chapter 1

important terms:-

Water is one of the important essential requirement for the human existence like other basic factors such as air, food, heat, light etc

The branch of civil engineering which deals with the supply of water for various purposes e.g. domestic, industrial, commercial and public is called Water Supply Engineering. In this engineering a scheme is constituted which is known as water supply scheme.

Wholesome water:- Wholesome water is that water which is not chemically pure, but does not contain any harmful to human health.

A good water supply scheme has to fulfill the following aspects:-

(a) To search source of water supply.

(b) Purification of water.

(c) Distribution of water to required place.

1.2 HYDROLOGICAL CYCLE:-

Hydrology in the science which deals with the occurrence, distribution and movement of water on the earth, including that in the atmosphere and below the surface of the earth. Water occurs in the atmosphere in the form of vapour, on the surface as water, snow or ice and below the surface as ground water occupying all the voids with in a geologic stratum.

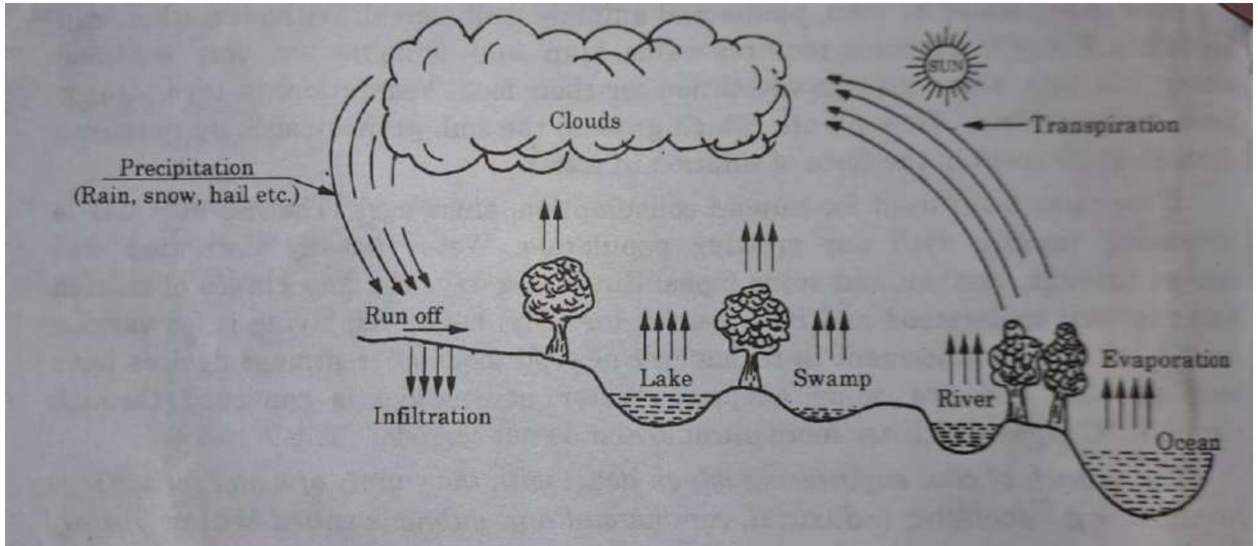


Fig. 1.1 : Hydrological Cycle

Water is lost in the atmosphere as vapour from the earth, which is then precipitated back in the form of rain, snow, hail, dew, sleet or frost etc. This pressure precipitation and evaporation continues forever, and thereby a balance is maintained between the two. This process is known as hydrologic cycle and is shown in fig 1.1. This cycle is also called water cycle.

1.3 IMPORTANCE AND NECESSITY OF WATER SUPPLY SCHEMES:-

For any living being water, air, food, shelter, etc. are the primary needs, in which water has the greatest importance. Everywhere water is required for various purposes, few of them are:

(a) for drinking and cooking.

(b) for bathing and washing.

(e) for watering of lawns and gardens for heating and air-conditioning.

(d) (e) for growing of crops systemsfor street washing.

(g) for fire fighting.

(h) for recreation in swimming pools, fountains.

(i) for steam power and various industrial processes etc.

Without food human can survive for a number of days, but water is such an essential element that without it he cannot. In the ancient times human required water for drinking, bathing, cooking etc, but with the advancement of civilization the utility of water enormously increased, and now such a stage has come that without well-organized public water supply scheme, it is impossible to run the present civil life.

1.4 VARIOUS COMPONENTS OF WATER SUPPLY SCHEME:-

The various components of a water supply scheme is shown in figure 1.2. This consist of various sources of water supply, different types of treatments and distribution of treated water to the consumers.

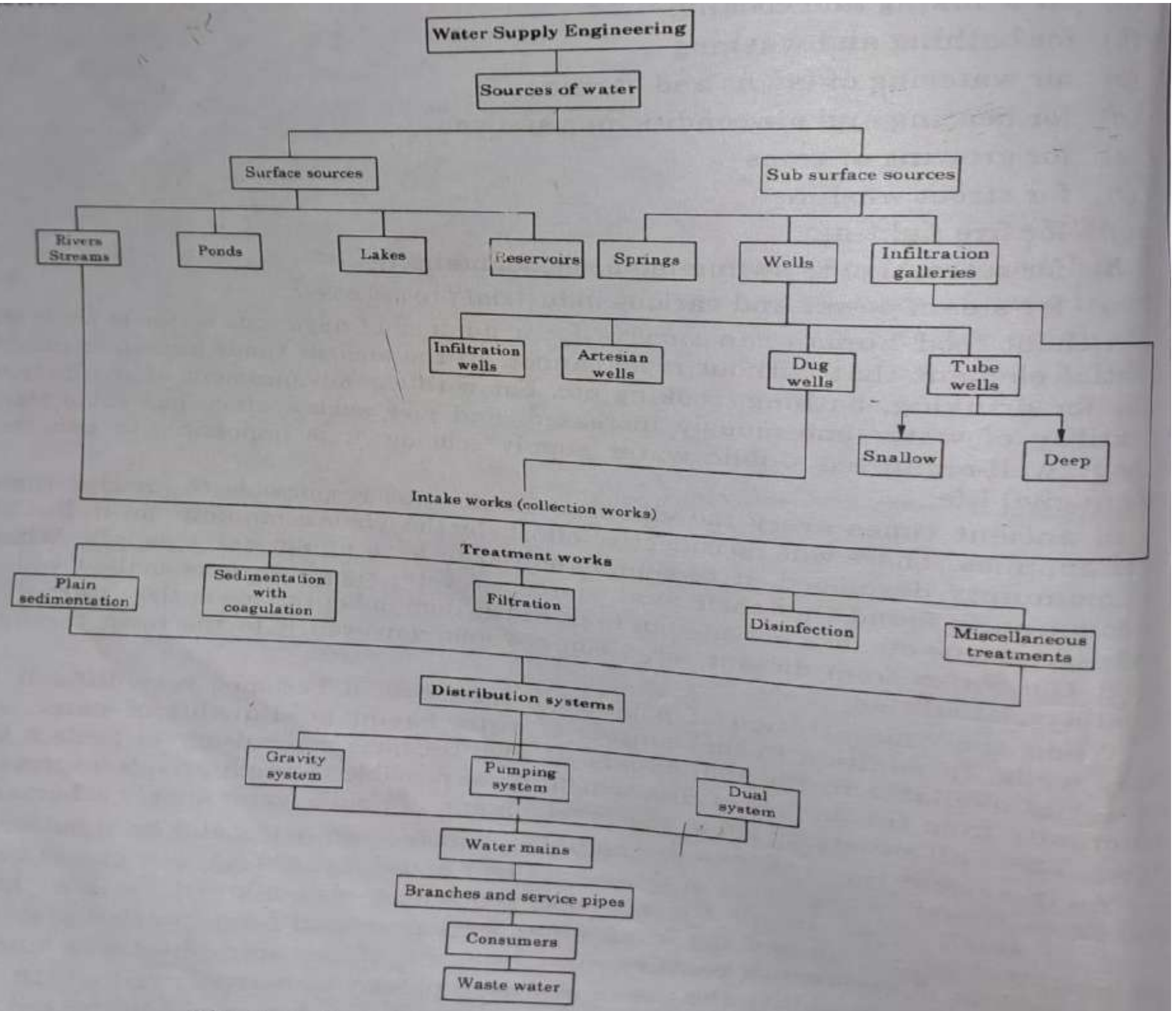


Fig. 1.2 : Flow Diagrams of Water Supply Scheme.

Chapter-2

Quantity of water

MADE BY RAKSHIT

★ QUANTITY OF WATER REQUIRED ★

QUANTITY OF WATER REQUIRED -

It is essential to determine the total quantity of water required for van purposes by the city or town while designing the water supply scheme of particular city or town. This total quantity of water determined, enables determine the size and capacity of all the constituents of the water supply scheme.

- The quantity of water required depends upon the two important factors.

These factors are -

(1) The probable population estimated at the end of the design period.

(2) rate of water consumed per capita per day.

★ VARIOUS TYPES OF DEMANDS ★

- **VARIOUS TYPES OF DEMANDS -** **It is very difficult to assess the quantity of water demanded by the public, since there are many factors affecting water consumption. Certain thumb rules and empirical formulas are, therefore, generally used to assess this quantity, which may give fairly accurate results. The use of a particular method or a formula for a particular case has, therefore, to be decided by the intelligence and foresightedness of the designer. The various types of water demands, may be broken down into the following groups:**

VARIOUS TYPES OF WATER DEMANDS

(1) Domestic water demand

(2) Institution and commercial water demand

(3) Industrial water demand

(4) Fire demand

(5) Public use demand

(6) Water required to compensate losses in waste and thefts.

So let discuss ➡

Domestic Water Demand - This includes the water required in private building for cooking, washing. Bathing, gardening, sanitary purposes etc. The domestic water demand depends upon the living conditions of the consumer. As per IS: 1172-1963 water required for domestic purposes for average Indian conditions per head per day may be taken as 135 litre. Table 2.1 shows the details of water requirement for domestic purposes. The total domestic water consumption may amount to 50 to 60% of the total water consumption.

Different use	Consumption in l/h/d
Drinking	5
Cooking	5
Bathing	55
Washing of clothes	20
Washing of utensils	10
Washing and cleaning of house	10
Flushing of water closets,etc.	30
Total	135

Minimum Domestic Water Consumption (Annual Average) in Small Indian Towns and Cities

Institution and Commercial Water Demand:-

Institution and Commercial Water Demand - Office buildings, stores, hotels, ware houses, shopping centres, health centres, schools, temples, cinema houses, bus and railway stations etc. Are include in commercial centres and commercial buildings. The quantity of water consumed in these buildings is known as commercial demand of water.

The water requirements of commercial and public places may be up to 50 litres / capita / day. The water supply requirements for various public building other than residential are given in Table 2.2 .

Establishments

S.No.	Various Types of Commercial Establishments	Average water consumption in litres/head/day
1.	Offices	60 – 100
2.	Factories	
	(*a*) where bath rooms are provided	45 – 90
	(*b*) where no bath rooms are provided	30 – 60
3.	Schools	
	(*a*) day scholars	85 – 90
	(*b*) residential	135 – 225
4.	Hostels	135 – 180
5.	Hotels	180 (per bed)
6.	Restaurants	70 (per seat)
7.	Hospitals (including laundry)	
	(*a*) number of beds not exceeding 100	350 (per bed)
	(*b*) number of beds exceeding 100	450 (per bed)
8.	Railway Stations	
	(*a*) junctions and intermediate stations where mail and express trains stop	70 (with bathing facilities) 45 (without bathing facilities)
	(*b*) intermediate stations where mail and express trains do not stop	45 (with bathing facilities) 23 (without bathing facilities)
	(*c*) terminal railway stations	45
9.	Airports – International and domestic	70
10.	Cinema Halls and Theatres (per seat)	20

Industrial Water Demand :-

Industrial Water Demand - This consumption includes water used in factories. This demand depends upon the nature of the city, number of industries and types of industries. On an average, 20 to 25% of the total water demand may be allowed for this type of demand in the design. The approximate quantity of water required for some of the manufacturing Unit are shown in table.

Table 2.3 : Water Demand for Factories

S. No.	Factory Products	Litres/kg. of Products
1.	Coal mining	14
2.	Sugar Industry	11
3.	Oil refining	12
4.	Butter	13
5.	Cheese	20
6.	Steel Industry	5
7.	Glass	75
8.	Paper Industry	160
9.	Synthetic fibres	230
10.	Ice factory	185

Fire Demand :-

It is the quantity of water required for fighting a fire outbreak. For high value cities , water requirement for this purpose is particularly essential.

For Indian conditions a moderate allowance of one litre per head per day for fire demand may be quite sufficient.

Public Use Demand :-

Public Use Demand - This demand of water includes quantity of water required for public utility purposes such as washing and sprinkling on roads, cleaning of sewers, flushing of streets, water for public parks, gardens etc. A provision of about 10% of the total consumption is made while designing the water works for a city, to meet the water demand public use.

The public-use demand of water for public purposes shall be taken as given in table 1 and the water requirements for Live Stock is given in table 2 below. Consumption of water for irrigation purposes in cities is given in Table 3.

TABLE 1

Table 2.4 : Water Requirements for Public Use

S. No.	Purpose	Water requirements
1.	Public Parks	1.4 litres/m^2/day
2.	Street washing	1.0 – 1.5 litres/m^2/day
3	Sewer cleaning	4.5 litres/head/day

TABLE 2

Table 2.5 : Water Requirements for Live Stock

S. No.	Live Stock	Water requirements in litre/animal/day
1.	Cows	68.25
2.	Dogs	18.20
3	Chickens	0.09
4.	Goats	13.60
5.	Horses	45.50
6.	Sheep	13.60

TABLE 3

Table 2.6 : Water Requirements for Irrigation Purposes in Towns/Cities

S.No.	Purpose	Water requirements
1.	Public Parks	16850 litres/hectare/day
2.	Private gardens	16850 litres/hectare/day
3	Roadside trees	28150 litres/km/day

Water Required to Compensate Losses in Waste and Thefts

The following are the reasons under this head:

(a) Stolen water due to unauthorised water connections.

(b) Bad plumbing that results leakage from joints and fittings.

(c) Damaged meters etc.

(d) Leaving public water taps open.

Per Capita Demand

It may be defined as total yearly consumption of water for water for a water for a water a water supply scheme divided by population of that area and the number of days in a year .

Per Capita Demand = Total consumption of water in litres

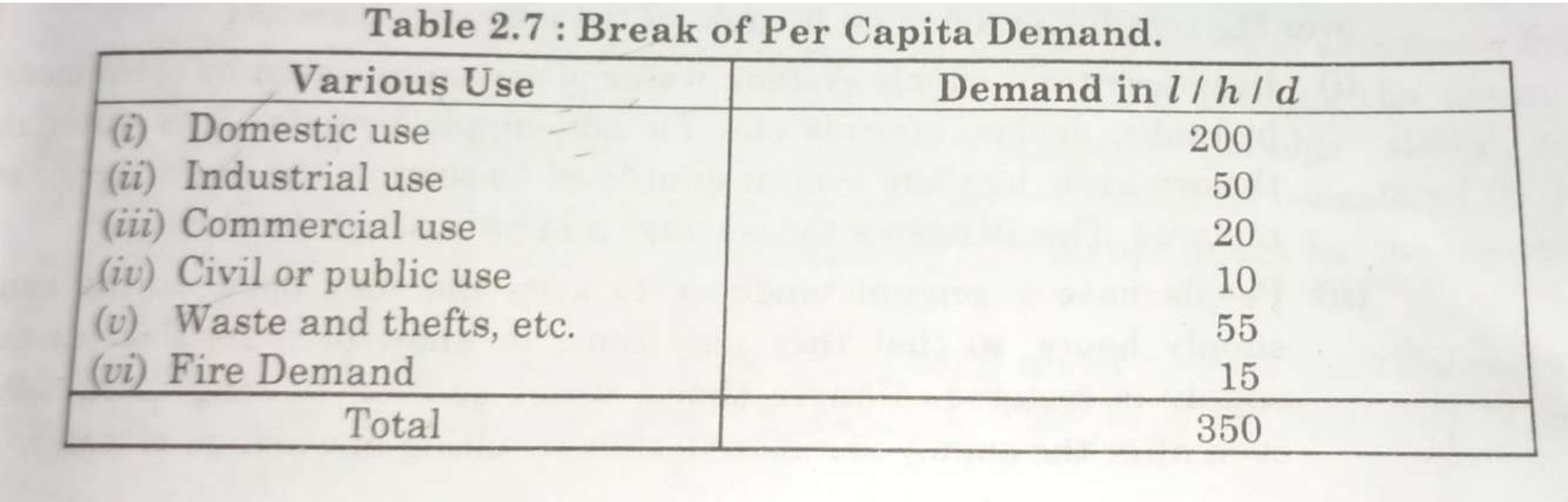


Table 2.7 : Break of Per Capita Demand.

Various Use	Demand in $l / h / d$
(i) Domestic use	200
(ii) Industrial use	50
(iii) Commercial use	20
(iv) Civil or public use	10
(v) Waste and thefts, etc.	55
(vi) Fire Demand	15
Total	350

Population × 365

Factors Affecting Per Capita Demand ★

- The per capita demand may ranges between 100 to 400litres/capita/day for Indian conditions. So while designing the water supply scheme, the factors which affect the per capita demand should be considered. Factors are as follows:-

- A) Climate Condition
- B) Types of Consumer
- C) Quality of Water
- D) System of supply
- E)Policy of charging
- F) Availability of sewerage facilities
- G)Pressure in the distribution system

- H) Industries and commercial places
- I) Cost of water

a) Climatic Condition :-

In hot condition the consumption of water is generally more because everybody takes bath twice or thrice and washes clothes .More water is used for drinking and also more water is consumed in running coolers etc. Hence , water consumption is much more in summer than that in winter.

b) Types of Consumer :-

Per capita consumption ore demand of water is also affected by the class or category of the consumer and their standard of living. Greater quantity of water is consumed by the people having higher economic status and higher standard and highly standards of living in comparison of middle class and lower class communities.

C) Quality of water :-

- If the quality of supplied water is good then the consumption of water is more and if quality of water is poor then the consumption of water will be lesser.

d) System of supply :-

Consumption of water will be lesser in intermittent water supply system and more in continuous water supply system.

e)Sewerage facilities :-

- If there is sewerage facility then consumption of water increases. Because in sewerage system more water is required to dispose off waste in comparison of old conservation system.

- f) Policy of charging :-
- If the water meters are used for calculation of water consumption and charged according to consumption then the consumption of water decreases. On the other hand if the charges are fixed type then the consumption of water increases.

g)Industrial and commercial places:-

- **If industrial and commercial are in large quantity in an area then more water is required. For that area which results on increases in per capita demand. Some industries need huge quantity of water.**

h)Pressure in the distribution system:-

If the pressure is high in the distribution system then in that case water will be available at great height and also the losses due to leakage are considerably increases.

Design Period :-

The future period or the number of years for which the water works are designed, is known as design period .

Variation in the rate of demand :-

Therefore, variation of demand can be mainly classified into following categories:-

1) Seasonal variation
2) Weekly variation
3) Daily variation
4) Hour variation

- 1)Seasonal **variation** :- seasonal variation occur due to the large use of water in summer season, lesser use in winter , and much less in rainy season .
- **2)Weekly variation :-** If the weekly consumption is recorded then it will be noted that even in one season , there are variations in the consumption of water for every week.
- **3)Daily variation :-** These variations depend on the general habits of people ,climatic conditions and character of the city as industrial , commercial or residential

- **POPULATION FORECASTING :-**

After selecting the design period and per capita, the next step is to determine the population for the prescribed design period. The present population and past population may be obtained from the records . The population goes on increasing year by births, decreased by deaths , increased or decreased by migration and increased or decreased due to any other reason . The population is affected by all the four above factors . The future prediction of population depends upon these .

- **Methods of population forecasting :-**
- **1)Arithmetical increase method.**
- **2)Geometrical increase method.**
- **3)Incremental increase method.**
- **4)Decrease rate of growth method.**
- **5)Graphical extension method.**

1)Arithmetical increase method :-

This is the most simple type of method of population forecast. This method is based upon the assumption that the population is increasing at constant rate. The rate of change of population with time is constant.

i.e. $dp/dt = C$ (a constant)

Formula :- $P_n = P_0 + n.\bar{x}$

Example=

Example 2.1: *The following data have been obtained from the census department :*

Year	1960	1970	1980	1990
Population	12,000	17,000	22,500	28,500

Calculate the probable population in the year 2000, 2010 and 2020.

Solution. The increase in population after every decade is 5000, 5500 and 6000 respectively.

The average increase $= \frac{1}{3}(5000 + 5500 + 6000) = 5500$

The probable population in various decades will be calculated by

$$P_n = P_0 + n \, . \, \overline{x}$$

For **2000**

Population $= 28500 + 1 \times 5500 =$ **34000 Ans.**

For **2010**

Population $= 28500 + 2 \times 5500 =$ **39500 Ans.**

For **2020**

Population $= 28500 + 3 \times 5500 =$ **45000 Ans.**

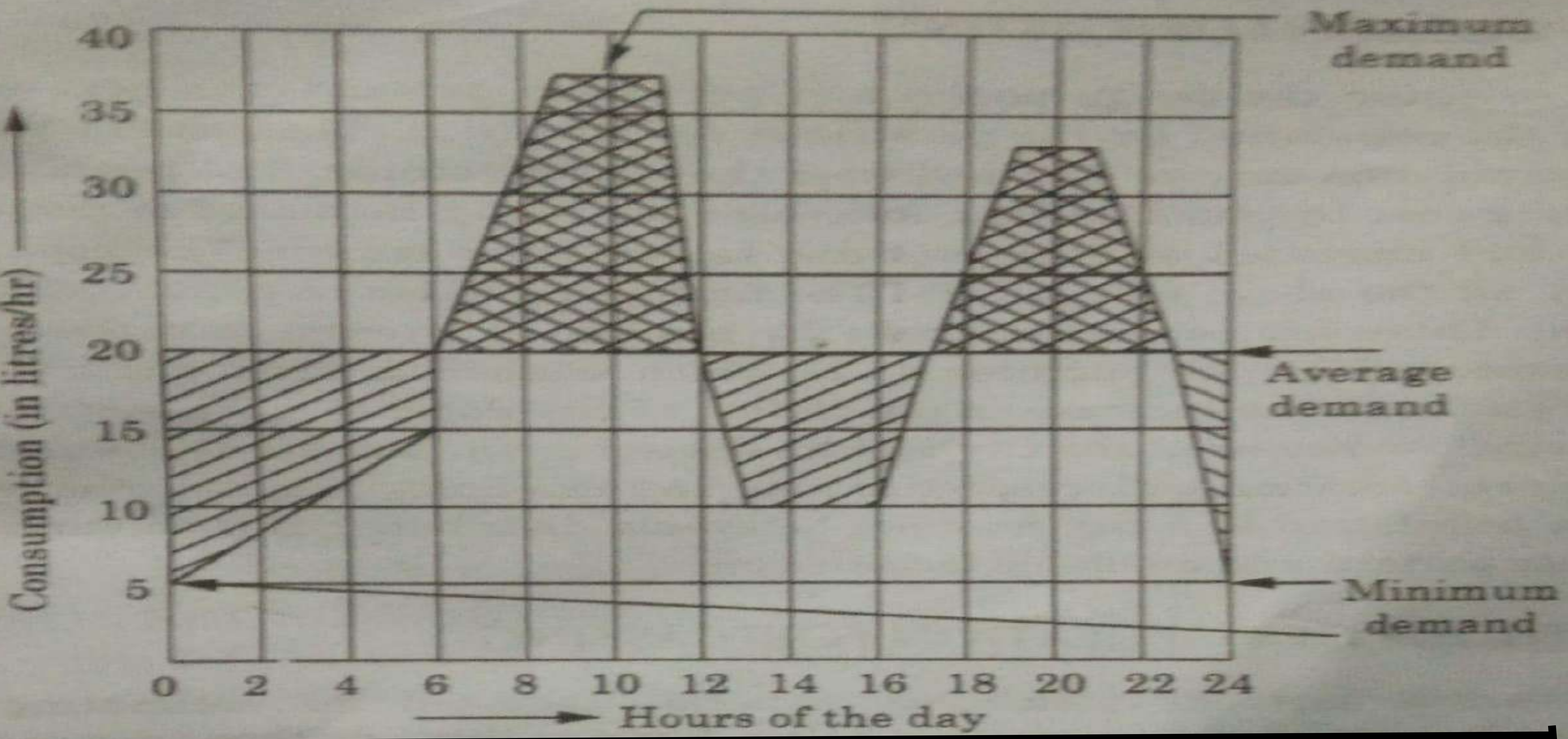


Fig. 2.1 : Variation in Consumption Throughout the Day.

Geometrical Increase Method :-

This method is based on the assumption that the % increase in the population from decade to decade or for a constant interval of time remains constant .

The population at the end of years or decades is given by the formula.

$$\boxed{P_n = P_0 \left(1 + \frac{r}{100}\right)^n}$$

where P_0 = Initial population *i.e.*, the population at the end of last known census.

P_n = Future population after n decades.

r = Assumed growth rate (%).

The growth rates *i.e.*, $\frac{\text{increase in population}}{\text{original population}} \times 100$ values, are computed for each known decade, and their average may be taken as the assumed constant per decade increase (r).

The average may again be either the arithmetic average or the geometric average

(*a*) arithmetic average $= \frac{r_1 + r_2 + r_3 + \cdots r_t}{t}$

(*b*) geometric average $= \sqrt[t]{r_1 \cdot r_2 \cdot r_3 \cdots r_t}$

The design engineers in the field generally consider the arithmetic mean, because it is slightly higher than the geometric mean, and hence gives conservative higher value of forecasted population.

Example of Geometrical increase method

Forecast the population by means of geometrical increases method :-

Solution.

Year	*Population*	*Increase in population*	*Percentage increase in population*
1940	8,000	–	
1950	12,000	4,000	$\frac{4000}{8000}\times 100 = 50.0\%$
1960	17,000	5,000	$\frac{5000}{12000}\times 100 = 41.7\%$
1970	22,500	5,500	$\frac{5500}{17000}\times 100 = 32.4\%$

$$r = \frac{50 + 41.7 + 32.4}{3}$$

$$r = 41.37\ \%$$

Then the population at the end of various decades will be as follows.

Year	*Population*
1980	$22500\left(1+\frac{41.37}{100}\right)^1 = 31808$ **Ans.**
1990	$22500\left(1+\frac{41.37}{100}\right)^2 = 44967$ **Ans.**
2000	$22500\left(1+\frac{41.37}{100}\right)^3 = 63570$ **Ans.**

Incremental Increase Method :-

This method combines both the arithmetic average method and the geometrical average method. From the census data for the past several decades, the actual increase in each decade is first found. Then the increment in increases for each decade is found. From these, an average increment of the increases ;It is called incremental increases method.

Example:-

Calculate the population for the decade 1980,1990 and 2000 by incremental increases method when the following data is given

Year	Population
1930	25000
1940	28000
1950	34000
1960	42000
1970	47000

Solution. For calculating increase in population and incremental formed

Year	Population	Increase in population	Incremental increase; i.e. increment on the increase
1930	25,000		
		3000	
1940	28,000		(6000 – 3000) = (+) 3000
		6000	
1950	34,000		(8000 – 6000) = (+) 2000
		8000	
1960	42,000		(5000 – 8000) = (–) 3000
		5000	
1970	47,000		
	Total	22,000	(+) 2000

$$\bar{x} = \frac{22000}{4} = 5500$$

$$\bar{y} = \frac{2000}{3} = 667$$

Now by using the formula

$$P_n = P_0 + n\bar{x} + n\,.\frac{(n+1)}{2}\,.\,\bar{y}$$

$$P_{1980} = P_{1970} + 1\,.\,\bar{x} + \frac{1(1+1)}{2}\,.\,\bar{y}$$

$$= 47{,}000 + 1 \times 5500 + \frac{1 \times 2}{2} \times 667$$

$= 53{,}167$ Ans.

$$P_{1990} = P_{1970} + 2\,.\,\bar{x} + \frac{2(2+1)}{2}\,.\,\bar{y} = 47{,}000 + 2 \times 5500 + 3 \times 667$$

$= 60{,}001$ Ans.

$$P_{2000} = P_{1970} + 3\bar{x} + \frac{3(3+1)}{2}\,.\,\bar{y} = 47{,}000 + 3 \times 5500 + 6 \times 667$$

$= 67{,}502$ Ans.

Decrease rate of growth method:-

The rate of increase in population goes on reducing , as the cities reach toward saturation , a method which make use of the decrease in the percentage increase, is many a time used, and gives quite rational results. In this method , the average decrease in the percentage increase is worked out, and is then subtracted from the latest percentage increase for each successive decade. This method however , applicable only in cases , where the rate of growth shows a downward trend. This will be more clear from the following example :-

Example 2.7 : *Given the following data, calculate the population at the end of next three decades by decreasing rate method.*

Year	*Population*
1940	*80,000*
1950	*1,20,000*
1960	*1,68,000*
1970	*2,28,580*

Solution. The table is self-explanatory.

Table

Year	*Population*	*Increase in Population*	*% Increase in population*	*decrease in the % increase*
1940	80,000			
		40,000	$\frac{40,000}{80,000}\times 100 = 50\%$	
1950	1,20,000			10%
		48,000	$\frac{48,000}{1,20,000}\times 100 = 40\%$	
1960	1,68,000			4%
		60,580	$\frac{60,580}{1,68,000}\times 100 = 36\%$	
1970	2,28,580			
Total				14%
Average per decade				$\frac{14}{2} = 7\%$

(*i*) The expected population at the end of year 1980

$$= 2,28,580 + \left[\frac{36-7}{100}\right] 2,28,580$$

= **294870 Ans.**

(*ii*) The expected population at the end of year 1990

$$= 2,94,870 + \frac{29-7}{100} \times 2,94,870$$

= **359740 Ans.**

(*iii*) The expected population at the end of year 2000

$$= 359740 + \frac{22-7}{100} \times 359740$$

= **413700 Ans.**

Graphical method:-

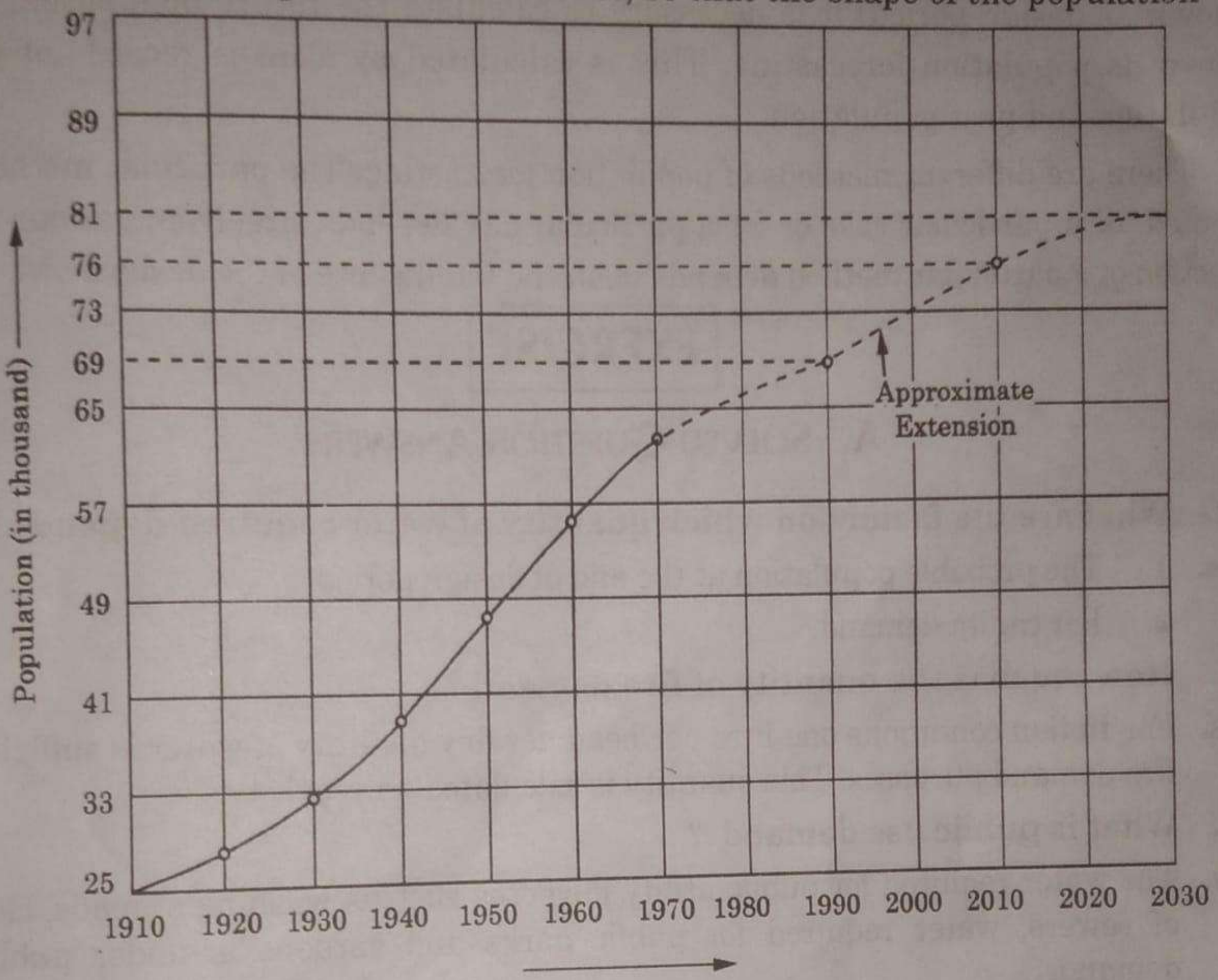


Fig. Graph Between Population and Time

Graphical method:-

In this method, a curve drawn between the population P and time T, with the help of census data of precious decades, so that the shape of the population curve is obtained – up to the present period. From the graph the expected population for 1990 shall be 69000 and for 2000 it shall be 73000. Similarly for 2010 it shall be 76000 and for 2030 it shall be 81000.

However, this method is less time consuming and are used by engineers.

QUANTITY OF WATER REQUIRED:-

It is essential to determine the total quantity of water required for various purposes by the city or town while designing the water supply scheme of a particular city or town. This total quantity of water determined, enables us to determine the size and capacity of all the constituents of the water supply scheme. The quantity of water required depends upon the two important factors. These factors are:-

(1) The probable population estimated at the end of the design period.

(ii) rate of water consumed per capita per day.

VARIOUS TYPES OF DEMANDS:-

It is very difficult to assess the quantity of water demanded by the public, since there are many factors affecting water consumption.

The various types of water demands, may be broken down into the following groups:-

(1) Domestic water demand.

(2) Institution and commercial water demand .

(3) Industrial water demand.

(4) Fire demand.

(5) Public use demand.

(6) Water required to compensate losses in waste and thefts.

Domestic Water Demand:-

This includes the water required in private building for cooking, washing, bathing, gardening, sanitary purposes etc. The domestic water demand depends upon the living conditions of the consumer

Minimum Domestic Water Consumption (Annual Average) in Small Indian Towns and Cities:-

Different Use	Consumption in l/h/d
Drinking	5
Cooking	5
Bathing	55
Washing of clothes	20
Washing of utensils	10
Washing and cleaning of houses	10
Flushing of water closets, etc.	30
total	135

(l/h/d means litre per head per day)

Institution and Commercial Water Demand:-

Office buildings, stores, hotels, ware houses, shopping centres, health centres, schools, temples, cinema houses, bus and railway stations etc. are include in commercial centres and commercial buildings.

Industrial Water Demand:-

This consumption includes water used in factories. This demand depends upon the nature of the city, number of industries and types of industries.

Fire Demand:-

It is the quantity of water required for fighting a fire outbreak. For high value cities, water requirement for this purpose is particularly essential. The most common are: (a) National Board of Fire Underwriters Formula:

$Q=1020 \sqrt{P} (1-0.01 \sqrt{P})$

Public Use Demand: -

This demand of water includes quantity of water required for public utility purposes such as washing and sprinkling on roads, cleaning of sewers, flushing of streets, water for public parks, gardens etc

Water Required to Compensate Losses in Waste and Thefts:-

The following are the reasons under this head:- (a)
Stolen water due to unauthorised water connections.
(b) Bad plumbing that results leakage from joints and fittings.
(c) Damaged meters etc.
(d) Leaving public water taps open.

PER CAPITA DEMAND:-

It may be defined as total yearly consumption of water for a water supply scheme divided by the population of that area and the number of days in a year i.e. Per Capita demand = Total consumption of water in litres

$$\frac{\text{Total consumption of water in litres}}{\text{Population x 365}}$$

It is expressed as litres per capita per day.

FACTORS AFFECTING PER CAPITA DEMAND:-

The per capita demand may ranges between 100 to 400 litres/capita/day for Indian conditions. So while designing the water supply scheme, the factors which affect the per capita demand should be considered.
Factors are as follows:-

(a) Climatic Condition in hot conditions the consumption of water is generally more because everybody takes bath twice or thrice and washes clothes.

(b) Types of Consumer : Per capita consumption or demand of water is also affected by the class or category of the consumer and their standard of living.

(c) Quality of Water: If the water supplied is safe and of good taste then, it will be consumed more. Because in that case, people will not use other sources of water (such as private wells, hand pumps etc

(d) System of Supply: If the system of water supply is intermittent then lessconsumption of water exists because the water is supplied only for certainfixed hours to the users. there are the following reasons:

(i) In intermittent supply system, water is generally stored by consumers in tanks, drums, utensils etc., for nonsupply periods.

(ii) People have a general tendency to keep the taps open during non- supply hours, so that they may come to know of it as soon as the supply is restored.

(e) Policy of charging: In the town where metering is done loss quantity of water will be used than the city without metering system

(f) Availability of Sewerage Facilities: As pointed out earlier, the water consumption will be more, if the city is provided with 'flush system' and shall be less if the old 'conservation system' of latrines is adopted.

(g) Pressure in the Distribution System: If the pressure in the distribution pipes is high and sufficient to make the water reach at 3rd or even 4th storey, water consumption shall definitely be more.

(h) Industries and Commercial Places: When there are large industries and commercial places in big number, consumption of water will be usually higher.

(i) Cost of Water: Water demand is less if the cost of water is high.

DESIGN PERIOD:-

The future period or the number of years for which the water works are designed, is known as design period. A water supply scheme includes huge and costly structures (such as dams, reservoirs, treatment works, penstock pipes etc.) which cannot be replaced easily.

VARIATION IN RATE OF DEMAND:-

The per capita demand or we can say that average annual demand is very necessary for planning and designing water supply system but may not be sufficient.
Therefore, variation of demand can be mainly classified into following categories:-

(i) Seasonal Variation

(ii) Weekly Variation
(iii) Daily Variation
(iv) Hourly Variation

(i) Seasonal Variation:- Seasonal variations occur due to the large use of water in summer season, lesser use in winter, and much less in rainy season.
(ii) Weekly Variation: If the weekly consumption is recorded then it will be noted that even in one season, there are variations in the consumption of water for every week
(iii) Daily and Hourly Variation: These variations depend on the general habits of people, climatic conditions and character of the city as industrial, commercial or residential.
The night flow (excluding industrial consumption) generally represent the magnitude of losses and wastes, since there is no appreciable domestic consumption during this time.

ASSESSMENT OF NORMAL VARIATIONS:-

Per capita consumption or demand varion not only from year to year and from season to season, but more important from day to day and hour to bour. Thes variations are expressed as percentage of the annual average daily consumption. Some common values are as under:
1. Maximum seasonal consumption:- It is 1.3 times annual average daily rate of demand.
2.Maximum monthly consumption:- It is 1.4 times annual average daily rate of demand.
3. Maximum daily consumption:- It is 18 times annual average daily consumption.
4.Maximum hourly consumption:- It is 1.5 times of annual average daily consumption.
From the above discussion 'Maximum hourly consumption of the maximum day can be computed as (i.e. peak demand)
=1.8 x 1.5 (annual average daily consumption)
=2.7 (annual average daily consumption)
2.8 POPULATION FORECASTING:-
After selecting the design period and per capita demand, the next step is to determine the population for the prescribed design period. The present population and past population may be obtained from the census records.

METHODS OF POPULATION FORECASTING:-

The various methods which are generally adopted for estimating future populations by engineers are described below. Some of these methods are used when the design period is small, and some are used when the design period is large.
Following are some of the important methods of population forecasts or population projections:-
1. Arithmetical increase method
2. Geometrical increase method
3. Incremental increase method
4. Decrease rate of growth method
5. Graphical extension method

Arithmetical Increase Method:-

This is the most simple method of population forecast.
This method is based upon the assumption that the population is increasing at a constant rate. The rate of change of population with time is constant i.e.

$$\frac{dp}{dt} = C \text{ (a constant)}$$

The population date for the last 4 to 5 decades is obtained and the population increase per decade (x) is calculated; the average of which (x) is then used as the design growth rate for computing future population.
Thus,
P_1 Population after 1 decade from present
$= P_0 + 1.x$
or
P_2: Population after 2 decades from present

$= P_1+1.x$ or $P_2=p_0+2x$

Similarly, $P_3= P_2+1.x$ or

$P_3 = P_0 +3x$

where, p_n=Future population at the end of n decades. P_0= Present population

n= Ne of decades between now and future x=Arithmetic mean of population increase in the known decades.

This method is not suitable for old cities or towns which have stabilized and for those large cities, which have reached their saturation point.

This method will be more clear from the following examples.

Example 2.1: The following data have been obtained from the census department:

Year	1960	1970	1980	1990
Population	12,000	17,000	22,500	28,500

Calculate the probable population in the year 2000, 2010 and 2020.

Solution:-

The increase in population after every decade is 5000, 5500 and 6000 respectively.

The average increase= $\frac{1}{3}$ (5000+ 5500+ 6000)= 5500

The probable population in various decades will be calculated by, $P_n+ P_o+n. x$

For 2000

Population 28500+ 1 x 5500 =34000 Ans. For 2010

Population 28500+ 2 x 5500 =39500 Ans.

For 2020

Population 28500+ 3 x 5500= 45000 Ans..

Geometrical Increase Method:-

This method is based on the assumption that the percentage increase in the population from decade to decade or for a constant interval of time remains constant.

The population at the end of years or decades is given by the formula.

$$P_n= P_o \left\{1+\frac{R}{100}\right\}$$

where:- P_o Initial population i.e., the population at the end of last known census.

P_n Future population after n decades.

R = Assumed growth rate (%).

The growth rates i.e $\frac{\text{increase in population}}{\text{original population}}$ x100 values, are computed for each known decade, and their average my be taken as the assumed constant per decade increase (r).

The average may again be either the arithmetic average or the geometric average

(a) arithmetic average $=r_1+r_2+r_3+.....r_t$

(b) geometric average $=t \sqrt{r_1+r_2+r_3+.....r_t}$

Incremental Increase Method:-

This method combines both the arithmetic average method and the geometrical average method. From the census data for the past several decades, the actual increase in each decade is first found. Then the increment in increase for each decade is found. From these, an average increment of the increases (known as incremental increases)

$$\boxed{P_n = P_o + n\bar{x} + \frac{n(n+1)}{2}\cdot\bar{y}}$$

where,

P_n= Population after n decades from present (ie., last known census) =

$\bar{x}$ = Average increase of populations of known decades.

$\bar{y}$=Average of incremental increases of the known decades.

Decrease Rate of Growth Method:-

The rate of increase in population goes on reducing, as the cities reach toward saturation, a method which makes use of the decrease in the percentage increase, is many a times used, and gives quite rational results. In this method, the average decrease in the percentage increase is worked out, and is then subtracted from the latest percentage increase for each successive decade. This method is however, applicable only in cases, where the rate of growth shows a downward trend.

Graphical Method:-

In this method, a curve is drawn between the population P and time T, with the help of census data of precious few decades, so that the shape of the population curve is obtained up to the present period.

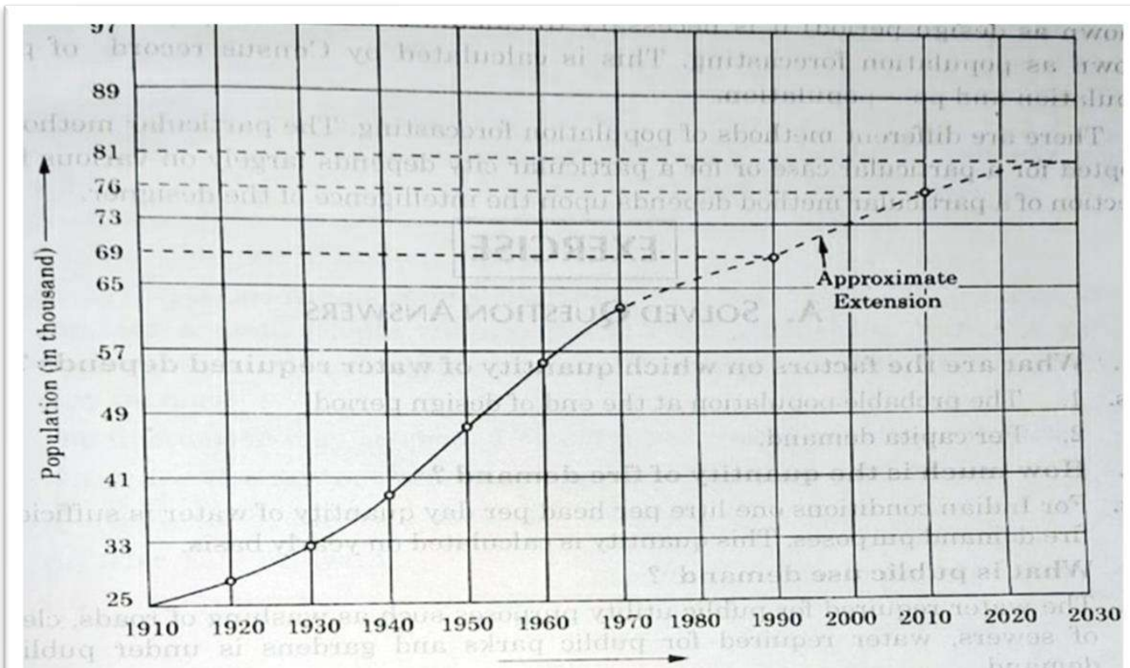


Fig. Graph Between Population and Time

The curve is then carefully extended from the present to the future decades. From the extended part of the curve, th population at the end of any future decade is approximately determined. This will be more clear from the graph drawn.

From the graph the expected population for 1990 shall be 69000 and for 2000 it shall be 73000. Similarly for 2010 it shall be 76000 and for 2030 it shall be 81000.

Chapter – 3
Quality of water

Introduction

Water which we get is not absolutely pure as it may contain clay, sand and silt or other inorganic matter. The involvement of such matters in water is called impurities in water. These impurities should not be included in the natural resources. Water should be free from harmful impurities.

Types of impurities

Impurities are divided into three types.

1. Suspended impurities
2. Colloidal impurities
3. Dissolved impurities

1.Suspended impurities

The large solid particles dispersed in water as impurities are known to be suspended impurities.

(I) Existence : Theseimpurities exist only in finelly divided conditions. These are microscopic.

(II) Effects : These have following effects :

(a) These cause turbidity in the water.

(b) These also cause unpleasant colour of water(**III**) **Inclusilt :** These impurities include:

(a) Bacteria (b) silt, clay, mineral matter

(c) organic matter (d) Algae

(e) protozoa (f) Fungi

2. Colloidal impurities

The finely divided solid particles parsent in water which are invisible to naked eyes are known as colloidal impurities.

(I)**Existenc** : These impurities remain moving due to the effect of electrically charged, absorbed joins by surface of solid particles.

(II) **Effects** :

(a) These have a great effect on the colour of water.

(b) These can give bad taste to water.

(III) **Include**:

(a) Acidic materials

(b) Basic materials

(c) Bacterias causing epidemic.

3. Dissolved impurities

The impurities originated by dissolving of organic compounds, inorganic salts and gases in the water when it flows over soil Or rock are called as dissolved impurities . (I) **Existence** : These exist in large quantity.

(II) **Effects**:

(a) They cause corrosion of boilers

(b) In metal form, they effect the taste and give red colour.(c) In case of gas , they effect taste and odour of water.

(III) **Include** :

(a) Salt (b) Metals

(c) Gases

(d) Vegetable and animal matters

* Necessity of water analysis

The process of determining the quality of water is called as analysatIion or analysis of water. This is necessary for the following reasons:

1. **Controllin Operation** : To control the various operation involved in purification plant.
2. **Purity determination** : The degree of purity of water can be find out.
3. **Amount of impurities** : These are helpful for determining the amount of impurities in water.

4. **Types of Impurities determination :** This is also done to find out the type of impurities :
5. **Quality determination** : This is very helpful in quality determination of water.

* Classification of water

(A) **Wholesome water** : wholesome water is that water which is not chemically pure, the not contain anything harmful to human health.

(B) **Palatable water :** The water which is tasteful for drinking and aesthetically pure, is known as plastable water.

(C) **Portable water :** The water which has both the characteristics i.e., of “Wholesome water” and “Plastable water” is known as potable water.

(D) **Polluted water :** The water which consists of undesirable substance which make it unifit for drinking and domestic use is known as polluted water.

(E)**Contaminated water :** The water containing pathogenic organisms is called as Contaminated water.

* Requirements of water for domestic use

(I) It should not lead to scale formation.

(II) It should be good in taste and also free from odour.

(III) It should be colourless.

(IV) It should be free from harmful salts.

(V) It should be free from bacterias or other disease producing organisms.

* Examination of water

(a) The outlines of the purification processes which are to be carried out are done on the basis of these tests.

(b) The operation of the daily treatment plants is done its basis.

(c) In ascertaining the quality of the raw water and the quantity of various impurities present in it.

(d) To check wether the treated is of the required standard.

* Sampling tech

Definition : The process of properly collecting the water undergoing various treatment tests is called as sampling of water. This is of great importance.

Method : Following steps are to be done during sampling.

Step (i) Sample bottle is sterilized either chemically or by heating. Chemically sterilization is done by treating it with sulphuric acid or nitric acid.

step (ii) Then at sample site, the bottle is firstly half filled with sample water and then it is emptied after proper shaking.

Step (iii) After that it is completely filled and a stopper is placed in position.

Step (iv) At last, a tag is put on the prepared sample bottles The following things should be written on tag :

(a) Date of sampling (d) place of sampling

(b) Number of sample (e) Time of sampling

(c) Source of water

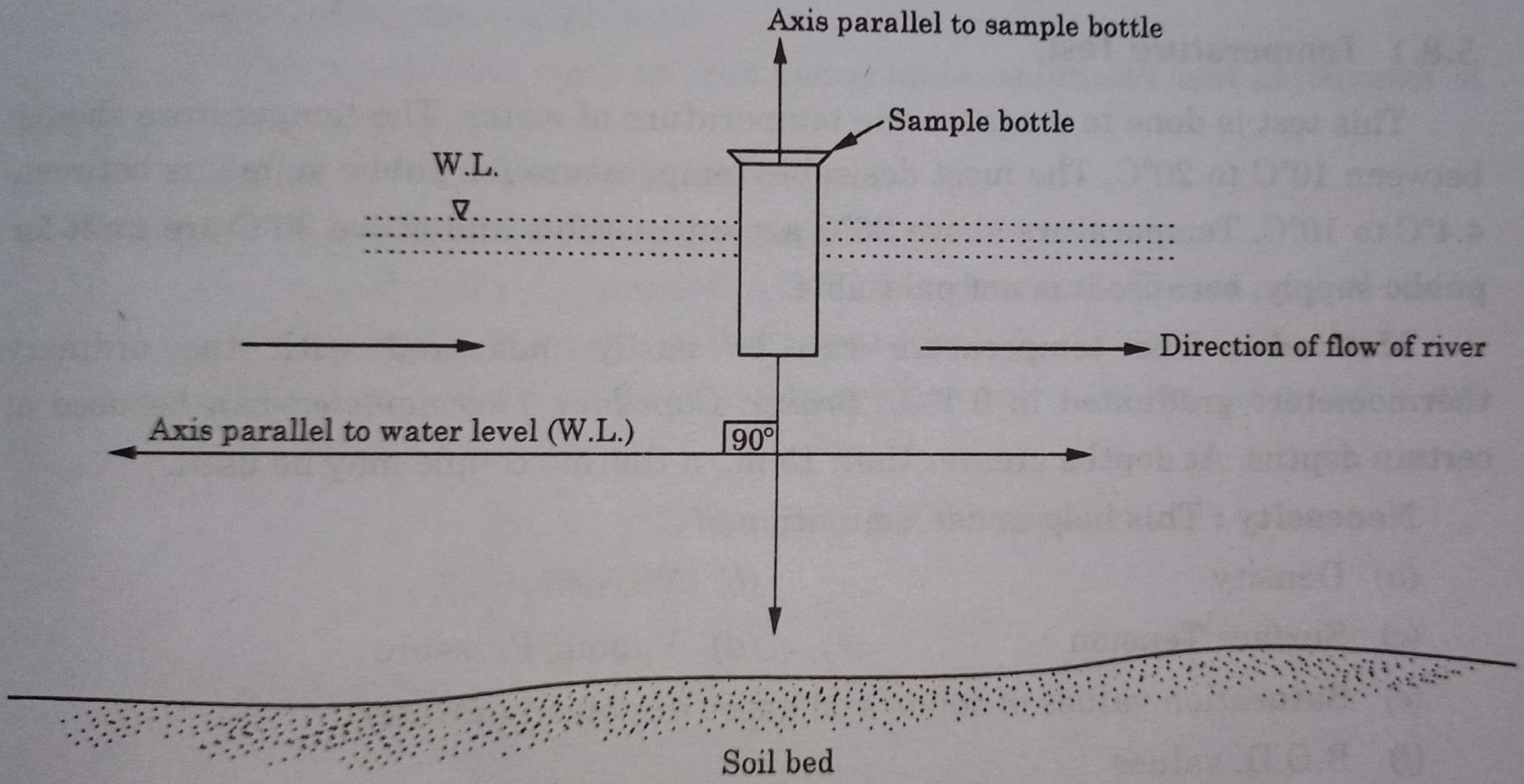


Fig.5.1 : Showing Technique of Sampling

- Precautions: following presentations should be taken :

- 1. **Sterilization of bottles** : The sterilization of bottles should be done before their use.
- 2. **Mouth of bottles** : While sampling, mouth of bottle should be in upwards direction as in figure 5.1.
- 3. **Base of bottle** : The base of bottle should not touch the bed of stream or river.
- 4. **Required quantity** : The required quantity in a sterilized sample bottle should be at least 100 c.c.

* Physical tests

Definition : The tests carried out for physical examination of water are called as physical tests.

Following physical tests are conducted:

(i) Temperature Test
(ii) Colour Test
(iii) Taste and odour test
(iv) Turbidity test
(v) Specific conductivity of water

i. Temperature test

This test is done to measure the temperature of water. The temperature shoula between 10°C to 20°C. The most desirable temperature for public supply is between 4.4°C to 10°C. Temperature above 26°C are undesirable and above 35°C are unfit for public supply, because it is not palatable.

Method : The temperature can be easily measured with the ordinry thermometers graduated in 0.1°C. 'Broken Capillary Thermometer' can be usedat certain depths. At depths greater than 15 m., a thermo couple may be used.

Necessity : This help in determination of :

(a) Density (b) Viscosity

(c) Surface Tension (d) Vapour PrPressure

(e) Saturation values of solids and gases dissolved in water.

(f) O B.O.D. Values

ii. Colour test

This test is very important as it may effect industrial processes and usage of potable water. Aesthetically it is undesirable.

Causes : Its main causes are : leaves, logs, peats and other organic matter either in true solution or in colloidal suspension.

Method : Following steps are taken :

(a) Firstly, the suspended matter present in water should be removed by centrifugal force.

(b) Then colour obtained is compared with standard colour solution or colour discs.

(c) Then, colour is expressed in numbers of a platinum cobalt scale. The colour produced by one milligram of platinum in a litre of distilled water has been fixed as the unit of colour.

Forpublic water supply, the number on cobalt scale should not exceed 20, and preferably should be less than 10. The colour in water is not harmful but it 1s objectionable.

v. Specific conductivity of water

The total amount of dissolved salts present in water can be easily estimated by measuring the specific conductivity of water. The specific conductivity of water is determined by means of a portable dionic water tester and is expressed in microm hoes per cm at 25°C.

The specific conductivity of water in micro mhones per cm at 25°C is multiplied by a coefficient (generally 0.65) so as to directly obtain the dissolved salt content in mg/litre or ppm. The exact value of this coefficient depends upon the type of salt present in water.

* Chemical tests

Sanitary quality of water is revealed by chemical examination of water. Following chemical tests are performed to examine sanitary quality :

(i) Hardness Test (ii) Total Solid Test

(ii) Chlorides Test (iv) Chlorine Test

(v) Lead Test (vi) Arsenic Test

(vii) Ph Value Test (viii) Fluorine Test

(ix) Iron and Manganese Test (x) Copper Test

(xi) Dissolved Gases Test (xii) Calcium and Sodium Test

* Membratechnique technique (MFT)

This is very simple and advanced method steps are as:

(i) Filter the sample of water through a sterilized membrane of special design, due to which all the bacteria are retained in membrane.

(ii) Now, put the membrane in contact of culture medium, named as M-Endos’ medium in incubater at 37°C for 24 hours.

(iii) After 24 hrs., membrane is taken out from incubator and colonies of bacteria are counted by microscope.

* Standards of water quality

Following are the standards of water to be used for domestic purpose.

Physical

1.	Temperature	10°C to 15°C
2.	Odour	0 to 4
3.	Colour	10 to 20 (platinum cobalt scale)
4.	Turbidity	5 yo 10 p.p.m (silica scale)
5.	Taste	No objectionable taste

Chemical :

Sr. No.	B.I.S STANDARDS	Expected Values	
1.	Total solids	upto 500	p.p.m.
2.	Hardness	upto 75	p.p.m.
3.	Chlorides	upto 248	p.p.m.
4.	Lead	0.045 to 0.10	p.p.m.
5.	Copper	1.1 to 3.1	p.p.m.
6.	P_H Value	6.5 to 8.5	
7.	Barium	1.0	p.p.m.
8.	Chlorine	0.1 to 0.2	p.p.m.
9.	Iron and Manganese	0.25 to 0.55	p.p.m.
10.	Zinc	16	p.p.m.
11.	Magnesium	124	p.p.m.
12.	Sulphate	249.6	p.p.m.
13.	Chromium upto	0.04	p.p.m.
14.	Arsenic	0.05	p.p.m.
15.	Cyanide	0.3	p.p.m.
16.	Fluorine	1.52	p.p.m.
17.	Cadmium	0.01	p.p.m.
18.	Dissolved Oxygen	5.3 to 6.2	p.p.m.
19.	B.O.D.	NIL	

Biological :

1.	B-Coli	No B-colie in 100 ml
2.	Most Probable Number	One in 100 ml

* Water quality standards for industrial supplies

The quality of water required for industries, depends upon the requirements of a particular industry. But in general, about 80% industrial waters are used for cooling and need not be of high quality. The dissolved solids in cooling water may, therefore, range from only few mg/l to 3500 mg/l or so. It need not, also be free from pollutants either organic or inorganic. It is however, essential to remove the growth of bacteria and other mciro organism. So as to reduce the fouling of the cooling equipment. Such water may also sometimes be treated an pH kept not less than 7, so as to prevent or reduce the corrosion.

Chapter-4

Intakes And Conveyance Of Water

Definition : The intake is the first structure from source end to permit the withdrawl of wate from the source and discharges into a conduit through which it will flow into the water work system.

TYPES OF INTAKES : Depending upon source of water, intakes are of following types.

1. **.**Lake intakes .

2. Canal intakes .

3. 3.River intakes .

4. 4. Reservoir intakesLet us study these one by one.

- **Lake Intake -** These are also termed as simple submerged intake or submersible intake .
- **Constructional Features –**
- (i) This intake is constructed under water in the bed of the lake.
- (ii) The top level is fixed below the lowest water level in the lake to draw wat during dry season.

- (3) It consists of a simple concrete block or a rock filled timber crib supporting the starting end of the withdrawal pipe laid in the bed of lake.
- (4) One end of pipe is connected to sump well where as the other end is fittedwith bell mouth opening which is covered at the top with a mesh.
- (5) In case of lakes, where silt tends to slit down, the intake opening isgenerally kept at about 2 to 2.5 m above the bottom of lake.

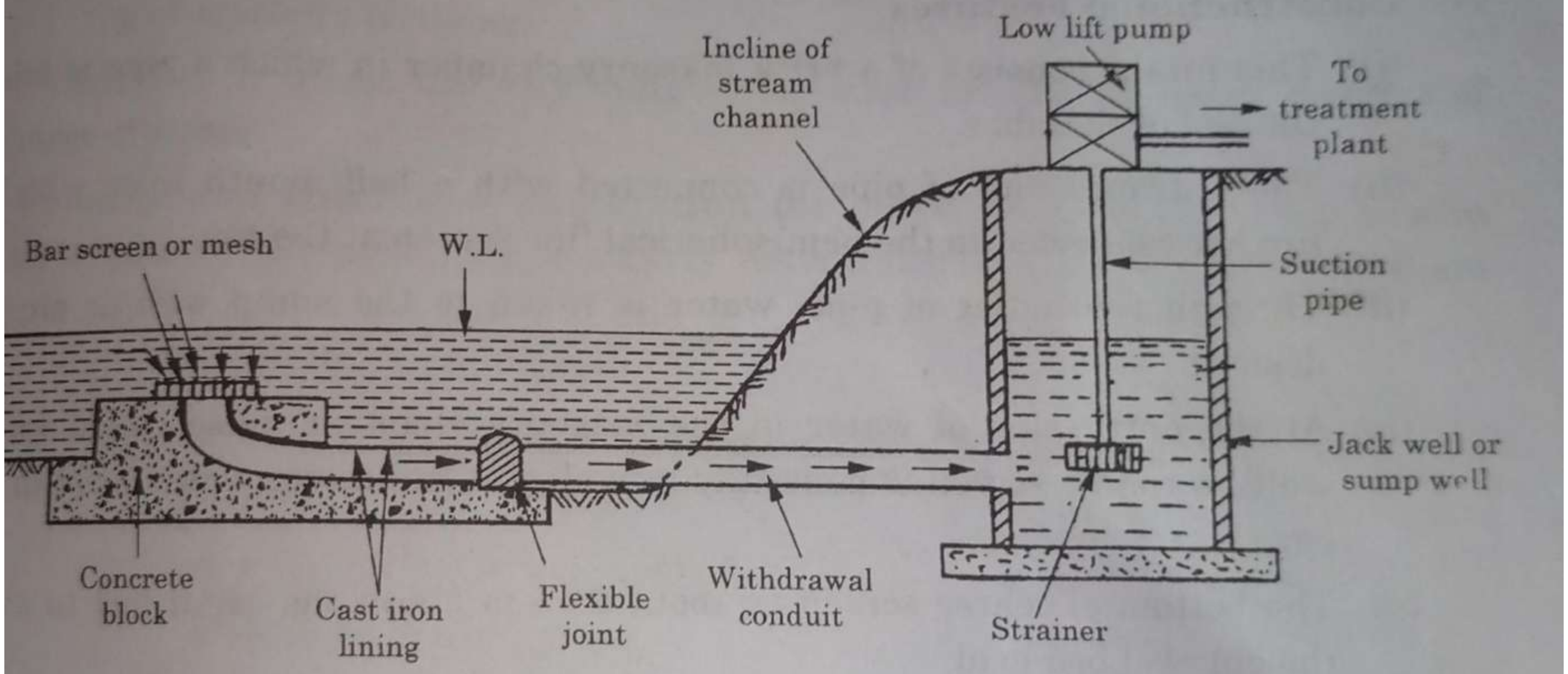


Fig. 4.1 : Simple Concrete Block-Submerged Intake

- **Working** : (i) Water from lake enters in the pipe through the opening covered with bar screen or mesh. This bar screen or mesh prevent the entry of debris, ice etc.into the withdrawal conduit.
- (ii) This water flows under gravity and joins the sump well.
- (iii) From sump well, water is pumped to the treatment plants for purification .
- (v) At last, purified water is discharged into the water works system.
- **Importance features – (**1) These intakes are cheap and simple in design.

- (ii) They do not obstruct navigation.
- (iii) These are widely used for small water supply projects to draw water from streams or lakes having little change in water surface elevation throughout the year.
- **Drawback or Unsuitability**: These intakes are not used on bigger projecte se rivers and reservoirs, as these are not easily accessible for cleaning and repairing .
- **Canal Intake -** The simple structure, generally in the form of masonry chamber, constructedpartially in canal bank is termed as canal intake.

- **Constructional Features**:
- (1) This intake consists of a brick masonry chamber in which a pipe is laid atthe bed of chamber.
- (ii) The entrance end of pipe is connected with a bell mouth inlet which is further connected to the hemispherical fine screen at the top.
- (3) Through the outlet of pipe, water is taken to the sump well or city, asdesired.
- (4) At the entry side of water in the masonry chamber. (also called intake well), a coarse screen is generally provided at minimum water level in the canal.
- (5) The bottom of coarse screen is about 0.15 m above the canal bed to avoidthe entry of bed load.

- (vi) Aren of coarse screen minimum provided 0.15 m/sec or so, as designed by limiting the flow velocity.

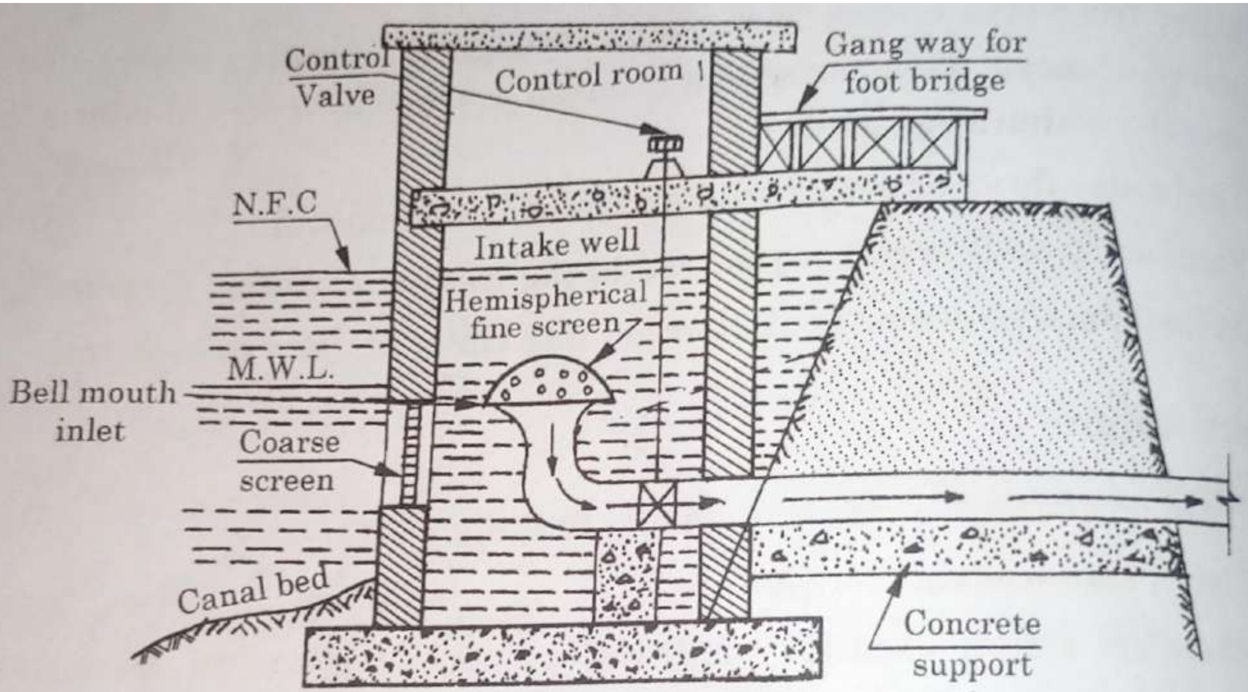


Fig. 4.2 : Canal Intake

- **Working Features –**
- **(1**) Water entry in the intake well takes place through coarse screen.
- (2) Then water enters the pipe through its bell mouth inlet provided with afine screen.
- (3) Now, through the pipe outlet, water gets discharge into sumpwell.
- (4) The flow of water is controlled by a valve provided which is separated fromtop of masonry chamber.
- **Suitability**: These are very suitable for large projects for large amountdischarge of water.

- **Velocity and Head Loss calculation for canal intake**. The head loss in intake conduit upto treatment works is determined by using Haezen William formula

$$V = 0.85\ C_H\ R^{0.63}\ S^{0.54}$$

where V = Flow velocity through the pipe in m/sec

C_H = Coeff. of hydraulic capacity

R = Hydraulic mean depth of pipe

S = Slope of energy line

and $$S = \frac{H_L}{L} = \frac{\text{Head loss}}{\text{Length of pipe}}$$

and thus, $H_L = S \times L$

- **River Intake**
- **These** are the masonry towers which are constructed on the bank of river.which are generally circular in cross-section.
- **Constructional features**
- **1**. It is provided on upstream side of the point of sewage disposal of city ortown so that the water entering in this is free from contamination.
- 2. The diameter varies from 4 m to 8 m.
- 3. Sump well function is served by the intake itself at its lower part.
- 4. Intake also serves an engine house for installing pumping equipments andalso as control room at its upward part.

- 5. A number of openings or part are provided with penstocks for letting water inside.
- (6) Coarse screen are also used to remove debris, dirt from water.
- (7) Water supply is regulated from control room.

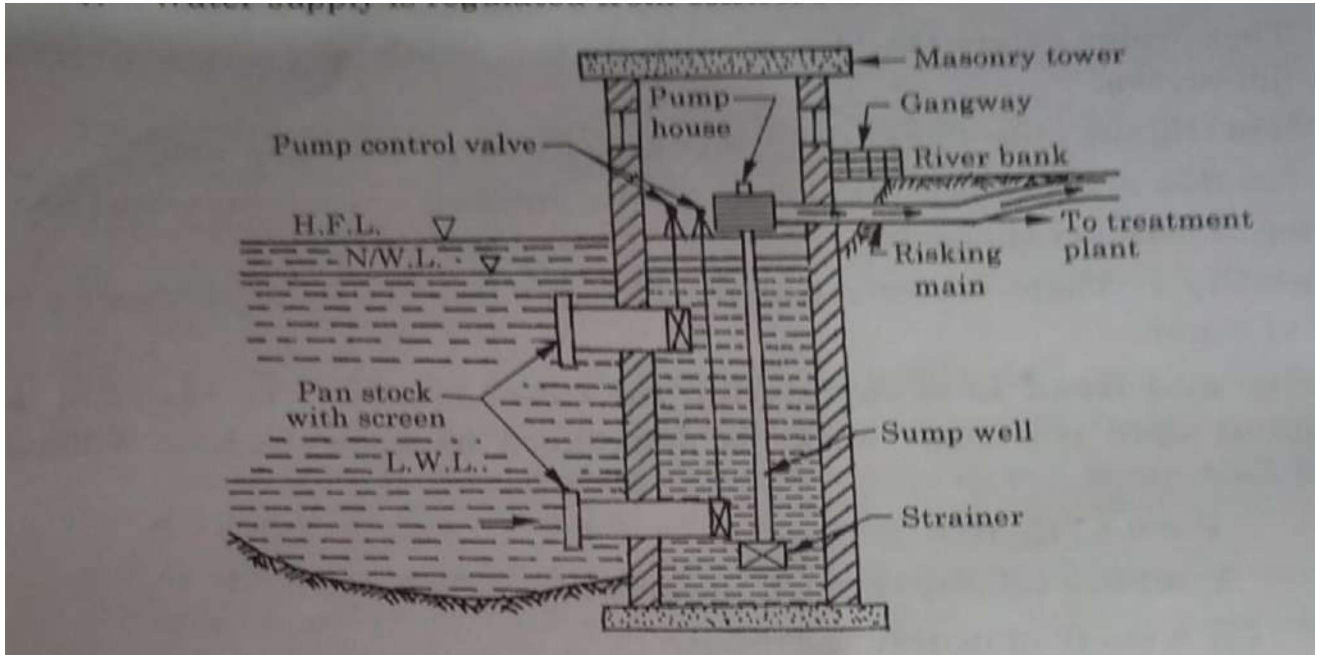


Fig. 4.3 : River Intake

- **Working Features**:
- (1) Water enters from the penstocks to intake (jack well).

- (ii) water passes through coarse screen and pumped from jackwell with the help of pump operated from control room.
- (iii) Then this pumped water is supplied to the purification plant.
- **Suitability**: These are particularly suitable where water level is more or lessstatic.
- **Reservoir Intakes -**The masonry or concrete structures constructed in deep water near upstream toe of the dam to draw water from earthen dam reservoir are called reservoirintakes.
- **Constructional Features** :1. The intake is provided with inlet pipes at different designed levels.

- 2. Each inlet pipe control valve is operated from the control house to regulatethe quantity of inlet water.

(3). Screens are provided to prevent the entry of debris and any other floating matter.

- (4) A main vertical pipe is inside the well. Water from this pipe is then taken to the outlet pipe.

4. A main vertical pipe is inside the well. Water from this pipe is ... to the outlet pipe.

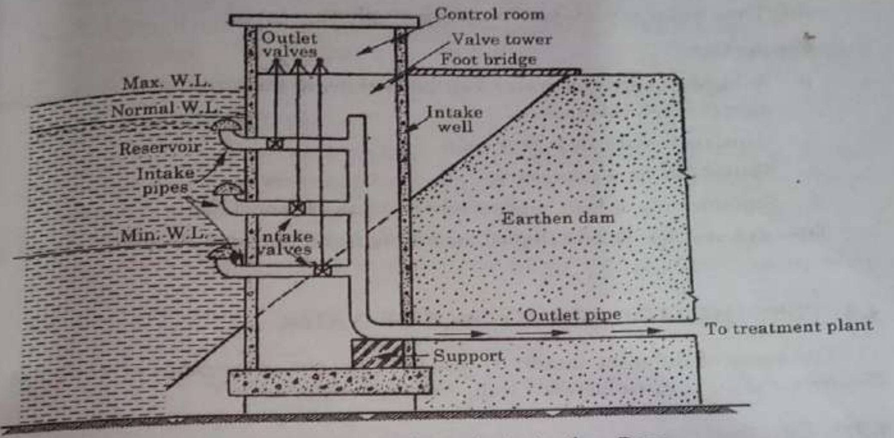


Fig. 4.4. (a) Reservoir Intake in Earthen Dam

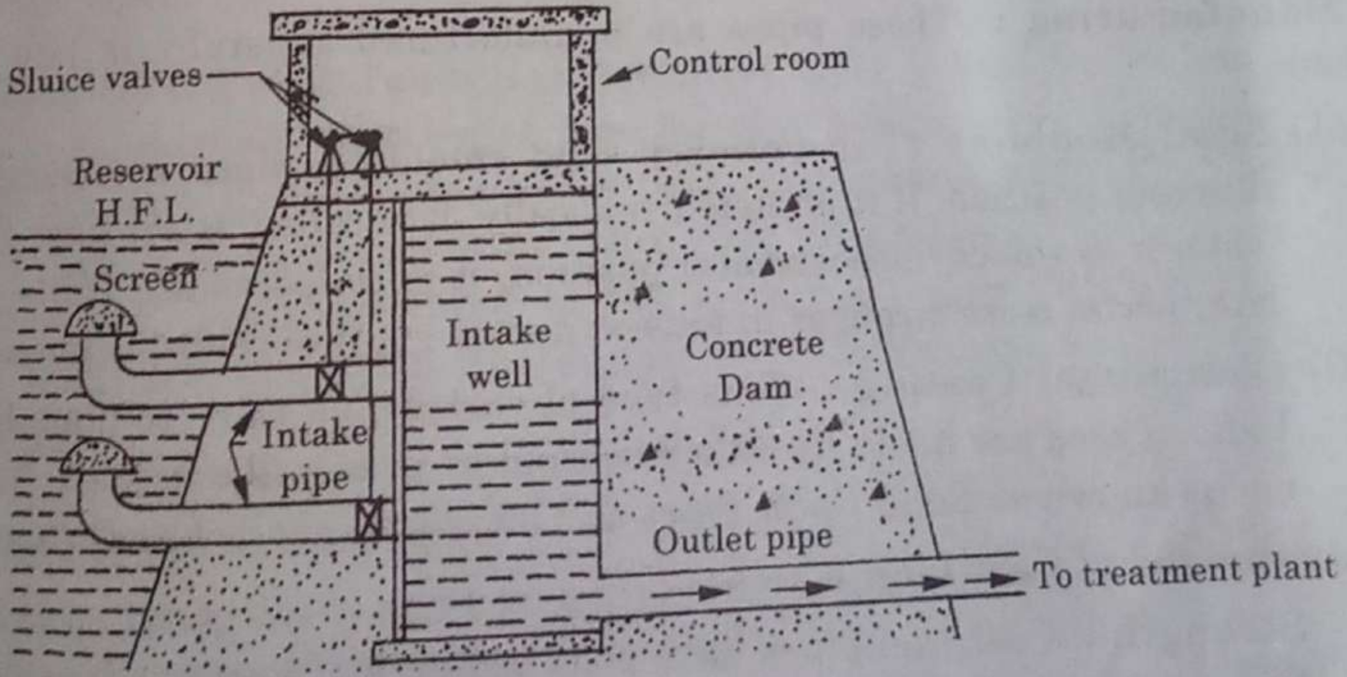


Fig. 4.4 (*b*) : Reservoir Intake in Concrete Dam

- **Working Features** : (1). The inlet valves are opened depending upon the water level in the reservoir and the quantity of water required.
- (2) Water goes to directly in outlet pipe in case of carthon dans and to inle well in case of concrete dam.
- (3) Then water is conveyed to treatment plant.
- **Properties- (1).** A huge quantity of water can be withdraw from reservoir of an earthendam through this intake.
- (2). Constructional cost is very high.

(3). Skilled labour is necessary.

(4). Suitable only at hilly regions where dams are constructed.

Disadvantage: This is slightly uneconomical and cannot be easily adopted for plain areas.

- **PIPES USED FOR CONVEYANCE OF WATER - The** pipes of different materials are used for the conveyance of water. Let usdiscuss some pipes manufactured from different materials
- **Cast Iron Pipes -** The pipes made of cast iron material are generally used for water supply scheme . These are called as cast iron pipes
- **Manufacturing -**These pipes are manufactured generally in two different methods:
- (A) **Sand Moulding**: In ordinary sand moulding, pipes are casted in two Anddifferent position. If it is casted vertically, it is called as Pit Cast Pipe when it is casted in horizontal position, it is called as Me Wane pipe. Thelater one is more stronger in tension and in rupture than the former one

- (B) **Centrifugal Casting**: This type of casted pipes are commonly used in India. These are made by either in sand or in metallic moulds. The former one is known as Sand Spun Pipes and later one is called as Delacoud pipes
- **Advantage and disadvantage of cast iron pipe**
- . **Advantages**:
- 1. Cast-iron pies have good strength.
- 2. It is easy to joint cast iron pipes.
- 3. It is easily available in market.
- 4. These are not subjected to corrosion easily.
- 5. These are available in many sizes.
- **Disadvantages**:
- 1. These pipes need careful handling.

- 2. When pipe diameter increases more than 1.2 meter it becomesuneconomical.
- 3. Pressure above 7kg/cm is not preferred in these pipes.

4. Capacity of C.I. pipes decreases with time due to tuberculation.

5 . These pipes are brittle in nature.

Steel Pipes

- **Manufacturing**: Mild steel is the material which is used i manufacturing of steel pipes. Welding and riveting is done for providing a water tight joint in steel pipe. Welded pipes are smoother and longer than riveted pipes. The diameter of such pipes may be up to 6 m or more. Galvanised steel pipes are more stronger than an ordinary one. These are used in the situation, where large dia and small thickness of pipes are required. These pipes are coated inside as well as outside to resist rusting.

Advantages or Properties:

1. Large Lengths: Steel pipes may be 6 m or more long and hence, very useful in case of large projects.
2. **Cheap**: Steel pipes are cheaply available in market.

1 . Resistant: Steel pipes can withstand at high internal pressure.

4. **Durable :** Steel pipe are very much durable. They may last long as 40 years or so.
5. **Flexibility**: This is most important property of steel pipes through whicthey can be easily laid on curves.
6. **light in Weight**: Those pipes are light in weight, hence there is difficulty in their transportation .

Disadvantages:

1. **Maintenance** Cost : Their maintenance cost is more.
2. **Rusting**: Steel pipes may get rusted by action of acidic or alkaline water
3. **Other UnsuitabIlitis**

(1) These pipes cannot withstand high negative pressures or vacuum the3. Other Unsuitabilities:may be created in them

.(ii) More repairing work is required by them and that's why these are no These suitable for distribution pipes.

Uses: Steel pipes are less used in India due to its disadvantages. But the carryinpipes with special coatings are still frequently used in U.S.A.

Asbestos Cement Pipes

Manufacturing: A dense homogeneous structure in the form of pipe which is composed of asbestos fibre and portland cement combined under pressure, in which strong bond is effected between the two, is called as 'Asbestos Cement Pipe,These pipes are generally available in size from 0.1 m to 0.9 m in diameters.

Advantages:1. Easy to transport: Transportation of these pipes are easy because these are light in weight.

2. Corrosion Resistant: These pipes resist corrosion, hence acidic water can be easily conveyed.
3. Flexibility: These are highly flexible and can permit as much as 12°. deflection.
4. Good carrying capacity: They have good water carrying capacity athey are very smooth and provide a hydraulically efficient pipe.
5. Labour Cost: Their labour cost is low as they do not require any skilled labour.

- **Disadvantages**:
- 1. **Undurable**: These pipes are not very much durable.
- 2. **Costly**: The market value of these pipes is high.
- 3. **Less Strength**: These pipes have low strength. They are soft and brittle.

- 4. **Damageable**: They can be easily damaged during transportation. Therefore, safe transportation is required.
- 5. **Small Size Distribution** : They can only be used as small sizedistribution pipes.

Wooden Pipes - Wood is being used since long for the construction of pipe. Modern wood pipes are manufactured from staves and are of two types. First type is machine banded uur pipe which is manufactured in small lengths at the factory. Second type is continuous pipe which is assembled on the job itself. The staves are manufactured from selected pine, fir, redwood, and cypress, free from knots and other defects. These pipes are designed to bear minimum 11.0 kg/cm internal pressure. The life of wooden pipes is 30-35 years and they have low friction coefficient due to which their carrying capacity is more. The carrying capacity of wooden pipes does not decrease with age.

Advantages:

1. These are not damaged by corrosive water.

2. These pipes can be easily repaired.

3.These pipes are light in weight.

4. They can be laid cheaply and easily.

Disadvantages:

2. They cannot bear high pressure and can leak in varying pressure.

2. These pipes are not suitable for intermittent water supply system, becauseunder such circumstances they are decayed by wet rot.
3. These pipes may collapse under heavy external loads.

P.V.C Pipes – P.V.C pipes belong to plastic pipes. These are manufactured from Polyvenyl cap chloride which is governed by provisions of IS (3076-1968).

Advantages:

1. These pipes can withstand pressure up to 10 kg/cm^2.
2. These are light in weight and hence transportation becomes easy.
3. These are generally used for minor works, as in house connections.
4. They include freedom from corrosion.
5. These are resistant to inorganic salts, alkaline etc.

Disadvantages:

1. A special care is taken to protect these pipes from concentrated oxidising acids, organic compounds etc. as these can attack rigid PVC materials.
2. The coefficient of expansion is high.
3. These are less resistant to heat.

Galvanised Iron Pipes (G.I. Pipes)

The iron pipes which are galvanised with zinc coatings, are called asgalvanised iron pipes. The diameter of pipes varies between 6 mm to 75 mm. Lengthof pipes varies from 1.2 m to 2.5 m. Generally, screwed and socketed joints ar provided for making connection between these pipes.

Advantages:

1. These are highly suitable for water pipe fittings inside houses andbuildings.
2. These are widely used in service connections.
3. These are cheaply available in market.
4. These are light in weight and easy to transport.
5. These are jointed with simple screw and socket joint.

Concrete Pipes -These pipes may be precast or cast-in-site. Plain concrete pipe may be used at such places where water does not flow under pressure. These pipes are joined with Bell and Spigot joints. Plain concrete pipes are used upto 60 cm diameter only, above it these are reinforced.R.C.C.

1. pipes are manufactured by the following methods:() Pipes having steel bar and mesh reinforcement, and by pouring concrete by usual method, tamping and curing.

(ii) Pipes having fabricated reinforcement and cast by centrifugal methods andcuring in tanks.

Normally R.C.C pipes are made from 1:2:2 cement, and aggregated. In difficult areas pipes can be constructed at the site by using local material. Thickness of pipes varies from 25 mm to 65 mm for pipe diameters varying from 10 cm to 120cm . Now a days prestressed concrete pipes are also available in the market , but these are not common.

Advantages:

1. These pipes do not corrode by the water, therefore, have long life, abyears.

2 .Surface of these pipes does not affect with time, hence carrying ca does not reduce .

3 .Their maintenance cost in low.

Disadvantages:

1. They are very heavy and difficult to transport.
2. They are difficult to repair.
3. These pipes cannot withstand high pressure.

Copper and lead pipes –

Copper pipes are not liable to corrosion, even if water contains some acids. These pipes can be easily bent and also do not sag if used for H supply. These pipes are only used in making gouseneck in the house co and carrying hot water inside the buildings.

Lead pipes are not used in India, because they cause lead poisoningcan be given bends easily and also can withstand high pressure.

Thesemostly used in sanitary fittings. In water-supply these are used in chlorinalum dosing. These pipes cannot be used for hot water supply, becausunder such circumstances.

JOINTS IN PIPES –

The meeting place of two adjacent pipes is called as joint in pipe. make the continuous length of pipe line, joints are very essential. Le some types of joints.

Socket and Spigot - JointThese are sometimes also called as bell and spigot joint. In this type of joint one ed is enlarged whereas the other end is normal. The enlarged end is called as ocket" or "bell" while normal end is called as "spigot". Spigot is fitted in socket. A w strands of jute are introduced in the space between socket and spigot. The

Neaining space is finally filled with molten lead solidification. A water tight joint is available .

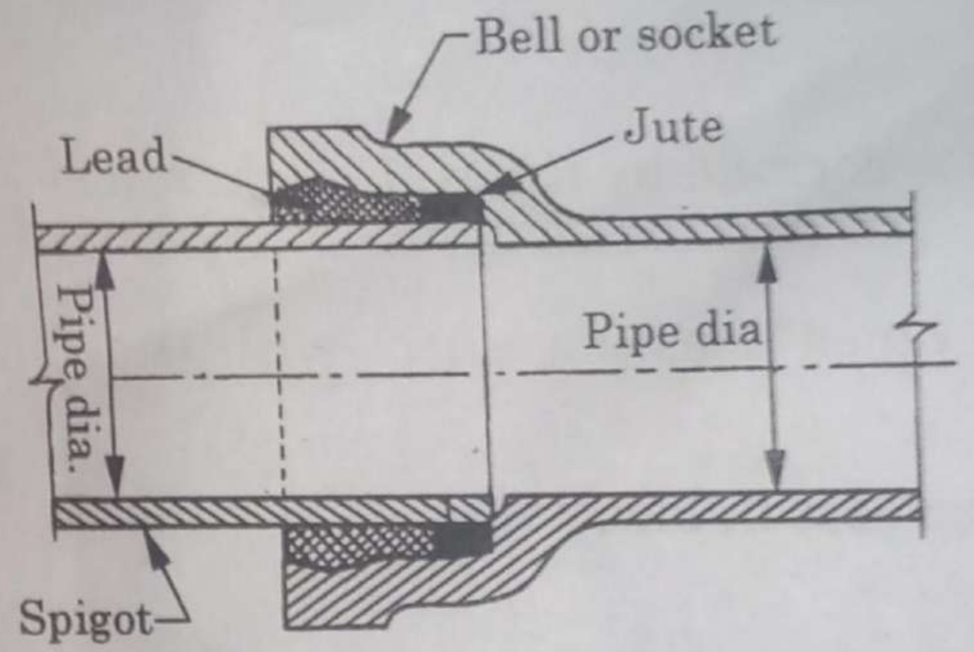


Fig. 4.5 : Socket and Spigot Joint

Properties or **Advantages**

1. **Flexible**: These joints are somewhat flexible.
2. Ensy Laying: They allow the pipes to be laid on flat curves without13 special requirements.
3. **Economical**: These are economical in case when patented compounds osulphur, cement mortar is used in place of molten lead.
4. **Water tight**: This joint is water tight so that no leakage can occur through it.

Disadvantage: The only disadvantage is that it requires skilled labour.

Flanged Joint - This joint is also mostly used for cast iron pipes. These joints are used fo pumping stations, filter plants, and at other locations where disjointing of may be necessary occasionally.

These joints are provided with flanges and due to this it is called joints. Cast Iron pipes are jointed in such a way that they have flanges a Both the flanges are bolted together after placing the gasket in between hus making a water tight joint.

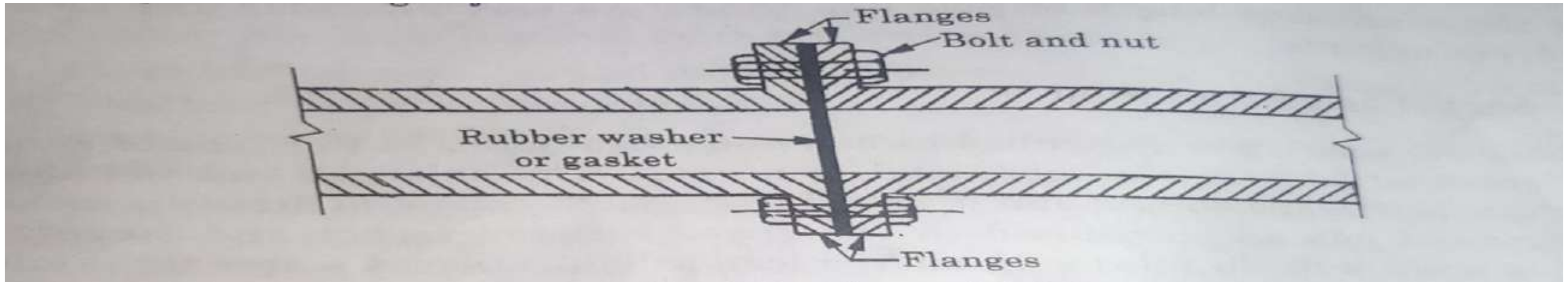


Fig. 4.6 : Flanged Joint

Advantages:

1. These are very simple in connection.
2. These joints are preferred if the water pressure is high.
3. These joints are very strong.

4. These can be used efficiently for indoor works such filter plants etc. in pumping stations.

Disadvantages: The only disadvantage is that these joints are brittle and hence cannot be used where deflections or vibrations are expected.

Expansion Joint - These joints are next one provided in cast iron pipes..Construction: These are provided at suitable intervals in a same length pipe line. These are so provided to counteract the thermal stresses produced due temperature variations. In this, a flanged ring (also called annual ring) is connecte to the socket or bell end. This ring can slide freely over spigot end. While makin this joint, a small space is left between face of spigot and inner face of socket whi is filled up by rubber gasket. The flanged ring is bolted at last. This will be me clear from the figure 4.7.

Working: When the pipes expand, the socket end moves forward and space left just gets close. Similarly when pipes contract, socket moves backward a gap is created. Annual ring or flanged ring all the time follows the movements socket. Thus, gasket ring maintains the gasket in position which further help making a water tight joint.

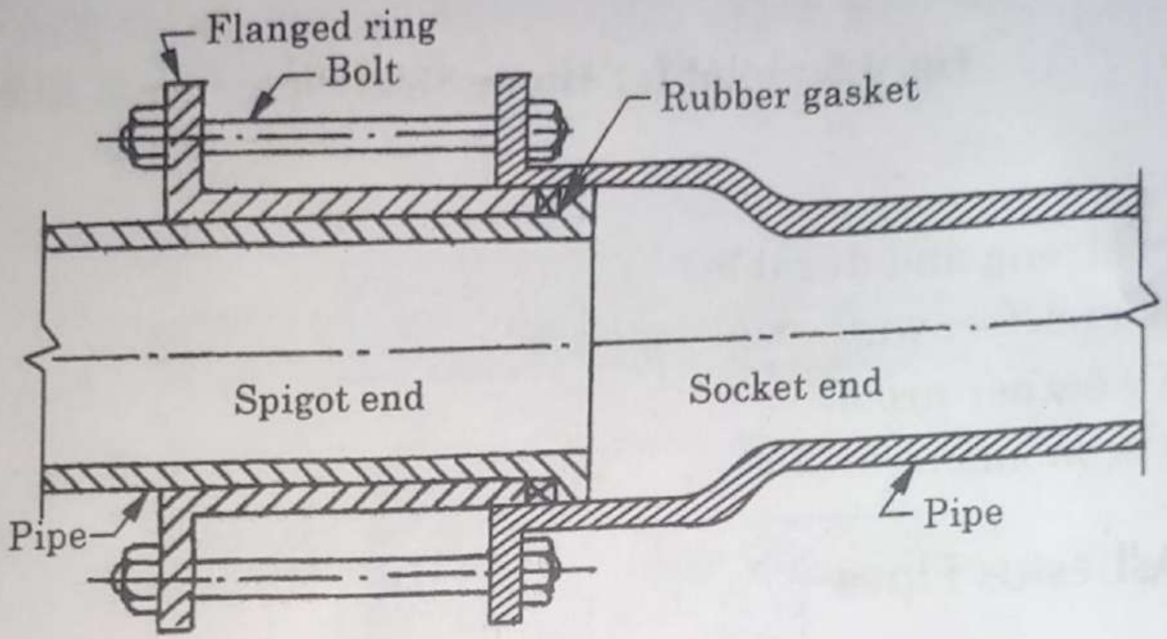


Fig. 4.7 : Expansion Joint

Advantages:

1. They counteract the thermal stresses produced due to the temperature variations.
2. These are water-tight.
3. These are also used when pipes are exposed to atmosphere.

   Disadvantages: This joint is slightly uneconomical.

Joint for Hume steel Pipe

Construction: Hume steel pipes are the patented form of R.C.C. spun pipes. These pipes have coats of steel shells and its inside is coated with cement mortar by centrifugal force process. These are coated to protect the pipes from external weather or soil action .

In this case, space between collar and pipe is filled up by jute or hump rope to maintain the alignment of pipes. The remaining gap is then filled up by rich cement mortar.

Advantages:1. These are strong and durable**.**

2. They make perfect water tight joint**.**

3. They are weather proof**.**

4.They are economical**.**

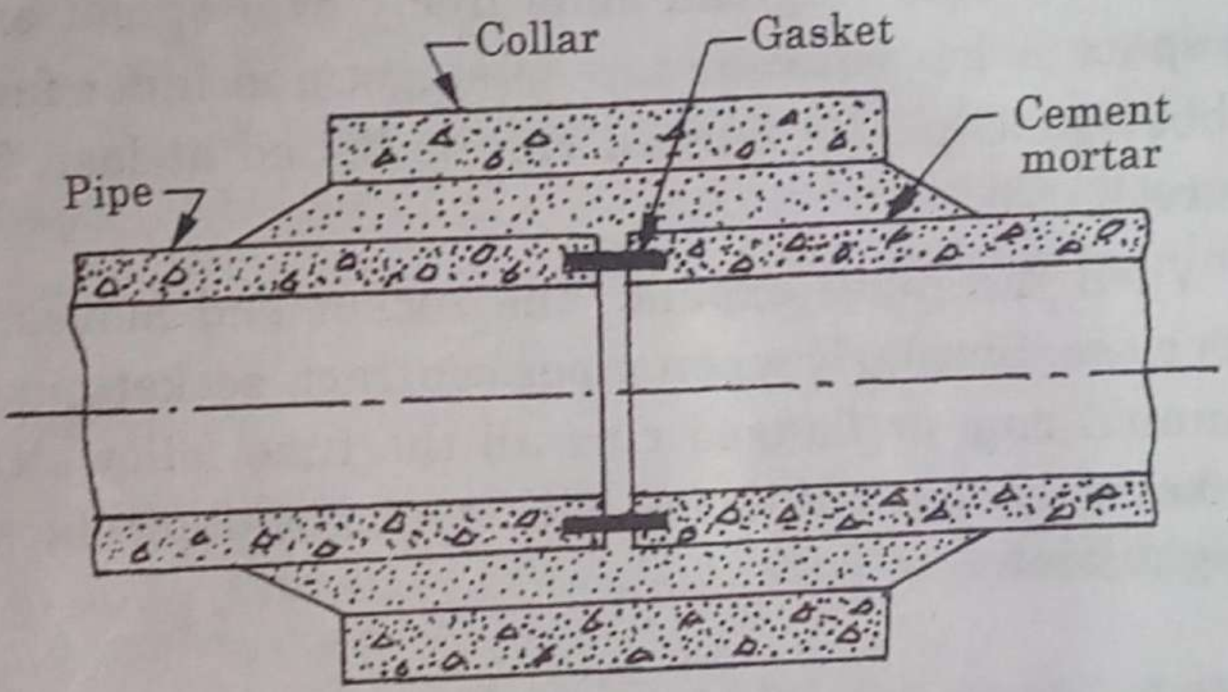


Fig. 4.8 : Joint for Hume Steel Pipe

Joint for Asbestos Pipes –

Construction: Asbestos cement is used for casting these pipes. Asbest fibres are mixed with this material for reinforcing the asbestos pipes. These pipe are generally made in 4 different grades.

In this case, pipes are coupled in a special manner and is called as simplex joint which consists of a pipe sleeve and two rubber rings which get compressed between pipe and interior of sleeve.

Advantages:

1. They are very strong and durable.
2. They are suitable for small size distribution pipes.

3.They are highly resistant to corrosion.

Disadvantages: These are costly and hence uneconomical.

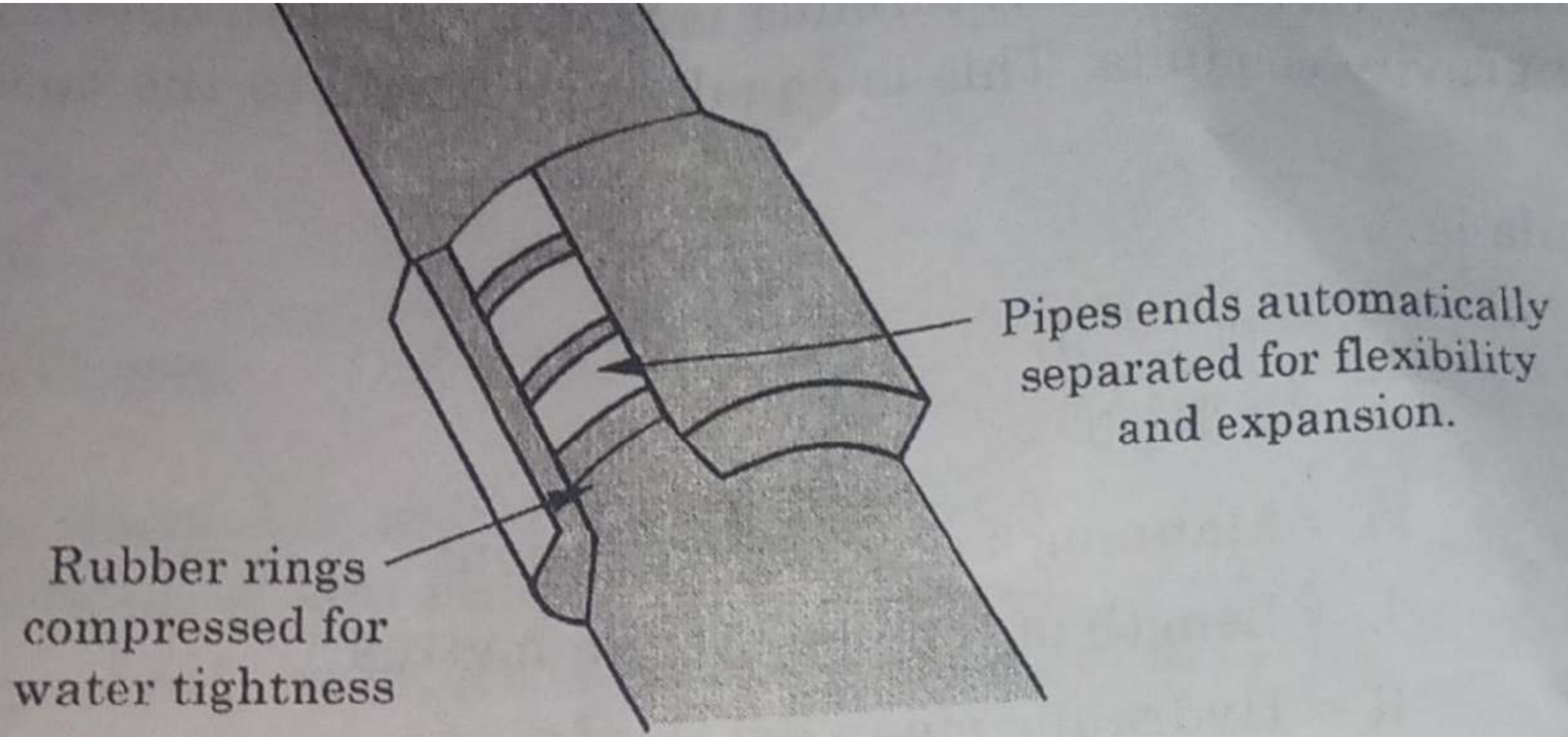


Fig. 4.9 : Joint for Asbestos Pipes

Screwed Joint -This joint is mostly used for connecting small diameter cast iron, wrought iron and galvanized pipes. The ends of the pipes have threads on outside, While socket or coupling has threads on the inner side. The same socket is screwed on both the ends of the pipes to join them. For making water tight joint zinc paint or hemp yarn should be placed in the threads of the pipe, before screwing socket over it.

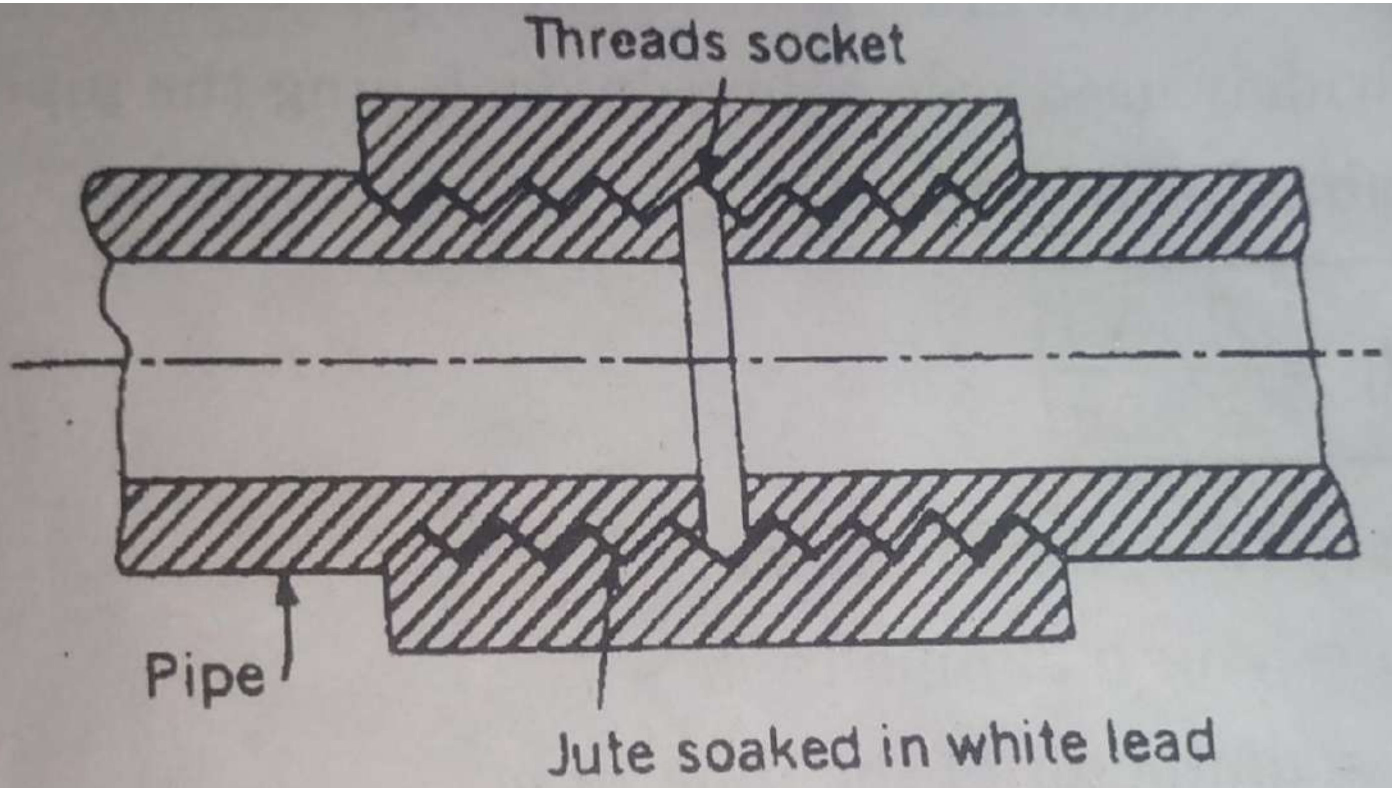


Fig. 4.10 : Screwed Joint

CHAPTER - 4

★ WATER TREATMENT ★

Introduction

In the previous chapter we have seen that water available in various sources contains, various types of impurities. We have also discussed the effect of these impurities and specified the requirements of wholesome water. The raw water which is found in various natural sources cannot be directly used by the public for the various purposes, before removing the impurities. For palatability the water should be free from unpleasant tastes, odours and must have sparkling appearance. The water must be from disease-spreading germs.

The amount and type of treatment process will depend on the quality of raw water and the standard of quality to be required after treatment.

Objectives Of Water Treatment :

The treatment given to water with the help of various treatment processes.

before supplying it to the public for various use (whether domestic, industrial, fire. etc.) is called as water treatment. The main objectives of water treatment are –

1. **Good Quality of Water -** The main objective is the removal of various impurities of raw water and thus making the water of good quality.
2. **Removing undesirable matters –** The mukiness and colour of water. Should be removed before supplying it for public use.
3. **Free from Germs –** The next object is to make water exactly pure by making it free from pathogenic germs as they can harmfully affect the human health.

4. **Removing odour and objectionable taste -** The next object is to remove. the objectionable odour and taste from water so that it become pleasant for public use.
5. **Make water fit for use -** The next object is to make water for domestic use as cooking, bathing, washing and various industrial uses.
6. **Eliminating the undesirable properties of water -** In this object, the undesirable properties of water like tuberculation and corrosion are eliminated as they affect the conduits and pipes.
7. **Proper amount of dissolved oxygen to water -** The next object is to give correct and adequate amount of dissolved oxygen to water.
8. **Coolness to water -** The next object for water treatment is to give coolnessto water i.e. water should be cool**.**
9. **Sparkling appearance to water -** The next object is to give a sparkling appearance to water which means water is pure and fit for public use.

TREATMENT PROCESS:-

The treatment process directly depend on the impurities present in water. For removing various types of impurities the following treatment process are used

S. No.	Impurity	Process used for removal
1.	Floating matters as leaves , dead animal etc.	Screening
2.	Suspended impurities as silt , clay, sand etc.	Plain Sedimentation
3.	Fine suspended matter	Sedimentation with coagulation
4.	Micro-organisms and colloidal matters	Filtration
5.	Dissolved gases , tastes and odours	Aeration and chemical treatment
6.	Hardness	Water Softening
7.	Pahtogenic bacteria	Disinfection

The character and degree of treatment will directly depend upon the nature of water of indirectly on the source. The water of surface generally contains large amount of impurities , therefore , they will require all the treatments stated above.

Various Types Of Treatment Processes:-

- **The various water treatment process are :-**

- **1. Screening**
- **2. Plain Sedimentation**
- **3. Sedimentation with coagulation**
- **4. Filtration**
- **5. Disinfection**
- **6. Aeration**

Screening -

Definition : A protective device generally provided in the front of the pumps or the intake works, so as to exclude large sized particles such as leaves, large objects, bushes, dead animals etc, in called an acroon. The process of excluding all these large sised particles with help of screen is called as screening.

Purpose: The main purpose of screening is to prevent the entry of undesirable large particles into the intake works and also to make water fit for treatment processes .

Types – There are two types of screening

1. Coarse Screening. **2. Fine Screening**

1. Coarse screening

The screening which is done usually by coarne screens is called as coarso screening. Coarse screens are also called as 'trash racks'. These screens are mostly in the form of iron rods or bar grill placed vertically at a distance. of about 2 to 10 cm centre to centre

Construction: Coarse screen bars are generally kept at an angle 18” to 60%The main purpose of this is to increase the opening area of screen and thus reducingthe velocity of flow. The velocity of flow through them should not exceed 0.75 to 1.0m/sec.

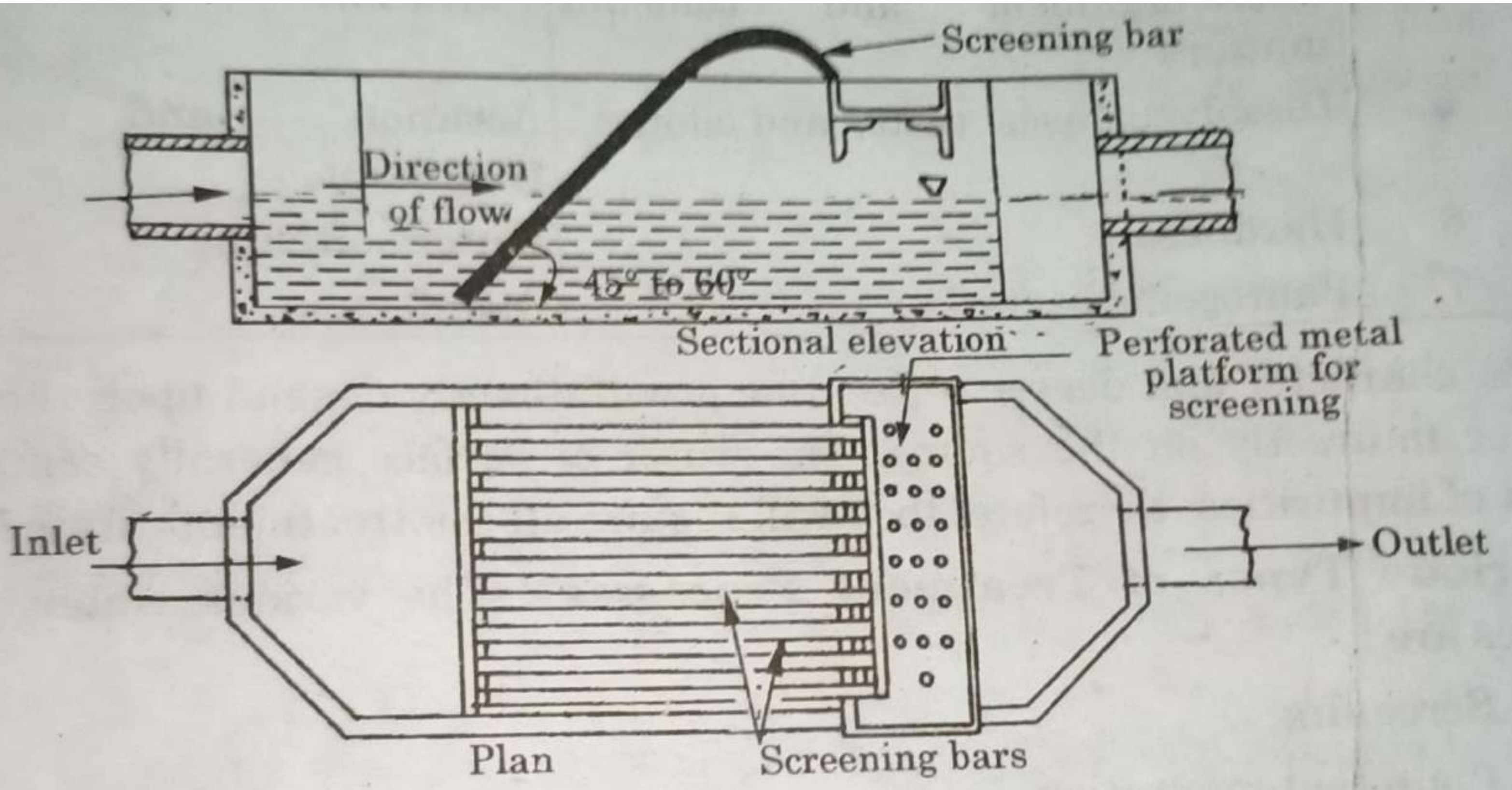


Fig. 4.1 : Fixed Bar Type Screen

2. Fine Screening

The screening which is done with the help of fine.screens is called as fine screening.

Construction - Fine screens are the trays or sections of wire mesh or cloth with less than 10 mm openings. These are provided next to the coarse screens.

Uses - These are provided to remove the fine suspended solids.

Disadvantages - The only disadvantage is that fine screens normally got clogged frequently and require frequent cleaning operations. That's why these are not used these days.

Removal of Debris after Screening - The debris collected or accumulated is removed from time to time. This will help in again free movement of water. The debris is removed manually or mechanically. Hand cleaning is preferred for small units and for large units, mechanically operated combs should be used.

(A) SEDIMENTATION

Definition - The process by which suspended particles are removed from the given water by the action of gravity is called as sedimentation.

Types - Sedimentation can be done in 2 ways.

1. **Plain Sedimentation**
2. **Sedimentation with co-agulation**.

1. **Plain Sedimentation -** In sedimentation process water is retaining in a tank or basin so that the suspended particles or the matters may settle due to action of gravity or natural aggregation. This process is known as sedimentation.

Principle: Particles which have higher density as compare to others settlequickly in tank. All the settle able suspended particles are considered as discreteparticles which do not change their shape, size and weight while settling. Verticalvelocity remains constant.

Factors affecting Plain Sedimentation -(1) Velocity of flow: It plays a vital role in moving the particles in horizontal direction.

(ii) **Size and Shape of Particles**: These affect the specific gravity of particles.

(iii) **Viscosity of Water**: It also affects as it offers frictional resistance to themovement of water and particles. It is affected by temperature.

Process of Plain Sedimentation - This includes the following steps:

1. The water is retained in a tank so that suspended particles may settle down due to force of gravity only.

2. As soon as the settlement of suspended particles take place, water is then taken out, from the tank without causing any disturbance to the suspended particles.

METHODS -

1. In past time, plain sedimentation was done with draw and fill method. In this method the water was filled in the tank and allowed to remain in tanks that suspended impurities may settle. After this the water was out from the tank when all the particles has been settled down.
2. Now-a-days this method is less adopted. Continuous flow type basinmethod is common.

In this method water flows continuously at uniform rate through tank. All the suspended impurities settle in the bottom of the tank and at least clear water is drawn out from the outlet. This will be more clear from the figure 4.2. Water has to move a long distance and during this movement suspended particles settle down.Hence, Plain Sedimentation is done in a right manner.

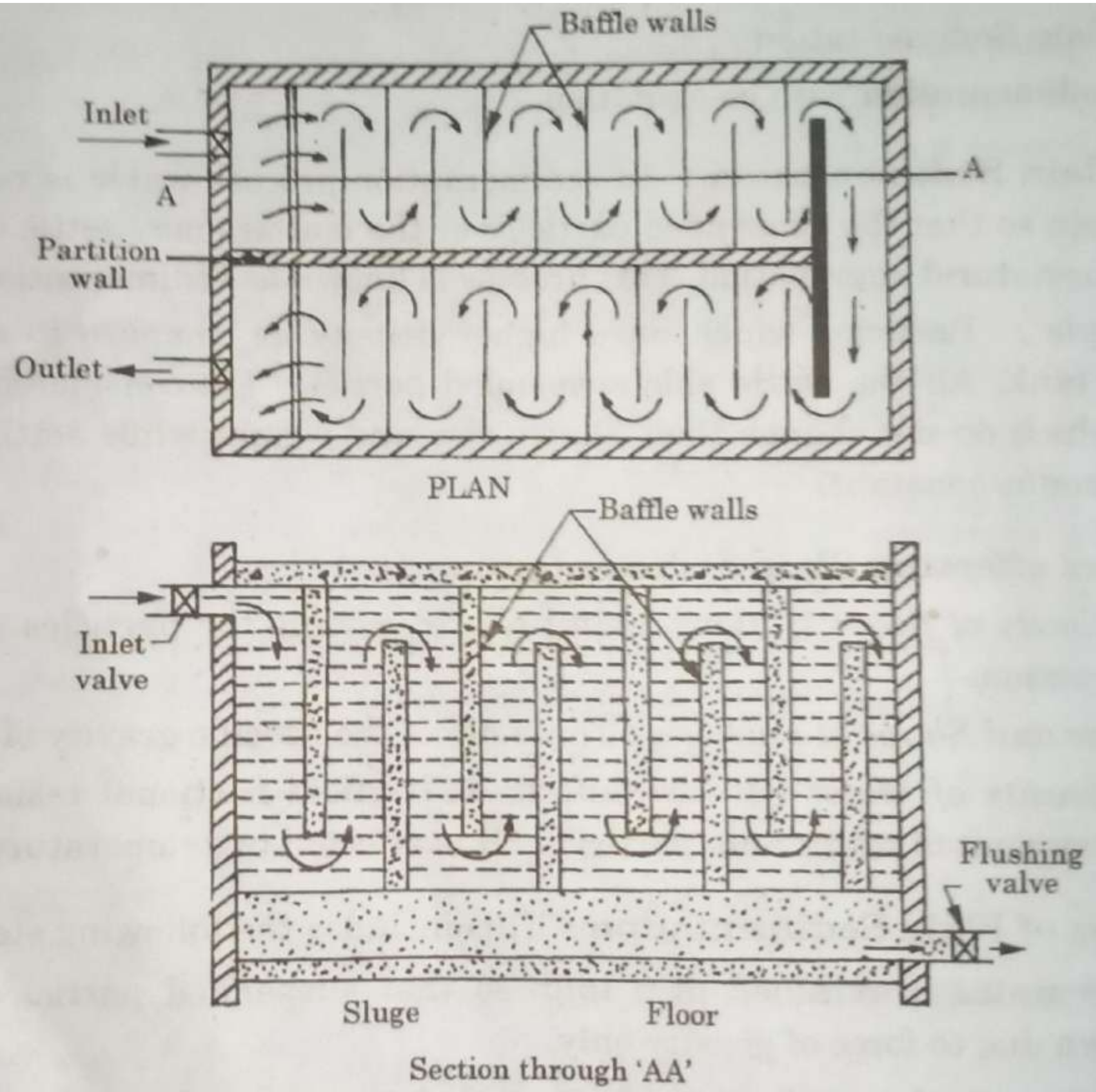


Fig. 4.2 : Rectangular sedimentation tank with baffle walls

Advantages – Plain sedimentation has following advantages.

1. **Prpreliminary Process –** This is preliminary Process as this process decrease the load on subsequent processed.
2. **Less Cost –** Cleaning cost of tank is less.
3. **Less Quantity of Chemicals are needed -** Very less quantity of chemicals are

needed for the subsequent processes.

Types of Sedimentation Tanks

The sedimentation tanks can basically be divided into two types; viz.

1. Horizontal flow tanks; and 2.

Vertical or up flow tanks.

These tanks may be rectangular or circular in plan. Both these types of tanks are briefly discussed here.

HORIZONTAL FLOW TANKS

In the design of horizontal flow tanks, the aim is to achieve, as nearly as possible, the ideal conditions of equal velocity at all points lying on each vertical line in the settling zone. The direction of flow in the tank is substantially horizontal.

(1) Rectangular tanks with longitudinal flow, such as the one shown in fig. They may be provided with mechanical scrapping devices, to scrap the sludge to the sludge pit located usually towards the influent end, from where it is continuously or periodically removed, without stopping the working of the tank. Such tanks are known as continuous flow type of sedimentation tanks. In such a tank, the

flow velocity is only reduced and the water is not brought to complete rest.

Raw water is simply stored and kept at rest for a certain period, say about 24 hours. The velocity is sufficiently reduced by providing sufficient length of travel. The velocity is so designed that the time taken by the sand particle to travel from one end to another is slightly more than the time required for settlement of that particle.

(ii) Circular tanks with radial flow, with central feed, is such **a** tank, the water enfers at the centre of the tank into **a** circular well provided with multiple porte, from which it emanates out to flow radially outwards in all directions equally. The water, thus, flows horizontally, and radially from the centre towards the periphery, of the circular.

2. VERTICAL OR UPFLOW SETTLING TANKS

Vertical flow tanks usually combine sedimentation with flocculation, although they may be used for plain sedimentation. They may be square or circular in plan, and may have hopper atoms. The influent enters at the bottom of the unit. The upflowed velocity decreases with the increased cross-sectional area of the tank. The clarified water is withdrawn through the circumferential or central weir.

When used with coagulants, the flocculation takes place in the bottom of the tank leading to formation of blanket of floc though which the rising floc must pass. Because of this phenomenon, these tanks are also called the Up-flow sludge blanket clarifiers.

(B). SEDIMENTATION WITH CO-ANGULATION

It is the process in which an insoluble gelatinous flocculent precipitates is formed by adding certain chemicals (known as coagulants) for absorbing the. suspended and colloidal matter and thus helping in quick sedimentation.

Necessity - When water contains large amount of very fine and light colloidalimpurities, it is practically difficult to eliminate them by plain sedimentation.

They can, however, be removed easily by increasing by changing them into flocculated particles.

For this purpose, certain chemical compounds, called coagulants are added into the water. By proper mixing of coagulants and water a gelatinous precipitate called **floc** is generated. The very fine colloidal particles present in water get attracted and absorbed in these flocs forming the bigger sized flocculated particles. These bigger size particles settle down easily and can be removed.

Process: SEDIMENTATION and co-agulation is required.

(C). FEEDING DEVICES FOR COAGULATION -

The devices which are used for feeding the coagulants to water for treatment orpurification of water are called as feeding devices. There are 2 methods.

1. **DRY FEEDING**: The process by which a coagulant is fed in water in a dry powder form is called as dry feeding. The common devices which are used for dry feeding of the coagulants are shown in Fig. 4.3. They are in the form of a tank with a hopper at bottom. Agitating plates are placed inside the

tank, so as to. prevent the arching of the coagulant. The coagulant, in the powdered form, is filled in the tank.

Importance: These devices are generally used for simplicity, neatness. These require very small space and freedom from corrosion. Dry feeding. equipments can be easily controlled.

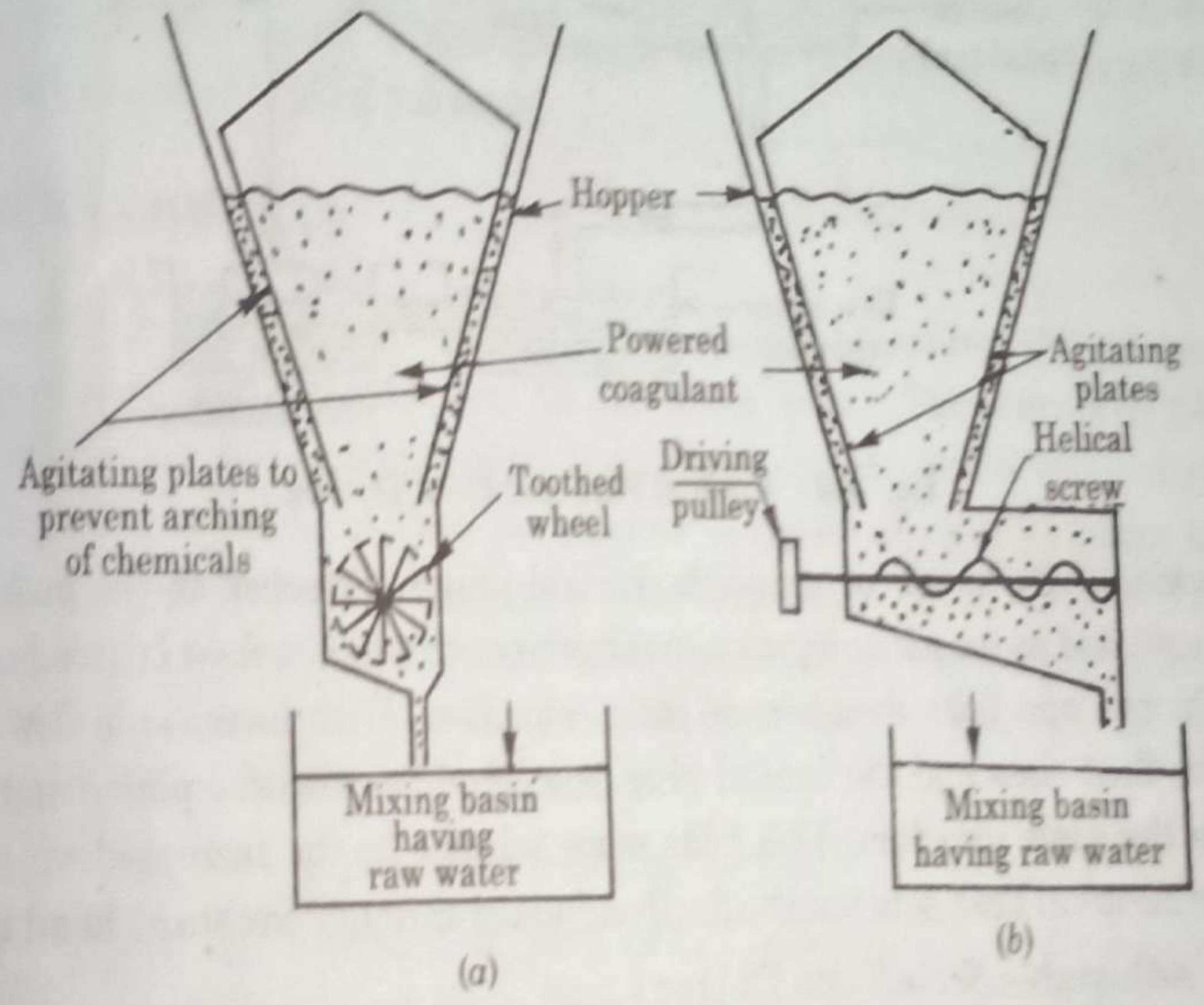


Fig. 4.3 : Dry Feeders

Working: In this method, congulant in powdered form is allowed to fall in the mixing basin in a known quantity. The dose of coagulant is regulated by speed of toothed wheel or by a helical screw. The speed of both is controlled by a venture device installed in the raw water pipes which bring water to the mixing basin.

2. **WET FEEDING**: The process in which coagulant is fed in water insaturated form is called as wet feeding.

Importance: These are important and suitable for those chemical whosesolutions can be prepared easily.

(a). Conical Plug And Float Device -

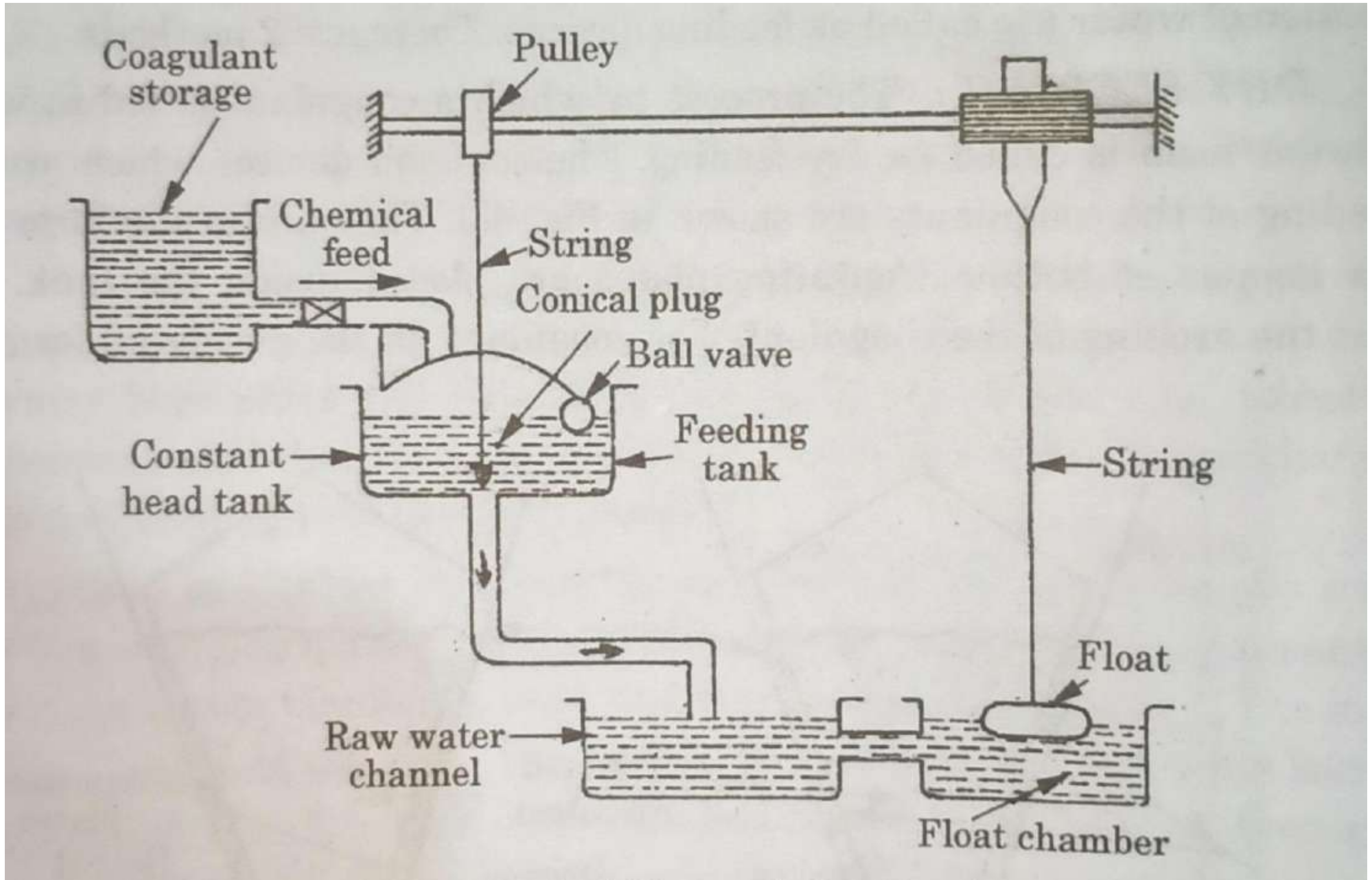


Fig. 4.4 : Conical Plug and Float Device

Working -

By means of string the conical plug is attached to the pulley. The pulley is rotated by a rack and pinion arrangement to which a float is attached. Raw water channel and float chamber are inter-connected. With increase in flow of raw water the float rises and the conical plug gets lifted because the pinion and pulley rotate in the same direction. This adds more solution to the increased water flow. Thus the chemical dose gets automatically adjusted through constant head tank.

(b). ADJUSTABLE WEIR TYPE DEVICE

Working - Rectangular holes in the sliding cylinder form the adjustable weir outlet its position is controlled by means of a lever, the float chamber and the raw water channel are interconnected. With increased flow of raw water the float rises. and the lip of the weir gets lowered adding more chemical to raw water flow.

Care Points - The application of the correct amount of coagulation chemical is done by chemical feed machines which may be controlled manually, automatically or spaced by the flow of liquid. Proper chemical dosage is determined by coagulation control tests commonly called ‘jar jests'.

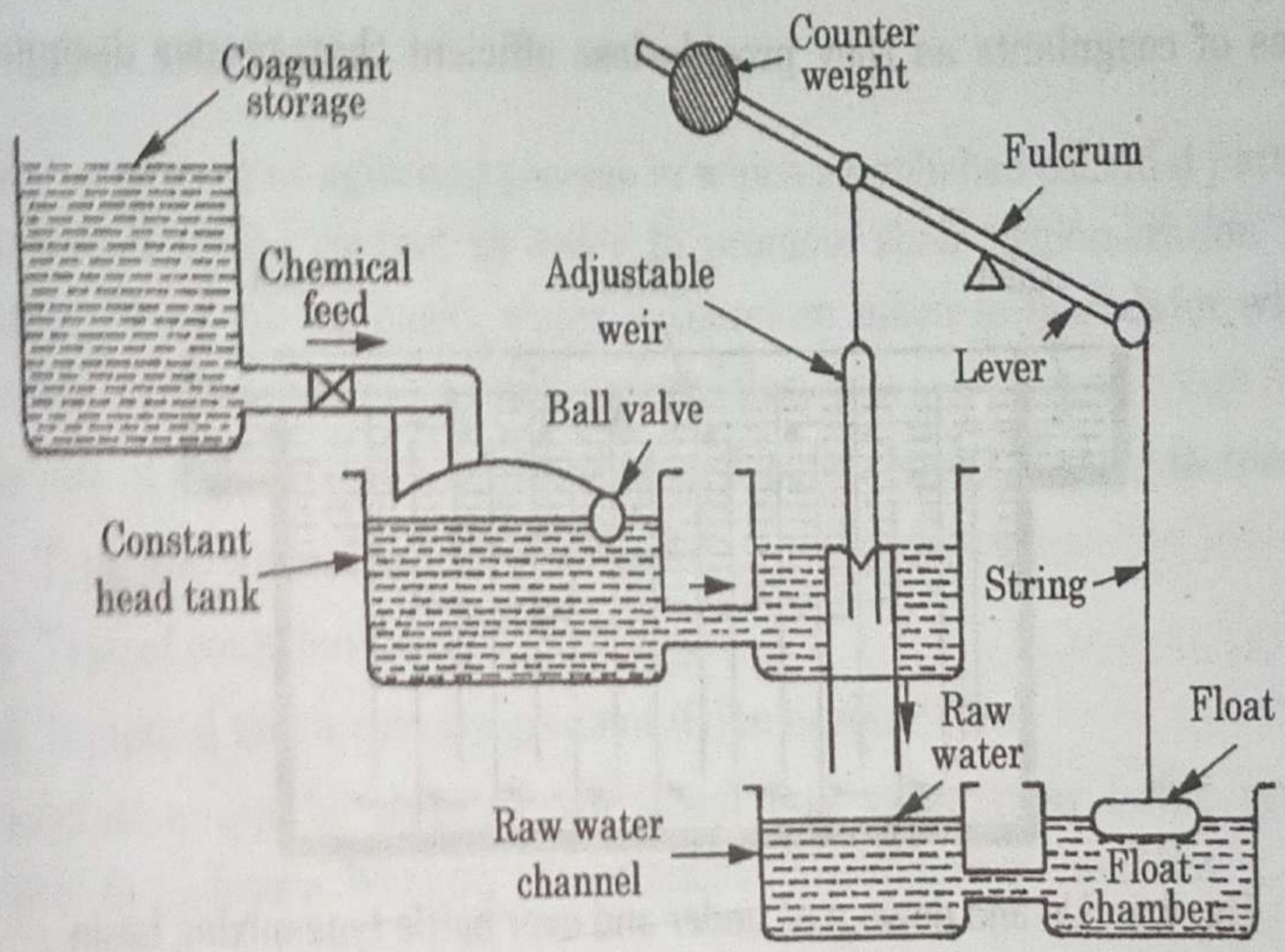


Fig. 4.5 : Adjustable Weir Type Device

(D). MIXING DEVICES

After adding coagulants in water, the next operation is to mix them thoroughly in water so that they fully disperse in the whole water. This mixing is done by mixing devices. In these devices first the coagulants are vigorously and rapidly mixed for about one minute. Then the mixture is gently agitated for about half an hour so that coagulants may react and start coagulation. The velocity of flow of water in mixing basins is kept between 15-30 cm/sec. The velocity in no case should be less than 10 cm/sec. and more than 75 cm/sec., because in first case the floc will settle down and in second case disintegrate.

Mixing can be done by one of the following devices:

(i). N BAFFLE TYPE BASINS

In these basins water may flow around about the end baffles and cause up and down under and over baffles. The baffle walls are placed and disturbances created by the provision of baffles give sufficient agitation as to necessary mixing to develop the floc. The baffle walls are 60-100 cm apart and the velocity of water is kept between 15-30 cm/sec. Figs. 4.6 show both the types of mixing basins. The detention period in these basins is kept 20-50 minutes. These are not suitable for small plants because these are costly in construction, have less flexibility of control, and greater loss of head. Such basins often require greater quantities of coagulants as they provide less efficient than proper designed flash mixers.

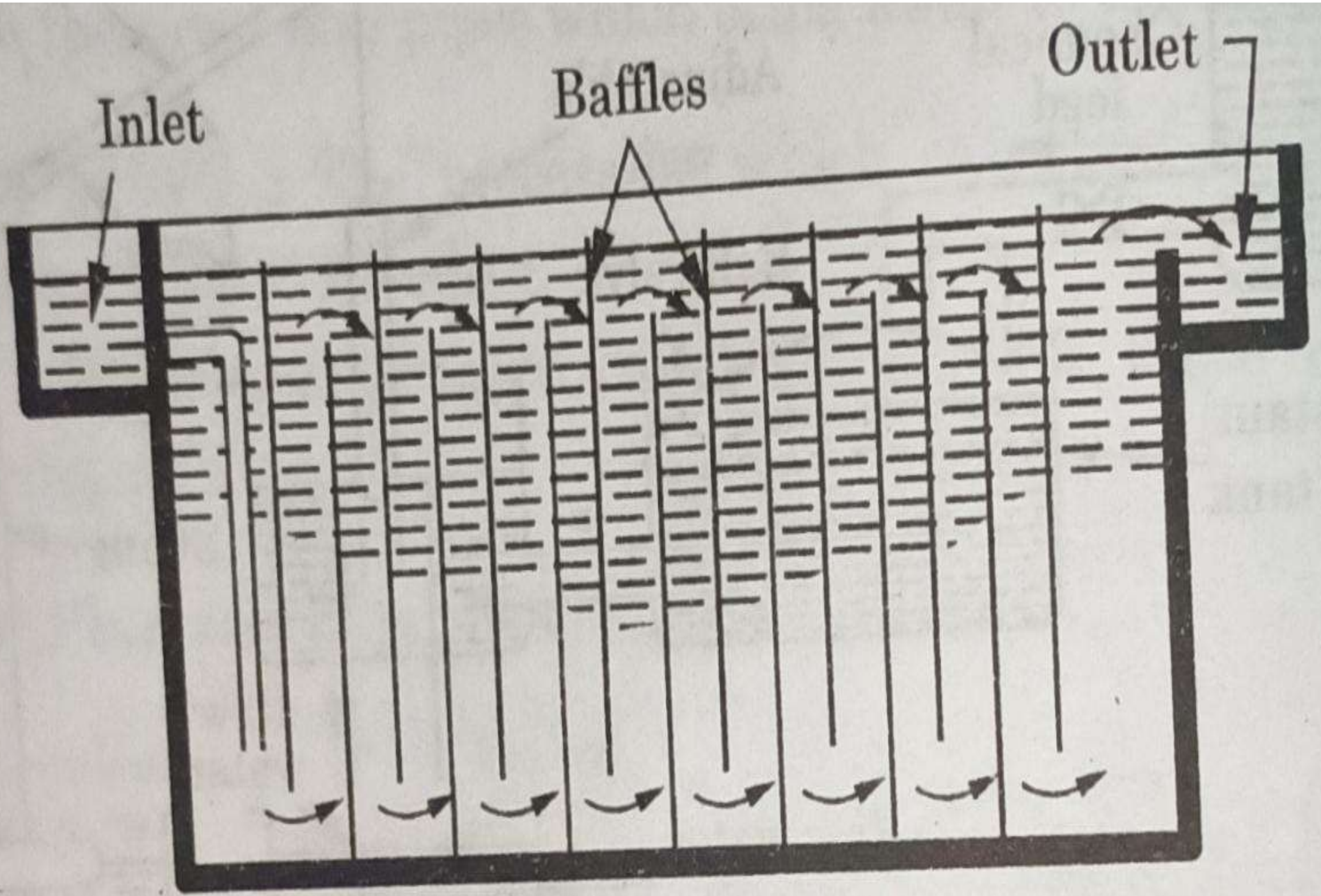


Fig. 4.6 : Up and down past under and over baffle type mixing basin

(ii). FLASH MIXER

In this device the solution of coagulants is mixed thoroughly in the water by means of a fan operated by electric motor suitable drive. The water enters in through the inlet, the deflecting wall deflects the water towards fan blades where chemicals also reach through chemical pipe. This mechanically agitated mixing basins are the best type of flocculating devices.

A typical mixing basin provided with a flash mixer is shown in fig.

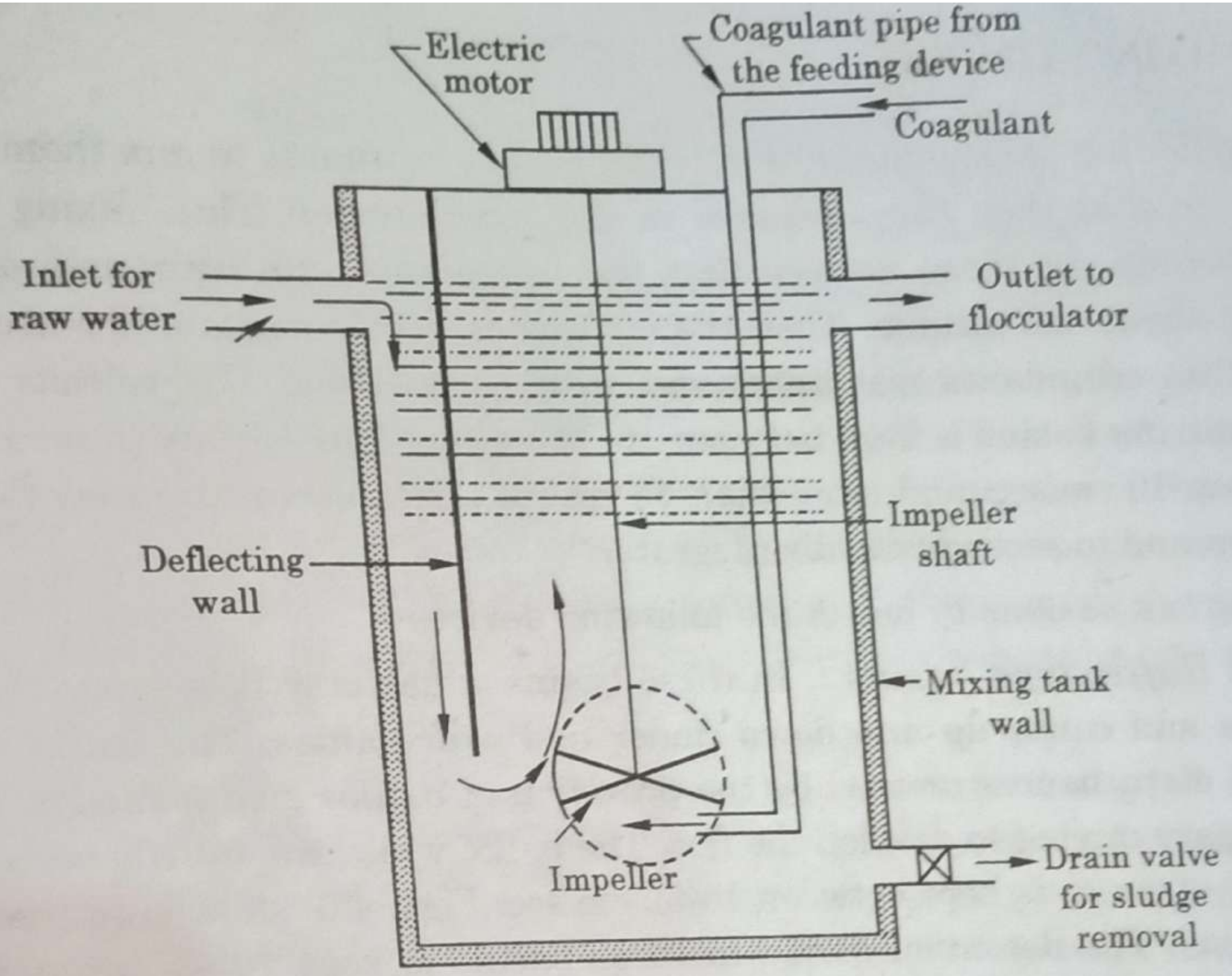


Fig. 4.7 : Mixing basic with a flash mixer

(E). FLOCCULATION -

The slow mixing or agitating procons in which established colloidal particles are brought into intimate contact in order to promote their agglomeration is called Docculation. From mixing basin, water in therefore taken to flocculator where it is given a slow stirring motion for building up of floc. The rate of agglomeration or flocculation depends upon following factors.

(1) Type and concentration of Turbidity

(2) Type of coagulant and its dose doses

(3) Temporal mean velocity gradient (G) in basin.

Flocculation can be done by horizontal flow rectangular baffle type or by mechanical flocculation. Working of mechanical flocculation are as follow **1.**. The water is gently stirred.

2. At lower velocities of about 30 cm/ second and longer detention period thesuspended matter comes in contact with chemicals added.
3. The particles flocculate and grow bigger in size i.e. agglomerate andsettles down quickly.

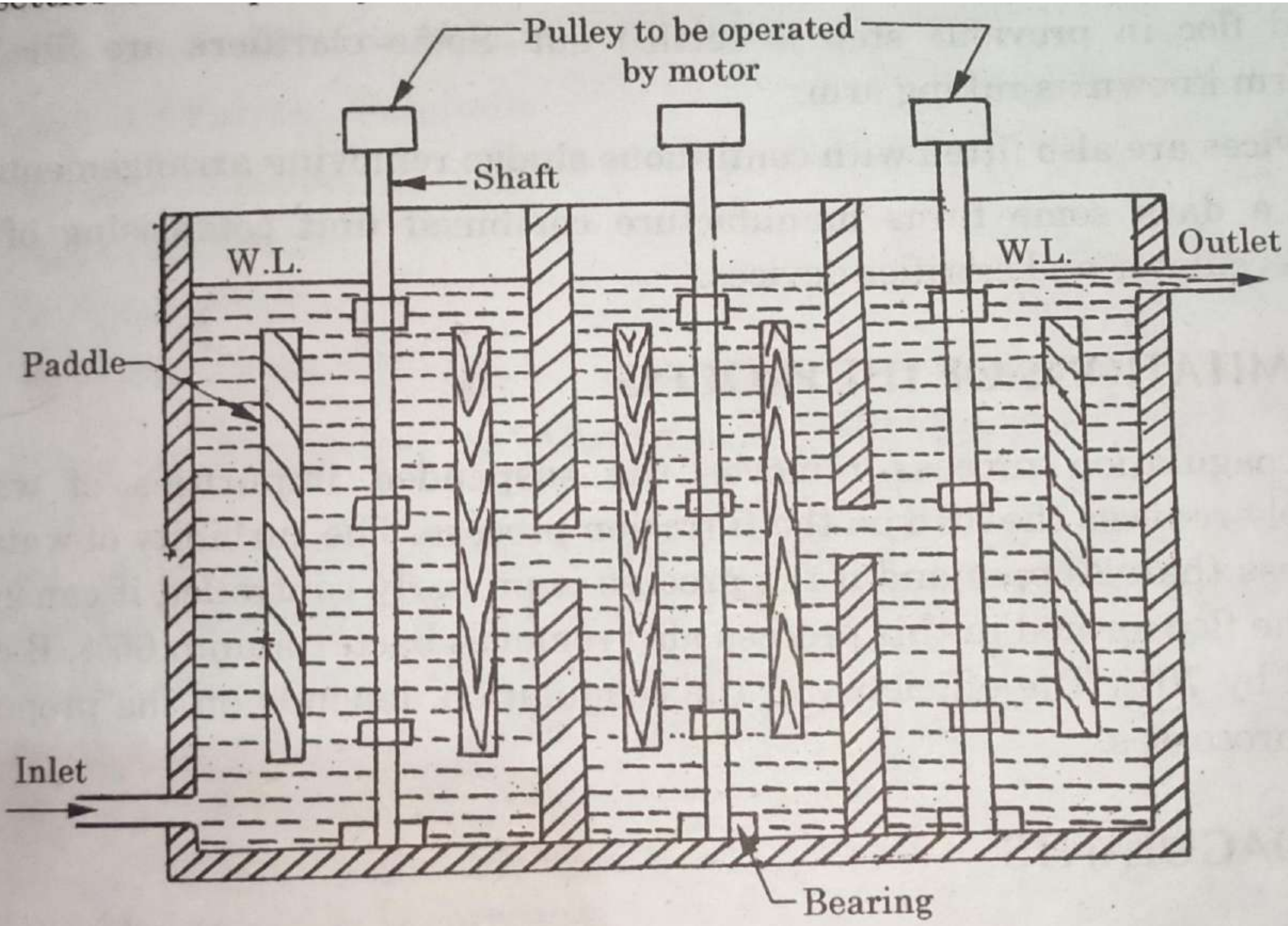


Fig. 4.8 : Flocculation Tank (Flocculator)

- Following are the advantages of mechanical flocculators over horizontal flow rectangular baffle wall tanks -
- (a) Requirement of chemicals is reduced by 10-40%.
- (b) Better floc formation.
- (c) Less capacity of tank is required therefore it is cheaper in construction.
- (d) More flexibility in operation, because it can be easily controlled.
- (e) Very small loss in head of water.
- (f) Can be easily installed in the existing plants.
- Mechanical flocculators have the following disadvantages:
- (a) Dead spaces in corners.
- (b) Low velocity near the shaft of paddles.
- (c) Bad short-circuiting.
- (d) Require skilled supervision and careful maintenance.

(F). CLARIFIERS -

In this operation the floc which has been formed above is allowed to settle and is separated from the water. This is done by keeping the water in sedimentation tanks which are also known as coagulation basins or clarifiers. The design of clarifiers is similar to that of plain sedimentation tanks. In the clarifiers the generated floc in previous step is settled out. Some clarifiers are filled with a moving arm known as raking arm.

These devices are also fitted with continuous sludge removing arrangements.

Now a days some firms manufacture combined unit comprising of feeding. mixing, flocculator and clarifier devices.

(G). LIMITATIONS OF THE PROCESS -

The coagulation process removes the suspended impurities of water and considerably reduces the load on the filtration process. The turbidity of water can be removed less than 20 ppm and if the process is properly controlled it can go upto 5 10 ppm. The floc formed in this process also removes bacteria upto 65%. B-coli index is removed by 70%. The efficiency of the coagulation depends on the proper control.of various processes.

(H). COAGULANT -

The chemicals added to water for forming an insoluble gelatinous flocculent precipitate during coagulation process are called as co-agulants.

Functions of **coagulants or coagulation**: The following are functions ofcoagulation :

(i) They remove turbidity.

(ii) They remove organic and inorganic matter.

(iii) They remove colour.

(iv) They remove harmful and other pathogenic bacteria.

(v) They remove algae, planktons and other organisms.

(vi) They remove taste and odour producing substances in water.

Factors Affecting Coagulation -

(1) Type of co-agulant.

(2) Quantity of coagulant.

(3) Characteristics of water such as

(a) type and quantity of suspended matter

(b) temperature of water

(c) pH of water

(4) Time, violence and method of mixing

Common Coagulants: The following are the common coagulants used forwater treatment:

1. Alum or Filtration or Aluminium Sulphate .
2. Lime and Ferrous Sulphate.
3. Chlorinated copperas.
4. Sodium aluminate.
5. Ferric coagulants.
6. Magnesium carbonate

1. ALUM OR FILTRATION OR ALUMINIUM SULPHATE -

Chemical formula is A2 (SO4)3. 8 H_2O .

(a) Aluminium sulphate or Alum is widely used as coagulant in the water treatmentplants. It requires the presence of alkalinity in water to form the floc in waters.

The following chemical reaction takes place :

(1) Al(SO4)3 18 H_2O + 3Na_2CO3 = 2Al(OH)3 + 3NaSO_1+3CO_2 + 18H_2O

(Aluminium sulphate) where Al(OH)s is the floc known as Aluminium hydroxide. Carbon dioxide is produced which is corrosive to metals. Na:COs does not form hardness inwater. It is rarely used as it is costly.

(ii) Al(SO4)3 18H_2O + 3Mg(HCO3)2= 2Al(OH) + 3MgSO4 + 18HO + 6CO_2

This reaction shows that alum is causing permanent hardness to water as Magnesium sulphate. The Aluminium hydroxide insoluble precipitate (floc) which attracts the other particles and grows in size and finally settles down.

(iii) $Al2(SO4)3.\ 18H_2O + 3Ca(HCO3) = 2Al(OH)3 + 3CaSO4 + 18H_2O + 6CO_2$ where Al(OH)3 is the floc produced.

The normal dose of alum is 5 to 20 parts per million which produces visiblefloc in water. The amount of alum required mainly depends on the turbidand colour of water.

Its dosage is given in table.

Table

S. No.	*Coagulant*	*pH value range*	*Normal dose in mg/1.*	*Density in kg/m^3*
1.	Sodium Aluminate	5.0 to 8.0	3.4 to 34.0	
2.	Ferric Chloride	5.5 to 11.0	8.5 to 51.0	830.8
3.	Aluminium Sulphate	5.5 to 8.0	5.15 to 8.50	514.3
4.	Ferric Sulphate	5.5 to 11.0	8.5 to 51.0	923.1
5.	Copperas (Ferrous Sulphates)	8.5 to 11.0	5.1 to 51.0	593.4

(b). FILTER ALUM -

It is very effective coagulant and extensively used throughout the world.

Properties: 1. It is cheap

2. It forms good floc.

3. It does not require skilled supervision for handling.

4. The treated water is very clear.

5. By using alum and main difficulty is to remove the water from theist disposal.

The problem of sludge disposal has been removed by the reuse of sludge. Floc

2. **Lime and ferrous sulphate**: Ferrous hydroxide requires a high degree of alkalinity for its formation, pH of water being 9 to 10 and for this purpose. Lime is added. The following reaction takes place.

$FeSO4.7H_2O + Ca(OH)= Fe(OH)2 + CaSO4 + 7H2O$

The precipitate Fe(OH)2 is oxidised by dissolved oxygen in the water.

$4Fe\ (OH)2 + O_2 + H_2O = 4Fe(OH)3$

where Fe(OH)3 is floc produced.

If lime is used in excess then soft waters are made caustic which undesirable. If water is already hard than this excess lime will soften it.

(3). CHLORINATED COPPERAS -

In some water works it is used successfully. It is a mixture of ferric sulphate and ferric chloride.

$$3FeSO4.7H_2O + 15Cl = Fe2(SO4)3 + FeCla+2I1H_2O$$

The ferric sulphate (Fe2SO4) and ferric chloride (FeCl3) forms the hydroxide floc.

$$2FeCl3Ca(HCO3)2 = 2Fe(OH)3 + 3CaCl2 + 6CO_2$$

$$Fe(SO4)3 + 3Ca(HCO3)= 2Fe(OH)3 + 3CaSO4 + 6CO_2$$

$$2FeCl3 + 3Ca(0)2 = 2Fe(OH)3 + 3CaCl_2$$

The chlorine and coppers are mixed in the ratio of 1: 7:8. Colour from water is also removed.

(4). SODIUM ALUMINATE ($Na2Al2NO4$) -

The best grade of it contains Al2O 55%, Na:O: 34%; Na2CO: 4.5% and Na(OH) 6.3%. It reacts very quickly to form the precipitate of aluminium hydroxide. The following chemical reaction takes place.

$$Na2Al2O4 + CaSO4 = CaAL2O4 + Na2SO4\ Na2Al2O4$$

$$+ CaCl3 = CaAl2O4 + 2NaCl$$

$$Na3Al2O4 + Ca(HCO3)2 = CaAl2O4 + Na2CO3 + CO3 + H2O$$

(5). FERRIC CHLORIDE -

FeCl3 or ferric chloride has been used successfully as coagulant in a number of water treatment plants. It is very valuable in treating soft and highly coloured waters. It is very useful in removing hydrogen sulphide and iron from well waters. ferric chloride is found in granular form. The reactions with lime and natural alkalinity are shown here.

(1) $2FeCl + 3Ca(OH)3 = 2Fe(OH)3 + 3CaCl_2$

(ii) $Fez(SO4)3 + 3Ca(OH)2 = 2Fe(OH)3 + 3CaSO$

(iii) $FeSO.\ 7H_2O + 2Ca(OH)2 = Fe(OH)2 + CaSO$ (iv) $4Fe(OH)2 + 2H_2O + O3 = 4Fe(OH)3$ (Floc) $Fe(OH)3$ is the floc which causes sedimentation.

Disadvantages of Ferric chloride -

(1) Ferric chloride dissolves readily in warm waters only.

(ii) In the presence of organic matter it is reduced to soluble ferrous.

(iii) It is very corrosive in soluble form.

(6). Magnesium Carbonate -

When magnesium carbonate reacts with water alongwith lime, insoluble compounds of magnesium hydroxide and calcium carbonate are formed as shown below.

$MgCO3 + Ca(OH)2 = Mg(OH)2 + CaCO3$ when sludge is formed.

(I). Optimum Dose Required For Co-Agulants -

The accurate amount of addition of chemical coagulants in a quantity of water is called as optimum dose of coagulant. The optimum coagulant dose is determinedby jar-test apparatus.

Construction: It consists of 4 or more beakers of 1-2 litres capacity. In eachjar stirring paddles of non-corrosive metal are placed. These can be rotated at any desired speed by gear and spindle arrangement. The following operations are adopted.

(1) Firstly, in every jar water is taken in real amount.

(2) After this, coagulant in varying amounts is added in each jar.

(3) Then all the paddles are rotated at a speed of 30 to 40 rpm with the help ofelectric motor for about 15 mts.

(4) Now speed is reduced and paddles are rotated for about 20 to 30 minutes.

(5) After this the rotation of paddles is stopped.

(6) The floc formed in each jar is noted. Then it is allowed to settle.

(7) The dose of the coagulant which gives the best floc is recorded as theoptimum dose of coagulants.

- **Note - This test should be performed frequently in water in works in order to determine the optimum dose and economical use of** coagulants. The jar-test should also be done continuously when the quality and characteristics of water change.

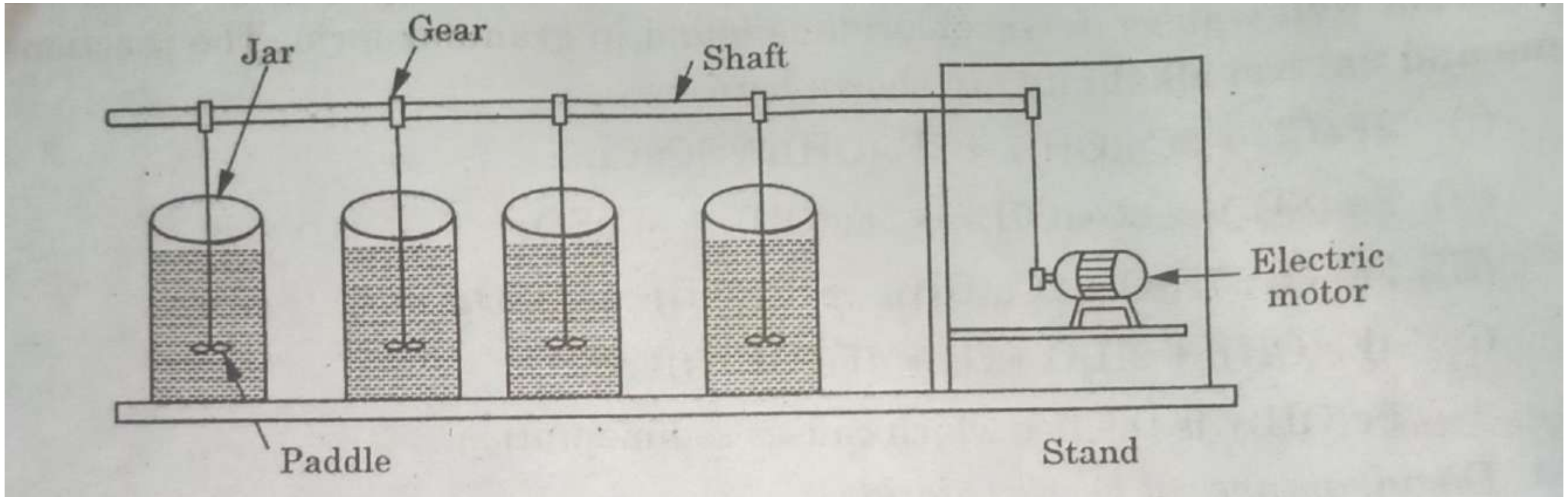


Fig. 4.9 : Jar Test

FILTRATION -

The process by which water is passed through the thick layers of sand or other granular materials for removing bacteria, colour, taste, colours and thus producing dear and sparkling water is called as filtration.

Theory of Filters -When water is filtered through bed of filter media, the following actions take place:

(i) **Mechanical Straining:** A large no**.** of voids present in between the **sand** grains retain the suspended matter on their surface as these matters are too large to pass through voids and they get arrested in them. In upper layers, most of particles are removed. The impuriti form a mat on the top of sand bed and hence helps in straining out impurities.

(ii) **Sedimentation and absorption** : Very small particles of suspended matter, colloidal particles and some bacteria settle in these small tanks or settling basin and thus this process helps in their removing from water. These particles adheres to sand particles because of physical attraction between two particles of matter.

This is only due to phenomenon of absorption.

(iii) **Metabolism**: It is the growth and life processes of living cells. Smallportions of organic impurities are also contained by suspended impurities. Theliving organisms also contribute to sedimentation and flocculation by forming sticky,gelatinous coatings on the surface of the filter grains.

(iv) **Electrolytic Action**: This takes place due to presence of electrical charges. of opposite nature in sand particles of filter media. Hence, the particles of sand attract towards each other and thus they neutralize the charges present on them. In this process, altering of chemical constituents takes place.

Types of Filters -

Acc. to type of filters used for filtration, it is of mainly 2 types :

1. Slow Sand Filter:
2. Rapid Sand Filter
   (a) Gravity type
   (b) Pressure Type

Slow Sand Filter -This filter was introduced in 1829 and was devised by James Simps on who was employed at chelsa water corporation. These filters were at their wide use the 19t century. But now-these-days these are less used.

(A). Construction Details -

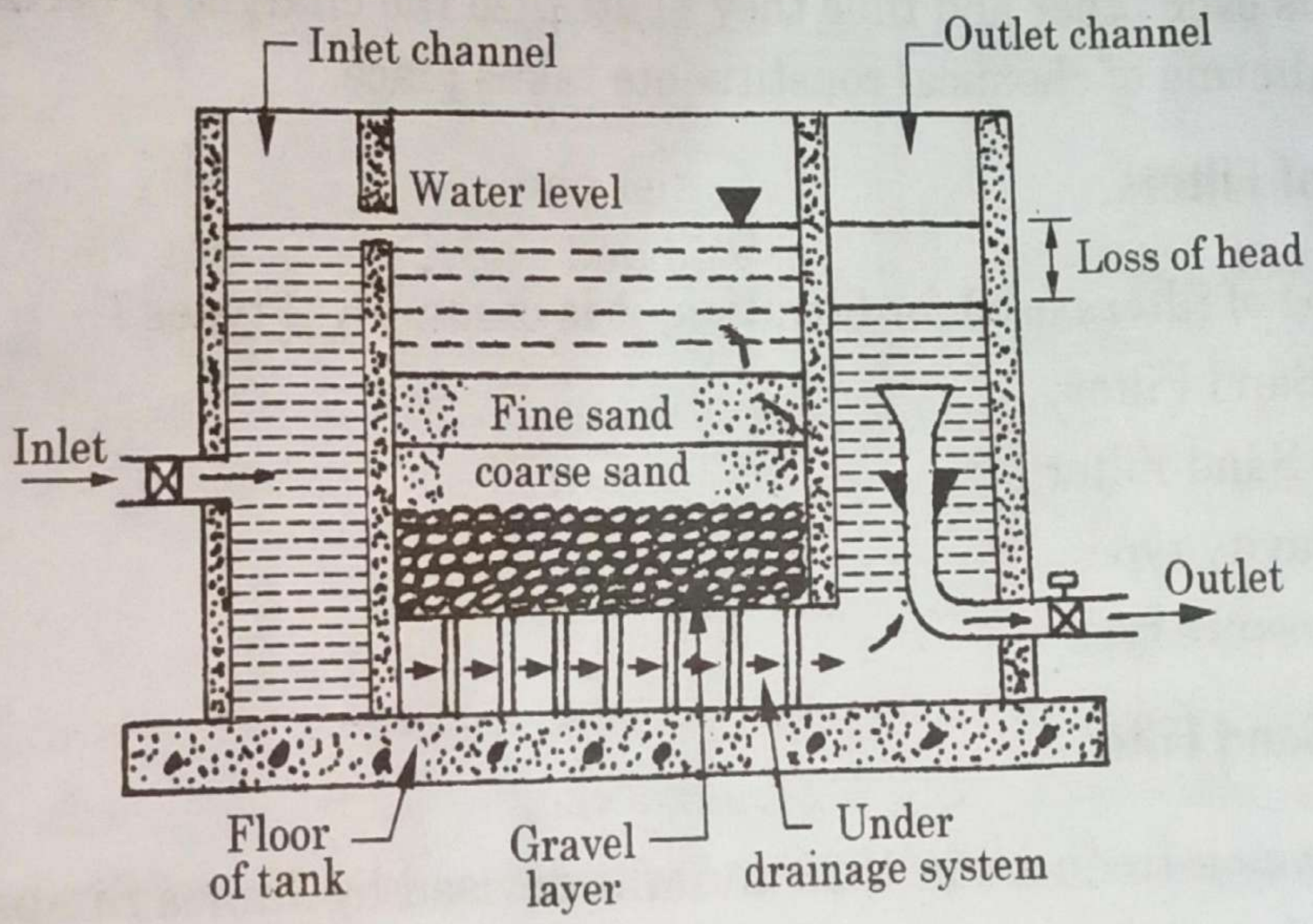
(1) **Enclosure tank**: This is like an open basin built below ground level. The water tight rectangular basin is constructed either in brick on in stone masonry. These tanks are about 2.5 m to 4 m deep and have a surface area of 100 m^2 and 2000 m^2 in play. At the bottom and 2 slope of 1 in 100 to 1 in 200 is provided towards the central drain.

(ii) **Filter media**: This consists of sand later, go to 110 cm thick. The uniformity coeff. varies from 2 to 3. bacterial efficiency will be better finer the sand, but the filtration will be at slower rate. The gravel is supported on bed of conc. sloping towards central longitudinal drain.

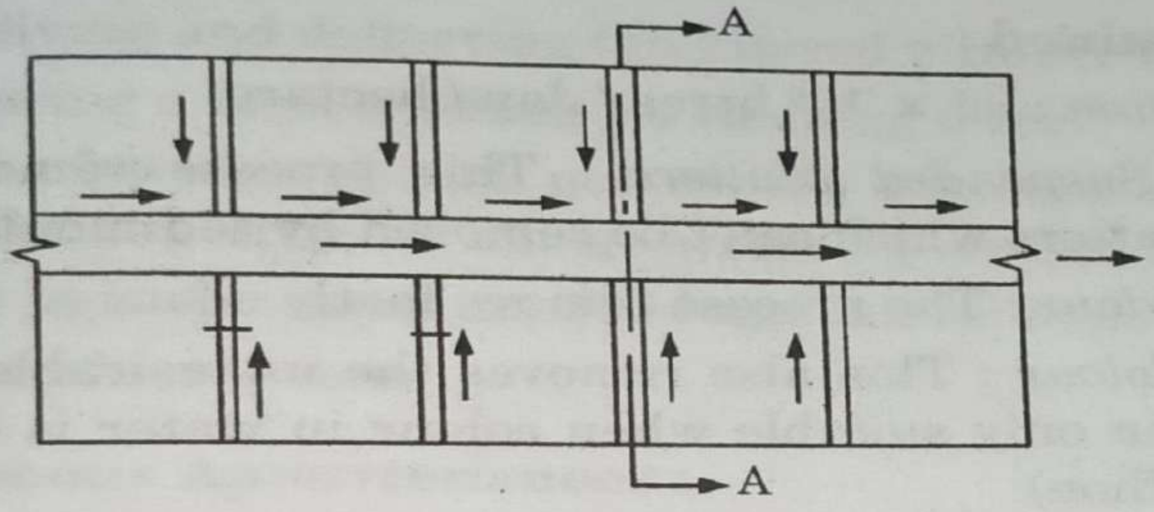
(iii) **Under Drain System**: A base to gravel later is given by this system. Basematerial is supported over this system which collects the filtered water and delivers it to clean water reservoir. Lateral drains are the earthens are pipes of 7.6 cm to 10 cm. dia. These drains collect the filtered water and discharge the main drain.

(iv) **Inlet and Outlet**: A chamber is fitted with sluice valve or float valve on the inlet side. The pipes at inlet is carried vertically in body of filter tank. An outlet pipe is provided in outlet chamber just below the water level in it. The depth of its mouth remains constant. The filtered water is collected inoutlet chamber.

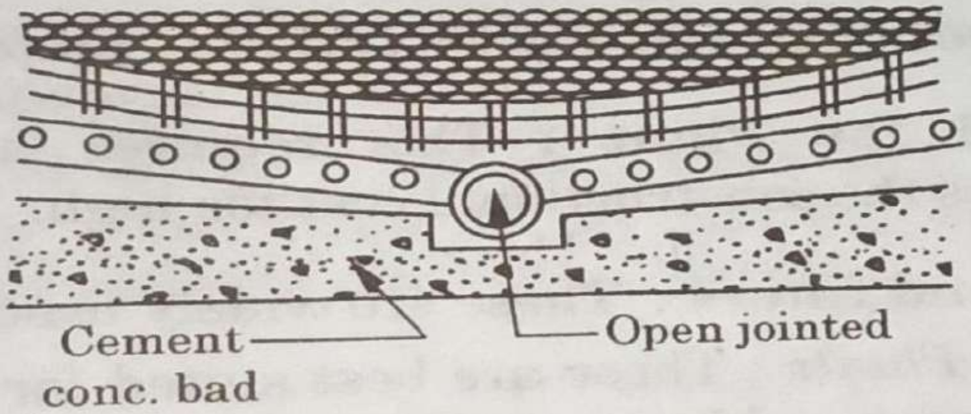
(v) **Miscellaneous Appurtenances**: A vertical pipe is provided passing throughsand layers. Special devices are provided to control the depth of water atconstant depth. The flow of water is measured by providing a meter andgauge arrangement.



(a) Slow Sand Filter (Section Elevation)



(b) Plan Showing Under Drainage System



(c) Section at AA Showing Details of Under Drains

Fig. 4.10

Working Details -

Working Features:

(i) Water enters from sedimentation tank and distributed uniformly over the filter bed. (ii) After percolating through sand layers, water get purified and then it is passed through lateral drains towards the central drain.

(iii) The flowing of water remains continued till the difference between water level on filter sand and in the outlet chamber is slightly loss. This loss is called as 'loss of head' or filter head and vary from 0.75 m to 1.25 m.

(iv) The increase in head loss takes place as time passes and when head loss.increases a specified value, the working of filter is stopped. Then, the layerof sand from top of bed is scrapped and replaced for again starting theworking of filter.

This filter works by a combination of both straining as well as microbiologicalaction. In the filter media, three zones are distinguished as.

(a) the surface coating, called 'Schmutzdecke’.

(b) the autotropic zone existing a few millimetres below schmutzdecke.

(C) the heterotropic zone which may extended to some extent 30 cm) in sandbed.

(C) **Results Obtained -**

(1) **Rate of filtration**: 62 x 10 litres / day / hectare

(ii) **Removal of Suspended Matters**: This process removes completely the suspended matters which can't be removed by sedimentation process.

(iii) **Removal of Odour**: The process remove fastly odour of water.

(iv) **Removal of Colour**: This also removes the undesirable colour from water.This process in only suitable when colour in water is less than 30 P.P.M.

(v) **Removal of Bacteria**: The extent of bacteria removal is upto 98-99%(Parts Per Million).more.

(vi) **Turbidity Removal**: This can remove turbidity up to about 50 mg/l or so.

(D) **Area Required for Plant**: This requires a large area for their construction that increases the constructional cost too high.

(E) **Uses of Slow Sand filters**: These are widely used in

(i) **Suited for Small Plants**: These are best suited for smaller plants and lowcolour carrying water and low turbidity.

(ii) **Economical**: These are very suitable to their maintenance cost.

(iii) **Easy Mechanism**: They have easy handling operation and mechanism.

(iv) **Efficiently used**: These are efficiently used because they remove turbidity,suspended matter, bacteria, low colour very efficiently.

Rapid Sand Filters (**Gravity Type**)

Now-a-days, slow sand filters have been replaced to a great extent by rapidsand filters. In 1900-1910, these were developed in U.S.A.

2. **Constructional Details** :

(i) **Filtration tank** (**Enclosure Tank**): Usually, the filtration tank is very small in size and therefore it is placed under roof. This is generally rectangular in plan and constructed either in masonry or by conc. coated with 2 D.P.C. the surface area is 20-50 m^2. The depth varies between (2.5-4.0) m.

(ii) **Filter Media**: This consists of sand layers, about 60-90 cm in depth, andplaced over a base material (gravel). Gravel is placed in 5 to 6 layers andHeach of thickness (10-15) cm. Sand used should be free from dirt, organicmatter and other suspended matter. San has effective size lies between(0.35 0.6) mm. uniformly coeff. decreases as effective size increases andthus increasing in rate of filtration.

(iii) **Under-Drainage System**: This was only provided to receive and deliver the filtered water in case of slow sand filters. But in this case, this is provided

(a) for receiving and delivering the filtered water to outlet.

(b) for allowing a back washing for cleaning filter.

The high rate of water should not exceed the settling velocity of smallest particles in filter. The two under-drainage systems provided commonly are (a) Perforated pipe system or manifold and lateral system.

(b) Pipe and strainer system

(iv) **Miscellaneous Appurtenances**:

(a) Wash water Troughs - are provided at the top of filters to collect the backwash water.

(b) Air Compressors: These are used to supply air for the agitation of sandgrains during washing of filters.

(c) **Rate Control Device**: For each filter unit, the flow of influent, the effluent, the wash water supply and the wash water waste must becontrolled by suitable rate control devices.

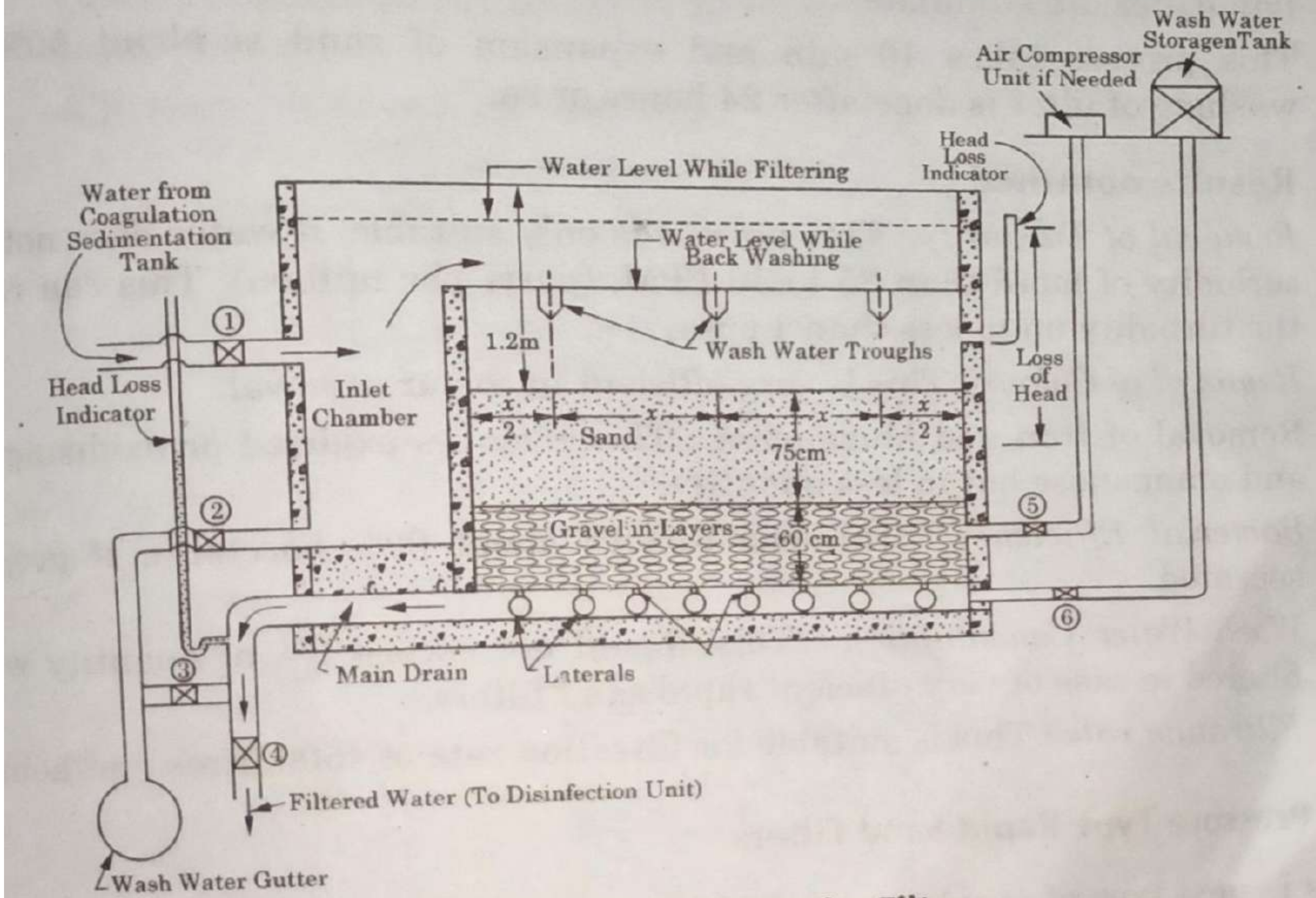


Fig. 4.11 : Rapid Gravity Filter

Working Features -

(i). From sedimentation coagulation tank, water enters through inlet pipe and distributed uniformly on the bed of sand.

(ii) The filtered water after filtration gets collected into the filtered water well.

(iii) Head loss in beginning is small but increases after the passage of time thatshows the bed has clogged.

Washing and Cleaning of Filter: This is done by back flow of water through sand bed.

Procedure:

(1) At first valve no. 1 is closed and water is drained out leaving few cms. depth of water on top of bed of sand.

(ii) Now, all the valves are closed and compressed air is passed into bed of sandthrough separate pipe system for about 3 minutes.

(iii) Loosening of dirt, clay etc. inside the bed of sand takes place due to agitating air.

(iv) Now valves (2), (3) are opened. The wash waster from wash water tankrises through the laterals, the strainers, gravels and sand bed.

(v) Expansion of sand takes place due to back flow water and thus all impurities are eliminated.

(vi) This process takes 10 min and expansion of sand is about 50%. The washing of filter is done after 24 hours or so.

Results Obtained -

(i) **Removal of Turbidity**: This process is only suitable, if water does not have turbidity of more than 35 to 40 PPM, (parts per million). This can reduce the turbidity up to less than 1 ppm.

(ii) **Removal of Colour**: This is very efficient in colour removal.

(iii) **Removal of Iron and Manganese**: This removes oxidized or oxidizing ironand manganese but in less quantity.

(iv) **Bacterial Efficiency**: This can remove about 92% baccteria, if properly. operated.

(v) **Wash Water Consumption**: This should not exceed 2% of quantity waterfiltered in case of very efficient rapid sand filters.

(vi) Filtration rate: This is suitable for filtration rate of 4500 litres / m^2/hour.

Pressure Type Rapid Sand Filters -

- This is next type of rapid sand filter that is in a closed container and water is passed through it under pressure. The pressure varies from 3 to 7 kg/cm^3.
- (a) **Constructional Details**: These can be constructed horizontal type or vertical type.

(ii) The dia of vertical varies from 2 to 2.8 m and length varies between 3-8 m.
(iii) Uniformly coefficient and effective size of filter is practically same as inrapid sand gravity type filters.

(iv)Under drainage system consists of pipe grids or false bottoms.

(b) **Working Details**: The operation/ working of pressure filter is same as that of gravity type except co-agulated water is neither flocculated nor sedimented before entering the filter. The flocculation takes place inside the pressure filter itself. The rate of filtration varies from 6000 to 15000 1/m2/hour of filter area.

Advantages -

(1) **Suited to small areas**: This filters is suitly applicable to small areas, towns and small estates.

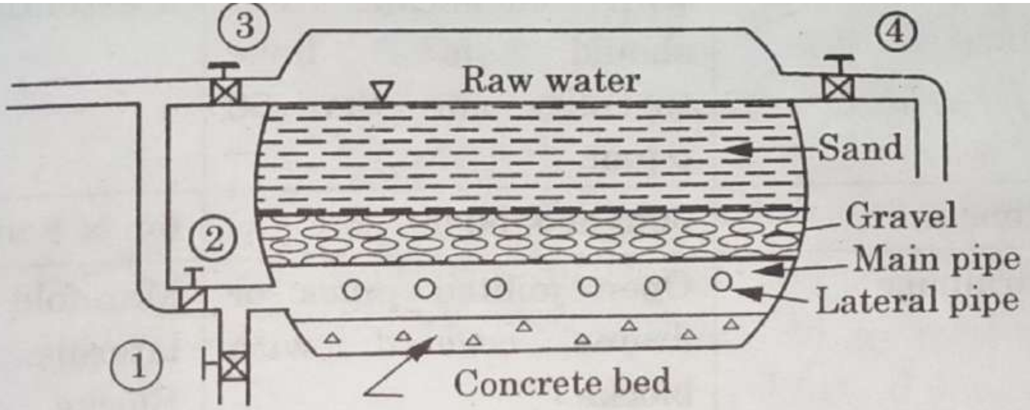
(2) **Flexible**: These filters are flexible as rate of filtration can be changed bychanging air pressure.

(3) **Less Fitting**: Less fitting are required for their installation.(i) Less Operation: Sedimentation and coagulation are not necessary beforefiltration.

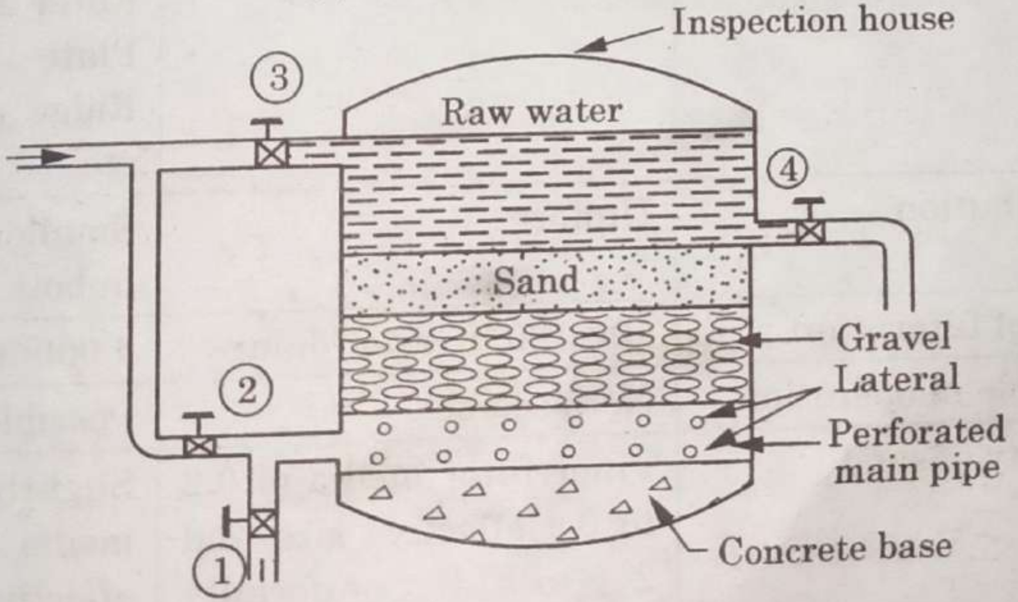
(4) **Less Area**: It require less area for their installation.

(5) **Compact Machine**: A pressure filter is a compact machine and can behandled easily.

(6) **Efficiency**: It have high efficiency.



(*a*) **Horizontal Pressure Filter**



(*b*) **Vertical Pressure Filter**

Fig. 4.12 : Pressure Filter

Disadvantages -

Small Overall Capacity: As the rate of filtration is high, the filter unit being smaller, the overall capacity of plant is small.

(ii) **Maintenance**: Their maintenance is difficult.

(iii) **High Cost**: Heavy cost is required on water treatment.

(iv) **Fixing of Back Water Channel**: Due to circular in plan, the fixing of back water channel is difficult.

(v) **Poorer quality of effluents**: As water is pump to higher rates, poorer quality of effluents are obtained.

(vi) **No Proper Inspection**: Proper Quality control and inspection is not required as filtration is done in a closed tank.

Chlorination Of Chlorine -

The process by which small quantities of chlorine or its compounds is added to water to disinfect it is called as chlorination. Chlorine has been found as the most ideal disinfectant throughout the world and used mostly at all the water works.

Application of Chlorine: Chlorine is applied in following forms.

(1) Bleaching powder or hypochlorites.

(ii) Chloramines.

(iii) Chlorine Dioxide. (iv) Gas Chlorine.

(v) Liquid Chlorine

Types of Chlorination

- Following are various types:
- (i) Plain Chlorinationi.
- (ii) Pre-Chlorination.
- (iii) Post Chlorination.
- (iv) Double Chlorination.
- (v) Super Chlorination.

- (vi) Break Point Chlorination.
- (vii) Dechlorination.

(i) **Plain Chlorination**: In this, only chlorine treatment is given to water sample. Raw water is fed into the distribution system after giving chlorine treatment only. This helps in ie. moving the bacterias, organis matters and colour from the raw water. This may be used during emergencies. The used quantity of chlorine required is about a single or more.

(ii) **Pre-chlorination**: This is the process of applying chlorine to water before purification (filtration) or rather before sedimentation. This helps in removing coagulation, and reduces the loads on filters. This also reduces tastes, odour, algae etc. This chlorine dose should be about 0.1-0.5 mg/l.

(iii) **Post-chlorination**: This is normal standard process of applying chlorinein the end, when all other treatments have been completed. The degree of chlorine should be as such as to leave a residual chlorine of about 0.1 to 0.2mg/1.

(iv) Double Chlorination: This term is used to indicate that water has been chlorinated twice-Pre and Post chlorination are generally used in this. This usespre-chlorination prior to normal postchlorination.

(v) Break-Point Chlorination: The chlorine when added in water:

(i) The bacteria are removed and .

(ii) organic matter is oxidised.

- **Advantages** of Break Point Chlorination,
- **Growth of Weeds**: It prevents growth of weeds in water.
- **Pathogens**: It destroys all the pathogenic bacteria.
- **Removal of Taste and Odour**: It removes tastes and odour from water.
- **Removal of Colour**: It removes objectionable colour from water.

- **Oxidization**: It oxidizes ammonia which is an impurity **in** water.

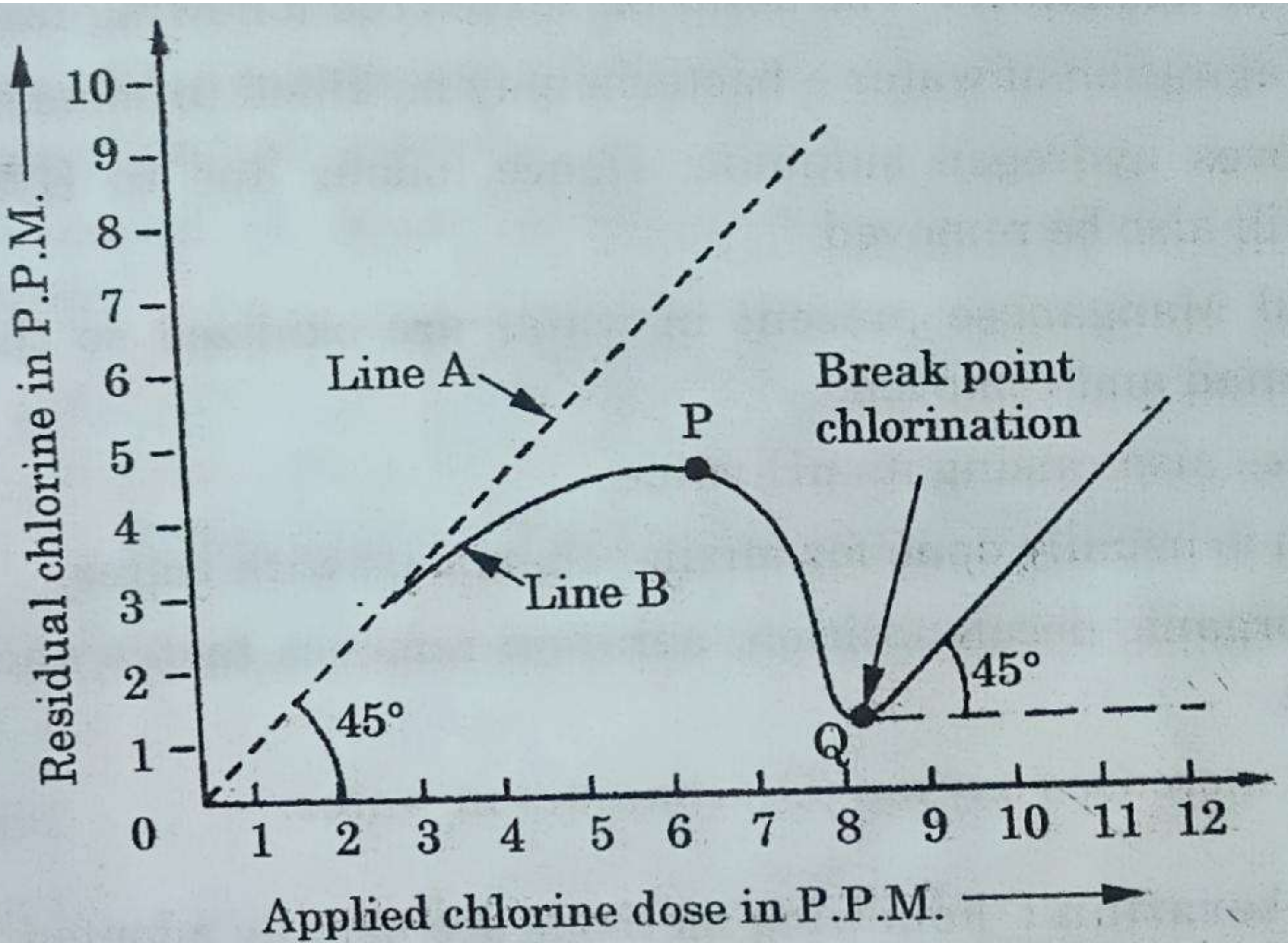


Fig. 4.14 : Graph Break Point Chlorination

(vi) **Super Chlorination**: This is a term which indicates the addition of excessive amount of chlorine to water. This huge quantity added is such that to give about 1 to 2 mg/l of residue beyond the break point in treated water.

(vii) **Dechlorination**: This means removing chlorine from water. This is required when sedimentation has been done. Dechlorating agents may also be added for this process.

AERATION

The process of bringing the water in intimate contact with air so as to absorb oxygen and to remove CO_2 gas and thus removing the unpleasant taste and odour from raw water is called aeration.

Necessity: The necessity of neration is to improve the quality of water which is drawn from great depths and by doing so, filtration is also not required.

Functions of aeration: The neration serves the following functions:

1. Due to agitation of water-bacteria may be killed to some extent.
2. It removes hydrogen sulphide. Hence, odour due to Hydrogen Sulphide (H_2S) will also be removed.
3. Iron and Manganese present in water are oxidized so that these can be precipitated and removed.
4. and hence also raising its pH value.

5.Aeration is usually done for mixing chemicals with water.

6.Due to organic decomposition, aeration removes tastes and odours caused by gases.

7. Aeration increases oxygen (O_2) contents in water.

Methods of Aeration: Following methods are usually adopted for aeration.

1. By flowing water through trickling beds.
2. mosphere as an open aque ducts and reservoir.
3. Spraying water through nozzles as in case of aeration fountain.
4. Aspiring air through water.
5. By mixing water and air under pressure to increase solubility of air.
6. Flowing of water over cascades, weirs, steps, rough etc.
7. Diffusing air through water.

Limitations of Aeration: Aeration of water has following drawbacks:

1. **Less economical Aeration is very less economical**. As only in warmer months, it is economical.

2. **Possibility of contamination**: In aeration, there is possibility of air borne contamination **of** water.
3. **Less reduction in taste and odour**: There is very loss reduction in odour and taste caused by chemicals due to industrial wastes discharged into receiving water.
4. **Difficulty in Neutralization**: A difficulty may arise during neutralization of CO; because additional quantity of lime may required for this purpose.
5. **Corrosion:** Aeration may add more oxygen in water and thus making itmore corrosive while removing iron and manganese.
6. **No efficient**: This (aeration) is not very efficient method of removal or reduction of tastes and odours caused by non-volatile substances.
7. **Difficulties in Special cases**:

(a) Iron and Manganese during aeration can be precipitated only during absence of organic matter.
(b) (b) The removal of odour is 50% only when symura was causuativeorganism.

Chapter -6

Laying of **Pipes**

Introduction

Pipes are required for the transportation of water to various places. Pipes are used for conveying and distributing water from the source to the place of consumption. Pipes may be of different materials depending upon the requirements at particular places. Pipes are generally laid below the ground level but some times they are also laid over the ground. Before laying of pipes special care is required for the long use of the pipes. Pipes are laid on a well compacted formation of sufficient width in order to avoid settlements. There should be proper gradient while laying of pipes. Due to proper gradient the transportation of water becomes easy.

LAYING OF PIPES

The various operations to be followed while laying underground pipes as follows.

(1) General planning of the area

(2) Setting out alignment of pipes

(3) Excavation of trench

(4) Bedding of excavated trench

(5) Lowering of pipes

(6) Laying of pipes

(7) Jointing of pipes

(8) Testing of pipe lines

(9) Back filling

Let us study these one by one.

General Planning of Area

Before taking up any pipe laying work, a detailed map of the area is prepared. All important roads, streets, lanes are marked clearly on it. Position of existing pipelines, sewer lines, gas pipes, are shown on the map. The length and size of the proposed water distribution pipe line should also be shown on the map. Proposed positions of valves, service connections, fire hydrants etc. should also be anticipated, so that provisions for their installation may be made during the laying of pipe line. This help in providing proper location of laying of pipes.

Setting out Alignment of Pipes

After general planning of the area the centre line of the pipe line is transferred on the earth's surface from the map of that area. To mark the centre line stakes are driven on the earth's surface. For straight work stakes are driven at 30 meter intervals whereas for curved path stakes are driven after 8 to 15 meter intervals. For hard surface iron spikes are used. By this we get the actual position of pipe line or the earth's surface.

Excavation of Trench

After making the centre line of the pipe alignment, the excavation of trenches for laying pipe line is started. The width of trench should be more than the external diameter of the pipe. At every pipe joint the depth of the excavation should be about 20 cm more (for one meter length) for easy jointing of the pipe. The pipe line should be laid more than 90 cm (say 1 m) below the ground level so that pipe may not break due to movement of heavy traffic moving over the road or railway.The excavation work is carried out by means of pick-axes or kassies. The work is done by manual labour. The excavated soil is carried out by means of iron pans or baskets. Proper protection should be made against damage from surface waters flowing into the excavated trenches from adjoining areas.If the soil of the excavated trench is soft then, the sides of the trench should be supported. The process of supporting the sides of trenches by wooden members is termed as timbering of trenches. Fig. 8.1 shows different methods of timbering of trenches in different soil conditions. Now, if the engineer-in-charge feels that there will be some danger to the adjoining structure by the excavation of soil, then, shorting up of the building can be done. This will be more clear from the figure 8.2

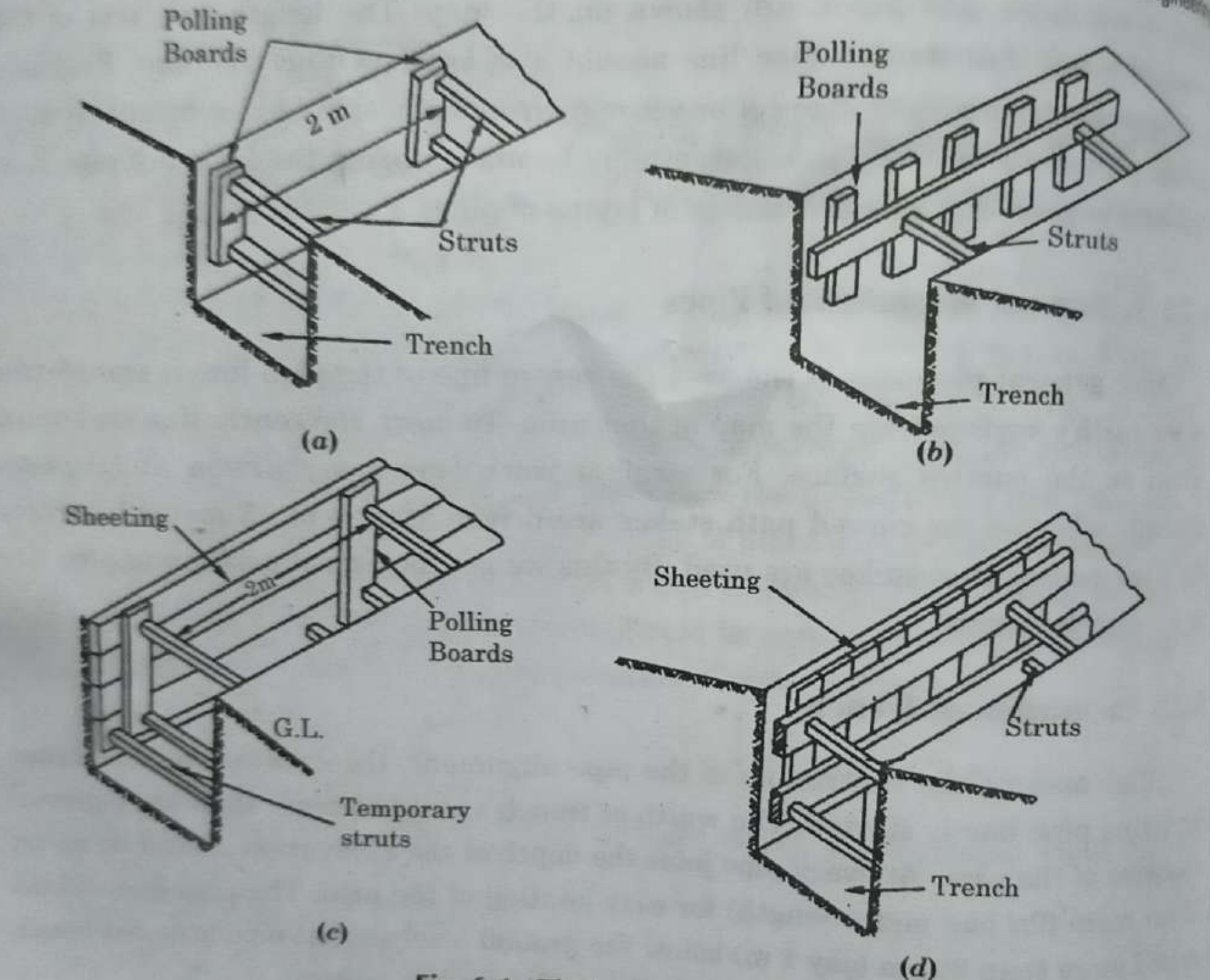


Fig. 6.1 : Timbering of Trenches

Precautions To Be Taken During Excavation

1. The excavated soil from the trench is deposited only on one side and a little away from the trench.
2. The drains, sewers etc. should be protected.
3. The pipe lengths should be stacked on one side of the trench. This side in other than the excavated soil deposit side.
4. Where the excavation is done below the ground water table, arrangements should be made for pumping of water.
5. The sides of the trench should be properly supported if the depth of excavation is large or if the soil of trench is soft
6. The signs indicating that a construction work is under progress should be placed at appropriate positions.

7. The material and equipment to be used during the construction work should be properly arranged at various places so that the interruptions to the traffic should be the least.

Bedding Of excavated trench

After excavation, the bottom of the trench should be prepared carefully. Pipe, when laid, are well bedded on a firm surface and are true to line and gradient. If trench bottom is very soft and unreliable, cement concrete bedding or cement concrete block supports may be provided for the pipes to rest upon. If this is not done, the line may deflect later on and may cause damage to the pipe joints.

Several methods of bedding the pipe in trench bottom are used, and they are shown in the following diagrams.

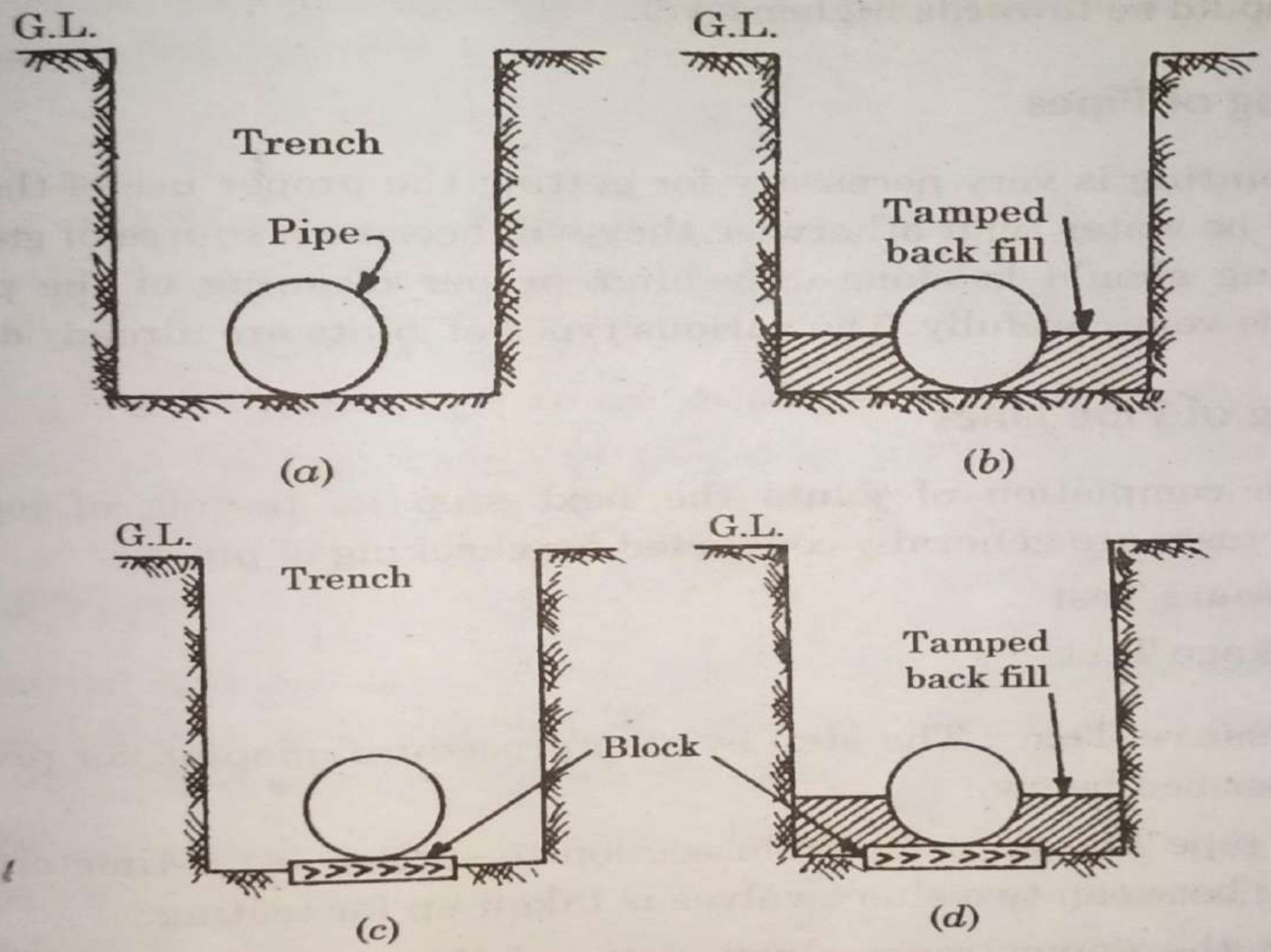


Fig. 6.2 : Bedding of Excavated Trench

Lowering of pipes

Pipes should be handled carefully so that no damage occurs to the material of pipes. The pipes should be lowered into the trench one by one and at proper place. The lowering of pipes is to be done with the help of derrick, rope or any other suitable equipment.

The pipes should not be thrown into the trench. The large sized pipes lowered into the trench with the help of chain pulley block arrangement. Hand lowering is done by means of a rope at each end with a rolling hitch. The socket face of the pipe should be in the direction of the progress of work.

Laying of Pipes

Before the laying of pipes, all dust should be carefully removed from the inner side of the pipes. Otherwise it can damage the protective coating of pipes. Laying of pipes should be done on a properly bedded trench through out the length. In case of sloping ground the laying of pipes should be started from the lower end side. The socket end should be towards higher level.

Joining of Pipes

Proper jointing is very necessary for getting the proper use of the pipe system. Joints should be water tight otherwise they will become a source of great wastage of water. Jointing should be done only after proper cleaning of the pipe ends and should be done very carefully. The various types of joints are already described in

Testing of Pipes Lines

After the completion of joints the next step is, testing of pipe lines. The following two tests are generally conducted for checking of pipes.

(a) Pressure Test

(b) Leakage Test

- (a) **Pressure Test**: The step by step procedure adopted for pressure testing of pipes is described below:

(i) The pipe line is tested from section to section. At a time only one section lying between two sluice valves is taken up for testing

(ii) First the downstream sluice valve of the section is closed and water isadmitted in the section through the upstream sluice valve. During filling air valve is properly operated to remove all air from the pipe.

(iii) Then the upstream valve of the section is closed to completely isolate the section from the rest of the pipe line.

(iv) Pressure gauges are then fitted along the pipe length of the section at suitable interval (generally 1000 mm or so) on the crown through holes leftfor this purpose.

(v) The pipe section is then connected to the delivery side of a pump through a small by-pass valve and the pump is started to increase the pressure in the pipe. The operation is continued till the pressure inside the pipereaches a pressure at least double of the maximum working pressure.

(vi) The by-pass valve is then closed and the pump is discontinued.

(vii) The pipe is kept as it is for 24 hours and inspected for any fall of pressure.This completes the pressure testing of pipes.

- (b) **Leakage Test** : After successfully completing the pressure test, the leakage test is carried out. Leakage test is to test maximum allowable leakage: which is determined by the formula:

$$Q = \frac{ND\sqrt{P}}{3.3}$$

Q=allowable leakage in cm/hr.

N = number of joints in the length of pipe

D=Diameter in mm

P = the average test pressure during the leakage test in kg/cm².

The amount of leakage should not exceed 55 litres / day / cm diameter of pipefor one kilometer length.

Back Filling

- After testing the pipe line, the trench should be refilled with the excavated material. The refilling of this excavated material back to the trench is known as back filling. Back filling has three steps. These are

(i) Step 1

(ii) Step-2

(iii) Step -3

(I) **Step -1** : In this step back filling is done from the bottom of the trench tothe level of the centre line of the pipe. This filling is done with the help of hands. The material should be deposited in the trench for its full width. Pipe should not damage during filling. Stones should be avoided during filling in this step.

(ii) **Step-2**: In this stage back filling is done from the level of the centre line of the pipe to a level 30 cm above the pipe. In this case the trench should be filled with all excavated material. Water if required can be added during this filling.

(iii)**Step-3**: In this case back filling is done from the level 30 cm above the pipeto a le el slightly above the adjacent ground level. The filling in this case can be done manually or mechanically. Now the traffic is allowed. After one month the filling is properly adjusted at ground level with the help of labour. Before the use of pipes, they must be disinfected. They are disinfected by keeping them fall with water and adding chlorine in this water. The amount of chlorine is such that the residue chlorine in water should be 50 ppm. This residue is maintained for 12 hours. Then the pipe is emptied and flushed with water.

CHAPTER : 7

BUILDING WATER SUPPLY

INTRODUCTION

In this chapter, we will deals with the water supply “ plumbing system “

Water supply fixtures and their installation

- Definition: The different types of fittings used in a building for installing ‘ water supply plumbing system ’ are called as supply fixtures.
- TYPES : There are various types of water supply fixtures

1) Ferrule : The right angled sleeva made up of brass or gun metal, and is jointed to a hole drilled in the water main, to which it screwed down with help of a plug

- It’s size varies from 1cm to 5cm bore.

2) Goose Neck : This is a small sized curved pipe bmade up of a flexible material usually 75 cm in length.

. Used for making connection b/w distributing main and service pipe.

3) Stop Cock : The control valve which controls the supply from water main is called as Stop Cock.

- It is provided just before water meter inside the house , keeping both of them in one chamber.
- They are extensively used in pipes upto 50mm sizes.
- This is housed in a suitable masonry with removable cover

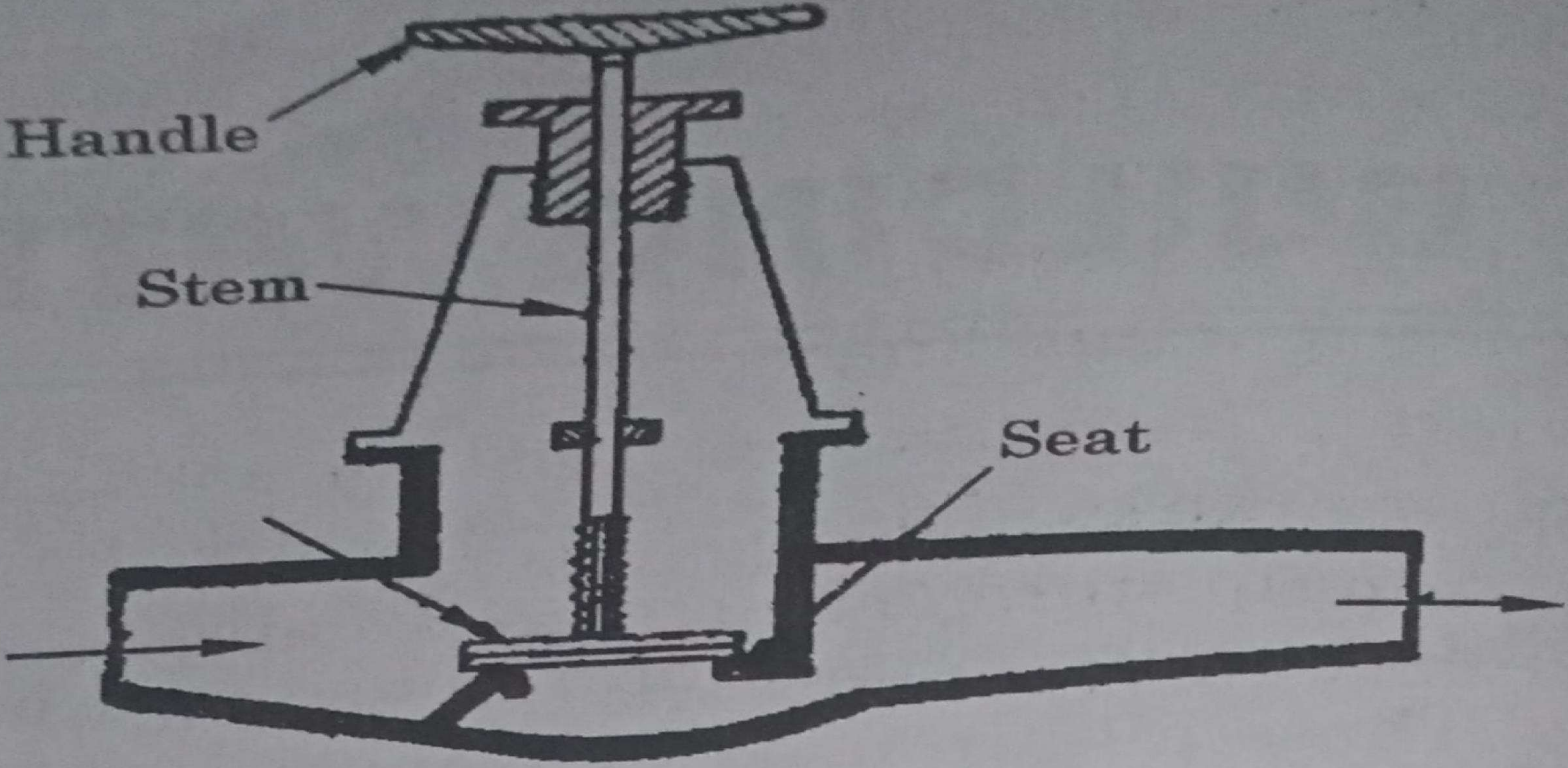


Fig. 7.1 : A Typical Stop Cock

4) Service pipe : This is a galvanised iron pipe.

. This is less than 50mm Phi

. This supplies water to building through municipal mains is this connected to main through goose neck and Ferrule.

5) Bib Cock : This is used for discharging water from pipe to consumer and also it controls the flow .

. This is generally made up of brass and provided in streets as well as in the building.

. They are available to be fitted in different pipes size from 10 to 50 mm dia.

. By rotating the handle of the bib cock , the orifice opens from a slight push given vertically upward , and closes down autdueomatically due to self – weight when the push is removed.

. The bib cocks should be water – tight and should not leak it may lead to considerable wastage of water.

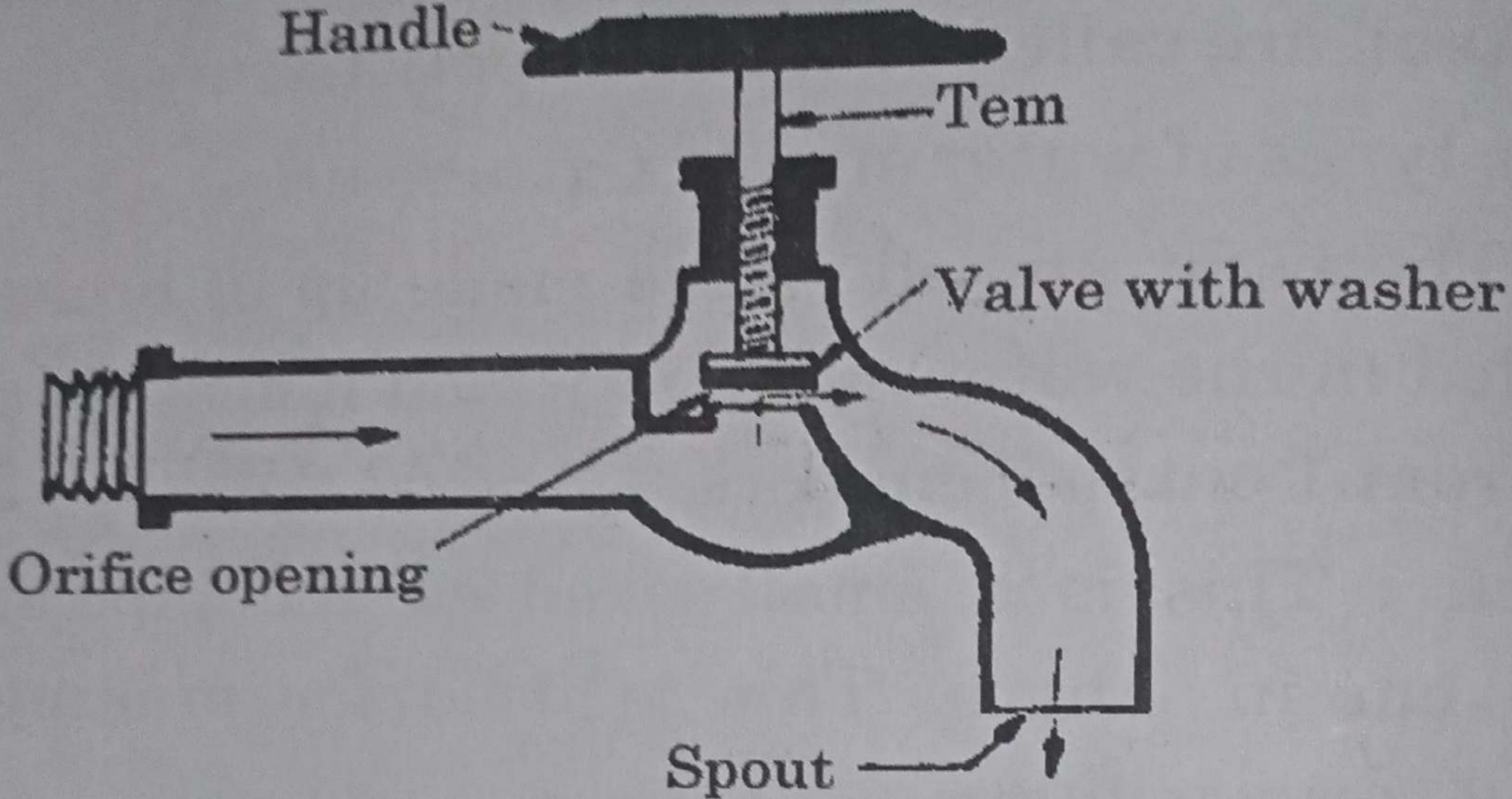


Fig. 7.2 : A Typical Bib Cock

6) Stop tap : This is provide just inside or outside the building on a pipe line .

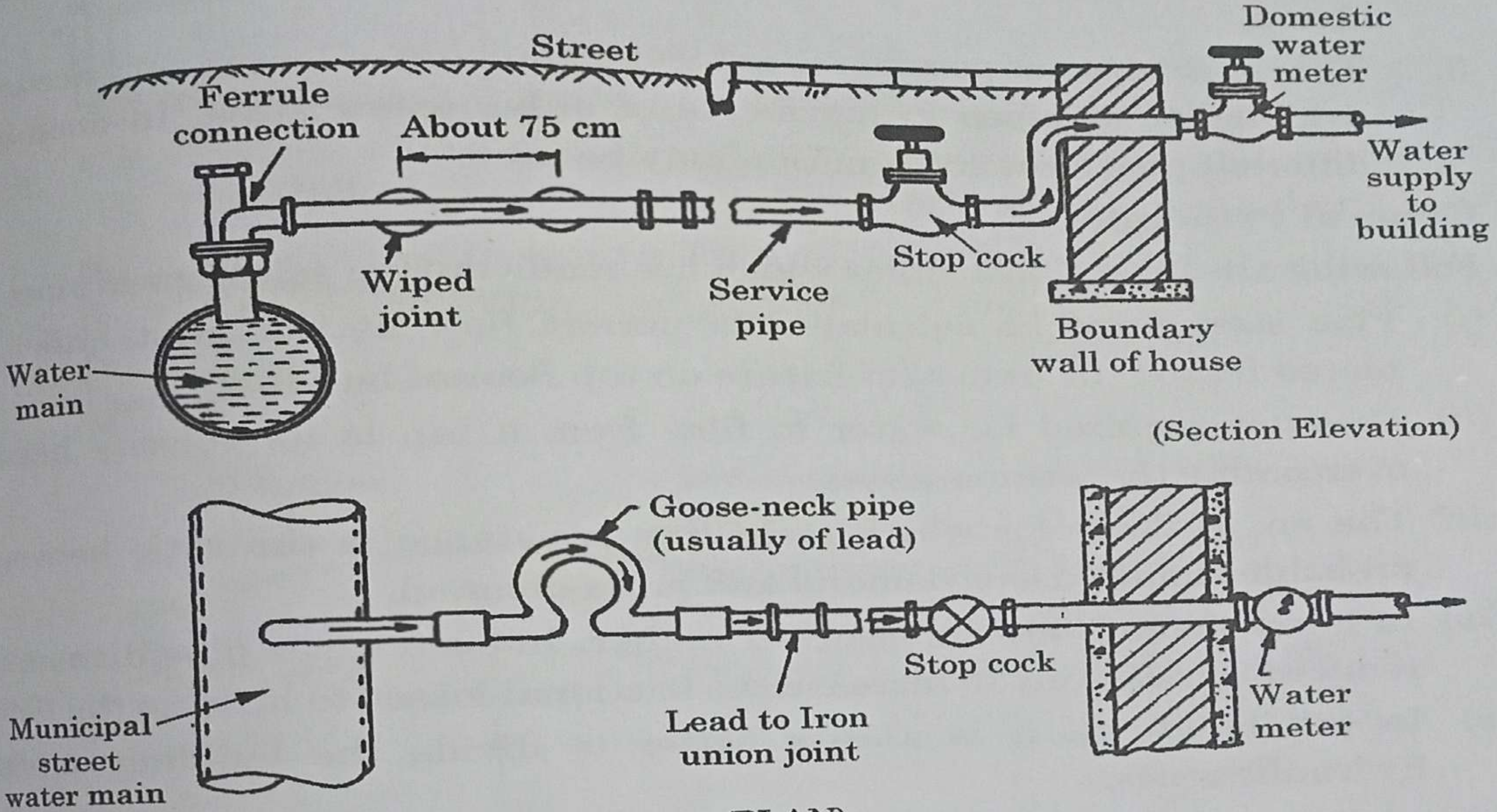
. These are used at cisterns in a building.

7) Storage tanks : The tanks provided for storing water from distributing main are called as storage tanks .

. The size of these tanks depend upon quantity of required water.

. The minimum storage by a tank should be equal to half day’s supply.

. Storage may be : overhead or ground type.



(Section Elevation)

(PLAN)

Fig. 7.3

CONNECTION TO WATER MAIN

- Water connection give by the local authorities to the consumer from city water distribution system is known as service connection.
- The following figure shows connection of water main to a consumer.

llowing figure shows connection of wat...

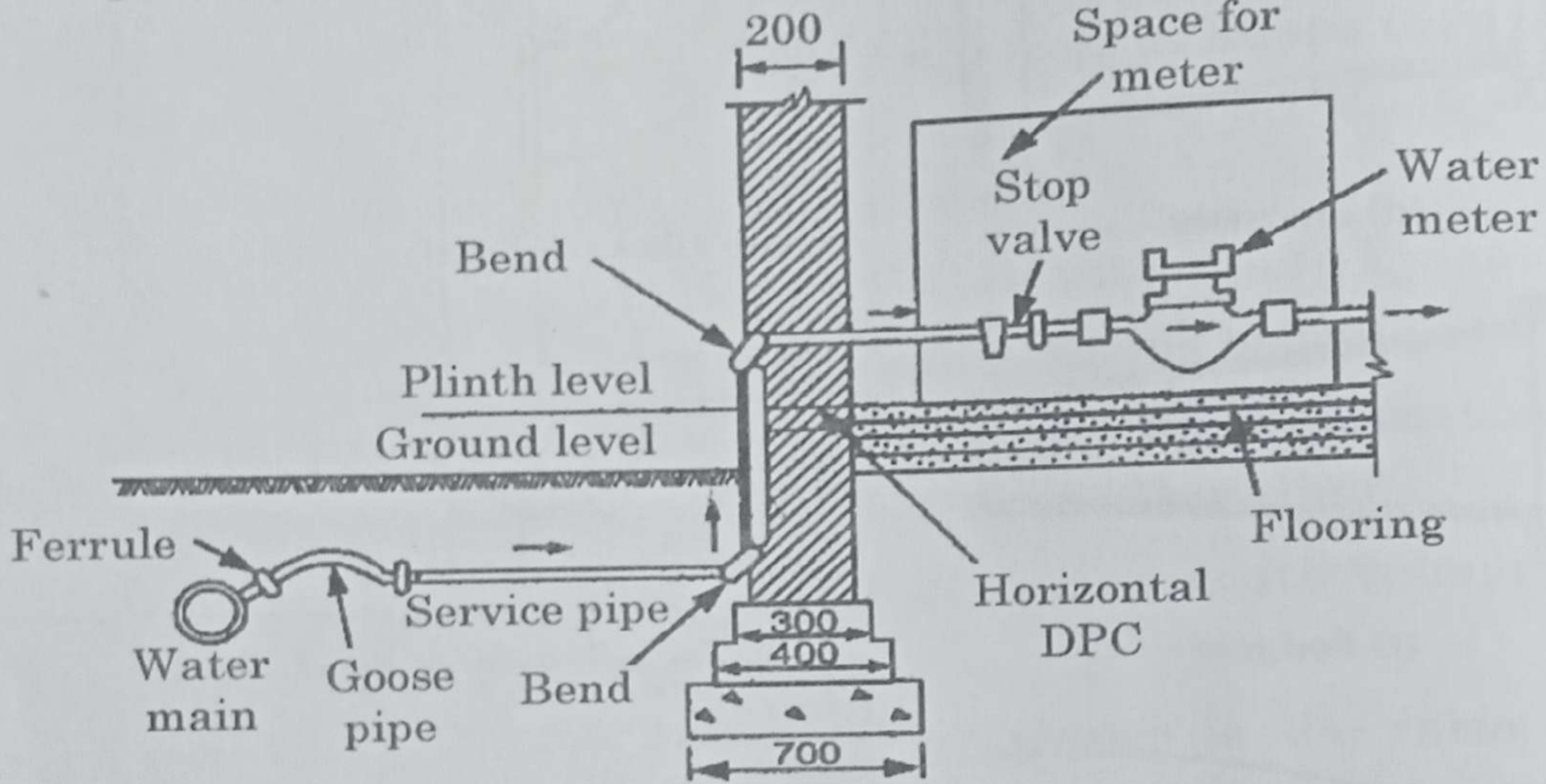


Fig. 7.5 : Service Connection

Operation : The following operation are involved in tapping of water main for house connection:

- 1) The soil is excavated upto the required depth till the distributing main for exposed.
- 2) Fix a temporary attachment below to the top of the main by a chain or strap. The attachment consists of circular water tight metal box with a revolving top .The top carries two stuffing boxes , placed at equal distance from the centre about with the top revolves. In one box , a drill and threader is placed whereas in the other box , a threader connecting Ferrule with a branch and screwed plug is placed

.

- 3) A hole is drilled in the main with the help of drill ande threaders.
- 4) As soon as the hole is bored , the covered is revolves till the threaded ferrule is on the hole.
- 5) Now ferule is screwed down in the main.
- 6) Then the tapping box apparatus is removed leaving behind the ferrule with the screwed plug which covers the outlet.
- 7) whenever required, the plug is unscrewed to allow the water to flow into the service pipe.
- 8) Now fill up the excavated soil back after protecting the connection with a cast iron covere.
- 9) After this fix a stop on the service pipe .

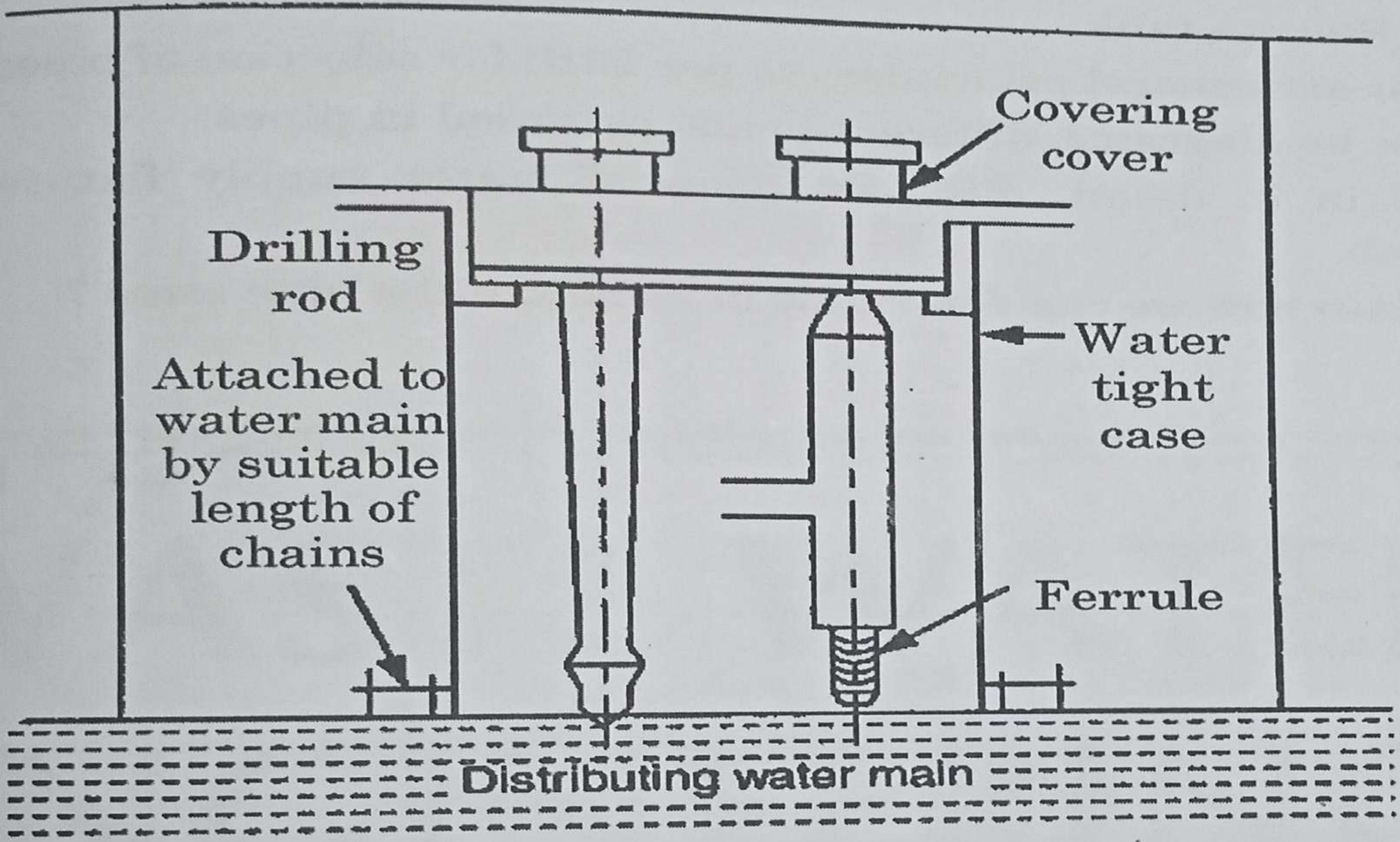


Fig. 7.6 : Tapping of water main

Ch – 8

Introduction to sanitation

Purpose of Sanitation

- To overcome the problem of generation of some undesirable matter of excremental natural,proper sanitation is required
- The purpose of Sanitation is to maintain an environment which does not affect the health of public.

- Sanitary engineering play’s a major role in the growth of cities

Necessity of systematic collection and disposal of waste water

- Water which has been already used, including other wastes,is collected and then disposed off safety at a suitable place to protect the human beings from various disease.
- So it is necessary to collect the waste water and disposed off systematically.
- The following are the point for which collection and disposal of waste water necessary:

- 1) Waste water and unhygienic food are responsible for spreading the various diseases like typhoid, paratyphoid fever , dysentery , cholera etc.
- The cause of these are improper sanitation.So collection and disposal of waster water is necessary to prevent the danger of diseases.
- 2) The flies, mosquitoes, bacteria etc. may breed on waste water and cause nuisance to the public. So it is necessary to take out all kinds of wastes from the city immediately to the safe place where it can be disposed off.
- 3) The collection and treatment is necessary for irrigation purposes. It helps to

- increase the fertility of land and also saves water from irrigation canals.
- Treatment works are required to treat sewage so that it may not pollute the atmosphere or environment.
- 4) It is necessary to dispose off properly human excreta to a sefe place before it creates unhealthy conditions in the locality

5) The waste water contains the organic matter and bacteria. So the proper treatment of sewage la necessary before the disposal. It is also necessary

because the untreated sewage may pollute the receiving land or water and make it unsate for further use.

6) The collection and treatment of sewage from individual houses is necessary by suitable means. The effluent obtained should be disposed off in a proper way otherwise it tends to create unhealthy conditions.

Waste and it’s Different Forms

- The used water, or anything else like solids or semi-solids which is thrown ofF finally in one form or the other is called a waste. Sources of waste are:
- Used water
- from houses, industries, gardens etc.,
- Solids or semi-solids
- in the form of grass, waste furniture, residue after combustion etc.

- So the waste may be in classified in the following three forms:
- (1) Dry waste
- (2) Semi-solid or semi-liquid waste • (3) Liquid waste.

Dry waste

- The waste in the dry form or free from moisture is called a dry waste.
- Dry waste comprises of

A) Rubbish

B) Ashes

C) Garbage

(a) Rubbish : These are the solid wastes like burnt grass, leaves, brokenfurniture, paper, decayed fruits.

(b) Ashes : Ashes are the residues which remain after the combustion orincomplete burning. These may be in the form of combustion of coke, timer and coal, furnaces of industries and residues from kitchens etc. These residues collectively called as ashes.

(C) Garbage : Garbage means the unwanted or undesirable material or substance like papers, glass, metals, plastics(non-burnable) etc. Garbage includes all types of semi-solid and solid waste products from roads, houses, streets, gardens, markets etc and also contains small quantities of sand, clay and gravel.

Semi- liquid waste

This type of waste contains organic matters eg. Human excreta or night soil.

Semi-liquid waste is collected by means of trucks, closed carts etc. and then it is buried in trenches. After 2-3 years, it is converted into manure and can be used for growing more crops.

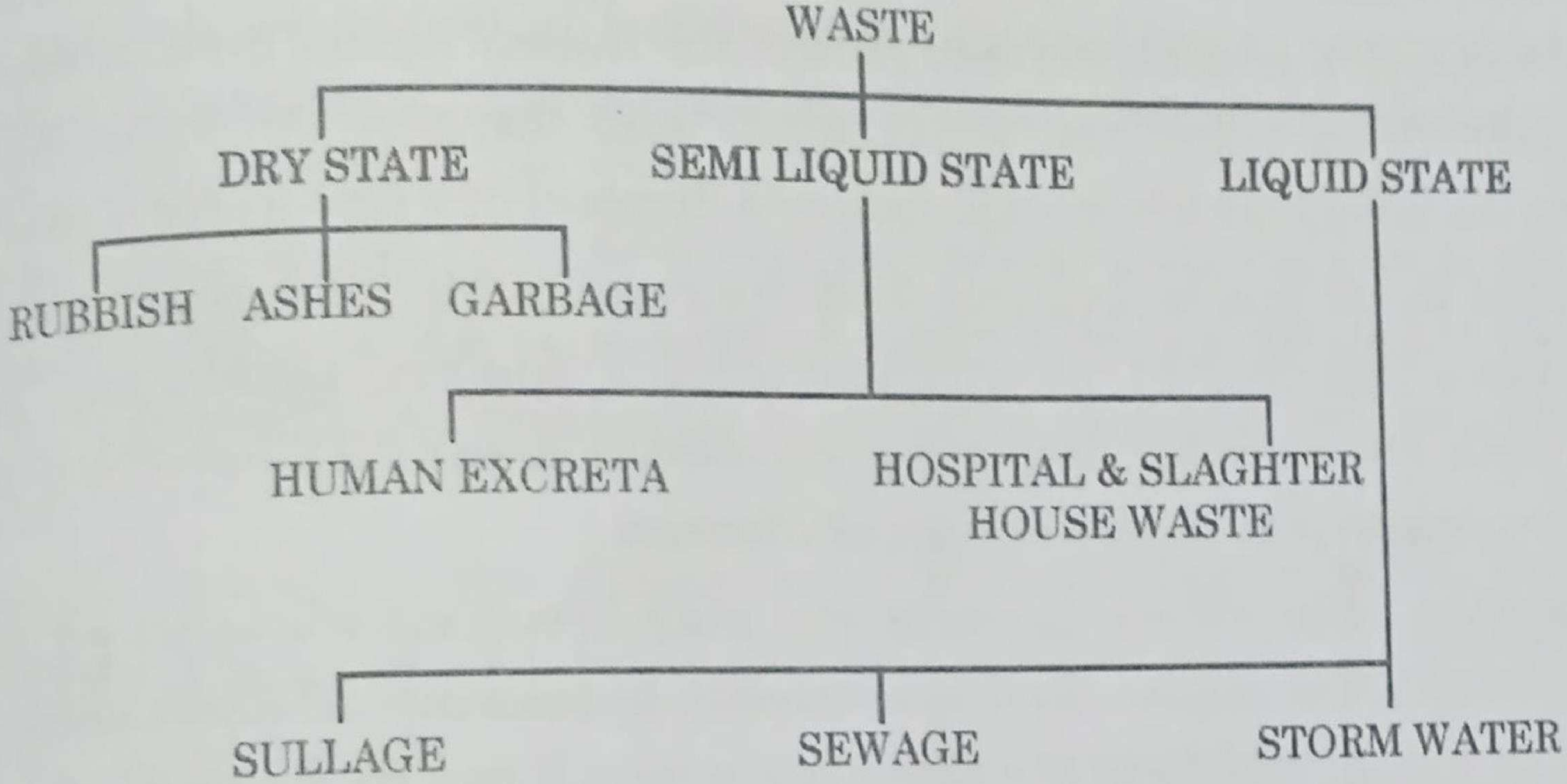
Liquid waste

- The used water from kitchens, bathrooms, wash basins, urinals, latrines,hospitals etc. is called liquid waste. The sources of liquid wastes are houses,hospitals, industries, factories, public places etc. Liquid waste is further classified as:
- (a) Sullage
- (b) Sewage
- (C) Storm Water
- Sullage : The liquid wastes form kitchens, bathrooms and was-basins are called as sullage. It contains only waste water which has not very

foul-smell. It is collected in open drains and disposed directly without any treatment.

- Sewage : It contains liquid wastes discharge form water-closets ,urinals , hospitals etc .
- Storm water : It is the liquid flowing in sewers during the rainy season Or after a period of rainfall.

Table 8.1 : Different forms of waste



Waste water Engineering

- The branch of engineering which deals with the removal and disposal of the liquid waste without causing any nuisance to the community is called Waste Water Engineering.

Sanitary Engineering and its importance

- Sanitary Engineering deals with the removal and disposal of wastes (either in solid or liquid form) of the city. The sanitary engineering or sanitation is necessary
- and important as it helps in:
- (1) To improve the environment for public health.
- (2) To make the natural streams free from pollution.
- (3) Protecting water supplies from pollution.
- (4) Proper drainage of rain water from the city.
- (5) Collecting and disposing off the domestic wastes from the cities.
- (vi) Preventing the occurrence and spreading of diseases like malaria, typhoid
- etc.
- (7) To provide closed sewers and efficient sewerage systems.

- (viii) Proper disposal of industrial wastes.
- (ix) General developments of the city.

Common Terms used in sanitary Engineering

- 1. Sewage: It may be defined as unwanted or undesirable matter either in solid, semi-solid or liquid form. The dry wastes are garbage, ashes etc. In other words the waste which contains suspended, colloidal and dissolved solids, is called sewage.
- 2) Sullage – The liquid wastes form kitchens , bathroom and wash – basins are called as Sullage.
- 3) Raw sewage: The untreated sewage is called raw sewage or crude sewage.

4)Domestic sewage: It is the sewage which originates from business buildings, institution, residential building, factories or industries. It may contain ground water, surface water or storm water. Domestic sewage is also called Sanitary Sewage.

6) Storm sewage : The excess water from rainfall which runs off on thesurface of ground is known as storm sewage. Surface water is different from the storm water.

7) Combined sewage : The domestic sewage along with surface or storm water, with or without industrial wastes is called combined sewage.

8) Dilute sewage : The sewage which contains less than 150 ppm ofsuspended solids and B.O.D. is called dilute sewage. It includes animal dung and horse drooping but they are less foul in nature and so does not create bad smell.

9) Fresh sewage : The sewage which contains dissolved oxygen (D.O.) at the point of treatment is called fresh sewage.

10) Septic sewage : The sewage which under the treatment process is called septic sewage.

11) Refuse : All types of solid wastes including garbage, ashes, rubbish, market refuse, rejected vegetables and food articles etc. are known as refuse.

12) Sewer : An underground pipe or Conduit which is used to carrying sewage is called sewer.

13) A common sewer : A common sewer is one in which all neighbour have equal rights to use.

14) Storm sewer : The sewers which carry Strom sewage along with surface run off and street wash is called Storm sewage.

- 15) Sanitary Sewer: The sewers which carry sanitary sewage and excludes all other types of sewage like storm sewage, surface water and ground water, is called as sanitary sewers.
- 16) Main or Trunk sewer : A sewer which receives the sewage from the tributary branches and branch sewers. In other words a sewer which receives the sewage from the collection system and conducts it into the final disposal point is called main sewer. It is also called as outfall sewer.
- 17) Laterals/lateral sewer: A sewer of smaller diameter which discharge into another sewer, having no other sewer tributary to it is called a lateral sewer. The house connections discharge the water into lateral sewer.
- 18) Branch sewer : It is a pipe which connects the lateral sewers to the main sewer. It receives the sewage from a small area and discharges it into a main sewer.

19) House sewer : It is a house connections sewer. A pipe conveying sewage from a single building to common sewer ise. Lateral pipe (immediate disposal) 20) Drain. A pipe or channel which carries waste-liquid from a house or group of houses to the sewer is called drain. An open channel is called an open drain. 21)Overflow sewer : The sewer which is built to carry the flows in excess of the capacity of an existing sewer is called an overflow sewer. It is also called relief sewer.

22) Combined sewer : The sewer which receives storm water, surface run offand sewage is called a combined sewer.

23) Barrel : A pipe having uniform diameter and wall thickness throughout itslength is called barrel.

24) Depressed sewer : When a section of sewer line is constructed lower thanthe other, then it is called as depressed sewer. It is to be done to avoid any obstacle. The pressure in this sewer is more than atmospheric and runs under the gravitational force.

25) Dry Weather Flow : The normal flow in a sewer during a dry weather iscalled Dry Weather Flow(D.W.F.).

26) Intercepting sewer : In a combined system a sewer receives dry weatherflow and storm water from various outlets and conduits such water to the point of treatment. This sewer is called intercepting sewer.

27) Separate sewer: A sewer which is only used to carry sanitary sewage ordry weather flow is known as separate sewer.

28) Sewerage : The various pipes are used to carry sewage. The network ofsewers or pipes used for transporting the sewage is called sewerage.

29. Sewerage system : The system of conduits and accessories used foraccomplish the sewerage is known as sewerage system.

30. Sewage treatment : It is the artificial process by which sewage is subjected to remove the objectionable constituents to make it less dangerous or offensive.
31. Sewage disposal : The art of disposing off sewage by any method is knownas sewage disposal.
32. Invert : The lower most surface of underground conduit or drain is knownas invert.
33. Vent pipe : It is a pipe line which is erected to provide circulation of air within drainage system. It is also used to protect trap seals from siphonage and back flow. 34. Anti-siphonage : The device, used to preserve the water seal in traps by ventilation is known as anti-siphonage.

PRINCIPLE OF SANITATION

- The principle of sanitation is to provide accessibility of water, proper orientation of building and better living conditions. It includes the followings points:-
- (1) Collection and Conveyance
- (ii) Orientation of the building

- (ii) Availability of water
- (iv) Disposal

- (i) Collection : The wastes from building should be collected as it is formed. The collected water is removed by providing underground pipes or conduits up to the final treatment point so that it may not create nuisance to the public.
- (ii) Orientation of the building : The construction and orientation of building should be proper. It is necessary to obtain sufficient light and fresh air in all the rooms. Bad construction causes the occurrence of dampness in building and so it should be prevented.
- (iii) Availability of water : The water requirements of the people should be fulfilled in proper way as it is anway essential part of life.

- (iv) Disposal : The sewage should be disposed off after proper treatment so that the sewage become harmless to land or aquatic life where the sewage is disposed off.

METHODS OF COLLECTION OR SANITATION

- The sanitation of a city is done by the following two methods: • (1) Dry or Conservancy system
- (ii) Water carriage system.

- In conservancy method, the waste products are conveyed to the treatment point or point where it is disposed off, without using the water. So this method is also called as dry method.

Conservancy System

- This method is very old and now-a-days it has become out of date. It does not use even in villages, small towns and the cities. In this method, different types of wastes is collected manually and transported using proper conveyance to the point of disposal. By this method, various types of wastes are collected, conveyed and disposed off separately. Therefore, it is called conservancy method. The wastes may be dry or wet.

Advantages of the Conservancy System:

- The following are the advantages of this system:
- (1) It is cheaper in initial cost.
- (2) The quantity of sewage reaching at the treatment plant is less.
- 3) It remains effective also in drastic condition like flood.

Disadvantages of conservancy System

- 1. Although it's initial cost is low but its maintenance cost is high.
- 2 The underground water may be polluted by using this method.

- 3. More land space is necessary for burring human excreta. So for big cities this system can not be used.
- 4. Under unusual conditions, decomposition of sewage will cause unsafe to the public. In other words this method entirely depends on the labours or sweepers. In the absence of labour, proper disposal of sanitation is not possible and the health of public will be in danger.
- 5. The serious diseases may be spread if the proper disposal of sewage is not to be done.
- 6. The sewage is removed once in a day so there may be chances of fly nuisance,

- 7. It is suitable only for single storey buildings houses. The multistoried buildings cannot be designed for this system because latrines are provided away from the living rooms.
- 8. The night soil carts cannot be allowed to pass through the main roads due to foul smell. Otherwise, it will cause great inconvenience to the traffic.

Water carriage system

- In this system, the wastes are get mixed with sufficient quantity of water by flushing and this waste mixture is transport for subsequent treatment and disposal and is very useful in practice now a days.

Advantages of water carriage method

- 1) For congested areas this method is more suitable. Also there is no inconvenience to the traffic. In this method only one sewer line is laid which requires less space as compared to conservancy system.
- 2) This method is possible for multi-storied buildings as the buildings can be designed compact as one possible unit.
- 3) No additional water is required as in conservancy system. In this system only normal water supply is sufficient.

- 4) In this system more quantity of sewage is treated. Also selfcleaning of sewers is possible even at less gradients with velocity of more sewage.
- 5) This is a hygienic method of collection as all the sewage matters are collected and conveyed without employing the human agency. So this method does not depend on human labour. The human agencies are used when sewers get chocked.
- 6) The sewage goes in closed sewers. So there is no nuisance in the atmosphere due to offensive matters and risk of epidemics can be reduced.

7) Less land is required for disposal works as compared to conservancy system in which more land space is necessary.

8. Also in this system, sewage can be used for many purposes after treatment.

Disadvantages of water carriage method

- 1. The initial cost of the syste is very high and the maintenance cost is also high.
- 2 In rainy season this system may be fail as large volume of sewage is
- required to be treated.
- 3. As in monsoon season more sewage is required to be treated but inremaining period very small sewage is to be treated. The

requirement of this system not same in different seasons. Therefore, the system is not economical.

8.8.3 Comparison of Water Carriage and Conservancy System

S.No.	*Water Carriage System*	*Conservancy System*
1.	The system involves high initial cost.	It is cheaper in initial cost because storm water passes separately in open drains.
2.	No risk of spreading epidemics or disease germs.	In this system the carts used for conveyance of night soil are accessible to flies and insects. Then these insects may transmit and spread out the disease germs in the locality.

S.No.	Water Carriage System	Conservancy System
3.	Aesthetic appearance of the city can be obtained by using this system. It is possible as sewers being underground do not affect the beauty of the place and also do not cause any inconvenience to the traffic. So the area appears neat and clean.	In this system it is not possible to obtain aesthetic appearance. In it the open drains are responsible for these problems and the area appears dirty.
4.	It is very useful for compact design and multistoried houses, hence universally employed in practice.	This system is applicable only for single storey building. It is because, this system is not compact.
5.	In this system less area is required for burying sewage or waste matter or disposal works.	More land is required for burying human excreta as compared to water carriage system.
6.	It is hygienic method because it avoids the use of human agency as far as possible for handling the wastes.	It is unhygienic method because manual labour involved for removal of human excreta.

7.	There is no foul smell as the closets remains clean and neat. Therefore toilets can be constructed with rooms as a compact unit.	There is foul smell from the closets therefore they are constructed away from the rooms. Nuisance creates due to bad smell resulting from decomposition of the accumulated night soil.
8.	The excreta is removed immediately.	Excreta are not removed immediately therefore its decomposition starts.
9.	It requires high technical knowledge or skill. Also skilled labour is required for operating the plants.	No technical knowledge or skilled labour is required.
10.	There is no problem of human agency as very few laborers are required. So it is independent system.	This system depends fully on human agency. So it may create problems in case of strike of labours.

CHAPTER - 10

LAYINGANDCONSTRUCTIONOFSEWERS

CONSTRUCTION OF SEWERS -

Sewers are generally circular pipes which are laid below the ground surface.

The complete design and drawing are required before execution and actual construction of sewers. It includes (a) sewer alignment plans (b) longitudinal sections of various sewers (c) detailed drawing of all the appurtenances.

Sewer appurtenances are those structures which are constructed along the sewersor sewerage system like manholes, drop manholes, flushing tanks etc.

LAYING OF SEWERS -

Sewers are laid down so that the sewage can flow under gravity and sloping towards the outfall. All sewer pipes are generally laid starting "heir outfall to starting end. Also the different points are located along the proposed alignment.These points are necessary for the construction of manholes.

STAGES OF CONSTRUCTION AND LAYING OF SEWERS

The process of placing sewers at the correct alignment with proper gradient known as laying of sewers. The various steps to be followed in construction and laying of sewers are:

(i). Setting out alignment of sewers .

(ii). Excavation of trenches and dewatering.

(iii). Setting the gradient with boning rod and checking the gradient.

(iv). Preparation of bedding.

(v). Handling of sewers and jointing of sewers.

(vi). Testing of sewers.

(vii). Backfilling of the trenches and restoration to original surface.

1. The small sewers should be laid in the straight line between manholes.
2. Large sewers can be laid on long and easy curves.
3. All the sewers should be laid in the direction of the natural slope of the ground to use gravity flow. It is necessary to minimize the excavation cost.
4. To raise the drainage from the basement into sewer, pumps may be used in the building.

5. The location of sewers should give minimum cost which can be achieve by providing short house connections.

CENTRE LINE OF THE SEWER -

(A). FIRST METHOD - In this method, two vertical posts are driven into the ground at known distances from the centre line. A sight rail is fixed between vertical posts at a convenient height as shown in Fig. 10.1(a). This method can be used for taking the levels of the proposed sewer line.

(B). SECOND METHOD – A line known as offset is marked in it parallel to the centre line of sewer at a particular distance say 3 m Fig. 10.1(b).

This line is used in locating the centre line of the sewer. This method has the advantage that it can be used simultaneously with the excavation work.

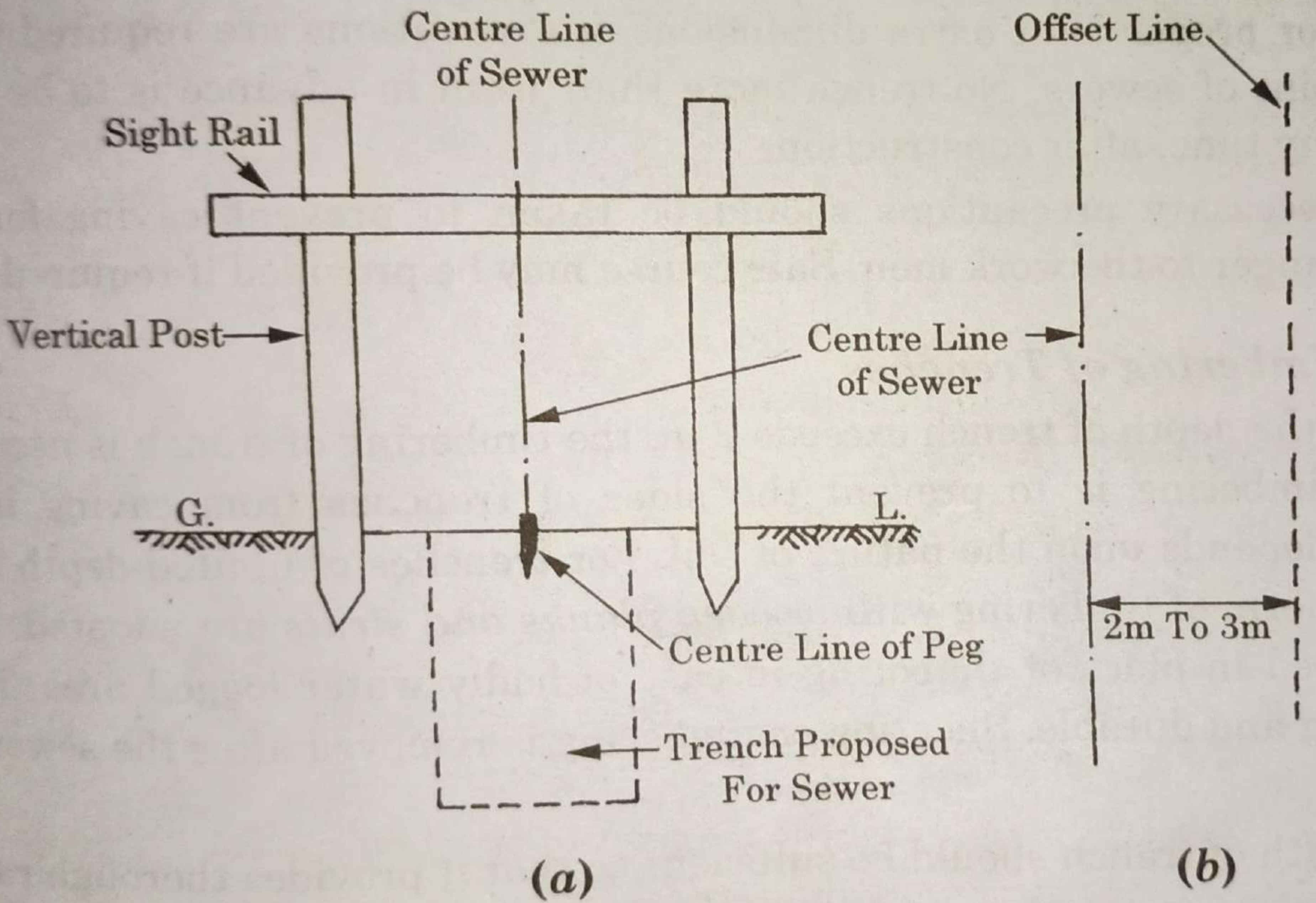


Fig. 10.1 : Maintaining Centre Line of Sewer

EXCAVATION OF TRENCHES -

1. For hard noil mechanical equipments are used.

2. The width of trench ahould be at least 175 mm more than the diameter of sewer for proper lowering and handling of the sewer pipe.

3. The width of trench is kept 50 cm more than the external diameter of the sowers at the place of jointing but in other places it is kept about 20 cmmore.

4. The minimum trench width is 800 mm which is necessary for jointing of sewer line.

5.Trenches should be supported with suitable materials in unstable soils toprevent caving or collapse of the side walls. Sheeting and bracing may also be provided in timbering the trenchen.

6. For proper joint extra dimensions of excavations are required to make the joint of sowers. No trench more than 18 m in advance is to be left open at 6.any time, after construction.

7. Necessary precautions should be taken to prevent caving for minimumdanger to the work men. Safe course may be provided if required.

TIMBERING OF TRENCHES -

When the depth of trench exceeds 2 m, the timbering of trench is necessary. The object of timbering is to prevent the sides of trenches from caving in. Type of timbering depends upon the nature of soil. For trenches of limited depth and width, the simple form of timbering with wooden planks and struts are adopted. Steel sheet piling is used in place of timbering in case of badly water logged area. It is water tight, strong and durable. Sheeting or timbering is removed after the sewer has been laid.

The width of trench should be sufficient so that it provides thorough ramming ofthe backfilling of material around the sewer.

Some of the common methods of timbering the trenches if excavation work arehown in Fig. 10.2 and Fig. 10.3.

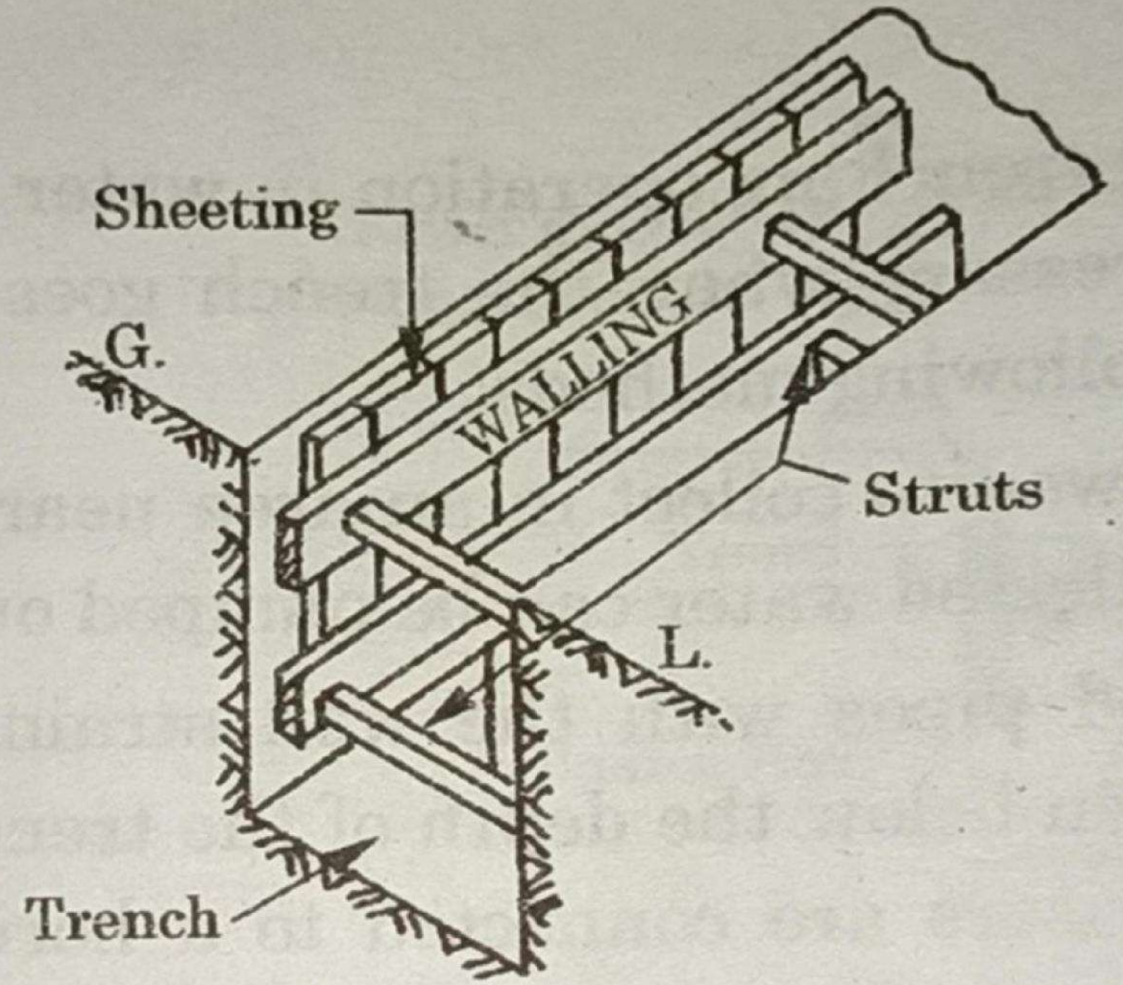


Fig. 10.2 : Sheeting of Trenches

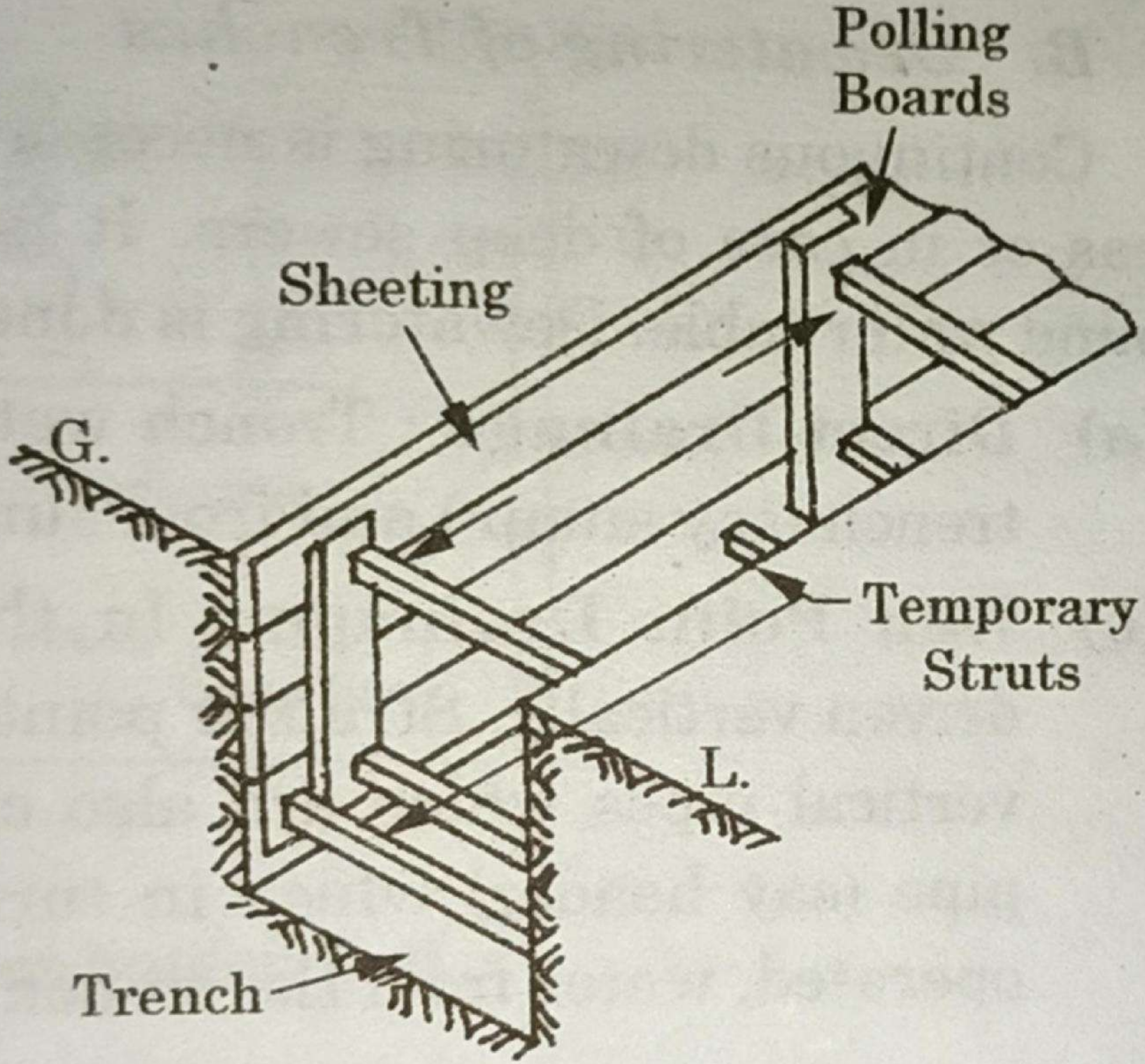


Fig. 10.3 : Timbering of Treches by boards & struts

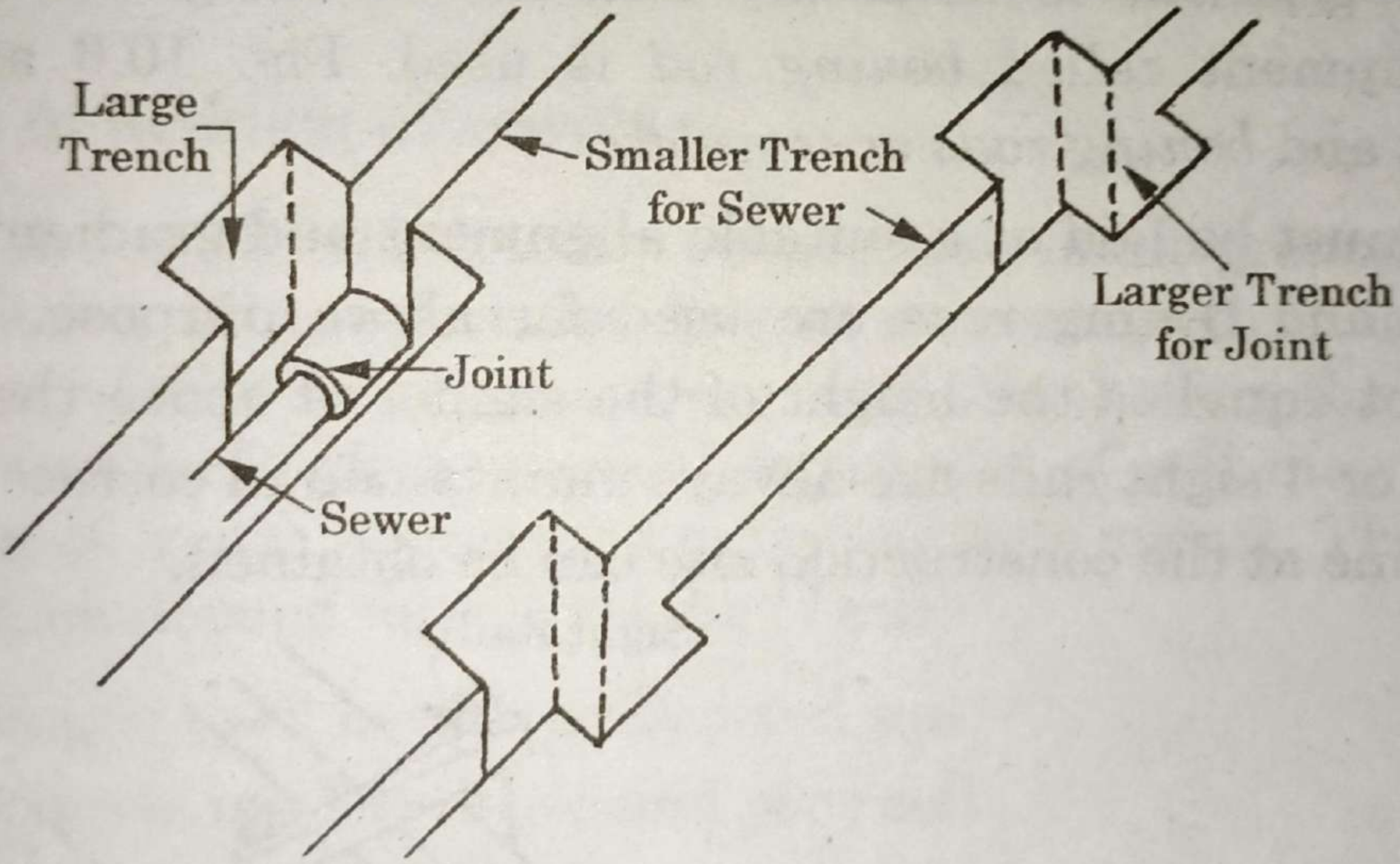


Fig. 10.4 : Excavation of Trenches For *Laying And Jointing Sewers*

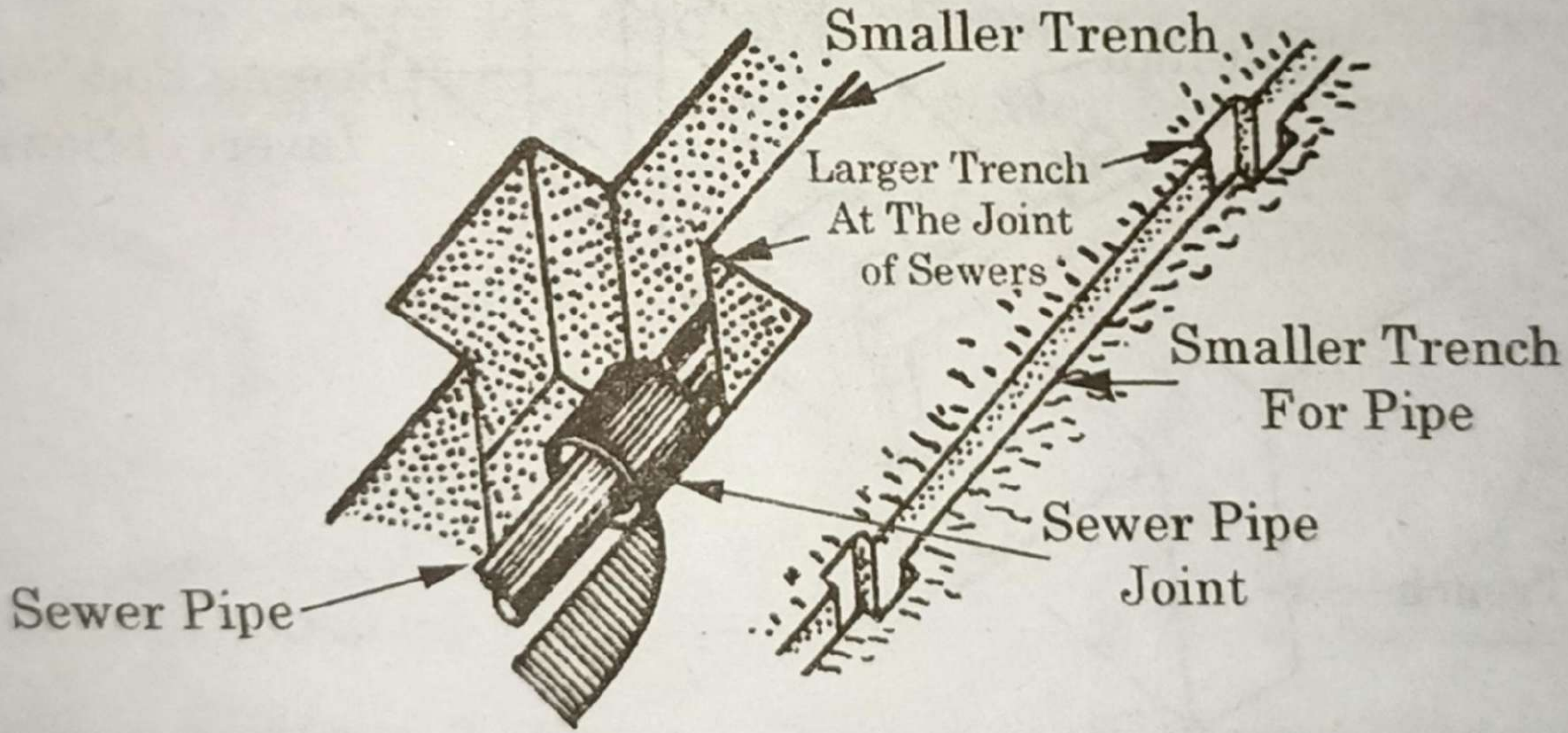


Fig. 10.5 : Excavation of Trenches

(B). DEWATERING OF TRENCHES

Continuous dewatering is necessary during trenching operation in water logged areas or in case of deep sewers. It is also necessary when the trench goen below ground water table. Dewatering is done by the following methods:

(A). Direct Drainage : Trench water is allowed to collect in an area nearby the trench (say sump) and from sump the collected water can be pumped out.

(B). Well Point Drainage: In this method pipes with the well strainer are driven vertically. Strainer points are taken below the depth of the trench. All vertical pipes which are also called as risers are connected to a horizontal pipe (say header) which in turn is connected to a pump. So when pump is operated, water from the trench is removed through this well point drainage.

CHECKING THE GRADIENT OF SEWER LINES -

The sewers must be laid at a suitable alignment and gradient to ensure gravityflow. Sight rails and boning rods are used for above purpose. The height of theboning rod is kept equal to the height of the sight rail above the invert line of thesewer. At least 3 or 4 sight rails are always maintained in correct level and gradientalong the sewer line at the construction site can be obtained.

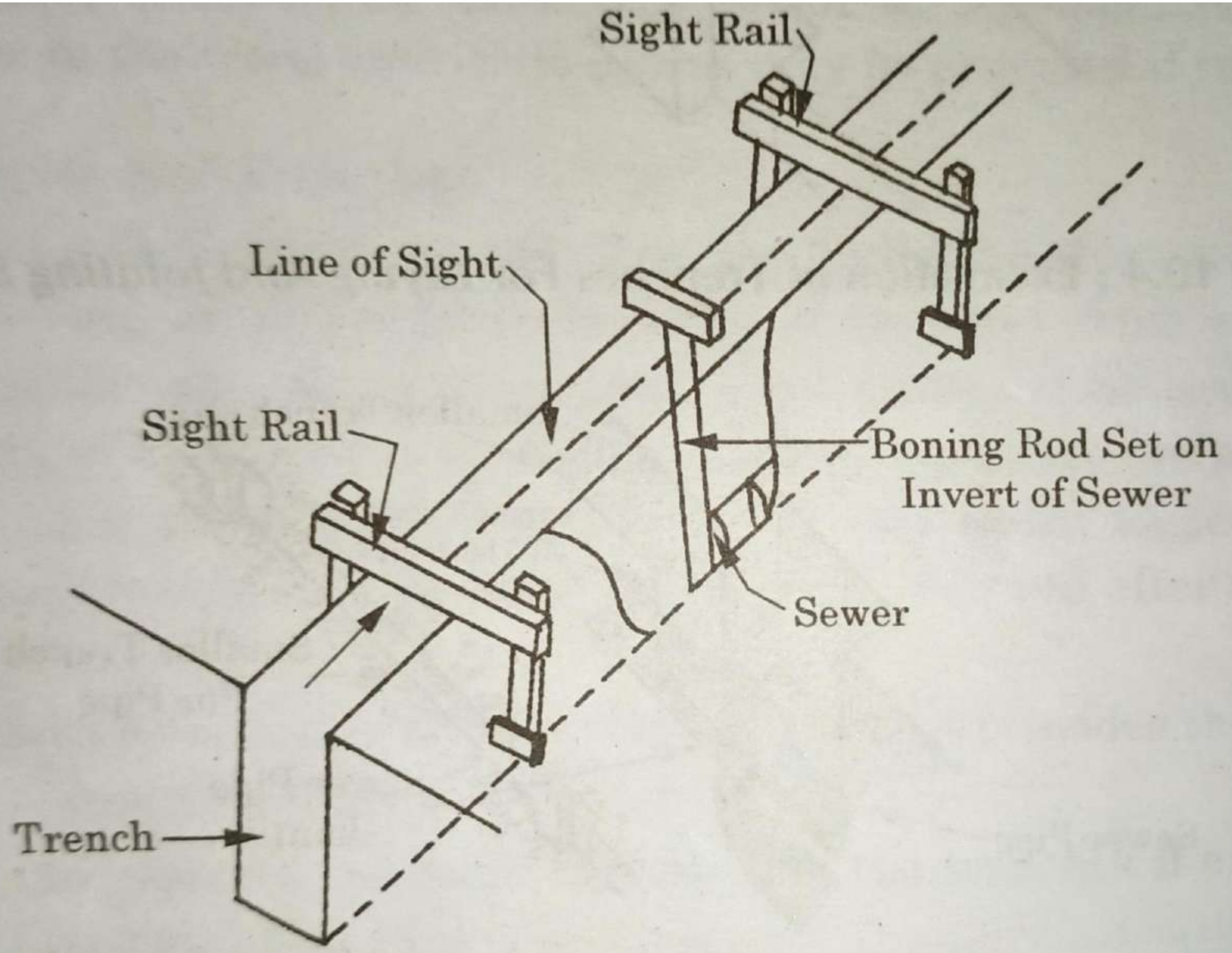


Fig. 10.6 : Gradient of Sewer Line

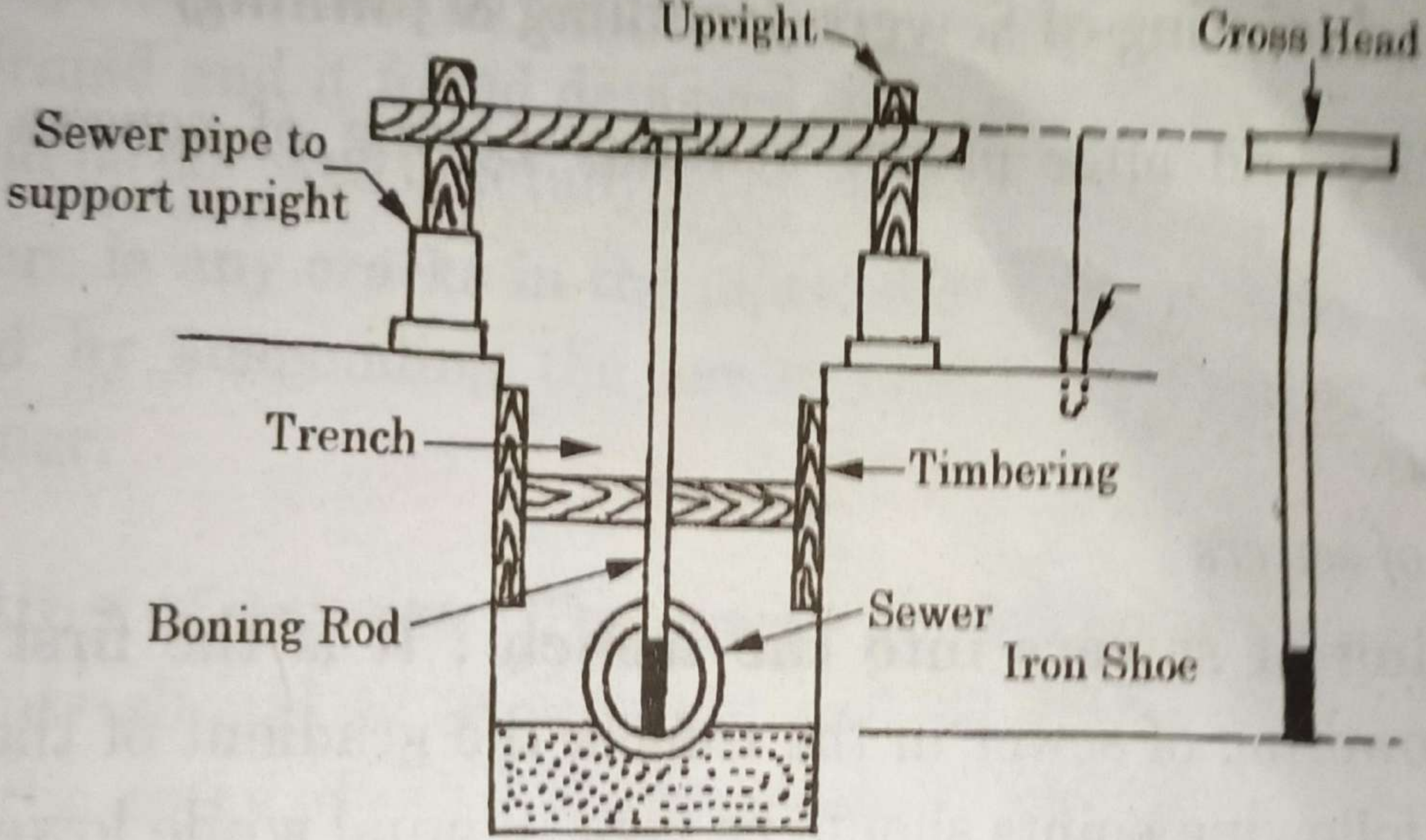


Fig. 10.7 : Arrangement of Boning Rod

TESTING THE GRADIENT -

The pipe of sewer should be tested for level after laying. For this purpose a straight edge is passed through the laid pipe. If the edge rests upon the peg as well as on the invert of the sewer for its full length then the level is proper. Otherwise the level should be corrected before proceeding further.

PREPARATION OF BENDING OF SEWERS

Sewers should never be laid directly on the excavated ground surface of the trench. After excavation of trenches, leveling is necessary. It is called bedding of sewers. It is necessary for receiving the sewer and distributing the load uniformly. In the absence of suitable bedding unequal settlement of soil may break the pipe. Therefore the bottom of trench is prepared to lay the pipe over it. There are differenttypes of beddings which depend upon the type of soil.

- Normal bedding is used in firm compacted soil.
- Haunch bedding is used for loose and poor soil.
- Encased bedding is used under heavy external load.
- Concrete bedding is generally provided for poor soil.

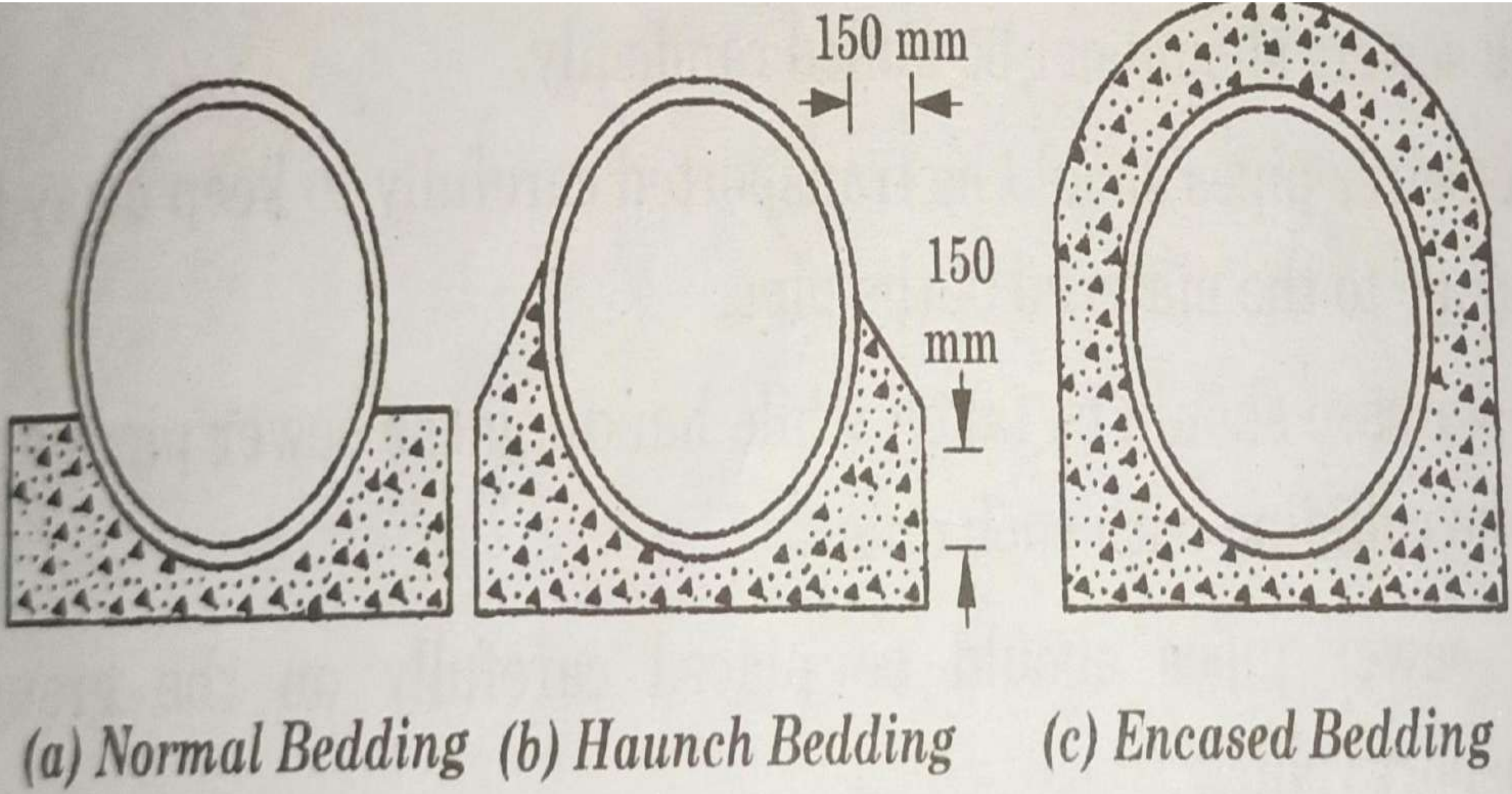


Fig. 10.8 : Types of bedding

LAYING AND JOINTING OF SEWERS (HANDLING & JOINTING)

The pipes are laid after proper bedding Laying of sewers may further beclassified as:

- Lowering
- Handling
- Jointing of sewers

(a) **Lowering of sewers into the trench:** It is the first step of laying of sewers Before lowering of sewer in the trench, the gradient of the sewer pipe must be checked. The following points should be kept in mind while lowering the sewers in trenches.

(A). The large sized sewers are lowered by a rope or chain. A steel hook is also very useful for lowering the sewers as shown in Fig 10.9.

(B). The smaller sized sewers can be lowered into the trench by hand.

(C). Pipes should be tested for level when it is laid and pressed in position. It may be done by passing a straight edge through pipe. The edge should be rest on the invert of the pipe. Otherwise the gradient is not proper

(D). Pipes, to be laid, should be free from any defects and cracks.

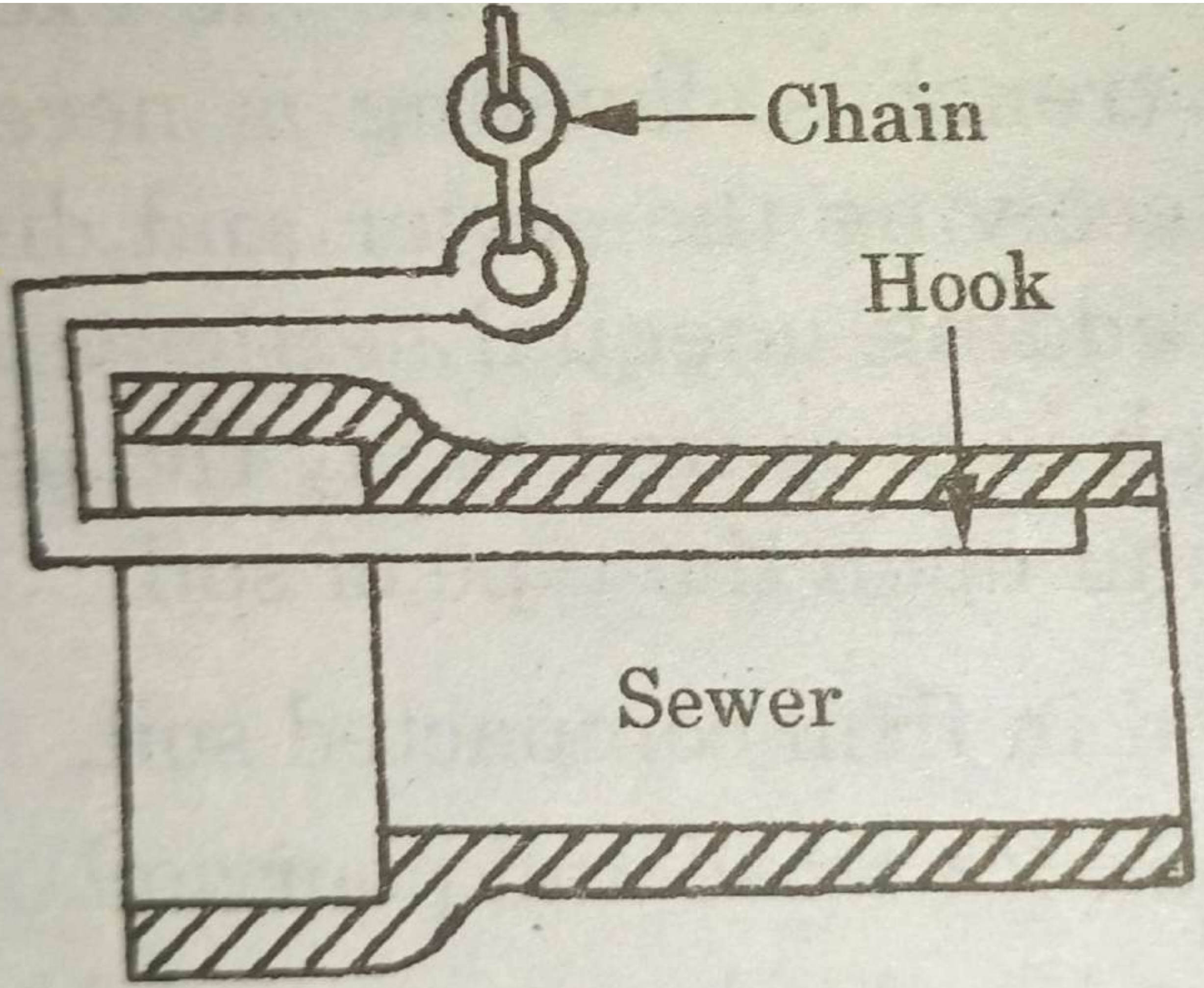


Fig. 10.9 : Hook and Chain for Lowering Sewer

HANDLING OF SEWERS -

1.The sewers should not be pulled randomly.

2.The sewer pipes should be transported carefully to keep away from must bedamage to the material of the pipe.

3. Proper care should be taken while handling the sewer pipes and the should not be colliding with each other.
4. The sewer pipes should be placed carefully on the ground.
5. If seepage is noticed on the outside surface then the sewer pipes are confirmed and it found damaged, then should not be used. Also the spigots should be checked carefully.

6. If there is any cracks in the pipes, it should be checked properly. It can betested by suspending the sewer pipe by a rope and striking it with a hammer.

JOINTING OF SEWERS -

The sewers of smaller sizes are jointed together byjoints. The joints should be water tight and should be done from one end. Properjoints prevent the entry of sub-soil water into the sewer. **TESTING OF SEWERS –**

The various tests are required before charge each section of sewer line between two consecutive manholes. The sewers are normally subjected to the following testsfor better functioning:

(A) Hydraulic or water test.

(B) Air-test.

(C) Tests for straightness or obstruction test

.(D) Smoke test

Hydraulic OR WATER TEST -

The test is performed for sewer line between two manholes. The steps of this test are as follows:

1. The lower end of sewer line is plugged by a rubber bag. Plugging is equippedwith a canvas cover as shown in Fig. 10.10. The rubber bag is connected to an air blower and it should be tightly fit with sewer pipe.
2. The upper end of the sewer in manhole is plugged with the funnel.
3. The whole sewer should be filled with water through the funnel. The funnel can be raised or lowered to maintain the required head. The head depends upon the

material of sewer e.g for stone ware and concrete sewers 1.5 m and for cast iron sewers the head is generally 9m.

4. The water loss is checked after 30 minutes and it should not exceed 30 ml for large size and 15 ml for small size sewers per cm diameter of pipe per 100 m length i.e. 15 or 30 ml/cm diameter of pipe/ 100 m length of sewer.

If the sufficient water is not available then water test cannot be performed. Andin this case to check the sewer leakage, air test is performed.

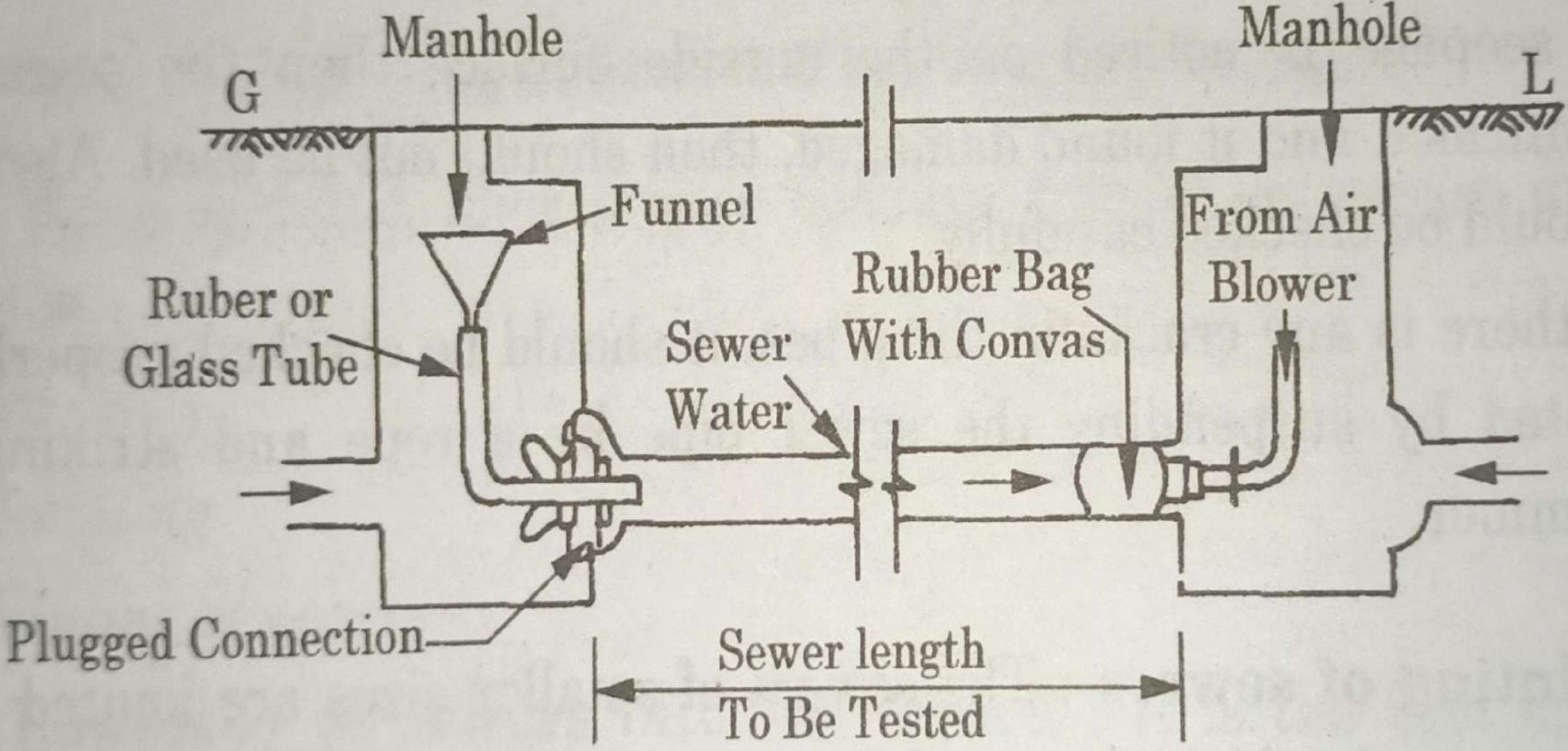


Fig. 10.10 : Hydraulic or Water Test

AIR TEST -

Air test is carried out to check the leakage in sewer pipe. This test is performed for larger diameter sewers where sufficient quantity of water is not available. In this test both the ends of sewers are plugged with hand pump and subjected an air pressure of 100 mm of water. To maintain a constant pressure of 75 mm, the joints of the sewers are assumed to be water tight. If the drop is more than 25 mm, the leakage of joints is traced out and so sewers should be repaired or replaced. The leakage point can be detected by applying soap solution to the joints and by viewing the presence of air bubbles.

If the sewer or section of sewer does not fulfill the requirement of above tests, then it indicates the leakage of pipe or joints and the sewer should be repaired or replaces.

TEST FOR STRAIGHTNESS AND OBSTRUCTION -

- The test can be performed by two methods as described below :

(A). In first method, a smooth ball of diameter 10 mm or less than the internal diameter of sewer is placed at the upper end of the sewer. The ball will roll down and come out through the lower end of the sewer if there is no obstruction.

(B). In the second method the straightness of sewer is to be checked. In it amirror is placed at one end of the sewer and a lamp is placed at anotherend. The full circle of light can be observed if the sewer is in straight line.Also the obstruction can be observed in the mirror.

SMOKE TEST -

This test is generally done for testing of vertical drainage pipes. The test is performed in the soil pipes and waste pipes. All trap seals should be filled with water before conducting test. Generally the smoke is produced by burning oil waste in the combustion chamber. After that smoke is forced into the pipe with the help of blower.

Leakage can easily be detected by seeing or smelling emitted smoke through leaky joints. The leaking joints can be repaired after detection.

BACK FILLING OF TRENCHES -

The process of placing the excavated soil back into the trench after the construction and testing of sewer line, is known as back filling. The trenches are required to be back refilled after removing the pebbles, stone pieces and lumps. The backfilling or excavated soil should be placed in layers of thickness varying from 15 cm - 20 cm. The trench is filled 150-200 mm above the ground level or upto a depth of 50 cm above the crown of the sewer pipe. The backfilled soil is watered and rammed before placing another layer. It is required to take care the settlement of soil. It is necessary as the soil sinks and comes to the road level due to movement of traffic.

NATURAL METHODS OF SEWERAGE DISPOSAL

INTRODUCTION

After passing the sewage through sewers, the next process is disposal of waste water or sewage. In other words, the disposal methods are used for disposing off waste water after passing through sewers. The sewage can be disposed off either after proper treatment or without treatment.

The sewage after suitable treatment is not subjected to any chemical reaction or decomposition. So the sewage become safe for disposal of sewage, either on land or large water bodies like sea, river or lake.

PURPOSES/IMPORTANCE OF SEWAGE DISPOSAL

1. Sewage may contaminate the water supply and sub-surface water in the absence of sewage disposal. So to eliminate the danger to the public health sewage disposal is necessary.

2. For maintaining suitable environment i.e. Free from pollution, proper disposal is necessary.

3. Sewage causes smell and nuisance as it is full of organic matter. So to make the sewage harmless, without causing odour or irritation, sewage disposal methods are necessary.

4. The sewage disposal methods are necessary for sustaining of aquatic life i.e. Co do not upset the aquatic life, proper disposal is necessary.

5. For providing better sanitary conditions in the locality or area, disposal methods are essential.

CARE TAKEN AT THE SITE OF SEWAGE DISPOSAL

1. For disposal it is necessary that no ugly matter should float on the water 1. surface.

2. During disposal the sewage should not be deposited at the bottom otherwie. It creates offensive smell.

3. Sludge tanks for disposal should not be formed at higher level.

4.Disposal should be such that it should not affect the aquatic life and contaminate the water.

WASTE WATER DISPOSAL METHODS

There are two most important methods of sewage disposal which are as follows:
(i) Dilution i.e. Disposal of sewage in water and self purification of stream.

(ii) Land Treatment or Land Disposal or Irrigation.

Both methods are straightforward. But it is necessary to check the quantity of sewage put in water or applied to land. It is because land or water should be capable of receiving the organic matters present in sewage

SEWAGE DISPOSAL BY DILUTION

Dilution is the disposal of sewage by discharging sewage raw into large natural or artificial water courses like sea, streams, lakes, rivers etc. This method is possible only when the natural water is available in huge quantity near the town. Also proper care should be taken while discharging sewage in water so that sewage may not pollute the natural water.

SITUATION SUITABLE FOR DILUTION

1.When diluting water is not used for navigation purposes.

2. It is suitable when the depth of water of water bodies at the point of disposal is sufficient and the favourable currents exist in a stream that can prevent the deposition of sewage near the intersection.

3. When, during flood, the receiving water will not cause backward flow in sewers.

4. This method is suitable when the dissolved oxygen (D.O.) is more in the diluting water.

5.Where the natural water course has large quantity of water and take the load of sewage safely without causing its pollution.

6.When the sewage is free from floating matter and settleable solids.

7. When the sewage is fresh or non-septic at the point of disposal.

8.When systematic mixing of sewage is possible. . This method is suitable when the city is situated near the natural water bodies such as sea, lakes, rivers, streams etc.

* DILUTION (DISPERSE THE SEWAGE MATTER INTO THE WATER)

Disposal method by dilution requires large volume of diluting water and this requirement should be available in the neighborhood of disposal works. The diluting water should be saturated with dissolved oxygen. The BOD should not exceed 25 ppm if the volume of diluting waters is less.

Chemical and biological changes take place and the organic matter load is stabilized. After sometime the water regain its natural purified state due to self-purification action.

The ratio between the amount of diluting water and amount of sewage is called dilution factor. Nuisance occurs when the dilution factor is less than 20.

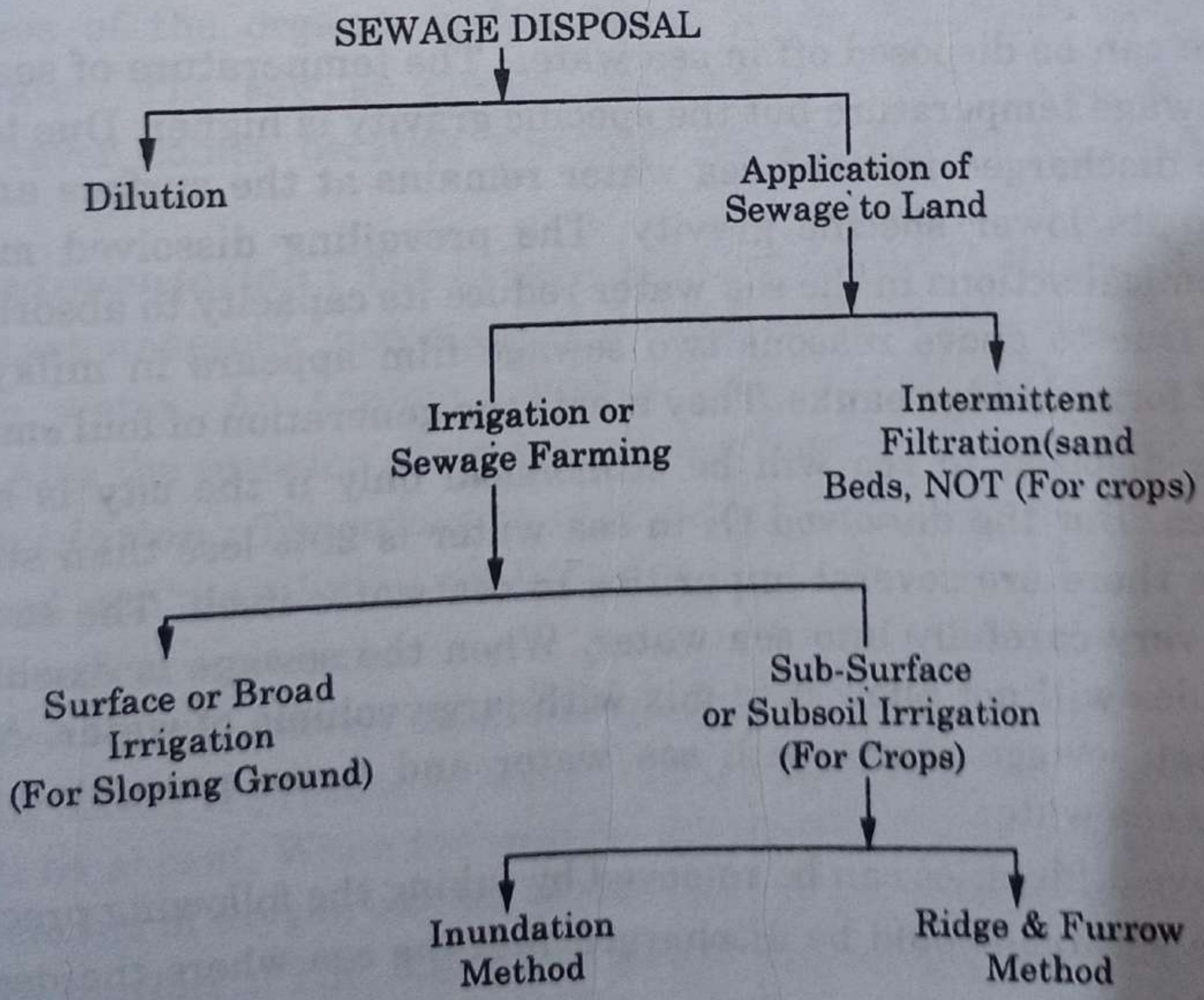


Fig. 14.1 : Methods of Sewage Disposal

DISPOSAL OF SEWAGE IN STREAMS/RIVER

When the sewage is discharged in streams, its organic matter get oxidised by the amount of dissolved O2 present in water, and this matter is converted into harmless substances. The natural water remove their deficiency of O2 (consumed by organic matter) by the absorption of atmospheric oxygen. The above action of water is known as self-purification of streams . From this action it is clear that oxygen of water is consumed by sewage and at the same time it is filled back into water by the atmosphere. This action is called reaeration and it is a complex phenomenon. This solution involves actual surface contact, diffusion of dissolved O2 from higher points to lower points of concentration and mixing by agitation or turbulences, and are the functions of depth of water. Tidal currents and wind waves also contribute to reaeration.

DISPOSAL OF SEWAGE IN SEA WATER

Sewage can be disposed off in sea water. The temperature of sea water is lower than the sewage temperature but the specific gravity is higher. Due to above reasons the sewage discharged film due to its lower specific gravity. The prevailing dissolved matters and the various chemical actions in the sea water reduce its capacity to absorb more quantity of sewage. Due to above reasons two sewage film appears in milky colour on the surface and forms sludge banks. They starts the generation of foul smell of H2S.

The above difficulties can be removed by taking the following precautions:

1. The sewage should be discharged into the sea where the depth of water is more.

2. Thee sewage discharging pipe should be taken sufficiently deep in sea 1.5 km, so that sewage may not come back again to the shore by heavy tides and create nuisance.

3. The outfall sewers should be provided with reflux valve to prevent back flow of sewage.

SELF -PURIFICATION OF STREAM

It is the natural process in which the oxygen of water of streams is consumed by sewage. Oxygen is consumed by decomposition and stabilization and at the same time streams are filled again by the atmospheric oxygen. All system of streams sanitation depends upon the natural self-purification.

The factors affecting self- purification are as follows :

1.Dilution 2. Sedimentation

3. Oxidation 4. Reduction

5. Sunlight 6. Currents velocity of currents

7.Temperature 8. Biological forces

1. **Dilution** : When the sewage is mixed up with large volume of water, the offensiveness of the organic matter is minimised by its dispersion through the diluting water. The sewage always remains in aerobic condition and anaerobic condition never comes because dissolved oxygen always remains present in the water.

2. **Sedimentation** : The heavier solids with slow current settle in the stream bed and start anaerobic decomposition. The products of decomposition are mixed again with water. An aerobic condition will develop when the dilution is not sufficient. Also the scouring of streams during flood will wash the deposits.

3. **Oxidation** : The oxidation of organic matter commences as soon as sewage is

discharged into the diluting water due to:

(i) Chemical action and

(ii) Growth and activity of oxidising organisms.

As long as O2 is present in water septic conditions will not exist and offensive smells will be absent. When the organic matter is completely oxidized there will be Ho more demand of oxvgen and the stream will be purified itself.

4. **Reduction** : The reduction occurs due to the hydrolysis of the organic matters biologically or chemically in streams. The complex organic matter present in the sewage is splitted up by anaerobic organisms. This action produces foul gases and the stabilization starts.

5. **Sunlight** : Sunlight has sterilizing effect on certain bacteria, bleachine powder and photosynthesis by which chlorophyll bearing organisms take energy from sun and convert it into food for other forms of life. CO_2 is absorbed and 02 is given off in this process. Pathogens are killed if exposed to sunlight. Hence sunlight helps in the self-purification. Algae grow in sunlight causing production of O_2. In this ways sunlight indirectly helps in the oxidation of unstable matter.

6. **Velocity of currents** : The natural self-purification of streams directly depends upon the currents of water, when there is no currents the sewage mattera deposit near the out fall causing formation of sludge tanks and foul odours. Slow currents are better for self-purification because sedimentation takes place causing growth of algae, resulting in the production of O_2. In heavy currents the sewage is thoroughly mixed up with stream and prevents all nuisances.

7. **Temperature**: Self-purification also depends upon the temperature of stream water as the activities of organisms depend on the temperature. Lower the temperature, slower the activities of organisms and hence slower the rate of decomposition of organic matter of sewage and vice versa. Therefore in summer stream will get self-purified in less time as compared to winter. However, the quantity of O_2 dissolved in water is more in cold water than in hot water.

8. **Biological forces** : Various types of bacteria, algae, protozoa etc. Are responsible for self-purification of streams as they attack on organic matters and convert it into chemical substances. Algae absorbs $CO_2$and supply O_2.

SEWAGE DISPOSAL BY LAND TREATMENT

Land disposal is the method by which the raw sewage or partially treated sewage is spreaded on the surface of land. Depending on the objective of disposal it

can also be termed as broad irrigation or sewage farming. The sewage water procolates in the ground and the Suspended solids remain at the surface of the ground.These organic suspended solids are partially oxidized by atmospheric action and partly attacked by bacteria.

ACTIONS IN DISSOLUTION OF SEWAGE

The following actions take place in disintegration of sewage:

(i) Physical action

(ii) Chemical action

(iii) Biological action

(i) **Physical action**: For the filtration of sewage, physical action takes place. Due to this action the suspended particles are removed. The particles retained on the surface are oxidised by aerobic action. The physical action mainly depends on the nature of soil as the sewage percolates into the subsoil. The pervious soils are more suitable than impervious soils. The fertilizing value of sewage is more because it contains nitrogen, potash, phosphate etc. So the sewage can be used for irrigation purposes as it contains more water.

(ii) **Chemical action**: The organic matter present in sewage is oxidized by bacteria present in soil. It is called chemical process.

(iii) **Biological action**. Biological action means the attack of bacteria present in soil as the sewage is applied on land. The sewage content is converted in to plant food with the help of bacteria. This food is used by the roots of the crops. The organie matter present in sewage decomposed under aerobic or anaerobic conditions. Aerobic is conditions are preferred as compared to anaerobic. It is because dissolved oxygen present in different soil layers and soil absorbs O2 from the atmosphere through air.

METHODS OF LAND TREATMENT

The land treatment can be done by the following forms:-

(a) Filtration

(b) Sewage Farming or Broad Irrigation.

The natural process is same in both the methods of land treatment i.e. The ltration of sewage by straining action of ground soil. The complex compounds of sewage are converted into harmless mineral salts, which are valuable fertilizers for tops etc. In actual practice, the sewage takes very long time for the formation of fertilizers.

In the process of filtration more depth of soil below the ground level plays a vital role. And in sewage farming, the sewage treatment takes place 510 cm depth. Table shows the recommended quantity of sewage which can be applied in sewage farming.

Table 14.1. Maximum quantity of sewage for sewage farming

S. No.	Nature of soil	Maximum quantity of sewage in m^3/hectare/day	
		Raw sewage	*Settled sewage*
1.	Loam soil	65–85	110–170
2.	Clayey loam soil	40–50	55–120
3.	Clayey soil	25–35	30–55
4.	Sandy loam soil	90–100	150–220
5.	Sandy soil	100–150	220–280

The land treatment method of sewage disposal is suitable under the following conditions :

1.In the areas where water table is much deep so that there are no chances of ground water pollution.

2.Where there natural bodies like streams, rivers etc. are not available for the discharging of sewage.or where the rivers run dry or have very small flow.

3 .Where there are good market value of vegetables so that more crops can be grown and good income can be obtained.

4.When the quantity of sewage is more which can not be disposed off in the natural water bodies like river, stream etc.

5. Where the overall rainfall is very low so that the lands can be irrigated by sewage.

6. As the porous soil allows good aeration so it is suitable where large area of land is sandy, loamy or alluvial.

Advantages and Disadvantages of Land Treatment Method :

Advantages :

1. By this method the land can be irrigated and the crop production is increased.
2. The cost of disposal is less in the presence of sufficient land.

3. This method is most suited to areas having low rainfall. Also the water from irrigation channels can be saved by using the sewage water for irrigation purposes.

4. The fertility of land may be increased by land disposal method.

5. Initial and maintenance cost of this method is low. As it does not require 5. any costly equipment so it is a cheap method.

6.The natural water courses are prevented from pollution.

7 It is the natural method of sewage disposal.

Disadvantages :

1. Theree are chances of spreading diseases in crops if treated water is used for growing crops.

2. The crop production on treated land is limited.

3. This method requires larger area for treatment of sewage and its disposal.

4. The land may become sick if proper care is not to be taken.

5. Sewage disposal depends upon the land availability as the land for disposal is not available during rainy and harvest seasons.

6. This method depends upon the type of soil as clayey soil is not suitable for disposal of sewage.

NUISANCE DUE TO DISPOSAL

Nuisance from land treatment or stream pollution may be classified into the following types:-

(i) Physical nuisance

(ii) Chemical nuisance

(iii) Bacterial nuisance

(i) Physical nuisance : It occurs due to deposition of suspended solids upon the banks of a stream. It is also due to deposition of sewage on the bed of water bodies. The physical nuisance is not good or unpleasantness. It is due to turbidity and colour. The other factors which affect the physical nuisance are volume of water and velocity of flowing water.

(ii) **Chemical nuisance**: This type of nuisance occurs due to the industrial wastes. Industrial wastes include substances which are harmful for fishes, acids which injure concrete structures and biler tubes. Due to chemical nuisance dissolved oxygen in the water is lost and it may also destroy green plant and fish life under worst conditions. The wastes produced from industries also tend to make water unfit for domestic use and more difficult to treat. These wastes include organic compounds.

(iii) **Bacterial nuisance**: It occurs due to presence of pathogenic bacteria in the sewage. These are also responsible for polluting the natural streams. These bacteria, if present, cause various diseases or death in worst conditions.

BUILDING DRAINAGE

MADE BY RAKSHIT

BUILDING DRAINAGE:-

The building drainage is an arrangement provided in a building for collecting and conveying the waste water. The drainage which passes the sewage through drain pipes to join a sewer line is known as building drainage.

AIMS AND OBJECTS OF BUILDING DRAINAGE

- *The following are the aims and objects of building drainage due to which it is very essential in buildings:*
- *1. Providing healthy conditions in the building.*

- *2. Disposal of liquid waste as early as possible.*
- *3. Avoiding the entry of foul gases from sewer into building*
- *4. Providing facilities for the quick removal of foul matter.*
- *5. Collection and removal of waste matters systematically.*
- *In the drainage system, various settings are provided like washbasins, water closets, urinals etc.*
- *In the drainage system, various settings are provided like washbasins, water closets, urinals*.

REQUIREMENTS OF GOOD BUILDING DRAINAGE

- *Before starting the plumbing work drainage planes must be prepared. The*

- *following are the requirements of a good building drainage*
- *1. A drainage plan of the building must be prepared before starting plumbing work.*
- *2. The drains should be laid in straight line between points of access and all changes of directions.*
- *3. The diameter of drains should be such so that sullage and domestic sewage.*
- *can be carried out efficiently.*
- *4. The levels of the building, sewer line and other point of outlet should be determined accurately.*
- *5. The detailed drainage plans should also be prepared.*
- *6. The drains should be laid in such a way so that future extension can be done easily.*
- *7.The branch drains should be as short as possible.*
- *8. The drains laid should be ensure their safety in future.*
- *9. The drains should never pass near or under the trees due to the risk or*

- *damage by the roots.*
- *10. The rain water should be removed quickly. Also waste matter should be*
- *removed quickly.*
- *11. All drainage system should be properly ventilated on the house side. The*
- *ventilation pipe should be higher length than the buildings. A inlets inspection chambers should be provided with fresh air inlets.*
- *12. An intercepting trap should be provided in house drain for disconnecting it*
- *from the main sewer, so that entry of foul gases can be prevented into the*
- *building*

Principal of house or building drainage

- *The following principles should be kept in mind while planning house drainage schemes*
- ***1 Quick Removal**: The drains should be laid in such a way thatsewage removed quickly from the building. The quick removal depends on the fall of the pipes. The slope of the drains should be sufficient for quick removal of sewage. It develop self-cleaning velocity in drainage*.

***2. Placing Lavatory Blocks:** The Lavatory blocks should be placed one above the other in case of multi- storeyed building. They should be located in such a way that minimum length of pipe line is needed. For preventing the construction of drain pipes under the walls of the building, the lavatory blocks should have its one of the walls as outside wall of the building.*

3. ***Traps*** *– traps are provided depending upon the discharge passing through the drain pipe. All the connections should be water tight inspection chambers are provided of all bends.*

4.Materials*: All the materials and fittings and fixtures should be sufficient hard, strong and no corrosive. All the drains should be aligned and laid straight as far as possible.*

5. Rain Water: *Rain water pipes i.e. R.W.P. should drain out directly the rain water into the street gutters from where it is carried to storm water drain/sewers.*

- ***6. Material for Pipes:*** *When it is required to provide the drain pipes under the walls, the drainage pipes should be of cast iron instead of stone ware. The pipes should be painted with coal tar and wrapped with asphaltic or canvas bags. These pipes are also surrounded by 10 cm thick layer of cement concrete. Inspection chambers on both sides are essential.*

GENERAL LAYOUT OF HOUSE DRAINAGEAS PER BIS SPECIFICATIONS

The following points should be kept in mind during layout of house drainage:

(i) The layout should be direct and simple as far as possible. All pipes should be laid in straight lines.

(ii) Significant changes in the direction of flow should be avoided.

(iii) The drains should be laid at such a slope so that self-cleaning may developed.

(iv) At the intersections or bends, manholes or inspection chambers should be provided.

(v) There should be gradual and smooth change in direction of flow. The angle between the intersecting pipes should be less than 45"

(vi) Laying of sewers under a building should be avoided as far as possible. It is because under mining at foundation may occur. If it is not possible to avoid, then sufficient gradient should be applied. Also for this, only C.I. pipes should be preferred.

- ***A building/house drainage arrangement plan:***- It may be defined as the arrangement provided in a house for the quick removal of waste water (solid or liquid) through drain pipes into a sewer, and is known as house drainage arrangement plan.

- ***TECHNICAL TERMS USED IN BUILDING DRAINAGE:***

- *The following are the important terms used in building drainage :*
- ***1. Soil pipe (S.P.):*** *The pipe through which liquid waste carrying human excreta can flow is known as a soil pipe.*
- ***2. Waste pipe (W.P.):*** *The pipe through which liquid-waste without human excreta can flow is known as waste pipe.*
- ***3. Vent pipe (V.P.):*** *The pipe installed for the purpose of ventilation is known as vent pipe. The top of vent pipe is provided with a cowl so that birds may not build their nests. This pipe is kept open at top and bottom to provide exit for foul gases and should be 1 m above the roof level.*
- ***4. Rain water pipe (R.W.P.):*** *The pipe which carries storm water is known as rain water pipe.*
- ***5. Fresh air inlet (F.A.I.):*** *The inlet provided for fresh air in the last manhole which connects the house drain with the public sewer (main sewer) is known as fresh air inlet. This pipes is kept at a height of 2 m from ground level.*

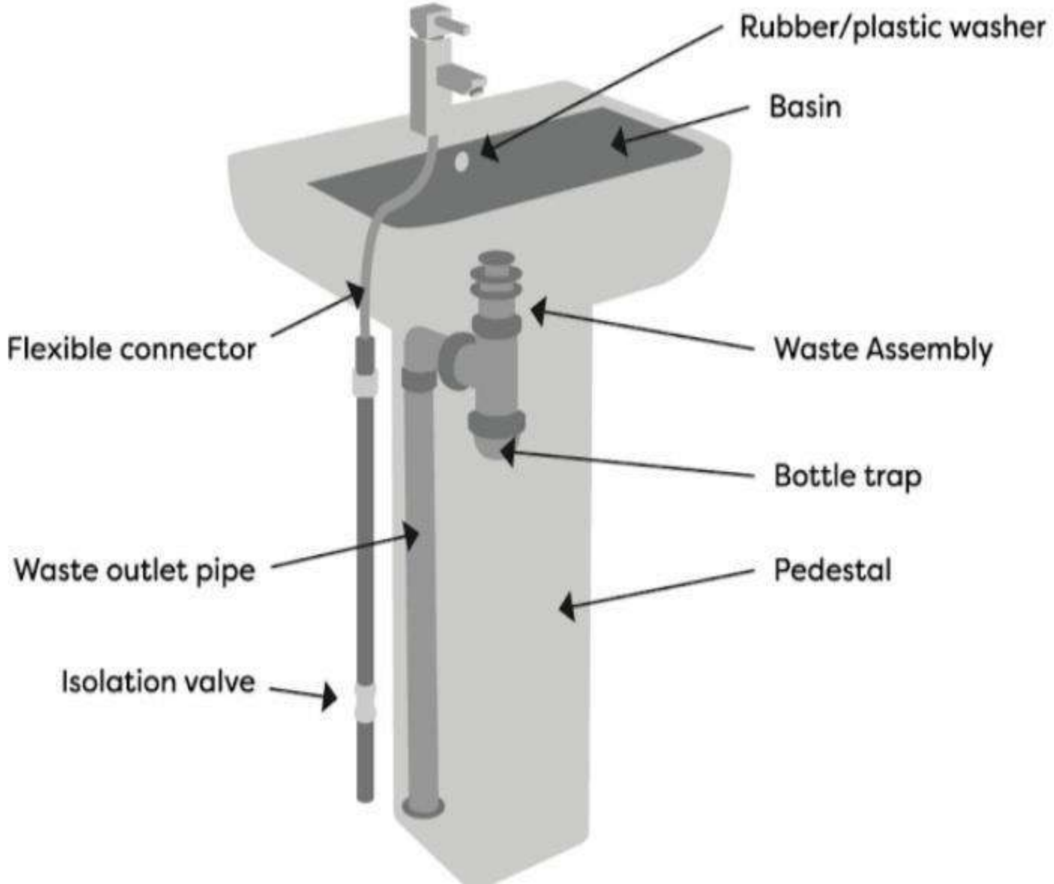
- ***6. Anti- syphonage pipe (A.S.P.).*** *Water seal breaks in the traps due to syphonic action which is called syphonage. The pipe installed in the building drainage to preserve the water seal of traps is called anti- syphonage pipe. It maintains proper ventilation and does not allow syphonic action. It supplies air to short drain pipe at the time of suction. It also acts as a vent pipe.*
- ***7. Warning pipe****. An overflow pipe of which outlet is fixed in exposed positionand conspicuous position to see the discharge of any water may be seen andfixed outside the building is known an warning pipe.*

•*DIFFERENT SANITARY FITTINGS AND FIXTURES*

- *The appliances required in building drainage for the efficient collection and removal of waste water from the building are known as sanitary fittings and fixtures. The following sanitary fittings are provided in buildings:*
- *1. Wash basins*

- *2. Sinks*
- *3. Water closets*
- *4. Urinals*
- *5. Flushing cistern*
- *6. Bath Tub.*
- *All types of sanitary fittings should be fixed against an external walls of the building. It is because to provide ventilation, natural light etc. Also by this arrangement, the waste can also be collected easily. The floors of rooms for fixing the sanitary fittings should be of non-absorbent material*.
- ***1.Wash Basin :-***
- *A basin provided for the purpose of washing hands, mouth etc. is known as Wash basin or lavatory basin.*

- *Types:-*
- *i) Pedestal type*
- *ii) Bracket type*
- *iii)Flat type*
- *iv)Angle back.*



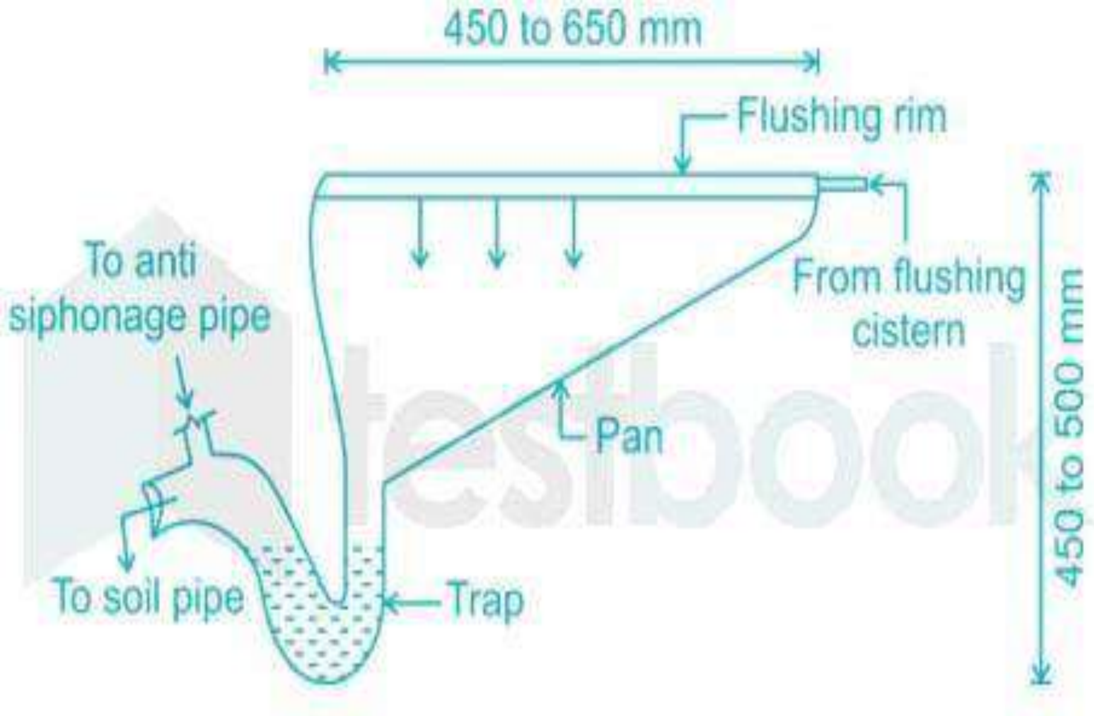
- ***Sink:-***

Sink is a rectangular shallow receptacle used in kitchen or laboratory for drainage off water. It is commonly made of glazed earthen ware, stone ware, stainless steel, fine clay or plastic. Now-a-days kitchen sinks made of steel are mostly in use. Kitchen Sink The kitchen sinks are provided with or without rim. The sink is provided with circular waste hole. The floor of sink is given a slope

towards the waste hole. It helps in cleaning. The kitchen sink is provided with a draining board on the right of the user. All the internal angles are round.

- ***Water Closets (W.C.):-***
- In other words, it is an appliance provided to receive human excreta directly.
- In residential buildings they should be located keeping in view the ventilation, so as not to cause any nuisance.
- They are made of either of Glazed Earth Ware or pottery or porcelain ware and are available in the market in different verities.
- Requirements of Good Water Closet :(i) It should be such that night soil do not stick to it so inner side is glazed.(ii) It must provide easy flushing.(iii) It must be suitable in use with less water.(iv) When night soil falls into the trap, its water should not be splashed.

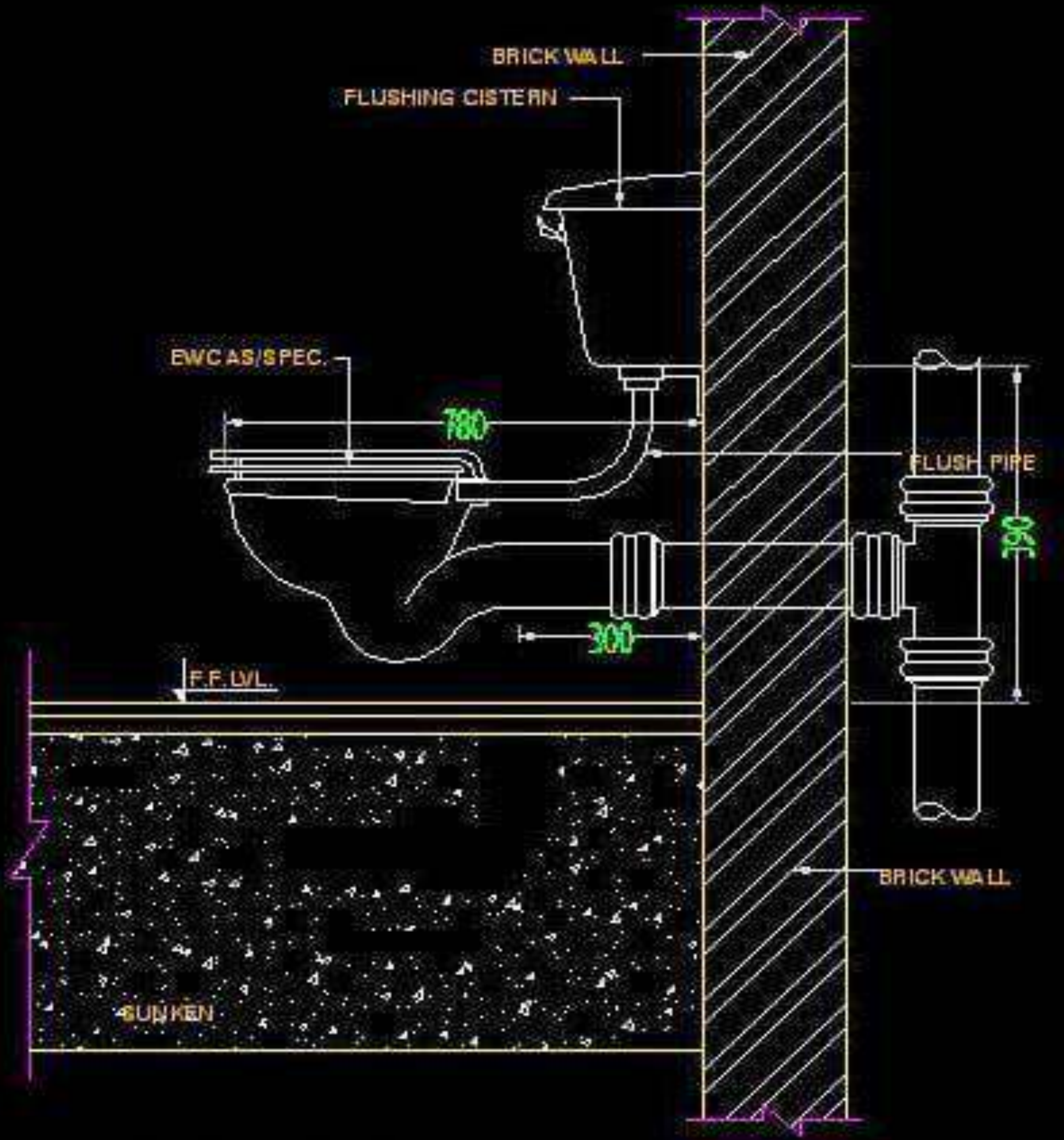
- Water closet may be defined as a water flushed plumbing fitting designed to receive human excreta directly from the user.
- ***Types of Water Closets:***
- *Water closets are of following types:*
- ***1. Indian or squatting type or oriental type***
- ***2. European or Pedestal type or western type***



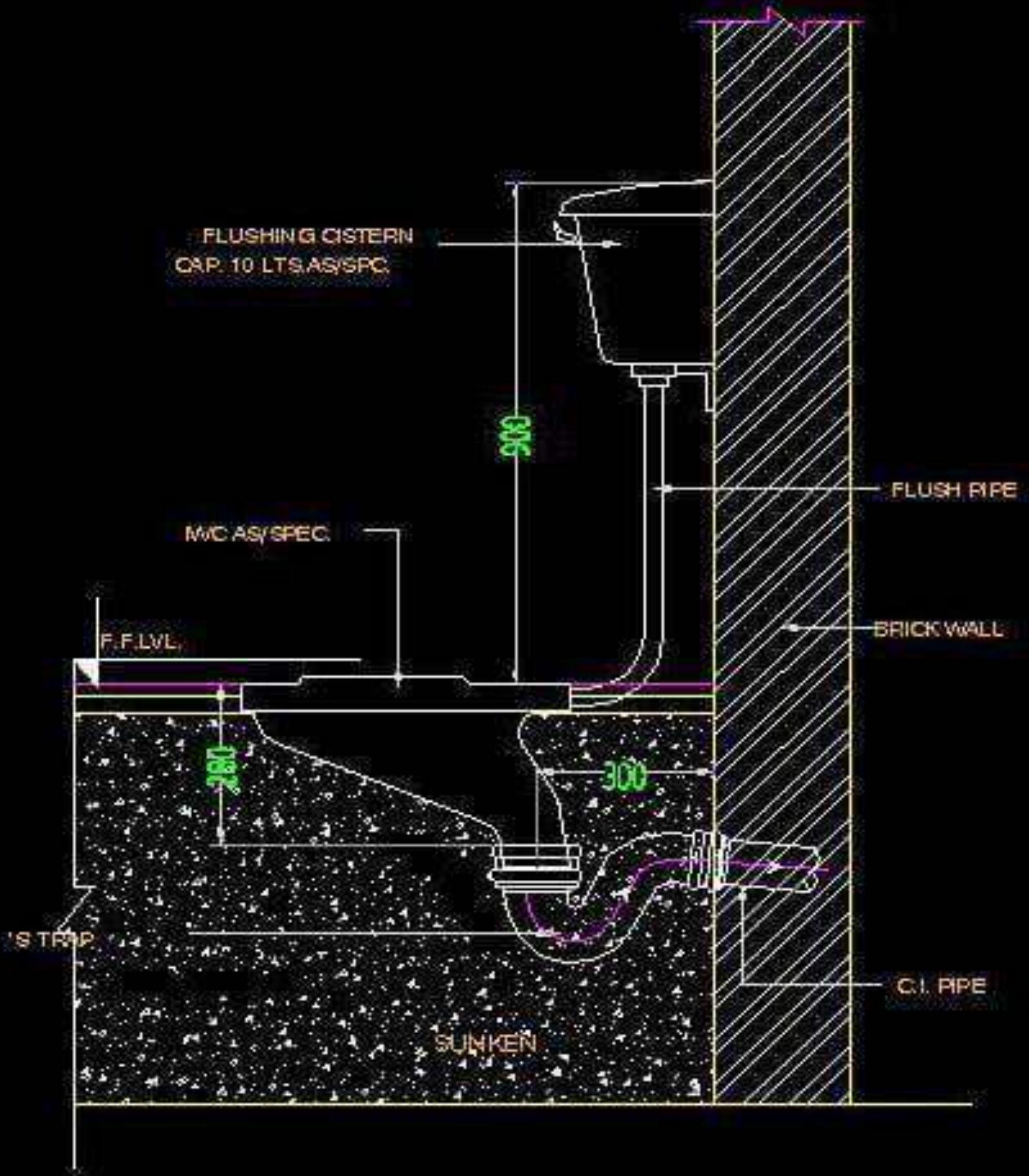
Indian type water closet

- *1. Indian or Squatting Type: It is made of vitreous China clay having its inner portion glazed to make it easy in cleaning. The pan is 450 mm to 630 mm in overall length and 450 mm to 500 mm height. The pan is connected with flushing cistern. Footrests are constructed integratedly with pan or are separately fixed on the floor. They are provided with a high level flushing cistern at a height of 2 m above the water closet. This is manufactured in two parts - (i) squatting pan and (ii) trap.*
- 2. ***Western or European style W.C:*** *A water closet provided with a seat and cover is known as western or wash down style W.C. It as a wash down water closet. It can be provided either high level flushing cistern at 1 m height or low level cistern at 0.19 m height*

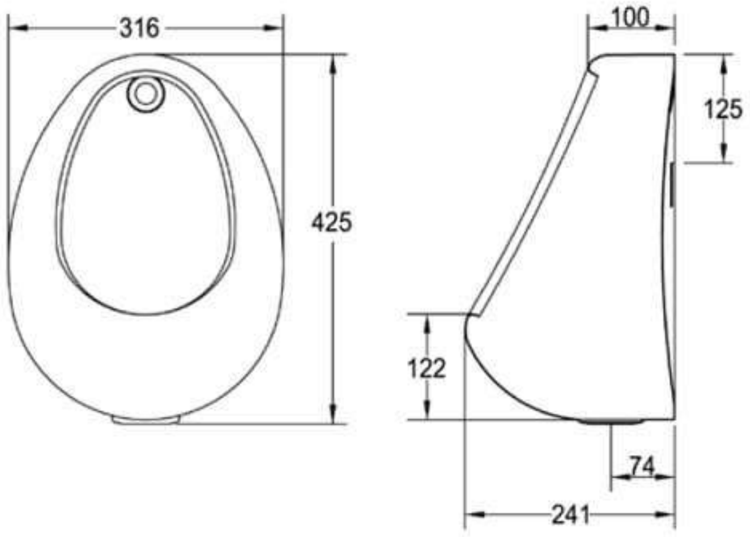
above ground level. It is provided either with p-trap or s-trap. Which is most commonly used in high class buildings. It is provided with a wide flushing rim and 5 cm trap of P or S type. The dimensions of this W.C. is 630 mm in length and 350-400 mm in height. Pan and trap are not separate in it. It is made of vitreous china with inner bastion glazed.



SECTION THROUGH WESTERN WC

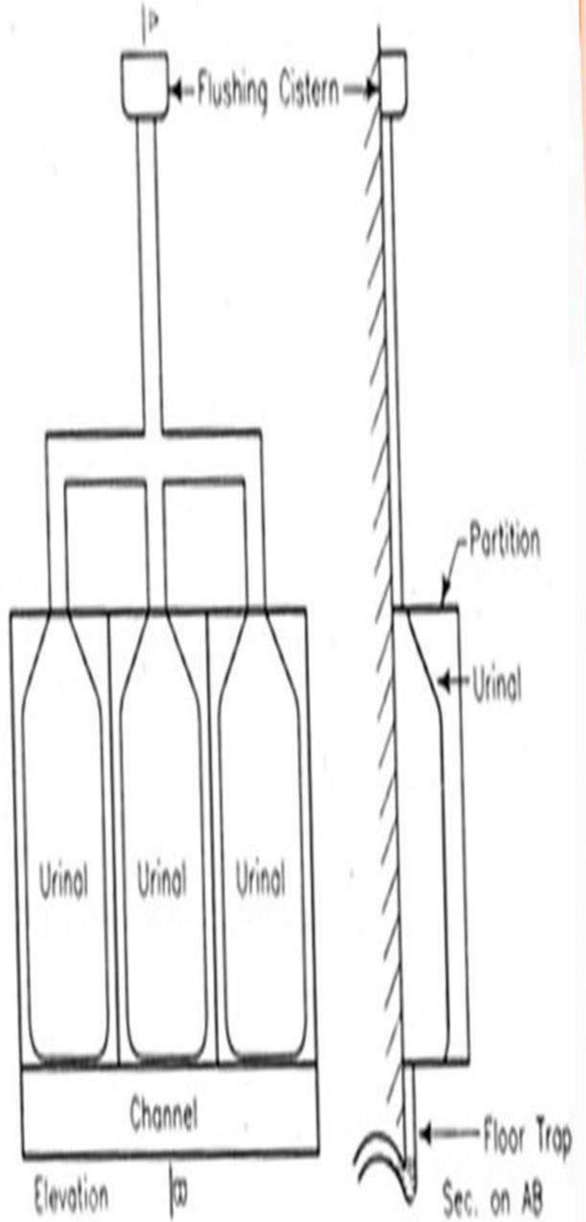


SECTION THROUGH INDIAN WC



Bowl Type Urinals

- **STALL OR SLAB TYPE –** It comprises of a flat wall with slab with partitions on sides. It has a floor channel to drain off the discharge through trapped outlet. The stall type urinal range may be flushed by automatic flushing cistern with a capacity of 10 to 15 litres. The details are as shown in figure below.



- ***Urinals:***
- *The arrangement provided for receiving human urine is called urinals. Urinals are available in different sizes and patterns. Following table shows sizes and patterns of Urinals.*
- *1.Bowl Type Urinals*
- *2.The slab and stall type Urinal*
- *3.The squatting plate urinals*

- *1. Bowl type urinals:-it is one piece construction and are made of porcelain, vitreous china clay. Each urinal is provided with two fixing holes on the side for fixing it on the wall.*

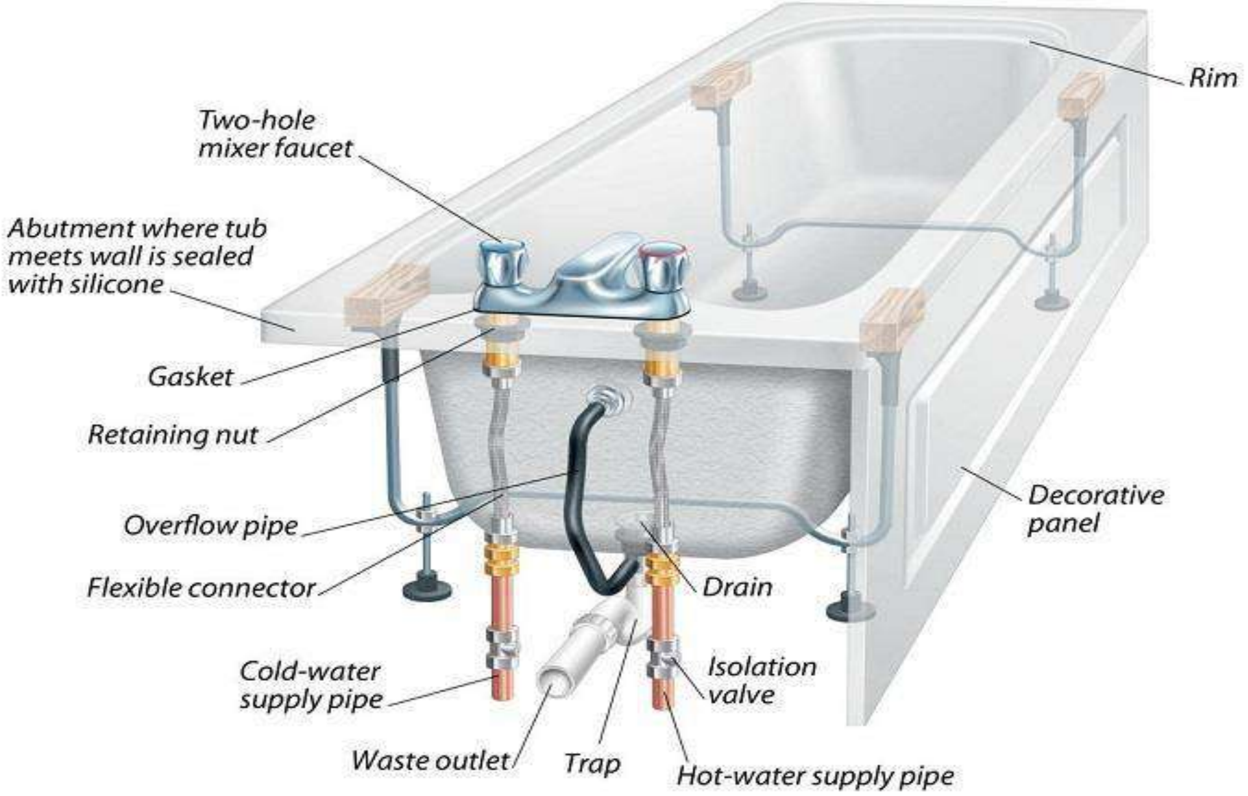
- *2.The slab and stall type urinals consists of a flat wall slab with partitions on sides and floor channel to drain off the discharge through a trapped outlet. These are generally provided in public places like restaurants, cinema houses , railway stations etc.*

- ***Flushing of Urinals:***

- *By urinals the contents are collected and discharged into sod pipe through floor trap. They are provided with automatic flushing cisterns, which operate automatically after an interval of 10 to 15 minutes. An antisyphonage pipe must be provided for locating various urinals in a multi-storeyedbuilding. The antisyphonage pipe is connected to soil pipe.*

- ***Flushing Cistern:-***
- *The arrangement provided for flushing out water closets or urinals is called a flushing cistern.*
- *Flushing cisterns are usually made of cast iron. Those are generally provided at a height of 2 m from floor level. The height may be about 60 cm from floor level. These are operated simply by turning a handle. The size of flushing cisterns is depend upon the discharge capacity. In some cases, automatic flushing cisterns are also provided which operate on the basis of siphon.*
- ***Types of Cisterns:** Cisterns are of following two types:*
- *(a) Bell type without valve*
- *(b) Flat bottom type with valve.*

- ***Bath Tubs:-*** *A tub provided for bathing is known as bathing tub. They are made of various materials such as marble, glazed fire clay, plastic, enamelled in, cast in porcelain enamelled and enamelled pressed steel etc. For public places glazed fire clay or porcelain enamelled cast iron baths are used. Previously copper baths were used but they have become obsolete now-a-days. Recently aluminium alloy and fibre glass baths have came in the market.*



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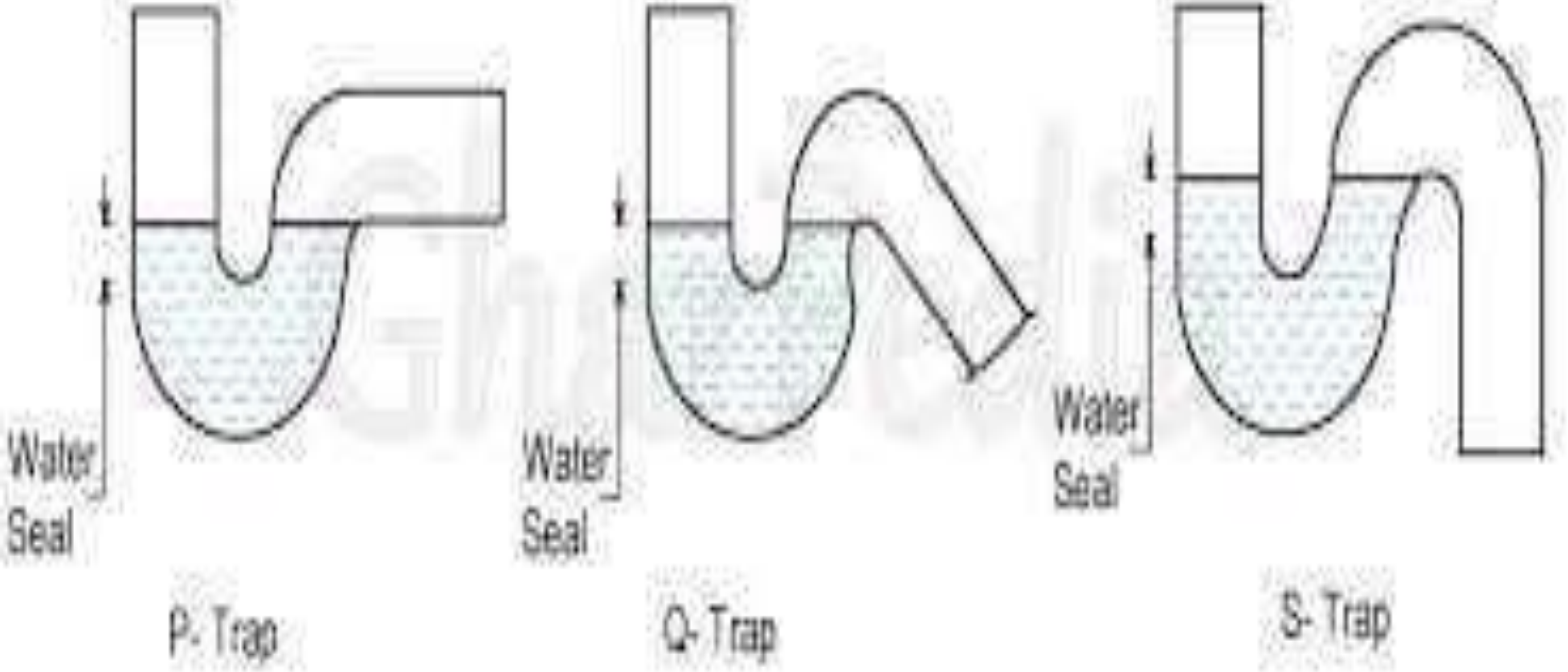
- ***TRAPS*** :-
- *The depression or bend provided in a drainage system which is used to prevent the foul air or gases in the atmosphere called a trap. Water is used for this function. So the trap prevents the passage of foul gases through it and allows the sewage to flow through it.*
- ***REQUIREMENTS OF A GOOD TRAP:-****The following are the requirements of a good trap:*
- *(i) It should be made up of a non-absorbent material i.e., does not absorb waste.*
- *(ii) It should provide always an adequate water seal.*
- *(iii) It should not obstruct or retard the flow of water by any rough surface, projection, or contraction inside it. So the inner surface should be smooth.*
- *(iv) It should have self cleaning velocity which helps in cleaning of water closets.*
- *(v) It should retain an optimum quantity of water which can be achieved by providing a deep water seal.*
- *(vi) For easy cleaning, a plug or cap must be provided.*

- *vii) It should be constructed of best enamelled substance so that human excreta may not stick to it.*
- *(viii) It should be fixed easily with the drain.*
- ***CLASSIFICATION OF TRAPS:***
- *The traps may be classified on the following basis*
- ***(1) On the basis of shape.***
- ***(2) On the basis of use of trap.***

- ***(i) According to the shape of trap:*** *The traps according to their shapes are classified as:*
- ***(a) P-trap:*** *The trap having the shape of latter P and legs of the trap are perpendicular to each other.*

- ***(b) Q-trap:*** *Having the shape of latter Q and legs of the trap are meet at an angle other than 90 degree.*
- ***(c) S-trap:*** *Having shape of latter S and legs of trap are parell.*



Traps According to Shapes

-
- ***PREVENTION OF BREAKING OF SEAL:***
- *The following precautions should be taken in order to prevent the breaking of real*
- *(1) The portion between the soil pipe and the trap must be connected to the vent pipe in order to avoid the termination of partial vacuum. It is because vacuum is responsible for breaking of seal.*
- *(2) The anti-siphonage pipe should be used in the buildings.*

SEAL IN TRAPS: *The vertical distance between inside lowest point (or dip) and inside highest point is called seal or water seal. The efficiency of trap depends upon the depth of a water seal. Therefore, deeper the seal in trap, more efficient in the trap. The depth of water seal varies from 2.5 to 10 cm.*

- ***CAUSES OF BREAKING OF SEAL:*** *The following are the causes of breaking of seal:*
- *(i) The seal may break due to faulty joints.*
- *(ii) The seal may break due to any crack in the bottom of seal from atmospheric agencies.*
- *(iii) The seal may break due to creation of partial vacuum in the sewer fittings.*
- *(iv) The seal may break due to increase in the pressure of sewer gases which occurs due to blockage.*

-
- *(v) The seal may break if it is not used regularly.*
- ***2)On the basis of use of trap:-***
- *The traps according to their particular use are classified as follows:*
- *1. Floor traps*
- *2. Gully traps*
- *3. Intercepting traps*

- *1. Floor traps: The traps which are used for admitting surface wash or waste water from the floors of baths or kitchens are called floor traps. Floor Trap They are placed at the starting points of waste water flow i.e in bath rooms, kitchens and sinks etc. The* *cover provided at the top be removed for cleaning the trap. A floor trap is also called* ***Nahni*** *traps.*

- *2. Gully trap: The trap which is used to receive waste water from sinks, baths, wash basins and rain water is called a gully trap. Gully traps are also suitable where coarse solid matter in likely to block the drain.*
- *3. Intercepting trap: The trap which is provided at the junction of a house drain and a sewer is called an intercepting trap.*

MAINTENANCE OF BUILDING DRAINAGE SYSTEM:

- *The following points should be kept in mind in order to maintain a building drainage system • (i) Phenyl or any other disinfectant should be used regularly to maintain good sanitary conditions.*
- *(ii) The washers of the leaky taps should be replaced at regular intervals.*
- *(iii) The entire system should be cleaned at least one time in a month.*

-
- *(iv) The waste matter should not be thrown openly.*
- *(v) The particle of sand, grit etc. should be collected separately and should not be mixed with the sullage or sewage in the drains.*

- ***INSPECTION OF BUILDING DRAINAGE SYSTEM****:*
- *The following points should be kept in mind while carrying out the inspection of the entire building drainage system • (1) The entire system should be surveyed and for this purpose, complete drainage plan of the building should be checked.*
- *(2) The flush, water closets etc. should be examined and if necessary, proper steps should be taken.*
- *(3) The presence of drainage should be detected as it indicates leakage.*
- ***The following tests are commonly employed for testing drains and pipes:***
- ***(1) Air test***
- ***(2) Coloured water test • (3) Smoke test***

- ***(4) Small test*.**

- ***(1) Air test:*** *In this test, air is forced in the selected section after plugging the ends. Then, a soap solution is applied. If there is any leaked joint, then, bubbles will form and necessary steps may be taken.*
- ***(2) Coloured water test****: If coloured water is added from one side, then, it will come out through the leaky joints which can be noticed.*
- ***(3) Smoke test:*** *The smoke is allowed to enter through one end and leaky joints, if any, can be detected.*
- ***(4) Smell test:*** *In this case, firstly, air is mixed with some-smelling Then, it is allowed to pass through the drainage pipes. If there are leaky joints, then, the same can be detected by smelling.*

-
- ***After testing, as above, if any joint is found defective, it should be repaired immediately.***

  Vent Pipe: *It is a pipe installed for the purpose of ventilation. The top of vent pipe is provided with narrow opening. So that the birds may not build their nest.*
- ***Warning Pipe:*** *It is a pipe fixed to expose position and check whether the discharge is over.*
- ***RWP:*** *It is a rain water pipe. It is used for carrying the storm water or rain water.*

Finish★

R.J.L.B Govt. Polytechnic College Loharu (Bhiwani)

【 Conveyance of Water】

Presented by :Amit Kumar

Pipes used for conveyance of water

The pipes of different materials are used for conveyance of water. Let us discuss some pipes manufactured from different materials. These pipes are following :-

- Cast iron piles

- P.V.C Pipes
- Steel piles
- AsbestosCement pipes
- Concrete pipes
- Copper and lead pipes
- Galvanised iron pipes

CAST IRON PIPES

The pipes made up of cast iron material are generally used for water supply schemes.

Manufacturing :- These pipes are manufactured by two method – 1 Sand Moulding
2 Centrifugal Casting

ADVANTAGES :-

1These pipes are strong and corrosion resistant .

2 These pipes are cheap and can be joined easily .

3 These pipes are large and have low maintenance cost .

P.V.C PIPES

P.V.C pipes belong to plastic pipes. These pipes are manufactured from polyvenyl chloride.

Advantages :-

1 These pipes can withstand pressure hoti 10kg/cm2
2 These pipes are light weight and easy to handle.
3 These are used for minor works, house connection .
4 These pipes are free from corrosion .

5 These pipes are resistant to inorganic salts, alkaline etc.

STEEL PIPES

Mild steel is used for manufacturing of steel pipes . These pipes are smoother , longer and provided with Welded water tight joint . These pipes are stronger than ordinary one .

ADVANTAGES :-

1 These pipes are cheaply available .

2 These pipes can withstand high pressure.
3 These pipes are more durable and flexible .
4 These pipes may be provided for 6m or long .

ASBESTOS CEMENT PIPES

A dense homogeneous structure in the form of pipe Which is composed of asbestos fiber and portland cement combined under pressure and pipes are formed is known as asbestos cement pipes .

ADVANTAGES :-

1 These pipes are available in size from 0.1 to 0.9m diameter .

2 These pipes are corrosion resistant and easy to transport .
3 These pipes are flexible and have low labour cost
4 These pipes have good carrying capacity and provide hydraulically efficient pipe .

Concrete Pipes

These pipes maybe precast or cast-in-situ . Plain concrete pipe may be used at sach places where water does not flow under pressure. These pipes are joined with Bell and Spigot joint. Nowadays prestressed concrete pipes are also available in market.

Advantages :-

1. These pipes don't corrode by water and have long life.
2. These pipes have low maintenance cost.
3. Surface of these pipes does not affect with time hence carrying capacity does not reduce

Copper and lead pipes

Copper pipes are not liable to corrosion even if water contains some tresses of acids. These pipes can be easily bent and also don't sag.

Lead pipes are not used in India because they cause lead poisoning. But they can be went easily and also can withstand high pressure. These pipes mostly used in sanitary fittings

Joints In Pipes

- The meeting place of two adjacent pipes is called as joint in pipe.

Types of joints in pipes

1 Socket and spigot joint

2 Flanged joint

3 Expansion joint

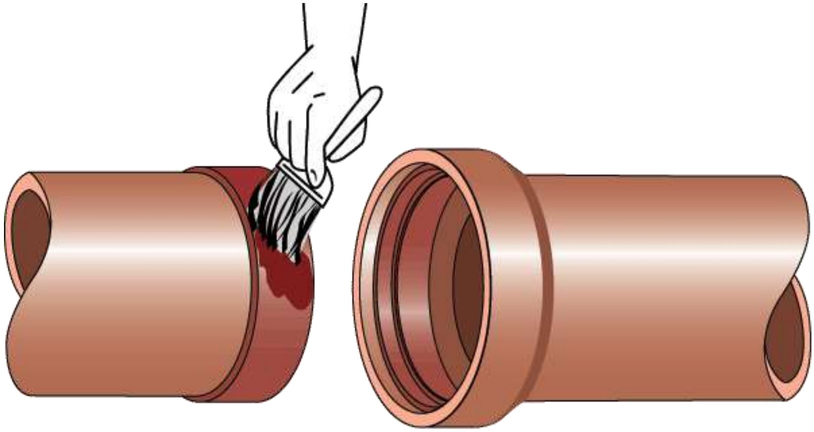
4 Joints for hume steel pipe

5 Joint for asbestos pipes

6 Screwed joint

Socket and Spigot Joint

In this type of joint one end is enlarged where as the other end is normal. The enlarged and is called



as “socket” or “bell” while the normal end is called as “spigot”. This joint is also known as “bell and spigot joint”. Spigot is fitted in socket . This joint is commonly used in cast iron pipes.

Advantages :-

1 This joint is flexible.
2 It can be easily laid on flat curves .
3 This joint is water tight .

Flanged Joint

This joint is also mostly used for cast iron pipes. These joints are used for pumping stations, filter plants and other locations where disjointing of the pipes may be necessary occasionally. These joints are provided with flanges and due to this it is called as flanged joints.

Advantages :-

1 These are very simple in connection .

2 These joints are very strong .

3 These joints are preferred if water pressure is high .

Expansion Joint

These joints are next one provided in Cast Iron pipes. When the pipes expand the socket end moves forward and space left just gets close. Similarly when pipe contract socket moves backward and gap is created. Thus, gasket ring maintains the gasket in position with further help in making a water tight joint .

Advantages :-

1 They counteract the thermal stressesproduced due to the temperature variations

2 These are water tight

3 These are also used when pipes are exposed to atmosphere

Distribution of Water

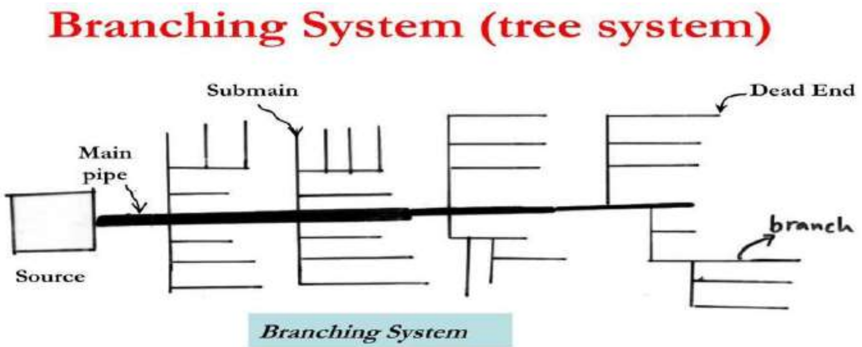
Distribution reservoir may be classified according to their position as surface or elevated reservoirs. These are also classified according to their materials of construction example Steel, RCC or masonry . The capacity of distribution reservoir depends on the maximum pumping capacity minimum safe yield of source of supply requirements for the fire extinguishing and maximum rate of consumption.

Layout of distribution

The distribution pipes are generally laid below the road pavement, thus, there layouts will generally follow the layouts of roads.
In general there are four different types of systems :1
Dead End system .
2 Grid Iron system .
3 Ring system .
4 Radial system .

Dead End system

This is also known as “Tree System” constructed as in the shape of a tree having a number of branches. A number of sub mains originate at right angle from the



main pipe. Each sub main is divided into several branch pipes called as laterals. These laterals provide service connections to the consumers.

ADVANTAGES :-

1 This distribution network can be solved very easily.
2 Less number of cutoff valves required.
3 As sort pipe lengths are needed, this help in easy laying of pipes.
4 This is cheap and simple.

Grid Iron system

This is also called as reticulation system or interlessed system. In this, there is interconnection between the mains, submains and branches. In a well planned City or town, roads are generally developed in grid iron pattern.

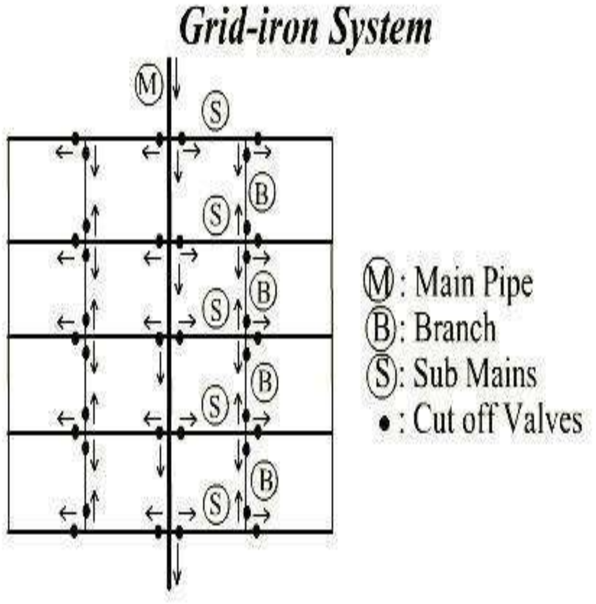
ADVANTAGES :-

1 water reaches at different places through more than a single route, losses becomes less.

2 Dead points are completely eliminated ,so safe from pollution.

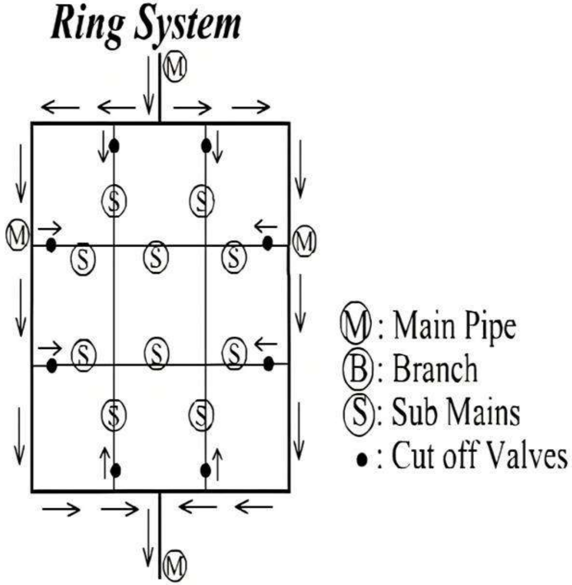
3 Very small area will be affected so, it can be repaired in less time.

4 Various cut off valves are provided andthus helps in easy diversion, when needed.



Ring System

This is also called as circular system as circular pipes are laid around the area to be served. Rectangular or circular blocks are made for distribution. Then main water pipes are laid on the peripheryof these blocks.



ADVANTAGES :-

1 Water reaches at different places through more than single route, losses becomes less.
2 Very small area will be affected, in case of repairs.
3 Various cut off valves are provided and thus help in easy diversion

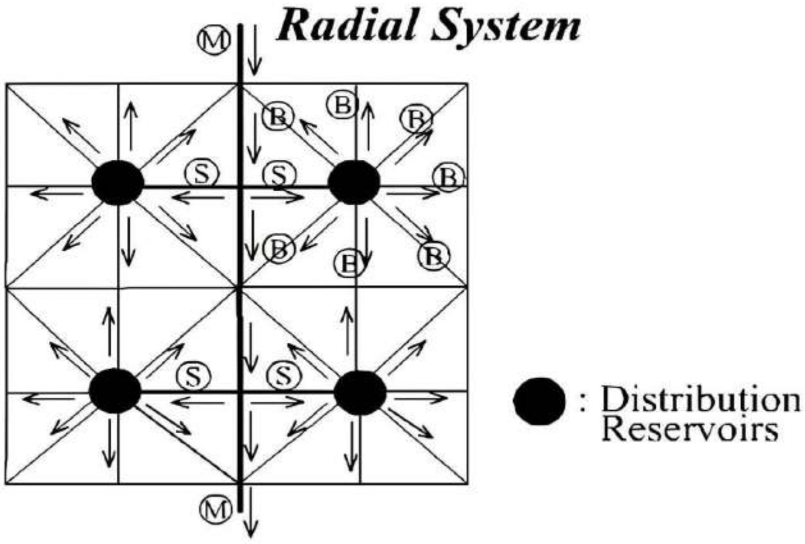
Radial System

This system is adopted for those areas, which have radial roads. From water mains, water is taken and pumped into the distribution reservoirs placed at different centres.

ADVANTAGES :-

1This method ensure high pressure and efficient water distribution.

2 Calculations for design of sizes are also simple.



SYSTEMS OF WATER SUPPLY

Water is supplied to various parts of an area under a particular system. Water is supplied under two systems :1 Continuous system. 2 Intermittent system.

1 **Continuous System :** Under this system, water is supplied continuously for 24 hours. This is a good system but results in wasteful use of water. If any leakage occur great volume of water get losted. Water remains fresh due to it's continuous supply.

2 **INTERMITTENT SYSTEM :** Under the system, water is supplied to the consumers only for peak periods during morning and evening. This is the most common system adopted in India. This method is adopted when either sufficient pressure is not available.

Detection of Leakage of Water

The cause due to which a considerable amount of water gets lost and wasted in a distribution system is called as leakage. The percent of loss of water from leakage may vary from 20 to 50%.

Detection of leakage of water :-

Leakage of water in a distribution system can be detected by following methods :-

1 By direct observation.
2 By using sounding roads.

3 By ploting hydraulic gradient (H.G.L) .
4 By using waste detecting metres.

Contents:

- Introduction
- Methods of disposal

I. Thermal drying

II. Incineration

III. Wet air oxidation

IV. Land fill disposal

Introduction

- Sewage **sludge** treatment describes the processes used to manage and **dispose** of sewage **sludge** produced during sewage treatment.
- **Sludge** is mostly water with lesser amounts of solid material removed from liquid sewage.
- Reducing **sludge** volume may increase the concentration of some of these toxic chemicals in the **sludge**.

SOURCE OF SLUDGE

- Domestic sewage
- Industrial sewage
- Water treatment plants

TYPES OF SLUDGE

- Humus sludge
- Activated sludge
- Digested sludge

CHRACTERISTICS OF SLUDGE

- PHYSICAL

  includes moisture, density, color, texture, fluidity and plasticity etc.

- CHEMICAL

  includes organic matter, volatile solids, Nitrogen, phosphate, fats etc.

SLUDGE TREATMENT

Main objectives-

- Digestion of organic matter by Common methods.
- Destruction of pathogenic organisms.
- Safe and aesthetically acceptable disposal of sludge.
- By product of methane is used as fuel & and helps in controlling temperature and also generates power.

UNITS OF TREATMENT

- *Thickening or concentration*

1. Reduction of moisture content of raw sludge.
2. Helps in reducing capacity of digestion tank and provides control of digestion condition.
3. It can produce sludge of less than 10% solid content.
4. Units of thickening are gravity thickener, floatation thickener, elutriation thickener.

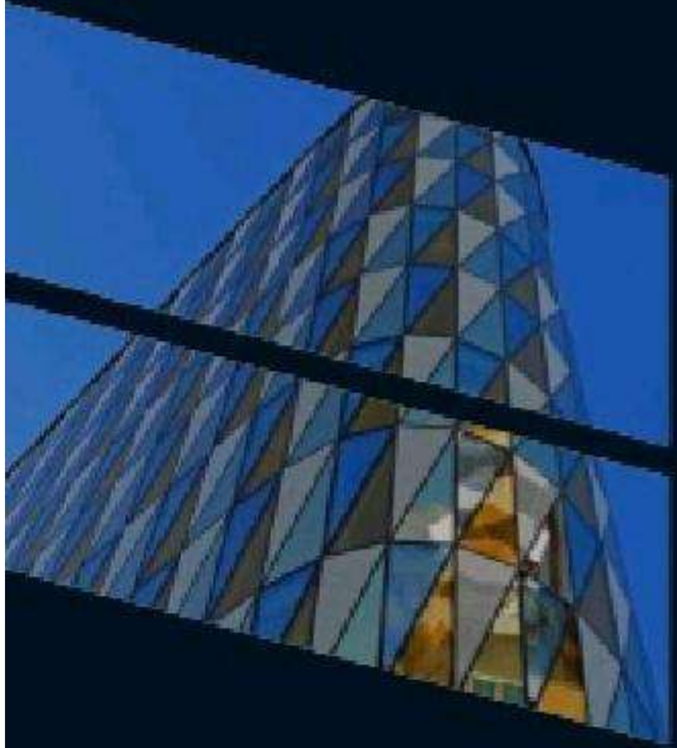
UNITS OF DIGESTION

- Anaerobic digestion –
- converts sludge into liquid & gases and also reduces odor, volume, putrescence & produces gases.
- Bacteria like saprophytic organisms are present that react on complex organic matter and decomposed.

UNITS OF TREATMENT

- **Dewatering**
  - produces sludge of greater than 10% solid content and is used after digestion process.
    - sludge drying beds.
    - Centrifugation
    - mechanical methods by
      vacuum filtration.

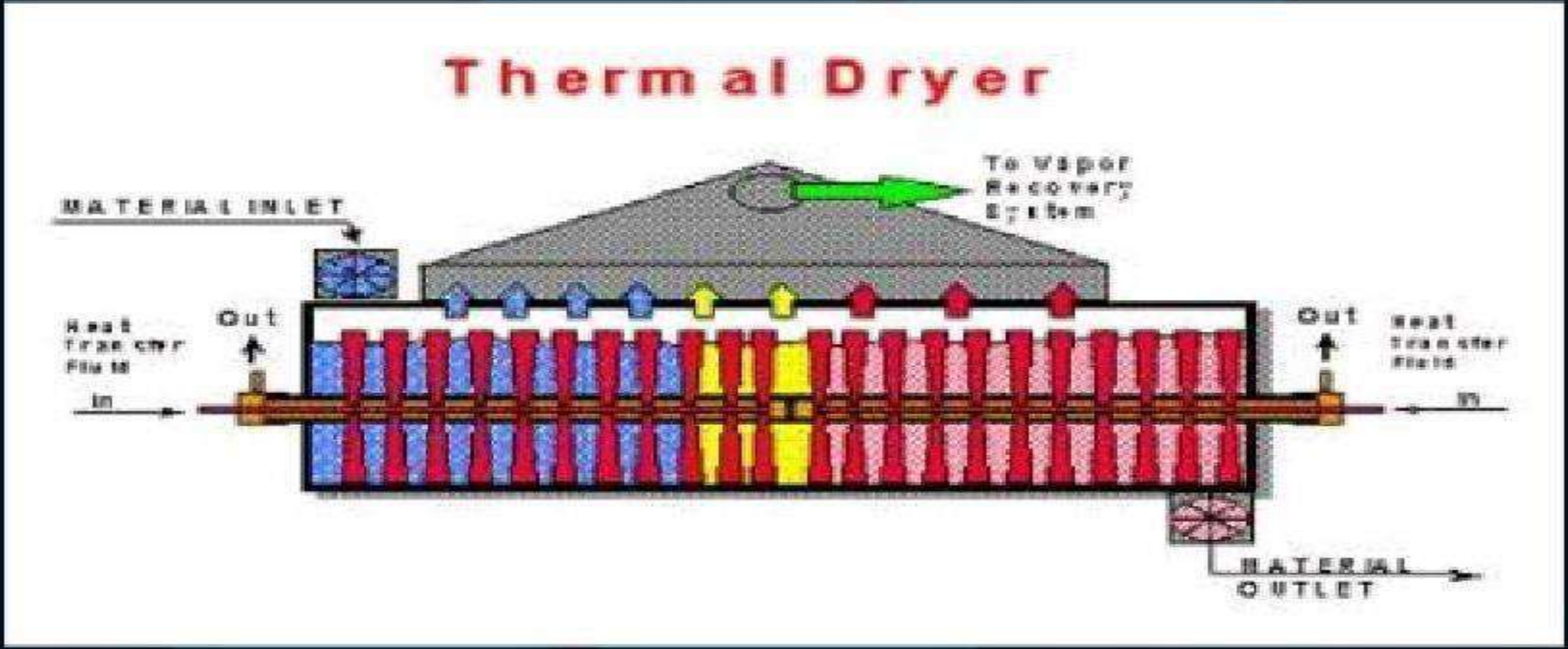
I. Thermal Drying



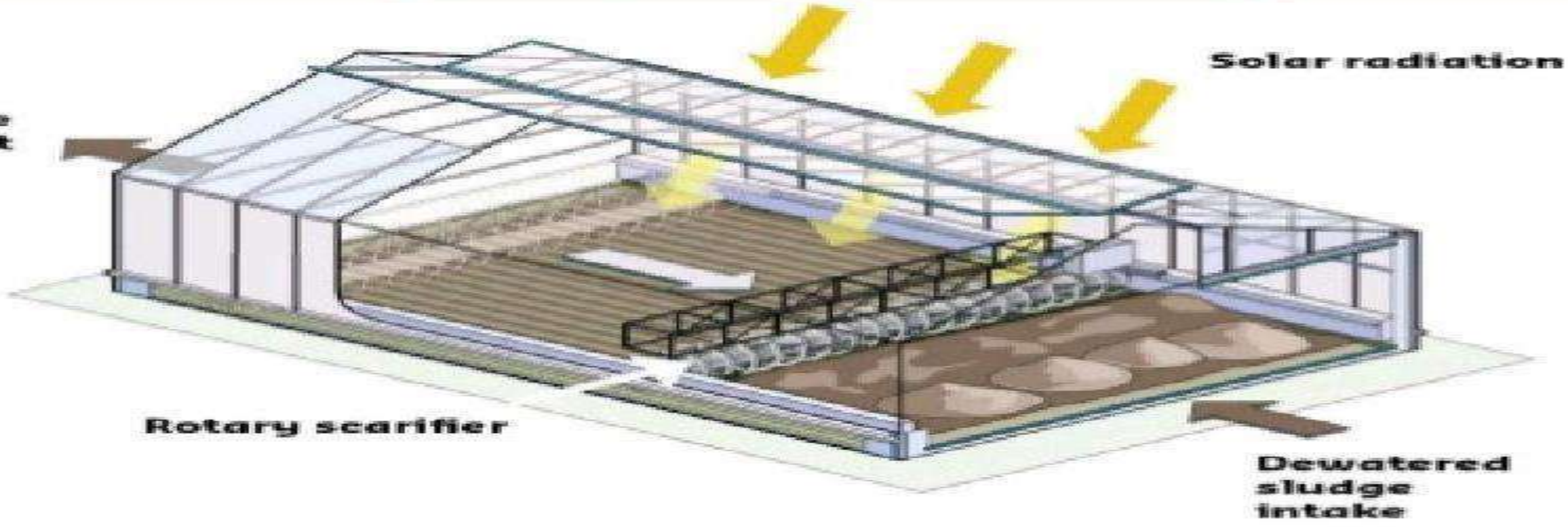
- Thermal drying involves the application of heat to evaporate water to reduce moisture content of the biosolids (sludge).
- High level of drying is achievable with production of dried sludge of up to 90 % dry solids content.
- Some heat drying systems are able to produce dense and dried sludge pellets which are easy to handle and to dispose of.
- The advantages of heat drying include reduced transportation cost, further pathogen reduction, and improved storage capacity.

Drying types:

1) Thermal dryer



2) Drying by solar Radiation



Operating principle of solar drying by Heliantis

ii. Incineration

To incinerate a combination of dried (90 to 95% Dissolved Solids) and dewatered sludge (20 to 25% Dissolved Solids).

Incineration process:

- Step 1: The dried and dewatered sludge is premixed
- Step 2: Premixed sludge is sent for drying
- Step 3: After drying, it is incinerated. The heat from the incineration process is recycled for the drying process.

- **Incineration is Use for energy content, but not of nutrients**

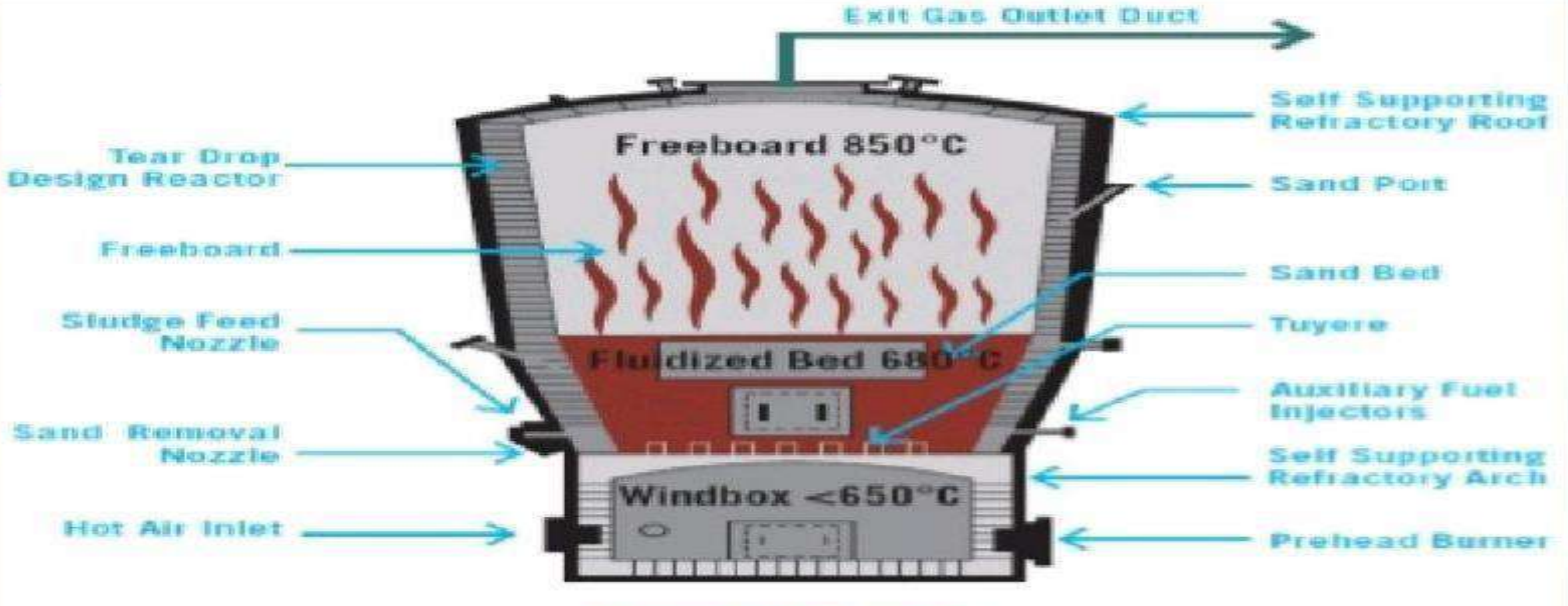
1. Mono incineration

- Calorific value of sludge high enough → no biogas use before, no stabilisation
- Water content not minimised (no full drying)
- Fluidised bed incinerator, incineration at 800 – 950 °C in fluidised sand bed
- Expensive

2. Co- incineration

- In coal power station
- In solid waste incinerators
- In cement production, ash is bounded to cement

Incinerator diagram:



Thermylis® Reactor

The branch of civil engineering which deals with the supply of water for various purposes e.g. domestic, industrial, commercial and public is called **Water Supply Engineering.**

In this engineering a scheme is constituted which is known as **water supply scheme.**

The provision of such a *scheme* shall ensure a constant and a reliable water supply to people for which it has been designed. Such a scheme shall help in supplying safe *wholesome** water to the people for drinking, cooking, bathing, washing etc. so as to keep the disease away and thereby promoting better health. would also help in supplying water for fountains, gardens, etc and thus helping maintaining better sanitation and beautification of surroundings, thereby reducing environmental pollution.

A good water supply scheme has to fulfill the following aspects :–

(*a*) To search source of water supply.

(*b*) Purification of water.

(*c*) Distribution of water to required place.

1.2 HYDROLOGICAL CYCLE

Hydrology in the science which deals with the occurrence, distribution movement of water on the earth, including that in the atmosphere and below surface of the earth. Water occurs in the atmosphere in the form of vapour, on surface as water, snow or ice and below the surface as ground water occupying the voids with in a geologic stratum.

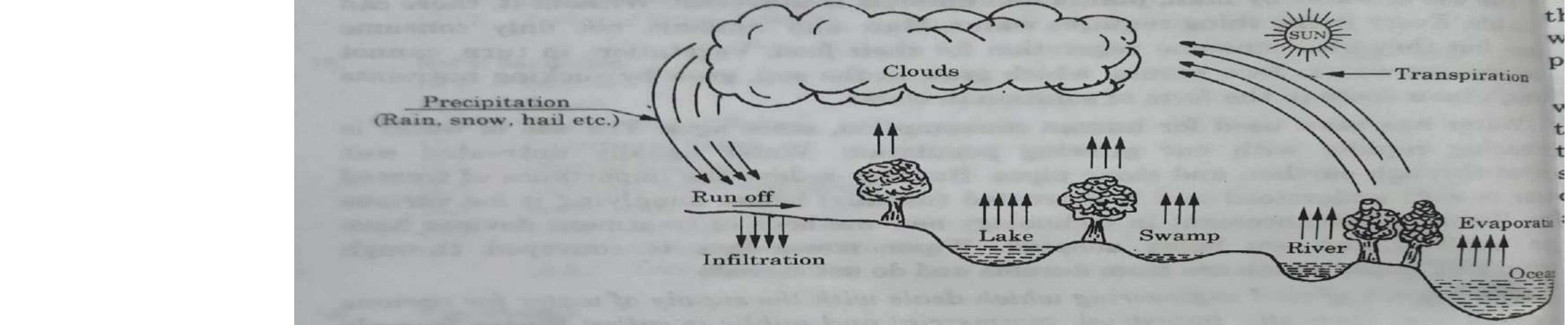


Fig. 1.1 : Hydrological Cycle

Water is lost in the atmosphere as vapour from the earth, which is th precipitated back in the form of rain, snow, hail, dew, sleet or frost etc. Th precipitation and evaporation continues forever, and thereby a balance maintained between the two. This *process* is known as *hydrologic cycle* and is show in fig 1.1. This cycle is also called *water cycle*.

Hydrologic cycle or the *water cycle* is the process of transfer of moisture fro atmosphere to the earth in the form of precipitation, and movement of the precipitat water by streams and rivers to ocean and lakes etc., and evaporation of water back the atmosphere. Fig 1.1 illustrates, diagrammatically, the complete hydrologic cycle.

1.3 IMPORTANCE AND NECESSITY OF WATER SUPPLY SCHEMES

For any living being water, air, food, shelter, etc. are the primary needs, in which water has the greatest importance. Everywhere water is required for various purposes, few of them are :

(*a*) for drinking and cooking

(*b*) for bathing and washing

(*c*) for watering of lawns and gardens

(*d*) for heating and air-conditioning systems

(*e*) for growing of crops

(*f*) for street washing

(*g*) for fire fighting

(*h*) for recreation in swimming pools, fountains

(*i*) for steam power and various industrial processes etc.

Without food human can survive for a number of days, but water is such an essential element that without it he cannot. In the ancient times human required water for drinking, bathing, cooking etc. but with the advancement of civilization the utility of water enormously increased, and now such a stage has come that without well-organized public water supply scheme, it is impossible to run the present civil life.

In ancient times every individual or family was responsible to arrange their water supplies. There was no collective efforts by the whole community for it. But as the community developed, it became essential to have public water supply. When the community found that their local sources of water supply such as shallow wells, springs, cisterns etc. are not enough to meet the demand of the town, they started to collect the water from distant large sources and conveyed it to the town through aqueducts, canals etc.

When the concentration of population increases, it becomes very difficult to locate wells. In addition to this sources of water having good quality of water, are not easily available to the individuals. It also becomes compulsory to protect the community from the danger of fire, which is not possible through private sources of water. These all situations led to the development, of public water supply schemes.

As in ancient times there were no pipes, which could withstand even moderate pressures, therefore engineers of those ages had to use pipes of clays, lead and bored wood in small sizes. In all these cases, the water was allowed to flow under gravitational force only and the weak pipes were protected from internal pressure. In the middle of eighteenth century, first time use of cast-iron pipes was started. Due to their high durability the use of cast-iron pipes was started everywhere. Due to their knowledge of hydraulic structures and various other works connected with water supply schemes, the complete designing, construction and maintenance of water supply schemes becomes the work of *Civil Engineers*. Therefore, for every Civil Engineer it is necessary to have the full knowledge of it.

1.4 VARIOUS COMPONENTS OF WATER SUPPLY SCHEME

The various components of a water supply scheme is shown in figure 1.2. This consist of various sources of water supply, different types of treatments and distribution of treated water to the consumers.

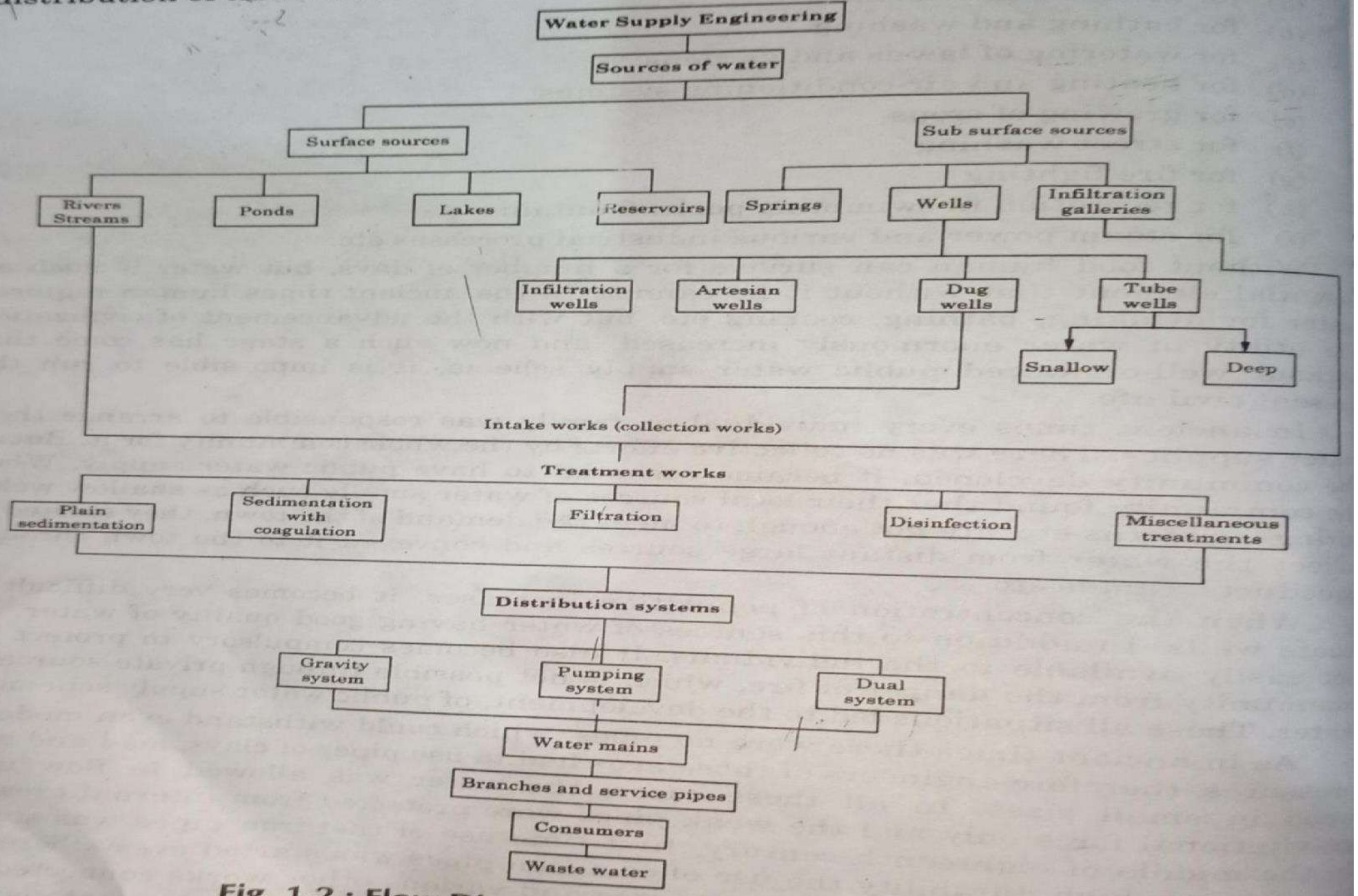


Fig. 1.2 : Flow Diagrams of Water Supply Scheme.

We will study all the above components in the following chapters.