BHUBANANANDA ORISSA SCHOOL OF ENGINEERING, CUTTACK

DEPARTMENT OF CIVIL ENGINEERING

LECTURE NOTE ON: WATER SUPPLY AND WASTE WATER ENGINEERING (TH4)

5TH SEMESTER

PREPARED BY : MRS. ASHA MISHRA

CIVIL ENGINEERING DEPT BOSE, CUTTACK

SOURCES AND CONVEYANCE OF WATER
<u>Sources of water supply-</u>

The sources from which the water is available for water supply scheme is classified into two categories.
(I) Surface sources
(i) Underground sources
<u>Surface sources-</u>
The water which is available from the surface of ground is known as surface sources.
(i) Lakes & stream
(ii) Rivers
iii) Pond
(iv) Storage reservoir

(i) **Lakes**:- A lake represent range body of water with land with impervious bed. So it is the source of water supply system. These water are free from undesirable impurities.

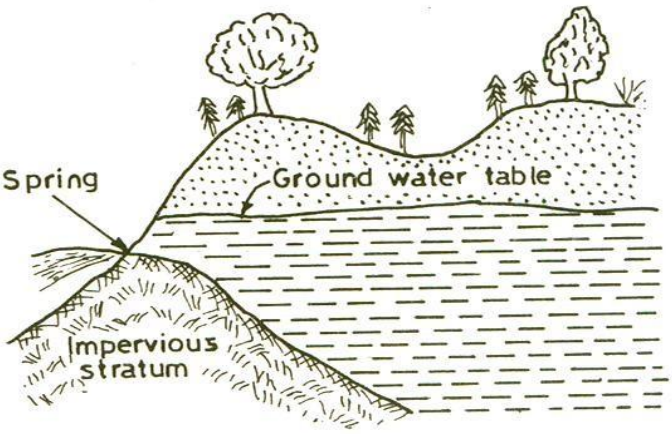
(ii) **Ponds**:- A pond is a man made body of standing water small than take. The water in pond is full of impurities so the pond cannot adopt as a source of water supply system.

(iii) **River**: - River is the main source of water supply system. The river is full of silt & suspended material so, the river water cannot directly use for public purpose.

(iv) **storage reservoir**:- An artificial storing of water by construction of dam across a valley is known as storage reservoir. It is also one of the source of water.

Underground source of water
In this type of source, the water that has percolated into ground is brought into the surface.
The following are the different underground sources of water.

(i) **<u>Spring-</u>**
when the ground water appears at surface due to any reason is known as spring. It is
source of water near the hilly area & base of hill



1. Artesian spring
2. Gravity spring
3. Surface spring

Artesian spring
In this type of spring the ground water comes to the surface under pressure.
These springs are formed due to pressure of crack in impervious layer.

These crack are continued upto ground surface. So springs are formed.

Gravity spring:

This type of spring are formed due to overflowing of water table.

The flow of gravity spring is variable with rise or fall of water tables.

In order to meet such fluctuations a trenches constructed near the spring. It acts as a storage reservoir.

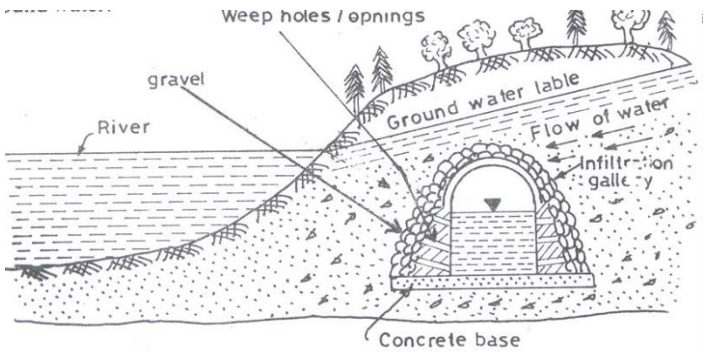
Surface spring:

1. This type of spring is formed due to obstruction of impervious layer, so the sub-soil water is exposed to ground surface.
2. The quantity of water in this type of spring is uncertain, so the cut-off walls are constructed to develop such spring.

(i) **Infiltration galleries**

It is the horizontal or nearly horizontal tunnels which is constructed through the water bearing starta. It is also known as horizontal well.

1. The gallery is usually constructed of brick wall with slab roof.
2. The gallery obtains its water from different water bearing strata by porous drain pipes.
3. The gallery is laid at a slope & the water is collected in the gallery is led to a sump from where it is pumped & supplied to consumer after proper treatment.



Infiltration wells

To obtain the range quantity of water the infiltration wells are sunk in series in the bank of a river.

1. The wells are closed at top & open at bottom
2. For purpose of inspection of well, the man holes are provided at the top.
3. The water infiltrates through the bottom.
4. At bottom sand bed is provided, so when water pass through sand bed, it gets
5. purified to some extent.
6. The infiltration well is connected through porous pipe to collecting sump, known as jack well.
7. So the water collected through the infiltration well, then flows through the jack well by gravity. The water from jack well is pumped to the purification plant for treatment.

(iv) Wells A well is defined as an artificial hole or pit made in the ground for the purpose of tapping water. It is the main source of water.

Following is the general classification of different types of well

(a) Shallow well

(b) Deep well

(c) Tube well

(d) Artesian well

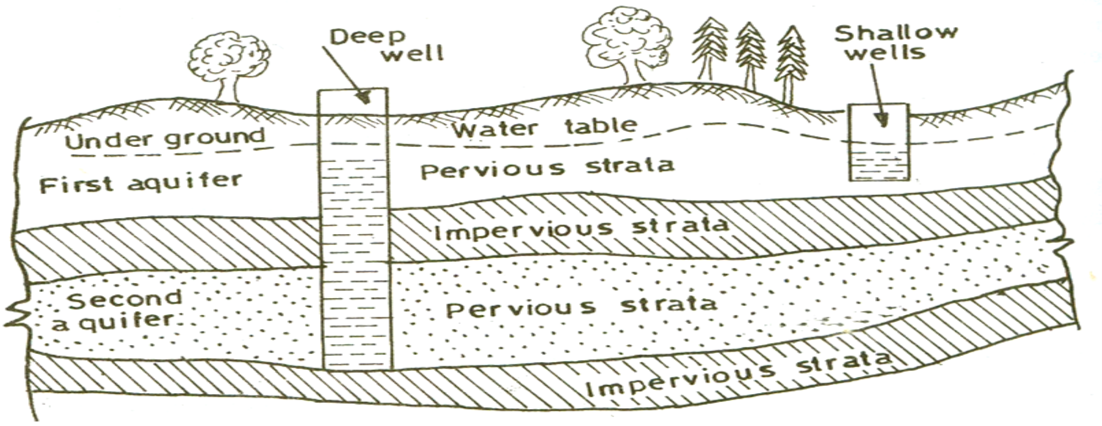
(a) Shallow well:

1. This well is constructed at the uppermost layer of earth surface
2. The diameter of shallow well is 2 to 6 meters.

3. ‘They may be lined or unlined from inside. The lining is also called steining.Its thickness is varies from 300 mm to 500 mm.
4. The maximum depth of well is 7mt.
5. It is also known as gravity well, draw well open well, dug well or percolation well.
6. The quantity of water is shallow well is vary according to water table. The depth of well below the water table is kept 6 to 8 meter so when water tables falls 3 to 5 meters, some water will available from the shallow well.
7. The quality of water in shallow well is better than river water. But the main source of contamination is the effluent near by the septic tank, soak well etc.

(b) <u>Deep well:</u>

A deep well is that well in which the water is obtained from the underneath ofanimpervious layer. The yield of a deep well is greater & constant as there is no quick fluctuation of the water level.



Types of well

1. According to condition of flow , wells may be classified as : Gravity wells & Pressure wells.

Gravity Well:

When the surface of the water in the water bearing stratum surrounding the well is at atmospheric pressure , the well is called **gravity well**.

Pressure Well:

When the aquifer is confined between two impervious layers, one above & other below, & the water in this aquifer is at a pressure greater than atmospheric , the well is called **pressure well**.

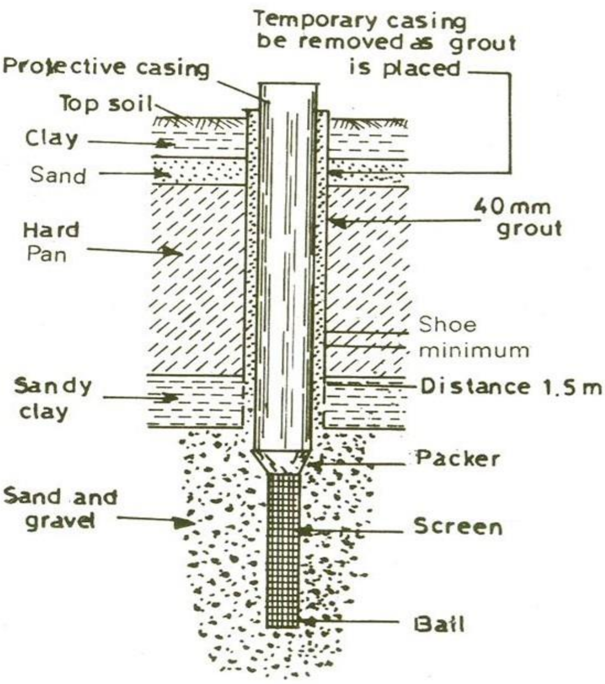
According to the type of construction , wells may be classified as :

1. Dug Wells ,
2. Bored Wells or Tube Wells
3. Driven Wells.

Dug Wells :- Small dug wells are generally excavated by hand. In loose soils, they are lined with brick, rubble or concrete. In rock, they are commonly left unlined. This lining is termed as **“Curb”**. In the case of a well used for domestic purposes , the upper portion of the curb is made impervious for a depth of 1.80m to 2.40m .Dug wells should be completed when the water table is at its lowest level .

Bored Wells or Tube Wells:-

1. A tube well is a deep well having a diameter of about 50 mm to 20omm & it obtains its quota of from a number of aquifers.
2. The Wind pipes are placed against the impervious layer .
3. The bore is drilled in the ground the diameter of bore is larger than tube well .
4. The depth of tube well is according to quantity of water required. Usually it is taken a 30 mt to 50 mt.
5. Then the pipes of tube well is then inserted in the bore hole. It consists a strainer & blind section.
6. The strainer is a perforated pipe which is provided with an arrangement such that only water will admitted to the inside of pipe.
7. when the pumping is started, it should done gradually to avoid sticking of hone sand on the external surface

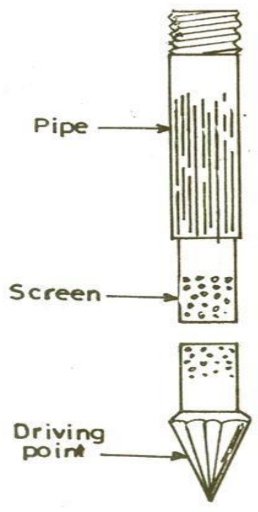


of strainer.

8. The strainer is cleaned through the perforation by allowing water from a high tank.
9. Under pressure or blowing air on reverse direction of flow. This process of removing tine particle surrounding strain or is known as well development.
10. The discharge from a tube well does not exceed 40 liters to 50 liters per second.
11. The quality of tube well water is generally very good, in many case it contains hardness.

Driven Wells (Percussion Wells) :

1. For domestic use , percussion type or driven wells develop smaller water supplies. The reason for this is that driven wells are shallow and of smaller diameter.
2. This is because of the difficulty in driving a large pipe to greater depths. All such wells will be located round a collecting well with a suction pump at a distance not exceeding 9m.
3. Driven wells are adopted to soft , granular formation. Percussion well consists of a drive point & a pipe as shown in Fig. below.
4. A piece of pipe pointed at one end & perforated for remaining length is driven into a water-bearing formation by a wooden hammer or hydraulic ram.
5. The diameter of the casing varies from 2.5 cm to 15cm. The whole pipe should be driven perfectly vertical as far as possible.



Pipe
Screen
Driving point

Yield from Well

Yield has been defined as the amount of water flowing into the well per unit time. It is expressed in litres per second or sometimes in cubic meter per day.

Methods of determination of Yield of the well:-

If D = the vertical distance from the water table to the bottom of the well. d = the depth of water in the well

R = the radius of the circle of influence

r = the radius of the well

p = porosity ratio k = constant, then

Yield of the well $Q = K_m (D^2 – d^2)/ \log_{10} (R/r)$ litre per minute.

Where Transmissibility constant $K_m = 3.143pk *1000/ (24* 60* 2.303)$

Problem :

The following observations were made on a 30 cm diameter tube well :—

1. Rate of pumping = 1500 litre / minute ,
2. Draw down in a test well 30m away =1.5m,
3. Draw down in another test well 60m away = 0.6m,
4. Depth of water in the well before pumping = 40m.

Determine the radius of the circle of influence & the transmission constant.

Ans. : Given H = 40m , h = 40 — 0.6 = 39.4m

So here $Q = K_m (D^2 – d^2)/ \log_{10} (R/r)$ litre per minute

$= K_m (40^2 – 38.5^2)/ \log_{10} (R/30) = K_m (40^2 – 39.4^2)/ \log_{10} (R/60)$

Solving for R by trial & error ,we get R = 94m. Now solving for K_m ,

$15.0 = K_m (40^2 – 38.5^2)/ \log_{10} (94/30)$

=> $K_m = 6.31$ (Ans.)

Measurement of an open yield :-

The yield can be determined by the following two methods:

Actual Pumping Method

Theoretical Method

Actual Pumping Method :

The specific yield of a well can be determined by the following formula –

$C ‘/ A = (2.303/ T) \log_{10} (S_1 / S_2)$

Where ,

C‘/A = Specific yield.

S_1 = Depression head in the well at the time immediately after the pumping was stopped. S_2 = Depression head in the well at time ―t ‘‘ after the pumping was stopped.

T = Time after pumping when measurement S_2 was taken.

Knowing the value of C‘/A , the discharge ―Q of the well can be determined by –:

$Q = (C'/A) * A * S$

Where , A = Cross sectional area of the well

S = Depression head

Theoretical Method :-

The approximate quantity of water entering or percolating in the wall can be calculated as :

$Q = A * V * B$

Where A = cross sectional area of the well opening

V = Velocity of water percolating in the well & B = Permeability constant.

Problem :

The water level in an open well was depressed by pumping up to 3.0 meter. The water level was raised by 1.5meter within 50 minutes just after stopping the pumping . Determine Yield from well , if the diameter of the well is 2.5 meter & the depression head is 3.3 meter.

Ans. Given $S_1 = 3.0m$, $S_2 = 3 – 1.5 = 1.5m$, T = 50 minutes = 3000 sec $C/ A = (2.3 / T) \log_{10} (S_1 /S_2$

1. $C'/A = (2.3/3000) \log_{10} (3/1.5)$
2. $C'/A = 0.0002307$

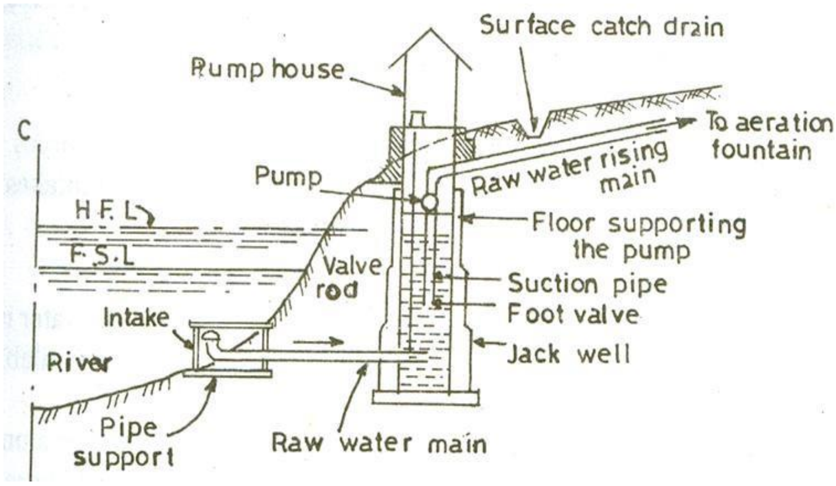
If d = 2.5m & S= 3.3m, then $A = 3.142d^2 = 4.909\ m^2$ Then $Q = (C'/A) * A * S = 0.0002307 * 4.909 * 3.3$ $= 3.737 * 10^{-3}$ litre per second Ans.

CHAPTER – 2 CONVEYANCE OF WATER

Transportation of Water:
The term transportation of water or conveyance of water is use to indicate the following two arrangement.
Drawing of water from sources of water, commonly known an Intake.
Leading the water from intakes to the purification plant & leading the treated water to consumer through the pipes.
Intake:
1. An intake is a structure which is constructed across the surface of water so as to permit the withdrawal of water from the source.
2. The structure should be made of brick, store masonry or Rack. It is to be water tight. It should be design for al forces likely to come upon it.

Site selection:
The location of an intake should be carefully made. The following are the consideration taken for selecting the site for intake.
(1) Controllng devices
(ii) Lost
(ii) Navigation channel
(iv) Permanency of supply
(v) Quality of water
(v) Situation

Design of Intake:-
The following are the factors which are considered while designing a intake.
(1) Factor of safety
(2) Foundation
(3) Protection of sides
(4) Screens or strainers
(5) Self-weight
(6) Size & number of inlet
(1) Factor of safety:- The intakes should be designed with sufficient factor of safety so that it cam resists the farces caused by the heavy wave, current, ice-pressure etc.
(2) Foundation:- The depth of foundation of an intake should sufficient so that no damage is done by water current.
(3) Protection of sides:- The sides of intake should be protected by cluster of piles.
(4) Screen or strainer:- The screen or strainer provided at the entry level of intake to avoid the entry of floating material & fish. The coarse screen size is placing metallic rod placed about 25mm to 50mm apart, 1hey remove large object. The fine screen consists of wire net having opening of size 6mm x 6mm.
(5) self weight:- The intake should have adequate self-weight so that the chances of its floating on washing by the up-thrust of water is minimize.
(6) Size & number of inlets :- The size of inlets to an intake should be sufficient so that required quantity of water is allow to enter.



Types of Intakes:-

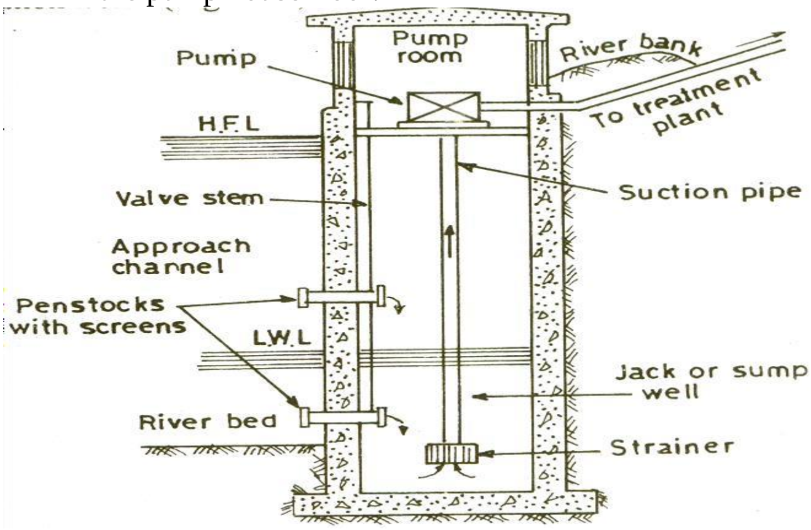
Fig. 4.1

Intakes are used to collect water for water works from various sources. The sources may be rivers , reservoirs , canals . Common type of intakes are :

1. River Intake
2. Reservoir Intake

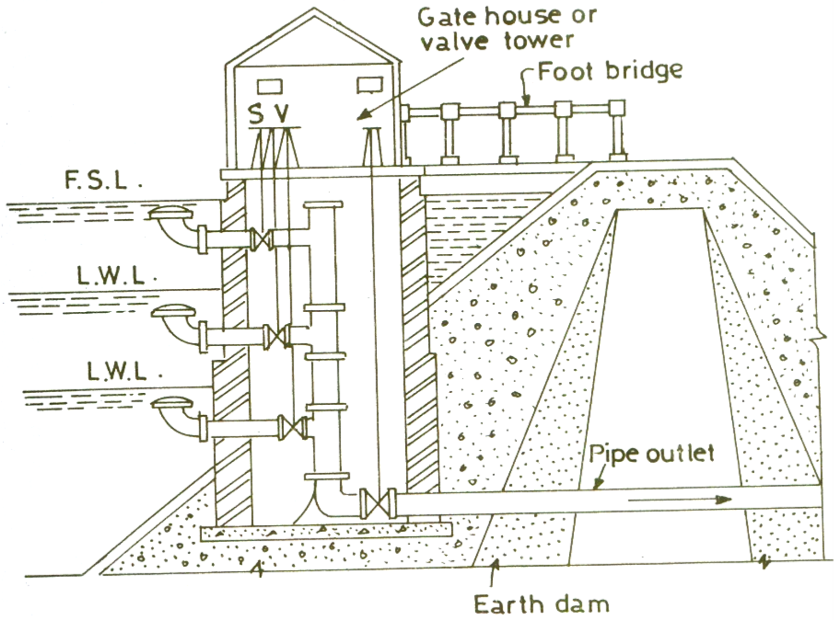
River Intake :-

1. It is a circular masonry tower constructed along the bank of river at such place from where required quantity of water can be obtained in the dry period
2. The water enters in the lower portion of the intake is known as the sump well from penstock.
3. The penstocks are fitted with screens to check the entry of solid and are placed on the downstream side.
4. The opening & closing of penstock valves is done with the help of wheels provided at the pump house floor.

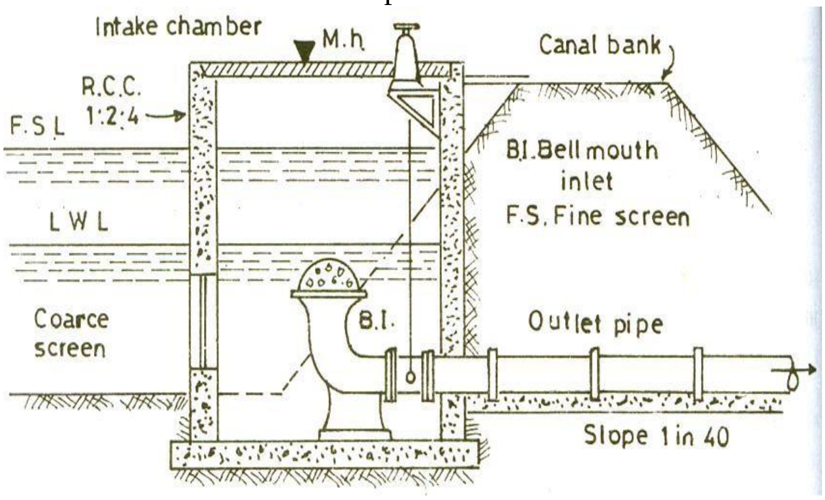


Reservoir Intakes :-

1. These consists of intake towers having no water inside other than in the intake pipes.
2. The interior of the tower is thus made available for inspection & operation . Fig. shows a reservoir intake which is usually located either along the upstream of an earthen dam or within the body of a masonry dam.
3. There are number of inlets protected by screen at different levels to draw in clear water from near the sources.



1. When the discharge of some river in summer remains sufficient to meet up the demand , but some rivers dry up partly or fully & can not meet the hot weather demand.
2. In such cases reservoirs are constructed by constructing weirs or dams across the river.
3. **Canal Intake**:-
4. Canal Intake is a very simple structure constructed on the bank of a canal & consists of a RCC or brick masonry chamber built partially in the canal bank.
5. Fig shows a canal intake.
6. It has a side opening fitted with course screen which excludes heavier matter from entering the conduit.
7. The end of pipe inside chamber is provided with a bell mouth fitted with a hemispherical fine screen.
8. The outlet pipe carries the water to the other side of the canal bank from where it is taken to the treatment plant.



Pumps for conveyance & distribution – types, selection, installation.

Pumping

The mechanical process by which the water is covered to flow at increased rate is known as n pump & the process using pump is known as pumping.

Necessity of pumps

Following are the purpose for which pumping is adopted

1. To lift the water to an elevated stroage tank.
2. To lilt the water from the sources to the water treatment plant
3. .To make available water at higher pressure during certain process of treatment.
4. To throw the water directly into distribution system.

Types of pump

1) Airlift pump
2) Displacement pump
3) centrifugal pump
4) Miscellaneous pump

Horse – power of pump (HP)

$\boxed{HP = WH/ 75}$ → Water horse power (WHP)

W = Weight of water in Kg per second

H = Total head in m.

Brake horse power (BHP)

$\boxed{BHP = \frac{WH}{75\,E} =}$

Q =A × V

- $Q = \frac{r\,d^2}{4} \times v$ H = h+hk
- $\boxed{}$

$$hf = \frac{F\,1v^2}{2\,g^d} = \frac{F\,1}{2 \times 9.81 \times d} \times \left(\frac{4Q}{r\,d^2}\right)^2 = \frac{F\,1Q^2}{12.1\,S}$$

E= efficiency of pump

h= total static head

hf= head lost in friction

f= co- efficient of friction

l= length of pipe

v= velocity of floor

g= accintuteto graving

d= diameter of pipe

Q= discharge

1. **Pipe materials – necessity, suitability, merits & demerits of each type**
2. **Pipe joints – necessity, types of joints, suitability, methods of jointing**

Laying of pipes – method

PIPE JOINTS :-

The common types of pipe joints are as follows :-

1. Spigot & socket Joint
2. Flanged Joint
3. Expansion Joint.
4. Flexible Joint
5. Collar Joint
6. Screwed & socket Joint

Spigot & Socket joint :-

1. This type of joint is commonly used in case of cast- iron-pipes.
2. For the construction of this joint the spigot or normal end of one pipe is centered into the socket of the other pipe.
3. Hemp yarn is then wrapped around the spigot, leaving unfilled the required depth of socket for lead.
4. A kneeled clay ring is then placed around the barrel & against the face of the socket. After this molten pig lead is poured into fill the remainder of the socket.

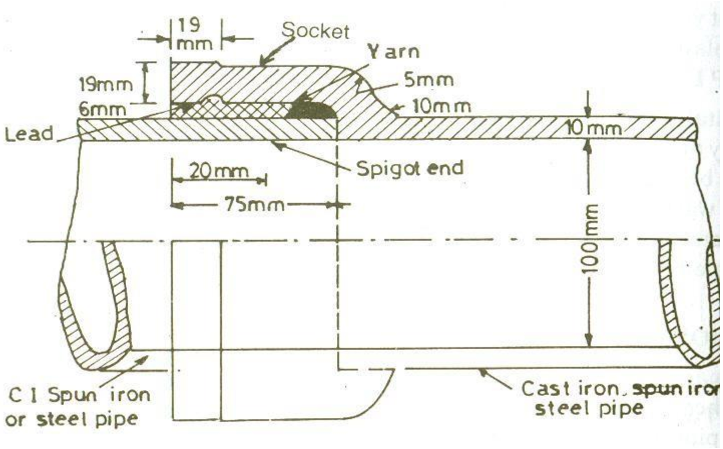
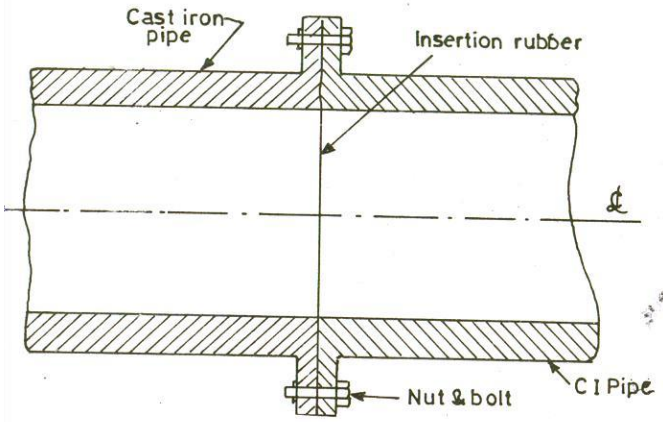


Fig. 4.5 **(**Spigot & Socket joint)

Flanged Joint :-

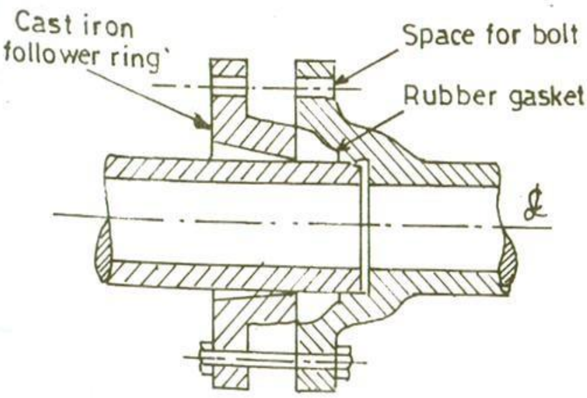
1. These joints are rigid & are easy to disjoint, as such used where pipe joints have to occasionally opened out for carrying out repair work as in pumping chamber.
2. The pipe in this case has flanges on its both ends, casted, welded or screwed with the pipe.
3. A gasket of rubber, canvass or lead is introduced between the two flange of cast iron pipes, which are then tightened with bolts & nuts.



(Flanged Joint)

Expansion Joint :-

1. These joints are used on pipes exposed to considerable differences of temperature allowing for free expansion or contraction without setting up thermal stresses in the pipes.
2. Here when the pipe expands , the socket end moves forward & when pipe contracts , it moves back word in the space provided for it & the elastic rubber gasket in every position keeps the joint water tight.



(Expansion Joint)

Flexible Joints :-

1. These joints are used for pipes to be laid submerged under water , where the bottom of the river is uneven with the possibility of settlement & consequent damage.
2. If one pipe is given any defection, the ball shaped portion will move inside the socket , & the joint will remain water proof in all the position .

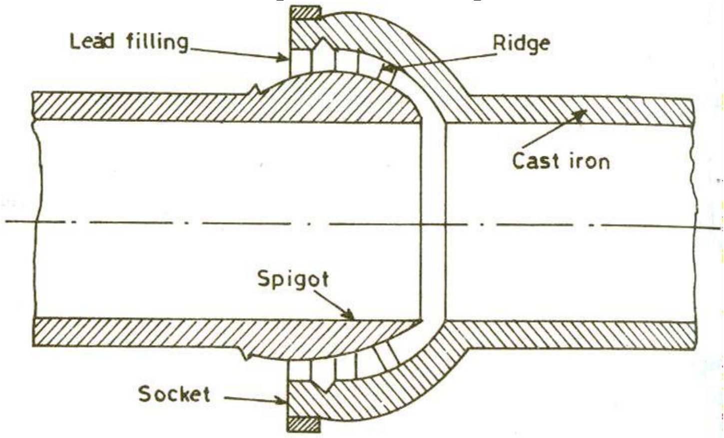
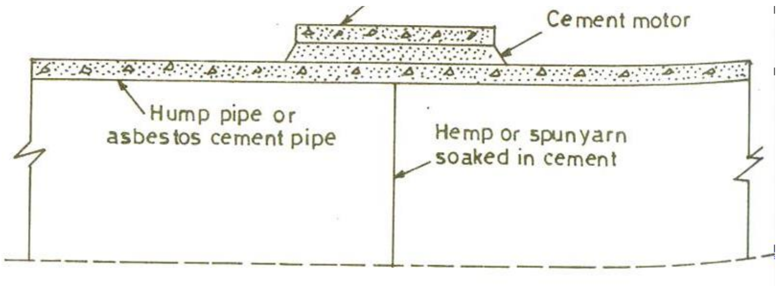


Fig. 4.8 (Flexible Joint)

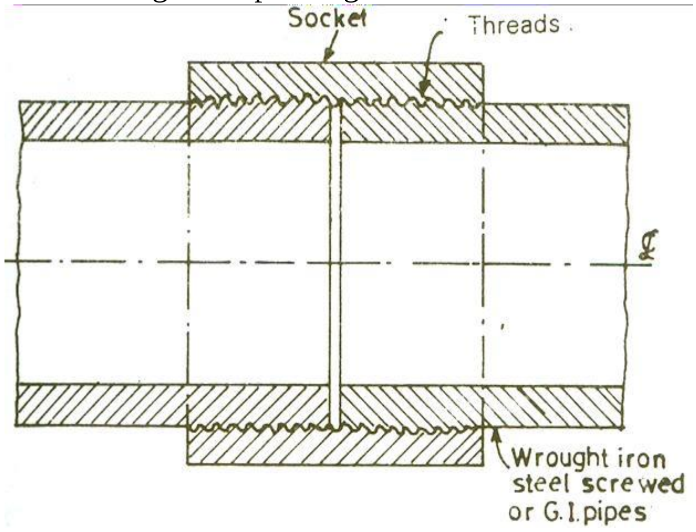
Collar Joint :-

1. This joint is mostly used for joining concrete & Asbestos cement pipe having bigger diameter.
2. A rubber gasket is placed between steel rings in the groove after bringing the ends of the two pipes in one level.
3. Then the collar is placed at the joint so that it should have the same lap on both the pipes. After this cement mortar (1:1) is filled in the gap between the pipes & the collar.



(Collar Joint)

Screwed & Socket Joints :- This is a simple type of joint commonly used for jointing screwed wrought iron or Galvanised iron pipes. In this joint , two ends of the pipes are threaded on the outside and on them a suitable jointing compound should be used before screwing socket over it having corresponding threads from inside.



(Screwed & Socket Joints)

Laying of Pipes:

Pipes are generally laid with a flat slope parallel to the hydraulic gradient to avoid any air locking trouble. Where there is slope, pipe laying should be done in an uphill direction to facilitate joint making.

Testing of Pipe Lines:-

After a new pipe line has been laid & jointed, it shall be subjected to the following two tests :

1. Pressure Test
2. Leakage Test

Pressure Test at a Pressure at least double the maximum working Pressure:

The procedure adopted for pressure testing of pipes is as follow

1. 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.
2. First the downstream sluice valve of the section is closed & water is admitted in the section through the upstream sluice valve. During filling air valve is properly operated to remove all air from the pipe.
3. Then the upstream valve is close to completely isolate the section from the rest of the pipe line.
4. Pressure gauges are then fitted along the pipe length of the section at suitable interval (generally 100 mm or so) on the crown through holes left for this purpose.
5. The pipe section is then connected to the delivery side of a pump through a small by-pass valve & the pump is started to increase the pressure in the pipe. The operation is continued till the pressure inside the pipe reaches a pressure at least double of the maximum working pressure.
6. The by-pass valve is then closed & the pump is discontinued .
7. The pipe is kept as it is for 24 hours & inspected for any fall of pressure. This completes the pressure testing of pipes.

Leakage Test at a Pressure to be specified by the authority :-

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 :

$$\mathbf{Q = (NDP^{1/2})/3.3}$$

Where Q = allowable leakage in cm^3/hr

N = number of joints in the length of pipe line

D = diameter in mm

P = the average test pressure during the leakage test in kg/ cm^2

Causes of corrosion in water system pipes

Pipes used to distribute drinking water are made of plastic, concrete, or metal (e.g., steel, galvanized steel, ductile iron, copper, or aluminium). Plastic and concrete pipes tend to be resistant to corrosion. Metal pipe corrosion is a continuous and variable process of ion release from the pipe into the water. Under certain environmental conditions, metal pipes can become corroded based on the properties of the pipe, the soil surrounding the pipe, the water properties, and stray electric currents. When metal pipe corrosion occurs, it is a result of the electrochemical electron exchange resulting from the differential galvanic properties between metals, the ionic influences of solutions, aquatic buffering, or the solution pH.

Remedies :-

1. Avoid placing of old pipes.
2. Avoid placing of rust pipes.
3. Control dissolved gases from water which flows through the pipes.
4. Rust preventives like lubricants , greases, oils are used to form a protective film to prevent corrosion.

Chapter 3

3.1 Flow diagram of conventional water treatment system

3.2 **Treatment process / units :**

3.2.1 Aeration ; Necessity

3.2.2 Plain Sedimentation : Necessity, working principles, Sedimentation tanks – types, essential features, operation & maintenance

3.2.3 Sedimentation with coagulation: Necessity, principles of coagulation, types of coagulants, Flash Mixer, Flocculator, Clarifier (Definition and concept only)

Water Treatment –

This is defined as the process of removing all those substances, whether bio logical,, chemical or physical, which are potentially dangerous or undesirable in water supply for human and domestic use

Main objective of water treatment

1. To remove pathogenic organisms and consequently to prevent waterborne disease.
2. To remove substance which impart color, taste or odor to the water.
3. To remove excess or undesirable chemicals or minerals from the water.

4. To regulate essential elements or chemicals that may being excess or lacking in a certain water supply (e.g. fluoridation or defluoridation of water, softening of water etc.)

5.To remove excess or undesirable dissolved gasses.

PROCESS OF WATER TREATMENT

The layout of conventional water treatment plant is as follows.

screening

River water frequently contains suspended and floating debris varying **in** size from rags to small rags. These solids can clog and damage pumps or impede the hydraulic flow in open channels and pipes. Screening is the first step in treating water containing large solids.

Type of Screening

A) Coarse screening

1. River water intakes are commonly located in a protected area along the shore to minimize collect ion of floating debris.

1. Lake water is withdrawn below the surface to prech.ide interference from floating materials.

2. Coarse screens of vertical steel bars having openings of 1-3 inches are employed to exclude large materials.

3. The clear openings should have sufficient total area so that the velocity through them is less than 3 feet per second.

4. These screens are available with mechanical rakes to take accumulated material from the bars.

5. A coarse screen can be installed ahead of a finer one used to remove leaves, twigs, small fish, and so on.

6. Whatever the source of water, it is necessary to insert some kind of screen in the system in order to prevent the passage of solids in the subsequent steps of water treatment.

7. If the source of water is a well, the screens tend to be designed to prevent the admission or sand from the water bearing strata into the pumping system.

8. Where water supply is drawn from rivers or lakes, the intake usually has to be screened and built of corrosion-resistant materials in order to prevent the admission of fish or bags or any other undesirable solids into the system.

Micro Strainer(Fine Screen)

1. The micro-strainer is a development of the drum screen that uses a fine woven stainless steel mesh with aperture sizes of 2O-60 p m to provide removal of relatively small solids.
2. It has applications in water treatment for removal of algae and similar size particles from water of otherwise good quality.
3. A micro strainer is also employed as a final tertiary stage to produce a high-quality sewage effluent. Because of the small mesh apertures, clogging occurs rapidly so that the drum is rotated at a peripheral speed of about 0.5 m/s and the mesh continually washed clean by high- pressure sprays. Strain ingrates in normal usage are 750-2500 m3 /m2Id.
4. The design of micro- strainer installations is based on the laboratory determination of emprical characteristics of the suspension known as the filterability index.
5. This parameter measures the behavior of the suspension with reference to its clogging properties and can be used to determine the allowable straining rate to prevent excessive clogging and possible physical damage to the mesh.
6. ln some locations where it is found that seasonally algal blooms become a nuisance, micro-straining has been introduced.
7. Micro-strainers are a very fine weave of stainless steel wire with apertures sufficiently small to prevent the passage of the microscopic algae which is normally found in an algal bloom.
8. Such a screening system is normally only required on a seasonal basis and in certain locations where these problems are prevalent.
9. Micro-straining is conducted at such a very small diameter orifice that it is sometimes considered to be a pan of filtration.

<u>Aeration</u>

10. Aeration removes odour and tastes due to volatile gases like hydrogen sulphide and due to algae and related organisms.
11. Aeration also oxidise iron and manganese, increases dissolved oxygen content in water, removes C02 and reduces corrosion and removes methane and other flammable gases.
12. Principle of treatment underlines on the fact that volatile gases in water escape into atmosphere from the air-water interface and atmospheric oxygen takes their place in water, provided the water body can expose itself over a vast surface to the atmosphere.
13. This process continues until an equilibrium is reached depending on the partial pressure of each specific gas in the atmosphere.

Types of Aerators
1. Gravity aerators
2. Spray aerators or Fountain aerators
3. Diffused aerators
4. Mechanical aerators.

Gravity Aerators (Cascades):

In gravity aerators, water is allowed to fall by gravity such that a large area of water is exposed to atmosphere, sometimes aided by turbulence.

Spray aerators or Fountain Aerators :

These are also known as spray aerators with special nozzles to produce a fine spray.

Each nozzle is 2.5 to 4 cm diameter discharging about 18 to 36 I/h. Nozzle spacing should be such that each m3 of water has aerator area of 0.03 to 0.09 m2 for one hour**.**

Injection or Diffused Aerators-:
It consists of a tank with perforated pipes, tubes or diffuser plates, fixed at the bottom to release fine air bubbles from compressor unit.
The tank depth is kept as 3 to 4 m and tank width is within 1.5 times its depth. If depth is more, the diffusers must be placed at 3 to 4 m depth below water surface.
Time of aeration is 10 to 30 mi and 0.2 to 0.4 litres of air is required for 1 litre of water.
Mechanical Aerators:
Mixing paddles as in flocculation are used. Paddles may be either submerged or at the surface.

SEDIMENTATION

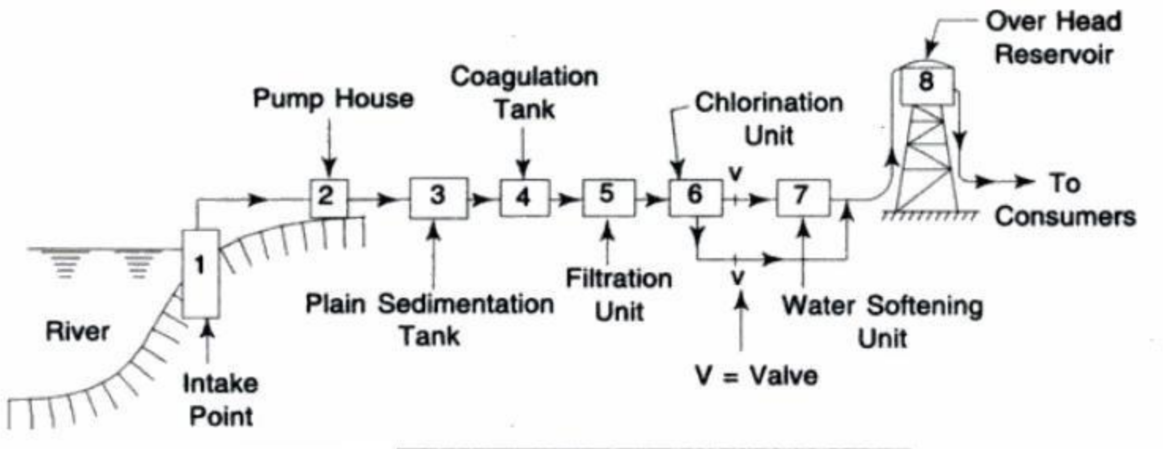
Sedimentation is the removal of the suspended particle by gravitational settling.
The Solid liquid separation process in which a suspension is separated into two phases —
• Clarified supernatant leaving the top of the sedimentation tank (overflow).
• Concentrated sludge leaving the bottom of the sedimentation tank (underfiow).

Purpose of settling
• To remove coarse dispersed phase.
• To remove coagulated and flocculated impurities.
• To remove precipitated impurities after chemical treatment.
• To settle the sludge (biomass) alter activated sludge process **I** tricking filters.

Principle of Settling
• Suspended solids present in water having specific gravity greater than that ot water tend to settle down by gravity as soon as the turbulence is retarded by offering storage.
• Basin in which the flow is retarded is called **settling tank.**
• Theoretical average time for which the water is detained in the settling tank is called the **detention period**
plain sedimentation.
when the impurities are separated from the suspending fluid by gravitational or natural aggregation of the settling particles, the operation is called plain sedimentation.

Sedimentation with coagulation (clarification)
when chemical or other substance are added to induce aggregation and settling of finely divided suspended matter, collidal substance, and the large molecule, the operation is called sedimentation coagulation.

Types of settling
Type I: Discrete particle settling - Particles settle individually without interaction with neighbouring particees.
Type II: Flocculent Particles — Flocculation causes the partides to increase in mass and settle at a faster rate.
Type Ill: Hindered or zone settling -The mass of particles tends to settle as a unit with indivdual particles remaining in fixed positions with respect to each other. Type Iv: compression
- The concentration of particles is so high that sedementation can only occur through compaction of the structure.



Flow diagram of treatment plant

TYPES OF SEDIMENTATION TANKS (CLARIFIERS)

Depending upon the nature of working, clarifiers are of the following two types:

1. Fill and draws type clarifies.
2. Continuous flow type clarifies.

1. Fill & draw a type clarifies:

1. **Working:** These are also knows also the quiescent type or intermittent type clarifiers .The working of tanks is simple .the water is filled in the tank and it is then allowed to test for a certain time. During the period of rest the particles in suspensions will settle down at the bottom of the tank .the clear waters then drawn off and the tank is cleared of silt and filled again.

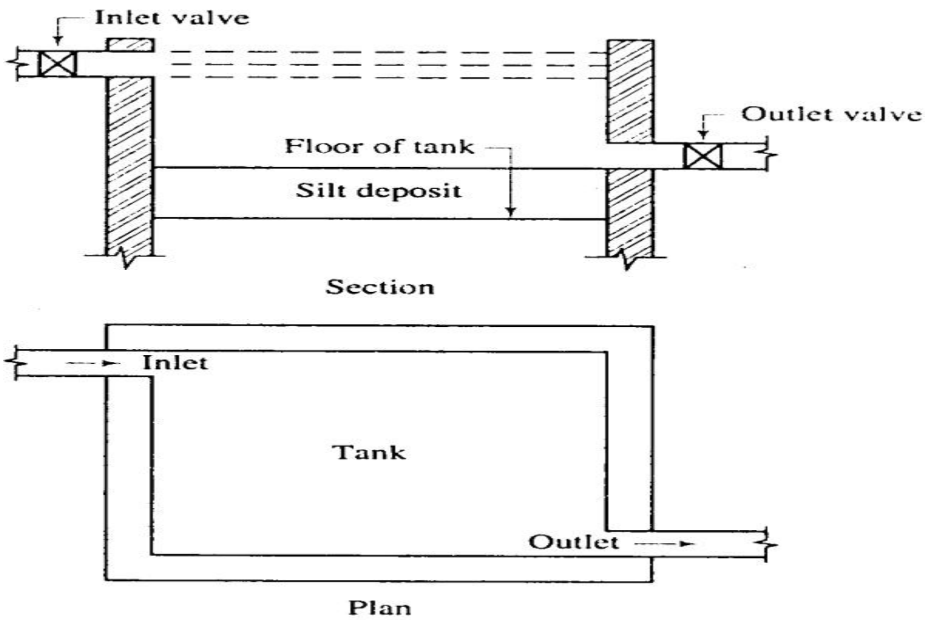
The usual period of rest to cause settlement of particles is about 24 hours or so .if time is required for inlet, outlet, emptying and clearing portion is added a period about 30 to 36 hours is required to put the tank again in working condition.

This means that the least two tanks will be required if an additional unit is to be provided as stand by ,the minimum number of tanks required under this type of working will not be less than three.

(iii)**Design consideration:**

The cubical contents of the tanks will represent the storage capacity of the tank. the provision is made at the bottom for accumulation of still . The outlet value is provide at the top of still deposit zone .the inlet and outlet for water are arranged at opposite ends as seen in plan of the tank fig.1 shows the plan section of a typically fill and draw type of clarifier.

1. **USE**:
2. ***T**hese tanks are mostly out of the use at present as they process many disadvantages



Fill and draw type tank

1. If velocity of the flow is reduced a large amount of suspended impurities from water can be easily removed .This is the principle on which continuous flow type of sedimentation tanks is working.

*The working operation of the tank is very simply as illustrated in fig2.The water enter the tank from one end as it travels towards the out let at the other end, its velocity is broken and radiuses by means of baffle walls. The walls contain opening at diffriencer level.

*The velocity of the flow is so adjusted that the time taken by a particle of the water to move from one end to other is slightly move then that require d for the settlement of suspended impurities in water.

*The entry of impure water from one end the exit of clear water from the other end are continuous .The flows of water is designed to meet the following two requirement .

1. The velocity of flows is such that suspend impurities of require size settle down at the bottom clarifier.

2. The total amount of flow from the tank within 24 hours equals to the daily demand of the water.
3. The silt is deposited at the bottom of clarifies and when it is accumulated in sufficient quantity, the flush valve is opened and the clarifier is cleaned.

SEDIMENTATION WITH COAGULATON:

*The turbidity is mainly due to the presence of very fine particle of clay still and organic matter.

* All these impurities are in a finely divided state & it is not possible to detain them in plain sedimentation tanks unless such tanks are designed longer detention period.

*The other alternative to remove such particles is to increase their size so that they become settleable.

The purpose of coagulation is thus to make particles of bigger size by adding certain chemicals known as coagulants to the water .

The coagulants react with the impurities in water and convert them in settleable size.

*The coagulation is to be adopted when turbidity of water exceeds about 40ppm.

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*The coagulation is to be adopted when turbidity of water exceeds about 40ppm.

PRINCIPE S OF COAGULATION:

The principle of coagulation can be explained from following two considerations.

(1)Floc formation: When coagulants are dissolved in water and thoroughly mixed with it. They produced a thick gelatinous precipitate. This precipitate is known as the floc and thus floc has got property of arresting the suspended impurities in water during its drowned travels towards the bottom of the tank.

1. **Electric charges:** The ions of floc are found to posses positive electric charge .Hence they will attract the negatively charged colloidal particles of clay and thus they caused the removal of such particle from the water.

*The surface of floc is sufficiently wide to arrest colloid and organic matter present in water. The term flocculation is used to denoted the process of floc formation and thus the formation and thus the flocculation flows the addition follows the addition of coagulants and its efficiency depends on the

USUAL COAGULANTS :

Following six are the usual coagulants which are adopted for coagulants :

(1)Aluminum sulphet .

(2)Chlorinated

coppers. (3)Ferrous

sulphate &lime.

(4)Magnesium

carbonate.

(5)Polyelectrolyte

(6)Sodium

aluminate.

1. ALUMINIUM SULPHATE:

2. This is knows the filter alum or alum only. Its chemical composition is Al_2 $(so_4)_3$ $18H_2$ $_0$.

3. The alum in water treatment practice is commonly supplied and used in the form of flawless or solids lumps and then applied in a solution from.

The advantages of using alum as a coagulant are as follows.

It also reduces taste and odour in water.

1. It is cheap.
2. It produces crystal clear water.

Generally the bicarbonate alkalinity is present in water and the chemical reaction involved between bicarbonate alkalinity and alum is as follows:

$Al_2 (So_4)_3\ 18H_2\ ^{\circ}+3Ca(HCO_3)_2 = 2Al(OH)_3 + 3CaSo_4 + 18H_2 o + 6Co_2$ ..

The aluminum hydroxide formed is insoluble in water and it behaves as folic.

If water possesses a little or no alkalinity, the lime is added to water. The chemical reaction is as follows. $Al_2 (So_4)_3\ 18H_2 O + 3Ca(OH)_2 = 2Al(OH)_3 + 3CaSO_4 + 18H_2 O$

This coagulant is found to be effective between PH range of 6.5 to 8.5.

In practices the dosage of alum varies from 5 to 30 milligrams per litre for normal water the usual being 14 milligrams per lit.

The disadvantages of using alum as a coagulant are mainly two.

It is different to dewater the sludge formal and further, it is not easy to distance it off also as it is found unsuitable for filling of lying lands.

The effective PH range for coagulation with alum is found to be too small and in some cases, the lime or caustic soda will have to be added to adjust the PH value at a proper level. This will increase the cost of treatment of water.

3. CHLORINATED COPPERAS:-

1. When chorine and solution of ferrous sulphate are fixed, the following chemical reaction takes place. $6FeSO_4 . 7H_2 O + 3Cl_2 = 2Fe_2 (SO_4)_3 + 2FeCl_3 + 42H_2 O$
2. The combination of ferric sulphate $Fo_2 (SO_4)_3$ and Ferric chloride is known as the chlorinated coppers , each one of the compound is effective as a flock and the combination is also quite effective.
3. The ferric sulphate and ferric chloride $FeCl_3$ both can be used independently with lime to act as coagulant and the chemical reactions involved would be as follows. $Fe_2 (SO_4)_3 + 3Ca (OH)_2 = 3CaSo_4 + 2Fe (OH)_3$ $2Fecl_3 + 3Ca (OH)¤ = 3CaCl_2 + 2Fe (OH)_3$.

The ferric hydroxide $Fe (OH)_3$ forms the flock. For ferric sulphate, the effective PH change is 4 to 7 and above 9.For ferric chloride, the effective PH range is 3.50 to 6.50 and above 8050.

4. FERROUS SULPHATE AND LIME:-

1. When ferrous sulphate and lime are added to the water, the following chemical reaction takes place. $FeSO_4 .7H_2 O+Ca (OH)_2 =Fe (OH)_2 +CaSO_4 +7H_2 O$.

2. The ferrous hydroxide $Fe (OH)_2$ thus oxygen in water and ferric hydroxide is formed as per the following chemical reaction. $4Fe (OH)_2 +2H_2 O=4Fe(OH)_3$.

   1. The ferric hydroxide $Fe(OH)_3$ forms the flock. For ferrous suphate, the effective PH range is 8.50 and above.

3. MAGNESSIUM CARBONATE:-

1. When magnesium carbonate is dissolved and is mixed with water along with lime the following reaction takes place. $Mg Co_3 + Ca (OH)_2 = Mg(OH)_2 +Ca Co_3$.

2. The compounds magnesium hydroxide $Mg (OH)_2$ and calcium carbonate are insoluble in water and the sludge formed in this process contains a sludge of $Mg(OH)_2$ and $Ca Co_3$. This coagulant is not at present flavored.

3. Polyelectrolyte"s:-

1. These are special types of polymers and depending upon the charge the carry, they are classified as anionic, cationic and nonionic only cationic polyelectrolyte's can be used effectively as independent coagulants. The others varieties can be used along with alum or other conventional coagulants.

2. The use of polyelectrolytes is still in pilot stage and they may prove to be an alternative to the alum in future.

3. SODIUM ALUMINATE:-

1. The chemical composition of this coagulant is $Na_2 Al_2 O_4 +Ca(HCO_3)_2 = Ca Na_2 \; Na_2 \; Na_2 Al_2 \; O_4 +Na_2 CO_3 +CO_2 +H_2 O \rightarrow$ (1)

$$Na Al_2 \; O_4 + Ca Cl_2 = Ca Al_2 \; O++2NaCl.........(2)$$

$$Na Al_2 \; O_4 = ca Al_2 \; O_4 + Na_2 \; So_4 \; .... (3)$$

   1. This coagulant removes carbonate or tempers or hardness as seen from equation 910 and it also removes non-carbonate or permanent hardness as seen from equation (2) and (3). The effective range of PH value for this

coagulant is 6 to 8.5. This coagulant is costly and hence it cannot be adopted for treating water on a large scale.

FLASH MIXERS:-

Flash mixture are used to achieve quickly mixing and then the transfer water from the flash mixture to the slow mixture known as floe water.

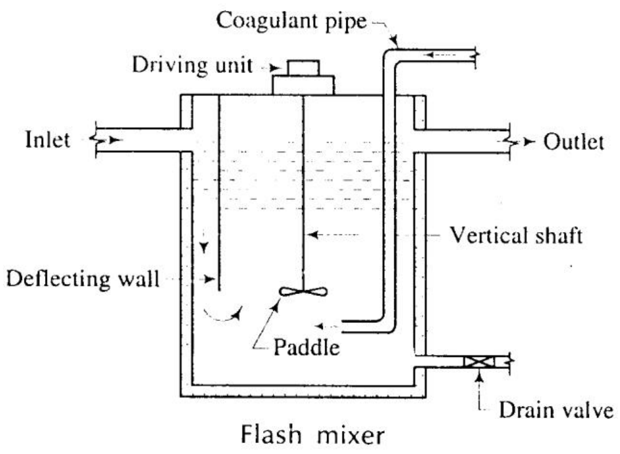


Fig.6.3

Fig.6.3. shows a typical flash mixer .The mixing is achieved by a rotating paddle situated at the lower end of the vertical shaft. The incoming water is defected toward the moving paddle by deflecting wall.

1. The coagulants are brought by coagulant pipe and also discharge just near the rotating fan.
2. Adriane value is providing to remove sludge from the bottom of flash mixture.

Figure below shows a typical flocculator. The slow mixing is achieved by rotating paddles. The paddles usually make about 2 to 3 revolted per minute.

FILTRATION

NECESSITY:

1. The sedimentation tanks remove a large perce4ntage of the suspended solids and the organic matter present in raw water.
2. The process of coagulation further assists in the removal of impurities present in the water .But even then; the resultant water is not pure and may contain some very fine suspended particles, bacteria etc.
3. In order to remove or to reduce the content of impurities still further, the water is filtered through the beds of fine granular material like sand .The process of passing though the bed such granular material is known as filtration .

PRINCIPLES OF FILTERATIONS:

Process of filtration consists of the allowing water to pass through a thick layer of sand.

Principles of filtration are:

1. **Mechanical straining:** The suspended participles which are unable to pass through the voids of sand grains are arrested and are removed by mechanical straining.
2. **Sedimentation:** The voids between sands grains of filter act more or less like small sedimentation tanks .The particle of impurities arrested in these voids, at here to the participles of sand grains and are the removed by the action of sedimentation.

3. Biological metabolism:

1. **T**he growth and silt process of the living cells is known as the biological metabolism.
2. When the bacteria are caught in the voids of sand grains, a zoological jelly or film is formed around the sand grains. This film contains large colonies of living bacteria

.The bacteria feeds on the organic impurities contained in water. They convert such impurities in to harm less compounds by the complex biochemical reaction.

4. **Electrolytic changes:** According to this theory when two substance whit opposite electric charges are brought in to contact with each other, the electric charges are neutralized and in doing so, new chemical substances are formed.

It is observed that some of the sand grains of filter are charged with electricity of some polarity. Hence, when particle of suspended and dissolved matter contain electricity of opposite polarity come into contact with such sand grains they neutral each other and neutralize result in the alteration of chemical characteristics of water.

CLASSIFICATION OF FILTERS :

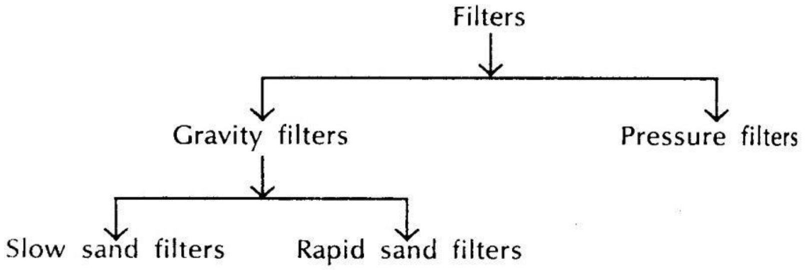
The filters are classified in to the following:

1. Slow sand filter
2. Rapid sand flitter.

The rapid sand filters are further subdivided into the following two categories.

1. Gravity types rapid sand filter.
2. Pressure type rapid sand filter.

The above classification is based on the rate of filtration .On the consideration of the gravity and pressure the filters may be classified as follows.



Combining the above two classification, there are following three types of filters.

1. slow sand filter
2. Rapid sand filter
3. pressure filter

SLOW SAND FILTERS:

1. **(1)PURPOSE :** Incase of slow sand filtration , the water is allowed to pass slowly through a layer of sand placed above the base of the ,material and thus the purification process are at simultaneously improving the biological chemical and physical characteristic of water.
2. The slow sand filtration is very well suited for rural are as in developing countries because of its simple operation and maintains procedure s. It thus provides safe drinking water at low recurrent cost.

ESSENTIAL PARTS: A slows sand filter consist of the following five parts.

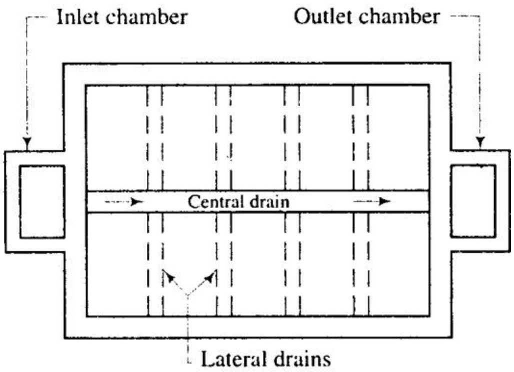
1. Enclosure tank

2. Under drainage system
3. Base material
4. Filter media or sand
5. Appurtenances.

1.**ENCLOSURE TANK:** A water tight tank is constructed either in stone masonry or brick masonry .The sides & floor are also coated with water proof material . The bed slope is about b1 in 100 to 1 in 200 towards. The central drain. The depth of tank is about 2.50m to 3.50m .The surface area of a slow sand filter may vary from 30m to 2000m or even more

2.**UNDER DRAINAGE SYSTEM:** The under drainage system consists of a central drain and lateral drain as shown in the fig. 6.4

The lateral drain is placed at a distance of about 2.5 m to 3.5m and they are stopped at a distance of about b500mm to 800mm from the walls of the tanks. The drains may be pipes which are laid with open joint.



Plan of slow sand filter

Fig.6.4

1. **BASE MATERIAL**: The base material is gravels &it is placed on the top of under drainage system .

Its depth varies from 300mm to 750mm .It is usually graded and laid in layers of 150mm .The topmost layer should be small size gravel and the lowest layer should be of bigger size gravel . Followings is a typical section of base material.

Top most layer150mm depth –size 3mmto 6mm

150mm depth-size 6mm to

20mm 150mm depth –size

20mm to

150mm depth – size 40mm to

65mm Total 600mm depth.

(Iv) FILTER MEDIA OF SAND:

1. A layer of sand placed above the gravels.
2. The depth of sand layer varies from 600mmto 900mm.
3. The effective size of sand varies from 0.20 mm to 0.30mm & the uniformity cp- efficient about 2 to 3.
4. The finer the sand, the better will be the efficiency of filter regarding the removal of bacteria but in that case , the output from the flitter is lowered.

5. APPURTENANCE:

1. The various appurtenances are to be installed for the efficient working of slow sand filter.
2. The devices for measuring loss of head for controlling depth of water above sand layer. And for minting rate of flows through filter are to be suitably installed.
3. The vertical air pipe passing through layer of sand help in proper function of filtering layer.

1. WORKING & CLEANING :

1. The water allowed to enter the filter through the inlet chamber. It descends through the filter media and during this process it gets purified.
2. Water is then collected in the outlet chamber and taken to the clear water storage tank.
3. The depth of water filter is to be carefully decided. It should neither be too small nor too high. Generally it is kept as equal to the light of filter media of sand.
4. For the purpose of cleaning the top layer of sand is scrapped or removed through a depth of about 15mm to 25mm. The water is then admitted to the filter. But the purified water is not taken into use until the formation film around sand grain occurs.

2. **RATE OF FILTERATION: -** The rate of filtration of a normal slow sand filter varies from 100 to 200 liters/ hours/ $\square^2$ of filter area.

RAPID SAND FILTERS (GRAVITY TYPE): -

1. **Purpose: -** The great disadvantages of a slow sand filter are that it requires considerable space for its installation. This requirement makes it uneconomical for places where land values are high.

   The difficulty of requiring moves space for slow sand filters can be obviated by increasing the rate of filtration which is accomplished in rapid sand filter by increasing the size of sand.

2. **Essential parts**: - Fig shows the layout of a typical rapid sand filter (gravity type) . It consists of the following five parts.

   1. Enclosure tank
   2. Under drainage system
   3. Base material
   4. Filter media
   5. Appurtenances

1. Enclosure Tank: A watertight tank is constructed either of masonry or concrete.
   1. The side and floor are also coated with waterproof material.
   2. The depth of tank is about 2.5m to 3.5m.
   3. *The surface area of a exit of rapid sand filter varies from $10m^2$ to $30m^2$.

2. Under drainage system: There are various forms of under drainage system of a rapid sand filter and most of them are patented by the manufacturers.

   *Following are two common types of under drainage system

1. perforated pipe system
2. pipe and strainer system

1. **Perforated pipe system**: In this system there is a central drain or manifold and to this manifold the various lateral drains are attached as shown in fig. 6.5
   1. The drains are usually made of cast-iron.
   2. The lateral drains are placed at a distance of about 150mm to 300mm.
   3. The lateral drains are provided with holes at the bottom side and such holes make an angle of 20° with the vertical as shown in fig. 6.5
   4. The perforated pipe system is economical and simple in operation.

2. **Pipe and strainer system**: In this system also there is a central drain or manifold with lateral drains attached on either side as shown in the fig. But in this system the strainers are placed on lateral drains instead of drilling holes.

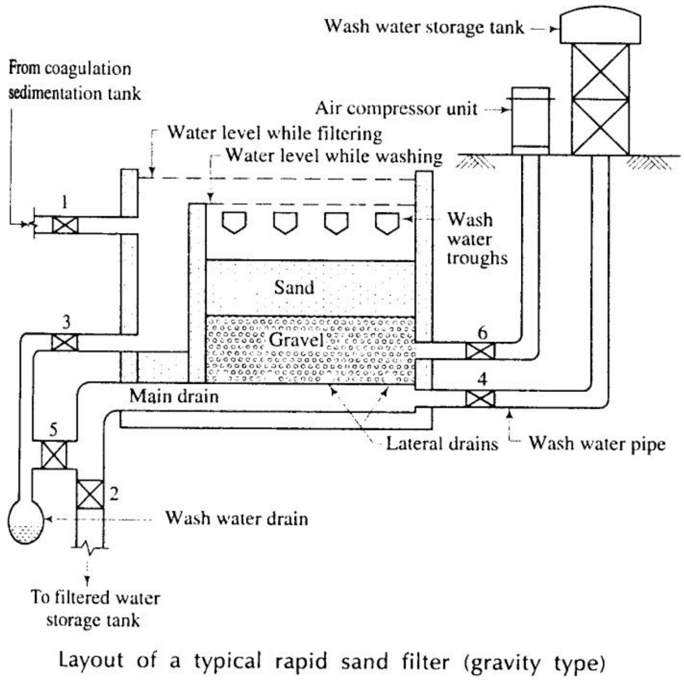
   1. A strainer is a small pipe of brass. It is closed at top and contains holes on its surface as shown in fig.6.5
   2. The strainers are either screwed or fixed on the top of lateral drains.
   3. When pipe and strainer system is adopted the compressed air is used for the purpose of washing the filter. This results in saving of wash water.

Following general rules should be observed in designing the under drainage system: -

1. The ratio of length of lateral drain to its diameter should not exceed 20.
2. The cross sectional area of central drain should be about twice the cross sectional area of lateral drain.
3. The total cross sectional area of perforations should be about 0.20% of the total filter area.
4. The cross sectional area of lateral should be about two to four times the total cross sectional area of perforations in it.
5. The perforations in the lateral drain should be of diameter 6mm to 12mm.
6. The spacing of perforation in the lateral drain should vary from 75mm to 200mm center to center.

7. **BASE MATERIAL:** The base material is gravel and it is faced on the top .of under drainage system.

1. *The gravel to be used for best material should be clean and free from clay , dust, silt and vegetable matter.



Layout of a typical rapid sand filter (gravity type)

Fig.6.5

2. The gravel particle should be durable, hard, round and strong.
3. The depth of base material varies from 450mmto 600mmgravel .It is usually graded and laid in layers of 150mm.
4. The topmost layer should be of small seize of gravel and the lower layer should be of big size gravel.

Following is a typical section of base material:

Top most layer 150mmdepth –size3mm to 6 mm

Intermediate layer {150mm depth-size 6mm to 12mm

{150mm depth -size 12mm to 20mm Lower layer 150mm depth- size 20 mm to 40mm

Total 600mm depth

5. **FILTER MEDIA OF SAND**: A layer of sand is placed above gravel.

*The depth of sand layer varies from 600mm t0 900mm.

1.THE coarse sand is used as filter media.

2. The effective size of sand varies from 0.35mmto 0.60 mm and the uniformity coefficient of sand is between 1.20 to 1.70 .Thus the space of voids between sand particles is increased and it result in the increase rate filtration.

3. APPURTENANCES:

1. **AIR COMPRESSORS**: The agitation of sand grains during washing of filter is carried out either by compressed air or by water jet or by mechanical rakes. When air is to be used an air compressor of required capacity should be installed.
2. **WASH- WATER THROUGHS:** The dirty water after washing of filter is collected in wash water through or gutter which is placed above sand bed level.
3. **RATE CONTROL**: There are various devices which may be fitted at the outlet end of the filter to control the rate of flow.

4. Working and cleaning: -

1. The working of a rapid gravity filter can be understood by referring to fig. 6.5.

The numbers placed near values indicate the following:

Valve 1 – Inlet valve.

Valve 2 – Filtered water storage tank valve.

Valve 3 – Waste water Valve to drain water from inlet chamber. Valve 4 – Wash water storage tank Valve

Valve 5 – Waste water Valve to drain water from main drain. Valve 6 – Compressed air Valve

2. The Valve 1 is opened and the water from coagulated sedimentation tank is allowed to enter the filter.
3. The Valve 2 is opened to carry filtered water to the filter water storage tank. All other Valves are kept in closed position. Thus when filter is in working condition only Valves 1 and 2 are in open position.
4. When the filter requires cleaning or washing it is carried out follows.

1. The Valves 1 and 2 are closed.
2. The Valves 4 and 6 are opened out. The wash water is then forced in the upward direction through the under drainage system, base material and filter media of sand. The compressed air assists the cleaning process of filters.
3. The Valve 6 is closed and the Valve 3 is opened out to carry dirty water through the inlet chamber to the wash water drain.
4. When washing of filter is over, the Valves 3 and 4 closed and Valve 1 and 5 are opened out. Thus, when filter is put into use after washing, the filtered water in the beginning is led to the wash water drain through main drain. This is continued for few minutes to condition the filter.
5. The Valve 5 is closed and the valve 2 is opened ou6t to put the filter in the normal working condition.
6. **Loss of head and negative head: -**When water passes through the filter it has to resist the frictional resistance. It therefore losses some of its head. The loss of head can easily be computed by knowing the water level in the filter and pressure of water in the outlet pipe. The difference between the two head s indicates the loss of head in filter. In the beginning when the filter is cleaned the loss of head is very small about 150mm. `to 300mm. the loss of head then gradually goes on increasing. The loss of head can be measured by inserting piezometers in filter as shown in fig. The difference of water level in two tubes indicates the loss of head.

    1. A stage then comes when frictional resistance offered by filter media exceeds the static head above sand bed. This is developed due to the deposit of suspended matter

in top layer of about 100mm to 150mm. thickness. The lower portion then act more or less like a vacuum and the water is succeed through the filter media rather than flittered through it. The fall of liquid level in the piezometer tube below the center line of under drainage system indicates the negative head.

2. The negative head thus formed tense to release dissolved air and other gasses present in water. The bubbles stick to the sand grains and the working of filter is seriously disturbed. This phenomenon is known as air binding as air binds filter and stops its working. The rate of filtration is consequently greatly reduced.
3. In case of rapid sand filter the allowable loss of head is about 3m. To 3.5m. and the allowable negative head is about 1200mm. The filter is to be washed when this limit of the allowable loss of head has been reached it is usually cleaned after 2 to 3 days.

7. **Troubles in operation: -** Following two troubles are generally encountered in operating rapid sand filter.

1. Mud **balls: -** The mud ball are generally formed near the top of filter media. They may even be formed and distributed throughout the filter. The mud balls are formed or caused due to insufficient washing of sand grains. The gelatinous film formed during filtration is not separated out from sand grains during washing. The mud balls interfere with the normal working of the filter and their size is about 25mm to 50mm.
2. **Cracking of filters:** - the fine material contained in the top layer of filter shrinks and this shrinkage leads to form cracks in the filter. These cracks are prominent near wall junctions.

To remove these troubles, the following remedies are adopted.

1. The mud balls are broken with the help of rakes or some such equipment.
2. The working of filters is carried out with high velocity of water.
3. The damaged portion of filter media is replaced.

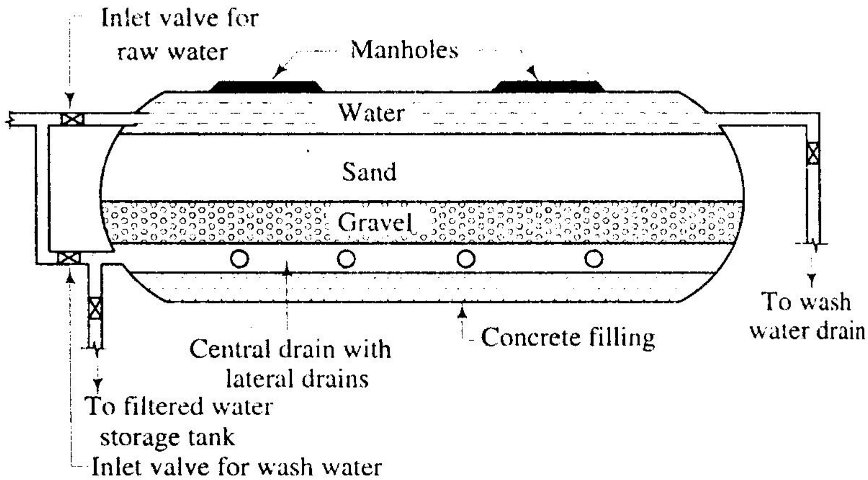
3. **Rate of filtration: -** The chief advantage of a rapid sand filter is that its rate of filtration is very high. It is about 3000 to 6000 liters/ hour/ m^2 the high rate of filtration results in considerable saving of space for the installation of filter.

4. **Efficiency of rapid sand filter: -**The efficiency of rapid sand filter is as follows.

1. Bacterial load: - The rapid sand filters are less effective in the removal of bacterial load. It is expected that they remove about 80 to 90 percent of bacterial impurity present in water.
2. The rapid sand filters are highly efficient in colour removal and the intensity of colour can be brought down below 10 on cobalt scale.
3. Turbidity: - The rapid sand filter can remove turbidity to the extent of 35 to 45 p.p.m. As water entering rapid sand filter is invariably given the treatment in coagulation sedimentation tank, it possesses less turbidity. This turbidity is brought down easily to the permissible limits by rapid sand filters.

PRESSURE FILTERS: -These filters are more or less similar to the rapid sand filters (gravity type) except with the following differences.

1. **Meaning of the term – pressure filter: -** The pressure filter does not indicate that the water is pumped through the filter under a high pressure loss. But it indicates that a filter is enclosed in space and the water passes under pressure greater than atmospheric pressure. This pressure can be developed by pumping and it may vary from 0.3 to 0.7 N/□□^{2}.
2. **Construction**: - The pressure filters are closed cylinders either riveted or welded. They may be of horizontal or vertical type. The diameters of pressure filters vary from 1.50m to 3.00m. and their lengths or height varies from 3.50m. to 8.00m. the manholes are provided at top for inspection.



Pressure filter — horizontal type

Fig.6.6

3. **Working**: - The water mixed with coagulant is directly admitted to the pressure filter. Thus the flocculation takes place inside the pressure filter itself. In normal working condition, all valves are closed except those for raw water and filtered water. The water is admitted through inlet and after it is filtered, it is collected in the central drain and converged to the filtered water storage tank.
4. **Cleaning**: - The compressed air may be used to agitate sand grains,
    1. The values for raw water and filtered water are in closed position and those for wash water and wash water drain are in open position during the operation of washing of filter.
    2. The cleaning of pressure filters may be required more be frequently.
    3. The automatic pressure filters are available in which washing of filter is done automatically at a predetermined interval of time or loss of head.
5. **Rate of filtration:**- The rate of filtration of pressure filters is high as compare to that of rapid sand filters. It is about 6000 to 15000 liters/hour/¤^{2}. Of filter area as compared to that of 3000 to 6000 liters/hour/¤^{2}. Of rapid sand filters.
6. **Efficiency**: - The pressure filters are found to be less efficient than the rapid sand filters in terms of bacterial loads, colour and turbidity.
7. **Suitability**: - The pressure filters are more suitable for public water supply projects. But they can be installed for small water supply projects such as colonies of few houses, industrial plants, private estates, swimming pools etc.

Introduction :

Next to air, the other important requirement for human life to exist is water. It is available in various forms such as rivers, lakes, streams etc. It is essential for life, health and sanitation. It is the principal raw material for food production and for many other uses outside the home. It also plays an important role in the manufacture of essential commodities, generation of electric power, transportation and industrial activities etc. The quality and reliability of a source of water will vary considerably, both in time and space. This means that characteristics (chemical, physical, and biological) will differ greatly depending upon the location and type of source. It also means that a given source may vary over the seasons of the year.

Water supply system:

This process consists of supply of purified water to the consumer by appropriate treatment to raw water.

Necessity of treated water supply:

The water when exposed to the atmosphere contains many impurities which are harmful to any living organism. If untreated water is consumed by living organisms it is likely to cause serious harm to their health. Hence in order to make water potable and free from various impurities, the purification methods are found out. Water treatment is necessary in order to improve the quality of water to make it appropriate for a specific end use. The end use may be drinking, industrial water supply, irrigation and many other uses.

Requirement of Water for different purposes

Water is the most essential commodity for the continuation of life. An adequate & clean water supply is the basic requirement for domestic use for various purposes like—

8. for drinking & cooking
9. for bathing & washing
10. for watering of lawns & gardens
11. for air-conditioning system
12. For street washing etc.
13. Water is also required for various types of industrial & commercial purposes.

Quantity Of Water :
Before designing any water supply project, first of all the estimation of quantity of water is required. These calculation based on two factor.
(i) Rate of demand
(ii) Population
Rate of demand : The requirement of water for various uses are properly analysed & the rate of

consumption per head is calculated.
Population: The number of persons to be served by the scheme is calculated & estimate of future population is worked out with

Rate of Demand

During planning a water supply scheme, it is the duty of the engineer to carefully examine the various types of water demand of the town & then to find out the suitable water sources from where the demand can be met. The various types of water demand of a city or town are:-

14. Domestic water demand
15. Civic or public demand
16. Industrial water demand
17. Business or trade
18. Loss and waste

Domestic water demand:

The quantity of water required for domestic purposes can be sub divided as follows

Drinking :

On the average and under normal conditions, it is about 5 litres per day. This amount is small but it is most important to supply water for drinking purposes with a high degree of purity. If water for drinking contains undesirable elements it may lead to epidemic.

Cooking :

The quantity of water required for this purpose will depend upon the stage of advancement of the family. For the purpose of estimation, the amount of water required for cooking may be assumed as about 5 litres per head per day.

Bathing:

The quantity of water required for bathing purpose will mainly depend on the habits of people and type of climate. The quantity of water under this category is assumed as about 40 to 60 litres per head per day.

Washing hand, face etc:

The quantity of water required for this purpose will depend on the habits of people and may be taken as 5 to 10 litres per head per day.

Household sanitary purposes:

Under this division, the water is required for washing clothes, floors, utensils etc and it is assumed as about 50 to 60 litres per head per day.

Detail of water requirement for Domestic purposes

Sl.No.	Description	Consumption of water per head per day in litres
1.	Drinking	5
2.	Cooking	5
3.	Bathing	55
4.	Washing of clothes	20
5.	Washing of utensils	10
6.	Washing of houses	10
7.	Flushing of Latrines etc.	30
	Total	135

Civic or public purposes:

The quantity of water required for civic or public purposes can be sub divided as follows:

Road washing:

On an average the quantity of water required for this purpose may be taken as about 5 litres/head/day.

Sanitation purposes:

In this division water is required for cleaning public sanitary blocks, large markets etc. the quantity of water required for this purpose may be taken as 2 to 3 litres/head/day.

Ornamental purposes:

This include requirement of water for beautification of the town.

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 quantity of water required for this purpose can be found out by applying certain empirical formula.

These are :-

19. National Board of Fire Underwriters Formula :

$$Q = 4637 \sqrt{P}(1- 0.01\sqrt{P})$$

Where Q = Quantity of water required in litres per minute. P = Population of the town in thousands

20. Freeman formula : $Q = 1136.50(P/5)+10)$

21. Kuichling's Formula : $Q = 3182\sqrt{P}$

22. **Buston**'s Formula : $Q = 5663\sqrt{P}$

Industrial purposes:

The quantity of water required for industrial purposes include requirement of water for factories, power stations, railways and airports. This demand depends upon the nature of the city, number 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.

Business or trade purposes:

This includes requirement of water for some trades such as diaries, hotels, laundries, motor garages, schools, hospitals etc. For a moderate city an average value of about 15 to 25 litres per head per day may be considered for this purpose.

Loss and waste:

It includes careless use of water, leakage in mains, valves, other fittings etc, unauthorized water connections and waste due to miscellaneous reasons. It may be due to overflow of service reservoir. The quantity of water lost due to all these reason is uncertain and cannot be effectively predicted.

Per capita demand:

It is the annual average amount of daily water required by one person and includes the domestic, industrial , and public use.

If Q = total quantity of water required by a city per year in litres & P = Population of the city Then Per Capita Demand in litre per day = Q / (P* 365)

Per capita demand (q) in litres per day per head =

$$\frac{total\ yearly\ water\ requirement\ of\ the\ city\ in\ litres}{365\ X\ design\ population}$$

Factors affecting Per Capita Demand :-

The various factors which affect the per capita demand are :-

1. **Climatic condition** :- Water requirements during summer are more than winter . During summer more water is used for bathing , drinking, air cooling, sprinkling in lawn, gardens etc. similarly in extremely cold countries, more water may be consumed because the people may keep their taps open in order to avoid freezing of pipes.

2. **Size of city** :- Generally the demand of water per head will be more in big cities than that in small cities. In big cities lot of water is required for maintaining clean & healthy environments and also in big cities the commercial and industrial activities are more.

3. **Habits of people** :- High class community uses more water due to their better standard of living & higher economic status. Middle class people consume water at an average rate and the slum dwellers consume very low amount.

4. **Industrial and commercial activities** :- More water will be required in highly industrialised city .

5. **Cost of water** :- More costly is the water less will be rate of demand. Hence the cost at which water is supplied to the consumer may also affect the rate of demand.

6.**Quality of water** :- A water works system having a protected & good quality of water supply would always be more popular with consumers. Hence more quantity of water will be consumed if the quality is good.

7. **Pressure in the distribution system** :- These would be of great importance in the case of localities having a number of two or three storied buildings. Adequate pressure would mean an uninterrupted and constant supply of water.

8. **System of supply** :- The system of supply may be continuous or intermittent. In continuous system water is supplied all the 24 hours while in case of intermittent system , water is supplied for certain fixed hours of the day only, result in some reduction in the consumption. This may be due to decrease in losses & other wasteful use.

9. **Development of sewerage facilities**: The existence of sewerage system in a locality wil lead to an increase in use of water for civic or public purposes.

10. **Policy of metering and methods of charging**: Water tax is generally charged in two different ways

23. On the basis of meter reading

24. On the basis of certain fixed monthly flat rate

When the supplies are unmetered and the charges are fixed, there will be more consumption of water. But when the supplies are metered, there will be less consumption of water which will lead to unhygienic conditions. And also there is a loss of pressure due to installation of meters and it adds to pumping cost.

Variation in Demand:

It has been seen that the demand does not remain uniform throughout the year, but it varies from season to season, even from hour to hour. So variation in rate of demand may be termed as

25. Seasonal variation.

26. Daily variation.

27. Hourly variation.

28. **Seasonal Variation**:- In Summer the water demand is maximum, because people will use more water in bathing , cooling, lawn watering, street sprinkling etc. This demand goes on reducing & in winter it becomes minimum, because less water will be used in bathing & there will be no lawn watering.

29. **Daily Variation :-** The rate of demand may vary from day to day also. This is due to habits of the consumer, climatic conditions, holidays etc. For example water consumption is more on Sundays and holidays than other working days.

30. **Hourly Variation :-** The rate of demand during 24 hours does not remain uniform & it varies according to hours of the day. For example, the consumption in the early hours of morning is generally less, increases sharply as the day advances, reaching a peak value between 8 AM to 11 AM, then decreases upto 1 PM and remains constant upto about 4 PM and again increases in the evening reaching a peak between 7 to 9 PM and finally falling to a low value in the late hours of night.

POPULATION :

In this method the person to be served by water- supply scheme & the future population is calculated to design the water supply system.

Method of population forecast

The following are the method of population forecast.

(1) Arithmetical increase method
(2) Geometrical increase method
(3) Increment increase method
(4) Graphical method
(5) Comparative method
(6) Zoning method
(7) Ratio & Correlation method
(8) Growth composition analysis method
(9) Logistic curve method

Arithmetical increase method:

31. This method is based upon the assumption that the population increases at a constant rate i.e the rate of change of population with time is constant.
32. This method is better applicable to large and established cities.
33. It will give lower population estimate than actual value if used for new cities.
34. In this method the average increase in population per decade is calculated and this increase is added to the present population to find out the population of the next decade.
35. As per this method the population in future decade is worked out by the following formula

$P_n = P_0 + nx$

Where P_n = forecasted population after n decades from the present

P_0 = population at present

n = no. of decades between present and future

x = average increase in population per decade

Example :

The population of 5 decades from 1930 to 1970 are given below in table. Find out the population after one, two and three decades beyond the last known decade, by using arithmetic increase method.

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

Solution :

Year	Population	Increase in population
1930	25000	
1940	28000	28000 - 25000 = 3000
1950	34000	34000 – 28000 = 6000
1960	42000	42000 – 34000 = 8000
1970	47000	47000 – 42000 = 5000
Total		22000
Average increase per decade (x)		22000/4 = 5500

As per arithmetical increase method:

$P_n = P_0 + nx$

36. Population after one decade

$P_{1980} = P_{1970} + (1\times x)$

$= 47000 + (1 \times 5500) = 52500$

37. Population after two decades

$P_{1990} = P_{1980} + (2\times x)$

$= 52500 + (2 \times 5500) = 58000$

38. Population after three decades

$P_{2000} = P_{1990} + (3\times 5500) = 63500$

Geometric Increase Method:

39. In this method, it is assumed that the percentage increase in population or percentage growth rate (r) from decade to decade remains constant.
40. This method is also known as “Uniform Increase Method”.
41. This method is suitable for new cities with unlimited scope of expansion.
42. As per this method the population can be forecasted using the formula

$P_n = P_0 (1 + \frac{r}{100})$

Where P_n = forecasted population after n decades

P_0 = population at the end of last known census

n = no. of decades

r = assumed growth rate (in %)