Construction Management

Chapter 1 (Lecture 1)

* Construction Management Framework:

Construction is a process of building or assembling any infrastructure. It differs from manufacturing. In manufacturing, there involves mass production of similar items without a designated purchaser, while construction takes place on a specified location for a specified client.

Construction activity has been in existence since ancient time of human civilization. It has created many wonders in the world and has provided many facilities for the benefit of the mankind.

Construction projects contain numerous interdependent and inter-related activities. The fast changing environment of the present era imposes numerous time, cost, finance, legal, ethical, environmental and logistic constraints, and include difficulties, uncertainties and risks. Though the concept of project construction is not new, project construction management is young and emerging discipline in construction industry.

The construction project is related with the construction of any infrastructure within budget, time and ~~require~~ required quality. Essential planning, proper design and well planned execution is required for the construction of any infrastructure. There are various types of construction like building construction, road construction, industrial construction, hydropower, irrigation infrastructure, communication infrastructure etc.

Components of Construction Management:

It is multifeceted (having many different aspects or features) task composed with different components as follows:

- physical space / land for construction
- Materials - for construction
- Machines, equipments and tools
- Human resources
- Technology
- Budget / Finance etc.

Advantages of construction project:

- Infrastructure development
- a means of uplifting National economy
- Establishment of technology and technology transfer.
- Basis for development
- Poverty reduction
- Rural - Urban linkage
- Integrated development
- Employment generation.
- Financial mobilization
- Increment in market
- Easy & safe transportion.
- Life-style upgradation.

etc.

Dis-advantages of Construction Project:

- Huge capital investment
- Environmental degradation
- International competition etc.

Necessity / Advantages of Construction Management:

- Efficient planning & Execution of construction activities.
- optimum use of human & material resources.
- Control unnecessary construction cost.
- Improves the quality of works.
- Proper co-ordination between all stakeholders.
- Complete the activities in shortest possible time. or minimise ~~the~~ delays.
- Save money without sacrificing quality.

etc.

Differences between construction project management and traditional management:

Construction project management differs from management of ongoing process on regular basis ~~in~~ in industry or traditional ~~mng~~ management. Though the basic management principles like planning, ~~for~~ forecasting, organizing, staffing, directing, motivating, monitoring, communicating, controlling and decision making are equally applicable in construction project management also but the risks, uncertainties and complexities make construction project management more difficult process. Some of the features which ~~m~~ makes construction project management differs from

The rest of the other management are summarized as follows:

→ Construction projects are unique and transient (short duration) in nature. Its organization is temporary.

→ Every construction projects are time bound with fixed life span and tasks. These task may create never-ending problems, especially when project are crashed, under relatively risk-prone, complex situations and resource constraints.

→ Project time and cost are correlated. Time delays can increase cost exponentially instead of linearly as in case of enterprises or industries.

→ project tasks leave no time for the training or learning process. It is handled and managed by multidisciplinary experts headed by a single responsible center, project manager.

→ Projects are flexible and runs with operational autonomy to manage the complexities due to risks and adaptation to environmental change.

→ projects being handled by a company; generally interact with each other socially, organizationally, technically and economically.

→ Project integration is relatively complex under dynamic project environments.

→ Construction projects are executed with the support of contracting agencies, whereas ongoing industrial processes are managed by the departmental staff and workers.

→ Construction projects are change oriented and self-managed.

with the accelerated change in the environment, management of multi-discipline, multi-dimensional, multi-location, multinational tasks need project management philosophy different from the ongoing traditional, functional, organizational structures of the ongoing industrial establishments.

1.1.) Construction Landmarks:

World Famous Construction:

Ever since the dawn (first appearance or beginning) of civilisation, man has been involved in some forms of construction activities. Even in ancient times, man created architectural marvels, which came to be regarded as the wonders of the world. These include the Pyramid of Egypt, the great wall of China, the Angkor temples of Cambodia, the tower of Babel, Taj Mahal in India, Hanging gardens-

[* The pyramid of Giza in Egypt contains more than 20 lakhs blocks, with an average weight of about 2.3 tons each. About 1 lakh persons worked on the pyramids for 3-4 months a year to build it in about 20 years.

* The great wall of China, built to provide protection against surprise enemy raids, is about 6400 km long and its height and width at top varies from 5 to 10 metres. It has 20 m high towers placed every few hundreds metres.]

in Babylon in Iraq, Leaning tower of Pisa in Italy etc. A most recent examples of man's achievement in this direction is the Burj Khalifa, one of the world's tallest buildings, which is in Dubai, UAE. The world famous landmarks, constructed in recent past are as below:

Table : World's famous Construction Landmarks

Facility	Name	Location	Features	Completed year
World's Tallest Building	Burj Khalifa	UAE	828 m tall	2010
World's Largest Building by Floor Area.	New Century Global Building	Chengdue, China	17,00,000 Sq.m.	2013
World longest Bridge (Two Bridge)	Lake Pontchartrain Causday	USA	38.4 Km	1969
World's longest (Suspension) bridge	Akashi-Kaikyo	Kobe-Naruto, Japan	1991 m	1998
World's longest (Cable-stayed) Bridge	Russky Bridge	Russia	1104 m (longest span)	2012
World's Largest Dam (embankment volume)	Tarbela	Pakistan	148.5 million cu.m.	1943
World's Largest Capacity Reservoir	Nalubaale	Uganda	20.5 billion cu.m.	1954
World's longest water tunnel	Delaware Aqueduct	New York, USA	135 Km	1944
World's longest Railway tunnel - Land	Seikan	Japan	33.5 miles	1985
World's longest Railway channel tunnel (under sea.)	Channel Tunnel	Britain-France	31.04 miles	1994
World's longest vertical tunnel	Laerdal	Norway	24.5 Km	2000

Construction Landmarks of Nepal:

In various timeline, Nepal passes through various kinds of regime. ~~on~~ on every regime, some of amazing construction landmarks were seen which is still existing. Basically infrastructure related to religious and cultures are the ornaments of Neplese historical construction landmarks. Durbar square area of Kathmandu valley, Singh durbar, 55-windows Durbar (Pachpanna-jhyale durbar), Patan Krisna Mandir, Janaki Mandir are some of the ancient and historic monuments. Munkamna cable car, Kulekhani reservoir, Bagmati Irrigation project, Gubeshwori waste water Treatment plant, Upper Tamakoshi hydropower project, Terai-Madhesh fast-track, ~~are~~ Bheri-Babai Diversion project etc. are the construction landmarks of recent & past years in Nepal.

History of construction effort in Nepal

→ First attempt, in 1769 A.D
  ↳ "Bahausa Adda" (Construction Bureau)

→ During Rana Regime (1846-1951) A.D.
  ↳ extended its departments to various parts of the country.

→ maintained royal palace, government buildings and undertook new buildings.

→ In this period, there way

"Public works Madhes-Pahad Report Niksari Adda" (PWMPRNA)
→ office situated at Bhadrakali
→ looked construction works outside valley.

Likewise, construction work inside valley way controlled by "Sadar public Niksari Adda" (or, central Public works

→ In 1934 A.D., a new department "Jana seva Bibhag" or Public service Department was set up to perform the civic works, task of municipalities: water supply, sewerage, street roads, lighting etc. in municipal towns.

→ The first engineering structure built in Nepal was an iron bridge over Bagmati river in 1850 A.D.

→ The first public water supply system was laid in Kathmandu valley during 1888 – 1895 A.D.

→ The royal palace, to clock tower and the suspension bridge on the river in Kathmandu were built during these years.

→ The first hydro-electric project at Pharping was completed in 1911.

→ The Raxaul-Amlekhganj Railway line by M/s Martin and Co. Ltd. of Calcutta and Dhusigha-Matatirtha Ropeway by M/s Keynor Son and Co. of London, were constructed in 1926-27.

→ The Rana regime lasted till 1951 when it was replaced by a democratic government. In the same time, the ministry of Transport was formed and it was responsible for construction works.

→ The new age of Nepese construction industry started only after 1951. The first five years Development plan was started in 1956. After that, construction activities in the country boost up automatically.

→ The Industrial Resolution, 1957 A.D. adopted by the government of Nepal declared construction as the 'priority sector' industry. As the priority sector construction firms enjoy income tax, holiday along with

other tax concessions for seven years from the date of incorporation, a more liberal depreciation rate, capitalization of pre-investment expenditure, provision of ~~foreign~~ foreign exchange faulities etc.

→ The first act which defined 'Contractor' was the Industrial Enterprises Act, 1974. It made provision for the classification and registration of Contractors. According to this act, all construction firms must register themselves with Ministry of works and Transport in class A, B or C, depending upon the technical manpower, value and number of works done, machinery and liquid assets available.

→ ~~After~~ Some construction projects like 'Siddharth Highway", "Trishuli hydropower" and "East-West Highway" etc. were started in Nepal which were tackled by Nepalese Contractors for the first time. After the completion of these projects, Nepalese Contractors began to appear all over the country and started to take part in the development work. They developed their capital, managerial skill and equipment simultaneously.

→ Till then Construction act had not come into existence, so Nepalese Construction industry could not develop so much as it should have seen in the period of Panchayat system.

→ After the restoration of of parliamentary democracy in 1989 A.D, Nepalese Contractors got some favourable condition to develop their capacity and got opportunities to take part in several Construction projects.

→ Nepalese Contractors then came in position to do all kinds of national Construction works as roads, buildings, dams etc. except mega projects.

→ At present all together more than 325 class A, 374 class B, 1347 class C and 15,000 class D contractors in Nepal.

Role of Construction Industry in National Economy:

→ In Nepal, about 10 percent of the GDP is contributed by the construction sector and is one of the largest employers.

→ It is estimated that this sector is creating employment opportunities to more than one million people in the country.

→ Nepalese contractors are now saving a huge amount of foreign currency from its flight to abroad by foreign contractors. So, it is contributing as export industries to the national economy.

→ In developing countries about 60% of the national budget is allocated on development works and significant portion of the development budget is allocated to construction sector in Nepal.

Construction Management
Chapter #1 (lecture #2)

1.2) Scope of Construction Management:

Physical infrastructure development is the ~~major~~ foundation that led to prosperous and developed nations. Investments on large scale infrastures are critical to enable a country to achieve long term ~~goal~~ growth and sustainable poverty reduction. It plays an important role in enabling poor people to participate in the growth process. Acess to education and health facilities which are indicators of economic development, can be greatly improved through better transport facilities, electricities, communications, water supply & sanitation services.

Construction management is the emerging scope of management. Any project require good construction manager for

- project ~~manager~~ management to speed up construction works.
- strong task management
- Co-operative environment between contractors, client & project team
- regular field reporting
- cost saving etc.

International and domestic construction markets are the major scope in present days. The market of the construction business in both international as well as domestic, its profitability, like any other business, fluctuates according to the law of supply & demand.

Scope of construction management can be understood by following areas:

H International export / ~~market~~ infrastructure market:

There are more than 225 top international companies competing with each other for the global

Construction tenders. Americans are in front of all of these Construction Companies. In the international market, building, transportation and petroleum supply activities Constitute the major area of Construction activities. The remarkable success that China has achieved, in reducing poverty over the last two decades is largely due to its massive investment on infrastructure - extending toll roads, irrigation, electricity and improved Communication into the more remote west. In India, Construction projects employ at least 31 million people of whom more than half are extremely poor migrant workers, and many are unskilled woman. Rapidly growing economy like Malaysia, South Korea, South Africa etc have established their economic status higher by investing largely in Construction projects.

Domestic Infrastructure Market / Nepalese Construction Industry

Nepal is entering into the era of building new Nepal. Development activities need to be increased many folds more than the present pace to achieve inclusive growth with equal opportunity of employment for improved prosperity of country reducing the poverty. There is direct relationship between development of construction industry and economic development of the country. Thus, we can easily trace out the prospects or opportunities of Nepalese Construction industry in building infrastructure as follows:

1.) Roads and Airports:

The goal of economic development can only be achieved through the establishment of adequate and efficient transport facilities. Nepal has about its two third area with rugged topography. Hence, an efficient road network has become a challenge. Likewise Nepal is land locked country. However, an improvement and extension of transportation network provides the opportunities to grow the economy. Nepal is still lacking sufficient road network. If road networks are extended, Nepal can be "Land Linked" between India and China. From which it can reap (gather) the benefit of transit point between these countries. Similarly, for tourism industry, which is regarded as one of the major source of foreign currency earning, many infrastructure development in different parts of the country including regional & international airports are the opportunities of the construction industry in Nepal. On the other hand, investment from the government in road sector is low and is not able to meet the requirement of the country and aspirations (ambitions) of the people. Hence, Contractors and Consultants can and have to play key role in this regard to attract the private sector to make investments in the road sector following the Built, operate and Transfer (BOT) approach.

2.) Irrigation and Hydropower:

Nepal is second richest country after Brazil in its water resource and it has the great prospects in generating hydroelectricity and constructing irrigation projects throughout the country. Although Nepal has a large reserve of water resources, it is not able to utilize them properly. At the end of FY 2072/73, the total peak demand was around 1423 MW but the power production was less than the demand. Hydropower production was around 829 MW only, which is merely 0.85 percent of the total potentiality of 83,000 MW. So, there is wider scope of hydro electricity market inside the nation and the possibility of exporting to India & Bangladesh as well.

The extension of irrigation facilities in the agricultural land can bring crop intensification (सघनता) and crop diversification (विविधता), which can help to generate employment & reduce poverty. At present, only 40% of cultivable land is covered by round the year irrigation. If power supply generation and irrigation is possible from the same project, it will be beneficial and cost effective. In this regard, the feasibility studies of such projects are required to develop the Nepalese construction industry.

3.) Real State and Housing:

According to population census 2011, the growth rate of population is 1.35 percent per annum. With the economic development of the country, the tendency of the flow of population is from rural areas to urban areas. It requires better real state, housing, market complex, good hospitals, school & colleges. Still there

are insufficient such facilities in Nepal. Though, there are lots of opportunities for local contractor on building real state and housing.

4.) Public Private partnership (PPP) in infrastructure development:

The government of Nepal liberlizes its policies after 1980's. Now, goverment has released the act related to Build, operate, own and Transfer (BOOT) ACt (PPP) – 2063 BS, Road safety policy 1999 A.D., BOOT Regulation (PPP) – 2064 B.S., Hydropower Act-1992 A.D., ~~private Envestment in infrastructure Build and operate ordinance – 2063 B.S.~~ private Financing in Build and operation of Infra-Structures Act.2063 BS. There is still some opportunity for the contractors through contractual PPP's as:

→ Build and Transfer (BT)

→ Build, operate and Transfer (BOT)

→ Build, operate, own and Transfer (BOOT)

→ Build, Transfer and operate (BTO)

→ Lease, operate and Transfer (LOT)

→ Develop, operate and Transfer (DOT)

PPP is regarded as the revolutionary approach towards infrastructure development which pulls resources, pulls in ~~experties~~ expertise, maximizing service delivery, magnifying scope opportunities and creates the employment opportunities for the contractors also.

⇒ Prospective PPP projects now in Nepal.

→ Kathmandu - Terai Fast Track
→ East - West Railway
→ Kathmandu Terai Railway
→ Kanti Rajpath
→ Birgunj - Jitpur Roadway
→ Kathmandu outer Ring Road
→ Jabakpur - Jaynagar Railway
→ Sitapaila - Dharke Roadway
→ ~~Nijgadh~~ Nijgadh International Airport.
→ Dry ports.
→ Truck Terminals
→ Bus Terminals
→ Cargo Complex at TIA
→ Cable Car & Ropeway
→ Road & Infrastructure Maintenance
→ Road Intersections
→ SKy Bridge
→ Sub-Way
→ Flyovers
→ City Parking etc.

In conclusion, there is huge task on construction of infrastructure facilities, both basic as well as developmental. Living between the two economic giants (India, China), who are accounted as the future superpower of the world in next two decades, and living at neighborhood of Bhutan, Nepal is still searching and endeavoring to find lasting solution to reduce poverty. Time is reach to learn lessons from the neighboring countries and march ahead for real achievements, which will largely depend upon development projects through construction industry.

1.3) Construction project characteristics:

→ is defined as a temporary endeavour undertaken to create a new product or service to achieve specified objectives within the assigned resources.

→ A program at macro level comprises one or more projects.

→ some examples of construction projects:

* Constructing a building.
* Developing a hydropower
* Designing a new transportation system.

In general the term 'construction project' refers to a high-value, time-bound, special construction mission with pre-determined performance objectives.

It employ huge resources of men, materials & machines

Thus, the construction project mission is accomplished within complex project environments by putting together human and non-human resources to form a temporary organization, headed by a project manager.

a.) Characteristics of project:

1.) Specific objectives:
- → a single definable purpose, e.g. item or result
- → usually specified in terms of cost, schedule and performance requirements

2.) Every project is Unique:
- → something different, something that was not done previously
- → It has specific location, different terrain, access, laws, labour market, public service etc.

3.) Life span:
- → defined beginning & ending time, can't be endless.
- → It has a life cycle consisting of formulation, planning, implementation and termination phases.

4.) Constraints:
- → Constraint of time, cost & quality performance.
- → time schedule for various activities, completion dates as deadline.
- → quality specifications.

5.) Team work:
- → work through a team
- → team members are temporarily assigned from various disciplines with varried experiences are pulled

together to form a temporary organization.

→ The project manager is the leader of the team who co-ordinates project activities, achieves unity in diversity, effectively manages conflicts, must be supported by project team.

6.) Flexibility:

→ should be flexible, not rigid.

→ should provide rapid response to changing environmental forces.

→ Flexibility is essential to control & manage project risks at different stages of life cycle, as project risk is related to time, cost, technology, scope & performance.

7.) Resource Integration:

→ project consume & co-ordinate resources

→ need appropriate interrelationship with physical, financial, human informations

→ Resource use is prioritized in disciplined way for optimization.

8.) Planning & Control:

→ Project requires effective & efficient planning & control systems.

→ Standards are set for project activities through planning

→ Actual performance is compared with standards to find out deviations and corrective actions are taken to control deviations.

9.) Contracting & Subcontracting:

→ Most of projects are contract based.

→ Contracts are of various types.

→ Proper contract planning and management is the key to effective project management.

(10) Beneficiaries:

→ All the project have beneficiaries who are ultimate users of the project outputs.

→ Project should be focussed on fulfilling the beneficiaries clients requirements.

b.) Project Categories:

Broadly, the major construction projects can be grouped into four groups:

* Building Construction Projects:

→ include all type of Building construction like residential, commercial, educational, hospitals, hotels, warehouse, marketing etc. It constitute the largest segment of the construction business.

* Infrastructure Construction projects:

→ includes dam, canal, highway, airport, railway, bridges, oil/gas pipelines, transmission lines, water supply & sewerage disposal networks, docks & harbors, etc. which are build up the infrastructure for the growth of the economy.

* Industrial Construction Projects:

→ includes construction of power generation, manufacturing, processing & industrial plants like nuclear & thermal power plants, steel mills, petroleum refineries, consumer good factories, industrial works, utility services, environmental works and human needs facilities.

* Special-Purpose projects:

→ include environmental works, emergencies, remedial works, installation & commissioning of equipment and complex key operations.

c) Project size classification

* Project size on time basis
  - → Long range strategic programs / projects (over 5 yrs.)
  - → medium duration projects (3 to 5 years)
  - → Normal duration projects (1 to 3 years.)
  - → special short term projects (less than 1 year.)

* project size on cost basis:
  - → mega value projects
  - → large value projects.
  - → medium value projects.
  - → small value projects.

d) Project objectives:

→ Each project is assigned predetermined objectives.

→ Project objective depend upon many factors that determine outcome.

→ The six main parameters that sufficiently define construction project objectives are
  - work scope
  - complexity
  - quality
  - productivity
  - completion time
  - cost.

→ The value of 3 parameters i.e. time, cost and resources productivity depends upon the effectiveness and efficiency with which the project managed.

Construction project & Environment [Chapter#1; lecture#3]

→ A project exists in association with its internal and external risk-prone environment, which undergo frequent changes

→ The internal environment of the project includes: Corporate objectives, stake-holders' interests, resources, problems, conversion processes and people management

→ The external environments are associated with changes in social, political, legal, economic and financial factors.

These external and internal environments have inherent uncertainties and are risk-prone. Most of the construction projects have one or more of the following characteristics/uncertainties associated with them:

* details of works are not precisely defined.
* Slope of works get modified during execution.
* Nature of work varies from job to job.
* Site work is located in remote areas
* Places of works are spread out.
* Resources requirements and organization of works differs with each task.
* Investments involved are large and the decesions entail (involve) risks.
* performance is sensitive to the unexplored site geology, uncertain weather and unforeseen natural calamities (disaster.)
* Rapidly changing technology, fast moving economic conditions and susceptible environments add new dimensions of project objectives.

4) Construction project life cycle phases:

Each project is divided into several phases. A typical construction project comprises of four phases i.e.

→ Project concept analysis phase / Project initiation phase
→ planning and construction procurement phase.
→ Construction (Execution & control) phase
→ close-up (including demobilisation) phase.

These phases are generally sequential but may overlap in some situations:

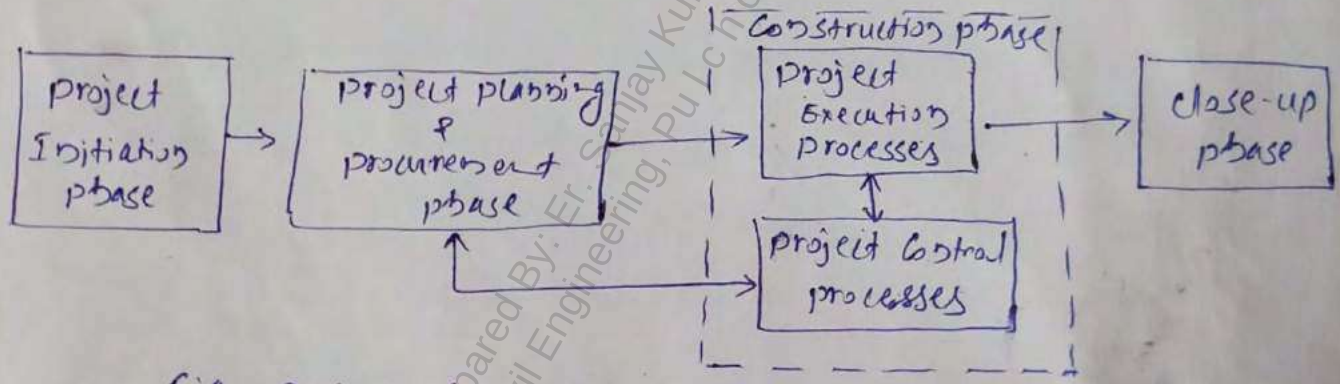


Fig. Project Construction Management phases

→ Each phase, depending upon its deliverables, contains a single or a group of processes. A process is an action or a set of actions that are performed to bring about a desired result.

→ Each process is fed with inputs; these inputs are processed ~~with~~ using tools and techniques to produce outputs.

→ The output of a process is generally followed with the start of one or more of the subsequent generally sequential processes.

→ The phases with processes in a typical construction project are outlined below; generally these project processes overlap

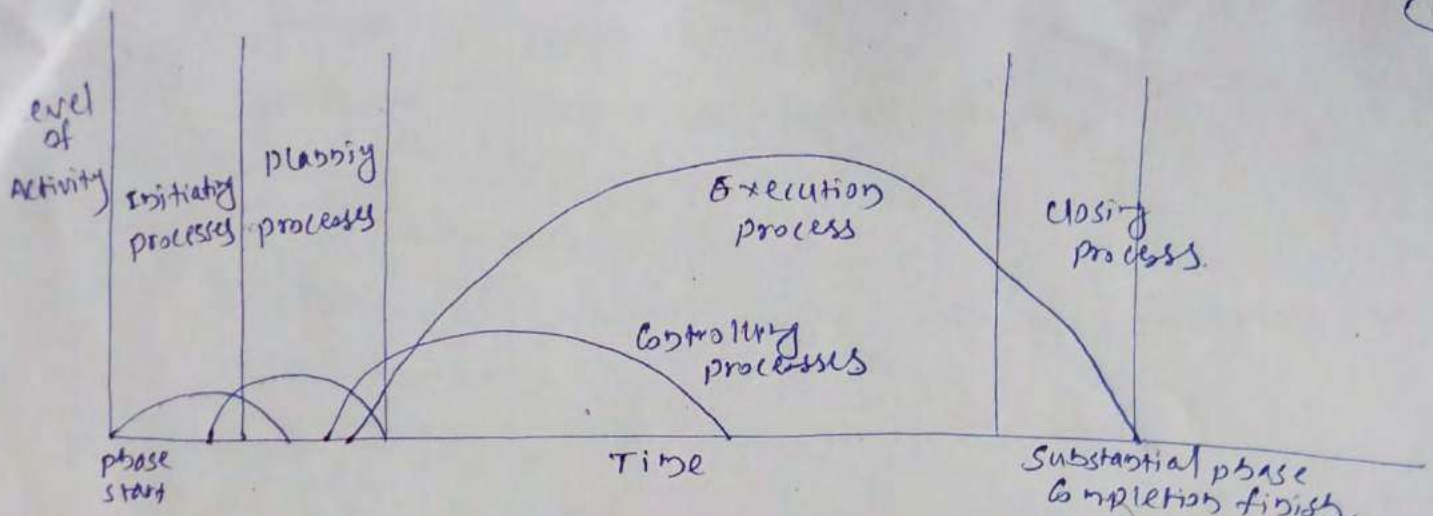


Fig. Processes in a construction project life-span

Project Initiation/Concept analysis phase:

→ Project Formulation:

~~→ project scope & implementation strategy.~~

→ output of this phase gives decesion for investment → whether to go ahead or no.

→ Project Need analysis

→ Feasibility study

→ Project Investment analysis & appraisal

→ Project scope formulation & implementation strategy.

Project planning phase:

→ develop a workable & manageable plan to accomplish the project mission

→ Design & drawing planning

→ Time planning

→ Resource planning

→ Cost planning & budgeting

→ Communication planning

→ Quality assurance planning.

→ Organisational planning.
→ Construction Contracts procurement planning
→ Resources mobilisation planning
→ Site administration & layout planning
→ Workers' safety, health and environmental protection plan
→ Risk Response plan.

Construction ~~Execution~~ phase:

* Execution processes:
  → manage & co-ordinate human & other resources to execute activities.
  → project site organisation
  → resource mobilisation
  → Scope quality assurance team development
  → information distribution & sharing
  → Contract administration
  → Time, cost, quality management
  → issue management
  → communication management.

* Control processes:
  → scope change control
  → Resources control
  → Schedule Control
  → Cost Control
  → Quality Control
  → Risk Response Control
  → Earned value performance Control.

Closing phase:
  → Project closure Report
  → Administrative closure
  → Contract close out
  → Reviewing project completion.
  → Lesson learnt.

1.5) Construction project Management:

→ Project management is the art and science of converting the client's vision into reality by working efficiently, effectively and safely.

→ Project management implies the application of knowledge, skills, tools and techniques to perform project activities within a given scope, time, cost and quality constraints.

→ In construction context, project management is the art and science of managing all aspects of the project to achieve the project mission objectives, within the specified time, budgeted cost & predefined quality specifications; working efficiently and effectively in the changing project environments with due regard to construction workers' safety & health.

→ The project Manager aims to achieve his mission, efficiently and effectively, to the client satisfaction by

- managing: time & progress, cost & cash flow, quality & performance and organisational behaviour
- with: assigned organisation resources.
- By: planning, scheduling, directing, monitoring & controlling resources.
- within: quality, time, cost & environmental constraints.

Modern projects differ from the past practices. The fast-changing environment of present era imposes numerous financial, legal, ethical, environmental, and logical constraints. They interact technically, economically and socially within the environment as well as with other organizations.

Construction management participants:

Project stakeholders or participants are the individuals and organisations who are actively involved in project execution or successful project completion. Key stakeholders in a typical project include:

- → Business promoters/owners
- → Architect - Engineering associates
- → Construction management consultants
- → Construction material, equipment suppliers.
- → Contractors
- → project Manager.

1.6) Relation between client, consultant and contractor:

→ The client, the consultant and the contractor are three major parties involved in construction activities.

→ The client is owner & ultimate user of the constructed facilities.

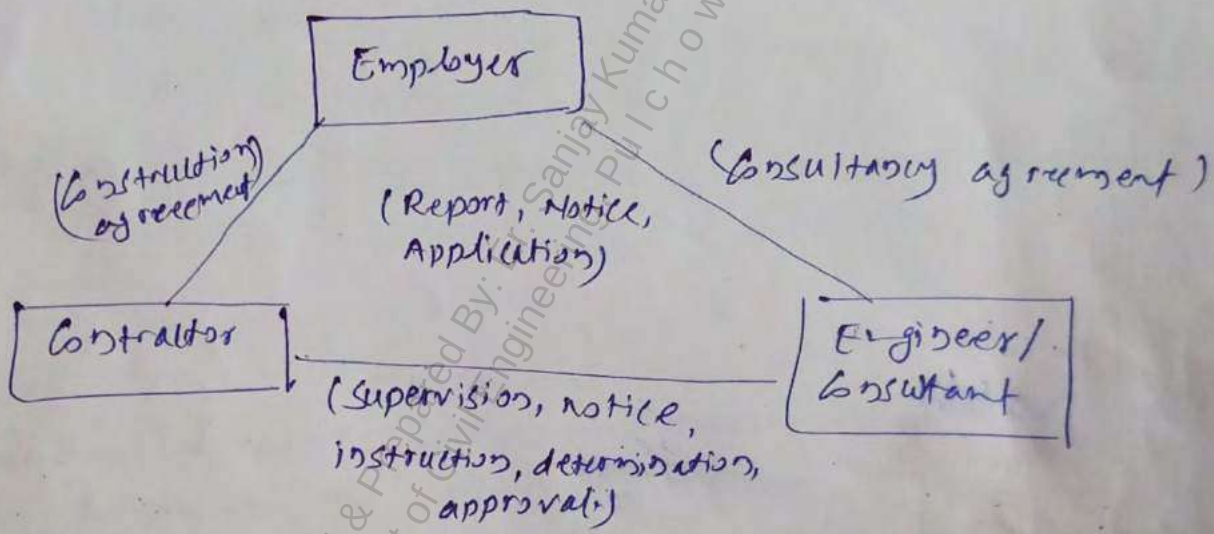
→ The consultant, in general is an engineer who is involved in planning, designing & cost estimation of the infrastructure facilities in close co-ordination with client.

→ The contractor is responsible for the quality control of the work and who builds the facilities as per the consultant's design and in close supervision & monitoring from client & consultant both.

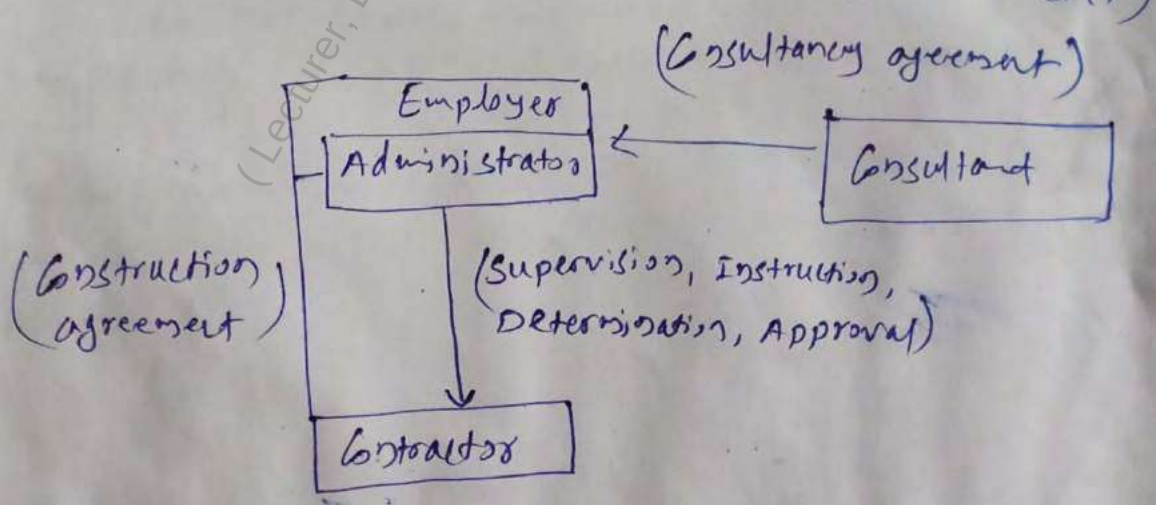
→ In simple way of understanding, the client is who draw/build the house in brain, the consultant is who draw/builds the house on paper and the contractor, the ultimate builder who builds the house at real site.

The major relation between these three parties are governed by the type of contract, its conditions and nature of the work. Client is investor who invest the money for the project. The consultant plays the bridge between the contractor & owner. Basically, according to the nature of role, the relation between them can be divided into either two party system or three party system.

Three party system (FIDIC)



Two Party system (Nepal Government project, Japanese system etc.)



Client

→ offer project through tender notice
→ sign the letter of acceptance.
→ prepares contract aggreement
→ approves the performance security
→ Ensures insurance in accordance with law
→ make advance payment (if any)
→ authorize the contractor to move on to site.
→ makes payment of per running bills of the contractor. (as certified)
→ should settle the disputes promptly in general if arises.

Contractor

→ Executes the works with full responsibility of quality, timely completion and safety of the work.
→ responsible for setting out, construction, carrying tests, care of works, rectify defects, insure for the Labourer, materials equipment, insure for third parties liabilities, take responsibility for the health and safety of worker, maintain specification of works, Compete the work and hand over the project.
→ After hand over also, the contractor is responsible for maintenance of defects during defect liability period (DLP.)

Consultant/Engineer:

- An individual engineer/architect, an independent professional organization, practicing firm, a government entity etc.
  - → Design, research and investigate for design.
  - → prepares cost estimates at different stages
  - → Help client in preparation of Bid documents.
  - → Help client in Contractor selecting procedures.
  - → Supervise the works for quality, cost & time controlling.
  - → Reporting to the client.
  - → Works as a client's representative/agent.
  - → Acts as arbitrator.
  - → Approve the bills and guide the client for payment.

Chapter 2 # Lecture #1

Construction planning & Scheduling:

2.1.) Construction planning :- Introduction:

"If you fail to plan, you are bound to fail"

→ is the most important constituent of the construction management.

→ planning actually means doing the project activities in mind before it is being done in actual field.

→ Planning is the course of action to achieve the desired results taking into consideration the present needs and future requirements.

→ planning forms the basis for the project scope, schedule, resources, quality, risk, and integration.

→ Time, cost, and quality are the main focus of the planning.

→ 4 M's or sometimes 5 M's of planning

- Material
- Money
- Manpower
- Machine

} Time managed.

→ For execution of project; effecient planning should be done which requires
- identification & understanding of sequence & magnitude of activities and their logical relationship.
- decide time requirement
- decide the time at which resources are required.
- decide type, nos. & duration of use of plant and equipment.

→ Planning is done to
- eliminate or reduce uncertainty.
- improve efficiency of the operations
- obtain better understanding of the objectives.
- provides basis for monitoring & controlling.

Objectives of planning:

The main objective of planning of a work is to execute the project or work economically in terms of cost, time & quality. The effective planning requires the following factors:
- proper design of each element of the project.
- proper selection of plant and equipment.
- proper arrangements of repair of plant and equipment at site.
- procurement of required materials well in advance.
- Ensure employment of skilled and unskilled employees.
- to provide welfare schemes for the workers
- to arrange ~~constant~~ appropriate flow of funds in entire project duration
- to provide required level of safety and compensations.
- proper arrangements of communication & mobility on site.

* Principles of planning:
- The plan should be readily understandable.
- should be realistic (not an optimistic)
- should be flexible
- should be comprehensive
- should incorporate the system of monitoring and controlling.

2.2) Steps and steges of planning:

Broadly, planning involves following steps:

- Setting objectives
- Determining the alternatives
- Evaluating the alternatives
- Selecting the best alternatives
- Formulating the real plan.

In detail, planning involves following steps:

- identifying the likely problems to be encountered in the execution of the work and obtaining necessary information.
- Ascertaining alternative, feasibility of execution of work and selection of the optimum plan.
- Fixing the time of starting of execution of work.
- deciding the time of delivering the materials at site.
- deciding the quantities & duration of various types of machines and equipment.
- Deciding the number of different types of labours for various works & ~~their~~ duration of their employment.
- Estimation of financial need.
- Estimation of the duration of completion of the work.
- Evaluation of the effectiveness of plan adopted.

Stages of planning:

1.) Preplanning / Feasibility stege:

→ overall objectives clearly defined.
→ A general frame work of the project is formulated.
→ A cost-benefit analysis is to be done along with cost analysis of different alternatives at site.

→ The planning under this stage developa picture to be for decesion making whether the project is accepted or rejected.

2.) Detailed planning:

→ detailed design & drawings are prepared.
→ Specification of materials are prepared.
→ Quantities calculation along with preparation of WBS (Work Break down structure) is prepared.
→ Sequence and scheduling of activities are prepared.

3.) Monitoring and Controlling:

→ the progress of construction activities are monitored as per ~~proposed~~ previously prepared schedule.
→ Updating of work schedule can be carried out as per actual progress of work.
→ preparation of the revised forecasts regarding the availability of various resources.

2.3.) Planning by Contractor and Client in Different Stages:

Planning by the client/owner/Employer:

a.) Pre-tender stage planning:

- Setting clear objectives of the project.
- Communication/information of objectives to the all parties and stakeholders.
- proper investigations, design, drawings, quantity estimates and cost required for the completion of the work.

- taking approval of the project from concerned authority.
- selection of project team and project appraisal. (assessment)
- selection of consultant
- Tendering and contract award (selection of contractor)

b) Construction stage planning:

- Make site available for the contractor
- revesion in objectives in responding unexpected events.
- timely payment and settlement of claims.
- Updating work schedule, progress of work.
- updating performance bond, insurance etc.
- timely decesion.

c) Post Construction stage planning:

- prepares project operation schedule.
- " project maintanance schedule.
- project ownership.
- Commertialization etc.

planning by Contractor:

a.) pre-tender stage planning:

- careful study of tender documents, drawing, specifications to confirm the quantities of each item of work.
- workout detailed quantity of materials required for different item of works.
- Determine the availability of construction materials at site or nearby site.
- Determine the method of work execution i.e. by labour or equipments.
- Thorough study of site and site investigations.

b) Construction stage planning / Contract planning:

- Studying the alternative methods of construction and to decide about subcontracting.
- Working out detailed quantities of materials required and fixing the methods of procurement and sources.
- Working out detailed construction workforce like skilled and unskilled manpower.
- Working out details of plants, equipment, their layout and repair & maintenance strategy.
- Planning for camp facilities, access, accomodations, site offices and layout.
- Planning for surveillance like proper lighting, ventilation, drinking water, sanitation, first aid treatment.
- Study interdependence of different items of works and fixing the their sequence.
- Finalize the work program of each item of work and to decide the dates of their starting and completion.

c) Post construction stage planning:

- demobilization of plants and equipment.
- demobilization of labours.
- clearance of materials inventory and its stock.
- Handover the project to client within targeted date.
- Responsible for the defect liability of construction within defect liability period.

Lecture # 2

2.4.) Preparing Schedule:

→ It is the process of arraging various activities and alloting time to each of them so that the project may be completed in an orderly manner and in specified time.

→ A construction schedule is a graphic representation which shows the construction activities with start and completion dates of each activity and the sequencial relationship among these activities.

Scheduling is carried out in advance of the project commencing and involves:

- identifying the tasks that need to be carried out
- estimating the duraction of activities they will take.
- allocating resources. (personnel & material.)
- scheduling when the tasks will occur.

Use of scheduling:

- The quantity of work involved, labour, material, equipment and money required at each stage of work can be determined by scheduling.
- The actual progress of the work can be checked from time to time by scheduling.
- The project can be carried out in systematic manner by the use of scheduling.

1) Advantages of scheduling:

→ By the use of schedule of work, alternative methods of execution can be examined and the most economical method can be selected. further, the effect of likely constraints can be evaluated at the planning stage.

→ It gives clear picture of quantity and type of materials, manpower, machines at different stage of construction.

→ As the time of starting of an activity is known, the arrangements of adequate resources can be done in advance.

→ The resource utilization can be optimized.

→ The actual progress of each activity can be evaluated with reference to planned program.

→ Inter-relationship between the activities is known hence their priorities can be set up.

→ Aplication of value engineering can be adopted.

2) Classification of scheduling:

Construction planning & scheduling requires
- Completing activities or operations
- supply of materials
- requirement of labours
- equipment & machinary required.
- Money/finance required.

These are known as.
- Construction
- material.
- labour
- equipments & machinary
- financial

} schedules.

a) Construction schedule and its preparation:

following informations are required to prepare Construction schedule:

- Various activities/operations to be done.
- Quantum of work to be done in each operation
- Unit of measurement
- Rate of progress of work with due allowance of environmental conditions.
- Number of labours required.
- Number and type of plants & equipment required.
- Date of starting & completing the activity
- Correlation between different activities/operations.

The procedure of construction schedule is as follows:

- The project is divided into number of operations/activities and their inter-dependence or relationship is studied. After that sequence of operation / activities are decided.
- The quantity of work involved in each operation/activity is determined.
- The time required for the completion of each operation as well as the completion of total project is determined.

Project ID
Budged Heading

year:
location:

S.N.	Activities	Total Quantity	Rate per week	Total Time Required	Month											
					I				II				III			
					1	2	3	4	1	2	3	4				

c) Material Schedule

→ This schedue is prepared well in advance of the start of the work. → This schedule is prepared from the construction schedule. → To avoid delay in execution of work, all construction materials should be at the site of work well in advance.

While preparing material schedule, following points must be considered!

- The materials should be delivered at site at least one week eairlier than its use.
- Materials in site should not remain unused for long duration.

Project ID:
Budged Heading:
year :
location :

S.N.	Description of materials	Total Quantity	Months / Weeks				
			I	II	III	IV	

d) Labour schedule!

The aim of this schedule is to determine the number of skilled and unskilled labour required for the execution of different operations on different dates. With the help of this schedule, required labour can be arranged well in time. It is difficult and costly to arrage the labour when required. It helps in reducing labour cost. A labour schedule can be prepared from construction schedule.

Project ID
Budget Heading

Year :
Location :

S.No	Description of Labour	Total Time required	Month / week							
			I	II	III	IV				

d) Equipment schedule:

→ To decide the type, number and dates on which a particular equipment will be needed, equipment schedule has to be prepared before the start of the project, so that it is arranged well in advance and brought at site as and when needed.

→ The aim of this schedule is to derive maximum advantage of the equipment when at site and remove it from site when its job is over, which will save money.

Project ID
Budget Heading

Year:
Location:

S.N.	Description of Equipment	Total no. required	Total duration required	Month / week					
				I	II	III	IV	V	VI

e) Financial schedule:

The estimated amount of money which owner or contractor has to provide to finance the project can be obtained from the financial schedule.

Control schedule

→ At the end of every fixed duration for e.g. weekly, monthly etc; project incharge has to send progress report to the central agency.

→ In order to complete the project within the specified time limits, the chief executive plans to provide resources such as equipment, machines and money.

* Benefits of Controlling:

→ The control system aids the management at various levels to perform their functions efficiently and effectively for achieving overall project objectives in construction project:

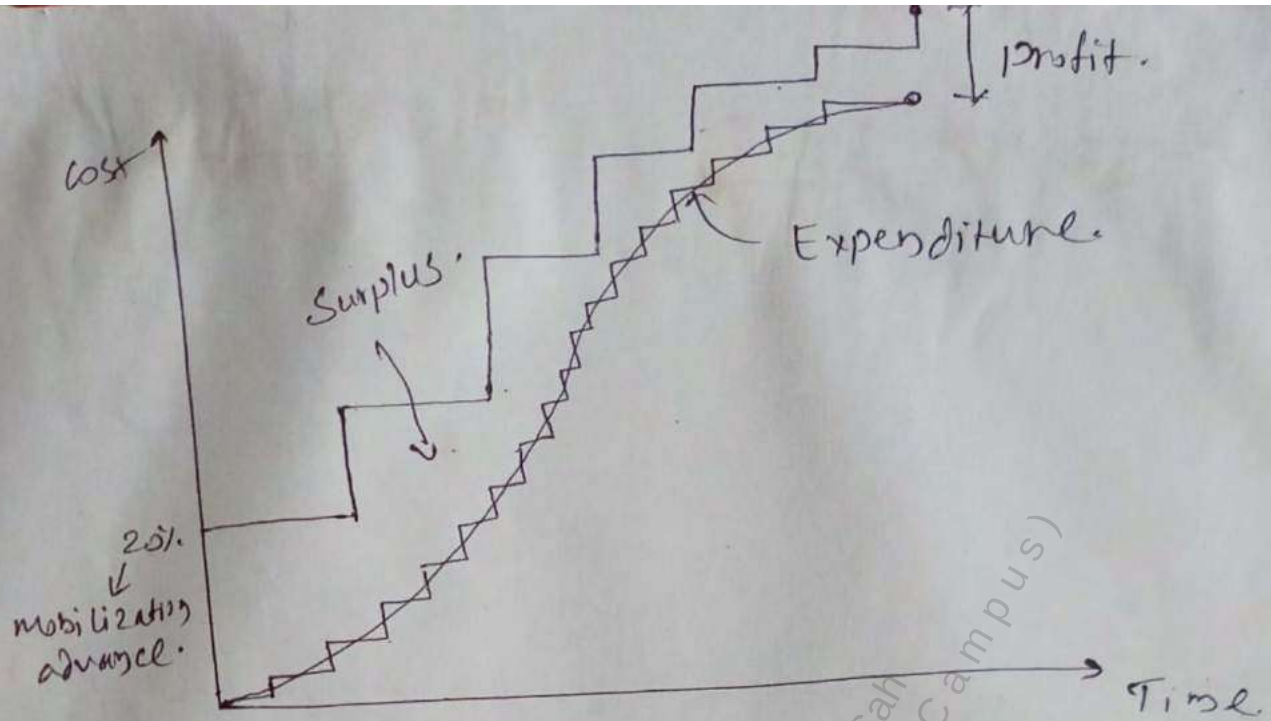
Cash flow ~~and financial accounting~~:

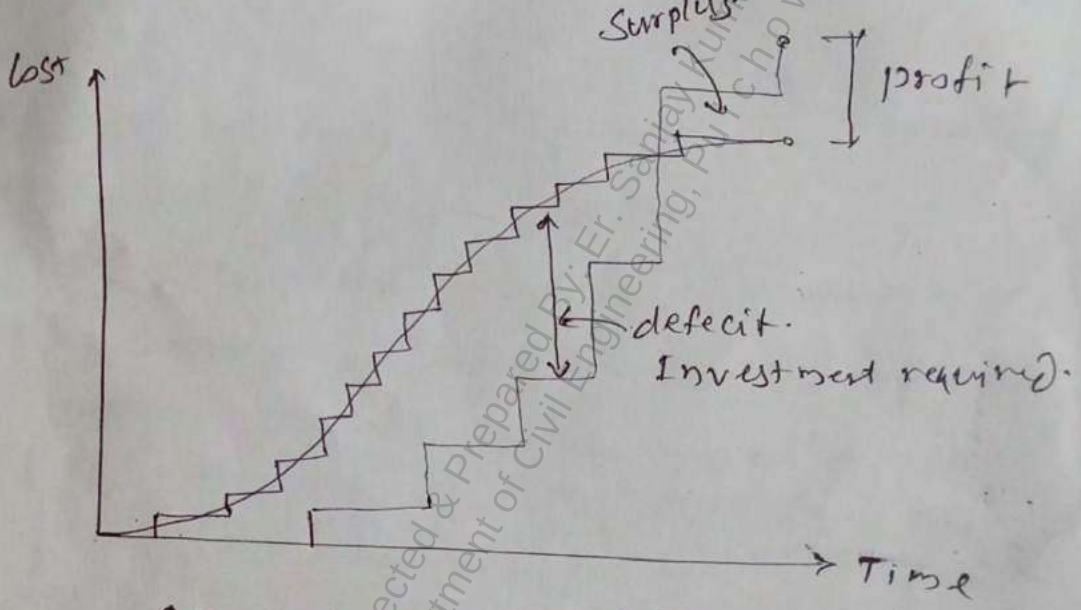
Cashflow - inflow & outflow of cash (money) in terms of time.

→ Cash is the lifeblood of any business.

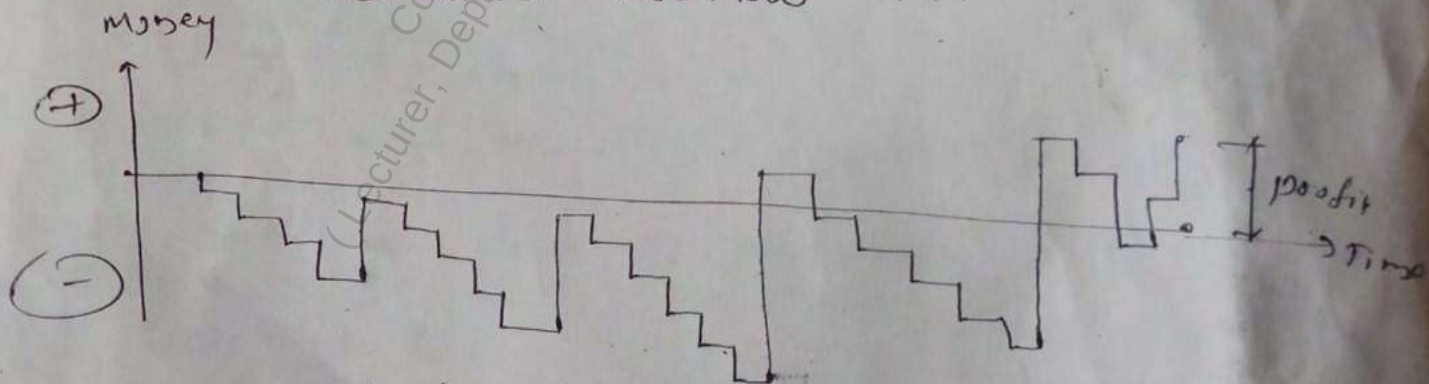
→ Timing of flow of cash is most important consideration in business.

→ Unpredicted charges to the cashflow can lead a company to business failure.

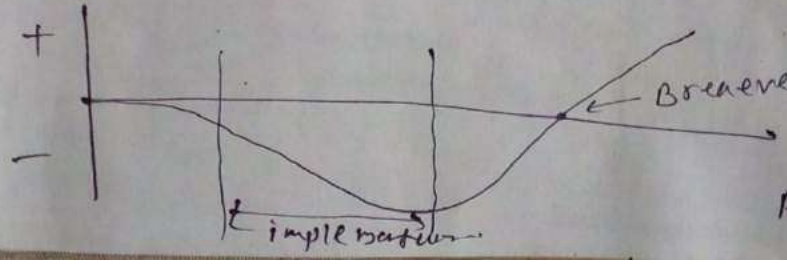




Sub-Contractor's cash flow.



Cash flow during construction



Project Cashflow.

Chapter #2
Construction planning and scheduling:
Lecture #3

Construction scheduling

* Bar chart:
  - Gantt chart
  - Linked bar chart
  - Milestone chart:

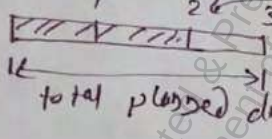
* Gantt chart / Bar chart:

→ Most common form of planning tool.

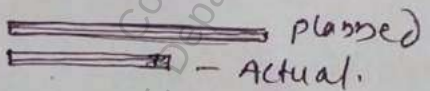
→ Horizontal bar or thick line. Consists of a list of activities with start time, duration & completion time plotted to time scale.

→ There is no fixed format for bar chart. They may vary from company to company and from manager to manager.

→ It can by used to monitor progress of activity.



or.



→ It can be used to estimate resource requirement at any time.

→ Simple Bare chart shows no interdependencies with other activities, however a linked bar chart shows relation with other activities too.

Typical Bar chart for Road Construction

SN.	Activity / Months	Duration	10	11	12	1	2	3	4	5	6	7	Remarks
1	Site clearance	2											
2.	Service track	2.5											
3.	Drainage Consti	6.5											
4.	E/W in Excavation	7.5											
5.	E/W in Embankment	7											

Advantages of Bar chart

→ clear pictorial model.
→ Simple to use & simple to understand.
→ to show progress & scheduling resources.
→ can be used to produce budget.
→ Good communication medium.

* Disadvantages:

→ No inter-relationship among activities.
→ difficult to manipulate data.
→ physical limit of size of chart.
→ Difficult to show critical path and float.

* Steps to be followed making bar chart

→ identify the activities to be done.
→ identify the sequence of activity in which they have to be undertaken.
→ Estimate time/duration for each activity.
→ Plot the various activities on suitable time scale.
→ Draw bars to show progress.

Milestone charts:

→ milestones mark significant events in the life of a project, usually critical activities which must be achieved on time to avoid delay in the projects.
→ Milestones should be significant and reasonable in terms of deadlines.

e.g. - installation of equipment
- Completion of phases. etc.

Network Diagrams:

→ It is a technique whereby the whole of project is broken down into specific parts so that each part can be evaluated in relation to other parts and time.

→ Network techniques is an outcome of improvement in the milestone charts.

→ There are various types of Network techniques, most popular of them are –

a) CPM (Critical Path Method.)

b) PERT (Program Evaluation & Review technique.)

a) CPM (Critical Path Method)

→ It is a deterministic model using single value for time estimates for activities of the project.

→ This method is used when time period required for each activity can be estimated correctly & precisely and project duration can be estimated correctly.

→ Cost is the major controlling factor. ~~cost consideration~~.

→ Enables planners and managers to thoroughly analyze the timing and sequential logic of all activities required to complete a project.

* Critical Path

→ It is the longest path of activities.

→ It determines the total project duration.

→ There may be more than one critical path in a network.

→ A critical path may consists of less no. of activities than non-critical path.

→ It is the starting point of project planning.

→ The critical activities (lying on critical path) demand the requirement of resources prior to other activities to complete the project in time.

Terminologies:

Dummy Activity:

→ doesn't consume any resources like time, cost, manpower, equipment etc. but used to show relationship only.
→ represented by Dashed line.

* Events:

→ occurances before or after an activity.
→ represented by circle, marked by a number.
- Head Event (End of an activity)
- Tail Event (Start of an activity)

→ the number on Head event must always be greater than that on tail event.

* Earliest Time & Latest Time:

- Earliest start time (EST)
- Earliest Finish time (EFT)
- Latest start time (LST)
- Latest finish time (LFT)

where,
EFT = EST + Duration of activity
LST = LFT - Duration of activity.

* Floats:

Float means the available free time for an activity, which is useful to manage the limited resources.
- Total Float (TF)
- free Float (FF)
- Independent Float (IF or Ind. Float)
- Interfering Float (Int. Float.)

* Total Float (TF)

→ total free time for an activity
TF = LST - EST = LFT - EFT

Free Float (FF)

→ spare time allowable for an activity so that the start time of succeeding activities are not affected.

FF of an activity = EST of succeeding activity
− EFT of same activity

* Independent Float (Ind. Float)

Ind. Float = EST of succeeding activity
− LFT of same activity

* Interfering Float (Int. Float)

Int. float = TF − FF

Use of CPM:

→ Resource allocation & smoothing.
→ determining critical path will identify those activities or events that needs attention either in completing the project timely or in reducing the time for completion.
→ Schedule updating.
→ Better time analysis for guaranting extension of time.
→ Co-ordination with many groups in time.
→ monitor the delay for claim settlement.
→ provides information for decision maker.
→ it can be used to reduce the project time with cost consideration.

PERT (Program Evaluation and Review Technique)

→ It is a probabilistic model using three values for time estimates for activities.
→ This model is useful where ~~In this model~~, the time period required can not be estimated by engineering analysis or judgement.

→ used for non-repetative jobs like research and development works, millitary operation, jet operation etc., where the time and cost estimates tend to be quite uncertain.

→ Time is the major controlling factor → Time oriented.

→ Three time estimates:

- Optimistic Time (t_o) – minimum time.
- most likely time (t_m) – normal time.
- Pessimistic time (t_p) – maximum time

$$\text{Estimated time } (t_e) = \frac{t_o + 4t_m + t_p}{6}$$

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

$$\text{Standard deviation, } \sigma = \left(\frac{t_p - t_o}{6}\right)$$

Similarities between CPM & PERT:

→ Both tools lead to the same end: a critical path and critical activities with slack time / float equal to zero.

→ Extensions of both PERT and CPM allow the user to manage other resources in addition to time and money, to trade off resources, to analyse different types of schedules, and to balance the use of resources.

* Differences between CPM and PERT:

CPM	PERT
* CPM is deterministic tool with only single estimate of duration.	* PERT is probabilistic method tool used with three estimates of duration.
* activity oriented ~~i.e. cost oriented~~.	* Event oriented i.e. time oriented.
* The deterministic factor is more so values or outcomes are generally accurate and realistic	* The probability factor is major in PERT, so outcomes may not be exact.
* Consider less uncertainty.	* Consider more uncertainty.
* is suited for routine projects requiring accurate time and cost estimates.	* Suitable for Research & Development related projects where the estimate of duration are uncertain.
* CPM also allows an explicit estimate of cost in addition to time, hence control both time & cost.	* PERT is basically a tool for planning & control of time.
(explicit - stated clearly, leaving no space for confusion or doubt.)	

2.5) Time Cost Trade-off:

[Trade off → a situation in which one balance two opposing situations or qualities]

* There should be trade-off between
  - doing the job accurately
  and - doing it quickly.

* Project Cost:

→ It is the total cost/expenditure incurred in any project in terms of manpower, equipment, machinary, materials and time to achieve a particular goal/output.

→ The total project cost is the sum of two distinct costs.

* Direct cost
* Indirect cost.

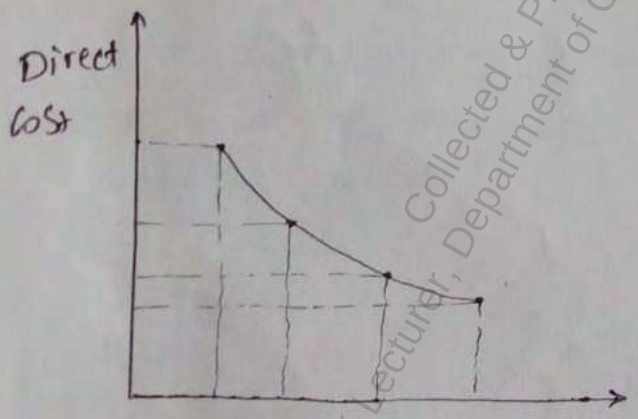
* Direct Cost

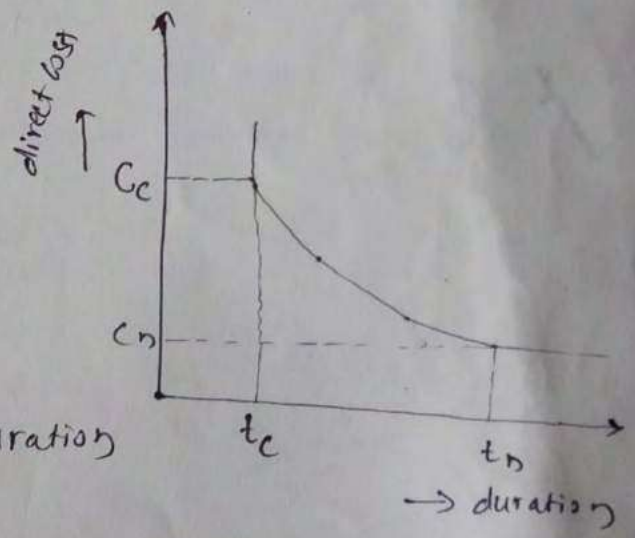
→ Cost directly identified with the activities of the project.

→ includes cost of material, equipment, labourer & energy required to execute the work.

→ By using more resources, project duration can be shortened but direct cost increases.

→ Direct cost decreases with ~~increase~~ increase in duration but this is done only upto a point known as normal cost point. Beyond this point, the direct cost can not be decreased, only project duration increased.





C_c - Crash cost (all critical activities crashed)

C_n - Normal cost (all activities done in normal ways.)

t_c - project duration for all critical activities crashed (minimum time)

t_n - project duration for all activities done in normal way.

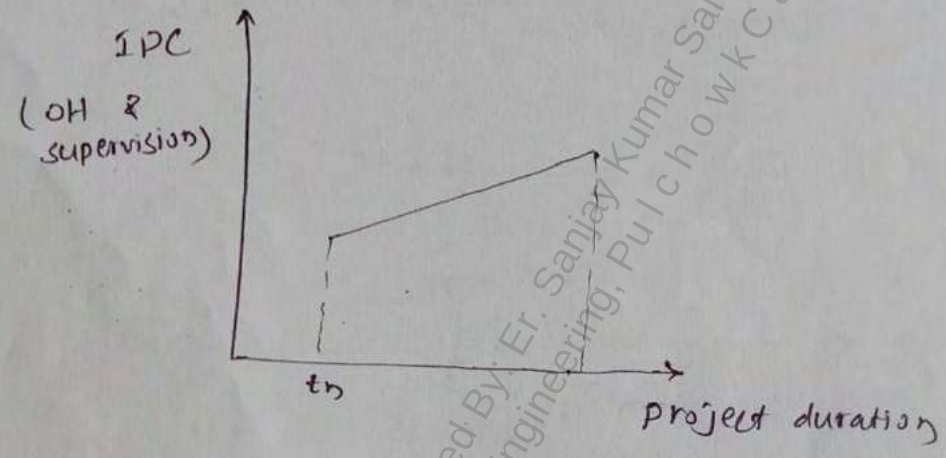
$$\text{Cost slope (CS)} = \frac{\text{Crash cost} - \text{normal cost}}{\text{Normal time} - \text{crash time}}$$

$$= \frac{C_c - C_n}{t_n - t_c} = \frac{\Delta C}{\Delta t} \rightarrow \text{increase in cost} \rightarrow \text{decrease in time}$$

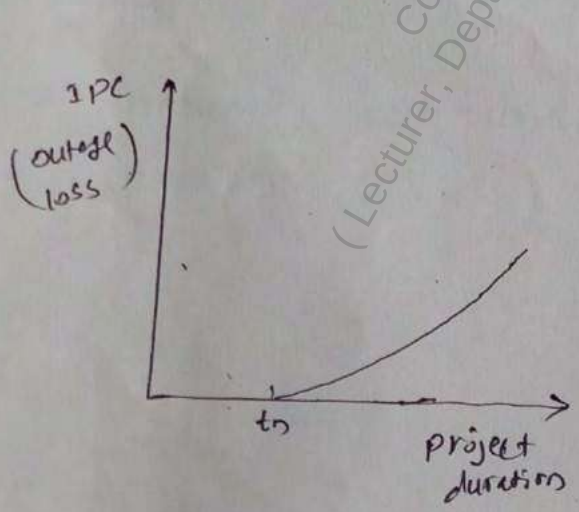
* Indirect Cost:

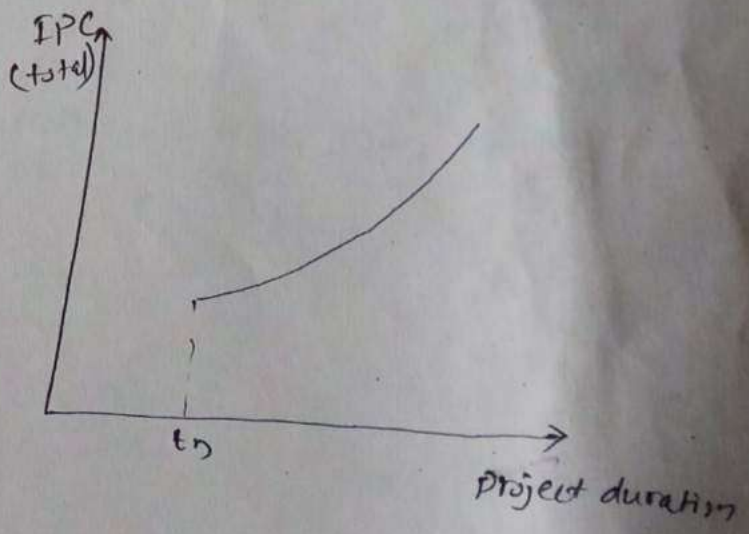
→ Cost which can not be allotted clearly to the individual activities of the project.

→ include overhead charges, administrative, establishment, supervision, storage cost, penalty, loss of revenue etc.



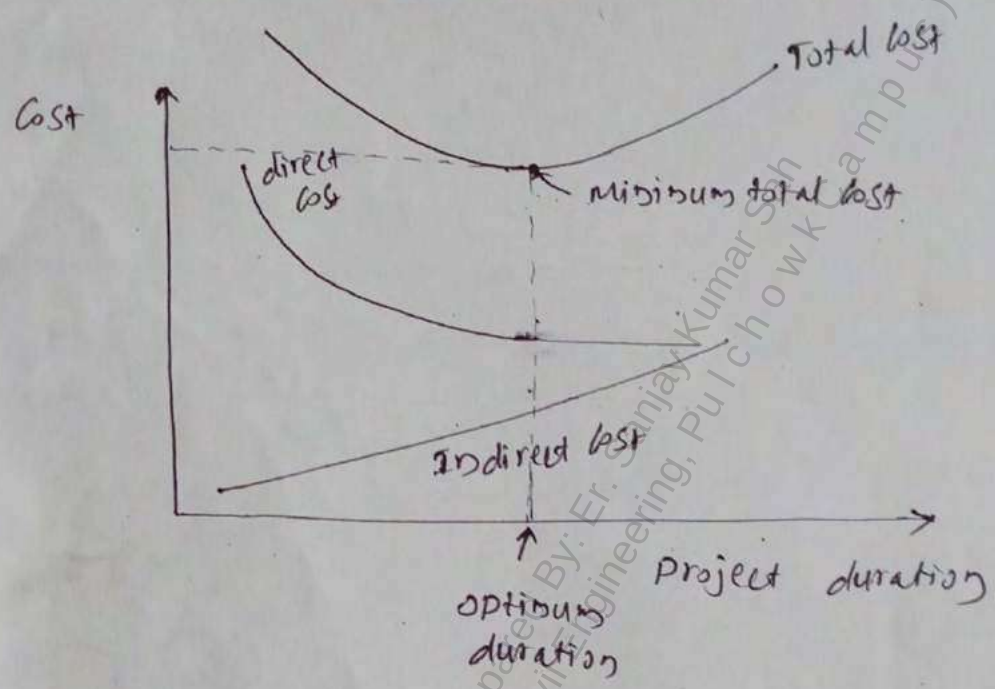
→ But loss of revenue, penalty due to delay etc. and their corresponding increase in cost must be added to the cost of OH. Such a ~~cost is~~ loss is called as outage loss.





Time Cost trade-off (Optimum Duration)

→ Reducing duration from normal duration increases direct cost but decreases indirect cost, so a point between is found which is most economical and resulted by adding both direct & indirect cost is called optimum duration.



→ the total cost for the project is minimum for certain project duration, called the optimum duration of project.

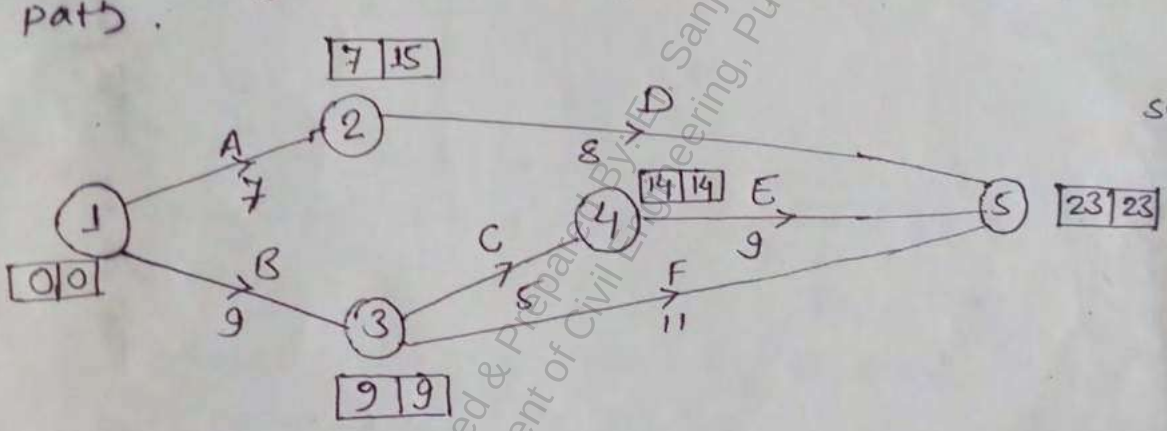
→ Generally, optimum duration is less than normal duration.

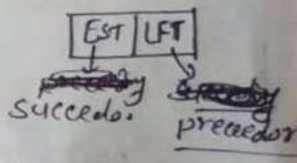
2073 Bsara. Chapter 2 ; Lecture #14 (Tutorial)

Q) 1. The details of a project are shown below. If the indirect cost per week is Rs. 300, find the optimal crashed result of the project Network.

Activity	immediate Predecessors	Time (Weeks) Normal	Time (Weeks) Crash	Cost (Rs.) Normal	Cost (Rs.) Crash
A	—	7	4	1800	2100
B	—	9	7	3500	3800
C	B	5	4	2500	2625
D	A	8	5	4000	4225
E	C	9	8	3000	3325
F	B	11	11	3000	—

Sol.) Drawing network diagram and identifying the critical path.





Possible Paths	Duration (weeks) Normal	Duration (weeks) Crash
A - D	15	9
B - C - E	23	19
B - F	20	18

Here B - C - E is the critical path with normal project duration of 23 weeks.

For all activities to be normal;

Direct cost = Rs. 17,800

Indirect cost = Rs. 300 x 23 = Rs. 6,900

∴ Total project cost = Rs. 24,700

Now, finding the cost slope of all activities and ranking them,

Activity	$\Delta C = C_c - C_n$	$\Delta t = t_n - t_c$	Cost slope $= \frac{\Delta C}{\Delta t}$	Rank
A	300	3	100	2
B	300	2	150	4
C	125	1	125	3
D	225	3	75	1
E	325	1	325	5
F	—			

Now, along critical path B-C-E, activity 'C' has least cost slope, so crashing it by 1 week. The project duration reduces to 22 weeks from 23 weeks as per detail below:

Path	Duration
A - D	15
B - C - E	22
B - F	20

Extra cost of crashing activity C = Rs. 125 × 1 = Rs. 125

∴ Direct cost = (125 + 17800) = Rs. 17,925

Indirect cost = Rs. 300 × 22 = Rs. 6,600

∴ Total cost = Rs. 24,525

Again, same path B-C-E remains the critical. So, crashing the activity B (next least cost slope) by 2 weeks. The project duration reduces to 20 weeks from 22 weeks as below.

path	Duration
A - D	15
B - C - E	20
B - F	18

Extra cost of crashing activity B = Rs. 150 × 2 = Rs. 300

∴ Direct cost = Rs (17,925 + 300) = Rs. 18,225

Indirect cost = Rs. 300 × 20 = Rs. 6,000

∴ Total cost = Rs. 24,225

Here, again same path B-C-E is critical. Therefore, crashing activity 'E' by by 1 week. The project duration reduces to 19 weeks from 20 weeks as below:

Path	Duration
A - D	15
B - C - E	19
B - F	18

Extra cost by crashing activity 'E' = Rs. 325 x 1 = Rs. 325

Direct cost = Rs. (325 + 18,225) = Rs. 18,550

Indirect cost = Rs. 300 x 19 = Rs. 5,700

∴ Total cost = Rs. 24,250

Here, the total cost in this duration is greater than previous one. Therefore, further crashing will not reduce the cost. Also, all the activities ~~on crashed~~ critical path are crashed. Now there is no option to reduce project duration.

Hence, the optimal project duration is 20 week and corresponding minimum cost is Rs. 24,225.

Also, the minimum possible duration of project is 19 week and corresponding minimum cost is Rs. 24,250.

3. *From the given network and data below, find the least cost schedule. Indirect experiences for the project is Rs. 250 per week.*

Activity	Predecessor	Duration		Cost	
		Normal	Crash	Normal	Cost
A	-	9	4	4500	6000
B	A	5	2	3000	4200
C	A	7	3	7000	7800
D	B	4	2	2000	2400

Sol". Finding the critical path

Possible Path	Duration (w)	
	Normal	Crash
A – C	16	7
A – B – D	18	8

Here, critical path is A – B – D with project completion duration be 18 weeks

Direct cost = 6500

Indirect cost = 18 × 250 = 4500

Total cost = 21000

Calculating the cost slope of all activities. Crashing in done starting from least cost slope amongst the critical activities.

Activity	Δ_c	Δ_t	Cost slope (Δ_c/Δ_t)	Rank
A	1500	5	300	4
B	1200	3	400	3
C	800	4	200	2
D	400	2	200	1

Here, activity 'D' has least cost slope amongst other critical activities. Therefore, crashing it by 2 weeks. The project duration reduces to 16 weeks from 18 weeks as detailed in table.

Path	Duration
A – C	16
A – B – D	18 – 2 = 16

Extra cost of crashing activity D = 2 × 200 = 400
Direct cost = 400 + 16500 = 16900
Indirect cost = 16 × 250 = 4000
Total cost = 20900

We see that both path becomes critical after crashing activity D. Now selecting common activity from both paths to crash. Here, activity 'A' is common for both of the paths. Therefore crashing it by 5 weeks. The duration of project reduces to 11 weeks from 16 weeks.

Path	Duration
A – C	11
A – B – D	11

Extra cost of crashing activity A = 5 × 300 = 1500
Direct cost = 16900 + 1900 = 18400
Indirect cost = 11 × 250 = 2750
Total cost = 21150

We see that, still there remains two critical path. In both of the paths activity 'A' is common and has been fully crashed. Activity 'D' is fully crashed previously. Therefore, remaining activates 'B' and 'C' are to be crashed by 3 weeks ['B' has 3 weeks, 'C' has 4 weeks] taking minimum of two for simulataneous crashing.

Path	Duration
A – C	8
A – B – D	8

Extra cost of crashing B and C = 3 × 400 + 3 × 200
= 1200 + 600 = 1800
Direct cost = 1800 + 18400 = 20200
Indirect cost = 8 × 250 = 2000
Total cost = 22200

Here, the total cost increases than previous one i.e. (reducing beyond 16 weeks) project cost at the project duration of 16 weeks is less than the succeeding duration.

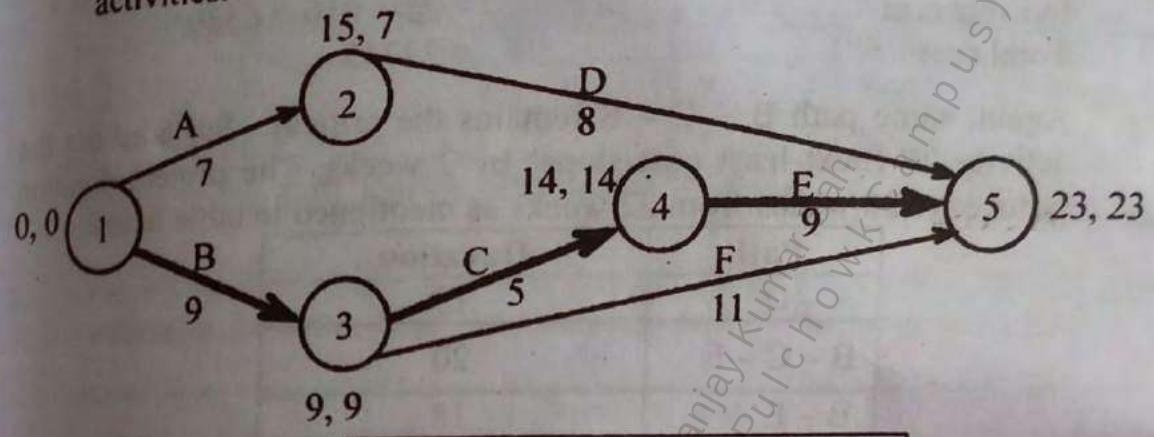
We can conclude that the optimal duration of project is 16 weeks with minimum cost = 20,900

But in fully crashed situation the minimum duration is 8 weeks with corresponding project cost = 22,200

4. *Consider the data of a project as shown in table below :*

Activity	Immediate predecessor	Time (weeks)		Cost (Rs)	
		Normal	Crash	Normal	Crash
A	-	7	4	1800	2100
B	-	9	7	3500	3800
C	B	5	4	2500	2625
D	A	8	5	4000	4225
E	C	9	8	3000	3325
F	B	11	11	3000	-

Sol^n. Drawing the network diagram and identifying the critical path and activities.



Possible Path	Duration (w)	
	Normal	Crash
A – D	15	9
B – C – E	23	19
B – F	20	20

Here, B – C – E is the critical path with project completion be 23 weeks

Direct cost = 178000

Indirect cost = $23 \times 310 = 7130$

Total cost = 24930

Now finding the cost slope of all activities and ranking them.

Activity	Difference in cost (D_c) crash lost - normal cost	Difference in time (A_t) = normal duration - crash duration	Cost slope	Rank
A	300	3	100	2
B	300	2	150	4
C	125	1	125	3
D	225	3	75	1
E	325	1	325	5
F		-	-	-

Along the critical path B – C – E, activity 'C' has least cost slope, so crashing it by 1 week. The project duration reduces to 22 w from 23w which is detailed in table below.

Path	Duration
A – D	15
B – C – E	22
B – F	20

Extra cost of crashing activity C = 1 × 125 = 125
Direct cost = 125 + 17800 = 17925
Indirect cost = 21 × 310 = 6620
Total cost = 24745

Again, same path B – C – E remains the critical . So, crashing the activity 'B' (next least cost slope) by 2 weeks. The project duration reduces to 20 weeks from 22 weeks as mentioned in table below.

Path	Duration
A – D	15
B – C – E	20
B – F	18

Extra cost of crashing activity B = 2 × 150 = 300
Direct cost = 300 + 17925 = 18225
Indirect cost = 20 × 3100 = 6200
Total cost = 24425

Here, again same path B – C – E is critical. Therefore selecting activity 'E' for crashing by 1 week.
The project duration reduces to 19w from 20w.

Path	Duration
A – D	15
B – C – E	19
B – F	18

Extra cost of crashing activity E = 1 × 325 = 325
Direct cost = 325 + 18225
Indirect cost = 19 × 310 = 5890
Total cost = 24440

Here the total cost in this duration is greater than previous one. Therefore further crashing will not reduce the cost [no activity remains to crash among critical path similarly no significant by crashing other activity except critical].

Hence, the optimal project duration is 20w and corresponding minimum cost = 24425

Chapter #3 (Lecture #1)

Planning Construction Materials

Classification of Construction Materials:

The type and quality of construction materials differ from project to project. Although, some basic materials, like cement, steel, water, and timber are common items, others vary with the type of the project. For example, most of the finishing materials that is being used in housing projects may not be required in industrial projects.

The primary purpose of classifying construction materials is to control quality, cost, and timely supply. There are many factors that need consideration while classifying materials, which include

- storage space
- useful life
- supply reliability
- inventory costs
- ease of identification
- construction sequence
- transportation requirements
- price
- procurement time
- procurement source, and
- project life.

In general, the construction materials can be grouped into anyone or a combination of the following categories:

* Bulky, one-time purchases, repititive use and minor materials.
* Vital, essential and desirable materials. (VED)
* Indigenous and imported materials.
* High price, medium price and low-price materials. (HML)
* High usage value, medium usage value and low usage value materials (ABC)

The most commonly used method for classifying construction materials is to group them into high usage value, medium usage value, and low usage value materials. This classification is achieved using the ABC analysis approach.

ABC classification of Construction Materials:

ABC analysis is the method of classifying items of materials involved in decision making on the basis of their relative importance. The ABC analysis is done to manage different inventories of an organization that are not all equal in value or order frequency. Thus, the inventory is grouped into three categories (A, B and C) in order of their estimated importance.

The material management technique of ABC analysis is generally used for inventory control of regular stock items. Studies show that regular stock items, depending upon their periodic requirement and costs, can be grouped into three groups of materials i.e. A, B and C, generally confirming to the following pattern:

ABC Grouping

Group class	Total items	Inventory costs
A	10% (5-15%)	70% (60-80%)
B	20% (15-25%)	20% (10-30%)
C	70% (65-75%)	10% (0-20%)

a) Group 'A' items: These are high usage value items, require the tightest control, frequent deliveries, close follow-ups and accurate records. Planning and scheduling of these parts require MRP (Material requirement planning), DRP (Distribution requirement planning) or EOQ (Economic order quantity) or other lot sizing techniques. Numbers of such items is about 10% (5-15%) of all items, which accounts for 70% (60-80%) of the total inventory costs.

b.) Group B items: These are medium usage value items, which require normal control and good records. These are less important than 'A' items and more important than 'C' items. Numbers of such items is about 20% (15-25%) of all items, which accounts for 20% (10-30%) of the total inventory costs.

c.) Group 'C' items: These are low-usage value items i.e. of lowest priority, require simplest method of control. Numbers of such items is about 70% (65-75%) of all items, which accounts for hardly 10% (0-20%) of the total inventory costs.

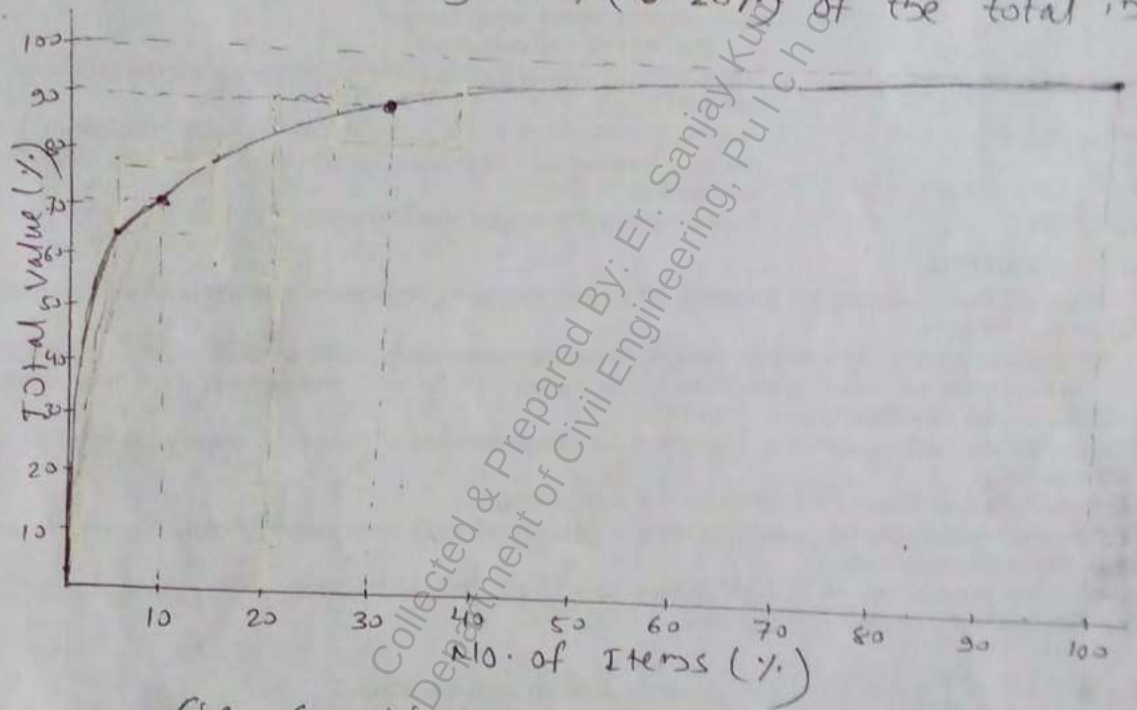


Fig. Graphical Representation of ABC Analysis

The above concept of ABC analysis can be applied for the categorisation of repititive construction materials, where the period of usage can be taken as the project completion period or on a yearly basis. The number of items can be considered as those required for the project execution. For further simplification, these can be restricted to the construction materials estimated for the works.

Advantages of ABC analysis:

→ It facilitates in selective control
→ Saves valuable time of management
→ Eliminates unnecessary paper work in various other control.
→ Categorization of materials makes cost effective and control.

Disadvantages of ABC analysis:

→ A wrong classification leads to cost increment and schedule delayed.
→ ABC analysis is unsuitable during market fluctuations.

Methodology used in ABC analysis (precedural steps)

The ABC group of construction materials can be carried out by following way:

→ Identify all the materials required and estimate quantities.
→ Assess the requirement during the period of consideration, i.e. yearly or project completion basis.
→ Determine the usage value of each item by multiplying the quantity required with corresponding unit rates.
→ Calculate the percentage usage value of each item with respect to total project or yearly usage cost.
→ Arrange items in the descending order of usage value.
→ Consider materials in the descending order of usage value. Compute cumulative usage value against each item.
→ Draw two horizontal lines demarcating the descending order of the cumulative purchase value at 70% (60-80%) level, 20% (10-30%) and 10% (0-20%)
→ The three groups separated by two horizontal lines starting in descending order of usage value can be classified as A, B and C groups.

Tutorial:

From the following details, draw a plan of ABC analysis.

Item	Units	Unit Cost	Usage value
1	7000	5	35,000
2	24000	3	72,000
3	1500	10	15000
4	600	22	13200
5	38000	1.5	57000
6	40,000	0.50	20,000
7	60,000	0.20	12,000
8	3,000	3.50	10,500
9	300	8	2400
10	29,000	0.40	11,600
11	11500	7.00	80,500
12	4100	6.20	25,420
13	1000	2.5	2500
14	500	7	3500
15	2850	2.5	7125
16	393	1.85	727.05
17	700	1.45	1015
18	355	0.98	347.9
19	15	5	75
20	150	6.50	975

Soln

First of all usage value are calculated for each items as in last column of above table.

Now, writing the above table in descending order w.r.t. usage value of each item and then calculating % of no. of item, cum. % of no. of item, % of usage value & cum. % of usage value as below:

Item Id.	Item %	Cum. % of Item	usage value	% usage	Cum % of usage	
11	5%	5%	80,500	21.7	21.7	
2	5%	10%	72000	19.41	41.12	
5	5%	15%	57000	15.37	56.49	A
1	5%	20	35000	9.44	65.92	Item - 20%
12	5	25	25420	6.85	72.78	usage - 65.92%
6	5	30	20000	5.39	78.17	B
3	5	35	15000	4.04	82.21	Item - 25%
4	5	40	13200	3.56	85.77	usage - 23.09%
7	5	45	12000	3.24	89.01	
10	5	50	11600	3.13	92.14	
8	5	55	10500	2.83	94.97	C
15	5	60	7125	1.92	96.89	Item - 55%
14	5	65	3500	0.94	97.83	usage - 10.99%
13	5	70	2500	0.67	98.51	
9	5	75	2400	0.65	99.15	
17	5	80	1015	0.27	99.43	
20	5	85	975	0.26	99.69	
16	5	90	727.05	0.20	99.89	
18	5	95	347.9	0.09	99.98	
19	5	100	75	0.02	100.	

3.2.) Material Wastage Standard:

Material wastage occurs during usage, handling and the execution of work. Materials quantity estimates are prepared by the quantity surveyors from the contract drawings. But there is inherent materials wastage associated with all types of materials. Material quantity surveyors must include standard wastage in materials estimates. The wastage of materials is expressed in terms of percentage of materials calculated theoretically from quantities of work involved and are termed as standard wastage.

The materials to be provisioned for wastage are

$$\text{Theoretical quantity of materials} \times \frac{100 + \text{standard wastage}(\%)}{100}$$

Standard wastage of the construction materials depends upon many variables. such as

- nature of work
- type of material
- workmanship
- Method of application.

The standard wastage can best be specified from experience. The typical standard wastage considered while estimating some of the materials in a housing project are as follows:

	Normal wastage
1.) Cement	2%.
2.) Sand	10%.
3.) Aggregate	5%.
4.) Concrete (structure)	2%.
5.) Concrete (Blinding)	10%.
6.) reinforcement (rebars)	3%.
7.) reinforcement (mesh)	10%.
8.) PVC sheeting	15%.
9.) steel for windows	7%.
10.) Timbering in trenches	5%.
11.) Stone Masonary	5%.
12.) Marble lining	20%.
13.) wood for door frame	5 to 7.5%.
14.) wood for shutters	10%.
15.) wood for flooring/walling	5 to 10%.
16.) Sheet roofing	2.5%.
17.) Tile roofing	5%.
18.) Floor tiling	2 to 5%.
19.) wall tiling	3%.
20.) painting	5%.

It may be noted that standard wastage, listed above, caters for wastage during the utilization. There are other kinds of wastage which can be controlled significantly through good management practices. The wastage listed below are the controllable wastage at various stages:

→ Wastage on account of designers specifying non-standard materials, having unattainable specifications.
→ Wastage due to incorrect purchasing, resulting in overbuying, wrong buying, unnecessary buying and untimely buying.
→ Wastage in transportation and handling, including breakage and pilferage (चोरी हुने)
→ Wastage during storage resulting from deterioration, improper storage, breakage, obsolescence and theft.
(being outdated)

3.3) Material Provisioning Process

Construction materials needed for a project work varies with the nature of the project. The determination of the type, quantity and specifications of the construction materials needs a detailed study of Contract's documents, including the bill of quantities, drawings, specifications; pre-tender estimates, and preliminary vendor enquires. Such a study consumes considerable time and is a systematic and gradual process.

The material provisioning process for each item generally follows the sequence outlined below:

1.) Study Contract documents to identify items for purchase.
2.) Estimate quantities to be purchased.
3.) Float inquiry indents to locate sources of supply.
4.) Invite quotations from selected vendors.
5.) Analyse quotations received and vendors' pre-qualifications
6.) Submit proposals for technical, financial and client's approval.
7.) Negotiate with vendors and finalise supply orders.
8.) Place purchase orders and monitor order execution.
9.) Conduct pre-shipment inspections, where necessary.
10.) Inspect goods received at site and initiate action where warranted for in-transit losses/theft/damages, short shipment and rejections of sub-standard supply item.
11.) Close material supply Contract after confirming no-further demand from concerned site manager. Inform accounts, planning, Costing and project manager, accordingly.

In detail, material provisioning process involves following steps:

a.) Identification of materials Package
- includes all the materials required for each item of work.

b.) Materials Quantity Estimation
- as per BOQ followed by norms for each item of works.
- must include wastage in materials.

c.) Scheduling Materials Requirements
- usage schedule (material schedule) based on construction schedue.

d.) Materials procurement Enquires.
- quality & its past records, recent test reports, performance reports, performance reports from old users etc.
- suppliers performance & financial status.
- suppliers management team, professional competency and engineering skills.
- support services etc.

e.) Finalisation of source Materials procurement:
- Comparision of various proposals.
- client's approval for proposed materials.
- Negotiation of terms of supply
  - prices
  - mode of transportation
  - mode of payment
  - mode of inspection
  - delivery schedule.
  - guarantee, penalties.

f.) Monitoring Materials Delivery schedule
- preparing & monitoring the material sample approval.
- pre-transportation inspection.
- obtain/verify periodic transportation/shipment information.
- checking custom clearances & other formalities.
- plan for material recieving, unloading, inspection, storing etc.
- checking quality & quantity as per requirement and obtaining discrepencies, if any, to inform for the further actions.

3.4.) Material Inventory Basics:

Inventory: A complete list of items such as property, goods in stock, or the content of a building etc.

Inventory Management:

It involves the control of the inventories that are used in production and construction process or produced to be sold in the normal course of the firm's operations. It is a technique to maintain the optimal level of stock of goods. An efficient inventory management helps to determine what to purchase, how to purchase, from where to purchase and where to stock, etc. In a construction site, overstocking of construction materials will mean high handling cost and understocking will result in stoppage of work due to lack of proper inventory management.

Need for Planning Inventory and objectives of Inventory Management:

Generally, each construction project starts with zero material stock and after the left-outs are disposed off, it ends up with zero-stock. Ideally, each construction activity prior to commencement should have zero-stock; during execution, there should be working stock sufficient for a very short period and should get replenished regularly as soon as it is about to finish; and finally, it should end up with zero-stock, when the activity is completed.

Inventory management helps to avoid over and under investment in inventries and also help to maintain the minimum level of inventory prepared for production and distribution. It always attempts to fix the ordering level and quantity to minimize the cost of ordering and holding inventories. The main objective of inventory management are:

a) to maintain adequate stock of raw material and finished goods for smooth construction, production and sales operation.

b.) to ensure an adequate supply of materials and orders of required quantity with a reasonable price.

c.) to provide the information about inventories for planning and control of inventory.

d.) to optimize the investment in inventories by minimizing carrying and ordering cost.

e.) to minimize the stock out and shortage.

Types of Inventory:

Inventries are the stocks of materials, a firm is manufacturing for sale and components that make up the product.

a.) Raw materials

b.) Work in progress

c.) Finished goods

d.) Stock of cash.

Inventory costs terminology:

* Inventory cost: is the cost of maintaining inventory. It comprises carrying cost and ordering cost.
* ordering cost: is the cost incurred in ordering the materials for construction.
* Carrying cost or Halding cost: is the cost incurred in storing or halding an item till it is required.
* Demand: is the number of units required per period of time. This can be deterministic as well as probabilistic.
* Lead-time: is the time period elapsed between placing an order and its arrival in the inventory stock.
* stock replenishment: is an operation that consists in making the stock full again in order to avoid stock-out. Replenishment is typically intiated by preorder to supplier.

Classification of Inventory Cost:

* Ordering cost (OC)

Ordering cost = Cost per order x Number of orders

i.e. $OC = C_o \times N$

where,

Number of order (N) = $\frac{\text{Total Requirement (Cost)}}{\text{Quantity per order (Cost)}}$

* Carrying cost (CC)

Carrying cost = carrying cost per unit x Average stock.

i.e. $CC = C \times (Q/2)$

$\therefore CC = (C_i \times P) \times \frac{Q}{2}$

where C_i = carrying cost expressed as % of unit price of an item

P = unit price of the item.

* Cost of safety stock (SSC)

Cost of safety stock = safety stock (unit) x carrying cost per unit

i.e. $SSC = SS \times C$

$= SS \times (C_i \times P)$

* Total Inventory cost (TC)

Total inventory cost = ordering cost + carrying cost + cost of safety stock

i.e. $TC = C_o \times N + C \times \frac{Q}{2} + SS \times C$

Chapter #3 (lecture #3)

Economic order Quantity (EOQ):

While planning repititive materials inventory, two important decisions that needs to be taken are:

- how much to order at one time, and
- when to order this quantity.

In other words,

It is required to decide the reorder quantity level and the reorder time cycle, so as to effect economy in cost of purchasing and carrying/holding inventory. EOQ is that quantity at which total inventory cost is minimum. For this the total carrying cost must be equal to total ordering cost. i.e.

Total ordering cost = Total carrying cost

i.e. $OC = CC$

i.e. $C_o \times N = C_i \times P \times \frac{Q}{2}$

i.e. $C_o \times N^2 = \frac{C_i}{2} \times Q \times N \times P$

i.e. $C_o \times N^2 = \frac{C_i}{2} \times A$

where, $A = Q \times N \times P$

= total consumption cost

= total consumption quantity × unit price

$\therefore C_o \times \left(\frac{A}{QP}\right)^2 = \frac{C_i \times A}{2}$

i.e. $Q^2 = \frac{1}{P^2} \frac{2C_oA}{C_i}$

$\therefore$ Economic order Quantity (EOQ) $= Q = \frac{1}{P}\sqrt{\frac{2C_oA}{C_i}}$

where, A = total consumption cost

C_o = cost per order

C_i = carrying cost expressed as % of unit price of an item.

Also,

Total least cost of inventory

$$= C_o N + C_i \times P \times \frac{Q}{2}$$

$$= C_o \times \frac{A}{Q P}$$

$$= 2 C_o N \quad \because C_o N = C_i \times P \times \frac{Q}{2}$$

$$= 2 C_o \times \frac{A}{Q P}$$

$$= 2 C_o \times \frac{A \times P}{Q} \times \sqrt{\frac{C_i}{2 C_o A}}$$

$$= \sqrt{\frac{4 C_o^2 A^2 \cdot C_i}{2 C_o A}}$$

$$= \sqrt{2 C_o C_i A}$$

The inventory cost function plotted in figure below is made up of inventory carrying cost function and ordering cost function. The inventory carrying cost (CC) and ordering ordering cost (OC) vary with the order quantity (Q), but they move in opposite directions i.e. when Q increases, CC increases and OC decreases. The intersection point of these two functions indicates the economic order quantity, EOQ, which results in least investment.

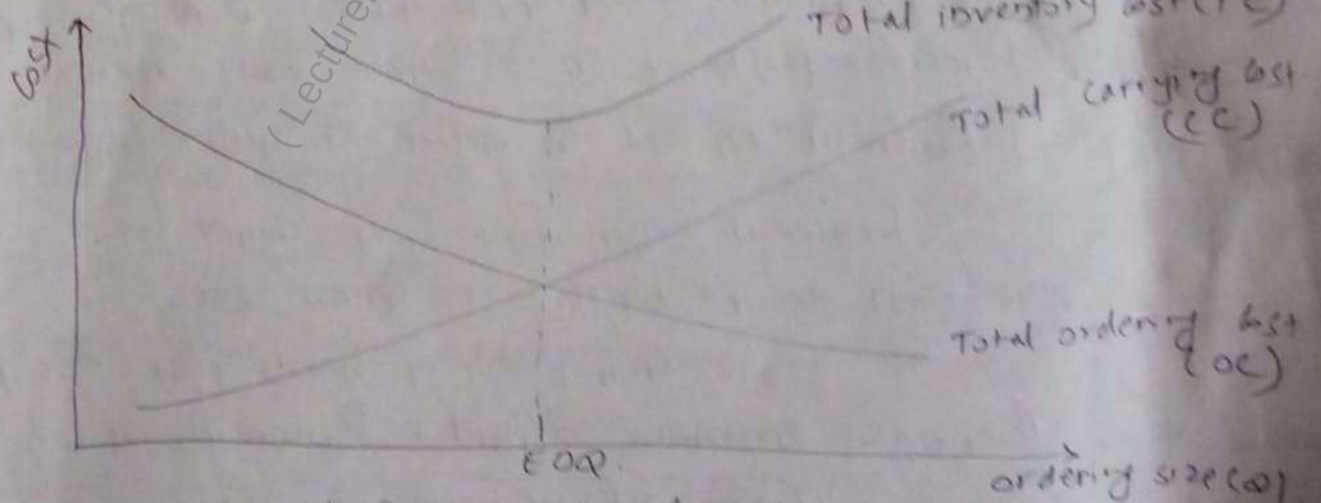


Fig. Material inventory cost function.

Trial and Error Approach of EOQ:

Under this approach, total cost (ordering cost and carrying cost) for each order size is calculated. The size of materials where the total cost is lowest, will be the economic order quantity (EOQ)

EOQ with quantity discount:

In business, the seller of goods offers quantity based discount to the purchaser. The quantity based discound will affect the unit price of goods. Generally, the larger the size of order, the greater the discount and lower the purchase price per unit. It also affects EOQ decision.

Stock level:

→ level of materials or inventories.

Minimum stock level or Safety stock: (SS)

It is that level of inventory that must be maintained in hand all the time. The inventory level should not go below this as it may create disturbance in the production.

Maximum stock level:

It represents the maximum quantity of item of materials that can be held in stock i.e. EOQ + SS.

Average stock level:

→ represents the average level of stock
i.e. SS + EOQ/2.

Re-order level or re-order point (ROL/ROP)

The level of inventory at which the re-order should be placed. If the order is made before this point, the average inventory will be high and carrying cost of inventory will increase. Similarly, if the order is made after reaching below this level, the stock will not be sufficient for operation. The re-order depends upon the lead time and safety stock.

ROL = Safety stock + lead time x average consumption
- Goods in transit.

Goods in transit (GIT):

Goods which have been ordered but have not yet been received. There will be goods in transit at the time of re-order if the lead time is longer than the order periods (ordering frequency).

3.5) Inventory planning process:

The construction materials inventory plan aims at evolving materials of stock-holding levels to meet project execution plan, with minimum inventory investment.

If all the items with similar characteristics are stored under similar conditions and procured from a similar source, then order cost and carrying cost can generally be considered as constant. However in real life situations, the carrying cost is not constant for all type of materials, but varies with consumption value, the volumetric size of material as well as with storage type, while ordering cost depends upon the location of source. For these reasons, while planning inventory, materials with similar source and storage characteristics can be grouped together and ordering cost

and carrying cost for each group can be determined separately.

Construction materials of different categories based on location of the supply source, can be further sub-divided into locally available materials and imported materials. These materials, from storage considerations, can be further divided into bulky and non-bulky items. It is also appropriate to consider lead-time for the supply of these materials.

a.) Planning Inventory of Repetitive Materials:

The inventory planning for the repetitive construction materials involve determination of economic order quantity, fixing of maximum and minimum stock limits, lead time for stock replenishment and reordering point (ROP) for each item of 'A' and 'B' category. Construction materials i.e. high value materials.

The simplified model of inventory replenishment pattern as shown in figure below depicts the economic order quantity, working stock, the safety stock, the minimum stock level, the maximum stock level, and the number of replenishment or re-order points (ROP), during the usage period, for each material.

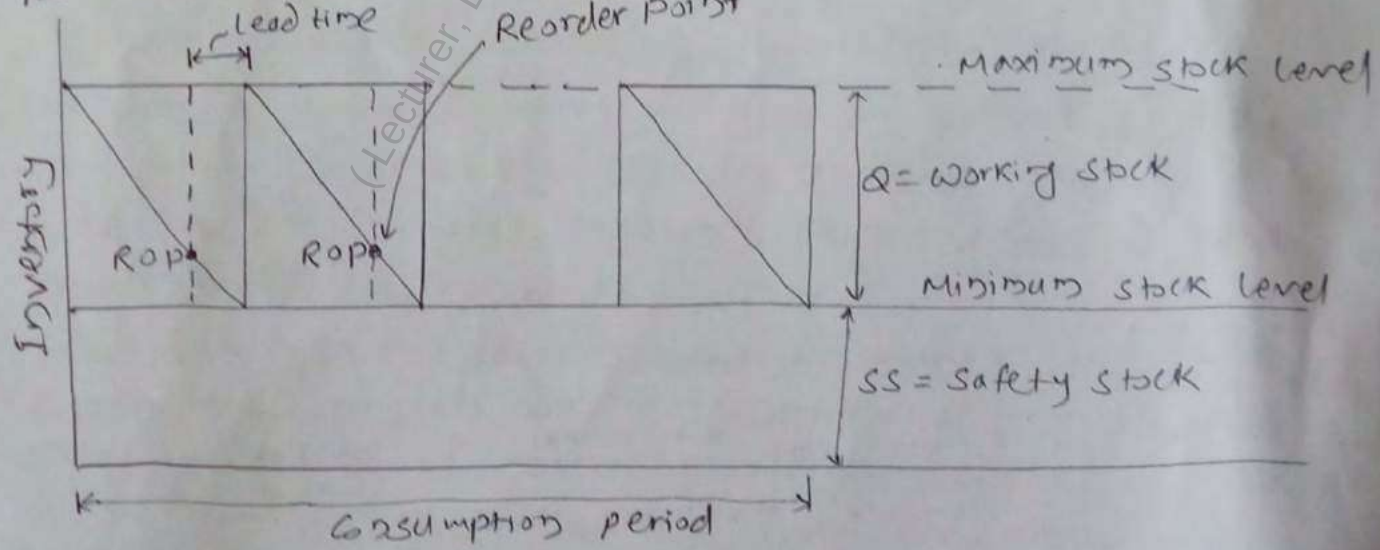


fig. Inventory Replenishment Model:

b) Planning Inventory of Non-repetitive one-time purchase Materials:

These are non-regular and mostly one-time purchased items of construction materials. These materials are purchased for a specific purpose, such as architectural fittings and fixtures, water supply and sanitation, HVAC and electrical and mechanical works and movable and fixed equipment like pumps and generating sets.

It is important that non-repetitive materials must be inter-linked with connected construction activities and specifications, and possibly codified during the identification stage. In case of non-repititive items, the aim should be to have a zero inventory prior to commencement of activity and after completion of the job with low average during execution.

The procurement of non-repetitive materials should be properly scrutinised, so that no surplus material is left-over, after the activity is completed. However, it should be remembered that it is better to stock in advance, if there is chance of non-availability in the market when these non-repetitive items are actually required.

C.) Minor Materials Items Inventory:

Minor materials consist of low-cost, commonly use and frequently needed stores or items for various construction activities. These stores include tradesmen tools and frequently used minor, indirect, regularly consumed materials like screws, nails and Cordage (cord or rope) etc.

Typical stores are needed for mobilisation of building construction projects by a contractor at remote location. The quantity of minor materials held at any point of time can be controlled by specifying minimum and maximum limits for each item.

6.) Application of Value Engineering in the procurement of materials:

Value Engineering:

→ It comprise a series of techniques that are aimed at an organised systematic effort directed at analysing the function of items, products, equipment, processes and procedures, for the purpose of accomplishing all the required functions at the lowest total cost. This cost covers not only initial cost but also ownership cost covering operation/maintenance, disposal costs etc., throughout the desired or specified life cycle of the articles or subject under study.

→ Value Engineering is the systematic application of recognised techniques by multi-disciplined teams, which identifies function of a product or service; establish a worth for that function; generate alternatives through the use of creative thinking; and provides the needed function reliably at the lowest cost.

→ Though, the definitions varies, the common focus in all these definitions is that the process of value engineering involves, function orientation, organised approach and creative thinking; having the basic equation, that is

$$\text{Value} = \frac{\text{Worth}}{\text{Cost}}$$

Function orientation:

The value of a product or service is the worth for the functions it perform and the cost allocated for performing the functions. The term 'function' is used to mean the purpose or use of a product. Thus, to measure worth, the product or process is first translated into the functions. Cost is also not simply the initial price but must also include follow-on costs during the life cycle of the product.

* Creative thinking:

The value of a product can further be divided into following categories:

1.) Basic value: The properties and qualities, which accomplish a useful purpose or service.

2.) Esteem value: The properties, features or attractiveness, which cause a customer to want or own it.

3.) Cost value: The cost of labour, material and various other expenses required to produce it.

4.) Exchange value: The properties or qualities that enable us to exchange it for something else we want.

The value of a product can be increased by:

* Improving the functional utility without change in cost.
* Retaining the same functions for less cost.
* Combining improved functional utility with less cost.

Both, value Engineering and Cost Reduction, aim at reducing costs but there is a basic difference between these techniques. Value Engineering is function-oriented, whereas Cost Reduction is production oriented. Value Engineering aims at functional cost effectiveness by avoiding unnecessary costs; it involves

multi-discipline team effort; and applies innovative and creative techniques to maximise value. On the otherhand, Cost Reduction aims at changing the method of production to reduce the production cost of an item, it involves usually an individual effort and generally, its emphasis is on analysis of the past practices and processes to reduce costs.

Value Analysis Job Plan:

The value Engineering job plan attempts to generate, identify, and formulate the best value alternative for making specific recommendations supported with proper data and identifying the actions necessary for its implementation. Miles' system followed a rigorous six-step procedure, which he called the value Analysis job plan, for conducting the studies. others have varied the job plan to fit their peculiar constraints. A modern version has the following steps:

i.) Planning and organisation: the study objectives, the composition of the study team, information on which to base the study, and designing the organisation for the study.

ii.) Information gathering: varies widely depending on the type of objective.

iii.) Functions and Cost Identification: tabulated in matrix format.

iv.) Development of ideas and means for solution: alternative methods and better ways of doing things are explored.

v.) Study and Evaluation of solutions: A number of techniques are used to identify the best ideas and prioritise them in terms of cost, time, and practicality.

vi.) Appraisal of proposed solutions: Developed initiatives are formally presented to senior management along with alternatives and appropriate financial analysis, where investment is required.

iii) Implementation phase: Selected proposals are implemented and new approaches are brought into practice.

viii) Follow up after implementation: It is essential that implemented proposals are systematically followed up to ensure that full benefits are achieved.

Creating Value Analysis Awareness:

Value analysis awareness can be created by subjecting each material procurement order to the following checklist:

a.) Eliminate: If the function does not add anything desirable to the end product.

b.) Alternate: Explore the better or cheaper alternatives.

c.) Standardisation: If the component performing function is a non-standard; locate a standard item that serves the purpose at cheaper rates.

d.) Modification: If the item cost is not reasonable in terms of its function to the end-product or end-operation, try modification, substitution, or combination of other functions to make it cheaper.

e.) Consumption reduction: Analyse the process to explore, if the consumption of the item can be cut down by value analysis.

f.) Redesigning Component: If the specifications and tolerances are too complex.

g.) Make decision: Analysis of reasonable cost of material, labour, over-heads, and reasonable profits roughly equals the quoted price. If not, further investigation is needed. Also examine part buy or buy unfinished parts and finish at your own works or vice-versa.

h.) Supply source: Locate another dependable source supply at a lesser price or better material at the same price, if the present source of supply is not the best.

i.) Imported Components: Can you do without it? If not, it is possible to obtain it from indigenous sources.

Scope for Application of Value Engineering in the Procurement of Materials:

Value Engineering is an important tool of materials management. There is virtually no group of materials or services which can not be value-analysed. In project environments, where the designs are finalised before the starting the project, there is great scope for value analysis in the materials procurement phase. Some of commonly used project materials, which can be value-analysed, are:

i.) Select materials of A (high usage value) and B (medium usage value) as categories for value Engineering. Even a small percentage of reduction, after value analysis, for an A item will mean substantial reduction in over-all costs.

ii.) Select materials whose quality, prices and deliveries are not favourable. Value Analysis can aid in finding substitutes, which can be obtained from other sources.

iii.) Select materials being imported. Value Analysis can assist in locating domestic substitutes.

40 Marks

x Calculate EOQ of cement with following details:

Total Quantity = Q x N = 12,000 bags.

$C_i = 15\% = 0.15$

$C_o = 10,000$

$P = 750$

We know,

$$EOQ = Q = \frac{1}{P}\sqrt{\frac{2C_oA}{C_i}}$$

where $A = Q \times N \times P$

$= 12,000 \times 750$

$$\therefore EOQ = \frac{1}{750} \times \sqrt{\frac{2 \times 10,000 \times 12,000 \times 750}{0.15}}$$

$= 1460.59$ bags

≈ 1500 bags (say)

$\therefore$ No. of orders $= N = \frac{12,000}{1500} = 8$

Tutorial:

* Calculate EOQ and reorder point if rebar required is 1000 tonnes; ordering cost is Rs. 10,000; carrying cost is 15%, rebar rate is Rs. 90,000 per tonne; safety stock is 50 tonnes; lead time is 4 days and consumption per day is 50 tonnes. (2071 Bhadra.)

Sol.)

Total Quantity = $Q \times N$ = 1000 tonnes

ordering cost, C_o = Rs. 10,000

Carrying cost; C_i = 15% = 0.15

unit price, P = Rs. 90,000

Safety stock, SS = 50 tonnes

Lead time = 4 days

Consumption per day = 50 tonnes

We know,

$$EOQ = Q = \frac{1}{P}\sqrt{\frac{2C_oA}{C_i}}$$

where $A = Q \times N \times P$

$= 1000 \times 90,000$

$$\therefore EOQ = \frac{1}{90,000} \times \sqrt{\frac{2 \times 10,000 \times 1000 \times 90,000}{0.15}}$$

$= 38.49$ tonnes $\approx$ 40 tonne (say)

$\therefore$ Number of order, $N = \frac{1,000}{40} = 25.000$

≈ 26

~~$\therefore$ Lead quantity per order, Q = 40~~

Now, total span of work = $\frac{1000}{50}$ = 20 days.

Now, let us plan the ordering point as below (14)
in table. As we know, the lead time is 4 days & consumption per day is 50 tonnes; it means if we place order on 1st day, it will come on site on 5th days only.

Days	-5	-4	-3	-2	-1	1	2	3	4	5	6	7	8	9
previous stock	-	-	-	-	-	80	70	60	50	80	70	60	50	80
No. of order	2	1	1	1	2	1	1	1	2	1	1	1	2	1
Material Received	-	-	-	-	80	40	40	40	80	40	40	40	80	40
Consumption	-	-	-	-	-	50	50	50	50	50	50	50	50	50
Balance stock	-	-	-	-	80	70	60	50	80	70	60	50	80	70

Days	10	11	12	13	14	15	16	17	18	19	20
previous stock	70	60	50	80	70	60	50	80	70	60	50
No. of order	1	1	2	1	1	1	-	-	-	-	-
Material received	40	40	80	40	40	40	80	40	40	40	-
Consumption	50	50	50	50	50	50	50	50	50	50	50
Balance stock	60	50	80	70	60	50	80	70	60	50	0

Chapter 4 (# Lecture # 1)

Familiarization with Construction Equipment:

Construction equipment plays a significant role in the execution of modern, high-cost, and time bound construction projects. An essential item of resources, construction equipment produces output at high speed and enables completion of tasks in a limited time. Equipment saves manpower, a source, which is becoming scarce, costly, and more demanding day-by-day. Moreover, equipment improves productivity, quality and safety.

The use of construction equipment depends upon the purpose and function. In general, construction equipment classification facilitates identifying the equipment, verifying stock, locating the spares, recording repairs, accounting for costs, indexing catalogues, logging performance, monitoring effectiveness, estimating output and planning procurements.

Advantages of using equipment:

→ Large and complex works can be carried out easily.
→ Increase the rate of output through work progress with best effective and efficient methods.
→ Reduce the overall construction costs especially for large projects.
→ Carry out the activities which can not be done manually or to do them more economically and much faster.
→ Eliminate the heavy manual work by human thus reducing fatigue and eliminates various other hazards and health issues.
→ Maintain the planned rate of production where there is shortage of skilled & unskilled labour.
→ Maintain high quality standards often required by present day design and specifications.

→ Equipment can work in adverse weather, climatic condition and topography.
→ Equipment helps to maintain construction site safer and cleaner.

Dis-advantages of using equipments:

→ Require huge capital investment
→ Need costly repair & maintainance.
~~→ Skilled persons~~
→ requires skilled person to operate equipment.
→ Replaces large numbers of labours and raise unemployment.
→ Contractors in small projects create issue over buying or renting of equipments and may charge high costs.
→ less environment friendly than green technology.

Equipment for Excavation:

Earthwork in Excavation is basic task in Civil engineering projects. Excavation may be in the surface of ground or below the surface of ground. Excavation is done for foundation or for collection & production of construction materials. Followings are the commonly used excavating equipment in the construction works:

a.) Excavator:

It has small hoe attached. Hoe is teeth attached bucket. It is capable of excavating to a depth. Excavation is done by teeth attached to a bucket, which is also capable of loading the excavated material directly to a transporting vehicle.

This is one of the largest pieces of construction machinary. This machine has a boom, stick and bucket and is able to rotate 360°, so one can easily dig and move soil to

ge distances without having to drive the excavator to different location.

Other tasks can also be accomplished by using hydraulic attachments such as grapples, augers or Jack hammers.

* Backhoe:

→ a mechanical excavator that draws itself a bucket attached to a hinged boom
→ Excavation done by down-ward motion.
→ only rotates 200°.
→ generally track mounted with small capacity.

b.) Power shovel / Loader:

→ It has a square tilting bucket on the end of the movable arms to lift and move materials. The loader assembly may be a removable attachment or permanently mounted on the vehicle.
→ These are also called loader because they are used to excavate earth and load into a truck or on to a conveyer belt. They may be either crawler mounted or pneumatic wheel mounted.
→ It is capable excavating loose materials but generally used for moving or loading loose materials like soil, sand or aggregates etc. as well as levelling of dumped soil in filling area.

c.) Dozers / Bulldozers:

→ Dozers are versatile mechanical equipment for scraping and excavating in both firm and hard soil to low depth.
→ It can push the excavated material to the other place with its blade.

Dozer/Bulldozer are generally track-mounted.

→ Dozers excavate and push earth with the help of a stiff blade that is fitted in front and controlled by two hydraulic cylinders.

→ A dozer can also be fitted with a backhoe attachment for ripping hard soil & rock, winch for uprooting trees, skidding boulders and heavy materials.

→ Major uses

* open pilot road on relatively mild sloped topography.
* remove vegetation, bush and shrubs.
* remove top soil
* remove tree stumb.
* Ripping rocks.
* Shall excavation with pushing.
* Levelling ground and spreading soil.

etc.

d.) Backhoe loader (familiar conversation, informally)

→ also called as loader backhoe or, colloquially shortened to backhoe.

→ It is a heavy equipment vehicle that consists of a tractor like unit fitted with a loader type shovel/bucket on front and a backhoe on the back.

→ Due to its versality and small size, backhoe loaders are very common in small construction projects.

e.) Drag lines:

→ The drag line is a multipurpose machine capable in wide range of operations. It works on soft to medium hard material.

It has a long light crane boom with buckets so that it can dig and dump the excavated material over long distances eliminating the need of hauling equipment.

→ It can handle wet material or under water digging standing on the firm soil from pit.

→ It may be track mounted, wheel mounted or truck mounted.

f.) Clamshells:

→ The name of this machine is derived from the shape of bucket. The shape of bucket is hinged double shell

→ This bucket performs the tasks such as digging, excavating and lifting material from narrow pits; deep foundations like coffer dam, well foundation, manholes etc. They can be specially used to lift the material vertically.

→ Clamshells are used to handle the loose materials such as sand, aggregate, gravel, crushed stones or loose soils etc.

g.) Trenching Machines:

→ These are special machines to dig trenches.

→ These machines are designed for excavating ditches of considerable length and varying depths and widths.

→ They are available in the different sizes & capacity.

→ very useful for digging water pipeline, gas pipeline, cable trenches and sewer ditches, where the soil & job conditions permit.

→ Usually they are track/crawler mounted which increase their ~~stability~~ stability and distribution of weight over large area.

Scrappers:

→ these are machines capable of cutting thin layer of earth and taking some excavated material in its bowl/container to be discharged in depressions uniformly.
→ can cut, haul and discharge material themselves.
→ scrapper can be self-propelled or tractor pulled type.
→ self-propelled can be track mounted type or rubber tire mounted.
→ not suitable in location where cutting blade can not work like gravely and rocky strata.

ii) Graders

→ Graders are basically the equipment meant to grade the road surface and other large surface area.
→ with the help of teeth attached to them, they can scarify earths surface to loosen the material which can eventually be shifted forward or to the sides by grading blades. These blades rotates upto 270° in the central ring making it unique to shift the material on all sides.
→ The self-propelled grader are also known as motor grader.

iii) Power Jack Hammer:

→ These are the equipment used to excavate hard rock by drilling and blasting method. Engine to drive the drilling bit is mounted over the jack Hammer.
→ These types of Jack Hammer are very useful for the excavating road or opening trail in mountainous road where larger equipment like air compressor can not be taken to site.

(a) Pneumatic Rock Drills:

- These are equipment for rock drilling operated by compressed air and hence they are called pneumatic rock drills. They can bore a hole in the hard rock upto several meters.

(b) Air Compressor:

These are very important part of excavating equipment when excavation to hard rock has to be done. These compressors drive drilling machines to drill holes in rock and power jack ~~hamer~~ hammer to drill & blast the rock. More than one drilling machine or Power Jack Hammer can be driven with the help of one compressor depending upon their capacity.

Compressor used in the construction project is relatively small, simple and strong enough so that they need minimum maintenance.

* other uses of air compressor
  - operate jack hammer & pneumatic rock drill to drill hole in rock for blasting and clearing.
  - cutting materials with the help of pneumatic circular saws or chains
  - run air operated centrifugal pumps at construction site.

Comparision between wheel mounted and track/crawler mounted heavy equipments:

→ track mounted have better capacity to operate in soft soil or rock surface.
→ track mounted can push large blade load
→ track mounted equipment gives more fatigue to operate than wheel mounted.
→ wheel mounted equipment has less damage on the road surface.
→ wheel mounted has greater output when considerable travel is necessary.

Chapter #4 (Lecture #2)

Transportation equipments:

a.) Trucks or Tippers:

→ Trucks are the hauling units that provide transportation facility for excavated materials, aggregates, construction equipment from one place to another.

→ Trucks can be an ordinary or dump type. ordinary trucks are also called flat-bed trucks which are not capable of self-empty the materials but dump trucks are capable of dumping the load automatically by lifting the body with the help of hydraulic attachment.

→ Trucks provide relatively low hauling costs due to their higher travel speeds.

b.) Rail wagons:

→ Rail wagons are mostly used in tunnel excavation. They are used when large quantity of material has to be transported to large hauling distance.

c.) Mini dumpers:

→ Mini dumpers are small front end dump trucks with small capacity bowl/container in the front.

→ They can dump or unload themselves, hence very handy to use at construction sites.

→ They are used when material to be transported is of very small quantity to a relatively short distance.

d.) Loaders

→ Front end loaders are primarily the equipment to load loose earth into a truck or other transporting device or into bins of crushers or mixers.

→ They are also used to excavate soft soil and transport it while transporting to a short distance.

→ Loader are used to load rocks and stones for crushing aggregates in jaw crusher at site.

e.) Belt Conveyor:

→ Belt Conveyor are generally of fixed type. Belt Conveyor are loaded with the help of loaders. Mostly it is used in gravel and sand quarries.

f.) Bucket Conveyors:

→ They are commonly used to transport earth or other construction material in vertical direction.
→ Bucket Conveyors are efficient means of [redacted] transporting loose materials vertically.
→ Loading is done manually or mechanically and emptying is done automatically.

g.) Ropeways:

→ Ropeways are used when material are to be transported from a fixed location to another fixed location
→ Ropeway buckets are loaded manually or by machine.
→ This is more often used in quarrying operation.

Earth Compacting Equipment:

Earth compaction is done to remove air entrapped into the soil and making it denser to acquire required strength. The equipment used to remove the air from the soil is called compacting equipment. Rollers are in general used for earth compaction.

a.) Smooth wheel roller:

For the compaction of cohesive soils, smooth wheel rollers are commonly used. It consist of three steel wheel one at front and two at back.

b.) Sheep Footed Roller:

→ This roller consists of a hollow steel drum.
→ They are suitable for clayey soil.
→ Pads of the shape of sheep's foot are attached on outer surface of hollow drum.
→ Hollow steel drum is filled with moist sand or stones to obtain the desired weight.

c.) Grid Roller:

→ The working principle of grid roller is same of that sheep footed.
→ The drum of this roller is covered by steel chain grids which gives more pressure on the surface to be compacted.
→ These rollers are used on granular materials when size of the grain is relatively larger.

d.) Vibrating Rollers:

→ Ordinary vibrating rollers are single type steel wheel.
→ It is suitable for granular soil.

e.) Tamping Rollers:

→ A tamping roller consists of one or more hollow steel cylindrical drums with rows of steel studs mounted on it.
→ These studs are punched into the soil and compact it by performing tamping and kneading action.
→ The cylinder drum can also be filled with water or sand to add extra weight while compacting.
→ Sheep footed roller & Grid rollers are type of tamping roller.

f.) Pneumatic Tired Rollers:

→ These are surface rollers and work on the principle of kneading action to produce compaction in the soil below.

→ This type of roller has rubber tyres are suitable for the compaction of the bituminous pavement.

g.) Frog Hammer/Monkey jumpers:

→ These compactors are very useful and handy when area to be compacted is very small.

→ They are generally used to compact backfilling around the man hole, backfilling of the culvert approach or on corners of the structures when other compacting equipment can not reach.

h.) Plate Compactors:

→ These are small hand held equipment used in compacting small area.

i.) Hand Held Roller:

→ These are small drum rollers, generally vibrating and self-propelled.

Aggregate Production & Handling equipment:

* Screening plants:

→ Screening is necessary in order to separate the aggregates by size.

→ Screening plants are selected depending upon the specification of aggregates that are required for the work. In general, following two types of screens are used:

i) Revolving screens

→ are most common types of screens used to wash and screen sand and gravel.
→ The maintenance and repair costs are low as compared to other type of screens.
→ Aggregates are separated by size and stored temporarily in bins below screen.

ii) Vibrating Screens:

→ It is most widely used screens for aggregate production for their efficiency and capacity to handle large amount of materials.
→ These plants come under multiple deck type, screens are installed one above another, called deck.
→ A vibrating mechanism is fitted to the steel frame which holds the screens, therefore all screens vibrate simultaneously.

Crushing plants:

→ A crusher is a machine designed to break and reduce large rocks into aggregates, gravels or rock dust.
→ Crusher may be used to reduce the size, or change the form, of waste materials so that they can be more easily disposed of or recycled, or to reduce the size of solid mix of raw materials (as in rock ore), so that pieces of different composition can be differentiated.
→ The stone chips-aggregates are the most important ingredients of concrete construction of buildings, dams, irrigation structures, bridges, water supply projects and other civil engineering constructions.
→ The product from crusher is taken to screening plant to separate various sizes of aggregates. The range of the sizes depends upon the need of a specific project.

a.) Jaw Crushers:

→ It operates by allowing stone to flow into the space between two jaws, one of which is stationary, while other is movable.

→ Stone is fed between these two jaws opening of which is bigger at the top from where stone is fed and smaller at the bottom to get aggregates reduced to required size.

→ The movable jaw exerts pressure which is required to crush the rock.

b.) Gyratory Crushers

The crusher unit consists of a heavy cast iron or steel frame with an eccentric shaft and driving gear in the lower part of the unit.

c.) Cone Crushers:

These crushers are used as secondary or tertiary crushers. They are capable of producing large quantities of uniformly fine crushed stone aggregates.

d.) Roll Crushers

It can be used as tertiary crushers to produce additional reductions in the size of stone after the output of a quarry has been subject to one or more stages of crushing.

e.) Impact crushers:

→ Impact crushers involve the use of impact rather than pressure to crush material. The material is contained within a cage, with openings of the desired size to allow pulverised material to escape.

→ Hammer mills can be taken as a type of impact crusher.

→ Rod mill is used to produce sand from crushed aggregates.

→ If steel balls are used to give impact in place of rod, then it is named as ball mill.

Chapter #4 (Lecture #13)

Concrete Construction Equipment:

Cement Concrete is mixture of cement, sand, coarse aggregate and water. It is the most widely used construction material in civil engineering construction. Due to its versality, adaptability, availability and economy, its usefulness all over the world and its low maintenance requirements; It is an excellent building material.

A.) Form Work Construction

Form work is either made up of steel or timber. The most commonly used material for repititive type of construction work is the steel plates. In smaller & non-repititive construction projects, timber and plywood are extensively used.

B.) Equipment for Batching of Materials:

→ After proportioning the materials for mix design, batching is done to achieve the correct measurement of the ingredients of the Concrete. Batching is measuring different ingredients of concrete to correct quantity.

→ Batching is either done of weight or volume. For small construction, simple weighing scale or volume batching are commonly used where as for larger concrete construction, automatic batching plant are used. Water and liquid admixtures are generally mensured by volume and other ingredients by weight. The batching plants are available in 3 categories:

* Manual
* Semi-automatic and
* Fully automatic.

c) Equipment for Mixing of Concrete:

The objective of mixing of concrete is to coat the surface of all aggregate particles with cement paste. Mixing allows the blend all ingredients of concrete into a uniform mass. Small quantity of concrete at micro level are mixed by hand which is termed as hand mixing. For good quality of work at macro level, mixing are done through mixing plant. Batch mixers and continuous mixers are two types of readily available mixers for concrete mixing. ~~Batch mixers can be further classified as:~~

→ In batch mixing, all ingredients are loaded into the mixer together or in a predefined sequence and mixed until a homogeneous material is produced and discharged from a mixer in a single lot. The output of a batch mixer is measured in kg/batch.

→ The continuous mixer on the other hand is generally dedicated to a single high volume product. Ingredients are continuously charged into the mixer in accordance with formulation. The mixing takes place as the material travels from the charging port to the discharge nozzle, from where it is continuously discharged. The output of a continuous mixer is measured in kg/hr.

→ Following types of batch mixers are in practice.

a.) Tilting type mixers:

Mixer consist of conical or bowl shaped drum with inside vanes. These vanes revolves on an inclined axis. It discharges mix by tilting drum without seggregation.

b.) Pan mixers:

In this mixer the pan or drum is static type. This mixer is provided with stirrer type of blades and roller for the mixing of grit cement, small granules. The stirrer or blade rotates about vertical axis during mixing. This type of mixer either used at a central mixing plant or at large concrete project or in a laboratory.

c.) Non tilting type mixers:

In this type of mixer, the drum is cylindrical and always rotate about a horizontal axis. The discharge of mixed concrete is obtained either by inserting chute into the drum or reversing the direction of rotation of the drum. Concrete is liable to segregate in this type of mixer due to slower rate of discharge.

d.) Transit mixers

Transit mixers are mounted on a truck. These mixtures are feed with aggregates and cement from a batching plant and add water to mix concrete. The drum of these mixers revolve 70-100 revolutions for complete mixing of concrete.

D.) Equipment for Transportation of concrete:

After mixing of concrete, it should be transported and placed at site as quickly as possible. Segregation and drying should be avoided while transporting the concrete after mix. For most of small jobs, concrete mix is transported manually with the help of wheel barrows or even in a pan carried manually. For any medium to large projects, mechanical equipments are used to transport the

Concrete from mixer to the form work where it has to be laid/placed in the final shape. Depending upon the type of work and equipment available, various methods of transporting of concrete can be practiced:

a.) Pan method:

This method of concrete transportation can be employed for small jobs, where quantity of concrete required is small and labours are available in cheaper rate.

b.) Bucket conveyors:

Bucked conveyors are used to transpoord concrete in vertical direction from bottom to top.

c.) Chutes:

They are used to transfer concrete from ground level to lower level. The chute section should be lined with metal sheet with uniform slope for full length.

d.) Dumpers and trucks:

These are special type of trucks. These dumpers are suitable to transport concrete for relatively longer distance without segregation and setting. Tipping lorries are also used to transport concrete.

e.) Belt conveyors:

Belt conveyors are very convenient in movement of concrete easily to different parts at site. It can transport concrete continuously and is suitable for hot climate, when other method of transportation are not feasible, belt conveyors are the best for alternate solution.

f.) Concrete pumps:

Concrete are transported through pumps. It is very suitable transferring system as it can place concrete at location where it is required

g.) Builders Hoist:

→ similar to bucket conveyors.

→ Now a days at multistory building sites upto 150 m, hoists are used to transport the concrete.

h.) Cranes:

Cranes are commonly used to transfer concrete (or any material) on site ~~for~~ from mixer or a plant of ~~the~~ delivery to formwork at any location or storey at a site.

(E.) Concrete Compaction Equipment:

Concrete mixes are heterogeneous mixture of cement, aggregates and water in a stiff state containing large voids and entrapped air. Consolidation is ~~achieved~~ can be carried out through compaction to remove air voids. Compaction is achieved by the use of mechanical vibrations.

a.) Internal vibrators/Needle vibrators:

It consists of three parts; power unit, flexible tube and vibratory head. The vibratory head is introduced into fresh concrete to vibrate allow ~~compacting~~ compaction of concrete.

b) Plate vibrators/surface vibrators:

→ used to compact concrete with lesser thickness.

→ extensively used in slab.

c.) Vibrating screed:

→ Vibrating screed are also the type of surface vibrators capable of compacting large area of concrete surface giving neat shape to the concrete. They are used in ~~finishing~~ finishing bridge decks ~~etc~~ and also concrete pavement of roads, apron and parking area.

d) Form Vibrator:

→ These vibrators are external vibrators and are attached to the outside of the concrete formwork.

→ They vibrate formwork and inturn formwork vibrates the concrete. These are used in compaction of precast concrete generally.

e) Concrete Rollers:

→ Large static rollers are used for compacting plum concrete construction with greater thickness.

→ Generally used in compaction of Dams.

f) Equipment for finishing of concrete:

After compaction of concrete, the concrete surface is finished by trawling, floating or by belts. Most of the concrete surface is finished by hand trowels for smaller surface area but power trowels are used for larger area. Similarly power floats are used to level area of concrete to accurate level.

Cranes for Lifting:

→ Cranes are versatile and most useful equipment. It is only single equipment capable of providing three dimensional movements to a load virtually in one continuous operation. It is able to perform the operations with speed, safety and precision. It is necessary to know the lifting capacity and working range of a crane to be selected to perform a given job.

→ Classification of Cranes:

a) Stationary cranes: It is also called derrick crane. These cranes have an exceptionally large working radius and can be designed to give any lifting capacity

They may be steam, electric or diesel driven. They may used on a wide range of works, from large civil works to industrial building construction, erection of plants, handing timber, hoisting works at ship yards, ports, loading and un-loading cargos at ports etc.

b.) Over head or gantry crane:

These cranes are used for handling loads over a long rectangular area such as in factories and workshops to move machines and other loads in any directions. These crans consists of a hoisting mechanism mounted on carriage or crab capable of travelling laterally across a girder which spans. The girder resting on wheels travels longitudinally on rails on an overhead gantry.

C.) Mobile crane:

These cranes are mounted on mobile units. Truck cranes have high mobility, whereas crawler mounted cranes move slowly.

d.) Tower crane:

→ Usually this crane is used in the construction of industrial and multi-storeyed residential buildings.
→ These cranes provide high lifting and large working radius.
→ They take limited space around the work site.
→ These are generally of fixed base type mounted on a foundation block.
→ Structural sections can be added to increase height of the crane. There is a vertical limit called "maximum free standing" height to which these cranes can safely rise above the base.
→ A self-erecting tower to greater vertical heights is fairly easy and economical.

→ A self-erecting crane has a short section of hydraulically operated erecting tower that is situated below slewing ring for this purpose.

→ It is also used in assembling of high industrial plants with elements of steel structure including loading and unloading works.

e.) Heavy lifting cranes:

These are basically the system that significantly increases the lifting capacity of a crane. Heavy lifting system consist of:

- → trailing counter weight
- → extendable counter weight
- → Ring system
- – Guy derrick.

Tunnel Construction:

→ Basically there are two methods of tunnel construction. The first one is conventional method and another is construction using tunnel boring machine (TBM.)

* Conventional method of tunnel construction:

→ The excavation of tunnel by drilling and blasting method is the traditional method of tunnel construction.

→ Excavation by manual operation or using excavating equipment is done for the soft soil.

→ For rock, drilling and blasting method is adopted.

→ The process of taking out excavated or blasted materials from tunnel is known as mucking. It is done manually in wheel barrows for small sections of tunnel whereas for larger diameter, tunnel tippers and loaders are operated inside, Rail wagons are used for mucking operations.

→ Tunnel ventilation is needed when excavation is in sufficient depth. It is done through exhaust pipes consisting of two pipes one pulls foul air from inside and another push fresh air inside.

→ Power is supplied into the tunnel for lighting as well as to run the equipment like exhaust fans.

→ Conventional tunnel construction process uses the following equipment:

* Excavators for soft ground
* Drilling machine
* Compressors to run drilling heads.
* Earth transporting equipment for mucking.
* Exhaust fans for ventilation
* Compressors to supply fresh air.

New Austrian tunneling method

* Tunneling by TBM (Tunnel Boring Machine):

→ Modern tunnels construction are done with the TBM. These are the machines which have programmed boring head called moles which drills rocky mountain to bore tunnel through them.

→ The muck is taken out through a pipe attached to the boring machine.

→ This method of tunneling is very fast and efficient.

→ TBM machines are very costly, the length of the tunnel can justify the use of TBM's they are economical.

→ TBM's are available of different capacity and size.

→ Once programmed before operating, these machines can progress in the fixed coordinates in all the X, Y, and Z direction.

Equipment for Hydraulic Construction:

The special types of hydraulic construction are construction of off shore oil rigs and deep sea harbors. These projects uses

- cranes
- excavating equipments
- concreting equipments

} of special types, size and capacity.

Construction of hydraulic structures in shallow waters where water is diverted with the help of temporary coffer dams and water is pumped out to facilitate excavation & concreting.

Special types equipments are used in lining of canals. These lining equipments are almost like concrete pavers.

Equipment for Highway and pavement Construction:

Highway construction involves earthwork in excavation, embankment construction and pavement construction.

× Sub-grade preparation and compaction:

The sub-grade is prepared after earthwork in excavation. Preparation of sub-grade includes site clearance, grading and compaction. A grader is used to grade the surface to achieve uniform surface both along cross section and longitudinal section. Final compaction of the sub-grade is done with the help of compacting equipment like rollers.

× Construction of sub-base and compaction:

After achieving the final and finished surface of sub-grade, sub-base is prepared. Sub-base construction involves quarrying of sub-base materials, screening of sub-base materials, transporting the materials to the site and spread by loader or grader and compact the sub-base in layers. The top surface is graded with the help of grader to bring it into final surface. The compaction is then done with the help of compacting equipment.

* Construction of Base Course:

Base Course is constructed in similar method of sub-base construction. Grader is very important equipment to be used for spreading, mixing, laying and finishing of base course. layer. Pavers and laying machines are also used in fully mechanised cases.

* Equipments for Bituminous Work:

a.) Bitumen Boiler: Bitumen boiler is used to heat bitumen to required temperature. Boilers fired with wood and coals are of common type. Modern boiler use diesel fuel burners to heat the bitumen to required temperature. These boiler can be stationary type or mobile type mounted on truck.

b.) Bitumen distributor: Bitumen distributor is truck mounted consisting of tank and distributing arrangements for bitumen through nozzles. The tank either had preheated bitumen or the the truck is already having bitumen boiler with burners fired by organic fuel, generally diesel or crude oil to control the temperature during transportation & spraying.

c.) Aggregate Spreader: Aggregate spreader is used for surface dressing work. Aggregates are spread uniformly in layer covering the bitumen spread. A dump truck with spreading attachment is fixed on the tail which spread aggregate in uniform manner.

d.) Asphalt Distributor: Asphalt distributors are used to apply prime or tak coats on a surface in preparation for paving. They are available in either truck mounted or trailor mounted and are considered the most important equipment on any asphalt surface treatment project. It consits of an insulated tank with a heating system, a spray bar and unique control system.

e.) Asphalt Concrete plant:

Asphalt Concrete is the mix of bituminous binder and different types of graded aggregates. For patch work asphalt concrete is batched and mixed manually. However for large jobs and quality of work, it is done in a batching and mixing plant called asphalt concrete plant.

f.) Asphalt Concrete Pavers:

A paver (pavement finisher, Asphalt finisher or paving machine) is a machine used to lay asphalt on roadways. It is normally fed by a dump truck which brings hot asphalt mix. They are also called as mat maker. They are the self-propelled machines on rubber tyre or truck mounted.

g.) Rollers: Compaction of pavement are generally done by pneumatic roller to ensure that aggregates are not broken and remain intact.

Selection of Appropriate Equipment:

Selection of construction plant basically involves planning the equipment, careful selection considerations and the basis for selection. These selection process may vary from company to company and from project to project. Equipment selection plays an important role in execution of any construction project as proper selection of equipment contributes to the completion of project timely, economically and with desired quality standards.

Basically there are two aspects of equipment selection:

→ Technical aspects governed by the performance, and

→ Economic aspects and commercial aspects mainly concern the contractor or equipment hire organizations from a bussiness sense.

After the selection from technical point of view, it is necessary to test the viability of the selection from an economic or bussiness point of view also. Planning for equipment selection involves following basis for selection:

→ Identification of task
→ Quantity of material/size of work.
→ Duration of work.
→ Changeable characteristics.
→ Haul Distance.
→ History of performance.

At the planning stage, before selection of equipment, depending upon the project, the Contractor may be required to gather/survey following informations:

→ geological conditions.
→ weather conditions
→ site conditions
→ transport facilities
→ Availability of fuel
→ Availability of labours
→ Availability of services (electricity, water etc.)
→ pollution standards etc.

Factors affecting selection of Proper Construction Equipment:

The selection of an equipment or plant system to perform an assigned task depends upon many inter-related factors as follows:

A.) Task Considerations

→ Nature of task and specifications.
→ Daily forcast of planned production
→ Quality of work and time allowed for completion.
→ Distribution of work at site.

→ Interference expected and inter-dependence with other operations.

B.) Site Constraints:

→ Accessibility to location
→ Maneuverability at site. (Planned and regulated movement.)
→ Working space restrictions.
→ Altitude and weather conditions
→ Working season and working hours.
→ Availability of local resources of manpower, materials and equipment.
→ Availability of land, power supply and water supply for workshop and camp.
→ Availability of local equipment hiring, repair and maintenance facilities locally
→ Availability of fuel, oil and lubricants.

C.) Equipment suitability:

→ type of equipment considered suitable for the task.
→ Make models and sizes of special purpose and general purpose equipment available, which can handle the task.
→ production capability, service conditions and delivery time of each equipment available.
→ Equipment already owned by the contractor
→ Usefulness of the equipment available for other and future tasks.

D.) Operating Reliability:

→ Manufacturer's reputation.
→ Equipment components, engine transmission, brakers, steering operator's cabin.
→ Use of standard components.
→ Warranties and guarrantees.

→ vendor's after sales service.
→ Operator's acceptability, adptability and training requirements.
→ structural design.
→ preventive maintenance program.
→ safety features.
→ Availability of fuel, oil and lubricants.

E.) Maintenance:
→ Ease of repair and maintenance.
→ vendor's after sales service, repairs, spares and maintenance.
→ Availability of spare parts.
→ standardization consideration

F.) Economic considerations
→ owning costs.
→ operating costs.
→ Resale or residual value after use.
→ Replacement costs of existing equipment.

G.) Commercial considerations:
→ Buy second-hand or new equipment.
→ Rent equipment.
→ Hire-purchase equipment
→ Purchase or lease.

Equipment selection analysis is not necessarily limited to above. It leads to alternative choices and followed up with management deciding on the required equipment. In most cases, the final equipment selection decision is likely to be a compromise between what is ideally required and what can actually be obtained economically.

Chapter 5 (Lecture #1 & #2)

Contract Management:

5.1) Method of Execution of Work:

Work execution is procurement of any goods, consultancy services or carrying out any construction work. Before procuring goods, consulting service or construction works; organization shall have to prepare specification, work plan, design, drawing & other special requirement or description.

Broadly, any construction work can be executed in two ways:
By
a.) Force Account (or Amanat - अमानत)

b.) By Contract.

recourse - ~~without~~ help
- ~~without~~ use

a.) Force Account

→ also known as 'Amanat" or departmental work or built approach strategy. As per PPA 2063 & PPR 2064; any work as repair & maintenance of ordinary type, regular petty works or sanitation work may be done by force account (Amanat.) Under this system, the workforce is on the owners payroll or account. The owner constructs the works using his own tool, staff, equipment etc. He himself handles procurement, logistics, supervision, scheduling, testing, inspection etc.

→ Execution of public works by using the resources of a public agency of the government, without recourse to competitive bidding or negotiated contract.

→ Maximum amount limit is Nrs. 1,00,000/- as per PPA, PPR.

b) By Contract:

Under this system, responsibility to execute the project is given to another person or organization or firm. The "Contract" means an undertaking by an organization, a firm or individual for

- Construction or repair works.
- Supply of materials
- Performance of services etc.

works can be executed through contract with either through sealed bidding, sealed quation or any other method except force account.

Public Procurement Act, (PPA), 2063 and Public Procurement Regulations (PPR), 2064 specify that there are three kinds of jobs which can be procured and executed. PPA, PPR along with Guidlines prepared by Public Procurement Monitoring office (PPMO) describes the following methods of work execution as per the total cost and type of works:

1.) Sealed Competitive Bidding (बोलपत्र): (PPR chapter 5; cl. 31-68)

a.) National Competitive Bidding (NCB)

It is sometimes also called as local competitive bidding. In this process, all the eligible bidders are invited to participate in bidding. Tender notice is to be published in national newspaper; a period of at least 30 days shall be given. NCB is necessary for public estity of estimated amount of work or goods is greater than 20 lakhs.

Upto 2 crore → No need of prequalification (PQ) but can be done if feels.

2 crore to - 1 Arab → PQ required.
(for general works.)

5) International Competitive Bidding: (ICB)

If the amount work or goods is big i.e. greater than 1 Arab. or if in < 1 Arab also, if the national or domestic contractors can not perform the job, eligible bidders are invited from all over the world. Tender notice shall be provided in national newspaper in English Language providing a period of 45 days.

For works or goods of amount 1 Arab - 5 Arab → International firm, organization or company must be JV with National / domestic firm, organization or company.

Invitation to ICB shall be invited in any of the following conditions:

→ where the goods or works as required by public entity are not available under competitive price from more than one firm, company, entrepreneur or supplier within Nepal.

→ where no bid was submitted in response to invitation to NCB for the procurement of goods, construction works or other services.

→ where under an agreement entered into with a donor party.

→ where the public entity has certified that the goods or construction works, being of complex and special nature have to be procured through ICB.

Consulting services: (Chapter 6; Cl. 69-83)

> 20 lakhs → EOI (Expression of Interest.)

Generally 20 lakhs - 10 crore → National EOI

" > 10 crore → International EOI

For less than 10 crore also, if services is of special type or complex nature → International EOI

15 days notice to invite RFP (request for proposal) if amount < 20 lakhs

30 days notice if amount ≥ 20 lakhs.

For < 20 lakhs → Technical & financial proposal from possible 6 or minimum 3 firms shall be invited from standing list.

For ≤ 5 lakhs for training, meeting, seminar like services can be purchased by direct negotiation.

2.) Sealed Quotation (Chapter 7; Cl. 84.) PPR
(सिलबन्दी दरभाउ)

Goods or any other services valuing upto 20 lakhs can be procured by inviting sealed quotation. A notice shall be published in local or national newspaper by giving a period of at least 15 days.

Amount ≤ 50 lakhs for medical equipments like x-ray machine, ECG, drugs & other medical equipments can be purched by by sealed quotation.

Other provisions related to Sealed Quotations:

→ Before inviting sealed quotation, a form of sealed

quotation stating clearly therein the specifications, (3(c)) quality, quantity, terms of conditions of supply and time & other necessary conditions for the goods, construction works or other services to be produced shall have to be prepared.

→ The sealed quotation once submitted cannot be withdrawn & amended.

→ The lowest evaluated sealed quotation falling within the cost estimate after fulfilling the terms and conditions shall have to be approved.

(D) → If no. of quotation submitted is less than 3, then, there shall be again notice publican for the same, but for 2nd time, there shall not be any limitation if ~~of~~ of no. of quotation.

3.) Direct Procurement: (Chapter 7; cl. 85, PPR)

Expendable or capital goods or consultancy services or construction works valueing estimated cost of ≤ 5 lakhs may be directly procured, provided that a ~~construction~~ public entity can not procure above the stated amount from any single person, firm, company or organization even if more than one time in a fiscal year.

But medicinal goods upto amount of 20 lakhs ~~be procured~~ & nepali products, goods valueing upto 15 lakhs rupees can be procured by giving notice in national newspaper.

Again, if any medicinal goods manufactured by only company, prequalified by WHO can be procured for any amount by direct negotiation.

4.) Works through Users Committee: (PPR, 97) U.

Construction works may be caused to be carried out by users committee or Beneficiary Community. Cost Estimate including overhead, VAT, contingency along with public participation valuing upto 1 crore rupees may be carried out or obtained from users committee or beneficiary committee. The main objective of the project is to create employment and to have the beneficiary community involved, such works may be caused to be carried by or such service may be obtained from users' committe or beneficiary community by fulfilling the procedure as prescribed.

5.) Works by Force Account (Amanat)

→ work to be carried out by a public entity itself. It is the execution of public work by using the resources of a public agency of the government, without recourse to competitive bidding or negotiated contract. Works done by a force account may apply following situation;

→ The size, nature and location of the works being unsuitable for competitive bidding.
→ works must be carried out without disrupting existing operations. ~~by crews familiar with those operations.~~
→ when implementing agency can bear the associated risks in a better way than the contractor
→ No contractor is intrested in carrying out the works.
→ Emergencies
→ Institutional derelopment.

6.) Procurement under special Circumtances:

→ Emergency/special circumtances.
→ depends on contract amount.

Chapter 5

Contract Management:

Contract:

According to dictionary, a contract is "an agreement to do something, especially one that is enforceable by law."

According to Contract Act 2056 "Contrat is an agreement between two or more than two persons to do or not to do something, which can be enforceable by law."

Modern economic life is based on contracts. We are free to make any bargain, we wish, provided that it does not conflict with the public interest. But when we have made any bargain then we have to carry it or compensate the other party for the bargain he has lost.

If there is dispute, our contract do not mean what we think, they mean. They mean what a JUDGE would think.

Hence, standard contract documents are to be followed.

Factors to be considered in preparing a contract:

1.) The contract must be fair
- The owner wants to have his project constructed &
- the contractor wants profit.

2.) The contrait must be clear.
- the intention of the contract is to communicate precise information to people who must act on it.

3.) Contract language must be consistent.
- Guilty, not leave him.
- Guilty not, leave him.

4.) Don't repeat
- Say it once, - say it in the proper place

5.) Use each part of the Contract for its proper purpose.

6.) Contract information must be retrivable
(हेर्न कुरा आफूले ठाउँमा प्रष्ट हुनुपर्छ)

7.) There must be foresight
- if any problem arise, there must be option to solve it.

8.) whatever you want, must be written in the Contract.
(भुल्नुपर्ने कुरा हो भन्न पाइँदैन)

why Contracts?

Significance /Importance of Contracts:

- to make agreement legally enforceable.
- to specify the Contractor must to and what the owner must pay.
- to record the terms of agreement.
- to specify what will be done if either party fails to perform.
- to specify the quantity & quality of works to be done.
- to specify the time frame within which the work is to be completed and payment to be made.
- to specify means, method, terms & time of payment.
- to identify the parties to agreement.
- to identify the official agents or representatives of parties to the agreement and define their authority & responsibilities.
- to set out in advance the courses of action that will be taken in different possible situations.
- to define words & establish common meanings.
- to specify 'what is' and 'what is not' included in Contract.

to specify how contract will be terminated. (5)
- to specify the responsibilities of the parties not just to each other but also to third parties such as: government, community in which work is to be done, workers, sub-contractors, ~~material~~ material suppliers, unions etc.

Elements of Contract/ Validity of Contract/ Elements for validity:

For contract to be binding an enforceable by law, the following elements ~~are~~ must be ~~there~~ present:

1.) Offer and Acceptance:

→ if a person offer ~~advances~~ a proposal to another person, who gives his acceptance, then contract exists. offer may be specific or general.

→ If a party makes a proposal ~~stating that~~ asking acceptance of proposal within specified time but doesn't recieve such notice of acceptance within specified time/period, then no contract exists.

→ If no time limit is specified in the proposal, then it must be accepted within reasonable time.

→ An offerer can not bind the offerre by a stipulation that if the offerer is not given notice of rejection then he shall be deemed to have accepted the offer.

→ If the offerer dies or become insane (senseless) before his proposal is being accepted, then no contract exists.

→ If the offerer offers proposal with condition to be fulfilled by the offeree before accepting the proposal and the latter does not do so then no contract exists.

2.) Consideration:
It is the cause, motive, price or impelling influence that induces a contracting party to enter into contract. It is described as something of value that is exchanged by the contracting parties.

3.) Capacity to Contract:
For a contract to be legally binding and enforceable, all parties must be capable to enter into contract. As per Contract Act, mad person, drunkards, insane and children below 16 years are not capable of signing contract.

4.) Lawful purpose:
If two parties agree to perform a job, which is against the law, the contract is invalid.

5.) Possibility of performance:
Impossible contract is invalid.

6.) Free Consent: (permission for agreement)
Contract should not involve coercion (दबाव), fraud, under influence, deceit (ठग, धोखा). otherwise, contract is invalid.

7.) Certainty / uncertainty:
Contract which can not be carried out because of various reasons (vague / ambiguous etc.) are not validity.

8.) Legal Relationship (सम्बन्ध)
There should be a clear intention of parties to enter into contract i.e. all necessary documents should be fulfilled as per law.

9.) Written: Verbal agreement can not be a contract.
Contract is made between two or more parties.

All Contracts are agreements but all agreements are not Contract:

Agreement + legality = Contract.

Agreement is acceptance of offer (proposal) with or without any condition. It may not have legal obligation. But Contract is an agreement concluded between two or more parties for performing or not performing a job, enforced by law. The main objective of Contract is to seek legal action/remedies if any party breached the Contract.
(Section)

Types of Contract:

Depending upon the ~~magnitude and~~ estimated cost and nature of work, design needs, funding requirements, complexities of work and owner's own preference, there are different types of Contracts.

Contracts for a ~~particular~~ particular engineering projects can be ~~classified as~~ classified as either Main Contract (Head Contract) or Sub-Contract. The main Contract (Head Contract) is directly between owner & Main Contractor, where as ~~sub-contract~~ Sub-Contract is between a Main Contractor and another Contractor called as Sub-Contractor.

Any engineering Contracts, whether Main Contract or Sub-Contract can be further classified in a number of ways depending upon particular characteristics or feature. as below:

1.) Classification by method of payment of Work:

There are three basic methods of payment used in engineering contracts:

→ Lump sum (fixed amount) Contract

→ Schedule of rates or unit price or Item rate or unit rate Contract.

→ Cost plus.. (overhead & profit) Contracts.

Sometimes, part of lump sum and part of unit-price contract is also adopted in a single project. Both the lumpsum and unit rate contracts may either be "fixed" or "subject to cost adjustment" as specified in the contract.

a.) Lump sum / fixed price / stipulated ~~sum~~ Contract:

- based on the available complete set of detail drawings and specifications quoting one single price which covers all the works and services required by the contract requirements. The lump sum price includes all direct costs of the contractor for labour, machines, materials and indirect cost such as field and front office supervision, secretarial support and equipment maintenance and support costs and also includes profit of the contractor.

Advantages:

→ No need of bill making

→ High degree of certainty about the final cost.

→ Contract administration is easy.

→ fixed price

→ Employers management personnel are free for another projects.

Disadvantages:

→ Contractor should be well experienced.
→ Unsuitable when change is expected.
→ possibility of low bidding and loss making situation to the contractor, which may lead to cost cutting, trivial claims, bankruptcy (failure, beggary)
→ Employer's minimum involvement in construction Management.

b.) Unit - price / Unit rate / Item rate / Schedule of rates Contract:

Project work are broken into different work items like brick work, concrete work, reinforcement work etc. The contractor quotes the price by individual item of work per unit of the work rather than as a single price of contract. A estimated quantity of each item of work are given. Based on estimated quantity of each item of work, the contractor quotes a unit price for each item of work of the project. The total price is calculated by multiplying the unit rate by estimated quantity and finally summing up the price for all items of work. The lowest reasonable bidder is determined and the contract is awarded.

In item rate contract, the interim progress payments for the contractors are based on precise measurement of the field quantities of completed work.

Advantages:

→ well understood and widely accepted type of contract.

→ Some flexibility for design change.
→ Some overlap with design & construction.
→ Good Competition in tender.
→ price is based on quantity of work.
→ Some extra work can be done with initial rate.

Disadvantages:
→ Claims resolution is difficult, quantity based and adversarial (characterized by conflict or opposition) Contract.
→ New items of works are difficult to price, limits to flexibility.
→ Limits on employer involvement in management.
→ If risk is high and likelihood of change, there would be no good indication of final price.

C) Cost plus overhead & profit Contract / Cost reimbursible Contract:
the Contractor is reimbursed the actual costs incurred in carrying out the work under Contract plus a fixed or variable fee based on certain criteria to cover overhead and profit. These are the common types under this category:

→ Cost + Percent of cost
→ Cost + fixed fee
→ Cost + fixed fee + profit sharing
→ Cost + sliding fee.

Advantages:
→ Extreme flexibility
→ Fair payment of work and good Control of risk.
→ Allow and require high level of employers involvement
→ Facilitate joint planning.

Disadvantages:
→ No estimate of final price at tendering.
→ Administrative procedures may be difficult and unfamiliar to all parties.
→ prudent to establish a maximum limit of reimbursible (sensible) cost.

~~c) Cost of Reimbursement:~~

c) Classification by the method of selecting the Contractor:

→ Competitively Tendered Contracts
→ Negotiated Contracts with selected Contractors.

a.) Competitively Tendered Contracts:

→ owner invites a quote for the works to be performed following a formal competitive procedure in which a number of tenderers submit bids based on complete plans and specifications.
→ The award of Contract is generally made to the lowest responsible bidder and agreement is made between the owner and the ~~Cost~~ Contractor.
→ Most widely used form of engineering Contract and is suitable for engineering projects where the nature and extent of the work under the Contract can be clearly identified.

b.) Negotiated Contract:

→ owner negotiates directly with a Contractor to arrive at a mutually satisfactory agreement to undertake the work.
→ owner can enter into Contract with a Contractor by negotiating the price and method of reimbursement.
→ Major items of negotiations are:
  * Level and amount of fee in addition to charge schedule.
  * Quality of work to be performed
  * projected time for completion.
→ Although, almost all type of Contracts like fixed price, item rate and cost plus fee can be negotiated; ~~the~~ in the most ~~common type of negotiated~~ cases, negotiation ~~are~~ type found

frequently in cost + fee type contract.

3) Classification by Contract strategy (i.e. Technical & Administrative Responsibility):

The implementation of an engineering project involves a number of separate tasks as follows:

* Project Management and Co-ordination
* Engineering Design (Conceptual & Detail)
* procurement
* Construction / installation / supply
* Supervision
* Contract Administration & Management.

Engineering Contracts can be classified by the manner in which these responsibilities are allocated. There are a number of classification by Contract strategy:

→ Conventional / traditional approach
→ Owner - Builder approach
→ Turn Key / Design & Build Contract
→ EPC Contract
→ Management Contract.
→ Build, Own, operate, Transfer (BOOT) Contract

a) Conventional / Traditional approach:

→ Consulting engineers / architects appointed to prepare detail engineering design, cost-estimates and specifications before the choice of Contractor.
→ Construction is undertaken by a Contractor, usually under unit rates or occasionally under lump sum Contract.
→ Design & Construction is separated by intervening tendering period.
→ Consulting team / owner is involved in inspection, monitoring or control during construction.

* Advantages:
  - → The design is complete before tender stage - price certainty.
  - → The risks are shared between the parties. Consultant takes the design risks and Contractor takes the construction risk.
  - → Well understood & widely used type of Contract.
  - → The tender gives a good indication of final price, where the likelihood of change, disruption and risk is low.
  - → good Competition at tender.

* Disadvantages/Weakness:
  - → As design is Completed before tender, the Contract is relatively inflexible & hence new items of work if any incurred, are difficult to price.
  - → The division of responsibility can cause Conflict.
  - → The owner/promoter and design Consultants have minimum opportunity for involvement in the management of Construction.

b.) Owner - Builder Approach / Force Account

- → owners perform both their own design work and some or all of the actual Construction with their own forces.
- → often referred as "force account".
- → owner may utilize many of the management and Conceptual design themselves, Consultants for some or all of the detail design and may depend upon Contractor for the actual hiring & supervision of the Construction labour.

Advantages:

→ The owner has direct day to day control over all activities
→ No risk of having to change incable contractors during construction

Disadvantages:

→ The owner assumes the full responsibility of the contractor
→ The owner's staffing requirements are high.
→ owner must handle procurement, logistics, ~~requirements~~, recruitment, training, labor relations, security, site (facilities) amenities, scheduling, payroll, inspections, testing, legal obligations etc.

(.) Design & Build / Turnkey Contract:

→ Single contractor is appointed to design, construct/erect, supply equipment and plant required and maintain a project to the satisfaction of client.
→ The employer will make the lumpsum payment to the contractor at the different stages of the work as per agreement.
→ useful when the work has to be completed within very short time & owner has no time to manage design & construction.

Advantages:

→ A fixed price offered in turnkey contract protect the client from cost overrun.
→ As both design & construction are the responsibility of one entity. So, it has overall shorter duration from conception to commissioning.
→ The responsibility of the contract lies with a single entity. Hence, there is no disputed responsibilities.

→ beneficial for the owner having less/no knowledge of design & construction.
→ Implementation of changes is simplified throughout the construction program.
→ The contractor is responsible for all the defects. Hence, the contractor is always interested for effective quality control.

* Disadvantages:
→ The cost of a turnkey contract may be significantly higher because cost estimates are often expressed on overall rather than detailed breakdown.
→ As the contractor has to do a lot of work to prepare the tender for bidding, there may be reduced bidding. Hence, the rate and contract price may not be competitive.
→ Due to minimal involvement of owner, the final result may not fully comply with expectations.
→ The promoter has to settle all commitments at early stage. This type of contract are very inflexible once they awarded.

d.) EPC Contracts
→ stands for "Engineering, Procurement and Construction" contract
→ the contractor designs, procures the necessary materials and build the projects either directly or by subcontracting part of the work.
→ In some cases, the contractor carries the project risk for schedule as well as budget in return for a fixed price depending on the agreed scope of work.
→ The cost is negotiated & finalized and paid in mutually agreed installments.

Management Contract:

→ an external organization (management consultant / contractor) is appointed by client to manage and co-ordinate the all activities of pre-design, design and construction phases of the project.

→ Management contracting is quite different from the conventional approach as it provides the professional services. It becomes a member of the client's team.

→ Client's involvement in the project is mandatory in this case.

→ particularly attractive to organizations that periodically build complex structures (e.g. hospital authorities, municipalities etc.) but do not desire to maintain a full time construction staff to supervise the projects on recurring basis.

Advantages:

→ project can be divided into large number of small packages and put out to tender only when required by the design & construction planning. This gives an opportunity to overlap design & construction and still obtain fixed prices for the construction work.

→ As the work can be splited into parts based on the discipline, handling size, expertise required – a good package competition can always be achieved.

→ project construction can be started early as work can proceed for part of the design and completed early as good overlapping between the construction activities can be achieved by better planning.

→ client has better flexibilities for making changes in the project even after the start of the project.

→ client even being unware of various knack of contract

management can lead the project to a success by taking advantages of experience of management contractor.

Disadvantages:

→ management contractor usually bears the risk for his professional negligence only.

→ As overall tender price is not known, final cost for the complete work is likely to remain uncertain for longer period of time.

→ Additional verification/ ~~duplication~~ inspection is required from the part of client with some duplication of staff in supervision plus additional administrative staff.

f.) BOOT Contracts:

Build - design, manage, project implementation, procurement, construct & finance.

Own - own the asset for the concession period and the license for the equipment used

operate - manage & operate plant, carryout maintenance, deliver product or service and recieve off-take payments

Transfer - handover plant in operating condition at the end of the concession period.

Advantages:

- promotion of private investment
- completion of projects on time without cost overrun.
- Good management and efficient operation
- Transfer of new & advanced technology.
- Utilization of foreign companies resources.
- Additional financial sources for priority projects.
- No burden on public budget for infrastructure development.
- positive effect on the credibility of the host country.

Disadvantages:

- Unavailability of experienced developers & equity investors.
- The inability of governments to provide necessary supports.
- The workability of corporate & financial structures.

Comparision of Turn-key and Boot projects:

→ BOOT projects are contractor financed Turn-key contract.
→ In Turnkey project, the risk of financing & operating is on owner; while in BOOT, it is on contractor/developer.
→ In Turnkey project, the feasibility study carried out by owner; while in BOOT, it is done by contractor/developer.
→ The commercialisation of project is the responsibility of owner in Turnkey project; while in BOOT, it is the responsibility of contractor/Developer.
→ In Turnkey project, the operation of the facility is carried out by owner after fixed short period (may be one to two years) while, in BOOT project, the operation of facility is carried out by contractor/promotor/developer till before final transfer to the principal/owner.

Chapter #5
Lecture #3

5.3) Tendering (Bidding) process:

Tender is an offer in writing to execute some specified works or to supply some specified goods subject to certain terms and conditions like time limit, method of payment etc.

For procurement by bidding, an invitation to bid can be made by following process:

* Inviting open bids by determining prequalification.
* Inviting open bids without determining prequalification

Bidding stages:

i) **Single stage - Single Envelope Bidding procedure:**
→ bidders submit bids in one envelope containing both the Technical proposal & the financial proposal.

ii) **Single stage - Double Envelope Bidding procedure:**
→ bidders submit two sealed envelopes simultaneously, one containing Technical proposal & another containing financial proposal; enclosed together in an outer single envelope.

iii) **Two stage - double envelope Bidding procedure:**

1st stage → bidders submit only Technical proposal. The bidder who have passed the 1st stage are only allowed to apply in 2nd stage. Also called as EOI in consultancy work & prequalification in case of construction work.

2nd stage: bidders submit only financial proposal in case of construction work and both Technical & financial proposal in consutancy work.

why tendering?
→ to select best contractor
→ to get quality work
→ to get work at competitive price
→ to maintain transparency
→ Public private partnership (encourage contracting procedure.)

Tender Notice:
→ Tender Notice is the notice of informations inviting bids from competent contractors. It should be widely published in daily newspaper depending upon the cost & nature of work.

When all the preliminaries i.e. development of project have been completed and owner has decided to proceed with work, tenders are invited. Legally, this is an attempt to ascertain if an offer can be recieved from interested contractors to execute the work within estimated cost & time.

Detail informations to be included in Tender Notice:
* Name & address of authorities inviting tender
* Nature of works & its location.
* Estimated cost of work.
* Cost of tender document.
* where & when the tender document will be available. (date, time, place.)
* The amount of bid security (earnest money) & its validity period.
* The place, manner, deadline for the submission of the bidding document
* Time of completion of work.
* ~~Date time & place of bid opening.~~
* The last date & time of submission of bid.

* Provision of e-bidding and its process.
* The place, date & time of bid opening.
* Expected date of acceptance of successful bids.
* reservation of right to reject tenders. etc.

In publishing a notice for invitation for NCB, a period of at least 30 days shall be given and at least 45 days in case of ICB.

In case of ICB, the public entity may give preference to domestic bidders as prescribed, and where domestic preference is to be so given, the matter shall be set forth in the notice on invitation to bid & bidding documents.

Preparation before inviting tender:

Before the tender is invited, complete set of tender document carefully prepared. These includes followings:

* Project preparation: The scheme the project is prepared with the detail study & design.
* Estimating of quantities: The quantities of all the items of works in the project are to be estimated.
* Cost Estimate: Tentative cost is derived with prevailing rates of item of work involved.
* Approval of estimate: Estimated cost should be approved by the concerning authority.
* Resource planning: The owner should allocate the necessary resources basically the budget should be arranged for the construction at different stages.
* Tender Document Preparation: All the documents required during tender (Tender Notice, Instruction to

bidders, qualifications, informations, Form of aggrement, (4) conditions of contract, Bill of quantities, specification, design drawings, form of securities etc.) should be prepared and should be approved by the concerned authority.

Bidding document / Tender document: [standard document @ PPMO]

Bidding Document is a document prepared by the concerned firm/public entity making invitation to bid. This includes instruction to bidders, specifications, drawing, design, terms of reference, schedule of work, evaluation criteria, bill of quantities, conditions of contract and similar other documents.

Matters to be stated in Bidding Documents:

* Tender Notice (Invitation for Bids)
* Instruction to Bidders (ITB)
* Bid-data sheet
* Bill of quantities.
* Work to be done by bidder.
* Time of supplying goods, completion of works.
* Provision regarding warranty, repair & maintenance.
* Type and quantity of nece
* Evaluation and qualification criteria.
* Bidding forms
  - Technical Bid
  - Financial Bid
  - Bid security
* Work requirements
  - Scope of works
  - Specifications
  - Drawings
  - Bill of quantities.
  - Work schedule.
* Conditions of Contract & Contract format.
  - General conditions of Contract (GCC)
  - Special conditions of Contract (SCC)
  - Contract formats.

Tender Guarantee / Bid Bond / Bid Security / Earnest Money:

- is the amount which is deposited at time of bidding a tender as guarantee of the willingness of carrying out the works, if awarded. It is usually 2 to 3% of the estimated amount of work either in cash or Bank Guarantee. This is refunded to unsuccessful bidder. If a successful bidder fails to carry out the contract, this amount is forfeited. The main objective of this guarantee are
  - restriction on unnecessary competition
  - punishment
  - compensation

Rule of Contract Interpretation:

* self - explanatory:
* Courts interprets in case of ambiguity.
* Contra preferentum rules of interpretation.

Sometimes word or term is capable of two different meanings with one favouring the party that did not draft the document. The ambiguity will be resolved in the favour of party not drafting the contract document.

Conditions of Contract:

Whenever agreement is reached between different parties, it is followed by certain terms and reference that bind all parties reaching the agreement. These terms and reference are called "Conditions of Contract." Its purpose is for the easy and smooth functioning of work and minimizing disputes. It contains two parts:

i.) General Conditions of Contract (GCC)
ii.) Special Conditions of Contract (SCC)

* General Conditions of Contract (GCC):

→ The document which tried to be standardized for all projects.
→ No need to write/change any provisions in GCC.
This ~~includes~~ includes followings:

i.) Definition & interpretations.
ii.) Assignments
iii.) obligations of the Contractor
iv.) Liability of Employer
v.) Measurement & payment to Contractor
vi.) Labor & labour welfare
vii.) Breach of Contract - finishing Contract.
viii.) Arbitration - settlement of disputes.
ix.) Suspension of work.
x.) Time Control
xi.) Quality Control.
xii.) Cost Control
xiii.) variations & price adjustment
xiv.) Liquidated damage / Bonus.

* Special Conditions of Contract: (SCC.) etc.

Since, all the clauses of GCC can not be applicable universally, they need modification, addition, or alteration depending upon the type & nature of particular project. All these parts are provided in separate part which is called as Special Conditions of Contract (SCC) or specific provisions. In SCC, following aspects are covered:

i.) Detailing of provisions in GCC.
ii.) Deletion of any provision in GCC which is inapplicable or,

inappropriate.

iii.) Amendement of any provision in GCC to cover more specifically or appropriately

iv.) Additions of the further provisions deemed necessary.

Prequalification:

The competency of contractor to handle contract of certain size, type, complexity, nature of works is determined before award by their experience, capacity, ~~~~, construction technology adopted & equipment etc. The tender forms are then issued only to those contractors who are on the list of "approved contractors qualified to handle the work.

This type of short-listing or prequalification of eligible bidder is done to avoid crowding of bidder with inadequate, staff, equipment, lack of experience, improper offer etc. It ensures that the invitation to bids extended only to those bidders who have adequate capability & resources to perform the particular contract satisfactorily taking into account their.

- Experience & past performance in similar contract.
- Capabilities w.r.t. personnel, equipment & construction facilities
- financial position
- Litigation history.

Matters to be stated in pre-qualification Document:

- qualification required for proposed work and in case of joint venture, the qualification of the partners
- document & information to be submitted by bidder to prove their qualification & eligibility
- lots / package of goods / construction works.
- Method of preparing proposal.
- Procedure of evaluating prequalification proposal.
- Major terms & conditions of procurement contract.
- Method, place, deadline for submitting prequalification proposals.

The requirement for prequalification of bidders:

The decesion whether to carry out prequalification is a matter of professional judgement based on a number of considerations about contract itself and about the actual process of prequalification. Contract considerations include size, complexity, limitations on completion time, the critical nature of works, environmental impact, associated risks, legal provisions of the country etc.

Therefore, prequalification should not be used for limiting competition to a predetermined number of potential bidders. All applicants meeting the specified criteria should be allowed to bid.

Post Qualification

No pre-qualification process is adopted. All eligible bidders participate in the bidding process. It may include:

i.) Single envelope system
- Both financial & technical proposals in a single envelope.

ii.) Double envelope system
- financial & technical proposals in separate envelopes.

In double envelope system, successful bidders are selected adopting one of the following three methods:
- Short list from technical proposal.
- Select the lowest bidder 1st & check technical proposal. If technical proposal fulfil minimum requirement, then select the party and if not, check for 2nd lowest bidder & so on.
- Give weightage to both technical & financial proposal. Select the bidder getting highest mark.

Pre-Bid Meeting:

→ is the meeting scheduled after invitation bid to get the views of prospective bidders, their comments and suggestions in formal way.

This is the opportunity for bidders to put forth their ~~viewpoint~~ viewpoints of tender after through study of tender conditions, site conditions, deficiencies which cause difficulties in bidding/executing. Employers should not hesitate to relax some of their rigid conditions to get a better offer. These are the pointers for proactive & effective dealing.

Opening and Evaluation of Bid/Tender:

* Opening Bid:

A public Entity shall have to open the bid in presence of the bidder or his representative, provided that there is no constraint for opening bid in absence of bidder or his/her representative.

* Preliminary Examinations of Bids:

The purpose is to identify/accept and reject bids that are submitted as per requirement of bidding documents before further detailed evaluation. This includes

- verification of signature
- registration
- J/V agreement
- Eligibility of bidders
- Bid security
- Qualifications etc.

* Detailed Evaluation of Bids:

The Bid Evaluation committee established by the implementing agency shall evaluate bids. The bid evaluation is the process to determine the "lowest evaluated substantially responsive bid" in accordance with the terms and conditions of the bidding documents. Evaluation of bids shall be on the basis of the information in the bids alone.

Evaluation and comparision shall have to be made by quoted price excluding VAT. The evaluation should be in accordance with the criteria and method set forth in the bidding documents. Technical, Commercial and financial aspects of all the bids shall be evaluated.

→ If any arithmatical error is found in a bid, the public Entity may correct such an error. If discrepency between unit rate & total amount; the unit rate shall prevail & the total amount shall be corrected as per the same rate.

→ If there is a discrepency between figures and words in a bid submitted by a bidder, the amount in words shall prevail.

→ The lowest bid price in confirmity with the qualification, evaluation criteria shall be the "lowest Evaluated ~~Substantive~~ Substantively Responsive Bid".

→ within 7 days of selection of bid, the public entity shall serve a notice of "intestent of acceptance" of such bid to the concerned bidders.

The basis for award of contract shall be the bidder with the "lowest evaluated substantially responsive bid" subject to

- → if bedders are pre-qualified
- → if the bid contains no substantial deviations from the specifications & Technical requirements.
- → if the lowest evaluated cost is well within the cost estimate.
- → if the rate analysis submitted by the bidder is logical & realistic.

Bid Evaluation report:

The bid evaluations committee shall prepare a Bid Evaluation Report, within 15 days of starting of bid evaluation, in the format contained in the standard Guide for Bid Evaluation and submit to the Competent Authority for further considerations & actions.

If there is no donor involvement or the donor does not require "no objection", the project Manager or Competent Authority may enter into negotiation/ ~~agreement~~ agreement process.

Award of Contract:

* "Letter of Intent" to accept the Bid/Contract:

Within 4 days of the approval of the recommendations of the Bid Evaluation Committee, the employer may issue the "letter of intent" to accept the lowest evaluated responsive bidder. This information is to be given to all the bidders through public notice in newspaper. If no other bidders/concerned persons submitted any complain about this selection, the contract is awarded to the selected bidder and called for agreement with required performance bond within 15 days through "letter of acceptance."

* Performance Security / Performance Bond / Guarantee:

It is the amount of money deposited by a successful bidder as a security for satisfactory performance. Security deposit equal to 5% of contract amount for Nepalese ~~contract~~ firm and 10% of contract amount for foreign contractor. This fund is refunded after completion of Defect liability period (maintenance period). If the work is unsatisfactory or contractor fails to perform his duty, this fund is forfeited.

Contract Agreement:

A contract may consist of number of document which contain collectively all the essentials of contract and which are usually linked together by cross-reference. Engineering contract document usually contains the followings:

→ Tender notice
→ Instruction to bidders (General rules & direction to Contractor)
→ Letters of submission of tender
→ Letter of acceptance of tender.
→ The addenda - The final Contract is obviously subject to the addition, or alterations agreed to by parties and such necessary correspondence exchanged and conditions modified is called "addenda".
→ Form of agreement
→ Condition of Contract
  - SCC
  - GCC
→ Schedule A - showing the details of materials if any, to be supplied by owner to the contractor.
→ Schedule B - BOQ
→ Specification
→ Drawings

Priority of Document:

The documents forming the Contract shall be interpreted in the following order of priority:

1.) Contract Agreement
2.) Letter of Acceptance
3.) Contractor's Bid
4.) Special Conditions of Contract (SCC)
5.) General Conditions of Contract (GCC)
6.) Specifications.
7.) Drawings
8.) Bill of Quantities.
9.) Addenda.

Selection of Consultants:

Consulting services consist of activities of intellectual and advisory nature that does not lead to measurable physical output and other than goods or civil works. Consulting services can be procured by following methods:

i.) Quality and Cost Based selection (QCBS)
→ weightage for both quality (Technical proposal) & Cost (financial proposal) given. Highest mark scoring firm selected).

ii.) Quality Based selection (QBS)
→ appropriate for complex & highly specialized assignments for which it is difficult to define precise TOR & required inputs from consultants.
→ selection procedure similar to QCBS except financial proposal of the selected highly ranked firms in Technical proposal are only opened.

iii.) Least Cost Based selection
- appropriate for assignments of a standard/routine nature or small assignments.
- financial proposal of all consultants passing minimum in Technical proposal are considered).

iv.) Fixed Budget selection (FBS)
→ TOR precisely defined, budget is fixed.
→ project where it is expected that there will be no changes during implementation.

V.) Consultants' Qualification selection (CQS):
- highly ~~expertise~~ specialized expertise required.
- critical, typically short term assignments.

vi.) Single-Source selection (SSS):
→ does not provide the benefits of competition in regard to quality & cost. → lack of transparency & hence can be used in exceptional cases.

Expression of Interest (EOI)

→ It is the process of short listing of the consulting firms. The notice inviting the EOI shall include the following matters:

a) The name and address of the public entity.

b) General description of the proposed assignment or project.

c) The source of funding for the proposed assignment.

d) The qualification of the consultant submitting the EOI.

e) If the consultant submitting EOI is a firm or company:

i) Profile of the firm or company

ii) Status of joint venture

iii) Details of experience in similar assignments.

iv) Bio-data of key human resources to be involved in the proposed assignment.

Request for proposals (RFP)

After the preparation of a short list, of EOI, Request for detailed proposals will be invited. The following matters should be included:

a) Letter of invitation to proposals.

b) Requirement of key human resources & certification of bio-data.

c) Matters of financial proposals shall be opened only after the evaluation of technical proposals.

d) Minimum pass score in technical proposal

e) whether the consultant is allowed to propose a separate action plan of its own and human resources for the concerned assignment.

f) whether the consultant is allowed to comment on TOR.

g) Source of finance required for proposed assignment.

Chapter #8

Site Management:

Responsibilities of Site Engineer:

i.) to supervise the work and ensure that the drawings and specifications are faithfully followed.

ii.) to ~~check up~~ co-ordinate to supply working drawings to the contractor so that the progress of work is not hampered.

iii.) to check up the progress of the work with the passage of time and submit progress report to the owner.

iv.) to check the quality of work, measurement of workdone, quantities, rate and pass the bill for payment.

v.) checking of layout and setting out of buildings w.r.t. existing references.

vi.) studying the workplan submitted by contractor and suggest for modifications, if any.

vii.) Inspecting and testing materials prior to their use at site as per sample approved.

viii.) ~~resp~~ Ensuring labour welfare, health & safety.

ix.) rejecting inferior quality of materials.

x.) In case of dispute between the contractor and the owner, the site engineer shall help to settle the disputes.

xi.) Maintaining all site documents ~~for~~ instructions, quantities of work, materials on site, reports and other documents and correspondence pertaining to ~~other~~ construction activities.

xii.) to ensure that no damages are being made on any part of the completed work at the time of handing over same to the owner.

Supervising work of a Contractor:

To ensure the works are carried out to an acceptable level of quality, the supervision is very important. Supervision of contractors is very difficult. It is often found that the contractor try to save money at the cost of quality of work. Moreover Contractor does not hesitate to use inferior materials, if found cheaper.

The following works should be followed for the supervision of works of a contractor:

i) Progress of work.
   → regular monitoring & supervision
   → checking schedule periodically
   → periodic discussions and meeting.

ii) Testing:
   → works, materials, equipments
   → Testing as per specification and contract
   → field supervision

iii) Regular supervision of works:
   → level work, plumbing etc.
   → safety procedures, workers, equipments etc.

Site order Book:

→ A site order Book is a register duly certified by client regarding number of pages it contains, each page being numbered, Name of work, Name of contractor, reference of contract/ work order etc.

→ Site order books shall be maintained on sites of works and should never be removed from there under any circumstances.

→ The Engineer-in-charge or his authorised representative shall duly record his observations regarding any work which needs action on the part of the contractor like

improvement in the quality of work failure to adhere (3) to the scheduled program etc. as per Contract agreement/ work order.

→ The Contractor shall promptly sign the site order Book and note the orders given therein by the Engineer-in-charge or his representative and comply with them.

→ The compliance shall be reported by Contractor to the Engineer-in-charge or his authorised representative in time so that it can be checked, recorded & approved.

H Record Keeping or Documentation:

→ Every activities relating to the work execution and procurement should be recorded and documented separately.

→ There are various steps in which the activities must be documented as a record.

→ A separte file index is necessary for every actions regarding the execution of works.

→ Documentation is a tool to reduce and resolve Contract disputes. It also maintain proper Communication.

* Few Situations of Documentation:

A.) Bidding and negotiation

→ delay in supplying bid documents (Correspondance, prebid meetings.)

→ findings of site inspection

→ Rate analysis of major items.

→ Construction schedule with critical activities.

→ Negotiation during finalization of award.

B.) During Signing of Contract Agreement and Mobilization Period:

→ Extension of validity of tender documents.

→ delay in payment of mobilization amount.

→ delay in supply of necessary drawings and documents
→ Site possession date should be recorded.
→ Site order Book etc.

C.) During Construction Period for Delays and Extra Costs:
→ changes in Contract work.
→ variation in quantities
→ Unusual site conditions
→ force majeure
→ Unusual inflation.

Procedure to prepare Bills:

Usually the payment to the contractor is made on the basis of the statement of workdone. These are called running bills. such running bills are prepared and submitted by the contractor for necessary verification and checking before payment is made. The following steps should be followed in preparing a bill:

i.) Measurement of work — Site Engineer (or representative)
Contractor (or representative)

ii.) Entry in Measurement Book

iii.) preparing a bill.

Measurement Book (M.B.)

All payments to be made to the contractor are made on the basis of measurements jointly taken by the Engineer and contractor. These measurements are recorded in a book called Measurement Book. This is an evidence of work done and measurement, and so, it act as valid document.

A Sample of M.B.

Location: Description of work:

Date of measurement:

Name of project:

S.N.	Description of work	Unit	No.	L	B	H	Q	Remarks

Muster Roll (Labour attendance record Book.)

Muster Rolls actually the register of employee which is usually kept on daily basis. Muster Roll is commonly used in the department to make payment to the labour engaged on daily basis. It should be clearly maintained as payment to the labour is done on the basis of this. It usually consists of the followings:

- → Name of employee
- → Age
- → sex
- → Date of joining
- → Employee No.
- → Type of Employment: Regular / Contract / daily etc.
- → Category / Designation:
- → Rate of Payment
- → Shift (if applicable)
- → Attendance.

See on sample from any book or Internet

Chapter #9

Project Maintenance:

Maintenance includes the repairs or preservation of an existing facility to prevent that facility's deterioration to an unsafe or irreparable state, or ~~to prevent~~ which involves the treatment of an existing facility to meet acceptable standards of operation or aesthetic quality.

→ Maintenance ensures that the entire production system is kept reliably productive and efficient in production and productivity target.

→ It is reffered to cost effective management.

→ The maintenance of a project is the activity required to check the probable damages or to correct any deficiencies cropped upon in the system.

→ Modern construction equipments are very costly. Therefore, regular maintenance is necessary.

(Benefits)

* Importance of maintenance / objective of maintenance:

i.) To maximize reliability and availability of an asset and get maximum possible return on investment.

ii.) To ~~extend~~ increase useful economic life, easy operation with optimum service, reduce risk and mitigate disaster.

iii.) To extend the life of assets by minimizing wear, tear and deterioration.

iv.) To prevent failure due to lack of maintenance.

v.) To minimize equipment breakdown which leads to unavoidable loss in production & causes low output.

vi.) To ensure operational readiness of all equipments required for emergency use at all time such as standby units, firefighting units and rescue units.

vii.) To ensure safety of personnel using equipments or facilities.

viii.) To minimize the frequency and severity of interruption to operating process.

ix.) To save the organization from costly rehabilitation in future by regular & preventive maintenance.

Types of Maintenance:

1.) Planned Maintenance:
   a.) preventive Maintenance.
      - Running Maintenance
      - Shutdown maintenance.
   b.) Corrective Maintenance
      - Breakdown maintenance.
   c.) Routine/Regular/schedue maintenance.
2.) Unplanned Maintenance
   - Emergency Maintenance.

1.) Planned Maintenance:
→ organized and carried out with forethought, control and use of records to a predetermined plan.
→ is the studied evaluation of all plant with intention of carrying out any maintenance before it is actually needed through breakdown or obvious deterioration in performance, with the aim of reducing emergency maintenance and associated costs in machine stoppage.

a.) Preventive Maintenance:
→ This type of maintenance is used in those cases where deterioration and failure patterns of item are known.
→ The routine inspections and servicing are designed to detect potential failure conditions and suggest action,

which may range from minor to major repairs to replacing parts.

→ generally includes replacement of spare parts, bolts, oil filter, fuel filter etc.

* Objective of preventive maintenance:
  → to minimize the possibility of breakdown.
  → periodic inspection to obtain optimum product effeciency at minimum maintenance cost.
  → to ensure safety of work-force.
  → reduction of downtime.

Preventive maintenance can be carried out on machines or projects either when running or during shutdown.

* Running Maintenance:
  → Maintenance can be done when the item is in service or while equipment is running.
  → This maintenance is carried out in a project so as to keep efficient daily operation.

* Shutdown Maintenance:
  → Maintenance, which is carried out when the project is out of service.

b.) Corrective Maintenance:
→ organized maintenance for repair of item to the acceptable standard where replacement is not ~~advisable~~ advisable.

* Breakdown Maintenance:
  → TO minimize breakdown
  → prevent overload and replace worn parts.
  → provide good lubrication
  → replace broken ~~belt~~ belts in fan, motor etc.
  → avoid use of wrong fuel.

c.) Regular / Routine / Schedule Maintenance:

→ Repair and maintenance are planned and undertaken on regular bass throughout the year.
→ It is the most cost effective since all repairs are identified early and carried out quickly to prevent other problems.
→ Routine for maintenance is prepared to use scarce resources properly.

2.) Unplanned Maintenance:

* Emergency maintenance:

→ An unplanned maintenance works due to accidental breakdown & damage.
→ Emergency works arise unexpectedly but they have to be solved instantly otherwise it may cause large revenue loss in the project.

Periodic Maintenance

→ include greasing, oiling, change of spare parts, sluice gate works etc. on periodic basis.

Diagnostic Maintenance:

There are failure in the project because people could not manage proper operation and management of the system. Different models should be prepared for categorizing maintenance works as:

i.) Categorizing maintenance works:
→ by identifying during inspection works and from suggestions from the concerned people.

ii) Prioritization of the maintenance works:
- identify priority based on need and resource available.
→ by scheduling & finding critical path as all works can not be done at same time.

iii) Planning maintenance work:
→ Routine maintenance work should be planned.
→ Unfinished previous work must be completed before new plans are made for the next period.
→ planning of maintenance works should be done on availability of funds, works on priority basis and cost effectiveness.
→ optimum cycle of maintenance should be introduced.

iv) Allocate & provide budget for maintenance works.

v) Provide different modules for attractive operation.

Maintenance planning and scheduling:

* planning & scheduling objectives:
→ minimizing the idle time of maintenance workers.
→ maximizing the efficient use of work time, material and equipment.
→ Maintaining the operating equipment at responsive level to the need of production.
→ to forecast future work and to balance workload.
→ to aim to the most of the ~~maintenance~~ maintenance work planned and scheduled.

Need / Requirement of Effective Maintenance planning:

→ Maximize utilization & minimize break-down
→ Maximize the use of labour resources.
→ Ensure effective and adequate technical information for effective maintenance.
→ Exercise inventory control.
→ Ensure safety of person on machine and other equipments.
→ protect the asset by regular maintenance.
→ plan maintenance at lower cost.
→ prepare maintenance schedule of equipments, buildings, irrigation & other infrastructure.
→ plan for routine, periodic & preventive maintenance.
→ plan for safety measures, guard, protective clothing, helmets gloves etc.

* Maintenance Planning:

planning is the process by which the elements required to perform a task are determined in advance before start of job. Good planning is prerequisite for sound scheduling. It includes all the functions related to preparation of:

- the work order
- Bill of quantity
- purchase requisition
- Necessary drawings
- Labour planning sheet including standard times.
- all data needed prior to scheduling and releasing the work order.

* planning procedures:

→ determine the job content
→ Develop work plan → include sequence, methods & procedures.
→ allocate team for the job.
→ plan and order spare parts/materials.
→ check and obtain special tool and equipments if needed.
→ Assign workers with appropriate skills.
→ review safety procedures.
→ set priorities for maintenance works.
→ assign cost accounts.
→ Complete the work order.
→ review backlog and develop plans for controlling it.
→ Predict the maintenance load using effective forecasting technique.

* Steps for formulating maintenance program:
→ make an inventory of all the works that require maintenance.
→ determine the volume of maintenance works annually.
→ establish the optimum cycle of maintenance for each type of work.
→ determine the machinary and manpower requirements to undertake the maintenance.
→ budgeting & establishing maintenance priorities.

* Contribution of effective planning & scheduling of maintenance:
→ Reduce maintenance cost
→ improve utilization of the workforce by reducing delays & interruptions.
→ improved quality of maintenance work by adopting the best methods & procedures. and assigning the most qualified workers for the job.

* Basic levels of maintenance planning process:
→ long-range planning → Covers a period of 3 to 5 years and set plans for future activities and long range improvement.
→ medium-range planning → Covers 1 month to 1 year.
→ short range planning:
→ Covers a period of one-day to 1 week. It focuses on the determination of all the elements required to perform maintenance tasks in advance.

* Maintenance Scheduling:

It is the process by which jobs are matched with resources and sequenced to be executed at a certain points in time.

→ deals with specific time, phasing of planned job together with the orders to perform the work, monitoring the work, controlling and reporting the job progress.

→ Successful planning needs a feedback from scheduling.

* Levels of Maintenance schedule:

→ Long range (Master) schedule.
→ Monthly schedule
→ weekly schedule.
→ Daily schedule.

* Requirements for effective scheduling:

→ written work orders that are derived from a well-created planning process.
→ time control.
→ Information about craft availability for each shift.
→ Information on the availability of special equipment and tools necessary for maintenance work.
→ information of plant production schedule and knowledge about the facilities when it will be available without interrupting production schedule.
→ well-defined priorities for maintenance works.
→ information of backlogs (jobs already behind schedule)
→ stocks of spare parts and information on restocking.

Estimating Maintenance Cost:

→ The maintenance cost of plant, equipment or infrastructure depends upon the type of service, product, type of material used in equipment, as well as on project environment.

→ Sometimes, it may be important to present a detailed justification for some of the intended maintenance works emphasizing consequences (financial and social) if they are not carried out.

→ Generally 1 to 5% of the total budget for this purpose is allocated.

→ In case of financial unavailability, the priority of maintenance work should be established.

Management of Maintenance and Financing:

An effective maintenance system includes the following elements:

- → Maintenance Policy
- → Control of materials.
- → preventive Maintenance.
- → Condition Monitoring.
- → Work order
- → Job planning
- → Priority and backlog control
- → Data recording system.
- → Performance measures or indices.

Financing is a field within economics that deals with the allocation of assets and liabilities over time under conditions of certainty and uncertainty. It is the science of money management. A key point in finance is the time value of money, which states that one unit of currency today is worth more than one unit of currency tomorrow. Finance aims to price assets based on their risk level and their expected rate of return.

* Cost of Maintence:

To carry out maintenance activities, some direct cost are involved. The investment in direct cost results the sound operation of plant and machineries that minimizes failure cost. It always recognized that the direct cost involved in regular maintenance is very less in comparision to resulting failure cost due to breakdown of machine if maintenance is not carried out in time.

* Direct cost:

These are the actual cost involved in maintenance of the plant. It is quantifiable and measurable. It includes:

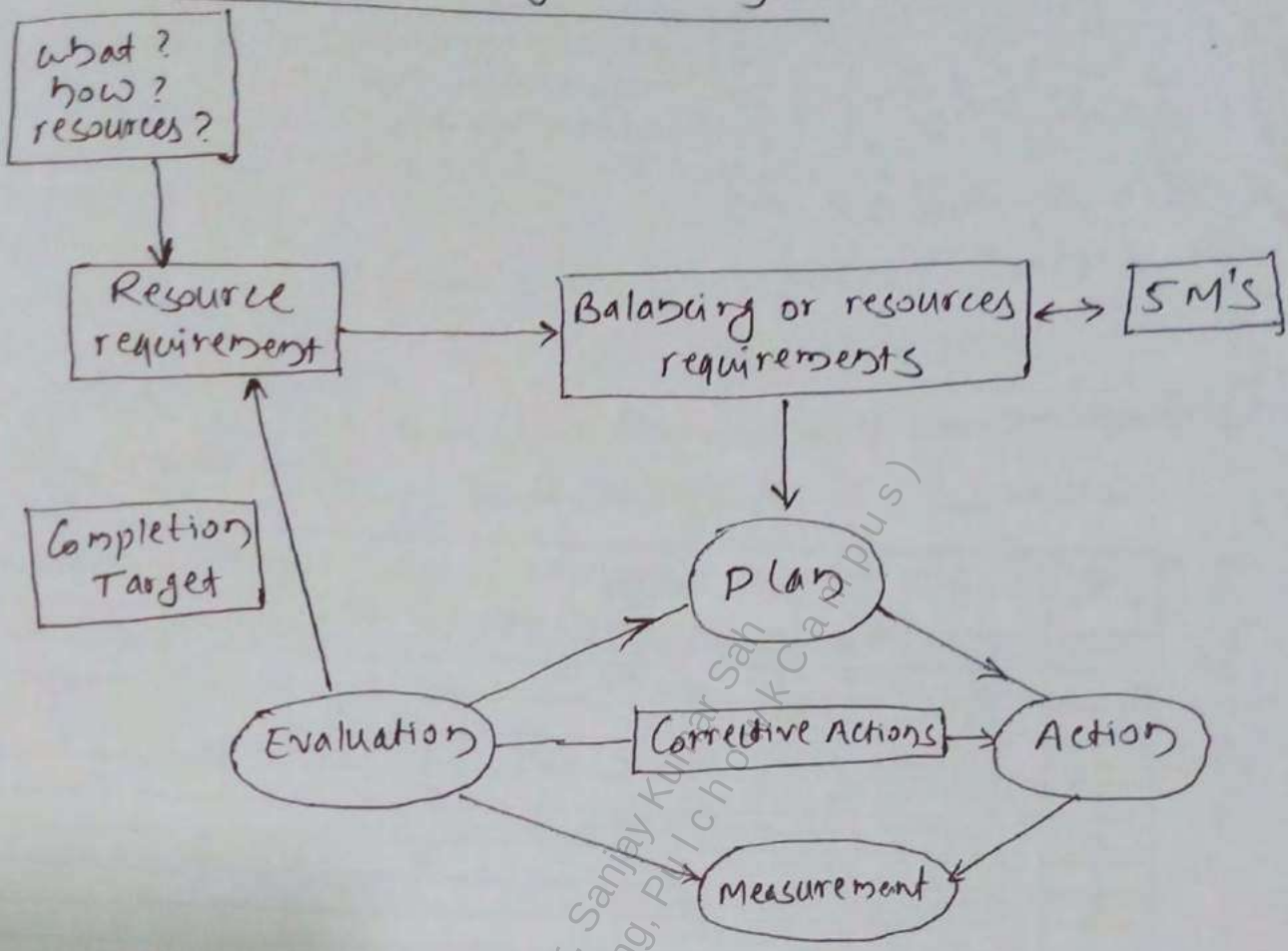
→ regular maintenance cost
→ Labour cost
→ Equipment, parts and components costs.
→ stock management cost
→ training and technological updating costs.

* Indirect cost:

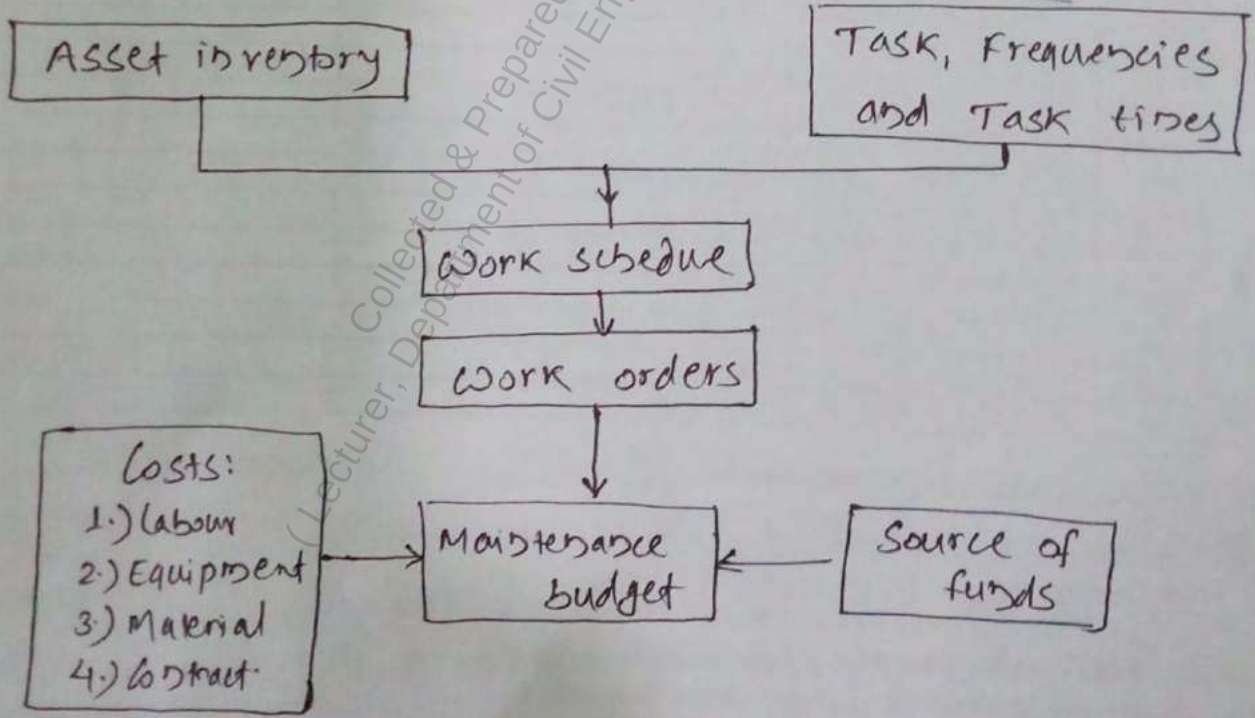
These are failure cost. They are not directly measurable in terms of money but they cause heavy financial loss to the organization. It includes followings:

→ Loss of production and service
→ Alteration in quality of product & services.
→ Delivery delays.
→ Deterioration in workplace and environment.
→ Loss of goodwill.
→ Depression in employees etc.

Maintenance Management cycle:



Maintenance Management System process.



Chapter #11

Regulatory Requirements:

Safety Requirements:

→ Many safety standards use the concept of a safety requirement to ensure that the system carries out the functions needed to make it acceptably safe.

→ An adequate risk assessment have to be carried out for the safety requirements.

→ Safety requirement is related with the frequency of various failure modes of component of a system, possible layers of protection needed to prevent failure from turning into an accident or process involved in the development of a system.

→ A safety requirement include safety function requirement and safety integrity requirement.

- a safety function is a feature of the system that provides a specific function that is relevant to the safety of the facility.
- Safety integrity is defined as a relative level of risk reduction provided by a safety function, or to specify a target level of risk reduction.

→ Safety requirements are the requirements for the purpose of risk reduction. to an acceptable level.

→ As construction industry is labour oriented where injury rate is found to be significant resulting expensive cost of accidents as well as even to loss of life also, efficient & cost effective safety requirements are needed at any industry or construction site.

Reasons for safety requirements:

1.) Humanitarian reasons:

The suffering and agony undergone by the injured worker and his family members is difficult to quantify in economic terms. Thus, accident should be prevented more on human considerations

2.) Economic reasons:

The accidents have their own costs, which include direct and indirect costs.

* Direct cost includes
  - medical expenses for the injured person.
  - Compensation amount to the injured person
  - legal charges.
  - Cost incurred in replacement of equipment and damaged material etc.

* Indirect cost includes:
  - slowdown in progress of work.
  - productive time lost by injured worker and fellow workers.
  - Decrease in productivity due to moral decrease after accident/injury.
  - over time payment to coverup the loss of time.
  - loss of confidence by client, worker etc.
  - loss of administrative work due to accident etc.

3.) organizational image & goodwill:

Good safety measure record boosts the morals of the workers resulting in higher productivity and better loyalty of the workers to the organization. Good safety measures will also enhance the public image & goodwill of the organization.

4.) Laws and Regulations:

The employer has to adhere to the laws and regulations laid down by the Government for the safety of the employees. The violation of thesse laws and regulation will attract punishment to the employer.

Safety Regulations:

It is necessary to frame a set of rules to promote safety of employees and to prevent the direct or indirect cost of accident. These safety rules should be strictly followed and administrated as a part of safety programme. while framing safety rules, the following points should be taken in consideration:

i.) The safety rules should be such that it does not cause annoyance (irritation) to an employee.

ii.) safety rules must keep pace with changing environments and industrial situations.

iii.) Safety rules should be clearly defined without ambiguity.

iv.) Safety rules should be such that they should be acceptable to the employees without resistance.

* Safety measures:

→ Safety is greatly influence by decision taken during the planning, design & implementation of construction project.

→ Some designs or construction plans are inherently difficult and dangerous to implement, whereas others may considerably reduce the possibility of accidents.

→ choice of proper technology, machines & material can also reduce the chances of accidents to a great extent.

→ The realization of the large costs involved in construction injuries provides a motivation for safety.

* Following safety measures are required at construction area:
  → Barriers around deep excavation
  → Safety belts while working at heights on scaffolding, ladders and formworks.
  → Safety Goggles, safety shoe & uniform while working with hot bitumen, dimolition works or drilling & blasting works etc.

* Safety Control devices:
  → informative sign and signals.
  → Caution sign and signals.
  → Danger sign and signals etc.

* Safety Code of practice:
  - Health and safety at work act.
  - Mines worker act.
  - factory worker's act.
  - Labour law & act etc.

General safety rules:

Some of the general safety rules which may serve as a guideline to worker, supervisor and owner are as follows:

i) Smoking should be strictly prohibited particularly near chemical or inflammable materials.

ii) Personal protective devices like safety goggles, aprons, safety shoes etc. must be used depending upon the type of works involved.

iii.) Power should be switched off before repairing the equipment.

iv.) High voltage equipments and machines should be fenced.

v.) Wiremesh and safety guards must be provided on all rotating parts such as pulleys, gear boxes etc.

vi.) Pressure vessels and their component parts must be periodically tested & defective parts should be promptly replaced.

vii) Inflammable materials should be stored separately and away from general stores.

viii.) Material handling equipments should have unobstructed path for their movement.

ix.) Mischievous acts should never tolerated and defaulter should be punished.

[Mischievous- an action causing or intended to cause harm or trouble.]

x.) Electrical connections and insulators should be checked at regular intervals.

xi.) Defective tools such as hammers, spanners should not be used.

xii.) only authorised employees should operate the equipment.

xiii.) loose dress must never be used while working on a machine.

xiv.) prompt first aid attention must be paid to any injured person.

xv.) Fire extinguishers should be kept in proper condition and at key places.

Workman's Compensation Board (Act.)

This act is for providing social security to the workers. Compensation is to be paid to the worker in case of accidents sustained during the course of employement and the amount is decided upon seriousness. The dependents are eligible to receive the compensation. This act is applicable to all persons employed in construction, maintenance, repairs, demolition works. Under this act, financial relief is given in the following cases:

i.) Death
ii.) Permanent total disablement
iii.) permanent partial disablement
iv.) Temporary disablement.

No Compensation is payable under following cases:

i.) if the disability does not last for more than 7 days and.
ii.) the injury not resulting in death is caused due to negligence of the worker.

There is a board or comision for Workman's Compensation who will decide about the settlement and distribution of the claims.

Fire regulations and Insurance:

x Fire safety:

→ Fire safety refers to precautions that are taken to prevent or reduce the likelihood of a fire that may result in death, injury or property loss.

→ Fire safety measures include those that are planned during the construction of a building or implemented in structures that are already standing and those that are taught to occupants of the building.

→ Threats to fire safety are reffered to as fire hazards which may include a situation that increases the likelihood of fire or prevent escape in the event a fire occurs.

* Fire regulations:

→ it is set of rules prescribing minimum requirements to prevent fire and explosion hazards arising from storage, handling, or use of dangerous materials or from other specific hazardous conditions.

→ The fire code is aimed primarily at preventing fires, ensuring that necessary training and equipment will be on hand, and that the original design basis of the building, including the basic plan set out by the architect, is not compromised.

→ The fire code also addresses inspection and maintenance requirements of various fire protection equipment in order to maintain optimal active fire protection and passive fire protection measures.

→ A typical fire safety code includes administrative sections about the rule-making and enforcement process, and substantive sections dealing with fire suppresion equipment, particular hazards such as containers and transportation of combustible materials, and specific rules for hazardous occupancies, industrial processes, and exhibitions.

* Fire safety issue in construction of new buildings:

→ fire place in building should be properly located, separated from timber construction or any other materials succeptible to fire.

→ occupants are encouraged to install appropriate portable fire extinguishers.

→ the demarcation of fire zones should be carried out in urban areas.
→ All buildings should be designed using construction materials which can contribute to control spreading of fire.
→ Every building should have an access enough to enable fireman to easily approach to building site.
→ All building should have sufficient ways for rapid evacuation.
→ the front entrance should have enough space so that a number people can gather and contribute in extinguishing the fire, if any.

* Insurance:
→ Insurance is the equitable transfer of the risk of loss, from one entity to another in exchange for an adequate consideration called as premium.
→ It is a form of risk management primarily used to hedge against the risk of a contingent, uncertain loss.
→ An insurer or insurance carrier is a company selling the insurance; the insured or policyholder is the person or entity buying the insurance policy. The amount of money to be charged for a certain amount of insurance coverage is called premium.
→ The insured receives a contract, called the insurance policy, which details the conditions and circumstances under which the insured will be financially compensated.

* Types of insurance:
i.) Health insurance
- Accident, sickness, and unemployment insurance
- long term disability insurance.
- workers' compensation insurance.

ii.) property insurance
- protection against risks to property, such as fire, theft or weather damage.

iii.) Contractor's All Risk (CAR) policy of insurance:
- personal injury, death
- loss or damage to property including works, plant, materials and Equipment.

iv.) Fire insurance

Environment Concern and Protection:

* Environmental Law:

Environmental laws are those rules, norms, values and practices which relate primarily to the protection of the whole or part of the environment such as air, water and land against pollution & misuse and the protection of ecosystem together with those ancillary issues which help to explain the areas such as public participation, access to information, remedies and procedures.

Environmental law, in its broadest sense, is an essential tool for achieving sustainability. It requires standards of social behaviour and gives a measure of permanency to policies. Environmental laws are based on scientific understanding and a clear analysis of social goals. These laws should set out rules for human conduct which is followed and should lead to communities living within the capacity of the earth.

* Evolution of International Environmental Law:

→ Stockholm Declaration, 1972
→ World Heritage Convention, 1972
→ Convention of International Trade in Endangered species of Wild Flora and Fauna, 1973 (CITIES)

→ World charter for Nature, 1982
→ Viena Convention for the protection of the ozone layer 1985
→ Montreal protocal on substances that Deplete the ozone layer, 1987
→ United Nations Conference on Environment and Development (Convention on Biodiversity), Rio Declaration, 1992.
→ UN Framework Convention on climate change, 1992 and Kyoto protocal 1997.
→ Basel Convention on the control of Trans-boundary Movement of Hazardous wastes and their Disposal, 1989.

* Emerging principles of International Environmental laws:
→ precautionary principle
→ polluter pays principle
→ principle of EIA
→ principle of sustainable Development
→ principle of Inter-Generational Equity
→ Principle of Common but Differentiated Responsibility.
→ Principle of strict liability.
→ Doctrine of Public Trust.
→ Permanent Sovereignty over the Natural Resources, PSNR.

Building Code:

A building code, or building control is a set of rules & norms that specify the minimum standards for building constructions. The main purpose of building codes are to protect public health, safety and general welfare as they relate to the construction and occupancy of building and structures. The building code becomes law of a particular jurisdiction when formally enacted by the appropriate governmental or private authority.

The building code deals with all important aspects of building construction from bye-laws through design and construction to installation of all services. The code lays down regulations which can be adopted by various construction departments in the country and the municipalities and other bodies. The code also lays down and prescribes a set of minimum provisions for design to take into account the aspects of safety with regards to structural sufficiency, fire hazards and occupational health aspects.

Building codes are generally intended to be applied by architects, engineers, constructors and regulators but are also used for various purposes by safety inspectors, environmental inspectors, real estate developers, sub-contractors, manufacturers of building products and materials, insurance companies, facility managers, tenants and others. Codes regulate the design and construction of structures where adopted into law.

* Roles of National Building Code:

→ Maintains uniformity for materials and technology.
→ Accounting for safety measures (safety, comfort and use value.)
→ Focusing on earthquake resistant buildings.
→ Emphasizing for use of spaces within the buildings.
→ Guiding to Engineers, sub-Engineers and masons.
→ Flowing information and standard regarding architectural electrical and sanitary designs.
→ Serving as a basic document to the local bodies for checking the designs submitted for approval by individuals/entity.

* Building Bye-laws:

It is mandatory to have building permission from concerned Urban Development office, Metropolitan & sub-metropolitan cities and Municipalities. There are building bye-laws prepared by concerned authorities. Building bye-laws are prepared to ensure public health and safety, planned urban development and planned built environment. It deals with

→ Right of way (ROW)
→ set back
→ Floor area ratio (FAR)
→ Ground Coverage
→ Height of the building
→ Guidlines for cultural heritage zone
→ clearance required from important sites etc.

* Quality Control:

In all construction projects, proper inspection and quality control become very important so that construction is carried out in accordance with the drawings and specifications. This will result in good quality construction at a reasonable cost. In many construction projects; good and safe design can be spoiled by careless execution. Therefore, inspection and quality control are as important as investigation and design. Once, the project is completed, it is very difficult and costly to cater on modification and carrying out changes to rectify any defects. During the inspection of works, materials and other products, it is always necessary to compare them with the predetermined standards. These standards laydown the limits of permissible variation.

* Elements of Quality

i) Quality characteristics.
ii) Quality of design
iii) Quality of conformance.

* Phases of Quality Control (QC) and Quality Assurance (QA)

Quality control (QC) and quality assurance (QA) progaamses in a construction project may be carried out in 3 phases:

i) **Phase I: Pre Construction (QA):**

Such as testing of raw materials like steel, cement, aggregate etc., design of concrete mix to match with the required grade of concrete, certification of skilled welders, quality assurance of equipments, matching capacity and right technical specifications, selection of

right type of consumables, such as electrodes for welding works etc.

ii.) Phase II : During Construction (QC.)

→ by ensuring effective supervision, adhering to specifications and designs and ensuring good workmanship in work items like structural fabrication, Concreting, Brick work, water proofing etc. backed up by field testing of samples.

iii.) Phase III : Post Construction (QA.)

→ By testing product samples like Concrete cubes, welding joints etc. by testing load carrying capacity of the system (in case of bridge), by testing water tightness (for water retaining structures), checking alignments (for roads etc.)

Valuation (Chapter 13)

(Lecture×1)

Valuation: Valuation is assessment of present fair value of a property at stated time. Valuation of anything is an estimate of the value of that thing in terms of money.

* Valuation is the process of estimating worth of a property.
* Valuation is an art of determining actual unbiased, legal and logical value of the property
* valuation is the technique of assessing the present fair value of the property.
* Property may be the land, building, both land and building, factory, machineries, jewelleries and other engineering structures of various types.
* The value of the property depends upon its structure, life span, location, maintenance etc.

Cost and value:

* Cost: Cost is the original cost to manufacture or construct a product or structure. It is related to cost of raw materials, labours, equipment etc. for manufacturing or construction.
* Value: Value means its worth or utility. It is related to functions of a product or building performed as well as cost incurred during manufacturing/construction along with operation cost. Value may either be less than or greater than the cost of product or structure.

Purpose of Valuation:

The main purpose of valuation are as follows:

i) Buying and selling of property:
→ to estimate the price for purchase or sell.

ii) Tax fixation: to fix municipal tax, property tax etc.

iii) Rent fixation:
→ necessary to determine or justify the rent of a property and is usually required for fixation of standard rent.

iv) Mortgage value or ~~secu~~ security of loans:
~~Acco~~ Amount of loans by bank and financial institutions are determined by the valuation of security of loans.

v) Insurance premium: To fix insured value of property excluding the cost of land as well as insurance premium.

vi) Compulsory acquisition: If goverment has to acquire the land and house for public infrastructure, compensation in terms of money for owners are estimated/ascertained by valuation of property.

vii) Partition of the property: to determine the market value of joint properties.

viii) For preparation of balance sheet of the firm/company.

ix) For Auction (लिलामी)

x) For determining court fee.

Principle of Valuation:

Following principles should be observed while evaluating fair and reasonable value of the property.

→ Cost depends upon supply and demand.
→ Cost depends upon its design, specification and location.
→ Cost varies with purpose
→ Cost depends upon age and condition of property.
→ Cost depends upon the psychology of the buyer and seller.
→ present and future use of property should given due wightage in valution.
→ Cost analysis must depend upon the statistical data.

Factors affecting the value of the property:

i.) Cost of construction
ii.) location of the property
iii.) climatic condition.
iv.) Rise in population ⇒ increase demand.
v.) Supply and demand function.
vi.) Rate of interest.
vii.) topography.
viii) Rent restriction act.
ix.) security on capital
x.) Abnormal condition - disaster, financial crisis etc.
xi.) Purpose of use. - residential, hospital, business complex etc.
etc.

Terminology:

* Gross income: Gross income is the total income or receipt from all sources without deducting the outgoing necessary for taxes, maintenance, collection, replacement or loss of income, ground rent etc. whatever it may be.

* Net income: Net income is the gross income less all outgoings which includes the taxes, premiums, repairs, insurance, management and collection charges, loss of rent, ground rent, sinking fund etc. necessary to maintain the property in a state, to command that income.

* Outgoings: outgoings are the expenses to be made by virtue of being in possession of the property and also the expenses of maintaining the property. Outgoings may be classified under the different heads of taxes, repairs, management and collection charges, insurance premiums, loss of rent. It should also include sinking fund.

a.) Taxes: This includes municipal tax, property tax which is to be paid by owner.

b.) Repairs: Amount for annual repairs of building to keep the same in a sound condition.

c.) Management and collection charges: This includes salaries for liftman, sweeper, pump attendant, electric charges for common lights, pumps, lift etc. with due allowance for the service charges.

d.) Insurance: include the amount of insurance premiums.

e.) Loss of rent: Part of a property may remain vacant for some period and will not fetch any rent for that period. Therefore the loss of rent is considered as outgoing expenses and deducted from calculated gross rent.

f) Voids: An allowance for those periods when property will be unlet and non-revenue producing.

g) Ground rent: when a structure is constructed on a lease hold property, then a specified amount in a specified period as may be agreed upon is considered as outgoing from the gross income of that property.

h) Income tax: The income from landed property, equally with that from other sources, is subject to income tax.

i) Sinking fund: Sinking fund is an amount which has to be set aside at fixed intervals of time, generally annually, out of the gross income so that at the end of useful life of the building or property, the fund should accumulate to the initial cost of the property.

Value classification:

* Book value: Book value is defined as the value of the property shown in the account book in the particular year i.e. the original cost less the total depreciation till that year. Thus, the book value of a property gradually reduces at a constant amount year after year to the limit of scrap value i.e. upto its utility period.

Book value = original cost - Depreciation.

* Market value: Market value of a property is the value at which it can be sold in the open market at a particular time. Market value must be free from forced value or sentimental value.

* Difference between market value and Book value:

Market value	Book value
a.) The value is fixed by purchaser	a.) The value is fixed by the rate of depreciation.
b.) The value may be higher during the subsequent years due to increase of price index.	b.) The value can not be higher during subsequent year even due to increase of price index.
c.) The value may be constant for a period	c.) The value can not be constant, rather is a gradual fall.
d.) This is applicable to any type of property.	d.) This is not applicable in case of land or metal articles like steel, copper, Gold etc.
e.) Market value is considered for valuation	e.) Book value is considered for account book of a company.
f.) This depends on forces of demand and supply, development of the area etc.	f.) Book value is not variable due its demand and supply or development of the area.

* Assessed value: value of a property recorded in the register of a municipality in order to determine the amount of municipal taxes to be collected.

* Distress value or forced sale value:
Distress value is the reduced value of the property due to financial difficulties of the seller, insufficient knowledge of the property valuation etc. It is always lower than the market value.

* Replacement value:
It is the present value of a property or portions thereof if these have to be replaced at current marked rates.

* Potential value: when a property is capable of fetching more return due to its alternative use or by advantageous planning or by providing some development works, such inherent value of

property is known as potential value.

* Monopoly value:
In case land is scarce little remaining for sale or certain properties possess special advantages with respect to adjoining property due to its location, frontage, size, shape, the owner may demand fancy price. Such value of a property is known as monopoly value.

* Sentimental value: when a property is sold or purchased at higher or lower value than market value due to playing of sentiments in the mind of the owner or purchaser, then this value is known as sentimental value.

* Speculative value: Speculation in agricultural land, ripe for building development, will cause values to rise, even before roads are made and services installed. A proposal to construct any infrastructure in an undeveloped area will cause a rise in value. Speculators purchase such properties at a low price as far as possible known as speculation value and sell it again at profit after a short duration, without spending any further amount towards its development.

* Scrap value: Scrap value is the value of dismantled materials of a property at the end of its utility period, and absolutely useless except for sale as scrap. It is the value of dismantled property (materials) after deducting labour charge to dismantle.

* Salvage value: It is estimated value of a perperty at the end of its utility period without being dismantled. This is generally accounted by deducting the depreciations.

* Comparison between scrap value and Salvage value:

Scrap value	Salvage value.
1.) This is the dismantled sale value of materials of an asset at the end of its useful life.	1.) This is the estimated value of an asset as a whole without dismantling at the end of its useful life.
2.) Scrap value is counted in the calculation of depreciation of a property at the end of the useful life and usually this is considered 10% of the cost of the structure or on lump-sum basis.	2.) Ordinarily, the salvage value factor in the calculation of depreciation is omitted by accounting scrap value.
3.) Scrap value of an asset is merely sale of scrap and has a limitation.	3.) Salvage value deposition may take the form of a sale of the asset to a purchaser who will continue to use it for the function for which it was originally designed. In this case salvage value dominate scrap value in the calculation of depreciation.
4.) Scrap value is not counted as negative quantity.	4.) There are times when it is negative quantity.

* Rateable Value:

It is the net annual letting value of a property. It is obtained after deducting the amount of yearly repairs from the gross income.

Sinking Fund:

The fund or amount of money deposited annually or periodically at a certain interest rate so as to accumulate the necessary fund to replace the building or structure at the end of its useful life is called sinking fund. The sinking fund is given by

$$\text{Annual sinking fund, } I = S \times i_c = S \times \left\{ \frac{i}{(1+i)^n - 1} \right\}$$

where, S = total sinking fund required
i = Rate of interest.
n = number of years of useful life
i_c = Coef. of annual sinking fund.

Capital Cost:

It is the total cost of construction including land or, the original total amount required to posses a property.

Capitalised Value:

The capitalised value of a property is the sum or amount, the interest on which at the highest prevailing rate would be equal to the net income out of the property.

Capitalised value = Net annual return x year's purchase

* Year's purchase (Y.P.)

Year's purchase is defined as the capital sum required to be invested in order to receive an annuity of Re. 1/- at certain rate of return.

Let an interest Rs. i_p/- be gained per annum on capital of Rs. 100.

∴ an interest of Re. 1/- be gained per annum on

$$\text{Capital} = \text{Rs. } \frac{100}{i_p} = \frac{100}{\text{Rate of Return.}}$$

Thus, to gain an annual income of Rs. x at a fixed rate of interest the capital sum should be

$$x \times \frac{100}{\text{Rate of interest.}}$$

∴ $Y.P. = \frac{100}{i_p}$ is termed as year's purchase for very long term purchase.

∵ A building, machine etc. becomes useless after certain years i.e. at end of its useful life. Hence, it is necessary to set aside a certain amount annually called sinking fund, then

$$Y.P. = \frac{100}{i_p + i_c}$$

where i_c, Coef. of sinking fund $= \frac{i}{(1+i)^n - 1}$

Obsolescence:

This may be defined as the loss in value of the property due to change in fashions, in designs, in structure, in adequacy to present or growing needs, necessity for replacement due to new inventions etc. Thus, though the properties may be physically sound, it may become functionally inadequate and its economical return becomes less.

Depreciation:

Depreciation is the loss in the value of the property due to its use, life, wear & tear, decay and obsolescence. This is an assessment of the physical wear and tear of the building or property and is naturally dependent on its original condition, quality of maintenance and mode of use. Thus, the value of a building or property (but not land) decreases gradually up to the utility period due to depreciation.

The book value of a property at a particular time is the original cost less all depreciation till the time.

* Types of Depreciation
  - → physical depreciation (wear & tear.)
  - → functional depreciation (Inadequacy, obsolescence.)
  - → Contingent depreciation (defects, pollution, scarcity of gas, water supply.)

Differences between Depreciation and obsolescence:

Depreciation	obsolescence:
1.) This is the physical loss in the value of the property due to wear & tear, decay etc.	1.) The loss in the value of the property due to change of design, fashion in structure of others, change of utility, demand and also specific detrimental influences.

Depreciation	Obsolescence
2.) Depreciation depends on its original condition, quality of maintenance and mode of use.	2.) obsolescence depends on normal progress in the arts, inadequacy to present or growing needs etc.
3.) This is variable according to age of the property. More the age, more will be the amount for depreciation.	3.) This is not dependent on age of the building. A new building may suffer in its usual rent due to obsolescence.
4.) There are different methods by which the amount of depreciation can be calculated.	4.) there is no method of calculation of obsolescence.

methods of Calculating depreciation:

a.) straight line method.

b.) Constant percentage method.

c.) Sinking fund method.

d.) Quantity survey method.

* a.) **straight line method:** In this method, the property is assumed to lose value by a constant amount every year, and thus a fixed amount of original cost is written off every year so that at the end of life, only the scrap value remains. i.e.

$$\text{Annual depreciation} = \frac{\text{original cost} - \text{scrap value}}{\text{life in years.}}$$

i.e. $D = \frac{C - S_c}{n}$

b.) Constant percentage method:

In this method, the property is assumed to lose its value by a constant percentage of its value (or book value) at the beginning of every year.

Let p be the percentage rate of annual depreciation expressed in decimal, C be the original cost, Sc be the scrap value & n be the life in years, then

$$p = 1 - \left(\frac{S_c}{C}\right)^{1/n}$$

$$S_c = C(1-p)^n$$

c.) Sinking fund method: In this method, the depreciation is assumed to be annual sinking fund plus the interest of the accumulated sinking fund till that year.

Annual sinking fund to provide for Re. 1 in n years

$$= \frac{i}{(1+i)^n - 1} = x \text{ (say.)}$$

An amount of Re. 1 per annum in n years $= \frac{(1+i)^n - 1}{i} = y$ (say)

∴ Rate of depreciation in n years $= x \times y = xy$

d.) Quantity survey method:

Value of property is studied in detail and loss in value due to life, wear and tear, decay, obsolescence is worked out. only experienced valuer can work out the amount of depreciation and present value of property by this method.

Qualification of Valuer:

A valuer is an expert who can work out the market value of a property based on scientific analysis and instances of sales. A good valuer is an engineer or architect who must possess sound knowledge of the following area of subjects:

- → planning, designing & construction works.
- → Surveying & levelling
- → Estimating and costing
- → Knowledge on market rate of land and materials.
- → Rate of interest.
- → Knowledge regarding rent act, and other prevailing acts and regulations.
- → Building codes and bye-laws.
- → Law of contracts
- → zonal importance of land & buildings.
- → Knowledge of vastu science
- → Report writing skills.
- → Computer skills etc.

Method of Valuation:

1.) Rental Method
2.) Profit Based method
3.) Depreciation Method of Valuation
4.) Capital value Comparision Method.
5.) Cost Based Method.
6.) plinth area Method.
7.) Development Method.

1.) Rental Method of valuation:

Value of Property = Capitalized Value

Capitalized Value = Net rent x years purchase.

Net rent = Gross rent - outgoing (expenses)

Expenses: Repair, taxes, sinking fund, insurance, management & collection charge, loss of rent etc.

$$\text{Year's purchase} = \frac{1}{i_p + i_c} \quad \text{(for definite)}$$

$$= \frac{1}{i_p} \quad \text{(for indefinite)}$$

$$\text{where, } i_c = \frac{i}{(1+i)^n - 1}$$

i_p = highest prevailing rate of interest in decimal

i = rate of interest for sinking fund

n = useful life of structure.

2.) Profit based method of valuation:

Generally, used in valuation of Hotel, Comercial Complex, Cinema Hall etc.

Value of Property = Capitalized value of building + value of land.

Capitalized value = Net income/profit x year's purchase

Net income = Gross income - outgoing

3.) Depreciation Method of valuation:

In this method, depreciated value of building is calculated.

Value of property = Depreciated value of building + Value of land

where, depreciated value of building is calculated as;

$$\text{Depreciated value of Building} = P\left(1 - \frac{Y_d}{100}\right)^n$$

where, P = present market value

Y_d = fixed percentage rate of depreciation.

n = life of structure.

4.) Capital value comparision method:

Used in land valuation by comparing the revailing rate of land nearby vicinity.

5.) Cost based method:

This is most accurate method of valuation in which detailed cost estimatation of property is carried out by drawings and as built structure.

Value of Property = Value of building by detailed cost estimate - total depreciation + value of land.

$$\text{Total depreciation} = \left(\frac{\text{Cost of building} - \text{Salvage/scrap value}}{\text{life of building}}\right) \times \text{Age of building}$$

6.) Plinth Area Method:

This method is most popular method of valuation. In this method, total plinth or, built up area of building is measured for valuation.

Value of Property = Total plinth area x prevailing plinth area rate - total depreciation + value of land.

7.) Development method:

It is applied in newly built town and colony.

Plotting of land is carried out by development method.

Developed value = cost of land + cost expenditure in development.

Report writing:

→ After doing all the calculation work, the valuation report is prepared for submitting the concerned department. The valuation report is prepared and submitted in the standard format approved by the concerned department.

→ It consist of three parts.

Part I: deals with all details about the property.

Part II: Include actual valuation, calculations and final value as ascertained by the valuer.

Part III: the valuer's declaration.

Finally Annexure is attached as supporting documents.

(2071 Bhadra) Problems on Valuation

2. Calculate the value of a building built 10 years ago having a plinth area of 450 sqm, constructed in the land of 1000 sqm. Current market value of land is Rs. 15,000 per sqm. and rate of building is Rs. 30,000 per sqm. Assume suitable data, if necessary

Solution

Age of building = 10 years
plinth area of building = 450 sqm.
area of land = 1000 sqm.
Rate of land = Rs. 15,000 per sqm.
Rate of building = Rs. 30,000 per sqm.

∴ Cost of land = Rs. 15,000 × 1000
= Rs. 1,50,00,000/-

Total cost of building = Rs. 30,000 × 450
= Rs. 135,00,000/-

Assuming annual rate of depreciation of building as 10%, the ~~cost~~ depreciated in building

$= Rs. 1,35,00,000 \left(1 - \frac{10}{100}\right)^{10}$
= Rs. 47,07,159/-

∴ Current value of Building (including plot of land.)
= Rs. 47,07,159/- + 1,50,00,000/-
= Rs. 1,97,07,159/-

(2070 Magh)

Workout the value of a cinema hall from following data

i.) Cost of land = Rs. 5 crore
ii.) Gross income = Rs. 2 crore
iii.) operating cost = 40% of gross income
iv.) Repair & Maintenance of machine = 5% of capital cost where capital cost = 40 lakh.
v.) Repair of Hall = 5% of gross income
vi.) Sinking fund for machineries whose life is estimated 25 years @ 4% allowing 10% scrap value
vii.) Insurance premium = Rs. 50,000 per year.
viii.) Assume year's purchase for 60 years at 8% and redemption of capital at 10%.

Solution

Gross income per year = Rs. 2,00,00,000/-

Outgoings:

i.) operating cost @ 40% of gross income = Rs. 80,00,000/-

ii.) Repair & maintenance of machineries
@ 5% of Rs. 40,00,000/- = Rs. 2,00,000/-

iii.) Repair of Hall @ 5% of gross income = Rs. 1,00,000/-

iv.) Sinking fund for machineries with 25 years life @ 4%.

total sinking fund = $I - S = I - 0.1I = 0.9I$
$= Rs. 0.9 \times 40,00,000$
$= Rs. 36,00,000/-$

Sinking fund cef. for machineries

$$I_C = \frac{i}{(1+i)^n - 1} = \frac{0.04}{(1+0.04)^{25} - 1} = 0.024$$

∴ Annual sinking fund required = $Rs. 36,00,000 \times 0.024 = Rs. 86,400/-$

v.) Insurance premium = Rs. 50,000/-

Total outgoings = Rs. 84,36,400/-

∴ Net income = Gross income - outgoings

= Rs (2,00,00,000 − 84,36,400)

= Rs 1,15,63,600/-

Year's purchase for 60 years @ 8% and redemption of capital @ 10% ;

$$Y_p = \frac{1}{I_p + I_c}$$

Coef. of sinking fund for 60 years, $I_c = \frac{i}{(1+i)^n - 1} = \frac{0.1}{(1+0.1)^{60} - 1}$

$= 0.0003295$

$I_p = 0.08$

$$\therefore Y_p = \frac{1}{0.08 + 0.0003295} = 12.4487$$

∴ Capitalised value = Rs. 1,15,63,600 × 12.4487

= Rs. 14,39,51,788/-

∴ Total valuation = Capitalized value of Cinema Hall + value of land

= Rs (14,39,51,788 + 5,00,00,000)

= Rs. 19,39,51,788/-

Exercises on valuation (From M. Chakraborti)

Q.N. 1.) Work out the valuation of a cinema house with the following data: Cost of land for life time period of the house (i.e. deferred value) = Rs. 1,20,000, gross income per year = Rs. 7,50,000. Expenses require per year.

(i) To run the cinema including staff salary, electric charges, municipal taxes including licence fee, stationery, printing etc. is 30% of gross income;

(ii) For repair and maintenance of machinery, plant, equipment, furniture, etc. 5% of their capital cost of Rs. 9,50,000; at 4%.

(iii) Sinking fund for machinery as in (ii) whose life is 25 years at 4% after allowing 10% scrap value;

(iv) Insurance premium is Rs. 10,000 per year. Assume year's purchase for 60 years at 8% and redemption of capital at 4%. Annual repair of the house 2% on gross income.

Solution:

Gross income per year → Rs. 7,50,000/-

Outgoings:

(i) Staff salary, electric charges & printing charges @ 30% of gross income → Rs. 2,25,000/-

(ii) For repairs & maintenance of machinery etc. @ 5% of Rs. 9,50,000/- → Rs. 47,500/-

(iii) Sinking fund for machinery etc. with 25 years life @ 4% on

Rs. 9,50,000/- * $\frac{90}{100}$ = Rs. 8,55,000/-

Sinking fund coeficient for machinery,

$$I_c = \frac{i}{(1+i)^n - 1} = \frac{0.04}{(1+0.04)^{25} - 1} = 0.024$$

(2)

∴ Sinking fund on Rs 8,55,000/- = 0.024 × 8,55,000/- ⟶ Rs. 20,520/-

(iv) Insurance premium per year ⟶ Rs. 10,000/-

(v) Annual repair of the house @ 2% on gross income ⟶ Rs. 15,000/-

Total Rs. 3,18,020/-

∴ Net income = Gross income − Outgoings

= Rs.(7,50,000/- − Rs. 3,18,020/-) = Rs. 4,31,980/-

= ~~Rs.~~

Year's purchase for 60 years @ 8% and redemption of capital @ 4%;

$$Y_P = \frac{1}{I_P + I_C}$$

Co-eff. of sinking fund for 60 years, $I_C = \frac{i}{(1+i)^n - 1} = \frac{0.04}{(1+0.04)^{60} - 1} = 0.0042$

$I_P = 0.08$

∴ $Y_P = \frac{1}{0.08 + 0.0042} = 11.88$

∴ Capital value = Rs. 4,31,980 × 11.88

= Rs. 51,31,922/-

∴ Total valuation = Capital value of house + value of land for 60 years

= Rs.(51,31,922 + 1,20,000)

= Rs. 52,51,922/-

Ans

Q.N.2) The cost of a new building is Rs. 2,50,000. Work out the depreciated cost of the building after 10 years, by straight line method and constant percentage method. if the scrap value is Rs. 25,000, assuming the life of building is 50 years.

Solution

a) Straight - line method:

$$\text{Annual depreciation} = \frac{\text{Original cost} - \text{Scrap value}}{\text{Life in years}}$$

$$= \frac{\text{Rs. } (2,50,000 - 25,000)}{50}$$

$$= \text{Rs. } 4500$$

∴ Depreciation for 10 years = Rs. 4500 × 10

= Rs. 45,000

∴ Depreciated cost of the building after 10 years

= Rs. (2,50,000 − 45000)

= Rs. 2,05,000/- Ans

b) Constant Percentage Method (or Declining Balance Method):

The percentage rate of annual depreciation for the constant percentage method;

$$P = 1 - \left(\frac{S_c}{C}\right)^{\frac{1}{n}}$$

Here, Scrap value (S_c) = Rs. 25,000/-

Original cost (C) = Rs. 2,50,000/-

Life of building (n) = 50 years

$$\therefore P = 1 - \left(\frac{25,000}{2,50,000}\right)^{\frac{1}{50}} = 0.045007413$$

∴ Value of property at the end of 10 years = $C(1-P)^{10}$

$= 250,000(1 - 0.045007413)^{10}$

= Rs. 1,57,739.34 /- Ans.

Q.N.3) A person has invested Rs. 80,000 in land and building expecting 6% return. The plot of land costs Rs. 20,000. Assuming the cost of annual repair to be Rs. 200.00, management charges Rs. 1,000.00 per annum and other outgoings at 20% of the gross rent, calculate the reasonable monthly rent if annual sinking fund coefficient is 0.01.

Solution:

Total investment in land & building = Rs. 80,000/-

Cost of plot of land = Rs. 20,000/-

∴ Investment in building = Rs. 60,000/-

∴ Annual net return required → Rs. 80,000 × 0.06

= Rs. 4800/-

Outgoings:

(i) For annual repairing → Rs. 200/-

(ii) Annual management charges → Rs. 1,000/-

(iii) Other outgoings → 20% of gross rent → Rs. 0.2x

(Assuming gross rent = Rs. x per annum)

(iv) Annual sinking fund → Rs. 60,000 × 0.01

= Rs. 600/-

Total outgoings = Rs. (1800 + 0.2x)

∴ Gross rent per annum = Net annual return + Total annual outgoings.

$\Rightarrow x = 4800 + 1800 + 0.2x$

$\Rightarrow x = \frac{6600}{0.8} = Rs.\ 8250/-$

∴ Gross rent per annum = Rs. 8250/-

∴ Reasonable monthly rent = $\frac{Rs.\ 8250/-}{12}$

= Rs. 687.50/-

Ans.

Q.N. 4) The owner of a building gets a net annual rent of Rs. 3500. The future life of the building is estimated as 12 years. But if recommended repairs are carried out immediately at an estimated cost of Rs. 30,000, it is expected to last for at least 30 years. Assuming the rate of interest as 8%, determine whether it is economical to carry out the recommended repairs to the building or leave it as it is.

Solution:

Net rent per annum = Rs. 3,500/-

Value before repair:

Assuming single rate of interest, sinking fund co-efficient for 12 years;

$$I_c = \frac{0.08}{(1+0.08)^{12}-1} = 0.0527$$

$$\text{yearly purchase (Y.P.)} = \frac{1}{I_p + I_c} = \frac{1}{0.08+0.0527} = 7.536$$

$\therefore$ Capitalised value = Rs. $3,500 \times 7.536$ = Rs. 26,376/-

Value after repair:

Sinking fund co-efficient for 30 years,

$$I_c = \frac{0.08}{(1+0.08)^{30}-1} = 0.0088$$

$$Y.P. = \frac{1}{I_p + I_c} = \frac{1}{0.08+0.0088} = 11.261$$

$\therefore$ Capitalised value = Rs. 3500×11.261 = Rs. 39,414/-

The difference of value after & before repair

= Rs. (39,414 − 26,376) = Rs. 13,038/-

Since the estimated cost of repair Rs. 30,000/- is greater than the increased value of the building after repair Rs. 13,038/-, It is not economical to carry out the recommended repair & so it is better to leave it as it is.

(6)

(Q. N. 5.) On a free hold plot of land measuring 300 m² and costing Rs. 60 per m², a building is constructed at a total cost of Rs. 2,50,000 including land and services. The building is expected to last 65 years. The owner expects a 9% return on the cost of construction and 6% on the cost of land. The rate of intrest on sinking fund is 5% and all other outgoings work up to 32% of the net income from the building. Assume the scrap value at the end of life period as 10% of the cost of construction. Determine the standard rent per month to be fixed for the building.

Solution:

Cost of land = Rs. 60 × 300 = Rs. 18,000/-

Total cost of building including land & services = Rs. 2,50,000/-

∴ Cost of building construction (excluding land cost) = Rs. (2,50,000 − 18,000)
= Rs. 2,32,000/-

Annual net return:

(i) On building cost @ 9% = Rs. 2,32,000 × 0.09 = Rs. 20,880/-

(ii) On land cost @ 6% = Rs. 18,000 × 0.06 = Rs. 1,080/-

∴ Net annual return required = Rs. 21,960/-

Outgoings:

Scrap value at 10% cost of building = Rs. 2,32,000 × 0.1 = Rs. 23,200/-

∴ Amount of sinking fund required = 90% of cost of building
= Rs. 0.9 × 232,000 = Rs. 2,08,800/-

Sinking fund co-efficient $(I_c) = \frac{i}{(1+i)^n - 1}$

$= \frac{0.05}{(1+0.05)^{65} - 1} = 2.189 \times 10^{-3}$

(i) Annual sinking fund required → Rs. 2,08,800 × 2.189×10^{-3}
= Rs. 457/-

(ii) Other outgoings → 32% of net return → Rs. 0.32 × 21960
= Rs. 7,027.20/-

Total outgoings = Rs. 7,484.20/-

∴ Gross rent per annum = Net annual return + total outgoings

= Rs. (21,960 + 7,484.20)

= Rs. 29,444.20/-

∴ standard rent per month = $\frac{\text{Rs. } 29,444.20}{12}$

= Rs. 2453.68 ADS.

Q.N.6.) A building constructed on a site measuring 20m x 30m is fetching a gross rent of Rs. 2,500 per month. The plinth area of the building is 140 m^2 and the cost of constructing it is Rs. 2,000 per m^2 of plinth area. The estimated life of the building is 70 years. Determine the present value of the property based on rental income assuming a net yield of 9%. For sinking fund accumulation, a compound interest rate of 5% may be assumed. Taxes, annual repairs and all other outgoings may be taken as 32% of the gross income, and the cost of land as Rs. 80 per m^2.

Solution:

Cost of building construction = Rs. 140 x 2,000 = Rs. 2,80,000/-

Cost of land = Rs. 20 x 30 x 80 = Rs. 48,000/-

Gross income per annum = Rs. 2,500 x 12 = Rs. 30,000/-

Outgoings

a) For taxes, annual repairs & all other outgoings = 32% of gross income

= Rs. 0.32 x 30,000

= Rs. 9,600/-

b) For sinking fund

Sinking fund coef. $(I_c) = \frac{i}{(1+i)^n - 1} = \frac{0.05}{(1+0.05)^{70} - 1} = 1.7 \times 10^{-3}$

∴ Sinking fund → Rs. 2,80,000 x 1.7×10^{-3} = Rs. 476/-

Total outgoings = Rs. 10,076/-

∴ Net income = Gross income - outgoings

= Rs. (30,000 − 10,076)

= Rs. 19,924/-

Also given, purchase coefficient, $I_p = 0.09$

∴ $Y.P. = \frac{1}{I_c + I_p} = \frac{1}{1.7 \times 10^{-3} + 0.09} = 10.905$

∴ Value of the property = Net income * Y.P.

= 19,924 * 10.905

= Rs. 2,17,271.22/-

Ans.

Q.N.7.) A leasehold property is to produce a net annual income of Rs. 12,000 for the next 30 years. The owner expects a return of 8% on his capital and also sets apart a sinking fund instalment to accumulate at 6% annually to replace the capital. Determine the value of the property.

Solution:

Coefficient of annual sinking fund, $I_c = \frac{i}{(1+i)^n - 1}$

$= \frac{0.06}{(1+0.06)^{30} - 1} = 0.0126$

rate of interest on capital, $I_p = 8\% \equiv 0.08$

∴ Year's Purchase, $Y.P. = \frac{1}{I_p + I_c} = \frac{1}{0.08 + 0.0126} = 10.799$

∴ Value of the property = Net annual income x Y.P.

= Rs. 12,000 x 10.7999

= Rs. 1,29,588/-

Ans

Q.N.8) A building is constructed at a cost of Rs. 2,50,000 on a land purchased at Rs. 50,000. The owner of the property expects a return of 9% on the cost of construction and 8% on the cost of land. The building is estimated to have a future life of 60 years at the end of which it requires Rs. 3,25,000 for constructing a new building in its place.

Determine the standard rent of the property. Given:

(i) Rate of interest for sinking fund at 6%;
(ii) Annual repairs at 1% of the cost of construction;
(iii) All other outgoings: 28% of the net income of the property;
(iv) Scrap value at the end of the useful life of the building as 10%.

Solution:

Annual net return required-

(i) on building cost @9% = 2,50,000 x 0.09 = Rs. 22,500/-
(ii) on land cost @ 8% = 50,000 x 0.08 = Rs. 4,000/-

∴ Annual net return required = Rs. 26,500/-

Outgoings:

Scrap value is 10% of cost of building construction = 0.1 x Rs. 2,50,000 = Rs. 25,000/-

∴ Amount of sinking fund required = Rs. 3,25,000 - Rs. 25,000 = Rs. 3,00,000/-

(i) Annual sinking fund required, $I = S * I_c$

where $I_c = \frac{i}{(1+i)^n - 1}$ = sinking fund coef.

$= \frac{0.06}{(1+0.06)^{60} - 1} = 0.0019$

and S = Total amount of sinking fund required = Rs. 3,00,000/-

∴ I = Rs. 3,00,000 x 0.0019 = Rs. 570/-

(ii) Annual repairs @ 1% of the cost of construction ⟶ Rs. 0.01 x 2,50,000 = Rs. 2,500/-

(10)

(iii) Outgoings 28% of net return $\longrightarrow 0.28 \times 26,500 = Rs.\ 7,420/-$

$\therefore$ Total annual outgoings $= Rs.\ 10,490/-$

$\therefore$ Gross rent per annum = Net annual return + total annual outgoings

$= Rs.\ (26,500 + 10,490)$

$= Rs.\ 36,990/-$

$\therefore$ Standard rent per month $= \frac{Rs.\ 36,990/-}{12}$

$= Rs.\ 3,082.50/-$

ANS.

Q.N.1) The owner of building gets a net annual rent 3500/- The future life of building estimated 13 years. But if recommended repair carried out immediately at an estimated cost of Rs. 30,000/-. It is expected to last for 32 years. Assuming the rate of interest as 8%. Determine whether it is economical to carry out the recommended repair to the building or leave as it is.

Solution:

Net rent per annum = Rs. 3,500/-

Value before repair:

Assuming single rate of interest, sinking fund coefficient for 13 years;

$$I_C = \frac{i}{(1+i)^{13}-1} = \frac{0.08}{(1+0.08)^{13}-1} = 0.0465$$

$$\text{yearly purchase (Y.P.)} = \frac{1}{I_p + I_C} = \frac{1}{0.08+0.0465} = 7.90377$$

∴ Capitalised value = Rs. 3,500 × 7.90377 = Rs. 27,663.20/-

Value after repair:

Sinking fund coef. for 32 years

$$I_C = \frac{0.08}{(1+0.08)^{32}-1} = 0.00745$$

$$Y.P. = \frac{1}{I_p + I_C} = \frac{1}{0.08+0.00745} = 11.434999$$

∴ Capitalised value = Rs. 3,500 × 11.434999 = Rs. 40,022.50/-

The difference of value after & before repair

= Rs. (40,022.50 − 27,663.20) = Rs. 12,359.30/-

Since the estimated cost of repair Rs. 30,000/- is greater than the increased value of the building after repair Rs. 12,359.30/-, It is not economical to carry out the recommended repair & so it is better to leave it as it is.

Q.N.2.) You have been asked to prepare a valuation report of the properties for buying purpose. Mention the various data which you will collect as a valuator.

Solution:

To prepare a valuation report of the properties, The various data which will have to collect as a valuator are as follows:

A.) Property Inspection

B.) Property Description

C.) Technical Details.

A.) Property Inspection: Data required for property inspection are as follows:

i.) Owner of the property
ii.) Location of the property
iii.) Plot Number of property
iv.) Land area
  a.) As per land ownership paper.
  b.) As per actual measurement.
v.) Surrounding Land Aspects.
vi.) Approach road details.
vii.) Proximity to the main road.

B.) Property Description:

i.) Type of property.
ii.) Land details
  a.) Shape
  b.) Topography
  c.) Frontage
  d.) Depth of Land.
iii.) Services available
  a.) Water supply
  b.) Electricity
  c.) Sewarage.
  d.) Communication/Entertainment

(iv) Surrounding properties.
(v) Immediate Environment.

c.) Technical Details:

i.) Anticipated future life time.
ii.) Type of structure.
iii.) Number of floors.
iv.) Height of each floor.
(v) Plinth area of building.
(vi) Compound Walls.
(vii) Types of Doors/windows/staircases
viii) Electric/Sanitary fitting.
ix) Pavements etc.