Vocational Higher Secondary Education (VHSE)

SECOND YEAR

CIVIL CONSTRUCTION TECHNOLOGY

Reference Book

Government of Kerala
Department of Education

State Council of Educational Research and Training (SCERT),
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Foreword

Dear Learners,

This book is intended to serve as a ready reference for learners of vocational higher secondary schools. It offers suggested guidelines for the transaction of the concepts highlighted in the course content. It is expected that the learners achieve significant learning outcomes at the end of the course as envisaged in the curriculum if it is followed properly.

In the context of the Right- based approach, quality education has to be ensured for all learners. The learner community of Vocational Higher Secondary Education in Kerala should be empowered by providing them with the best education that strengthens their competences to become innovative entrepreneurs who contribute to the knowledge society. The change of course names, modular approach adopted for the organisation of course content, work-based pedagogy and the outcome focused assessment approach paved the way for achieving the vision of Vocational Higher Secondary Education in Kerala. The revised curriculum helps to equip the learners with multiple skills matching technological advancements and to produce skilled workforce for meeting the demands of the emerging industries and service sectors with national and global orientation. The revised curriculum attempts to enhance knowledge, skills and attitudes by giving higher priority and space for the learners to make discussions in small groups, and activities requiring hands-on experience.

The SCERT appreciates the hard work and sincere co-operation of the contributors of this book that includes subject experts, industrialists and the teachers of Vocational Higher Secondary Schools. The development of this reference book has been a joint venture of the State Council of Educational Research and Training (SCERT) and the Directorate of Vocational Higher Secondary Education.

The SCERT welcomes constructive criticism and creative suggestions for the improvement of the book.

With regards,

Dr. P. A. Fathima
Director
SCERT, Kerala

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ABOUT THE COURSE

Civil engineering is one of the oldest disciplines of engineering which can be dated back to the first time when somebody laid a tree across a river to cross it. It is one of those branches of engineering which have both a scientific as well as artistic aspect to it. Construction of structures is a major activity of civil engineering. At the same time, water resources engineering and environmental engineering are also another two major disciplines of this subject.

In the first two modules named ADVANCED SURVEYING, CIVIL CONSTRUCTION and DRAFTSMANSHIP, in the first year, the students step into the preliminary part of construction. During the second year another two modules are incorporated ESTIMATING AND COSTING, WATER SUPPLY and SANITARY ARRANGEMENTS. All these four disciplines are the most needed topics in view of its importance in the present trends of the construction industry. A lot of work force is needed in the construction sector at the skilled, semi skilled level and supervisory level in India and internationally.

The study of estimating and costing reduces wastage of money, time, labour etc. in construction. It also helps in scheduling all the above parameters properly so as to acquire optimum output from minimum resources.

The study of water supply and sanitary arrangements helps to utilize the most precious natural resource - water with proper planning so that huge amount of money can be saved in water supply thus wholesome water can be supplied without fail to society. Through the study of Sanitary arrangements the refuses can be collected, conveyed and disposed scientificaly by approprate techniques.

Major Skills (with Sub-skills)

- Measuring Skill
- Estimation Skil
- Tabulation skill
- Execution skill
- Management skill
- Organisation skill
- Drafting skill
- Analysing skill
- Supervising skill

- Planning skill
- Logical reasoning skill
- Co-ordinating skill
- Communicating skill

SYLLABUS

Module 3: - Quantity Surveying & Costing

Unit 3.1 - Introduction to Quantity Survey — Periods: 49

Estimation - Purpose of estimation - Data required to prepare an estimate - Standard units of measurement - Units and modes of measurement as per IS 1200 - Types of areas - Plinth area, floor area, carpet area and circulation area - Specification of items of work - Necessity of specification- General specification of I class buildings - Detailed specifications of different items of work - Earthwork excavation, PCC works, RR masonry, Brick masonry, and plastering.

Unit 3.2 - Types of Estimate — Periods: 188

Preliminary or approximate estimate - Plinth area estimate - Cubical content estimate - Detailed estimate - Work charged establishment - Different methods of estimation of buildings - Exercises of residential buildings - Bar bending schedule.

Unit 3.3 - Analysis of Rates — Periods:15

Factors affecting cost of an item of work - schedule of rates - Analysis of rates of different items of work - Earthwork excavation in ordinary soil and hard soil - PCC work - RCC works - RR masonry - Brick masonry - Analysis of rates - Preparation of abstract of cost using spreadsheet.

Unit 3.4 - Contracts & Tenders — Periods: 10

Contract - Tender - Earnest money deposit - Security deposit - Kinds of contracts - Work order form - Administrative approval - Technical approval - Procedure for inviting tender - Invitation of tenders - e tender - Contract agreement - Conditions of contract - Obligations of contractor, engineer and client - Measurement book- Muster roll.

Unit 3.5 - Network Analysis — Periods: 10

Introduction - Developing a network using CPM - Developing network using PERT Difference between PERT and CPM - Construction safety management.

Unit 3.6 - Valuation of buildings Periods: 68

Factors affecting the value of a property - Purpose of valuation - Valuation based on cost - Valuation based on profit - Methods of valuation - Sinking fund method- Depreciation method - Quantity survey method - Mortgage - Annuity - Rent fixation.

List of Practicals

Unit 1 Plinth area calculation

Prepare the plan, elevation and section of a two storied residential building and find out the plinth area (2 nos.)

Unit 2 Measurement Practice

a) Measure the dimensions of a compound wall. (1no)

b) Measure the dimensions of a single room and prepare the sketch. (Inner and outer dimensions) (1 no)

c) Measure the dimensions of all components of a residential building and prepare the line sketch. (2 nos)

Unit 3 Quantity survey

Calculation of quantities of following items of works by measuring the dimensions of an existing building / building under construction.

a) Earth work in excavation for foundation
b) RR Masonry for foundation and basement
c) Masonry for super structure
d) RCC works
e) Plastering
f) Floor finishing works

Unit 4 – Estimation (Long wall Short wall method)

a) Estimation of quantities of items of a compound wall (1 no.)

b) Estimation of quantities of items of a single room (1 no.)

c) Estimation of quantities of items of a residential building (2 nos.)

d) Estimation of quantities of items of a school building (1 no.)

Unit 5 – Estimation (Centre line method):

a) Preparation of detailed estimate using given centre line plan (3 nos.)

b) Preparation of detailed estimate using centre line method for a given plan (4 nos.)

Module 4: Water Supply & Sanitary Arrangements

Unit 4.1 - Sources and treatment of water — Periods: 7

Sources of water - Impurities in water- Factors affecting the selection of sources of water- Hardness in water and its removal- Steps in water purification- Aeration - Sedimentation with coagulation- Filtration - Chlorination -Water softening-Water demand for Residences, Restaurants, Cinemas and Theatres, Day Schools, Boarding Schools, Hostels, Hospitals with Laundry, Offices, etc. (per head per day) IS standards of potable water.

Unit 4.2 - Water supply system — Periods: 15

Distribution of water - Continuous and intermittent system - Layout of distribution system - Gravitational system - Pumping system - Combined system - Factors affecting storage of water - Rainwater harvesting - Objectives - methods - Collection for different uses - Rainwater collection for groundwater recharge

Unit 4.3 - Plumbing — Periods: 208

History of plumbing- Plumbing tools- Types and sizes of pipes - Pipe fittings - valves - Water tap with censor- Water meter- Fire hydrants - Pipe fixtures -Pipe joining materials - Method of laying pipe lines - Types of pumps -Hot water appliances and installation -House connection from public water supply system- Lay out with estimation of plumbing system- Study of rain water harvesting system -Irrigation system for domestic farming and gardening (drip and sprinkler)

Unit 4.4 - Sanitary System — Periods: 90

Introduction - Technical terms -Traps -Inspection chamber- Different systems of sewage disposal -Conservancy and water carriage system-Classification of water carriage system-Comparison between conservancy and water carriage system- Septic tank - Different types -System of plumbing- Layout and estimation of sanitary system in a building - Waste management - Methods of waste disposal - Waste minimisation.

Unit 4.5 Sanitary fixtures — Periods: 20

Wash basin- Showers - Sink -Water closet (Indian and European type)- Bidet- Health faucet-Flushing cistern .Maintenance and repair of plumbing system.

List of Practicals

Unit 01: Study of tools, Identification and its working

Unit 02 : Plumbing

Pipe cutting with hacksaw- Pipe threading with Die set - Study of different types of fittings (L-Bow, Bend, Tee, Coupling, Reducer, Union, Plug)

Fixing of pipe fittings with pipes using Threaded connection, shellac and cotton. teflon tape and solvent cement.

Make a flanged joint connection using GI Flanged pipes of convenient diameter

Practicing water tap connection in a water line

Practicing parallel connections of three water taps in a main water supply line

Making a house water connection from a public water supply line with water meter fitting.

Practice a drip irrigation connection for domestic purpose and small scale farming

Draw neat sketch of a layout plan of water supply system of one bedroomed residential bulding (2 nos)

Draw a neat sketch of layout plan of a rain water harvesting system for a residential building.

Unit 03 : Sanitary system

Practice shower fitting with stop cock

Practice the wash basin and kitchen sink fitting with necessary piple fittings

Practice the Indian type water closet fitting with necessary fittings

Practice the European type water closet fitting with flushing cistern and health faucet

OVERVIEW OF MODULE III

This module covers the various aspects of estimating the quantities of items of work involved in building construction and building services. It elaborates on the calculation of quantities of different items of engineering works so as to know its approximate cost, the quantities of materials required and the labour involved for its satisfactory completion, before the commencement of the project. It covers the rate analysis, valuation of properties, network analysis and contract and tenders so as to enable the students to prepare estimates, to find out the material quantities, make specifications and construction scheduling and to prepare tender documents.

This module will fulfill the needs of the students who would like to work in the construction management/ building construction sector. The students will be able to obtain jobs in quantity survey sector and those who are willing to start their own enterprise in the construction sector can acquire the desired competencies with the help of this curriculum.

Vocational skills expected from this module are:

- Measuring skill
- Estimation skill
- Tabulation skill
- Execution skill
- Management skill
- Organisation skill
- Preparation of drawings and detailed estimates of buildings.
- Making quantity survey
- Finding out quantities of materials and labour for executing the work

Unit 3.1 Introduction to Quantity Survey

This unit gives an introduction to quantity survey and deals with purposes of estimation, data required to prepare an estimate, units and mode of measurement of various items of work etc. This unit also covers different types of areas like plinth area, floor area, carpet area, and circulation area. General specifications and detailed specifications of various items of building works are also described in this unit. Preliminary knowledge regarding quantity survey can be obtained after completion of this unit.

Learning Outcomes

The learners:

- Identify the need of estimation. Get a thorough knowledge of data required for estimation.
- Identify the units of measurement of various items of work.
- Acquire indepth knowledge on the methods of measurement of various items of work.
- Compare the difference in modes of measurement of various construction activities.
- Compare different types of horizontal areas of a building.
- Understand the terms relevant to the construction project.
- Calculate different work of areas.
- Apply the knowledge in construction related activities.
- Get awareness on the necessity of specification and how it affects the cost of construction.
- Get a thorough knowledge of the detailed specifications of items of work.
- Understand the steps involved in an item of work.
- Execute various construction activities.
- Manage and administer material allocation

Concepts

An estimate can be defined as the process of calculating the quantities and costs of the various items required in connection with the work. It is the preparation of the probable cost of the proposed work from its plan and specifications.

Purposes of Estimation

1. Find out the amount of money required to complete the work.
2. For public works administrative approval, allotment of funds and technical sanction are done based on the estimate.
3. Find out the quantities of materials required for their timely procurement.
4. Fix up the completion period from the quantity of work involved.
5. Prepare the construction schedule and arrange the funds according to the programme.
6. Invite tenders and prepare bills for payment.
7. An estimate of an existing property will be required for its valuation.
8. Calculate the required number of labours of different categories to complete the work according to the programme.
9. Assess the requirements of tools, plants and equipments for the timely completion of the work; and
10. Justify the investment of the project.

Data required for the Preparation of an Estimate

a) Drawings: The quantities of various items of work are prepared from the drawings. Hence a fully dimensioned drawing showing the plan, different sections and other details should be available for the preparation of a detailed estimate.

b) Specifications: The rate of an item varies depending upon the specification. So specifications are necessary for analysing the rates of items..

c) Rates: The cost of an item of work is obtained by multiplying the quantity with its rate. So, rates for different items of work are necessary for the preparation of an estimate.

Assessment activity

Preparation of a chart on the data required to prepare an estimate and an oral test based on the purposes of estimation

3.1.2 Units and measurements

The measurement of works done or supply of materials made are done accurately in units decided by ISI for making payments. The standard units of measurement of some of the items of work are:

- Earth work in excavation for foundation - cu.m.
- Earth filling / sand filling - cu.m.
- Cement concrete in foundation - cu.m.
- Damp proof course - sq.m.
- PCC works - 10 dm^2
- RCC works - 10 dm^2
- Brick work in cement mortar for foundation, plinth, super structure etc, - cum
- Random rubble masonry in cement mortar - cu.m.
- Ashlar masonry in cement mortar - cu.m.
- Flooring with different types of floor covering - sq. m
- Wood work for door and window frames -10 dm^3
- Door and window shutters - sq. m
- Reinforcement in RCC work - quintal
- Iron grills in windows - kg
- Plastering - sq. m
- Painting - sq. m

The mode of measurement of various items of building works are:

Excavation for foundation

Measurement is taken as area of the bottom of foundation multiplied by the depth of foundation,

Reinforced cement concrete:

Quintel is worked out by multiplying the length, width and thickness PCC and RCC are classified and measured separately. For RCC works the quantity of reinforcement is calculated separately by its weight.

Damp proof course:

DPC is measured by its area.

Brick work:

For brick work, its cubical content is taken. For walls deductions are made for doors and windows.

Flooring:

Measured in square metre. Dados shall be measured in square metres and skirting shall be measured in running metres, stating the height.

Plastering:

All plastering works are measured in square metre unless otherwise specified. Deductions for openings exceeding 0. 5 sq. m but not exceeding 3 sq. m each shall be made for one face of the wall only, when both faces are plastered with same plaster.

Whitewashing, colour washing and distempering:

All items are measured separately and measurement is same as those of plastering.

Painting

Painting should be measured in square metres unless otherwise specified. No deductions shall be made for openings less than 0. 5 sq. m.

Roofing:

The mode of measurement of roofing depends on the type of roof. For RCC roofing it is measured by multiplying the length by the width and thickness of the slab. Sheet roofing is measured by its superficial area and the wooden purlins on which the sheets are fixed are measured in cubic metre. The measurement of steel supporting members is done in Kg.

Assessment Activity

Practical activity on measurement of various items of work.

3.1. 3 Definition of plinth area, floor area, carpet area and circulation area:

Plinth area: Plinth area is the built up covered area of a building measured at floor level of any storey. It is calculated by taking the external dimensions of the building at the floor level. Court yards, open areas, balconies and cantilever projections are not included in plinth area. Supported porches are included in plinth area.

Floor area: Floor area of a building is the total area of floor in between the walls. Sills of doors and other openings, area occupied by walls, pillars, pilaster and other supports are not included in floor area. Floor area is equal to plinth area minus area occupied by walls.

Carpet area: Carpet area of a building is the useable area or liveable area or lettable area. This is the total floor area minus the circulation area, and other non usable & livable areas as sanitary accommodations.

Circulation area: Circulation area is the floor area of verandahs, passages, corridors, balconies, entrance halls, porches, staircases etc. which are used for movement of persons. It is of two types:

Horizontal circulation area: Area used for the horizontal movement (verandahs, passages etc.)

Vertical circulation area: Area used for the vertical movement (stair, lift etc.)

Assessment activity

Practical activity on measuring various types of areas.

3.1. 4 Specifications of items of work

An engineering specification contains detailed description of all materials and workmanship which are required to complete an engineering project in accordance with its drawings and details. The specification is furnished separately along with drawings and it is an essential part of an engineering contract. The drawings with the specifications will completely define the structure.

Necessity of Specification:

1. The cost of unit quantity of work is governed by the specification.
2. Specification of a work is required to describe the quality of different materials to be used for the work.
3. This also specifies the workmanship and method of doing the work and thus serves as a guide to the supervising staff, for the execution of the work.
4. A work is carried out according to the specification and the contractor is paid for the same. Any change in specification changes the rate.
5. Specification is necessary for the preparation of tenders.
6. Specification is necessary to specify the equipments, tools and plants to be engaged for a work and thus helps in procuring them beforehand; and
7. Specification is an essential contract document.

General specifications of I class buildings and II class buildings:

In general specifications, nature and class of works, names of materials and proportions that should be used in the various items of work are described. Only a brief description of each activity is given and it is useful for estimating the project.

Detailed specifications of various items of work:

Detailed specifications, give the method of construction and specify the nature of work. Study of the detailed specifications of the following items of work will help to understand how each item of work is carried out in site, and the requirements regarding the material, labour, workmanship etc.

- Earth work in excavation of foundation trenches.
- Cement Concrete (PCC)
- Reinforced Cement Concrete (RCC)
- Random Rubble Stone Masonry
- Brick Masonry
- Plastering with cement mortar

Assessment Activity

Preparation of field visit report after thorough inspection of specifications of various items in construction sites.

TE Questions

1. Define estimation.
2. Estimate is an important construction document. Justify the statement listing its purposes.
3. For the preparation of an estimate various data are required. List them.
4. Write down the unit of the following items of work:
   a) Earth work in excavation in foundation.
   b) RR masonry for foundation
   c) RCC 1:2:4 for roof slab
   d) Plastering
5. Explain the mode of measurement of brickwork for walls.
6. Define plinth area.
7. Differentiate between floor area and carpet area.
8. There are two kinds of circulation areas. Write a brief note on them.
9. Define specification.
10. Explain the needs of specification.
11. Give a brief description of detailed specifications of earth work excavation in foundation.

Unit 3.2 - Types of Estimate

About the unit

This unit deals with two methods of estimation of quantities of various items of work which helps to prepare the detailed estimate of a building. It also includes preparation of approximate estimates & bar bending schedule for calculation of actual quantities of steel.

Learning outcomes

The learners :

3.2.1 know different types of estimate.

- prepare approximate estimates.
- make feasibility studies of projects.
- select appropriate methods of estimation.

3.2.2 understand methods of estimation.

- compute the quantities of different items of work and calculate the estimated cost.
- Prepare detailed estimates of residential buildings.

Concepts

3.2.1 Types of estimate

Preliminary or approximate estimate: The preliminary or approximate or rough estimate is made to find out an approximate cost within a short time and to check the financial viability of the project. Detailed drawings and designs are not required and a line sketch as per the requirements may be needed for the purpose.

Purposes of an approximate estimate:

- To investigate feasibility
- To save time and money
- To investigate benefit and comparison of cost with utility
- Adjustment of planning
- To obtain administrative approval
- For insurance and tax schedule

Plinth area estimate: To prepare an estimate by this method, the plinth area of the building should be determined first. The plinth area multiplied by the plinth area rate of the locality for similar buildings constructed recently will give the estimated cost.

Additional information

In the absence of the plan of a building or when only a line plan is drawn, the plinth area can be found out from the floor area. For this add the area of walls at the rate of 15% to 18% (but 8% for RCC framed structures) to the floor area.

Cubical content estimate: In this method the volume or cubical content of the proposed building is worked out and multiplied by the rate per cubic volume of similar buildings in the locality. This is more accurate than the plinth area estimate.

Detailed estimate: This is the most accurate method of estimation. In this method, the quantities of all the items of work are calculated from the drawings. By multiplying these quantities by their respective rates, the cost of all the items of work are worked out individually and then summarised. All other expenses required for the satisfactory completion of the project are added to the above cost to get the total cost.

Work charged establishment: The work charged establishment are the employees who are employed directly on the work for the actual execution of the work or for the supervision. For such work charged establishment, an amount of 2 % to 3 % of the estimated cost of works is provided in the estimate.

Assessment Activity

Classroom exercises of estimation by plinth area method and cubical content method

3.2.2 Methods of Detailed Estimation

The detailed estimate is done in two steps. The first step is to find out the quantities of each item of work and it is done in a standard tabular format known as 'Details of measurements and Calculation of quantities'. The second step is the 'Abstract of Estimated Cost' in which the cost of each item is found out and the summarisation is done to get the estimated cost.

For finding out the quantities of the items, the dimensions are taken out from the drawings. For symmetrical foundations the following two methods can be adopted for estimating the quantities of earthwork in excavation in foundation, foundation concrete, stone masonry or brick masonry in foundation and plinth, and brick masonry in superstructure.

1. Long wall short wall method or Separate or Individual wall method; and
2. Centre line method.

Long wall short wall method: In this method, find out the external length of walls running in the longitudinal direction (long walls), out-to-out and the internal length of walls running in the transverse direction (short walls) , in-to-in, and calculate quantities multiplying this length by the breadth and height.

For this, find out the centre to centre length of long walls and short walls separately from the plan. For long walls, add to this centre length, one breadth of the item which gives the length; and multiply this length by the breadth and height of the item to get the quantity. For short walls, subtract from the centre length, one breadth of the item which gives the length and multiplying this length with the breadth and height of the item the quantity can be obtained.

Additional information

For making the concept clear, draw the plan of foundation trench, foundation concrete and the plan of each footing or steps of wall ; and find out lengths of long walls and short walls.

Assessment Activity

Classroom exercises of finding quantities by long wall short wall method after preparing plans at various levels of a building.

Centre line method : In this method the sum total length of all walls are found out and then the quantities are found out by multiplying the total centre line length by the breadth and height of the item. For buildings having cross walls, for every junction of cross wall with the main wall, half breadth of the respective item is to be deducted from the total centre line length. For buildings having different types of walls, each set of walls shall have to be dealt with separately.

Assessment Activity

Classroom exercises of preparation of detailed estimate by centre line method.

Bar bending schedule

Bar bending schedule is a tabular format showing the details of reinforcement such as diameter of bar, shape of bar, number of bars, length including hook, crank etc. weight per metre length, total weight and the type of bar. The length of bar should be accurately calculated keeping in view the hooks, crank and overlapping. For this the following formulae can be used:

For straight hooked bar: L = l +18d, where;

L = total length of bar

l = length of bars up to hooks

d = diameter of bars

For single crank bar: L = `l + 18d +. 5h, where

h = height of crank

= depth of bar from top of slab or beam – top cover- thickness of bar

For double crank bar, L = l + 18d+ 2 x. 5 h

For 2 legged stirrup L= 2(a+b) + 24 d where;

a = width of stirrup

b = depth of stirrup

For 4 legged stirrup, L = 4 (a + b) + 24d

Simple way to calculate the weight of re: bar

Weight/m of rebar in kg = D × D/162.2

D = diameter of bar in mm

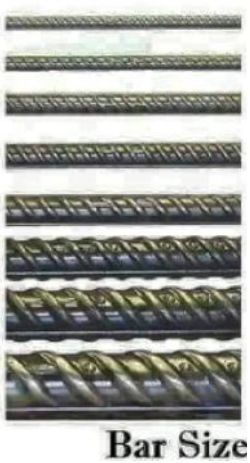
Eg: Weight of 1 m long bar having 10mmdia

= 10 × 10/162.2

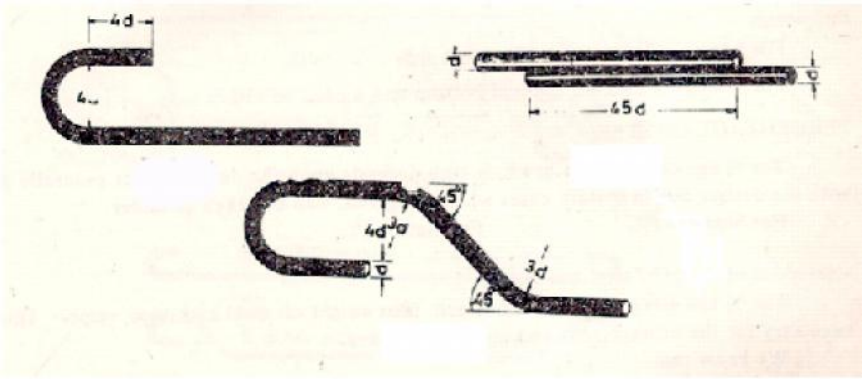
= 0.617 kg

TE Questions

1. Prepare an estimate of a building project with a total plinth area of 150 sq. m from the following details.
   a. Plinth area rate is Rs 15,000/ sq.m.
   b. Cost of water supply @7% of cost of building.
   c. Cost of sanitary and electrical installations @7. 5% of cost of building.



Bar Size



Sl. No.	Details of Bar Shape	Length of Hooks	Total Length of Bar
1.	Diameter [Straight bar] 4d 4d l	2[9d] = 18 d (both hooks together)	[l + 18 d]
2.	[Bent-up at one end only]] $x = \frac{l}{4}$ to $\frac{l}{6}$ D 45° x l D = Vertical distance (C/C) between bars	2[9d] = 18d (both hooks together)	[l + 18 d + 0.42 D]
3.	(Double bent-up bar) $x = \left(\frac{1}{4}\text{ to }\frac{1}{6}\right) l$ l D 45° 45° x x	2[9d] = 18d (as for above cases)	[l + 18 d + 2 × 0.42 D]
4.	(Overlap of bars) 40 d to 45 d (Joint)	2[9d] = 18d	Overlap length at joint = [(40 d to 45 d) + 18 d]
5.	l_1 l_2	[Here, one hooks height = 14d] 2 × (14d) = 28 d	[$l_1 + 2l_2 + 28$ d]
6.	l_1 l_2	2(12d) = 24 d	[$2(l_1 + l_2) + 24$ d]

d. Cost of Architectural features @2% of cost of building.

e. Cost of roads @5% of cost building cost.

f. Cost of P. S and contingencies.

2. The plinth area and plinth area rate of a residential building are 200 sq. m and Rs 18,000/sq. m respectively. Determine the total cost of building assuming suitable provisions.

3. Prepare the rough cost estimate based on unit cost per unit plinth area on the basis of a four storied building having carpet area 2000sq. m for obtaining the administrative approval of the government. It may be assumed that 30% of the corridors, verandhas, lavatories staircase etc. and 105 of built up area will be occupied by walls. the following data are given

Plinth area rate of building	-	Rs 22,000/sq.m.
Extra for special architectural treatment	-	5% of total cost
Water supply and sanitary installations	-	6% of building cost

4. Estimate the following quantities in the standard form of a residential building with a given plan and section.

a. Earthwork excavation for foundation

b. P. C. C for foundation

c. R. R masonry for foundation and basement

d. Brick work for super structure

e. Flooring

f. Plastering of all the walls.

Assessment activity

Classroom exercises on finding the length of bars and prepare the bar bending schedule and a field visit to study bar bending.

Unit 3. 3: ANALYSIS OF RATES

The analysis of rates deals with the calculation of quantities of materials and labour required per unit quantity, required for each item of work and thereby finding out the rates of various items of construction activities. This is done with the help of DSR. This is essential for estimating cost of construction. The study of analysis of rates will also help in procurement of materials in construction projects.

Learning Outcomes

The learners:

- analyse the factors which affect the cost of an item of work.
- identify how cost of construction can be reduced.
- read data book and familiarise schedule of rates.
- calculate the rate of different items of work by calculating the quantities of ingredient materials and labour using DSR (District Schedule of Rates).
- manage construction and material purchases.
- understand methods of preparing estimates using computer.

Concepts

Rate analysis is the process of arriving at a reasonable rate per unit work for a particular item following its specification:

The purposes of rate analysis are:

- To determine the current rate per unit of an item in the locality.
- To examine the viability of rates offered by the contractor.
- To calculate the materials and labour required for project planning.
- To fix up labour contract rates.

3.3.1 Factors affecting cost of an item of work

The following factors affect the rate and thereby the cost of an item of work:

- Specification of an item of work which indicates the quality and proportion of materials and the method of construction.
- The present rate of materials for the item of work at the work site (including transportation).

- Daily wages of different categories of labourers required for the work at the locality
- The range of lead and lift required for deposition of materials to carry out the item of work.
- Percentage charge of overheads which includes insurance etc.
- Besides these the site condition, site organisation and cost control during execution affect the cost per unit of an item of work.

Schedule of Rates:

To facilitate the preparation of estimates and also to serve as a guide in setting rates, a schedule of rates for each kind of work should be maintained by different engineering departments and kept up- to- date, This is a booklet containing rates of various engineering items. It also gives the rates of materials, daily wages of labour, carriage expenditure and tables for quantities of various materials required in construction. This is prepared on the basis of the prevailing rates in each locality including the cost of transportation and all other charges.

3.3.2 Analysis of rates of different items of work

1. Earthwork excavation in ordinary soil
2. Earthwork excavation in hard soil
3. PCC – 1:4:8
4. RCC – 1:2:4
5. RR masonry in CM 1:8
6. Brick masonry in CM 1:6

Example : 1

Prepare the rate analysis of earth work in hard soil for foundation and using the soil for filling the basement . The remaining soil depositing on the bank with initial lead upto 50m and lift of 1.5m

No	Quantity	Details	Unit	Rate Rs.	Amount	Remark
1	Nil	The rate analysis of earth work in hard soil for foundation and using the soil for filling the basement. The remaining soil depositing on the bank with initial lead upto 50cm and lift of 1.5m Material				Rs 3520/- for one cubic metre of earth work in hard soil for foundation and using the soil for filling the basement . The remaining soil depositing on the bank with initial lead upto 50cm and lift of 1.5m
2	4.00 3.00	Labour Man mazdur Boy mazdur	Each/day Each/day	500/- 400/-	2000/- 1200/-	
3		Conveyance charge				
4		Add 10% as profit for contractor	**Grand total**		320 **3520/-**	

Example : 2

Prepare the rate analysis for one cubic metre of 1: 4: 8 cement concrete using 40mm broken stone.

No	Quantity	Details	Unit	Rate Rs.	Amount	Remark
		The rate analysis for one cubic metre of 1: 4: 8 cement concrete using 40mm broken stone.				
1	 0.95 0.475 0.95	Materials 40mm broken stone Sand cement	 Cubic m Cubic m tonnes	 1800 2000 5000	 1710 950 855	RS 4900/- for one cubic metre of 1: 4:8 cement concrete using 40mm broken stone.
2	 0.1 1.0 1.4	Labour Mason Man mazdur Woman mazdur	 Each/day Each/day Each/day	 500 400 350	 50 400 490	
3		Conveyance charge				
4 5.		Add 10% as profit for contractor **Grand Total**			445.5 **4900/-**	

Example 3

Prepare rate analysis for brick work in cement mortar 1:6 using country burnt bricks 19x9x9 cm in ground floor

No	Quantity	Details	Unit	Rate Rs.	Amount	Remark
		Rate analysis for brick work in cement mortar 1:6 using country burnt bricks 19x9x9 cm in ground floor				Rs 7018.5 for brick work in cement mortar 1:6 using country burnt bricks 19x9x9 cm in ground floor
		Materials				
	500nos	Country burnt bricks	nos	10/each	5000	
	0.24	Dry sand	Cubic m	2000	480	
	57.6kg	Cement	tonnes	5000	288	
	0.7 0.35 0.35	Labour Mason Man mazdur Woman mazdur	 Each/day Each/day Each/day	 500 400 350	 350 140 122,5	
		Conveyance charge				
		Add 10% as profit of contractor			638	
		Grand Total			7018.5	

3.3.3 – Analysis of rates and preparation of abstract of cost & bills using electronic Spreadsheet

TE Questions

1. List the purposes of rate analysis.
2. The cost of a particular item of work depends on various factors. Enumerate them.
3. Prepare the rate per unit of RCC 1:2:4

Unit 3.4: CONTRACTS & TENDERS

This unit deals with the terms and procedures adopted in awarding public works. Terms like contract, tender etc. are familiarised and an introduction to the financial components related to contracts are also stated. This unit also describes the legal provisions to be followed while undertaking a contract, the duties and responsibilities of an engineer, contractor and client. The billing procedures in public works like measurement book, muster roll etc. are also included in this unit. This also gives an introduction to e-tender; the latest mode of inviting tenders.

Learning Outcomes

The learners;

- Understand terms contract and tender.
- Identify organisational principles.
- Understand the financial components related to contract.
- Know the statutory elements related to contract.
- Acquire awareness on different kinds of contract.
- Understand the terms used in contracts.
- read and prepare work order.
- Understand the organizational principles.
- Know procedure for inviting tenders and other details.
- Reading and filling of tenders.
- Preparation of tender
- Awareness of latest technologies in the field of contract /tender.
- Understand contract agreement and conditions of contract.
- know the legal provisions and rule to be followed while undertaking a contract.
- Understand the statutory principles.
- Know duties and responsibilities of contractor, engineer and client.
- Work as a team.
- Acquire indepth knowledge on making entries in measurement book and billing. understand the procedure of making bills in public organisations.

  Prepare muster roll. understand the organidational regulations.

Concepts

3.4.1 Contract

A contract is an agreement, which will be valid in law, between two or more parties for provision of supplies and/ or services against a consideration of monetary value.

Tender: Whenever a government agency or firm wants certain works to be done, services to be rendered or any purchases to be made, they float tenders in order to get the work done at competitive prices. Tender is a written offer submitted by the contractors to execute the work or supply of material etc. at certain rates.The person who quotes the lowest price, agreeing to the terms and conditions imposed on him will have to sign an agreement stating that he will perform the said work as per the requirements.

Earnest money deposit (EMD): While submitting the tender the contractor will have to deposit an amount which is about 2. 5% of the estimated contract value of the project, This amount is called the Earnest Money Deposit (EMD). This is collected in order to avoid the contractor from refusing the acceptance of the contract. The EMD of unsuccessful contractors will be refunded to them If the lowest quoted contractor refuses to take up the work, his EMD will be forfeited.

Security Deposit: Once the tender of a contractor is accepted, the contractor has to deposit 5 % of the tender amount with the client. This amount, which is inclusive of the EMD already paid, is called the Security Deposit. The security deposit serves as a guarantee that the contractor performs the work satisfactorily. It is refunded to the contractor after a maintenance period of 6 or 12 months from the date of hand over of the work. During this period, if there is any defect in the work, its cost of rectification will be deducted from the security deposit.

Kinds of Contract: The different types of contracts for execution of civil engineering works are;

1. **Item rate contract or Unit price contract (Schedule contract)**

   For item rate contracts contractors are required to quote rates for individual items of work on the basis of schedule of quantities furnished by the department.

2. **Percentage rate contract:**

   In this form of contract, the department draws up the schedule of items according to the description of items sanctioned in the estimate with quantities, rates, units and amounts shown therein. Thus the department fixes up the item rates of the

tender, The contractors are required to offer to carry out the work at par with the rates shown in the schedule or at percentage above or below the rates indicated in the schedule of work.

3. **Lump – sum contract:**

   In this form of contract, contractors are required to quote a fixed sum for execution of a work complete in all respects i.e, according to the drawing, design, and specifications. within the specified time. The departmental schedule of rates for various items of work are also provided which regulates the payment of the contractor in respect of the items of work involved for any addition or alteration not covered by the original work.

4. **Labour contract:**

   This is a contract where the contractor quotes rates for items of work exclusive of materials which are supplied by the department.

5. **Materials supply contract:**

   In this form the contractors have to offer their rates for supply of the required quantity of materials, inclusive of all local taxes. carriage and delivery charges to the specified stores within the time fixed in the tender.

6. **Piece Work Agreement:**

   The piece work agreement is that for which only a rate is agreed without reference to the total quantity of work to be done. In this type of agreement detailed specifications and the total cost of the whole work to be done are mentioned. It is terminable from either end at any time and there is no security money and penalty.

7. **Cost plus percentage rate contract:**

   In this type of contract, the contractor is paid the actual cost of the work plus an agreed percentage in addition as profit. This is adopted when the material and labour rates are liable to fluctuations.

8. **Cost plus fixed fee contract:**

   In this type of contract, the contractor is paid an agreed fixed lump-sum amount over and above the actual cost of work.

9. **Cost plus sliding or fluctuating fee scale contract:**

   In this type of contract, the contractor is paid the actual cost of construction plus an amount of fee inversely variable according to the increase or decrease of the estimated cost, Higher the actual cost. lower will be the value of the fee.

10. Negotiated contract :

When work is awarded on contract by mutual negotiation between the parties without call of tenders, it is said to be a negotiated contract.

Work Order Form, Administrative approval and Technical approval:

Work order:

A letter of acceptance known as work order is issued first to a contractor intimating that his rate has been accepted and to perform a formal agreement within a specified number of days. After the formal agreement is performed for the contract, a formal letter is issued to the contractor to take up the site of work and the date of completion is treated from the date of issue of this letter.

Administrative Approval :

Administrative approval is the formal approval given by an Administrative Department of the Government for a work for which the preliminary estimate has been framed by the engineering department. After getting the administrative approval, the engineering department takes up the work. and prepares detailed designs, plans and estimates and then executes the work,

Technical Approval:

Technical approval or technical sanction means the sanction of the detailed estimate, design calculations, quantities of works, rates and the costs by the authority of the engineering department. Only after getting the technical sanction, the work is taken up for execution.

Assessment activity

Preparation of chart showing different types of contracts and an oral test on the terms contract, tender etc.

3.4. 2 – Procedure for inviting tenders, invitation of tenders:

The contract for a work is given on the basis of tenders submitted by the contractors, The form in which it is to be submitted is supplied by the department to the eligible contractors on usual payment of cost. The tenders are invited by issuing tender notice which should be in the standard form of the department. It is displayed in the notice board of the division and also circulated to the subdivisions and other divisions of the department. For wide publicity of major works. the tender notice is required to be published in two local daily newspapers. The tender notice should have the following details:

- Name of the authority inviting tender
- Particulars of contractors eligible to submit tenders
- Name of work and its location
- Estimated cost of work
- Price of tender form and other tender documents
- Earnest money to be deposited
- Time of completion
- Last date of sale of tender paper, last date of submission
- Last date, time limit, and place of receipt of tender and also time of opening of tender
- Accepting authority

Besides the above it contains general directions, brief items and conditions of acceptance and validity of tender etc.

The tender form and other documents are to be purchased on cash payment from the office inviting tender during office hours on all working days. All the tender documents are signed by the contractor page by page after necessary entries are made. A forwarding letter on the letter head of the contractor with the bank draft or other form of earnest money is enclosed in a closed cover along with the tender documents. The cover is then sealed and dropped in the tender box within the time limit. The name of the work and the name of the contractor are superscribed on the cover.

e-tender:

e-tendering is an internet based process where in the complete tendering process, from advertising to receiving and submitting tender related information are done online. This enables firms to be more efficient as paper based transactions are reduced or eliminated facilitating for a more speedy exchange of information.

Contract agreement and conditions of contract:

A contract agreement is a bond. the contractor and the department are bound by the terms and conditions of the contract. The contract agreement stipulates the quantities of works and rates, the detailed specifications of various items of work to be done, the time limit within which the whole work shall have to be completed and various other conditions.

Conditions of contract: The conditions of contract specifies the following :

- Amount of security deposit
- Compensation for delay
- Action when whole of the security deposit is forfeited
- Contractor remains liable to pay compensation
- Extension of time
- Completion certificate
- Payment on certificate
- Monthly bill
- Payment of bill
- Departmental materials
- Execution of work in accordance with drawing and specifications
- Alteration of design and specifications
- No compensation for alteration
- Compensation in case of bad work
- Works to be opened for inspection
- Notice before the work is covered
- Maintenance period
- Care of departmental tools and plants
- Labour
- Work on Sundays
- Changes in constitution
- Supervision by higher officers
- Arbitration etc.

Additional conditions like insurance, lighting and guarding etc, are inserted in the conditions of contract according to the character of the work to be carried out.

Measurement Book:

Measurement for all works done and supplies received in connection with a sanctioned estimate are recorded in a special type of note book usually of size 15cm x 10 cm known as Measurement Book (MB). The pages are machine numbered and each page contains the columns for particulars, details of actual measurements in terms of number, length, breadth and height or depth, quantity, rate and amount. It is one of the very important records of the department.

Additional information:The M – book format, details of writing up of M-book, issue of M-book, test checking of measurements etc. can be transacted in detail.

Muster Roll:

The daily attendance and turn out of the daily rated skilled and unskilled labourers are recorded in the muster roll. The attendance of the labourers and the quantity of works executed are recorded in the muster roll.

Additional information:Transact the idea by demonstration of muster roll format and mentioning the rules to be followed while writing muster roll so that the learner gets the ability to prepare the muster roll.

Assessment activity:

Preparation of bills giving details of works in MB format.

Preparation of muster roll giving the details.

Class test on invitation of tender, conditions of contract and e-tender

3.4. 3 Obligations of the Contractor, Engineer and Client

Contractor:

- Inspect the site and study soil conditions before tendering and investigate the accessibility, availability of electric power, water supply conditions and the local law and order.
- Collect local rates of material and labour and prepare analysis of rates for the items.
- Go through the different clauses of the conditions of contract.
- Start the work on time and carry out the work as per drawings and specifications. Any omission in the specification or any extra work should be carried out after getting the written approval of the engineer.

- Designate a representative to act for him in his absence.
- All royalties and license fees are to be paid by the contractor.
- Follow the labour act truly.
- Submit the claims for extra works, and bills for payment in due time.
- Safeguard the completed portion of work until its handing over to the client
- Hand over the completed work in a sound condition.

Engineer:

- To prepare the necessary drawings, specifications, and estimate.
- To check up the soil conditions.
- Preparation of tender papers inviting tenders, sale of tender paper after investigating the soundness of contractor, preparation of comparative statement etc.
- Supervise the work and ensure that drawings and specifications are followed.
- Give necessary instructions to supply working drawings to the contractor.
- Check the quality of work, measurement of work done, quantities, rates and pass the bill for payment.The amount to be paid for extra works shall be determined by the engineer according to the terms of contract.
- If a contractor fails to show the proportionate progress of work as per the time of completion, take necessary actions as per the terms and conditions.
- The engineer is not liable to losses made by the contractor . He shall see that the contractor has removed rejected materials and rectified the defects in work.
- In case of disputes between the contractor and owner, the engineer shall help to settle them by technical analysis.
- Ensure that no damages made on any part of the completed work at the time of handing over.

Client :

- Appoint an engineer and give him power to work on his behalf.
- Intimate the engineer about the requirements of the project including desired time of completion.
- Obtain necessary sanction for construction from the authority in collaboration with the engineer.

- Give necessary sanction of the estimated cost to the engineer.
- Enter into contract with the contractor by signing the documents.
- Give possession of the site to the contractor.
- Give necessary help for obtaining permission for electric and water supply connection from other organisations.
- Make payment to the contractor on production of certified bills from the Engineer.
- Do not interfere in the progress of the work directly and make any addition or alteration without the knowledge of the Engineer.
- Take over possession of the completed project timely from the contractor.

Assessment activity

Judge the active participation of students in the expert sessions with the engineer and contractor

Judge the active participation and have an role play on the duties of engineer, contractor and client.

TE Questions

1. Define the following terms:
   a) Contract
   b) Tender
   c) Earnest Money Deposit
   d) Security deposit.
2. Differentiate between administrative approval and technical approval.
3. Briefly explain measurement book and muster roll.
4. Explain the duties of an engineer.

Unit 3.5: NETWORK ANALYSIS

This unit deals with scheduling of civil works by managing time and cost effectively through construction project planning techniques like CPM and PERT. This unit also deals with safety measures to be made sure in construction sites.

Learning outcomes

The learners:

- Understand network analysis and its importance
- Prepare a network diagram
- Acquire knowledge essential to project planning and scheduling
- Acquire thorough knowledge of the sequence of construction activities.
- Control different activites
- Identify uncertainities in activities
- Help in project planning and scheduling
- Distinguish between the two methods
- Manage construction sites safely

Concepts

3.5.1 Introduction

Network analysis is the method of planning, scheduling and controlling the progress of various items of work of a construction project. The advantages of applying network analysis in construction projects are:

- Provides an integrated construction management.
- Determines project duration more accurately.
- Identifies the effect of delays in advance for timely corrective action.
- Facilitates optimisation of resources.
- Provides a scientific method of progress reporting and progress control.
- Enables the management to take better decisions for effective monitoring of projects.

  Critical Path Method (CPM) Programme Evaluation and Review Technique (PERT) are the two methods of network analysis.

The terms related to CPM and PERT are:

1. Event or Node : This is either the beginning or end of a job. This is represented by a number enclosed in a circle or a rectangle, It requires no time or resources in itself.
2. Predecessor event: It is an event that immediately comes before another event without any intervening events.
3. Successor event : It is an event that immediately follows another event without any intervening event.
4. Activity : It is the performance of a specific task. It requires time and resources to perform an activity.
5. Predecessor activity : It is the activity that immediately comes before another activity without any intervening activity,
6. Successor activity : It is the activity that immediately follows another activity without any intervening activity.
7. Dummy : It is an artificial activity which indicates that an activity following the dummy cannot be started until the dummy activity is completed. In a network diagram it is represented by dotted lines.
8. Network or Arrow diagram : This is an arrow diagram to represent the relationship of the activities and events.
9. Arrow: It is drawn to represent each activity, joining two events,
10. Most likely time estimate: This is the time estimate in which an activity can be completed under normal conditions.
11. The optimistic time estimate: This is shortest possible time in which an activity can be completed under ideal conditions.
12. The Pessimistic Time estimate: This is the maximum possible time in which an activity can be completed when everything went wrong and abnormal situations prevailed.
13. Duration : This is the estimated time required to perform an activity,
14. Earliest Start: This the earliest time when an activity can be started.
15. Earliest Finish: This is the earliest time when an activity can be finished.
16. Latest Start: This is the latest time when an activity can be started without delaying the completion of the project.

17. Latest finish: This is the latest time when an activity can be finished without delaying the completion of a project.
18. Total float: This is the amount of time by which the start or finish of an activity can be delayed without delaying the completion of a project.
19. Free float: This is the amount of time by which the finish of an activity can be delayed without delaying the earliest starting time for the following activity.
20. Slack time: This is the difference between the latest allowable time and the earliest expected time.
21. Critical Path: This is the path that determines the minimum time required to complete a project.
22. Range: This is the difference between the longest time and the shortest time taken by the job.
23. Variance: This is the mean of squared deviations of each individual figure from the mean.
24. Standard deviation: This is the square root of the variance.

Problem: Draw a network diagram with the following logic of various activities,

(i) A is the first operation of the project.

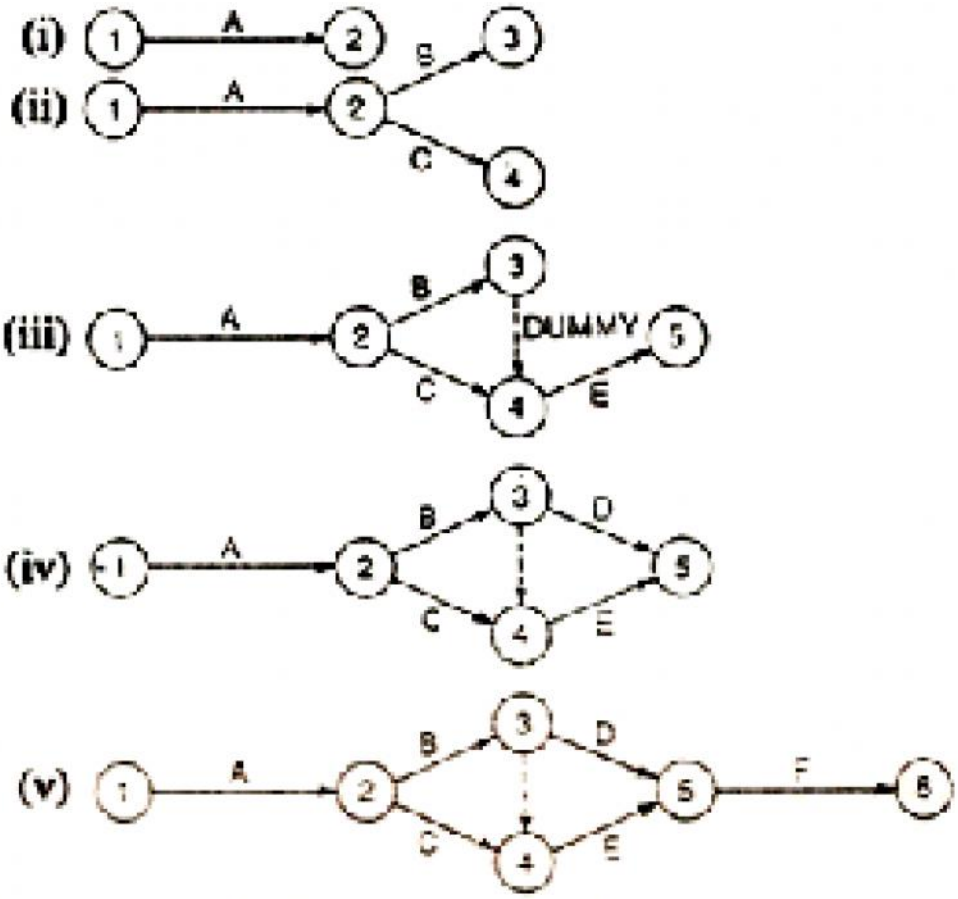
(ii) B and C start concurrently but can start after A only.

(iii) E cannot start Until B and C are complete.

(iv) B precedes D

(v) Start of F depends upon completion of D and E.

Solution: The pictorial representation of the activities is an shown below



Assessment activity:

Conduct a class test on terms used in network analysis.

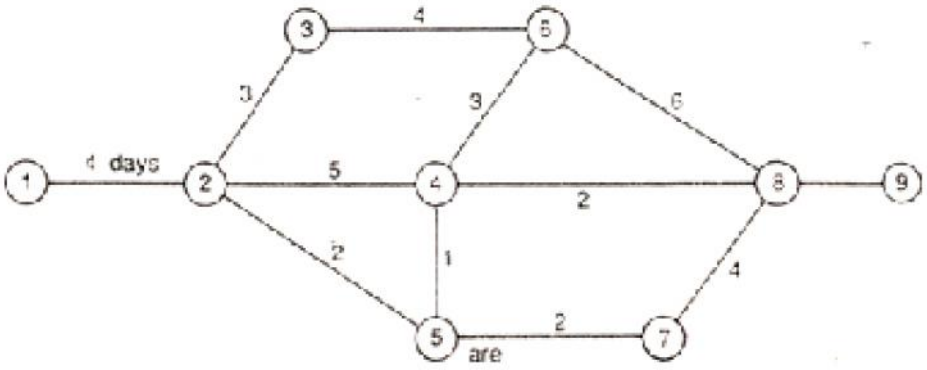
3.5.2 Developing a network using CPM

CPM network is activity based. This does not take into account the uncertainties involved in the estimation of time for the execution of an activity. The activities are represented by arrows, These arrows. are connected in order of sequence of operations.

The steps involved in preparation of a CPM chart are.

- Identify the activities of the project and list them.
- Estimate the duration of each activity.
- List the activities which immediately precede and follow each activity.
- Interconnect the activities and events by drawing a network.
- Number the activities in such a way that the number at the head of each arrow is larger than the number at the tail of the arrow.
- A chart should be prepared to list each activity with an appropriate designation, duration, earliest start, earliest finish, latest start, latest finish and total float.
- Determine the critical path.
- The path which is having zero slack time is known as critical path, Critical path is that which takes the maximum time in completing the project from start to its completion.

Path 1-2-4-6-8-9 takes 24 days and by this time all activities are complete, Hence this is the critical path.



For example in this Network the different paths are

1 - 2 - 3 - 6 - 8 - 9 = 4 + 3 + 4 + 6 + 6 = 23 days

1 - 2 - 4 - 8 - 9 = 4 + 5 + 2 + 6 = 17 days

1 - 2 - 5 - 7 - 8 - 9 = 4 + 2 + 2+ 4 + 6 = 18 days

1 - 2 - 4 - 6 - 8- 9 = 4 + 5 + 3 + 6 = 24 days

1 - 2 - 4 - 5 - 7 - 8- 9 = 4 + 5 + 1 + 2+ 4 + 6 = 22 days

Assessment activity

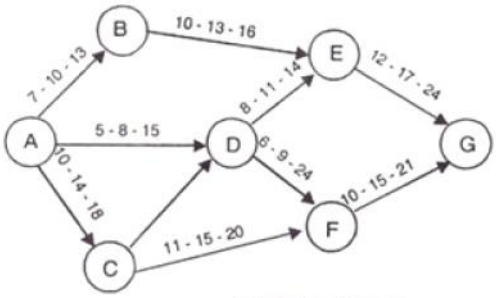
Assignments/classroom exercises on preparing network diagram using CPM method with the given details.

3.5.3. Developing a network using PERT:

PERT considers that the activities of the projects and their network relationships are well defined. But it allows uncertainties in activity durations because it is extremely difficult to estimate the exact time a job will take for its completion due to lot of variables.

Assessment activity:

Assignments/classroom exercises on preparing network diagram using PERT method with the given details.



. PERT-network.

The expecteted time is calculated in Table :

Predecessor event	*Successor event*	T_c	T_L	T_p	$T_e = \frac{T_o + 4T_L + T_p}{6}$
A	*B*	7	10	13	10
A	*C*	10	14	18	14
A	*D*	5	8	15	8.67
B	*E*	10	13	16	13
C	*D*	3	5	7	5
C	*F*	11	15	20	15.17
D	*E*	8	11	14	11
D	*F*	6	9	14	9.33
E	*G*	12	17	24	17.33
F	*G*	10	15	21	15.17

3.5.4 Difference between CPM & PERT

3.5.5 Construction Safety Management

PERT	CPM
Event oriented	Activity oriented
Time is not related to cost	Time is related to cost
Probabilistic network	Deterministic network
Used for research development projects	Used for repetitive projects

Importance of Construction Safety:

The construction industry in India today is expanding day by day and complex in nature too.

The social concern of the safety of construction workers and their protection against injury arising out of their employment has an important role in this field,

1. Humanitarian Concern: When an accident happens, the suffering of the injured workers and their families is difficult to quantify in economic terms. The contractor should never ignore this even if he has insurance against accidents.
2. Economic Reasons: Even if a contractor has insurance, the cost of accidents will come out of his own pocket through an increase in insurance premiums. In addition, there are other indirect costs that result from accidents.
3. Laws and regulations: As per different acts and laws, the employer should look after the safety of the employee. Violation of these laws will be subject to punishment.
4. Organisational Image: A good safety record can produce higher morale and productivity and stronger employee loyalty. It will also increase public image and therefore, makes it easier to acquire negotiated jobs.

Safety Measures

There have been many rules and recommendations laid down for improving safety.

A contractor can improve safety performance using the following guidelines:

(i) New workers should be given a safety orientation.

(ii) For every project, the contractor must study in advance the possible accidents that the proposed construction methods, procedures and equipment may create. Then an accident prevention programme should be devised to take care of those accidents.(iii) The contractor should enforce the use of approved equipment for personal protection such as hard hats (helmets), safety belts, safety glasses, goggles, hearing aids, gloves, etc.

(iv) The contractor should integrate safety programs with other programs, such as scheduling and budgeting during preplanning procedures. This will help to identify possible accidents inherent in the work to be done, to suggest remedial training if necessary, to assure that proper tools and equipment will be available for the work, and to verify that the methods selected are safe, according to required standards.

(V) Periodic checking of tools and equipment is necessary in order to make sure that they are well maintained.

(vi) Conduct periodic safety meetings, such as tool box meetings, to provide safety education on the job.

(vii) Seek and obtain full cooperation from all subcontractors on the project, Many accidents occur just because of lack of coordination, These kinds of accidents can be avoided easily by administrative effort.

Assessment activity

Conduct a seminar on importance of construction safety and safety measures.

TE Questions

1. What are the advantages of applying network analysis in construction projects?
2. Differentiate between event and activity.
3. What are the differences between PERT & CPM?
4. Explain the importance of construction safety management.
5. Give a brief note on safety measures in construction projects.
6. The following table lists the activities, duration and their sequence of operation, Draw a network diagram for these activities and prepare a table showing their ES, EF, LS and LF times. Find the total float and free float for each activity. Determine the critical path and its duration.

Activity	Duration (Days)
1 - 2	8
1 - 3	10
1 - 4	5
2 - 7	6
3 - 4	3
4 - 5	7
4 - 7	0
5 - 6	4
5 - 7	3
5 - 8	6
6 - 8	5
7 - 8	5

Unit 3.6 Valuation of building

This unit deals with the method of valuation of buildings for different purposes like sale, availability, housing loans from financial institutions, acquisition by government agencies etc. This chapter explains methods like sinking fund method, depreciation method etc for evaluation of a building arithmetically.

Learning Outcomes

The learners:

- Understand valuation and its purposes, analyse the factors which affects an successful commpletion of the unit, learner will the alue of a project
- Get thorough knowledge on various methods of valuation.
- Perform valuation of building.
- Know the terms of mortgage
- Understand rent fixation.

Concepts

3.6.1 Valuation of Building

Valuation is the art of assessing the present fair value of a property at a stand time. It is the estimate of the value of a particular item in terms of money, It is based on certain facts and factors.

Cost and Value

Cost means the actual cost of construction or purchase, while value means the present market value which may not be the same as the cost. Value depends upon the supply and demand, whereas, cost is a constant amount required for construction.

Purposes of Valuation

Following are the main objects of valuation of the property :

a) When the owner of the property wants to sell it,

b) When a man wants to purchase a property, its valuation is required to assess its market value.

c) The valuation of property is done for fixation of the municipal tax wealth tax estate duty etc.

d) For determining the rent of the property, its valuation is required, because usually the rent is fixed on certain percentage 6% to 10% of the amount of valuation.

e) When loans are required to be taken against the security of the property, its valuation is required.

f) When the property is acquired by Government by law for paying its compensation, valuation is required.

g) For getting the insurance of the property, its valuation is required.

h) When a case is to be filed with respect to property, for determining court fee valuation is required.

i) For reinstatement it becomes essential to know the value of the property.

j) For preparation of balance sheet of a company/firm. In such cases premises to be valued as going concern. The property of the firm is to be shown in balance sheet.

Factors affecting value of property:

The value of a building mainly depends on:

- Type of building
- Materials used in the construction
- Durability
- Situation of site
- Shape
- Frontage
- Present market rate of materials
- Market rate of land
- Height of building
- Roof covering materials
- Water, electrical, telephone and sewer facilities etc.

3.6.2 Methods of valuation

Valuation of a property may be prepared by different methods like:

(a) Valuation based on cost

(b) Valuation based on profit

(c) Depreciation method

(d) Sinking fund method

(e) Quantity survey method

The appropriate method of valuation depends on the nature of the property as well as availability of reliable data. In valuation, it is customary to check one method by another method.

Valuation based on cost:

In this method the actual cost of construction of the building or purchase cost is taken into account After suitable depreciation and considering other points its present value is determined.

Valuation based on profit:

This method is used for the valuation of hotel, cinemas, theatre buildings etc, For which the capitalised value mainly depends on the profit. In these cases, the annual net income is worked out after deducting all the expenditures. The net profit per year is multiplied by the year's purchase to get the valuation of the building.

Depreciation method:

Depreciation is the reduction in value of a property or building due to its userlife, wear and tear, decay or obsolescence. Depreciation is dependent on original condition, quality of maintenance and usage.

In this method the building is divided into four parts ie; a) walls b) roof c) floor and d) doors and windows. The cost is worked out on the present day rates, The life of each of the four parts is worked out with the help of standard tables and the depreciated value is calculated applying a specific formula. This depreciated value is exclusive of cost of land, water supply, electric and sanitary fittings etc.

The depreciated value can be calculated by the formulae

$$D== P[\frac{100-rd}{100}]^{n}$$

where p= present cost,

n= no of years, rd = rate of depreciation

Rate of depreciation for various life periods are as follows

LIFE	rd
100 years	1.00
75 years	1,30
50 years	2.00
25 years	4.00
20 years	5.00

Example . 1

A building situated near theside of a main road on a land of 500 sq.m The Built up area is 15x20sq .m. The building is first class type with all facilities and age of building is 30 years . Work out the valuation of property . Assuming the life of building is 50 years.

Plinth area rate is 15000/sq .m

Cost of land = 7500/ sq .m

Plinth area = 15×20

= 300 sq. m

Present cost by plinth area method = 300×15000

= 75,00000/-

Depreciated value D $= P[\frac{100-rd}{100}]^{n}$

n = 30 years ,for 50 years rd=2.00

D = 75,00000

$= 75,00000 \times \left[\frac{100-2.00}{100}\right]^{30}$

$= 75,00000 \times \left[\frac{98}{100}\right]^{30}$

$= 75,00000 \times 0.98^{30}$

Cost of land = 7500×500

= 37,50,000

Present value of building = depreciated value of building +cost of land

= $75,00000 \times 0.98^{30} + 37,50,000/-$

Example . 2

A intends to buy a land of I lakh sq.m located near a big city to develop intoplots of 700 sq,m. each after providing necessary roads ,paths,and other amenities, The current rate of price for each plot is RS 6000/ SQ . M . He wants a net profit of 20% each. Work out the maximum price of land at which he may purchase ,the land .Assume 30% of the land is used for roads and other amenities.

Total land is 1,00000 sq.m

Area for road = $\frac{30}{100} \times 100000$

= 30000sq ,m

Total plot area for sale = 100000- 30000

= 70000sq .m

No of plots = $\frac{7000}{700}$

= 100 nos

Total rate = $6000 \times 700 \times 100$

= 42, 00,00,000/-

Expenses

Cost improving land by leveling and fencing =7 5/sq.m

Cost of improving land= 100000x75

= 7,50,0000/-

Cost of constructing roads=,water supply ,drainage, electrification etc is RS 50/,SQ.M for whole area

ie = 50x100000

= 50,00,000/-

Engineers and Architects, expense for planning ,surveying,supervising etc is 3% of selling price

ie = 0.03x 42, 00,00,000/-

= 1,26,00,000/-

Misclaneous expense =1% of selling price

= 0.01x42, 00,00,000

= 4200000/-

Contractor's profit at 20 % of selling price = 0.20x 42, 00,00,000/-

= 8400000/-

Total expense = 75,00,000+50,00,000/-+1,26,00,000+42,00,000/-+84,00,000

= 2,64,50,000/-

Max price that can be given for the land=42, 00,00,000 - ,64,50,000

= Rs 39,35,50,000/-

Purchasing rate = Rs $\frac{39,35,50,000}{100000}$

= Rs 3935.5/SQ.M

Sinking fund method:

In this method, the depreciation is equal to the annual sinking fund plus the interest on the fund for that year, A fund which is gradually accumulated and set aside to reconstruct the property after the expiry of the period of utility is known as sinking fund. If A is the annual sinking fund ,b, c, d represents the interest on sinking fund for subsequent years and c is the original cost.

At the end of	Sinking fund	Total sinking fund	Book value
First year	**A**	**A**	**C -A**
Second year	A+b	2A+b	C-(2A+b)
Third year	A+c	3A+b+c	C-(3A+b+c)
Fourth year	A+d	4A+b+c+d	C-(4A+b+c+d)

Quantity survey method:

In this method each and every item of construction is measured, its cost is worked out and depending upon the conditions of the item , suitable depreciation is allowed on the cost of the item. The abstract is prepared by adding all the costs of the items with allowance for depreciation. This is the most reliable method.

3.6.3 Mortgage and Annuity

Mortgage:

When any person wants a loan against the security of his property it is called a mortgage loan. The financial institution which grants the loan is known as the mortgagee and the person taking the loan is called the mortgager. Usually loan is granted taking into consideration the present value of the property, For determining the present value, valuation is done.

Annuity:

The return of capital investment in the form of annual instalments is known as annuity.

Rent fixation:

Every Government official occupying Government accommodation has to pay rent which is called standard rent. For calculation of standard rent , cost of building, cost of water supply, sanitary and electric installations etc. are calculated at 6 % interest and divided by 12 which will give the rent per month.

In case of private properties, the net income is worked out by dividing the capitalized value by a proper figure of the year's purchase. To get the gross rent, outgoings such as annual repairs, municipal taxes, property taxes, and sinking funds etc. are added to the net income. This gross rent divided by 12, which will give rent per month. This is also known as standard rent

In case of private properties, the rent depends upon the situation, demand, type of construction, accommodation and facilities provided.

Assessment Activities

Class test, Oral test, Assignments/classroom exercises on Rent Fixation

TE Questions

1. What are the various methods of valuation?
2. An owner of a bungalow made some renovations to make his building more attractive. Which method will you adopt to remnovate it?

3. What do you mean by standard rent and how it is calculated?
4. Define the terms sinking fund and scrap value

Extended Activities

Module III

1. Calculate the quantities of different items of work of a building.
2. Prepare a notice inviting tender for the proposed extension of a school building for advertising in a daily.
3. Prepare a planning schedule for the construction of a residential building project by CPM/ PERT method.
4. Valuate an existing building for the purpose of acquisition by Government.

Detailing of practicals

Practical Activities

Unit 1 Plinth area calculation **25 periods**

Prepare the plan, elevation and section of a two storied residential building and find out the plinth area (2 nos.)

Unit 2 Measurement Practice **35 periods**

a) Measure the dimensions of a compound wall. (1no)

b) Measure the dimensions of a single room and prepare the sketch. (Inner and outer dimensions) (1 no)

c) Measure the dimensions of all components of a residential building and prepare the line sketch. (2 nos)

Unit 3 Quantity survey **38 periods**

Calculation of quantities of following items of works by measuring the dimensions of an existing building / building under construction.

a) Earth work in excavation for foundation

b) RR Masonry for foundation and basement

c) Masonry for super structure

d) RCC works

e) Plastering

f) Floor finishing works

Unit 4 – Estimation (Long wall Short wall method) 40 periods

a) Estimation of quantities of items of a compound wall (1 no.)

b) Estimation of quantities of items of a single room (1 no.)

c) Estimation of quantities of items of a residential building (2 nos.)

d) Estimation of quantities of items of a school building, (1 no.)

Unit 5 – Estimation (Centre line method): 100 periods

a) Preparation of detailed estimate using given centre line plan, (3 nos.)

b) Preparation of detailed estimate using centre line method for a given plan (4 nos.)

Project: Prepare the plan, section and elevation of a residential building and the detailed estimate (1 no.)

MODULE IV

Water supply and sanitary arrangements

Overview of Module IV

It is essential to update the the skills and knowledge to cater to the demands of a rapidly progressing present day construction industry. Keping this objective in view the curriculum incorporated a module on water supply and sanitary arrangements since it is an important building service.

Among all building services to be provided in a building be it a residential or a public building water supply and sanitary arrangements are the most essential services. So well trained members with necessary skill sets are in great demand to attend to the minor or major jobs in this field. This module provides the student with know-how about technique and the knowledge of plumbing systems in buildings in addition to latest technology developed in water supply and sanitation, solar heaters, hot water installations etc. After the successful completion of the module, the learner will be capable of preparing the lay out plan of water supply as well as sanitary works of public and domestic systems and execute plumbing works and their repairs.

Unit 4.1 Source and Purification of Water

This unit covers the selection of source of water, the impurities in water, its purification, removal of hardness in water. It also discusses the different methods of purification of water, the per capita demand of water for different types of premises, etc.

Learning outcomes

The learners:

- understand the quality of water.
- differentiate between hard and soft water.
- understand methods of water purification.
- control the quality of water& demand of water for various premises.

Concepts

Sources of water and impurities in water

(a) Rain water

(b) Surface water

1. Ponds & lakes
2. Streams and rivers

3. Storage reservoirs
4. Oceans

(c) Sub surface/ Underground sources

1. Springs
2. Infiltration galleries
3. Infiltration wells
4. Wells and tube wells

Factors affecting the selection of source

1. The quantity of water available.
2. The quality of available water.
3. Distance to the source of supply.
4. General topography of the intervening areas.
4. Elevation of the source of supply.

Impurities in water

(a) Dissolved impurities: Dissolved gases O_2, CO_2, H_2S, etc.

1. Inorganic salts

Cationic $^{++}$, Mg^{++}, Na^{+}, Fe^{++}, Al^{+++} etc.

Anions CO_3^-, Cl^-, SO_4^-, NO_3^- etc.

2. Organic Salts

(b) **Suspended Impurities**

1. Inorganic – clay & sand
2. Organic – Oil globules, vegetables & animal material

(c) **Colloidal Impurities**

Finely divided clay and silica

$Al(OH)_3$, $Fe(OH)_3$, organic wastes

(d) **Microscopic matters**

Bacterial, Algae, Fungi etc.

Hardness of water

Hardness of water is that characteristic which prevents the lathering of soap. In other way we may define it as "Soap consuming capacity of water".

Types of hardness

(a) Temporary hardness – It is due to the presence of dissolved bicarbonates of calcium, magnesium and other heavy metals and the carbonates of iron and other metals also.

It can be removed by boiling of water when bicarbonates are decomposed yielding in soluble carbonates or hydroxides, which are deposited as crust at the bottom of the vessel.

(b) Permanent Hardness – It is due to the presence of dissolved chlorides and sulphates of calcium, magnesium, iron and other heavy metals.

Permanent hardness cannot be removed by boiling. It is the difference between total hardness and temporary hardness. It can be removed by special treatments only.

Hard water & Soft water

The water which does not produce lather with soap but produces insoluble white precipitate is called hard water.

Water which produces lather with soap is known as soft water.

Properties	Hard water	Soft water
Dissolved salts	Salts of Mg, Ca and other heavy metals	Does not contains such salts
Wastage of soap	Soap is wasted to get desired results	Does not waste
Cleansing quality of soap	It is depressed due to hardness and a lot of soap wasted during washing and bathing.	It is good in soft water as it gives lather readily
Taste of water	It is usually better than soft water. The label on the bottle of mineral water shows that it contains Ca^{++} ad Mg^{++} ions.	Less better as ions of Ca^{++}, Mg^{++} are not present in soft water
Strong teeth and bones	It helps in producing strong teeth and bones due to present of Mg^{++} and Ca^{++} ions	Does not help as such

Prevention of lead dissolution	Lead, piping used for distribution of water in old houses are coated with $CaCO_3$ present in hard water. This prevents any of the poisonous lead dissolving in the drinking water.	Does not help as such.
Elevation of boiling point of water	Due to the presence of dissolved salts, the boiling point of water is elevated. So more fuel and time is required for cooking.	Less time and fuel required and no deposition of carbonate in the inner walls of utensils.
Effect on health	It causes bad effects in our digestive system. Moreove,r there is increased deposition of Calcium Oxalate crystals in the urinary track. .	No such effects is observed.

Assesment activity

Class test, oral test, charts, print outs, assignments.

IS standards of potable water

Property	Desirable	Permissible
Colour	Hazen unit 5Hz	25Hz
Odour	Unobjectionable	
pH	7 to 8. 5 ;	No relaxation
Total dissolved solids	500mg/l	2000mg/l
Alkalinity	200mg/l	600mg/l
FeS	0. 3mg/l	1. 0mg/l
Magnesium	0. 1mg/d	0. 3mg/l
Sulphate	200mg/l	400mg/l
Nitrate	45mg/l	100mg/l

Chloride	250mg/l	1000mg/l
Fluoride	1 mg/l	1. 5mg/l
Arsenic	0. 05mg/l	No relaxation
Chromium	0. 005mg/l	No relaxation
Copper	0. 05mg/l	No relaxation
Cyanide	0. 05mg/l	No relaxation
Lead (Pb)	0. 05mg/l	No relaxation
Mercury	0. 001mg/l	No relaxation
Zinc	5mg/l	15mg/l

Total coliform bacteria –10 coliform in 100ml (95% of samples should not contain coli form bacteria in 100ml),

E-Coli form bacteria - Nil/100ml

Methods of purification of water

a. Screening
b. Plain sedimentation
c. Sedimentation aided with coagulation
d. Filtration
e. Disinfection
f. Aeration
g. Softening
h. Other treatments like fluridation, recarbonation etc

Screening

Course screens and fine screens are placed in front of pumps to screen or intake works so as to exclude particles, debris, animals, trees, branches, bushes, etc. Fine screens prevent the fine suspended solids.

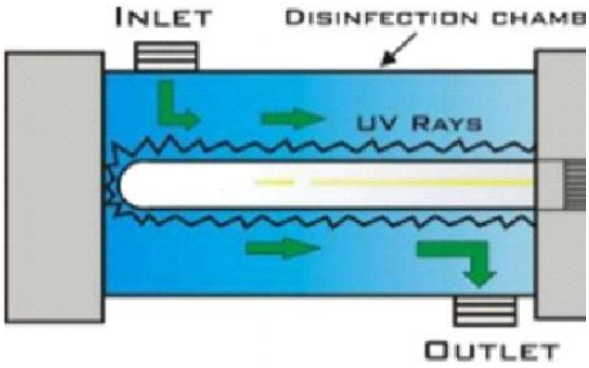
Sedimentation

The suspended impurities can be removed by plain sedimentation. Special basins are constructed to purify the surface water of rivers or reservoirs.

Sedimentation with coagulation

If the water contains colloidal impurities (Specific gravity 1 to 1. 2) it will not settle down by plain sedimentation. In such cases, coagulants are added for sedimentation. e.g. Alum.

Filtration



Disinfection by Ultra Violet Rays

Though screening and coagulation removes large percentage of suspended solids and colloidal impurities, it may contain very fine suspended particles and bacteria. To make water potable and palatable it is filtered through the beds of gravel, granular sand, etc. This emoves colour, odour, turbidity and some pathogenic bacteria too.

Disinfection

Disinfection is the process of killing of pathogenic bacteria by the methods of boiling, UV rays, chlorine, bromine, iodine, excess lime, ozone, potassium permanganate, etc. Residual chlorine of 0.2 mg/litre (ppm) is required to safeguard against contamination of water during distribution.

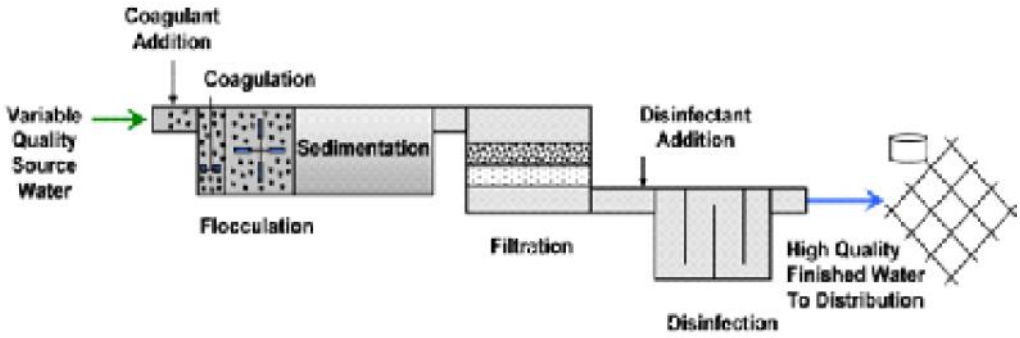
Aeration

Water acration is the process of increasing the oxygen saturation of water. Aeration water treatment is effective for management of dissolved gases such as carbondioxide, some taste and odour problems such as methane and hydrogen sulphide, as well as volatile organic compounds. Aeration raises the P^H of water.

Water Softening

It is not necessary to remove hardness of water for public use since it causes no major harm to health. But it is done to reduce the consumption of soap, lower the cost of maintenance of plumbing fixtures, improve taste of food preparation etc. The temporary hardness of water can be removed by boiling. The permanent hardness can be prevented by lime soda process, Base Exchange process, De-mineralisation process, etc.

Layout of a water treatment plant



Domestic method of treating water

a. Domestic filter containers. These are made of stainless steel two containers placed one above the other. The upper container. base fits in the rim of lower container, It is used in individual homes. Its efficiency can be improved by adding chlorine tablets or chlorine solution to disinfect the water.

b. On Line Filters- These are filters available in the market and can fixed directly on a water tap. They use granulated filter media, activated carbon and crystals of silver iodide. The filter media traps suspended particles, while the activated carbon removes colour, odour and gases from the water.

c. Domestic Ultraviolet purification systems- Excellent sterilization occurs when UV rays of sufficient intensity passes through water. Most living cells including bacteria and viruses either die or loss their capacity to reproduce. Water is clear and free from suspended matter if it is installed immediately before the point of use.

Assessment Activity

Field report, active participation in field visit, Quiz etc.

Demand of water for various purposes

- The various types of water demand are:
- Domestic water demand
- Industrial water demand

- Institution and commercial water demand
- Demand for public use
- Fire demand
- Water required to compensate losses in waste and thefts

Domestic water consumption

Use	Consumption in lit/head/day
Drinking	5
Cooking	5
Bathing	55
Washing of clothes	20
Washing and cleaning of houses	10
Washing of utensils	10
Flushing of water closets	30
Total	**135**

Water requirement for other establishments

Sl. No	Type of establishment	Average water consumption in lit/head/day
1	Offices	45-90
2	Factories	
	a. With bathrooms	45-90
	b. without bathrooms	30-60
3	Schools	
	a. day scholars	45-90
	b. residential	135-225
4	Hostels	135-180
5	Restaurants	70(per seat)

6	Hospitals	
	a. number of beds <100b	340(per bed)
	b. number of beds >100	450(per bed)
7	Hotels	180(per bed)
8	Nurses homes and medical quarters	135-225
9	Railway stations	23-70
10	Airports	70
11	Cinema halls/ theatres	15

TE Questions

1. What are the differences between soft water and hard water?
2. Prepare the flowchart of water purification.
3. _____ is the per capita consumption of water for domestic purpose as per Indian Standards.
4. Give the IS standards for potable water.

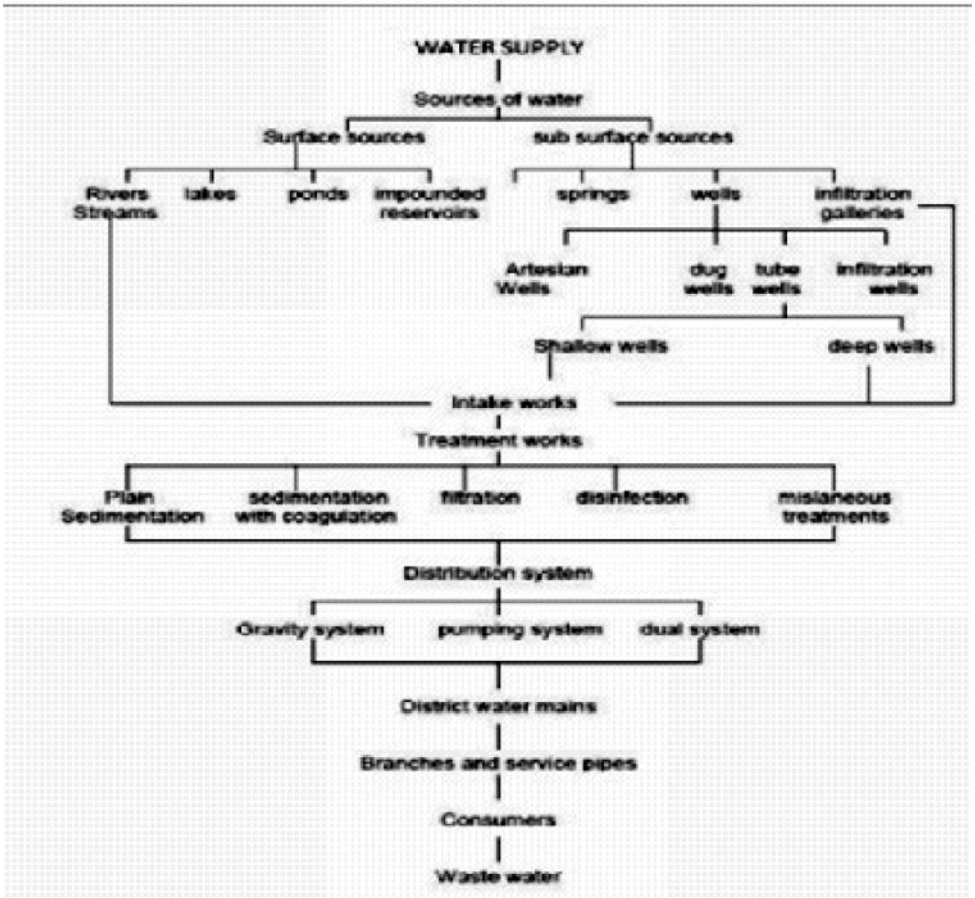
Unit 4.2
Water supply system

This unit deals with distribution of water, different water supply systems, layout of distribution systems, types of distribution systems, and their merits and demerits.

Learning Outcomes

The learners :

- Aware of the requirement of a good distribution system, its working and arrangements of Pipes in the system.
- capable of preparing a layout of the purification system.
- aware of different types of distribution systems.
- able to understand rainwater harvesting.



Flow chart of water supply system

I. Systems of distribution

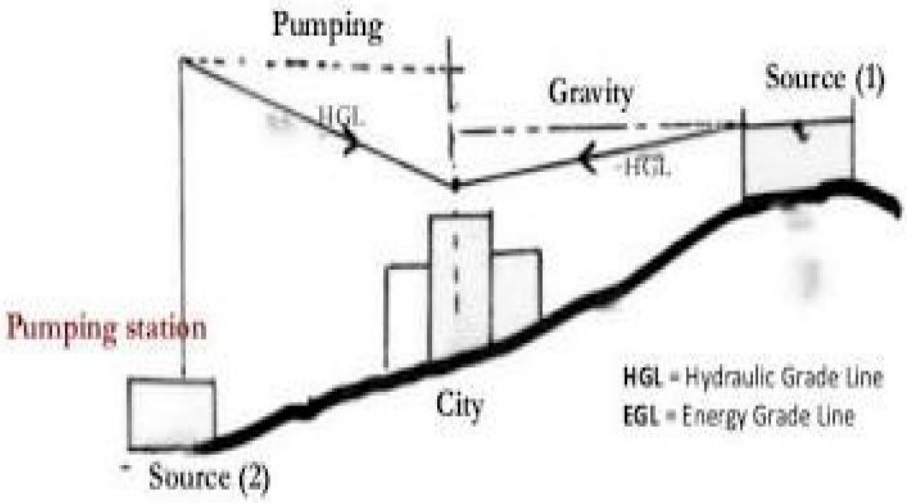
a) Continuous Water Supply System

In this case water is available for 24 hrs. So the system is always under pressure and there is no chance of infiltration. Therefore negative pressure cannot occur and as a result the quality of water is better. As the supply is continuous more consumption and less contamination.

b) Intermittent System

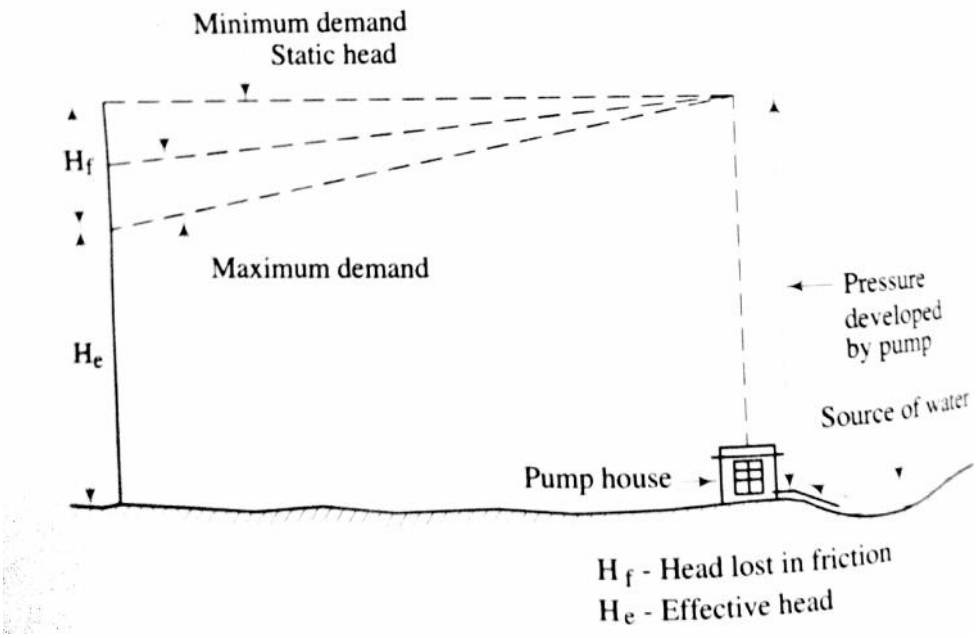
In this case water is supplied at regular intervals throughout the day. For example water may be supplied for few hours in the morning and few hours in the evening. As it is not continuous the consumption is less. Due to negative pressure the quality of water is not so good compared to the case of continuous supply.

II **a) Gravitational system**



In this system water is transported through pipes by gravity only. It is the most reliable method of distribution used when the source of water supply is situated at a higher level than the distribution area.

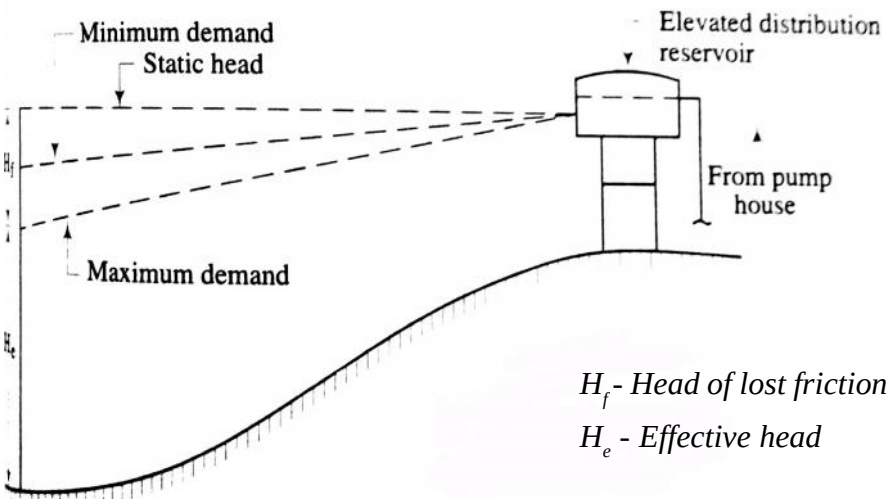
b. Pumping System



In this system water is directly pumped into the mains leading to the consumers. Its reliability depends on the availability of power supply.

c. Combined gravity and pumping system

In this system the treated water is pumped and stored in an elevated distribution reservoir. The excess water during low consumption remain in the elevated reservoir and can be supplied during peak periods.



Different Lay outs of water distribution

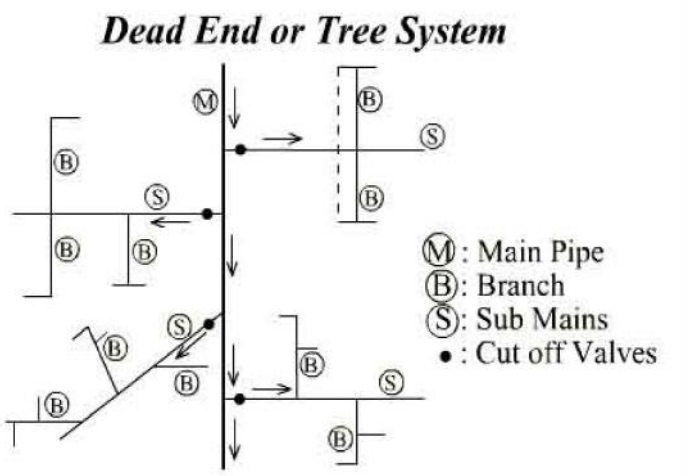
(a) Dead end or tree system

(b) Grid Iron System

(c) Circular or Ring System

(d) Radial System

Dead end System



It is the system in which each street or block is supplied separately from the main. So there is end of the system at each end of a block.

The pipe line branches just like a tree branches ie. the main line has more diameter and the diameter of branch lines goes on decreasing. Since the pipe terminates at dead ends there is no circulation of water. So water is polluted due to contamination.

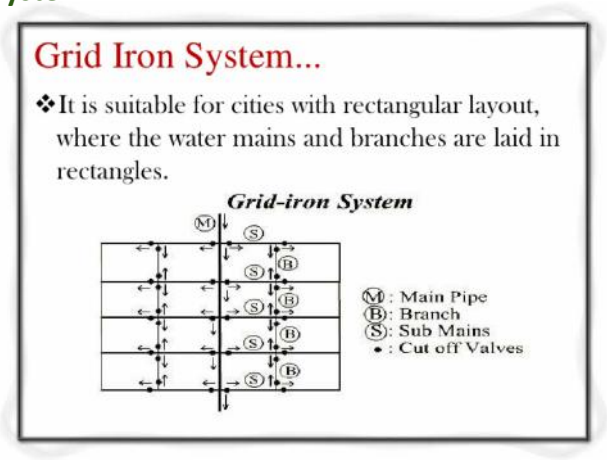
Advantages

- It is good for a city which has been developed haphazardly.
- As it requires less number of valves it is economical.
- This type of system is easy to construct.

Disadvantages

- Large area cut off during repairing.
- When tap is not opened for a long time bacterial growth may take place.
- When tap is not opened for long time water may be contaminated.

b. Grid Iron System



In Grid Iron System the whole distribution system is interconnected. So the water remains in circulation and there is no contamination of water. Because water does not stand still at any point and it continues circulation.

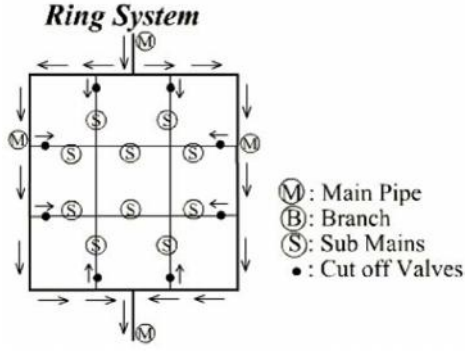
Advantages:

- In this system as the whole distribution system is interconnected water can reach from more than one direction.
- It provides better quality of water.
- During its repairing lesser area cut off.

Disadvantages

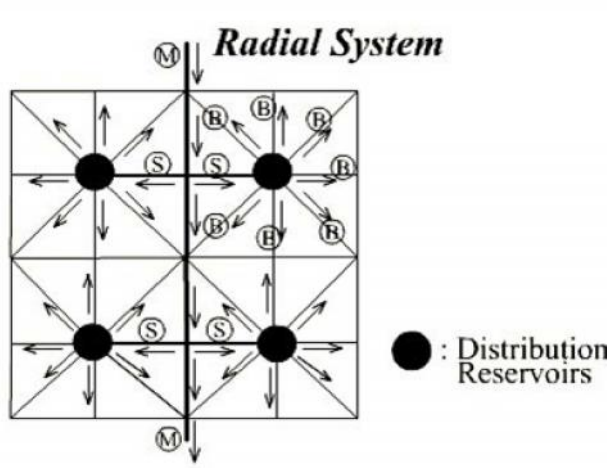
- The main problem in grid iron system is that, a lot of valve to cut off a small area in case of accidental hazards.
- This system is difficult to design.
- The network of pipes forming loops is possible only in well planned cities.

c. Circular or Ring System



Supply to the inner pipes is from the main around the peripheral boundary. It has the same advantage as grid iron system. Smaller diameter pipes are needed.

d. Radial System



It is a zoned system. Water is pumped into the distribution reservoirs and from the reservoirs it flows by gravity to the tree system of pipes. The pressure calculations are easy in this system. Layout of road need to be radial to eliminate loss of head in bends. This is the most economical system if combined pumping and gravity flow is adopted.

Requirements of a good distribution system

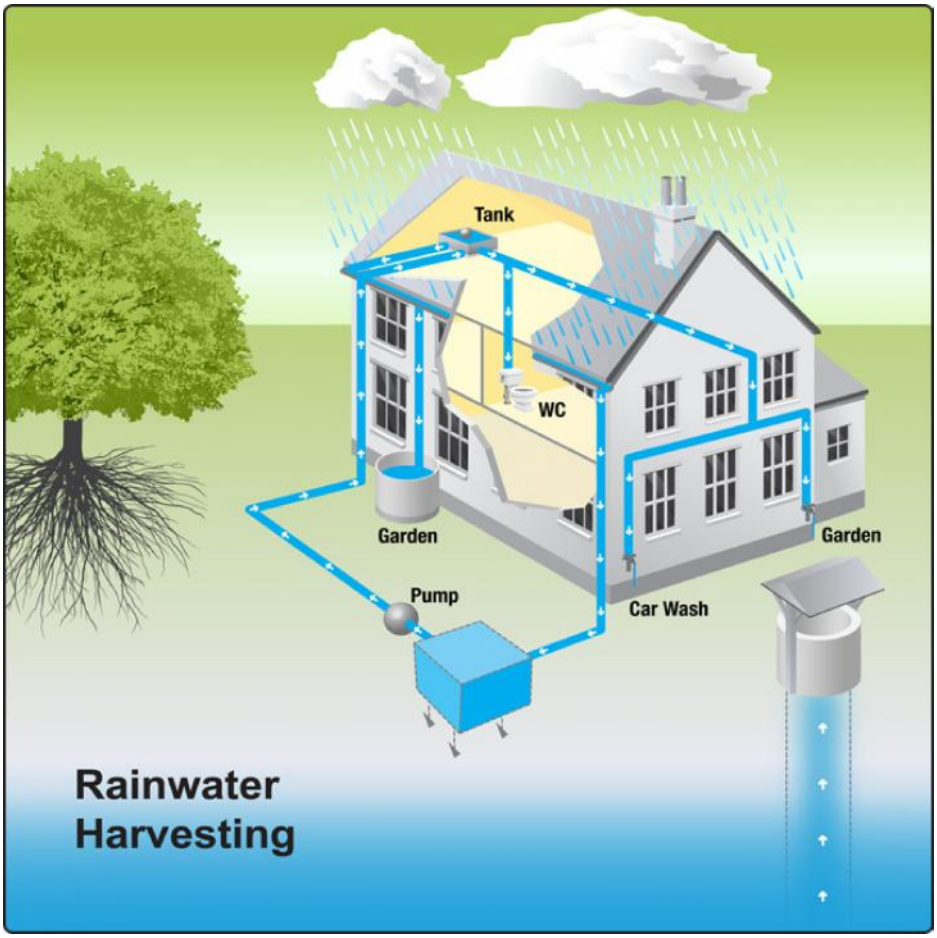
- Water quality should not get deteriorated in the distribution pipes.
- It should be capable of supplying water at all the intended places with sufficient pressure head.
- It should be capable of supplying the requisite amount of water during fire fighting.
- The layout should be such that no consumer would be without water supply, during the repair of any section of the system.
- All the distribution pipes should be preferably laid one meter away or above sewer lines.

It should be fairly water tight so as to keep loses due to leakage to the minimum.

Rain water harvesting

Rain water harvesting is the system to recharge the acquifer by rainwater through an artificial system at a rate more than that obtained conditions of natural replenishment and or collect and store rain water.

The technique used to increase the recharge of ground water by capturing the storm water is known as rain water harvesting. In other words, rain water harvesting is a process by which the ground water reservoir is enhanced at a rate exceeding these under natural conditions.



Objectives of rainwater harvesting

a) Reducing loss of water by its running off.

b) Avoiding flooding of roads.

c) Meeting the demands for increasing need of water, and

d) Reducing ground water contamination.

Methods of rain water harvesting

e) By storing of water in tanks or reservoirs

f) By construction of pits

g) By recharging of ground water and

h) By digging wells.

In the simplest method, rooftop harvesting involves taking down a PVC or MS pipe of 90-120 mm diameter from the roofs outlet to the ground floor which can be connected to a water tank (placed above the ground level or below the ground level) or to the underground water table. The rainwater before collection should however generally be passed through simple sand and charcoal filters. It is for the removal of suspended and organic particles from the rainwater runoff collected from the roofs or courtyards as in figure shown

Rain water collection for different uses

Rain water collection for different uses can be practiced by collecting the water carrying down from the roof into a storage tank of plastic, R C C, or masonry. The tank can be placed either above the ground or below the ground depending on the availability of space and cost consideration, cleaning and disinfecting the tank at regular intervals and making of filters is a must. In a campus where sufficient space is available the water can be stored in an open excavated pond which also serves as a settling place for impurities.

Rain water collection for ground water recharge

When rainwater collection for direct use is difficult or costly or impracticable, then ground water recharge option can be easily practiced to supplement the decreasing ground watertable of the area. The ground water recharging can be practiced by directing the rain water to infiltrate into the ground to join the watertable through a recharge well with a pressure filter depending on the available circumstances.

Assessment Activity

Field report verification, oral test, viva voce, preparation of sketch, class test, assignments.

TE Questions

1. Compare the dead end system and grid iron system of distribution of water.
2. What are the advantages of Radial system of distribution of water?
3. ……. is the distribution of water for a planned city.
4. Mention any four requirements of a good distribution system.

UNIT 4.3 PLUMBING

This unit deals with the different types and sizes of pipes and tools used in plumbing systems, fixtures, fittings, methods of laying pipelines, types of pumps, connection to public water supply systems, estimation of plumbing layouts, installation of hot water appliances, rainwater harvesting systems, irrigation systems for small scale or domestic farming and gardening.

Learning Outcomes

The learners:

- understands the importance of plumbing systems.
- select the appropriate tool for Particular plumbing tasks.
- select different pipes based on various as requirement of plumbing works.
- select different pipe fittings according to the necessity.
- understand the need and workings of water meter and, its location in a layout.
- know the location and need of fire hydrant in buildings.
- select fixtures for plumbing works.
- select the appropriate material for joining of pipes.
- develop skill in aligning pipe line with its accessories.
- select pumps according to the situation.
- develop skill in making connections with necessary fittings to tap water from public water connection.
- fix hot water appliances in the plumbing system.
- prepare layout of water supply system to new buildings / proposed with estimate
- understand the rain water harvesting tank and fix it at an appropriate location in buildings
- skill in irrigation works. for domestic and small scale farming or gardening.

Concepts

Plumbing

History of Plumbing

The term plumber comes from the Latin word for lead 'plumbum', meaning lead worker, Plumbers were skilled lead workers who fitted and repaired the apparatus

of water distribution in and out of a building. Clean water and safe waste removal is an imperative part of our everyday life.

Plumbing had its origins in ancient civilizations such as Greek, Roman, Persian, Chinese. Indian etc., cities The ancient developed public baths and had to provide potable water and remove waste water as large numbers of people lived. In most large cities today, solid wastes are send to sewage treatment plants in order to separate and partially purify water before emptying them into streams or other bodies of water.

Plumbing tools

1. Guiding and testing tool
   (a) Straight edge (b) Square (c) Level (d) Plumb bob
2. Marking tool
   (a) Pencil (b) Chalk liner (c) Scriber (d) Compass & divider
   (e) Punches
3. Measuring Tools
   (a) Rule (b) Tape
4. Holding tools
   (a) Pliers (b) Clamps (c) Vices (d) Wrenches
5. Cutting tools
   (a) Saws (b) Clamp (c) Rasps (d) Chisels (e) Wire-cutter
   (f) Shears (g) Hatchet
6. Scraping and Grinding tools
   (a) Scraper (b) Grinders
7. Boring and threading tools
   (a) Drills (b) Counter sinks (c) Pies (d) Taps (e) Pipe cutter
8. Striking and fastening tools
   (a) Hammer (b) Screw driver

9. Soldering and joining tools

(a) Soldering iron with bits (b) Solder pit (c) Ladle
(d) Fire pots (e) Heating torches (f) Blow lamp

Straight Edge - This tool is mostly used for scribing lines and testing faced surfaces and edges.

Level - It is used to test the accuracy and level of the completed pipe lines.

Plumb bob - Used to check vertical lines.

Scriber - Used to mark very fine lines.

Compasses and Dividers - Used by plumbers for marking arc and division.

Punches - Used for marking drill centers.

Pliers - Used for holding or unscrewing union nuts and similar work.

Vices - Used to hold a piece or metal or pipe rigidly for cutting or screwing

Wrenches - Used for gripping pipes and nuts.

Saw - Used for cutting pipes,

Files & Rasps - Used for removing the metal by rubbing.

Chisels - For cutting hard substances. Flat chisels are used for straight cutting. Plugging chisel is used for clearing out the joining from between brick work when inserting plugs.

Shears - Used for cutting or shearing sheet metal.

Pipe cutters - used for cutting metal pipes.

Threading dies - Used to make thread in pipe lines.

Taps - Used for cutting internal threads on a pipe or fitting.

Soldering Iron - It is used to raise the temperature of metal to a point when it can be tinned and soldered.

Blow lamp - It is used for healing soldering iron and joining lead pipes and filling lead in joints.

Types and sizes of pipes

According to materials used:

Cast iron – Used in water main when water pressure is very high.

Steel Pipes – Used in water mains when water pressure is high. It is costly and is affected by adverse atmosphere. So it should be properly treated before use.

GI Pipes – They are made of wrought iron coated with Zinc. Used for plumbing services inside the building. Pipes are easily connected by socket joints by masking threads on the end of the pipe and jointed to another pipe with help of a socket.. Tee, elbow, bend, cross, reducer, etc.

Wrought Iron Pipes – These pipes are with threaded ends and have many advantages over cast iron pipe. They have less joints; joints are tighter and stronger and alignment is better maintained. It is expensive than G.I, pipes.

Copper Pipes – They are used for hot water supply installation as they have high tensile strength, and are very light and can bent easily because of their walls. Copper pipes are sometimes chromium plated.

PVC Pipes – Used increasingly for supply of cold water. They are light weight, non corrosive and do not require any threading.

Lead pipe – Its main advantage is flexibility and durability. The most common use of lead pipe are a flexible connections called a goose neck, between water supply main in the street and a house service pipe; as a strap in the drain pipe from plumbing fixtures; as a flexible connection between a roof gutter and a rain leader and as a flexible connection between a water closet seat and the cast iron pipes of the plumbing system.

Asbestos Cement Pipe – Asbestos Cement is composed of asbestos fibre and Portland cement combined under pressure. In these pipes a coating of bitumen is given. It is used mainly in pipes in the distribution and collection systems.

Size of pipes

The pipe size is expressed in terms of area to be served or in terms of fixture units.

Domestic pipe sizes (PVC)

15mm (½")

20mm (¾")

25mm (1")

32mm (1¼")

36mm (1½")

40mm (2")

Types of pipe fittings

Coupling – It is used to join same diameter of pipes in a straight line.

Reducer – It is used to connect two pipes lines of different diameter.

Tee – It is used for taking branch from a line such as reducing tee, union, tee, etc.

Elbow – A pipe fitting for providing sharp change of direction in a pipe line, such as 90^0 elbow, 135^0 elbow, union elbow etc.

Bend – This is of various sizes to change the direction of water to any direction.

Plug or Cap – It is used for plugging or blocking the end of the pipe line for future extension from the line.

Cross or Junction - This fitting is for branches to right angles to each, which is known as cross union.

Union

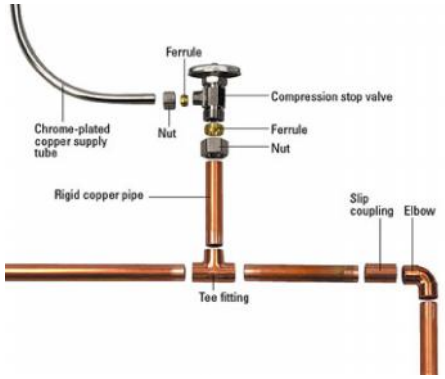
It is used to separate two pipes easly for any repair work in a pipe line. It has threads in opposite direction at both ends

Ferrule

It is a right angled sleeve made of brass or gun metal jointed to an opening drilled in the water main,to which it is screwed down with a plug.

Goose neck

It is a small sized curve pipe of a flexible material ,usually lead and about 75cm length forming a flexible connection between the water main and service pipe.



Water meter

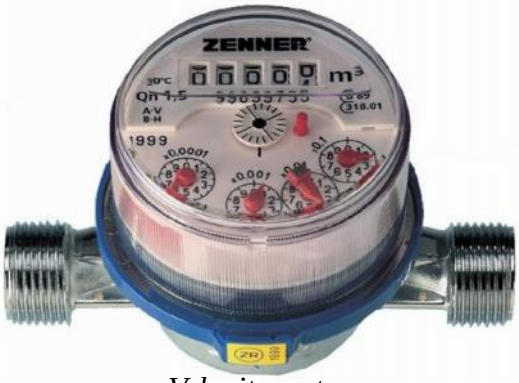
Water meters are the devices which are used for measuring the quantity of water flowing under pressure through a pressure conduit. They are installed on all the house connections.

The main two types of water meters are:

(1) The Velocity Meter or Inferential Meter

(2) The Positive Meter or the Displacement Meter

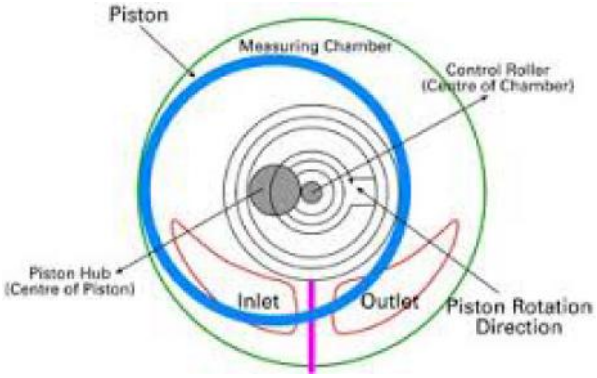
1. Velocity meter



Velocity meter

The velocity meter measures the velocity of water flowing through it. When multiplied by the cross sectional area it gives the quantity of water used. Automatic arrangements are made to record the integrated discharge over a period of time. It is usually used for large discharges and can also be used for small discharges but the accuracy is less, The examples are Rotary meter, Turbine meter, Venturimeter.

2. Positive meters



The positive meters are more accurate because they measure the quantity of passing water by counting the number of times the meter chamber is emptied and filled. The capacity of the meter chamber multiplied by the number of times it is filled and emptied will directly give the quantity of water flow over the given period of time. The examples are reciprocating type, oscillating type, disc type. etc. Disc meters are available in sizes from 16mm to 150mm in diameter with safe operating capacities of 90 to 4500 liters of capacity per minute.

Comparison between Velocity meters and positive displacement meters are:

a. Velocity meters are cheaper than displacement meters.

b. Velocity meters are lighter and require lesser head.

c. . Velocity meters are less accurate.

d. If anything stops the rotation of rotary meter or turbine meter, the water will continue to flow without being recorded.

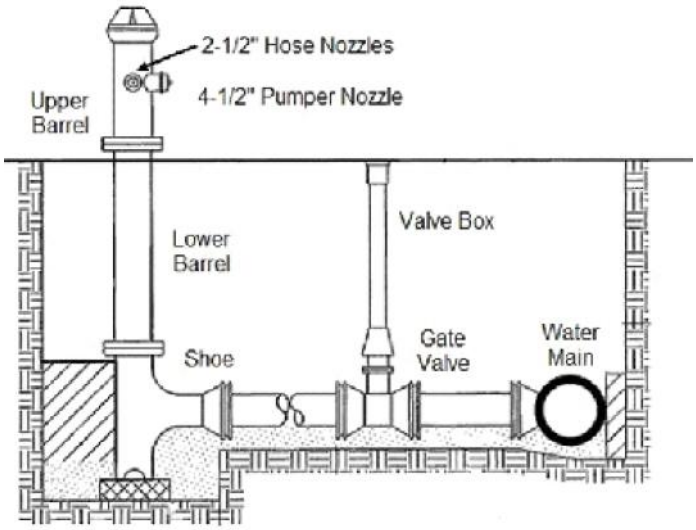
e, Velocity meters can be installed only on horizontal flows. For vertical pipe lines positive meters are to be installed.

Fire Hydrants

A hydrant is an outlet provided in a water distribution main or a sub main for a pipe of atleast 15 cm diameter for tapping water mainly during fires. During fires the nearby hydrant is connected to the fire hose and the water obtained from the hydrant

is used for extinguishing fire. The water required should be at higher pressures than domestic use since it is used at high buildings . This is done by connecting the outlet of the hydrant to the fire engine, it boost its pressure so that the water comes out from the engine through smooth nozzles and can thus used for high buildings.

Typical Fire Hydrant Installation



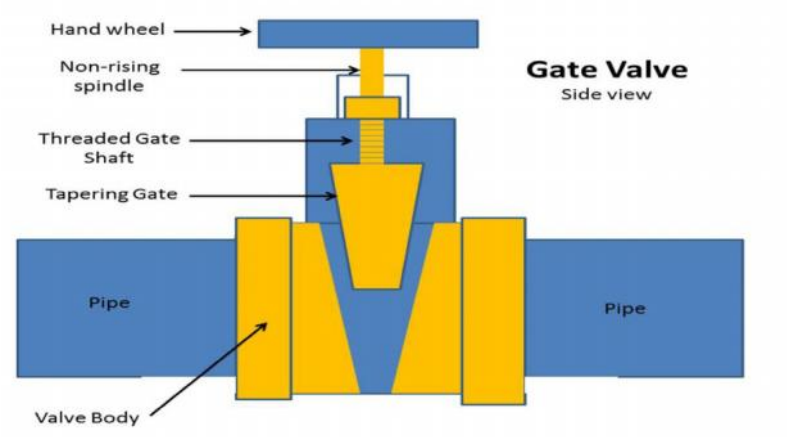
Requirements of a good hydrant

a. It should be easy to connect to the hose.

b. It should be cheap.

c. There should uninterrupted water flow.

Valves



Gate Valve or Sluice valve : This is used to regulate the flow of water through the pipe. In large pipe lines. bringing water from the source to the city, they are generally located along the pipe line at intervals of about 3 to 5kms. so as to divide the pipe line to different sections

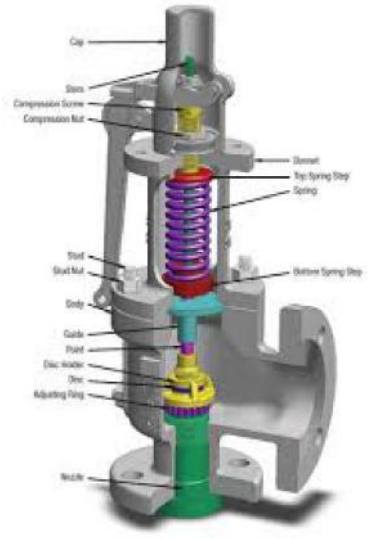
In this the flow is controlled by a sliding gate operated by means of a spindle with screw to move the gate in opening and closing.

Air Valves – Air valves are the special kind of valves which are generally placed along the pipe line on both sides of sluice valves and also on the downstream side of sluice valves. When water enters in the pipe line it also carries some air with it which tends to accumulate at high point of the pipe line. When the quantity of air increases it causes serious leakage to the flow of water. Therefore it is most essential to remove the accumulated air from the pipe line. Air relief valves are used for these purposes.

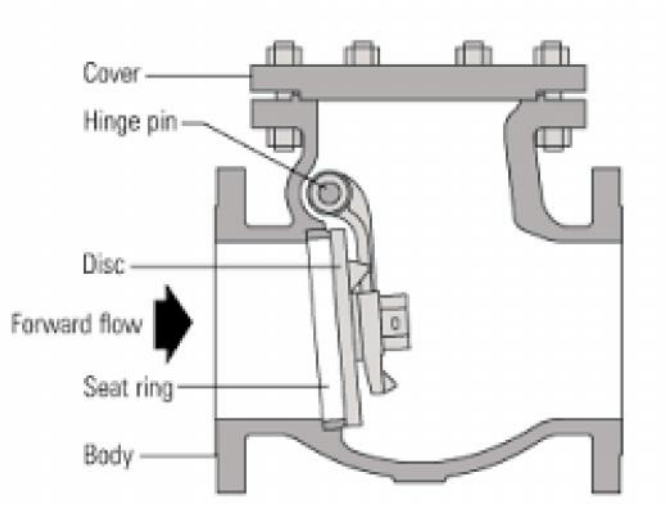
Stop valve or stop cock

They are small sized sluice valves and are installed in service pipes serving the undo splitting cocks. They operate on the same principle of sluice valves and they are usually used up to sizes of about 50mm. They are placed on water pipes leading to flushing tanks, wash basins, water tanks, etc.

Pressure relief valve – Water hammer pressure in pressure pipes can be reduced by using pressure relief valves. Such a valve is adjusted to open out automatically as soon as the pressure in the pipe exceeds a certain fixed predetermined value. It is useful in small pipelines, where the escape of a relatively smaller amount of water will alleviate water hammer pressure.

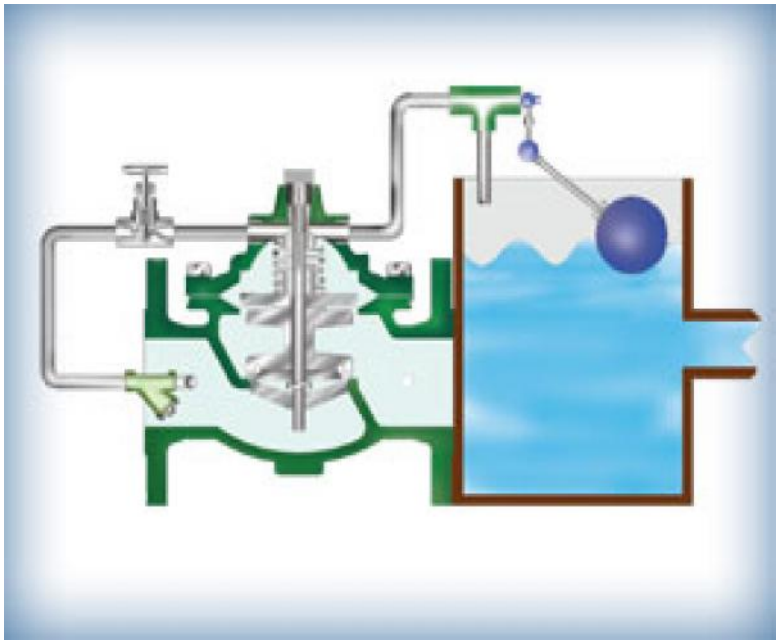


Check valve or non return valve – They prevent water to flow back or in the opposite direction. They may be installed on the delivery side of pumping sets, so as to prevent the back flow of stored or pumped water, when the pump is stopped.



Ball valve or Float valve

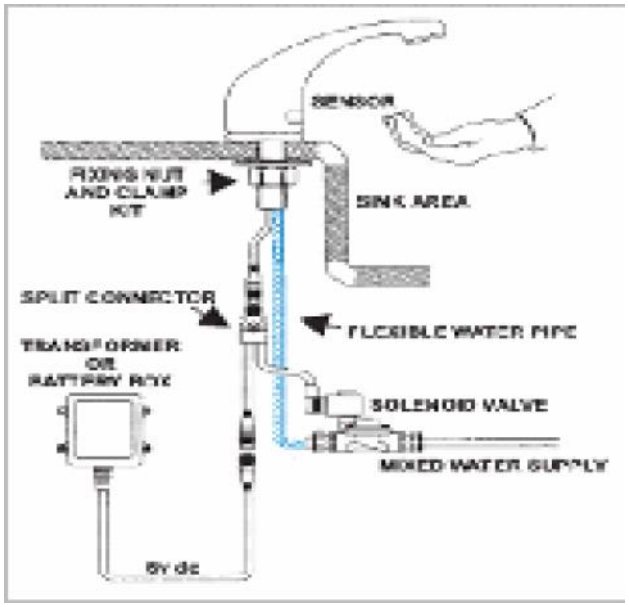
It is fitted in flushing cisterns, reservoirs, storage tanks etc. It is an automatic valve When the water level in the tank is raised to the full supply level the valve is self closed. It is fitted at the end of the inlet in the tank. The parts are ball valve and lever.



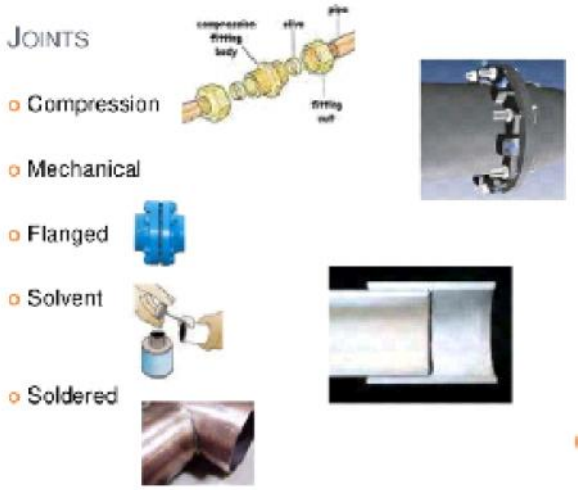
Water tap with Sensor

It combines four key components: solenoid valve, infrared sensor, power source and a tap unit.

When the sensor detects the presence of an object (user's hands) in front of the tap and sends a signal to the solenoid valve to initiate the flow of water. When the object is no longer present the infrared unit sends an electronic signal to the solenoid valve again to terminate the flow of water usually after a few seconds.



Types of joints in pipelines



Spigot and socket joint: The cast iron pipes are joined by this joint. The enlarged end of the pipe is called socket end and plain end is called spigot.

Expansion joint: This type of joint is used in very long pipe lines to make provision for expansion of pipe.

Ball and socket joint: It is called universal joint. This joint is used in those places where it is apprehended that the pipe line is likely to settle down.

Flanged joint: This is simple joint and is used when the pipes have flanges on the ends.

Collar joint: This joint is mainly used for connecting RCC pipes.

Screwed joint: This joint is commonly used in small diameter pipes. Such GI pipes. The pipes are screwed together by a socket.

Laying out of Water supply pipelines

Pipes conveying water from source to the distribution system consists of a network of pipe lines. The main pipe lines are of the same size - one or two in number made of steel or R. C. C. The branch lines are of cast iron and the house connection pipe lines are galvanized Iron.

The main pipe lines are buried in the ground and distribution lines are laid along the roads and streets. The alignment should be such as to follow the profile considering cost and pressures. The pipes are laid on compacted soil formation to avoid settlement and there should be at least 1m earthen cover between top of pipe and road surface.

Testing of pipe lines

After the pipe line has been laid and fitted with all appurtenance and accessories painted both from inside and outside by suitable paints, the pipe line is to be tested for pressure test on the pipe line as follows:

- The pipe line is tested from section to sections between two sluice valves.
- The downstream sluice valve is closed and the water is allowed to enter through the upstream valve after properly operating the air valves.
- The upstream valve is closed through which water is admitted so as to isolate the section.
- The pressure gauges are fitted along the length of pipe line at suitable interval say 1 km through holes provided for this purpose.
- The pressure in the pipe line is raised by a small hand pump till the test pressure is nearly 25 to 50 percent above the highest pressure.
- The pipe and the joints are then visualized for water tightness. The applied pressure should be maintained for 24 hours without any loss.
- When the field pressure is less than 2/3 rd of the work test pressure, the observation period is extended for another 24 hours.
- The pipe is finally emptied through drain valves, and the observed defects in the test are rectified so as to make the line fit for use.
- After the satisfactory completion of the pressure test, a leakage test at a pressure to be specified for a duration of 2 hours is also to be performed.

Assessment Activity

Identification of tools and materials, verification of samples collection, preparation of sketches, discussion notes, market survey report, identification of valves, oral test, practical activities

TE Questions

1. Differentiate between gate valve and pressure valve?
2. Name any three types of joints in pipe lines.
3. How a pipe line is tested fir water pressure
4. What is the advantage of censor tap?
5. Gate valves are used in …… .
6. Compare union and coupling in plumbing system.

7. Write the function of a water meter?
8. Compare Water meters of Disc types and those of rotary types?
9. Draft the water supply lay out plan of a residential building?

Pumps

Purpose Of Pumps

- To lift water from the source when water cannot flow by gravity to the mains.
- To lift water from the treatment plant when sufficient slope is not available between different treatment units.
- To lift water after the treatment to the distribution mains.
- When the pressure in the distributing mains is to be increased so as to enable water reach at elevated points.

Types of pumps

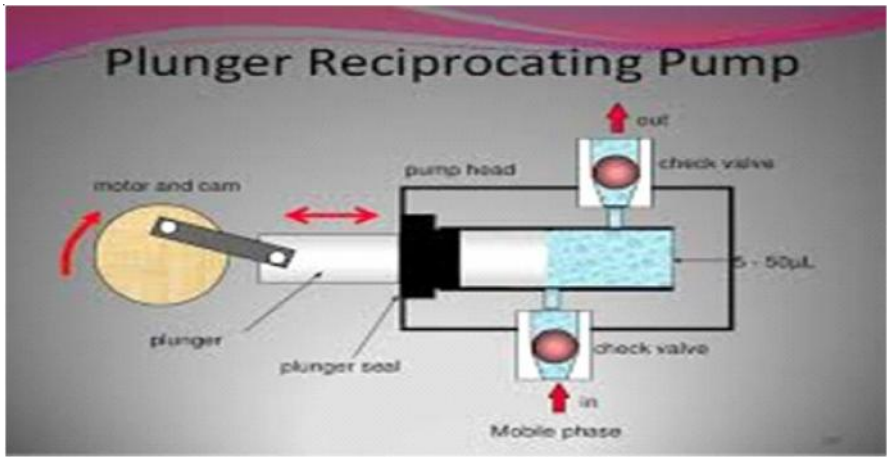
1. Roto-Dynamic pumps
2. Displacement pumps

Roto-Dynamic pump has a wheel or a rotating element which rotates the water in a casing and thus imparting kinetic energy to the water. There are two types of such pumps:

a. Centrifugal pump, b. Axial flow pump.

Displacement pump works on the principle of mechanically inducing vacuum in a chamber thereby drawing a volume of water which is then displaced in to the chamber. There are two types of such pumps:

(a) Reciprocating pump, Rotary pump



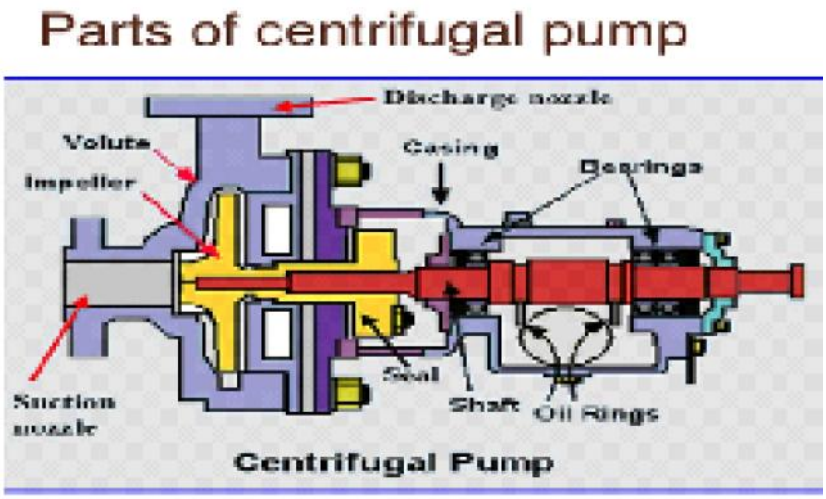
Advantages of Displacement pump

1. It gives a constant discharge with variable heads.
2. They are durable and flexible.
3. High efficiency is possible if the valves and packings are in good condition

Disadvantages of Displacement pump

1. Intial cost is high about four times more than centrifugal pumps and maintenance cost is also high.
2. Reciprocating pump occupies large space; six to eight times the space required by horizontal centrifugal pumps.
3. They are not suitable for water containing sediments. In such cases sudden stoppage leads to damage of the pumps.
4. Single acting reciprocating pump produce, pulsating flow.

Advantages centrifugal pump



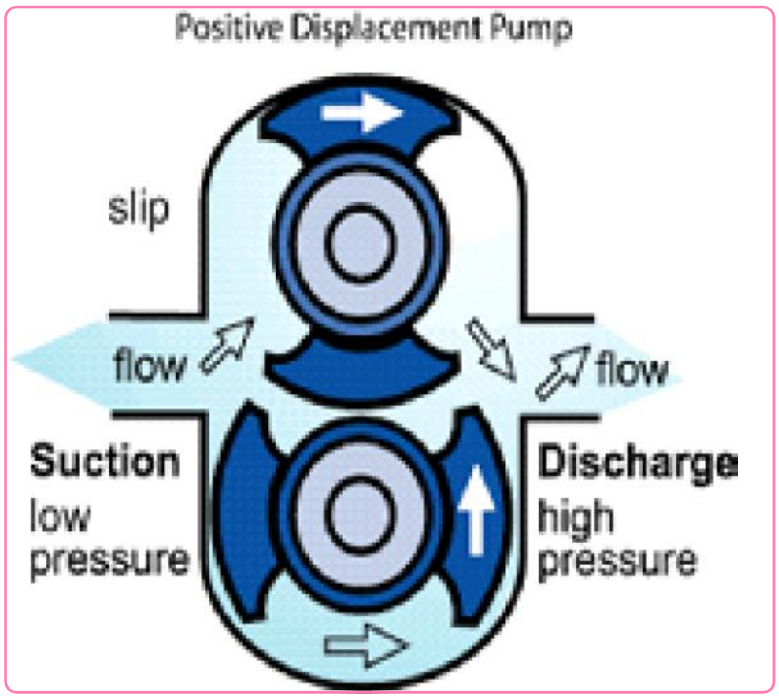
1. Initial cost and maintenance cost is low.
2. Their size is compact and can be installed in limited space.
3. Their mechanism is simple and thus less skilled labour is required for their operations and repairs.
4. The discharge obtained is steady and non pulsating.
5. They can be used for water containing silts and etc.

6. They are durable and safe against high pressure.

Disadvantages of centrifugal pump

1. Such pumps requires priming.
2. Such pump should not be started with discharge valve open to avoid overloading and at the same time it should not be started for a long time with discharge valve open to avoid high pressures.
3. For high heads, efficiency is low.
4. The discharge from such pumps varies with variable heads of water Uniform discharge is possible only by varying rotating speed which is not practical and economical.

Rotary Pump



Advantage of Rotary pump

1. They require no priming as they are self primed.
2. The flow is nearly free from pulsations.
3 As they have no valves they are simple to construct and easy to repair as compared to reciprocating pumps.
4. They are often used for in protection systems in buildings and in small water supply systems.

5. Their discharge is high at moderate heads.

Disadvantages of Rotary pump

1. The initial cost is high.
2. They are not durable as they require frequent repair of gears.
3. Water containing sediments damages the pump.

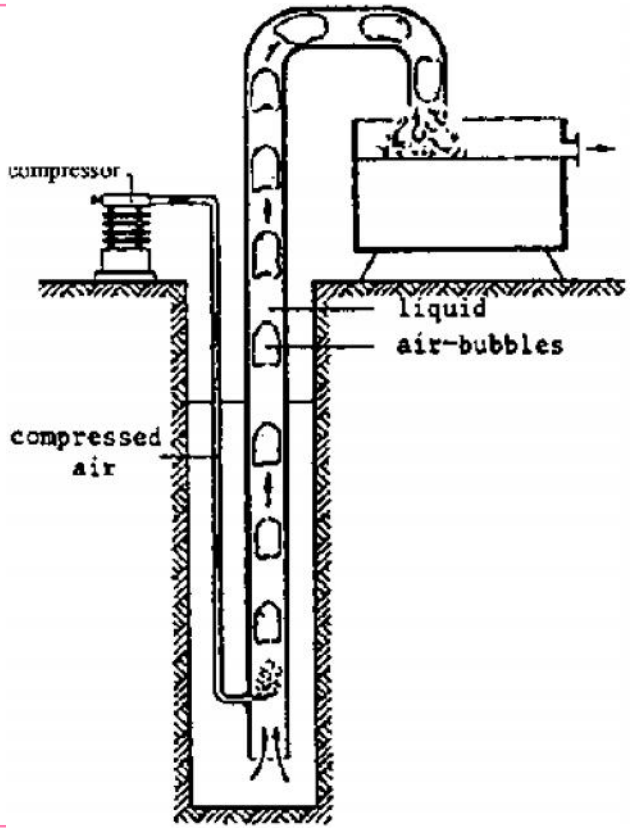
Miscellaneous Types of pumps

Air Lift Pump and b. Jet Pump

a. AIr lift pump

Air lift pumps are used to lift water from deep wells to about b 60 to 80 metres. In such pumps compressed air is forced into the source through a small air pipe and is released and mixed with the water through a diffuser at the reduction pipe at the bottom of the source. The water mixed with air has lesser density than the surrounding water and rises up. A separator placed at the outlet removes air from water.

Advantages of Air lift pumps:



1. In spite of lesser efficiency air lift pumps can discharge large amounts of water from smaller diameter wells.
2. The air lift pumps are not damaged by sediments so it can be used in damaged wells.
3. They are cheaper, simple and reliable in operation.
4. There are no movable parts in contact with water; so it can be used for highly acidic or alkaline waters.
5. The pumping from a number of wells can be done by installing a common compressor unit and
6. The yield from a well can be increased by using more amount of compressed air.

Disadvantages of Air lift pumps:

1, To increase the effectiveness of the pump the depth of well has to be increased than required. This creates additional expense.
2. An air lift pump is not adopted for lifting water much above the ground level, for this purpose an additional pump is needed.
3. Their efficiency is low.
4. The flow is not continuous but intermittent.

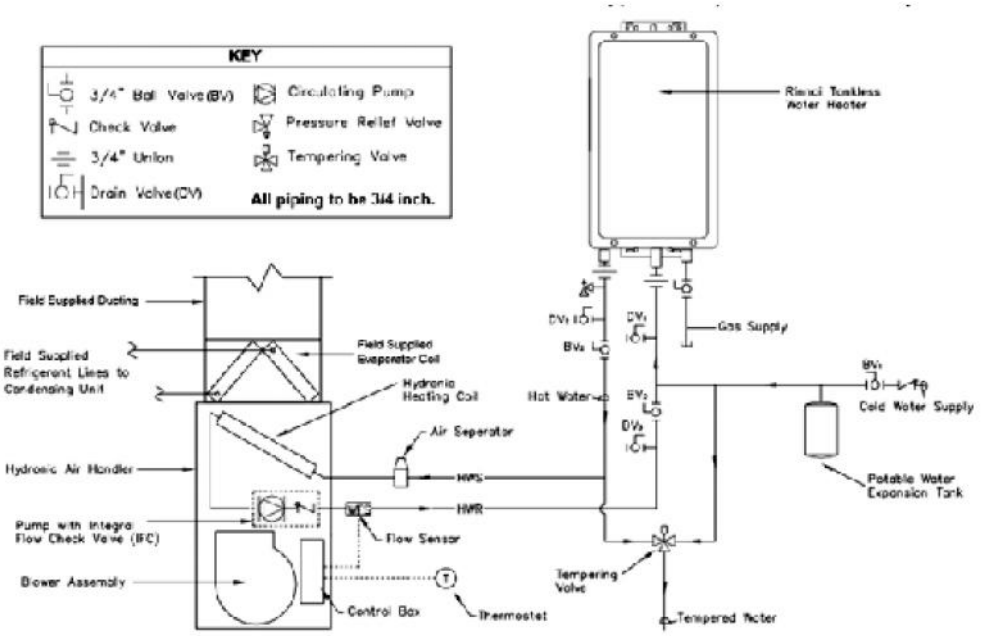
b. Jet pumps

Jet pumps are usually used for pumping water from smaller wells. They are portable and sometimes used in construction works for dewatering trenches. Its efficiency is low of the order of 25 percent. They are compact and light in weight and are easy to handle.

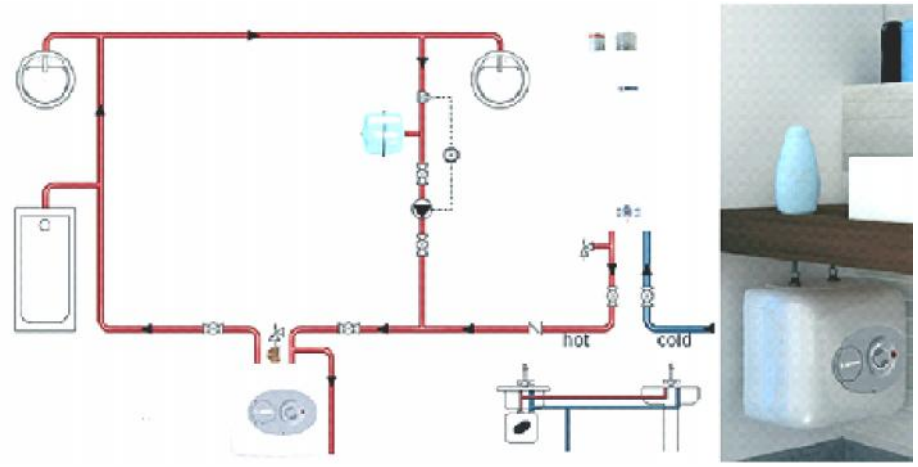
Factors affecting the efficiency of pump:

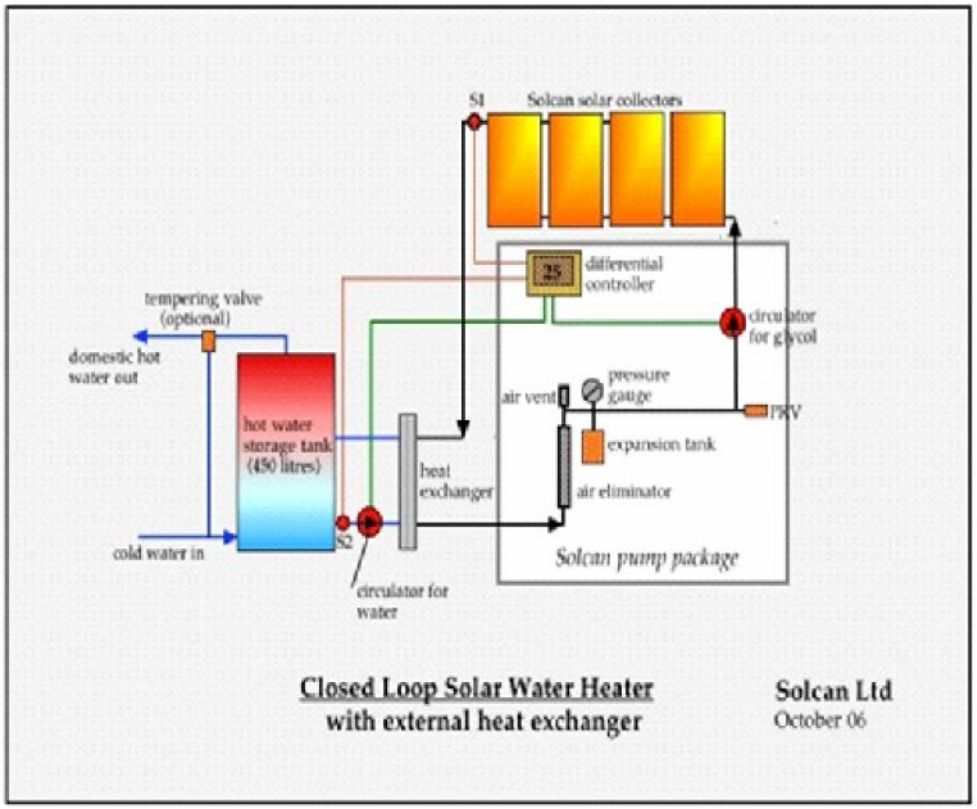
1. Capacity of the pump.
2. Importance of water supply scheme.
3. Initial cost of pumping arrangement
4. Maintenance cost.
5. Space available for locating the pump.
6. Number of units required.
7. Total lift of water required.
8. Quality of water to be pumped.

Hot water Appliance in plumbing System



Typical Piping Arrangement For Direct Space Heating and Domestic Water Supply with Tankless Water Heater. Open Loop

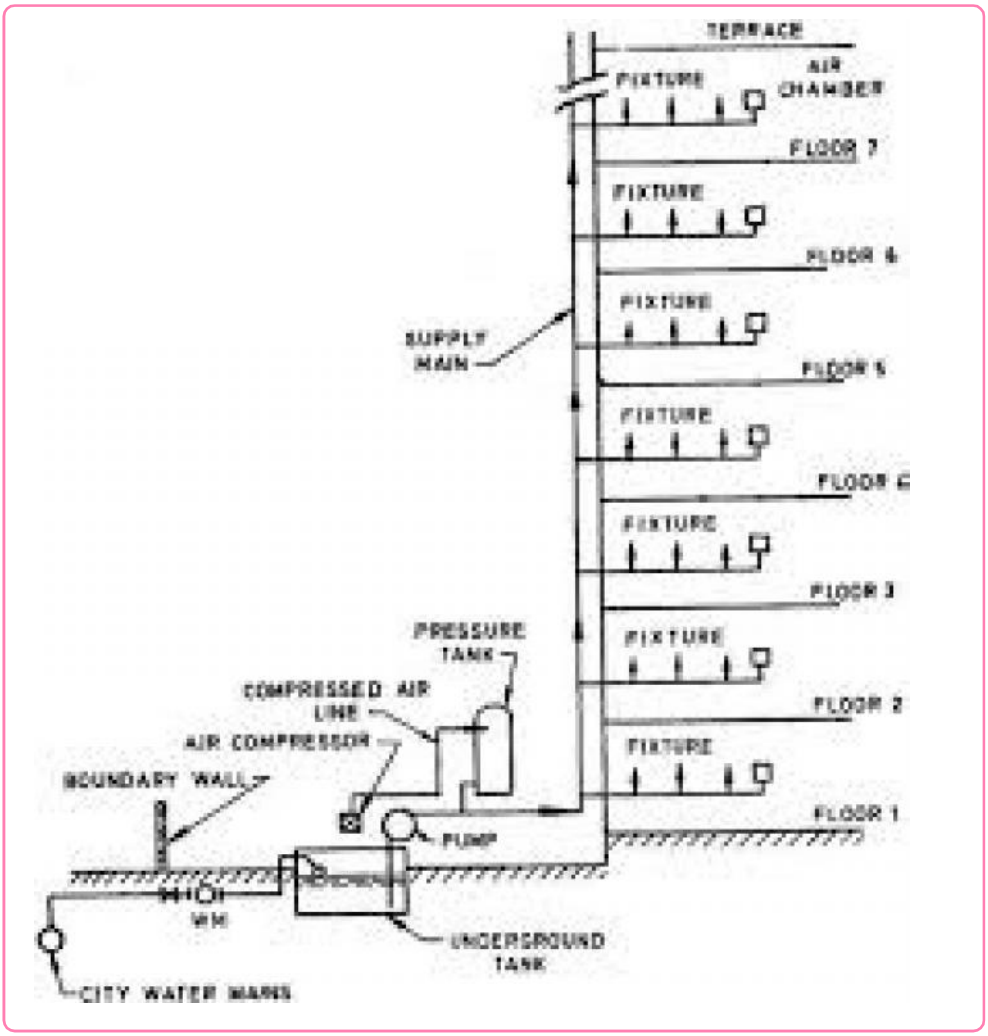




The common hot water delivery pipe shall leave the hot water heater near its top and shall be of not less than 20 mm bore generally, and not less than 25 mm, if there are other hot water taps in the same storey as that on which the hot water heater is situated. Hot water taps shall be of types causing minimum friction or alternatively oversized taps. may be provided such as 20 mm tap on a 15 mm pipe.

The vent pipe shall be connected to the highest point of the heater vessel and it shall not project downwards inside it as otherwise air may be trapped inside, resulting in surging and consequent noises. At no point, after leaving the vessel shall the vent pipe dip below level of the connection. A vent pipe may, however, be used for supply of hot water to any point between the cold water tank and the hot water. Vent pipes shall not be provided with any valve or check valves.

House connection from public water supply system



Testing of the System after Installation

After the hot water system including the hot water heaters has been installed, it shall be carefully charged with water, so that all air is expelled from the system. The entire system shall then be hydraulically tested to a pressure of 5 kg/cm^2 or twice the working pressure whichever is greater for a period of at least half an hour after a steady state is reached. The entire installation shall then be inspected visually for leakages and sweating. All such defects, if found, shall be rectified by removing and remarking the particular section caulking of threads, hammering and welding of leaking joints shall not be allowed.

Assessment Activity

Verification of Market visit report, Sketch of fixtures Participation in Discussions, oral test, viva, class test

Irrigation system for domestic farming and gardening

Sprinkler irrigation is a method of applying irrigation water which is similar to natural rainfall .

Water is conveyed under desired pressure (2 to 5 kg/cm2) developed by a pump through a network of pipes, called mainlines and sub-mains to one or more laterals and is sprayed into the air through sprinkler nozzles or perforations so that it breaks up into small water drops (0.5 to 4mm in size) which fall over the land or crop surface in an uniform pattern at a rate (0.06-5000 LPH) less than the infiltrability of soil. The pump supply system, sprinklers and operating conditions must be designed to enable uniform application of water.

Advantages

a) Elimination of field channels and their maintenance.which increase the production area

b) Harmful ditch weeds, which have allelopethic effects, do not appear with sprinkler irrigation.

c) No water losses in conveyance which amounts to 35% in surface irrigation methods

d) Close control over water application i.e., no runoff losses because water is applied below or equal to infiltration rate.

e) Convenient for giving light and frequent irrigations.

f) Higher application efficiency over surface methods of irrigation.

g) Sprinklers give a gentle rain that does not clog or compact the soil ensuring better and quicker germination of seeds resulting in more plants per unit area

h) Suitable in undulated lands, soils with shallow depth and areas located at higher elevation than the water source.

i) Feasibility of frequent, short water applications for germination, cooling & frost protection to plants, etc.

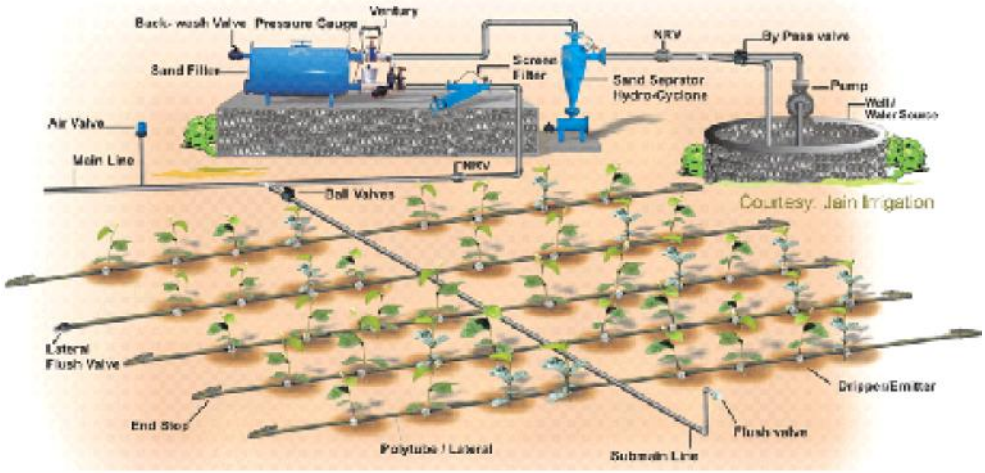
j) Higher yield and water saving over surface irrigation methods

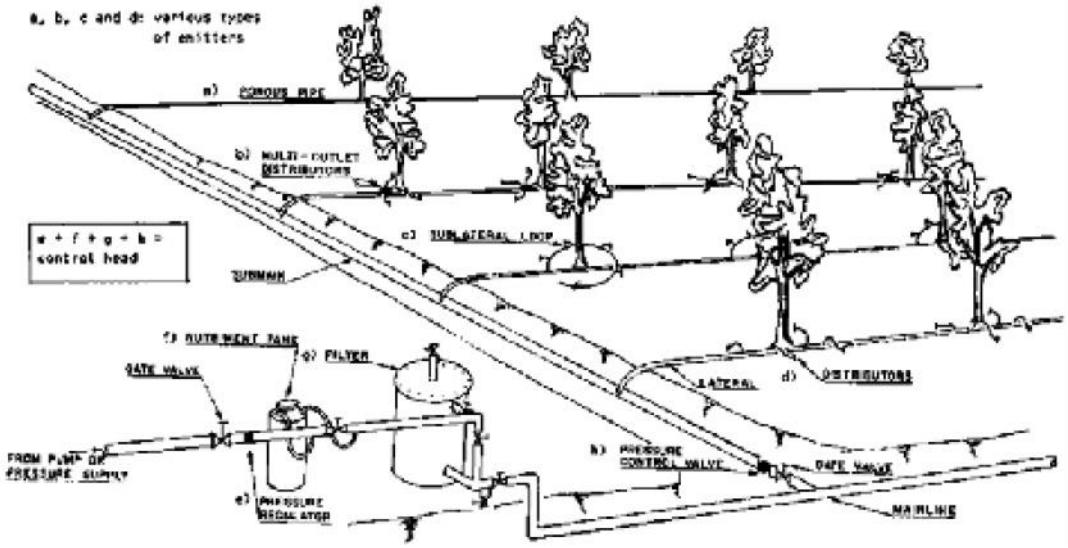
DRIP IRRIGATION

It is a method of conserving water and irrigating plants when required intelligently.

It consists of small plastic emission devices are pre inserted into the pretubing at specified intervals during the tubing extrusion processes .resulting in labour saving for the end users.Drip in line may be installed below the surface also, such as the soil surface may be kept dry and the surface damage can be avoided. The inline drip tubing can be rolled and reused many years making it cost effective.

The pumps used should pumped water to operate the drippers at its optimum pressure, considering all the losses of pressures at suction head, delivery





head,pressure losses in main pipes,drippers .branc pipes .lateral tubes. Filters etc

If distribution is through over head tanks,it should sufficiently elevated to have optimum pressure at drippers so that all drippers can operate simultaneously.There should be a minimum pressure of 1kg/sq. cm or the tank should be at a height of 10m.

The time of working of the pump= water required by the plant/day in litres ÷Rate of water supplied in litres/hour.

Maintenance

Either P.V.C or H.D.P.E pipes are used for drip irrigation. If P.V.C Pipes are used it should be laid at a depth of 1.5m in small trenches. At the end of branch pipes either flush valves or end caps should be fitted.

Drippers are inserted at the end of lateral tubes connected to branch pipes by making holes or it can be connected directly to the lateral. It can also be connected by micro tubes. The drippers should be protected from dirt, silt ,bacteria , organic matters, if so it can be cleaned by washing .

Filters are connected at the end of delivery pipe . It can be cleaned by back wash To identify the pressure changes and control pressure valves and pressure gauges should attached with filters. Filters should be fixed firmly to the floor to avoid vibrations occurs during the working of the pump.

Verification of Market visit report, Sketch of fixtures, Participation in Discussion, oral test, viva, class test

TE Questions

1. Mention the different types of pumps used in plumbing system.
2. What are the advantages of centrifugal pump over displacement pump?
3. Define the term priming.
5. What are the functions of fire hydrants?.
6. Suggest the most appropriate location of rainwater harvesting tank in a building.
7. What are the factors affecting the selection of type of pumps?
8. Identify the most suitable type of pump for high rise buildings.
9. List the factors affecting the efficiency of a pump.

Unit 4.4
SANITARY SYSTEM

This unit includes the study of technical terms in sanitary engineering, sanitary fittings and fixtures, pipes, sewage disposal and treatment and the estimate of sanitary systems.

Learning Outcomes

The learner;

- Aware the technical terms in sanitary system.
- understand the objective of traps in sanitary system.
- select the suitable type of sewage disposal.
- connect to the public sewer adopted for a particular situation
- draft & design septic tanks for different requirements, and other types of plumbing system in buildings. .
- select and fix proper sanitary pipes and fittings fixtures
- prepare the lay out with estimate of sanitary systems, and
- Aware of waste management methods

Concepts

Sanitary Systems

Introduction

It is the system of pipe fittings, fixtures etc. used for the scientific and methodological collection, conveyance, treatment and disposal of the waste water so that public health can be protected from offensive and injurious substance. The sanitary sewage includes excreta, domestic sewage (used water from home or community which includes toilet, bath, laundry, lavatory and kitchen sink wastes) and industrial wastes.

Technical terms

Refuse: Refuse is the general term used to indicate what is rejected as left out as worthless either in liquid, semi solid or solid form. It is divided into six categories – (a) garbage (b) rubbish (c) sullage (d) sewage (e) subsoil water (f) storm water.

Garbage: It is dry refuse (waste paper, decayed fruits and vegetables, grass and leaves, sweepings from streets, market, public places)

Rubbish: Sundry solid waste from offices, residences and other buildings of combustible nature.

Sullage: Waste water from bathrooms, kitchens, washing places and washbasins, etc., without any bad smell, organic matter is absent or in negligible amount.

Sewage: Includes liquid waste from the community includes sullage, discharge from latrines, urinals, stables, industrial wastes and also ground surface and storm water that may be admitted into the sewer. Its decomposition produce large amount of malodorous gases and it may contain numerous pathogenic bacteria.

Subsoil water: Ground water that finds it entry into sewer through leaks.

Storm water: It indicates rainwater of the locality.

Sanitary sewage: Sanitary sewage or domestic waste mainly derived from residential and industrial establishments, and is foul in nature. It is divided into domestic sewage and industrial sewage.

Domestic Sewage: From lavatory basins, urinals and water closets of residential building, office buildings, theaters and other institutions. As it contains human excreta and urine, it is extremely foul in nature.

Industrial Sewage: Waste water obtained from industrial and commercial establishments. It contains organic compounds and may not be amendable to conventional treatment methods.

Night Soil: Term used to indicate human and animal excreta.

Sewer: It is an underground conduit or drain through which sewage is carried to a point of discharge or disposal.

Sewerage: The term means the structures, device, equipment and appurtenances intended for the collection, transportation and pumping of sewage and liquid waters but excluding works for the treatment of sewage.

Waste water: Waste water includes both organic and mineral matter carried through liquid media.

Soil pipe: A pipe through which excreta flows.

Waste pipe: A pipe which carries only the liquid waste.

Vent pipe: Provided for the purpose of ventilation of the system. A vent pipe is open at top and bottom to facilitate exit of foul gases. It is carried at least 1m higher than the roof level.

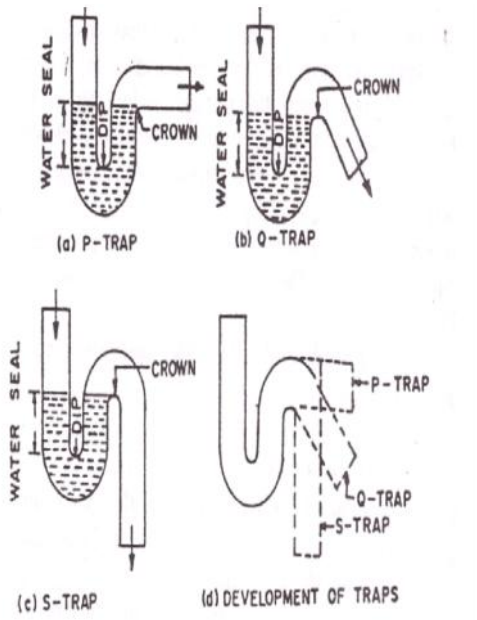
Rainwater pipe: Pipe which carries only rain water.

Antisiphonage pipe: This is installed in the house drainage to preserve the water seal of traps. In multi storied buildings a sudden flush of water from an appliance of in the upper floor causes the air in the short branch drain pipe connecting a fitting on the lower floor creates a vacuum in the downstream side of water seal in the trap of floor fitting. The antisiphonage pressure acting on the other side of water seal therefore forces the water up the trap and siphons it out into the branches, thus breaking the water seal. Water seal in the trap may be got broken by providing an antisiphonage pipe which connects the downstream side of the water seal to the atmosphere.

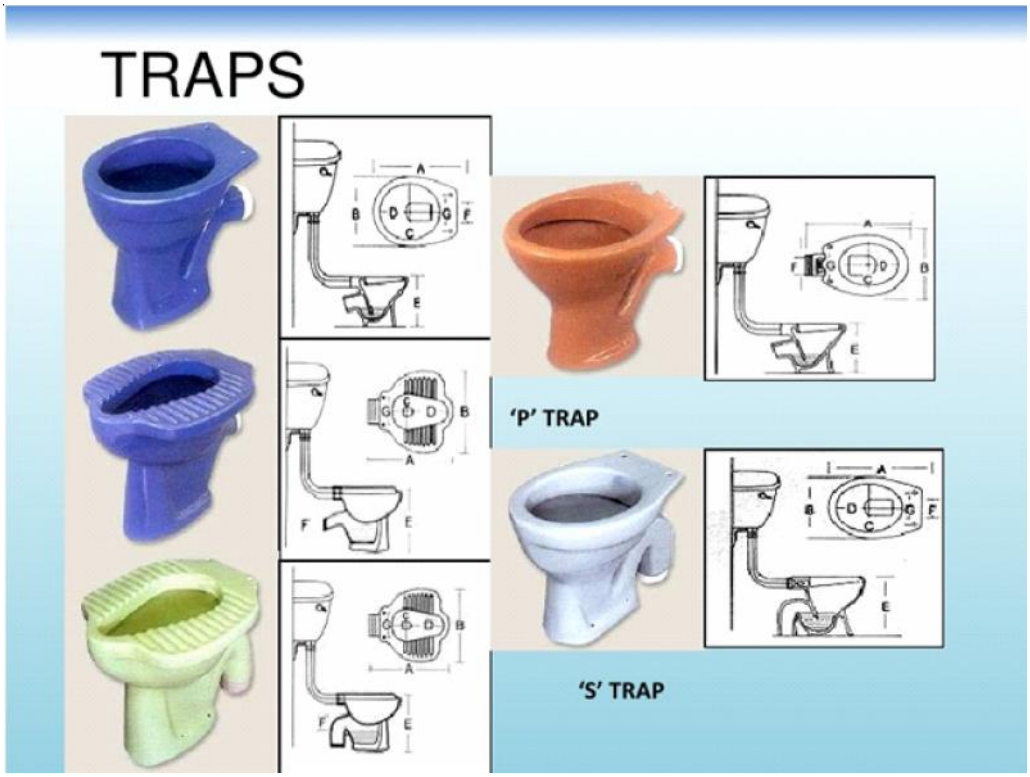
Size of sanitary pipes

Soil pipe	-	100mm dia
Waste pipe horizontal	-	30 to 50mm dia
Waste pipe vertical	-	75mm dia
Rain water pipe	-	75mm dia
Vent pipe	-	50mm dia
Antisiphonage pipe	-	50mm dia
Connecting soil pipe	-	50mm dia
Connecting waste pipe	-	40mm dia

Traps



It is a depressed or bent fitting which when provided in a drainage system always remain full of water, thus maintaining a water seal. It prevents the passage of foul air or gas through it; though it allows the sewage or waste water to flow through it. The depth of water seal represents its strength or effectiveness. The depth of water seal varies from 25mm to 75mm.



Characteristics of trap

- It should possess adequate water seal always to fulfill the purpose of its installation.
- It should be non absorbent material.
- It should free from any inside projections angles or contractions so that flow is obstructed or retarded.
- It should be simple in construction
- It should be self cleansing
- It should possess suitable access for cleaning.

Classification of traps

P-trap – This has the shape of letter P, in which the legs are at right angles to each other.

Q-trap or half strap – This has the shape of letter Q, in which the two legs meet at an angle other than a right angle.

S-trap – This has the shape 'S' in which both the legs are parallel to each other, discharging the same direction.

Classification according to use

(a) Floor trap or nahni trap

(b) Gully trap

(c) Intercepting trap

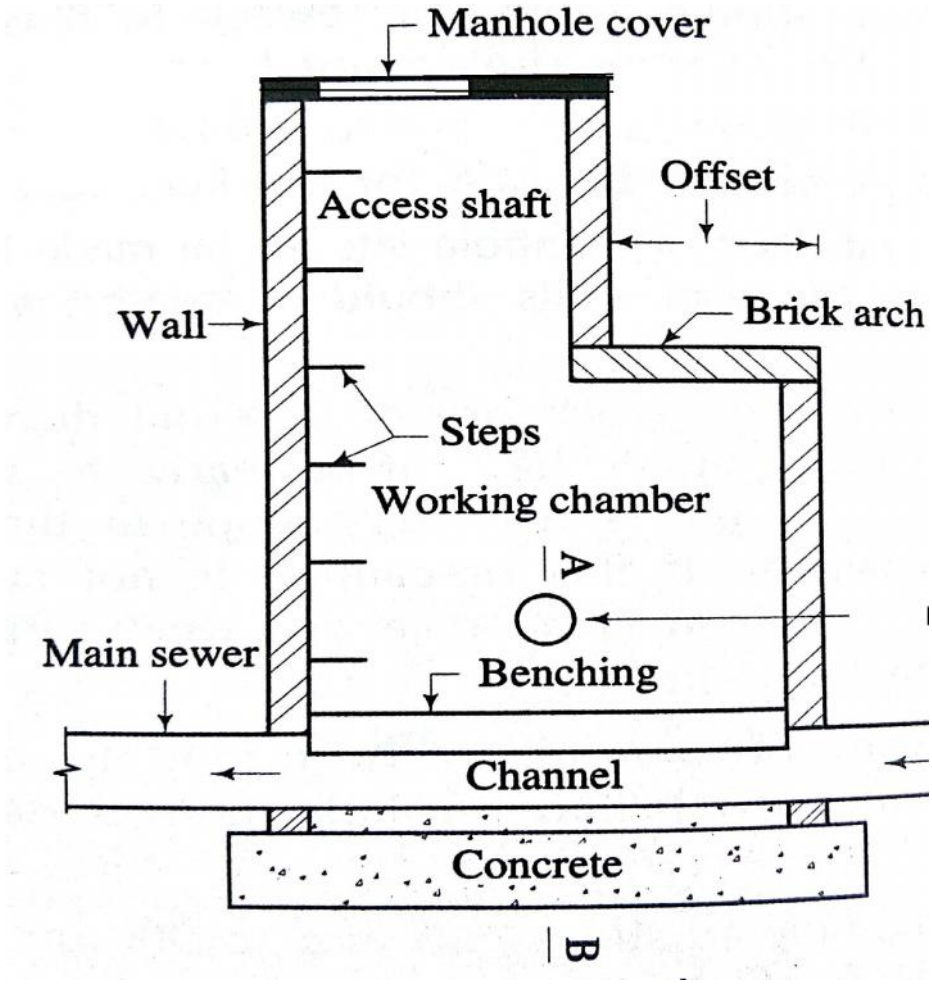
Floor trap – It is used to collect wash water from floors, kitchens and bathrooms. It forms the starting point of waste water of floors. It is made of cast iron, with a gravity at top, to exclude entry of solid matter of big size. This cover can be removed to do frequent cleaning of the trap. These traps have small water seal.

Gully trap – These are special traps which disconnect sullage drain (collected from bath, kitchen etc.) from the main drainage system. It is usually S or P trap. It is provided at the external face of a wall. It thus receives waste water from baths, kitchens etc, and pass it on to the house drain carrying excremental discharge from water closets .

Intercepting trap – It is provided at the junction of house drain with the public sewer or septic tank. The trap has an opening at the top called the cleaning eye or roding arm having a tight fitting plug, for frequent cleaning of the trap. This trap has water seal of about 100mm and it is provided in the last manhole of house drainage system. It thus conveys sewage from house to public sewer. The main advantage of providing intercepting trap is to prevent the entry of sewer gases from public sewer line to house drain.

Grease traps – It is used in large hotels, restaurants or industries where large quantities of oily wastes are expected to be thrown out with the the water flow. If the oily or greasy matter is not separated it will be stuck to the building drainage system in the form of ugly scum and consequent obstruction to reaeration.

Inspection Chamber



Deep manhole

Different types of sewage disposal

Depending upon the type of waste two systems may be employed for its conveyance and disposal

(a) Conservancy system (b) Water carriage system

Conservancy System – Ithis type various types of wastes such as night soil, garbage etc are collected separately in vessels or deposited in pools or pits and then removed periodically atleast once in 24 hours.

Water carriage system – In this system collection, conveyance and disposal of

various type of wastes are carried into with the help of water.

In this system specially designed latrines called water closets (WC) are used which are flushed with 5 to 10 liters of water after its use by every person. The human excreta is thus flushed away and led to suitably designed and maintained sewers. The sewers are the underground closed pipes which are laid on suitable longitudinal gradient so that flow takes under gravity and proper flow velocity is maintained to keep the sewer clean.

Classification of water carriage system

(a) Separate system

(b) Combined system

(c) Partially separate system

Separate system – There are two separate systems of sewers.

(i) The one intended for the conveyance of foul sewage only such as faecal matter, domestic waste waters, the washings and draining of places such as slaughter houses, laundries, stables and the waste water derived from the manufacturing process

(ii) The other for the rain water, including the surface washing from certain streets, overflow from public baths and foundations, etc. the sewage from the first system of sewers can be led to the treatment works.

Combined system

Advantages of combined system:

In an area where rainfall is spread throughout a year, there is no need of flushing of sewers, as self cleansing velocity will be developed due to more quantity because the of addition of storm water.

Only one set of pipe will be required for house plumbing.

In congested areas, it is easy to lay only one pipe rather than two pipes as required in other systems.

Disadvantages of combined system:

It is not suitable for the area with small period of rainfall in a year because water flow will be small due to which self cleansing velocity may not develop in sewers, resulting in silting. Large flow is required to be treated at the sewage treatment plant before disposal. hence results in higher capital and operating cost of the treatment

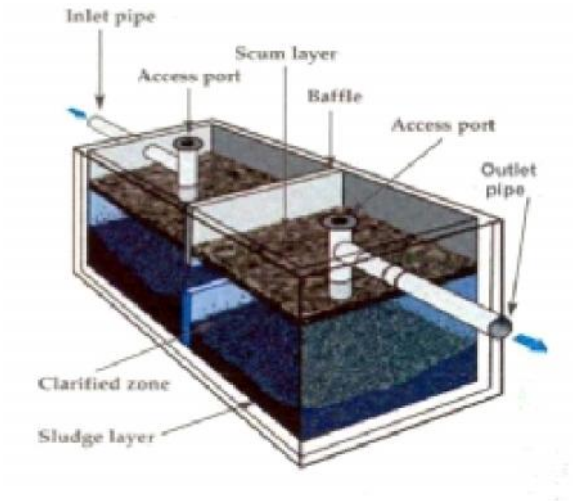
plant, When pumping is required this system is uneconomical. During rains overflowing of sewers will spoil public hygiene.

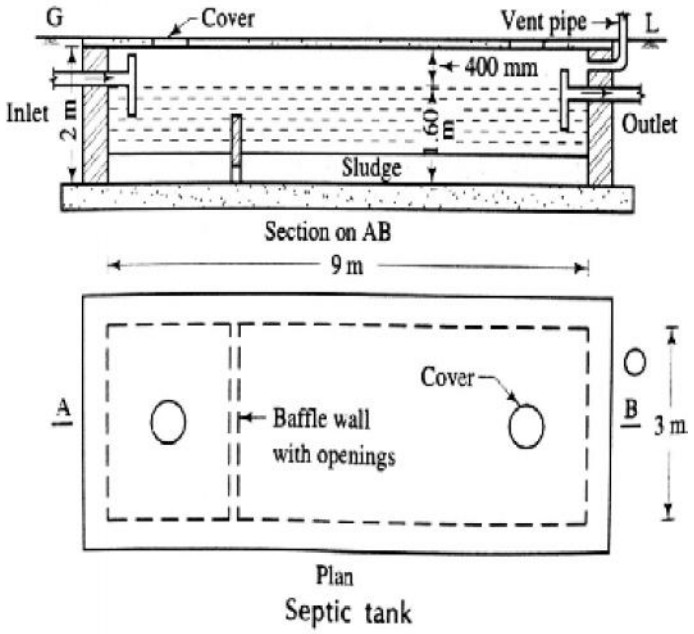
Partially combined system – In this system only one set of underground sewers is laid. These sewers admit the foul sewage as well as the early washing by rains. As soon as the quantity of storm water exceeds a certain limit, the storm water overflows and is thus collected and conveyed in open drains to the natural streams.

Comparison between conservancy and water carriage system

Conservancy System	Water carriage system
(a) The system is unhygienic.	The system is hygienic.
(b) There is lot of foul smell.	No foul smell.
(c) Compact house design is possible.	Compact design is possible.
(d) More labor force is required.	Less labour force is required.
(e) Initial cost is small maintenance cost is high.	High initial cost, low maintenance cost
(f) No technical persons are required	Technical persons required for operation and maintenance.
(g) Risk of spread of epidemic.	No such risk.
(h) Large land required for the disposal of untreated sewage.	Small kind is required for the disposal of treated sewage.
(i) System for rural condition	System for urban condition.

Septic Tanks





Septic tank

Septic tank is a special form of primary sedimentation tank with longer detention time in which digestion of settled sludge is carried out by anaerobic decomposition process. Since foul gases are evolved during the digestion process the tank is kept completely covered on the top, with a provision of a high vertical vent shaft for the escape of these gases. Since the effluent contain foul substances, it is disposed of either for sub surface irrigation or in soak pits or through other suitable methods

Different Kinds of Septic tanks

Concrete septic Tank- Concrete septic tanks are susceptible to cracking or even separation if the concrete mix is not good and if the tank is not properly maintained. These cracks will allow effluence to seep out of the concrete septic tank and may allow ground water to seep in. Blockage will cause the system to back up. Run off is also dangerous and cannot be detected by a standard dye set.

Plastic Septic Tank

Plastic septic tanks are largely impervious to the rusting and cracking of steel and concrete septic tanks. Still they have problems. Low effluent level can be a sign that a plug at the bottom of the tank has become dislodged. Even if the effluent level is normal during pumping, any plugs should still be manually inspected after pumping. While the plastic septic tanks are resistant to chemical process of a septic system, their lighter weight makes it prone to structural damage.

The light weight can also cause the tank to shift in the ground during periods when the soil is wet. A plastic tank can rise out of the ground breaking pipes along the way.

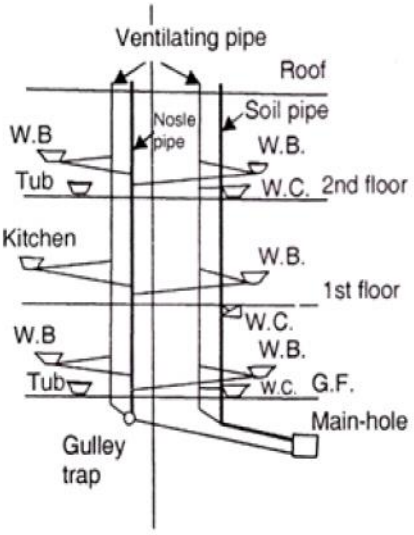
Aerobic Septic Tank

Aerobic septic tanks use the aid of oxygen to increase the decomposition of the effluent. They are mostly used to replace the failed septic tank. They are 2 to 3 times costlier than other tanks. But they are highly efficient and saves money by reclaimed area for the drain field from a prolonged life. It requires more frequent and intensive maintenance.

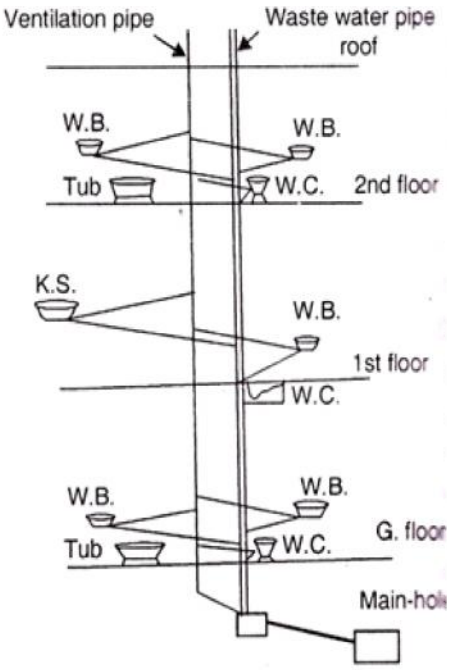
System of plumbing

There are four system of plumbing for building drainage.

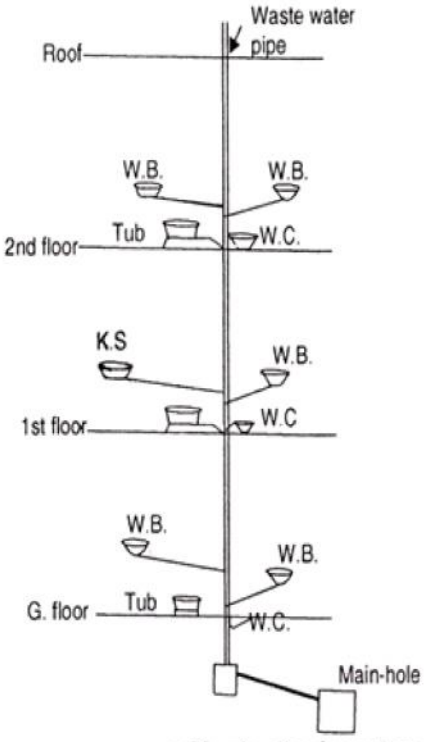
a. One pipe system
b. Two pipe system
c. Single stack System
d. Single stack partially ventilated system



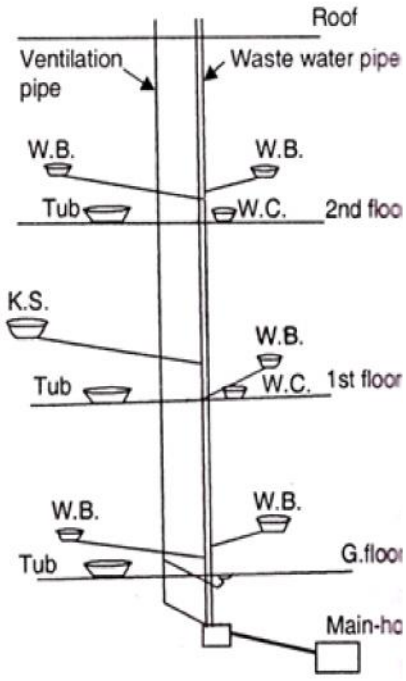
Two-pipe system.



One-pipe system.



. Single-stack system.



. Single-stack partially ventilated system.

a. One Pipe System

In this system the lavatory blocks of different stories are placed one above the other so that all soil wastes and waste water collects to one vertical pipe by providing branches to different floors. This main pipe is connected to the drainage system. All the traps of sanitary fittings are completely ventilated.

b. Two pipe system

There are separate soil and waste pipes for collecting waste from different floors through branches. The soil pipes are connected directly to the drain but waste pipes are provided with gully trap. All the traps are ventilated.

c. Single stack System

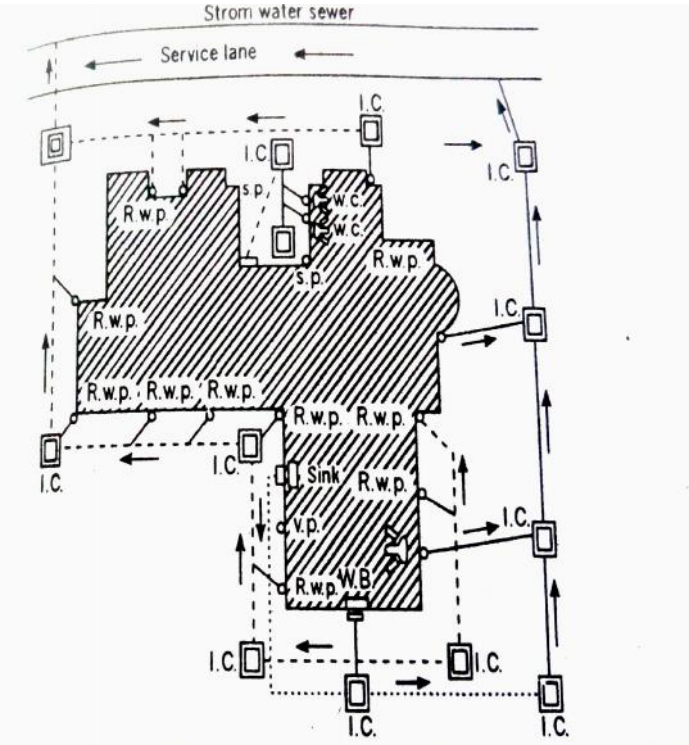
It is similar to single pipe system but not ventilated

d. Single stack partially ventilated system

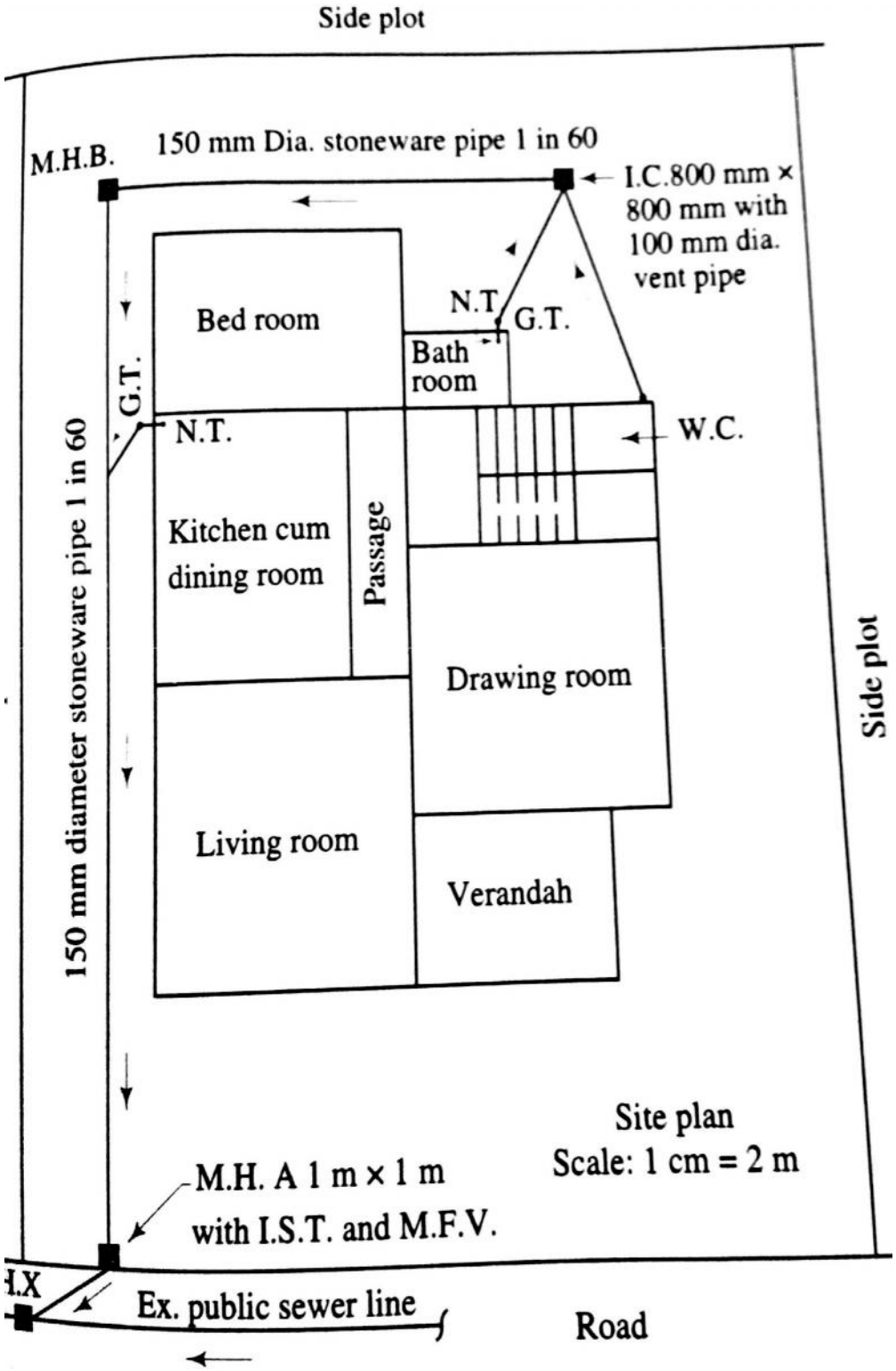
There is only one soil pipe for collecting discharge from all sanitary fitting but only one vent pipe for ventilating traps of water closet.

House drainage plans

House drainage plans



Typical drainage layout of a large building


Side plot
M.H.B.
150 mm Dia. stoneware pipe 1 in 60
I.C.800 mm × 800 mm with 100 mm dia. vent pipe
Bed room
N.T.
G.T.
Bath room
G.T.
N.T.
W.C.
Kitchen cum dining room
Passage
Drawing room
Living room
Verandah
150 mm diameter stoneware pipe 1 in 60
Side plot
Site plan
Scale: 1 cm = 2 m
M.H. A 1 m × 1 m
with I.S.T. and M.F.V.
I.X
Ex. public sewer line
Road

The following point should be kept in mind while preparing drainage plans

- The drains should be laid at such a slope that self cleansing velocity is developed in them 1 in 40 for 10 cm pipe, 1 in 60 for 15 cm pipe, 1 in 90 for 23 cm pipe
- All the drainage system should be ventilated. On the house side the ventilation pipe should be carried sufficiently high above the buildings .All the inspection chambers should be provided with fresh air inlets
- All the drains should be laid in such a way so as to ensure their safety in flow.
- The drain should be laid in such a way that future extension can be done easily if desired.
- If the quantity of sewage flowing in a pipe is small, an automatic flushing tank may be provided on its top for flushing it.
- All the rain water pipe sweeping from the house and both water should be discharged on a gully trap and should be disconnected from the drain

All the soil pipe should be carried direct to the man holes without gully traps

Disposal of Waste

Various methods of disposal of waster which have been practiced in developed countries and in developing town are detailed below:

1. Land fill

Scientific method of disposing solid wastes on land by spreading them in layers, compacting them to the smallest practical volume and covering them with soil at the end of each working day in a manner that protects the environment.

Land fill methods are

a. Pit method

b. Area method

c. Ramp method

a. Pit method

It is done by excavating a trench and placing garbage in layers. The excavated earth is then used as cover and heavy compaction machinery is used to consolidate the waste. This method is used in level topography.

b. Area method

Area method is used on uneven land where garbage is put on layers above ground level , composed and covered by earth.

c. Ramp method

The ramp method takes the advantage of uneven land profile. Garbage is laid in layers in slopes and covered with earth. The final profile is in the form of a ramp.

2. **Incineration method**

It is a controlled combustion process of burning all combustible waste and to reduce it to a residue containing no combustible material . In cinerated materials are converted into gases ands liquid and released to air. It has an advantage over land fill method and consumes no land.

3. **Volume reduction/compaction method**

This method is applicable to transportation system as well as disposal system.

4. **Pyrolysis**

In pyrolysis process, waste is heated indirectly from external heat source and is charred in the absence of air. This is a very recent modern method utilizing energy recovery process from waste.

5. **Bio gas**

Slaughter houses,food packaging industries and cold storages produces organic gases which can be converted into biogas

6. **Pelletisation**

It is the production of fuel pellets from solid waste. Pellets can be used for heating plant boilers and for generation of electricity.

7. **Composting**

Composting can be defined as the biological decomposition of the organic constituents of wastes under controlled conditions. This process can take place in the presence or absence of oxygen ie. aerobic or anaerobic composting.

8. **Vermiculture**

Vermiculture uses earth worms to decompose the organic wastes , and has been demonstrated in small scale projects.

Additional Information

Smoke test -Testing of soil pipes, vent pipe and rain water pipe,, drain pipes and all other pipes are which above ground should do gas tests. Smoke test shall be conducted by the smoke produced by burning oily waste or tar paper or similar material in the combustion chamber.

Water test –The drain pipes are subjected to test pressure of atleast 1. 5m head of water at the highest point of section under test. The test shall be carried out by suitably plugging the low end of connection if any and then filling these system with water.

Assessment activity

Prepare lay out plan of sanitary systems of different buildings with estimate, lecture note verification, class test, preparation of sketches in the classroom, oral test, evaluating activity log of OJT in this concept, participation in group work.

TE Questions

The sewer which transports the sewage to the point of treatment is called

a) house sewer

b) main sewer

c) out fall sewer

d) none of these

2) The sewerage system originates from

a) out fall sewer

b) main sewer

c) house sewer

d) none of the above

3) When a rainy season extends up to five months like in India, the preferred system would be

a) confined system

b) separate system

c) partially separate system

d) none of the above

4) The sewer pipes have to be designed and checked for

a) Only maximum flow

b) Only minimum flow

c) Both maximum and minimum flow

d) None of the above

5) The minimum and maximum diameter of sewers generally adopted in the designs may be

a) 15 cm & 100 cm

b) 15 cm & 300 cm

c) 25 cm & 450 cm

d) 60 cm & 300 cm

6) Traps are provided in the sanitary water

a) To trap the rats and snakes

b) Preventing the foul gas from sewers

c) To dissolve the foul gas in sewers

7) Anti siphonage pipes are provided

a) With a w.c. trap

b) In the grease trap

c) In the out let of septic tank

d) In the starting point of sewer line

e) In the manhole

8) The liquid waste in kitchen, bathroom & wash basin is known as

a) Sullage

b) Liquid waste

c) Sewage

d) Surface water

e) None of these

9) The tests conducted for checking the drainage pipe is

a) Smoke test

b) Water test

c) Straightness test

d) Pressure test

e) All the above

10) An intercepting trap is provided at the junction

a) A house sewer and a municipal sewer

b) An un foul house drain and foul house drain

c) Any two house drain

d) None of these

11) A gully trap is provided at the junction of

a) A house sewer and a municipal sewer

b) An un foul roof or a kitchen drain

c) Any two house drain

d) None of these

12) A pipe which is installed in house drainage to preserve the water seal of trap is called

a) Vent pipe

b) Waste pipe

c) Anti-siphonage pipe

13) AC pipes are normally joined by using

a) Bell and spigot joint

b) Simple joint

c) Lock joint

d) None of these

14) For joining small sewer pipes of diameter less than 0.6 or so the preferable joint is

a) Ball and socket joint

b) Simple joint

c) Lock joint

15. Differentiate between sewer, sewage and sewerage in sanitary engineering.

16. What are the advantages of water carriage system over conservancy system?

17. Mention the different types of pipes in sanitary system.

18. What are the functions of trap and Antisiphonage pipe.

19. Gully traps are used in ……

20. Floor traps are used in …….

21. Prepare a neat sketch of septic tank for five users.

22. Compare the one pipe system and two pipe system of drainage disposal.

23. Mention the four types of drainage disposal systems in buildings? Prepare the sketches of each?

24. Mention any three characteristics of traps.

25. Give the names of any four types of traps in sanitary system.

Unit 4.5 Sanitary Fixtures

This unit explains the methods of fitting different fixtures like wash basins, sink, shower, water closet, health faucets, bidets, etc, with its accessories in the appropriate location of the building. The unit also deals with the various types of troubles in plumbing with its rectification methods.

Learning Outcomes

The learner;

- Fix wash basin with its accessories at the appropriate location in a building.
- Fix sink with its accessories at the appropriate location in a Building.
- Fix shower with its accessories at the appropriate location in a building.
- Fix bidet with its accessories at the appropriate location in a building.
- Fix flushing cistern with its accessories at the appropriate location in a building.
- Fix health faucet with its accessories at the appropriate location in a building.
- Identify troubles in plumbing system and rectification.

Concepts

Sanitary fixtures

Wash basin

These basins are generally of either pedestal type, or bracket type, They are usually made of pottery, porcelain enameled, cast iron pressed steel or plastic. They are manufactured in different shapes and sizes. They are provided with two hot or cold holes for passing of inlet. There is a provision for outlet waste pipes and over flow They are usually fixed 80cm above the floor level.

Water closet

The three types of water closet are

1. Squatting type
2. European or sitting style
3. Anglo Indian type

The oriental/squatting type requires 10 to 15 liters of water for flushing and cleaning purposes but the European type requires lesser quantity of water. The pan and the trap are available in two different pieces. The pan has an opening for antisiphonage pipe. The water closet is fixed just above the floor level in squatting position.

2. European type

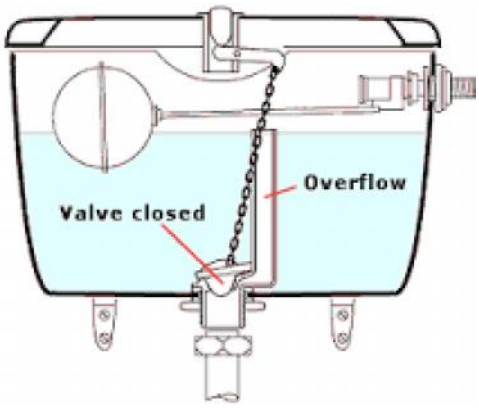
It is a wash down water closet fitted with a pan with seat and cover. The pan has flushing rim to spread the flush water. The excreta directly falls on the trap. he closet is fitted P trap or s trap. It can also be used in upper floor.

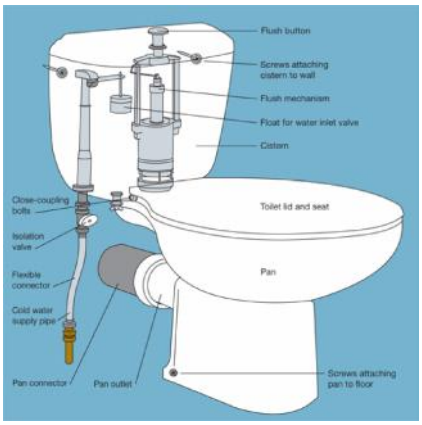
While the Indian type WC the upper floor to be depressed to receive the pan fixed at the floor level.

3. Anglo Indian Type

The main advantage of Indian type water closet is it can be used at the squatting position fixed at the floor level, while the European type water closet cannot conveniently used in squatting position as the legs of the user cannot rest on the rim conveniently. However Indian type water closet excreta does not fall directly on the trap. The Anglo Indian type water closet covers the defects of both. The the closet is fixed about 40cm above the floor level, However the upper rim of the pan is properly enlarged so that the leg can rest on it while using the squatting position. The inner shape of the pan is intermediate between the two pipes with the wider top area of the trap .The excreta directly falls on the trap.

Flushing Cistern





Flushing cisterns are used for flushing water to closets and urinals. These are made of cast iron or porcelain. For Indian type WC, cast iron flushing cistern is commonly used. For the European and Anglo Indian type closets ,porcelain cistern are commonly used fixed at about 600 mm above the floor levels. The low level flushing cisterns are decent in look and can operate very easily by simply turning a handle.

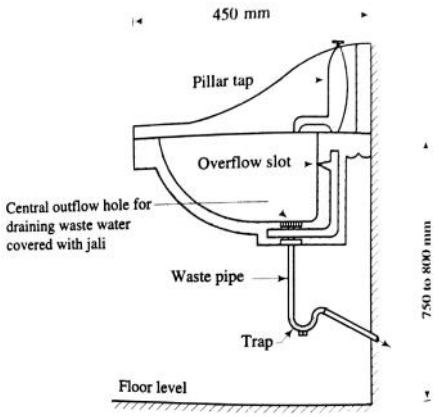
Flushing cisterns are two types: 1. Valve-less Siphonic type and 2. Valve-fitted with siphonic cistern. Bell type flushing cisterns are commonly used in Indian type water closets and are examples of valve-less symphonic type.

Sink

It is a rectangular receptacle used in kitchen or laboratory for draining of water. It is commonly made of glazed earthen ware, steel, enamel, stainless steel etc. It is mounted such that there should be sufficient light through the window. The height from floor to trap is usually 80 to 90 cm. The sink is connected to the water supply pipe line through a stop cock. The waste water is disposed through a waste pipe with a strainer avoid solid waste entering into the pipe cause block in the system. The waste pipe is connected to the public drain through a trap. The trap prevents the entry of foul smell into the system from the public sewer by the water seal,

Wash Basin

It is made of white glazed earthen ware, steel or enamel. Wash basins are fixed on



Wash basin fixed on wall

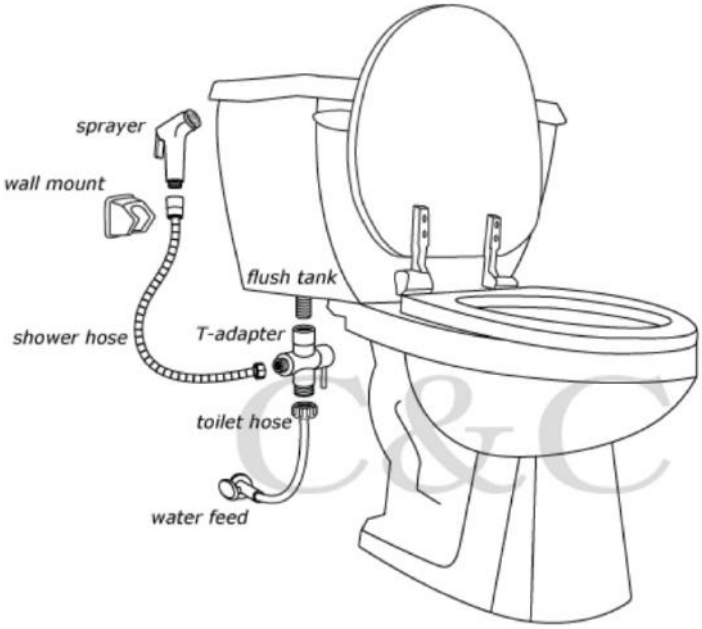
the wall or on the floor. The bowl is fitted with be waste pipe for disposing waste water through a strainer. The waste pipe is connected to the drainage line through a trap to prevent the entry of foul smell in to the system, The potable water can be tflowed inthrough a water tap connected to the main pipe line through a stop cock.

Bidets

The purpose of bidets is to help clean off toilet after use. There are two types of bidets -the stand alone type and the toilet seat bidets.

The stand alone bidets are separate fixtures placed next to the water closet ,while the toilet seat bidets are placed over the toilet seat so that there is no need of getting up to clean. In case of a stand alone type after using toilet one has to stand up move over to the bidet and use it to control temperature and flow of water. In case of toilet seat bidet activate the wash button on the bidets by remote control or on the toilet seat . A nozzle will appear and rinse the areas to be washed. Press the stop button after washing and the nozzle will return back into the toilet seat. The modern bidets are electronically operated so that they can be operated by sitting on the toilet using controls next to the user.

Health Faucet



Repair and Maintenance of the system

The general troubles are stoppage of fixtures and drain pipes These include.

a. Burst or leaking supply pipes
b. Low supply pressure
c. Leaking faucets, flush tanks and valves
d. No water supply
e. Muddy or dirty water
f. Water hammering, whistling or noises
g. Bad odours in the sewer

Stoppage of fixtures and drain pipes can be repaired by filling the fixture with water and surge it with rubber suction and force pump. This pump will dislodge the blockage and force the liquid down the drain. If this does not work, then drain the contents of the fixture through the cleanout plug. Clean the drain pipe through a wire brush. If the blockage is not removed clean out should be opened and drain pipe should be cleaned.

Stoppage of water closet uses the rubber suction and force pump speedily. If this does not work, force the flexible spiral wire into the drainage pipe.

For stoppage of drain pipe within the building . insert the flexible spiral wire through the cleanout and trying push the object and pull out with the help of spiral wire.

Leaking supply pipes - The first step is to identify the source of leak and turn off and do the repair.

Low supply pressure in the service pipe line can be detected with the help of pressure gauge with Tee connection at successive p[oint on the supply pipes. Supply pipes may be cleaned by either pushing or pulling through the pipe a scrapper which passes through the pipe,

TE Questions

1. Explain with diagram the working of flushing cistern.
2. Draw a typical house drainage plan of a residential building.
3. Identify any two modern sanitary fitting with their purpose.
4. Draw the flow diagram of an irrigation system for a domestic farm of 10 cents cultivating vegetables.

Extended activities

1. Prepare the survey report of IS standards of well-water samples collected from houses.
2. Prepare water supply scheme for a proposed housing colony with 10 residences. (Assume suitable data).
3. Draw layout plan of a newly constructed two bed-room residence.

List of Practicals

1. Study of tools, Identification and its working (6 Periods)
2. Pipe cutting with hacksaw- Pipe threading with Die set - Study of different types of fittings (L-Bow, Bend, Tee, Coupling, Reducer, Union, Plug) perform the fitting practice with the above mentined pipe fittings in the lab. (22 Periods)
3. Prepare the arrangement shown in given fig with necessary fitting and fixture it to a wall with clamps and screws (2 nos.) (12 Periods)

4.. Fixing of pipe fittings with pipes using Threaded connection, shellac and cotton. teflon tape and solvent cement. (12 Periods)

5. Make a flanged joint connection using GI Flanged pipes of convenient diameter (10 Periods)
6. Practicing water tap connection in a water line (10 Periods)
7. Practicing parallel connections of three water taps in a main water supply line (16 Periods)
8. Making a house water connection from a public water supply line with water meter fitting. (20 Period)
9. Practice a drip irrigation connection for domestic purpose and small scale farming (20 Period)
10. Draw neat sketch of a layout plan of water supply system of one bedroomed residential bulding (2 nos) (20 Period)
11. Draw a neat sketch of layout plan of a rain water harvesting system for a residential building. (20 Period)
12. Practice the wash basin and kitchen sink fitting with necessary piple fittings (20 Period)
13. Practice the Indian type water closet fitting with necessary fittings (20 Period)
14. Practice shower fitting with stop cock (valve) (10 Period)
15. Practice the European type water closet fitting with flushing cistern and health faucet (20 Period)

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3. Quantity Surveying : A. K KAMALA
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5. Estimating and Costing :R. L PEURIFOY
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2. Water Supply and Sanitary Engineering : RANGWALA
3 Water Supply treatment and disposal : MEDCAFF & GRAW
4. Water Supply Engineering : SANTHOSH KUMAR GARG
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1. SP35(S&T)1987: Hand book of Water supply and Drainage withspecial Emphasis on Plumbing by Bureau of Indian Standards.
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6. Solar water heater (C.B.RI) by M. L GUPTA & SRIVASTAVA.
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