

**GOVERNMENT POLYTECHNIC
KENDRAPARA**

**DEPARTMENT
OF
CIVIL ENGINEERING**



LECTURE NOTES

Year & Semester: 3rd Year, 6th Semester

Subject code/Name -Th-2, Construction management

By Bhagabata Jena, PTGF, Civil

CHAPTER-1

INTRODUCTION TO CONSTRUCTION MANAGEMENT

CONSTRUCTION MANAGEMENT

The process of implementation of management principles in construction procedures and methods is called construction management.

Aims and objectives of construction management

Following are the various Aims and Objectives of construction management:

- a) Completing the work within estimated budget and specified time.
- b) Evolving a reputation for high quality workmanship.
- c) Providing safe and satisfactory working condition for all personnel and workers.
- d) Taking proper decisions at the most practical level through delegation of authority.
- e) Motivating people to put their best effort.
- f) Create an environment of encouragement to work as a team.

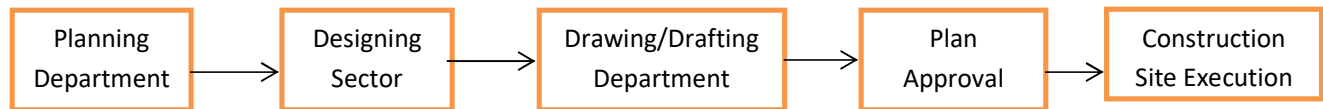
Functions of Construction Management

1. Planning and Scheduling-

Planning- This method includes finding various alternatives, evaluating all the alternatives, and finding out the best alternative for any particular construction work or method.

Scheduling- Scheduling is the process of fitting the best alternative to a time scale. In shortly, scheduling means when to perform what construction work.

2. **Organising-** Organising is the process of division of construction work into various manageable departments.



3. **Staffing-** Staffing is the process of recruitment of proper candidate to proper department.
4. **Directing-** Directing is the process of assigning various task to the individuals or employees and directing them with proper guidance to perform the specified task.
5. **Controlling-** Controlling is the process in which the performance of doing a task is checked, evaluated, assessed properly for efficiency and any change or problem in the task is identified, corrected and implemented. This increases the efficiency of the organisation.

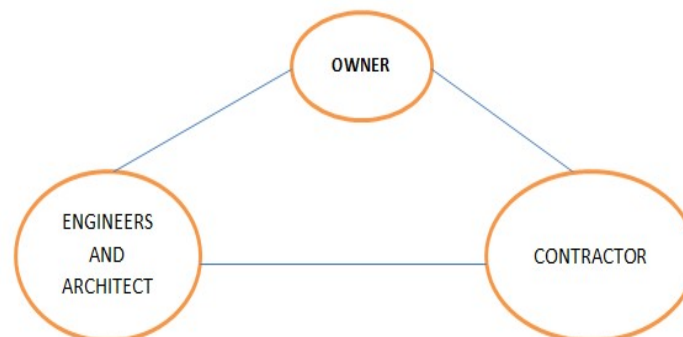
6. **Co-ordinating-** Co-ordinating is the process in which the members of the organisation co-ordinate with each other for completion of a task. It can be intra-department or inter-department coordination.

CONSTRUCTION TEAM

The Construction team consists of a Owner, Engineers, and Contractors.

1. **Owner-** Owner is a person/a group of person who take the final decision of any construction activity. The owner holds the authority of financing the construction work. Any change in the scope, plan or schedule of any construction activity is approved by the owner.
2. **Engineers/Architects-** Engineers are the technical employees who take care of all the technical works of a project. The Engineers includes all core branches like Civil, Mechanical, Electrical Engineers that execute their individual roles at the project site. The Architects beautifies the building and increases its aesthetic aspect.
3. **Contractor-** The contractor of any construction project takes care of all aspect like providing construction materials, arranging labour and equipment for construction work.

Relationships within a construction Team



RESOURCES FOR CONSTRUCTION INDUSTRY

1. **Materials-** Bricks, Stones, Cement, aggregates, steel, shuttering, scaffolding, timber, water-supply arrangements, plumbing materials, etc.
2. **Human Resource-** Technical Manpower (Engineers, Architects, Surveyors) and Labours(Skilled, Semi-Skilled, Unskilled)
3. **Machinery-** Construction equipment like rollers, vibrators, mixers, tower cranes, transit or miller trucks, dumpers, etc.
4. **Space-** Space is of utmost importance for construction activities like storing material, site office, for placing of equipments, for carpentry works.

5. Funds- The most important resource for any construction industry is fund. Without proper funds the construction work cannot progress at all.

CHAPTER-2 CONSTRUCTION PLANNING

CONSTRUCTION PLANNING

Construction Planning is the process of finding out various alternatives of performing a particular construction project and finding out the best alternative for implementation.

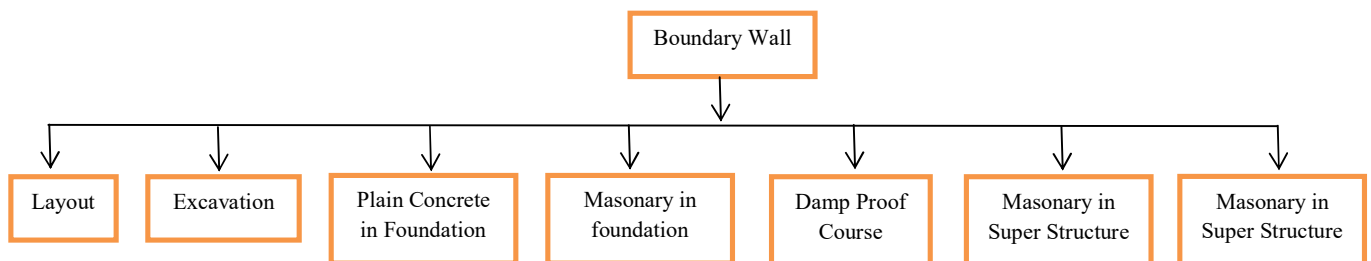
IMPORTANCE OF CONSTRUCTION PLANNING

1. Construction planning is the starting phase of all management functions in a construction project.
2. A construction project can be well managed if it is well-planned.
3. Planning of a construction work includes WBS(Work Breakdown Structure) which includes dividing a large work into simple manageable components.
4. Construction planning is important for controlling the progress of construction work by basing it on a planned schedules and planned strategies for backup provisions.
5. Planning in construction forecasts the resource requirement for the construction process (machinery, funds, materials, etc.)
6. Construction planning is a tool used in planning departments to identify problems that are likely to occur during construction and plan strategies before-hand to tackle such construction problems.

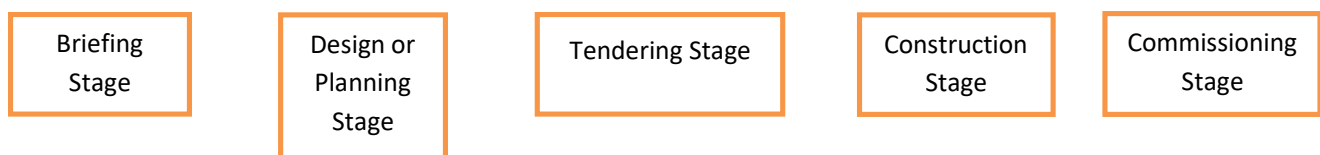
Work Break-down Structure (WBS)

The Work Break-down Structure is a technique in which a construction work is separated into separate recognisable activity which can be managed properly.

[Example of a WBS of a Boundary Wall Construction is given below]



I. Stages in Construction



1. Briefing Stage

- i. Understanding the purpose of the project from the client. (**Conceptualisation** of Construction Project)
- ii. Appointment of project manager to the Client
- iii. Formation of a Project directing committee
- iv. Assess the feasibility of the project
- v. Detail Technical and Non-Technical Investigation of the construction site, material, equipment and labour availability
- vi. Preparation of a brief report describing the purpose of the construction project, the investigation details, their possible alternatives and their feasibility.

2. Planning/Designing Stage:

- i. To determine the method of construction
- ii. To prepare detail design, working drawings, specifications, bill of quantities, cost estimates and preliminary construction steps or programme plan including time schedule
- iii. Conduct of Pre-Tendering and Post tendering activities for the contractor to investigate the feasibility of performing construction activities at the site, economy of engaging labour and equipment performance.
- iv. Summarization of the whole construction project including proper design and estimate as per the convenience of the client for approval.

3. Tendering Stage:

- i. Quotation formation with details of the construction work, the items of work along with the rates.
- ii. Publish of Notice inviting tenders from various contractors. (e.g. Class A to Class F contractors)
- iii. Evaluation of terms, conditions, work specifications and completion of various bids from individual contractors.
- iv. Choosing of bidder with best term and condition matching the requirements of the project and approval of owner.
- v. Awarding of the contract to the **Best Bidder** (henceforth called as the **Contractor**)
- vi. **Contract** documents are prepared which includes all information of the project to the last detail that **binds** the Client and Contractor in **legal** terms until the completion of the project.

4. Construction Stage:

- i. This is the actual **Realisation** of the project.

- ii. This stage includes construction work starting from surveying, layout, excavation, concreting, masonry works, plastering, flooring, wiring, plumbing, etc.
- iii. The execution of construction work is properly supervised by engineers-at-site as per the planned schedule as designed during the planning stage.
- iv. Coordination between contractor and engineers is important at this stage
- v. Quality of material and workmanship is closely monitored to maintain the quality of construction work.

5. Commissioning Stage:

- i. Performance of the construction work is evaluated and nature of maintenance work is determined
- ii. Quality check of various construction works is conducted by non-destructive techniques.
- iii. Finally after all evaluations are assessed to be perfect the project is handed over to the client denoting the end of construction work and end of contract.

II. Stages in Construction Planning

The Planning Stage consists of following two stages:

1. Pre-tender Stage:

Pre-tender stage is the stage in which the contractors are allowed to visit the location of construction for evaluating the feasibility of the construction project for proper bidding. A pre-tender project report is documented which includes all details about the site investigation, local weather report, labour availability, and the working environment of the construction site.

- a) The bidder is allowed to carry out investigations like survey of land, labour, materials, local weather condition and equipment functionality.
- b) The Contractor can examine the drawings and specification of construction work to identify various items of work.
- c) The Contractor can properly estimate various alternatives for most suitable and economical method of construction.
- d) Prepare a tentative schedule of construction works and estimate the completion time of the project.
(Final Work Plan)
- e) Finally, the contractor fixes the overheads and the profit margin and finalize the tendering price for completing the work within stipulated time.

2. Post-tender Stage/ Contract Stage:

- i. Contract stage occurs after the award of the contract to the contractor and it extends till the end of the construction project.
- ii. In this stage the contractor evaluates the best alternatives to execute the construction work effectively and most economical way.
- iii. Coordinate for execution of the project as per the planned schedule.

- iv. Various techniques/methods are used to assess the progress of a particular project (Gantt Chart, CPM, PERT)

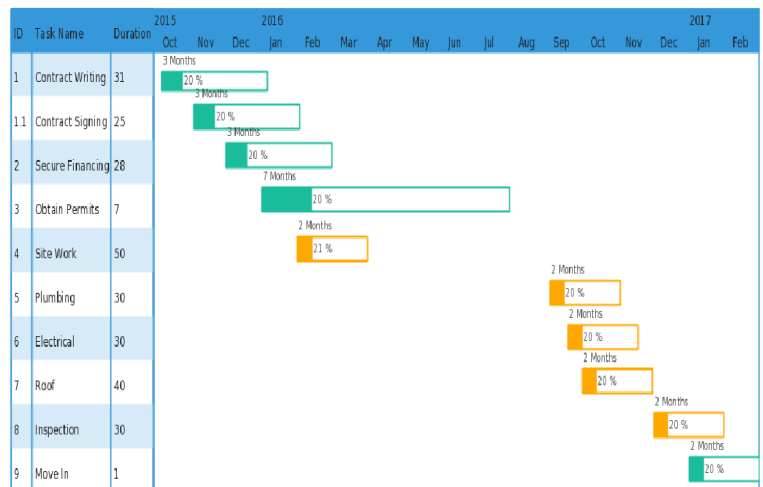
III. Construction Scheduling

Construction scheduling or simply **Scheduling** in construction means the process of fitting final work plan into a time scale indicating start and completion time of each and every construction activity.

1. Gantt Chart Scheduling:

Gantt Chart is a chart that is used for scheduling of construction activities. The Gantt chart consists of the Construction Activity on the Y-axis and the Time duration on the X-axis. Also, called Bar Chart.

The activities are shown separately by bars where the length of bar shows the duration that the particular construction activity takes to complete.



The progress of the construction activity is shown by shading the bar with colour or hatching.

Note: The disadvantages of Gantt Chart are:

- * It does not show inter-dependency between activities. (Does not show if the progress is delayed or not)
- * Critical activities cannot be known.

2. Network Analysis and Scheduling:

Network analysis consists of methods to assess the various construction activities, their inter-dependency with each other, and find out the activities that need most attention during the progress of a construction project.

Network Analysis consists of following methods:

- A. Critical Path Method (CPM)
- B. Programme Evaluation and Review Technique (PERT)

Features of Network Planning:

2. The network shows the critical activities and events which need special attention during progress of the project.
3. The network can be used for time-cost optimisation.

(Optimising means not using too much or too less of the resources available, i.e. optimised utilisation)

4. Resources can be allocated or diverted from one activity to other for optimising. (Resource Allocation)

Following are the terms associated with Network Analysis:

- a) **Activity**- Progress of a specific task or construction activity which has a definite beginning or end is called activity.
- b) **Event**- The beginning or end of an activity is called an event
- c) **Network**- Network is the inter-connection of multiple events and activities showing their inter-dependency among them.
- d) **Dummy**- Dummy represents a dummy activity which does not consume any time or resource but shows the importance of completion of an activity before start of another. Dummy serves two purpose:
 - a) Logical purpose
 - b) Grammatical purpose

A. CRITICAL PATH METHOD (CPM)

Critical Path Method is a network analysis technique used for scheduling of construction activities.

Features of CPM:

1. CPM is activity oriented method. (i.e. it depends on activity)
2. CPM is used for projects that are repetitive in nature or deterministic in nature.
(All activities and their time durations are well known before hand)
3. CPM is used for Construction projects.

Terminology for Critical Path Method:

1. Activity duration- The time duration that an activity takes to complete. (T_{ij})
2. Earliest Start Time- Earliest time at which an activity can start (EST)
3. Earliest Finish Time- Earliest Time at which an activity can finish (EFT)

$$EFT = EST + T_{ij}$$

4. Latest Start Time- Latest time at which an activity can start without delaying the project (LST)
5. Latest Finish Time- Latest time at which an activity can finish without delaying the project (LFT)

$$LFT = LST + T_{ij}$$

Floats:

- i. Total Float (F_T) - Total Float is the time by which the start or finish of an activity can be delayed without delaying the completion of the project.

OR

(remember any one)

ii. Free Float (F_F)- Free Float is the portion of total float (F_T) that can be used without delaying the succeeding activity.

$$F_F = F_T - S_j$$

iii. Independent Float (F_I)- Independent Float is the excess time that exists if the preceding activity ends as late as possible and the succeeding activity starts as early as possible.

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

iv. Independence of activity- It is the time duration by which an activity is independent of the completion of its preceding activity and the start of its succeeding activity

v. Slack(S) - Slack is the time duration difference between the (LST~EST) or (LFT~EFT) of any particular activity.

$$\text{Head Event Slack} = S_i = (LST - EST)$$

$$\text{Tail Event Slack} = S_j = (LFT - EFT)$$

vi. Interference float is the head event slack

$$F_{IN} = F_T - F_F$$

Critical Path

Critical Path is the path in the network that connects critical activities having Total Float value equal to zero (i.e. where $F_T=0$).

Critical Activity and Events are those activities and events respectively which lie on critical path

Advantages of CPM:

1. Makes the whole project financially economical.
2. The CPM Network analysis identifies critical activities and events.
3. Proper attention can be given to the critical activities and events.
4. Resource allocation can be done economically basing on the CPM network analysis.
5. The CPM analysis shows the dependency of activities and the activities that can be delayed without delaying project completion. (It is done by utilising Float Values)

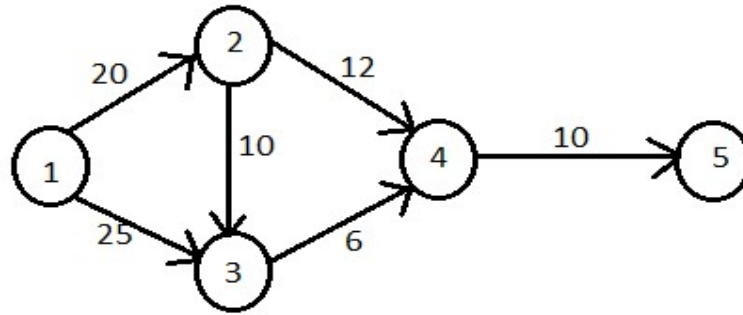
Example 2.1

For the following data draw the network, find the EST,EFT,LST,LFT, F_T , F_F , F_{ID} . Find the critical path and the project completion period.

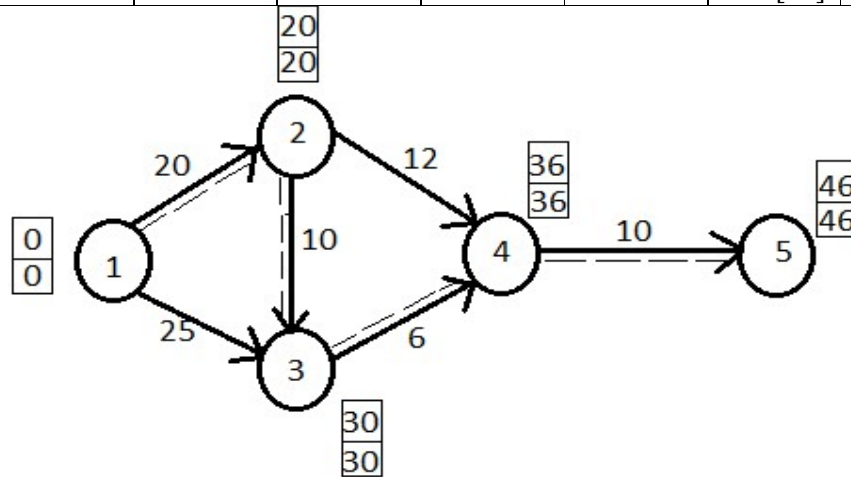
Activity	Duration
1-2	20
1-3	25
2-3	10
2-4	12

3-4 6
 4-5 10

Solution:



Activity	Duration in days	EST	EFT	LST	LFT	F _T	F _F	F _{ID}
1-2	20	0	20	0	20	[0]	0	0
1-3	25	0	25	5	30	5	5	5
2-3	10	20	30	20	30	[0]	0	0
2-4	12	20	32	24	36	4	4	4
3-4	6	30	36	30	36	[0]	0	0
4-5	10	36	46	36	46	[0]	0	0



The
 Activity 1-
 in the diagram above (dashed arrow)
 The Project completion time is **46 days**.

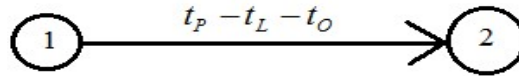
Critical Path is:
2-3-4-5 as shown

B. PERT Network Analysis

- a. PERT is Programme Evaluation and Review Technique.
- b. This method is a probabilistic approach.
- c. The completion duration of any activity cannot be determined (it means it is generally variable)
- d. This method of scheduling is used for Research organisation. (Not suitable for construction organisation)
- e. The completion time period for any activity is expected time (T_E).
- f. There are three time periods in expected time:
 1. Pessimistic time (t_p) - The maximum time period that an activity is expected to be completed if everything goes wrong.

2. Most Likely time (t_L) - The time period that an activity is expected to be completed if everything goes under normal condition.
3. Optimistic time (t_O) – The minimum time period that an activity is expected to be completed if everything goes good.

g. An activity in PERT analysis is represented as:



h. Expression for Expected time (T_E) is shown below:

$$T_E = \frac{t_P + 4t_L + t_O}{6}$$

Differentiate Between CPM and PERT

Sl. No.	CPM	PERT
1	It is called Critical Path Method	It called Programme Evaluation and Review Technique
2	It is Activity Oriented	It is Event Oriented
3	It is Deterministic Approach	It is Probabilistic Approach
4	This Method is suitable for Construction Organisation	This method is suitable for Research Organisation
5	This method is utilised for repetitive projects	This method is used for completely new project.

CHAPTER-3

MATERIAL MANAGEMENT

CONSTRUCTION MATERIALS

Construction materials are the materials that are utilised for construction purposes.

Construction materials consist of Cement, sand, aggregates, brick, timber, steel, scaffoldings, glass panels, PVC Pipes, wires, plumbing accessories, colour paints, etc.

STORAGE OF CONSTRUCTION MATERIALS

Schemes of storage of materials depend on the following factors:

a. Type of material:

The storage of materials depends on the type of material to be stored. Materials like sand, aggregates can be stored outside but cement has to be stored in a damp-proof store.

b. Access of materials:

The storage of materials depends on the material accessibility. If the materials like scaffoldings are stored then it should be placed such that it can be placed and removed easily (i.e. accessibility)

c. Location of materials:

The materials should be stored at such places that it is not damaged due to climatic conditions and avoid catching of fire due to increased temperature. (Inflammable materials are stored securely)

d. Amount of materials:

The Store room size should be sufficient to accommodate materials securely within it. It depends on the amount of materials to be utilised during construction activity.

Important Guidelines for storage of different construction materials

1. Cement- It should be placed in dry storage area. Cement should not be stored for long duration.
2. Form-works- Formworks should be placed at stores free from white ants and placed such that counting of formwork is possible and can be accessed easily.
3. Equipment and Machineries- Equipment must be stored at places of minimum corrosion or dust.
4. Steel Bars- Steel bars should be stored in lots and painted to avoid corrosion.
5. Ready Fittings- Plumbing and timber footings must be stored securely in stores in dry condition.

Stores

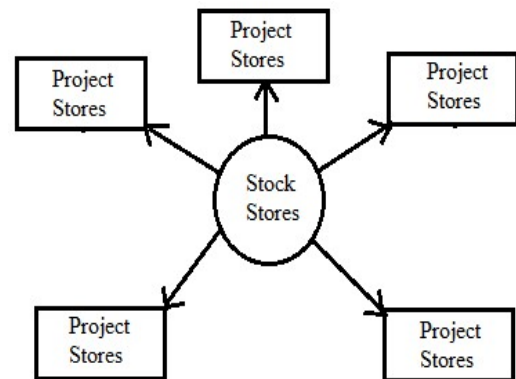
A store is a place where materials of construction are properly placed in arranged manner and stored for various construction activities.

There are two types of stores:

- a) Project Stores
- b) Stock Stores

a) Project stores- These stores are arranged at construction sites. Once the project at site is complete the on- site stores are dismantled or utilised for other purposes.

b) Stock Stores- Stock Stores are storage places for common building materials. Big construction companies have a separate stock stores from where materials are issued for construction works at various number of construction sites.



Various Principle of Material Management

- a. Planning of storage space and minimisation of movement of men and materials.
- b. Handling of materials like receiving, storage, in-process handling, inspection, packaging, shipping and transportation should be coordinated
- c. Material flow pattern must be based on operation sequence and equipment management.
- d. Optimum utilisation of space for material handling.
- e. Safe handling conditions to avoid breakage of materials.
- f. Reduction of unproductive time.

The objectives of material management are:

- 1. Efficient material planning
- 2. Procurement of materials
- 3. Buying /Purchasing of materials
- 4. Storing and Inventory Control
- 5. Supply and distribution of materials to construction site
- 6. Safeguard the quality of materials

TERMINOLOGY:

- 1. Stock:

Stock of materials means various construction materials that are grouped into separate sub-heads and stored in stores.

- 2. Inventory:

The amount of materials stored in stock is called inventory. The inventory in stock is always monitored so as to avoid shortage of construction material during the progress of construction project.

3. Issue of materials:

When materials are need in construction they are issued from the stores so as to keep record of materials, its amount consumed and remaining, time of issue, etc. to keep track of materials utilised in the construction process.

4. Indent:

Indent is a document generated by the user for the procurement of materials. It consists of a UIN (Unique Identification Number) and details of the material.

5. Invoice:

Invoice is a document that lists the type of material purchased, its amount or number, rate of each item purchased, bill of quantities and the total cost incurred during the purchase.

6. Bin Card:

Bin Card is a document used to record the status of a material in stock. It consists the details of the amount of material in stock, amount of material received and the problem attached to the goods (material).

7. Stock Taking:

Stock taking is the checking of the quantity and condition of inventory stored. It is the investigation team that takes the responsibility for stock taking. This is useful for writing-off losses after the end of a particular task.

8. Stock Control:

Inventory or Stock control are the two processes in material management that utilize the scientific procedures to divide stocks into various categories and handle important materials. There are two types of inventory control: a) ABC Analysis b) VED Analysis

9. Reserve Stock limit:

It is the maximum amount of materials that can be stocked in stores.

10. Minimum holding limit:

Minimum holding limit of stock is that amount of materials at which it must be ensured that the procurement for purchase of that material is initiated.

Difference between various terms:

1. Bin Card and Stores Ledger:

Bin Card	Stores Ledger
a) Bin Card consists of quantity of material received, issued and remaining in stock.	a) Store's Ledger keeps record of each and every transaction of material from the stores.
b) Bin Card Contains quantity details only.	b) Stores Ledger contains both quantities of material and monetary details.

c) Bin card is stored in store rooms only.	c) Stores Ledger is kept in accounting departments.
d) Bin cards are first recorded and then materials are issued.	d) Entering in stores ledger occurs after transaction.

2. Ordering and Issuing

Ordering	Issuing
a) Requirements of various departments are noted and forwarded to purchasing departments.	a) Various materials are issued to respective departments when materials are demanded.
b) Materials are not available at stores during ordering	b) Materials are available at the stores during issuing.

3. Stock Control and Inventory Control

Stock Control	Inventory Control
a) Stock control is the method to manage materials directly at the stores.	a) Inventory control uses procedures to manage materials indirectly.
b) ABC and VED analysis are utilised in managing materials at stores properly.	b) Inventory Control uses the tools like reserve stock, minimum and maximum stock limit, stock remaining, etc.
c) Stock control is done at stores directly by handling materials.	c) Inventory control is done at accounting departments.
d) Stock Control cannot directly evaluate when to procure materials.	d) Inventory Control can sense the need of procurement at proper time.
e) Categorisation/Division of materials into different categories is done to store materials properly and securely.	e) Inventory control avoids the excess blockage of funds in stores and further avoids funds shortage while the project is progressing.

4. Accounting of Stocks and Accounting of Tools & Plants:

Accounting of Stocks	Accounting of Tools and Plants
----------------------	--------------------------------

<p>a) Quality and quantity of stocks are recorded.</p> <p>b) When stocks are in shortage, the values are deducted in accounts.</p> <p>c) This account register is closed half-yearly.</p>	<p>a) Only quantity details are recorded.</p> <p>b) Tools and Plant items are recorded here even if they are in shortage and written later.</p> <p>c) This account register is closed yearly.</p>
---	---

MATERIAL MANAGEMENT PROCEDURES

Stages of Material Management:

1. Register of Suppliers:

A register of suppliers is maintained containing cost of materials supplied by them. It is updated at regular intervals.

2. Calculate the quantities of materials:

Quantities of materials are calculated/estimated from drawings and specifications.

3. Supply Schedule:

According to plan of work, supply of materials, must be fit into a time frame (time duration). A supply schedule is prepared so that material reaches site of work before the start of planned work.

4. Purchasing:

Depending on supply schedule materials are purchased before time to keep materials ready before construction of particular work.

5. Ordering of materials:

Ordering of material is done basing on the quantities required at a time or in phases.

6. Inspection:

Before the material is brought on to site, inspection should be done. If any rejection is needed, can be done before sending it to site. This will avoid further dispute at later stage.

7. Acceptance and issue of materials:

The materials after being brought to the site are properly stored. Bin cards are generated and other accounting registers are prepared to keep details of the materials purchased and stores in stores and the materials used in construction site (transaction of materials).

8. Use of Network Analysis:

Network technique like CPM can also be used to manage the schedule of materials and the critical events like purchase and order of vital items can be taken care of.

9. Tool & Plants (T&P):

Tools and Plants are procured in a project work for a specified purpose. Tools and plants include construction machinery (Compactors, vibrators, Rollers), vehicles(Trucks, jeeps, dumpers),

tools(Hammers, rammers, shovels), surveying instruments(compass, theodolites, dumpy levels, staff), engineering instruments(Compression testing machine, CBR apparatus, pycnometer),etc.

- The account register is specially maintained to enter the receipt and issue details of tools and plants. That register is called as **T&P account register**.

METHOD OF STOCK AND INVENTORY CONTROL

a) Stock Control:

The materials stored at stores are controlled by stock controlling procedures. There are two stock controlling procedures: a) ABC analysis b) VED Analysis

a) ABC Analysis

In ABC analysis the whole stock is separated into three categories:

- 1) Category A 2) Category B 3) Category C

Category A Materials are stored in stores and managed in senior management level. Without the consent of the senior management the Category A materials cannot be utilised in the project.

Category B Materials are those materials which are controlled at medium management level.

Category C Materials are those materials which are under control of the junior management level.

b) VED Analysis

In VED analysis the stock is divided into three categories:

- a) Vital b) Essential c) Desirable

Vital- These materials are of vital importance. Without these materials any construction task cannot proceed at all. This material is managed at senior management level. Even if vital materials are less in quantity then also it is controlled at senior management.

Essential- These materials are important for construction (essential but not vital)

Desirable- Materials which are desirable for any construction work but are not essential. These materials are managed at junior management level.

b) Inventory Control:

Inventory Control is the procedures used for the controlled management of materials at accounting departments. Inventory control also uses the ABC analysis for material management. The main objectives of inventory control are:

1. **To avoid the excess blockage of funds of the organisation:**

Funds are important for construction project to proceed. But if unnecessary utilisation of funds is done for the purchase of materials, the funds may get blocked and may not be available at other stages of construction project.

2. **To see that the project is not starved of materials when needed:**

The inventory control utilises the concept of maximum/minimum stock limit, reserve stock(inventory), etc. This allows the organisation to take timely action for procurement of Vital or Category A materials, shortage of which the project would starve and delay progress.

Accounting Procedures of Stores: (Short Note)

The accounts of stores are based on the fundamental principle that cost of every article is ultimately debited to the **final head** of the account created for each **particular work** (as simplified in the **WBS structure**). In case of materials, tools & plants, road metal when required for a specific work can be immediately booked under final head.

But in certain cases like purchase of cement & steel immediately purchased due to requirement at site, cannot be booked in the final head of the work directly. It is because the quantity of material to be used at site is uncertain. So these materials are booked under a separate head temporarily called as **suspense head**. After the completion of the particular work, the suspense heads are **put up to the final head** and the suspense head of that particular work is cleared.

Disposal of Surplus Material:

Materials in construction project are sometimes in excess due to:

1. Reduction in construction work.
2. Change in design & specification.
3. Excess ordering of materials.

This results in surplus of materials at the end of construction project. These materials are disposed of by following two ways:

1. They are diverted to other construction sites for use.
2. If these cannot be used further in construction, it is auctioned in public after necessary permissions from responsible authority.

I. Writing-off Losses:

If it is found that the loss of materials have occurred in spite of taking all the pre-cautions and no-body can be blamed, then a loss statement is reported along with the attachment of the stock-taking officer's findings and investigation report. The loss is finally written off under the order of the senior authority.