost Benefit Ratio

This evaluation method related the benefits with its investment cost:

$$\mathrm{CBR} = \sum_{t=1}^{n} \mathrm{Bt}(1 + \mathrm{r}) - \mathrm{t} \div \sum_{t=1}^{n} \mathrm{Ct}(1 + \mathrm{r}) - \mathrm{t}$$

When CBR is greater than 1.0, the project accepted and if it is less than 1.0, the project is rejected. This criterion measures the benefit out of the project per unit of the cost outlay. It is can discriminate better between large and small investments. The cost benefit ratio may rank projects correctly in the order of decreasing efficient use of capital.

CHAPTER FOUR

Risk Management in Construction

Risk is "the probability of occurrence of some uncertain, unpredictable and even undesirable event(s) that would change the prospects for the profitability on a given investment. Risk in relation to construction is defined as a consideration in the process of a construction Project whose variation results in uncertainty in the final cost, duration and quality of the project. Risk attitude is a chosen response to uncertainty that matters, influenced by perception‘. Without taking proper account of the people aspects of managing risk, the risk process will be subject to unseen influences, leading to unreliable results and ineffective actions.

Risk in the Construction Industry

Construction works are hazardous by nature and accidents are frequent and often severe. The annual toll of deaths, bodily injuries and property damage in construction world is very high. Not only this but construction works involve large amount of investment especially in public projects. All of this increases the risk of construction business and makes handling of financial matters more critical.

Risk management is now widely accepted as a vital tool in the management of projects, although risk management become firmly institutionalized across the industry sectors, it is only comparatively recently that this has extended to include the construction industry.

When an accident happens it is difficult to find who should answer for it if there is no risk management system in place. By setting up a contract management system the company will be able to hold people responsible when an accident occurs since each department will be working closely with the contract management department. During the establishment phase of the contract, each department or party should work with the contract engineer on what their specific needs are, to make sure that there is not anything left out. This will make the implementation phase of the contract more efficient

There are different ways of risk management in construction industry among them Insurance and cost contingency.

Insurance

Insurance may be suggests that of protection from loss. It is a kind of risk management, primarily used to hedge against the risk of a contingent or uncertain loss. Insurance is a financial device for transferring or shifting risk from an individual or entity to a large group with the same risk.

An insurance contract may be accept that one party (the insurer) accepts vital insurance risk from another party (the client) by agreeing to compensate the policyholder if a nominal uncertain future event (the insured event) adversely affects the policy holder.

Benefits of Insurance

Business Risk

The success of any business is based on mitigation and controlling risk it encounters. For example, airlines carry an enormous amount of risk when they fly planes full of passengers each day. The plane itself is very expensive, the passengers can face injury and death in case of a crash, and the baggage could get lost or damaged in the normal course of operations.

Safety by Awareness

Insurance is not just about paying losses that occur but also preventing losses in the first place from occurring. Insurers are better educated and aware of the causes of various losses and they can offer professional assistance for avoiding the most common causes of losses.

Economic Stimulation

The premium is received regularly in installments. Large funds are collected by way of premium. It helps in collecting saving from a large number of persons. The funds can be gainfully employed in industrial development of a country.

Providing Security

Insurance helps in decreasing the likelihood of financial hardship in case of a disaster or loss. Life as well as businesses today faces lot of uncertainties. There is always a fear of sudden loss. There may be a fire in factory, storm in the sea or loss of life. In all these cases it becomes difficult to bear the loss. Insurance provides a cover against any sudden loss.

Health and Wellness

Given the increasing incidence of lifestyle diseases and escalating medical costs, Insurance provides the benefits of protection against critical diseases and hospitalization expenses. From a business standpoint, providing health insurance to employees is a valuable tool to attract and retain the best employees.

Parties to construction projects, i.e. consultants, contractors, sub-contractors and suppliers, are all, in their own right, exposed to various risks. No matter how small or simple the project, it can still go wrong and as soon as the contract is signed, the contractual parties inherit risk. The guideline further discusses that risk awareness is of paramount importance to all parties to ensure that any possible risk occurrence may be reduced.

Types of Construction Insurance

Contractor’s All Risk Policy (CAR)

This policy is specially designed to give financial protection to the Civil Engineering Contractors in the event of an accident to the civil engineering works under construction.

Professional Indemnity Policy

This policy is meant for professionals to cover liability falling on them as a result of errors and omissions committed by them whilst rendering professional service. Professional indemnity insurance (PII) covers professionals, such as architects, engineers and other consultants, and claims against them arising out of the professional services they provide.

Typically the cover includes, and claims may arise from the services involved where they include: A breach of professional duty; Negligence; Bodily injury and property damage arising from service negligence; Fraud/dishonesty other than a company director‘s dishonesty; Infringement of intellectual property; Breach of duty/confidentiality; Defamation; and Loss of documents.

Contractor Plant and Machinery insurance Policy

Construction equipment and machinery used on the project is subject to damage and can be protected by what is known as an equipment floater policy. This policy covers equipment that moves from job to job (the equipment "floats"). The equipment covered, often referred to as off-road vehicles dozers, scrapers, power shovels, loaders, cranes, pumps, and pavers. The major losses that typically occur are due to theft and vandalism. No liability component is attached as the policy only covers damage to the equipment.

Contractors' plant insurance recognizes the dependency of the construction industry on a wide range of plant and machinery; from tower cranes and large mobile cranes, to excavators, generators and hand tools. Due to the nature and use of these types of plant, they are susceptible to risks such as damage on site, damage in transit, fire and theft. During a construction project, plant and machinery can be more susceptible to losses during transit and movement. Theft, fire, and damage caused during the loading, unloading and re-sitting process are all common risks and can cause significant interruption to a project if they occur.

Automobile Insurance

There are two broad categories of risk involved when a contractor operates automobiles. First, there is loss or damage to the contractor's own vehicles caused by collision, fire, theft, vandalism, or other hazards. Second, there is liability for bodily injury to third parties or damage to their property caused in some way by the operation of the contractor's licensed vehicles. Automobile liability coverage will cover any vehicle fitting into one of three categories--owned automobiles, hired or rented automobiles, and non-owned automobiles such as employees' personal automobiles used in conjunction with official business.

Worker's compensation policy

The fundamental objective is for injured workers to receive prompt medical attention and monetary assistance. Another principle behind worker's compensation is that of strict liability of the employer, regardless of any fault by the employee. Contributory negligence of the employee will not affect the employer's liability, except in cases where the worker was under the influence of drugs or alcohol.

Bid Bonds

Bid bonds assure the owner that if the contract is awarded to the successful bidder, that bidder will enter into contract with the owner. Bid bonds, certified checks, and sometimes negotiable securities may be accepted as bid security. The amount of bid security a public body may require in Ethiopia shall be in the range of 0.5% to 2% of the total estimated contract price.

Advance payment guarantees:

If the client agrees to make an advance payment (sometimes referred to as a down payment) to a supplier, a bond may be required to secure the payment against default by the contractor.

Performance and Payment Bonds/ Contractual Security

After award of the contract, the contractor is required to provide performance and payment (labor and materials) bonds on all public works contracts as a guarantee against potential lien claims and failure to complete the work. Under a performance bond, the surety has an obligation to the owner for any additional costs to complete the contract due to the contractor's failure to comply with its contract requirements.

Pleas referee other types of construction insurance.

Cost contingency

Cost contingency is included within a budget estimate so that the budget represents the total financial commitment for the project sponsor. The estimation of cost contingency and its ultimate adequacy is of critical importance to projects, hence the need to evaluate the effectiveness of contingency sum as a construction risk management tool and also determine how it can be improved. Contingency has been defined as the amount of money needed above the estimate to reduce the risk over runs of project objectives to a level acceptable to the organization

One of the simplest methods of estimating contingency margins for construction project is to consider a percentage of the estimated contract value such as 10% across the entire project commissioned by the owner which is derived from intuition, past experience and historical data.

The allocation of small amount of contingency for projects may result in significant losses. On the other hand, high amount of contingency may decrease the chances of winning the contract.

Construction safety

Construction is one of the most dangerous occupations in the world, incurring more occupational fatalities than any other sector in both the United States and in the European Union. In 2009, the fatal occupational injury rate among construction workers in the United States was nearly three times that for all workers. Falls are one of the most common causes of fatal and non-fatal injuries among construction workers. Proper safety equipment such as harnesses and guardrails and procedures such as securing ladders and inspecting scaffolding can curtail the risk of occupational injuries in the construction industry. Health and safety legislation in the construction industry involves many rules and regulations. For example, the role of the Construction Design Management (CDM) Coordinator as a requirement has been aimed at improving health and safety on-site.

Construction safety: is the process of seeking to improve or maintain a safe work environment while people are doing their job/duty.

Basic definitions

- **Health** - the protection of the bodies and minds of people from illness resulting from the materials, processes or procedures used in the workplace.
- **Safety** - the protection of people from physical injury. The borderline between health and safety is ill-defined and the two words are normally used together to indicate concern for the physical and mental well-being of the individual at the place of work.
- **Welfare** - the provision of facilities to maintain the health and well-being of individuals at the workplace. Welfare facilities include washing and sanitation arrangements, the provision of drinking water, heating, lighting, accommodation for clothing, seating (when required by the work activity), eating and rest rooms. First aid arrangements are also considered as welfare facilities.
- **Occupational or work-related ill-health** - is concerned with those illnesses or physical and mental disorders thatare either caused or triggered by workplace activities. Such

conditions may be induced by the particular work activity of the individual or by activities of others in the workplace.

- **Environmental protection** - arrangements to cover those activities in the workplace which affect the environment (in the form of flora, fauna, water, air and soil) and, possibly, the health and safety of employees and others. Such activities include waste and effluent disposal and atmospheric pollution.
- **Accident** - defined by the Health and Safety Executive as ‘any unplanned event that results in injury or ill health of people, or damage or loss to property, plant, materials or the environment or a loss of a business opportunity’.
- **Near miss** - is any incident that could have resulted in an accident. Knowledge of near misses is very important since research has shown that, approximately, for every ten ‘near miss’ events at a particular location in the workplace, a minor accident will occur.
- **Dangerous occurrence** - is a ‘near miss’ which could have led to serious injury or loss of life. Dangerous occurrences are defined in the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (often known as RIDDOR) and are always reportable to the Enforcement Authorities. Examples include the collapse of a scaffold or a crane or the failure of any passenger carrying equipment.
- **Hazard and risk** - a hazard is the *potential* of a substance, activity or process to cause harm. Hazards take many forms including, for example, chemicals, electricity and working from a ladder. A hazard can be ranked relative to other hazards or to a possible level of danger.

A risk is the likelihood of a substance, activity or process to cause harm. A risk can be reduced and the hazard controlled by good management.

It is very important to distinguish between a hazard and a risk - the two terms are often confused and activities such as construction work are called high risk when they are high hazard. Although the hazard will continue to be high, the risks will be reduced as controls are implemented. The level of risk remaining when controls have been adopted is known as the residual risk. There should only be high residual risk where there is poor health and safety management and inadequate control measures.

Benefits of Good Occupational Safety and Health

- Reduced lost time
- Reduced need to provide cover for personnel absent from work because of injury
- Reduce sick pay payments
- Reduce need for time-consuming accident investigation and consequent saving in management time and production down-time
- Reduced potential for prosecution and other enforcement action by authorities
- Reduction in the number of claims for compensation by injured personnel
- Reduced employer's liability insurance premiums
- Improved morals
- Improved image of company, both in terms of employer and competent contractor

Some of the major causes of accidents in construction sites

A. ***Falls***: falls from elevation are from roof and scaffolds
B. ***Struck by:*** caused by heavy construction equipment such as trucks, graders, scraper and improperly stored construction materials.
C. ***Caught in between***: such as the collapse of excavation or trenches, Caught between a moving piece of equipment and another surface
D. ***Electrocution***: involves contact with live electrical parts. In the study, the contact most frequently was with high voltage lines, usually contacted by a piece of construction equipment such a crane or an aerial lift

Hazard

Hazard is the *potential* of a substance, activity or process to cause harm. Hazards take many forms including, for example, chemicals, electricity and working from a ladder. A hazard can be ranked relative to other hazards or to a possible level of danger. There are different hazards in construction sites among them:

Physical Health Hazard such as;

- Noise
- Vibration
- Working Environment

- Ionizing Radiation
- Air pressure variation
- Ergonomics

Chemical Health Hazard such as;

- Solids
- Liquids
- Vapors, Aerosols &Gases

Biological Health Hazard such as;

- Bacteria, Fungi
- Parasites

Hazard control measures

Proactive measures:- Action to be taken in advance precautionary measures and its implementation

Safety training

- Inspection and checklist
- Personal protective equipments (PPE)
- Reactive measures- Action to be taken after accident occurs
- Medical aid
- Accident reporting and analysis

Proactive measures: safety training & program

- Training aims at preventing and minimizing the accident
- Education to the workers is provide
- Safety measures committee is formulated

- Charts, posters and show films on the need to follow safety measures should be displayed
- The careless workers should be discontinued after sufficient warnings
- First –Aid training to at least one worker in a team
- Proper medical checkups of the workers before employment and also periodically

Personal protective equipment

Personal protective Equipments (PPE) plays a vital role in safety. Depending on the activates involved, PPE is chosen. E.g. as far as masks are concerned there are different types of masks are available but the right choice depends on the activity for which it is to be selected.

HEAD PROTECTION

Falling objects, overhead load and sharp projections are to be found every where on construction sites. Safety helmets protect the head effectively against most of the hazards.

Everybody should wear a helmet whenever on sit and particularly working in an area where overhead work is going on (hard-hat area). This area should be clearly marked with safety signs.

Figure 4.1 Head protection

HEARING PROTECTION

The noise level in some areas on construction sites are often above the level which causes sensory hearing less to workers in the vicinity.

The common form of protection in industry is ear defender consisting of a head band and cup.

There are several types of head bands depending upon helmet attachment.

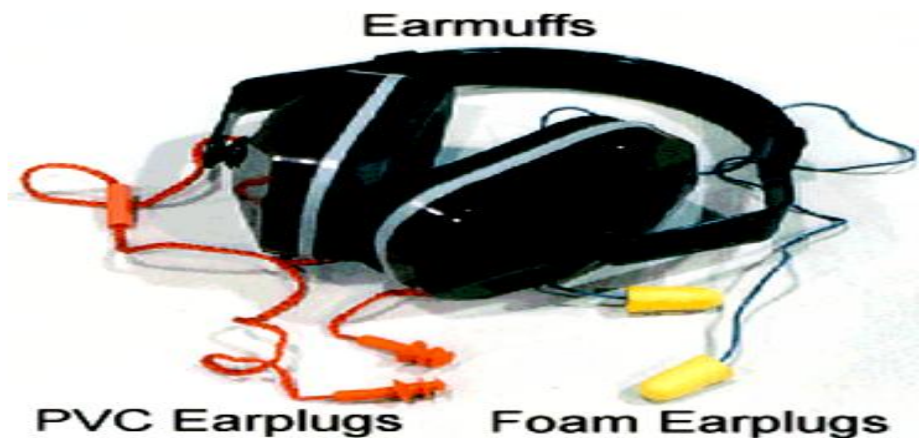


Figure 4.2 ear protection

EYE PROTECTION

The chances of eye accidents are there in jobs like breaking, cutting, drilling, chipping, dry grinding, welding etc.While working on these jobs, goggles, safety glasses or shields are the only practical solutions

Wearing of eyewear is readily accepted, as danger from flying particles and dust are obvious to most construction workers.

Figure 4.3 eye protection

RESPIRATORY PROTECTION

On construction sites such as rock crushing, sand blasting, asbestos insulation/dismanteling, welding/cutting paint spraying, blasting etc. harmful dust, must or gas may be present

Whenever there is a presence of toxic substances, respirator must be worn. The correct type will depend upon the hazards and the work conditions

Figure 4.4 Respiratory protection

BODY PROTECTION

Skin is extremely vulnerable to all types of hazards in work like painting, welding , sewer works, demolition works, etc. leading to different types of skin diseases.

Full sleeved shirts and trousers provide good protection against many of the hazards. In cause of ionizing radiation use of shielding layers inside the cloths is necessary.

HAND &FOOT PROTECTION

Hands are most important as most of the work is done by hands. They are susceptible to wounds, abrasion, fractures, strains and also are subjected to environmental variations

Protective gloves solve the purpose of preventing any hazards to hands

Foot injuries can be

- Due to crushing
- Due to penetration

Safety footwear are types like:

- Leather shoes-climbing jobs
- Normal shoes-heavy duty work
- Rubber safety wellington shoes- corrosive substances,
- chemicals and water(with steel toes)

SAFETY BELTS&HARNESS

Major accidents in construction are due to falls from height where the provision of safe working platforms are impracticable

- ✓ Wearing of a safety belt or harness and line or lanyard attached to a reliable strong point above the working position will serve the purpose of safety
- ✓ Full harness is preferable to a safety belt
- ✓ Sometimes safety harness is supplemented by use of safety nets
- ✓ A safety harness and lanyard must
- ✓ limit the fall to a drop not more than 2 m
- ✓ Be strong enough to support the weight
- ✓ Be attached to strong structure thought firm anchorage
- ✓ In case where rescue operations may arise (underground sewer work) chest or body harnesses is compulsory for the workers

Figure 4.5 safety belt