UNIT II   CONVEYANCE OF WATER

INTAKE:

The basic function of the intake structure is to help in safely withdrawing water from the source over predetermined pool levels and then to discharge this water into the withdrawal conduit (normally called intake conduit), through which it flows up to water treatment plant.

Intake consists of

a)   Conduit with protective works

b)   Screens at open ends

c)   Gates and Valves to regulate flow

Factors Governing Location of Intake

1. As far as possible, the site should be near the treatment plant so that the cost of conveying water to the city is less.
2. The intake must be located in the purer zone of the source to draw best quality water from the source, thereby reducing load on the treatment plant.
3. The intake must never be located at the downstream or in the vicinity of the point of disposal of wastewater.
4. The site should be such as to permit greater withdrawal of water, if required at a future date.
5. The intake must be located at a place from where it can draw water even during the driest period of the year.
6. The intake site should remain easily accessible during floods and should noy get flooded. Moreover, the flood waters should not be concentrated in the vicinity of the intake.

Design Considerations:

General considerations in design of intakes are:

a) Reliability of Operations:
        Intake structures should ensure safety of design and reliability of operations.

b) Quality of Water:
        Point of intake should be located such that water of test quality is available. Study of intake should be made before its selection. Incase of large rivers, intake should always be submerged and above water bed so as to prevent entry of silt.

        Incase of large variations intake should be located at certain depths so that excess of turbidity and micro organisms are prevented from entering conduit.

Part of intake should be for from settlements, sewage plant and other sources of pollution water supply reservoirs should be located in uninhabited valleys.

c) Structural Strength

Intake structures should be strong enough to resist such forces such as floods, impact of boats, debris etc.

d) Economy of construction

If intake conduit is short, it may be merely an extension of suction side of pump. If however too long, it would be more advisable to interpose a wet well or chamber near pump than to have long suction pipe as it proves costlier and also it involves greater head loses.

Types of intakes

Depending upon source of water, intakes are classified as,

1)   Reservoir intakes.

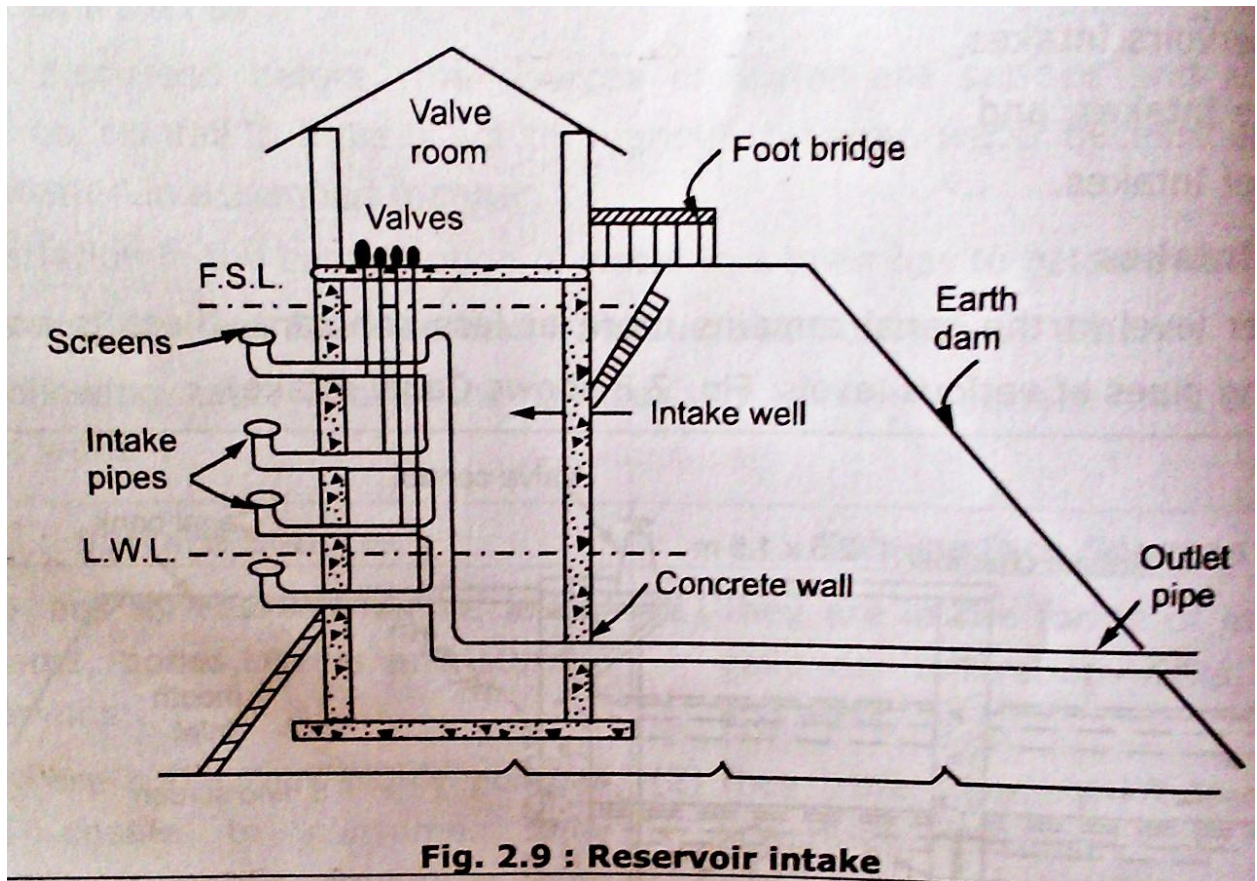2)   River intakes

3)   Canal intakes.

4)   Lake intakes

Depending upon the position, intakes are classified as,

1) Wet intake
2) Dry intake

Reservoir intakes:-

These comprise intake towers having no water inside other than in intake pipes. The interior of tower in thus made available for inspection and operation.

The intake located either along upstream toe of an earthen dam or within body of masonry dam. There are number of inlets provided at different levels as water table fluctuates. This enables to drain clear water from near surface.

Fig. 2.9 : Reservoir intake

RiverIntake

A river intake consists of a port (conduit) provided with a grating and a sump or gravity well. The conduit is supported on pillars 1-2m above the bottom to prevent entry of silt. Also it is kept 1m below the top surface to avoid entry of floating particles. Velocity should be kept less than 0.15 m/s to prevent entry of small fish.

River intake structure should be constructed above the point of sewage disposal or industrial waste water disposal. River intakes are likely to need screens to exclude large floating matter. The bottom of the river intake must be sufficiently stable.
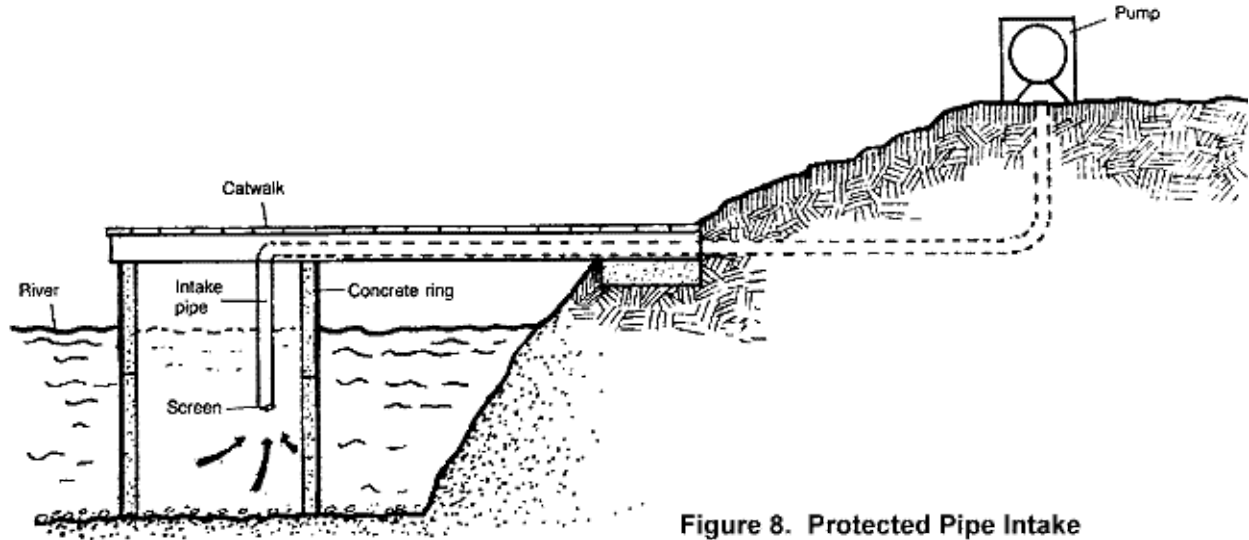
Figure 8. Protected Pipe Intake

Pipe is surrounded by well made partially or wholly filled with riprap water is led to suction pipe to wet well where it is pumped to supply.

Canal intake: It is comparatively a simpler arrangement consisting of a brick masonry chamber built partially in canal bank. It has side opening fitted with coarse screen which excludes heavier matter from entering conduit. Entry of water into conduit is controlled by gate valves. As this intake obstructs a portion of water way resulting in increase in velocity, it is often necessary to pitch both up and down stream in order to protect it against scouring.
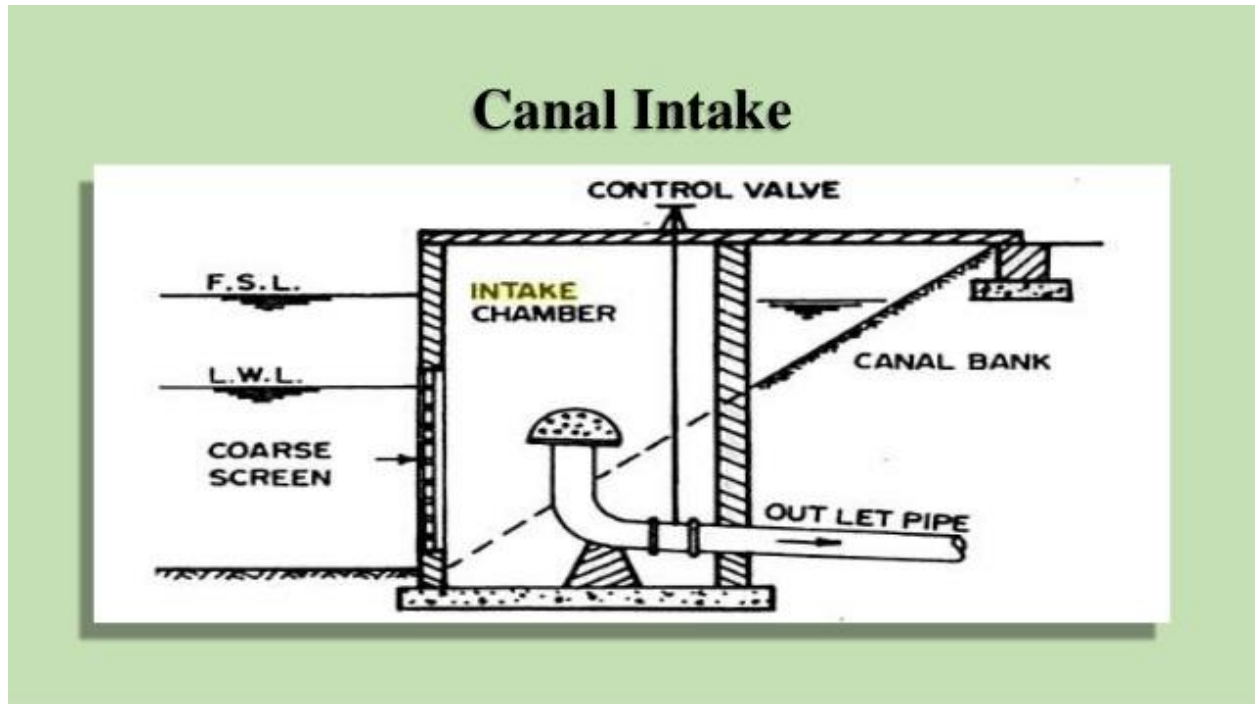
Wet Intake

- It consist of a circular shell filled with water up to the reservoir level and has a vertical inside shaft which is connected to the withdrawal pipe
- the withdrawal pipe may lie over the bed of the rivers or may be in the form of tunnels below the river bed
- openings are made into the outer concrete shell as well as, into the inside the shaft
- gates are usually placed on the shaft, so as to control the flow of water in the shaft and the withdrawal conduit
- The water coming out of the withdrawal pipe may be taken to pump house for lift (if treatment plant is at high elevation) or may be directly taken to treatment plant.
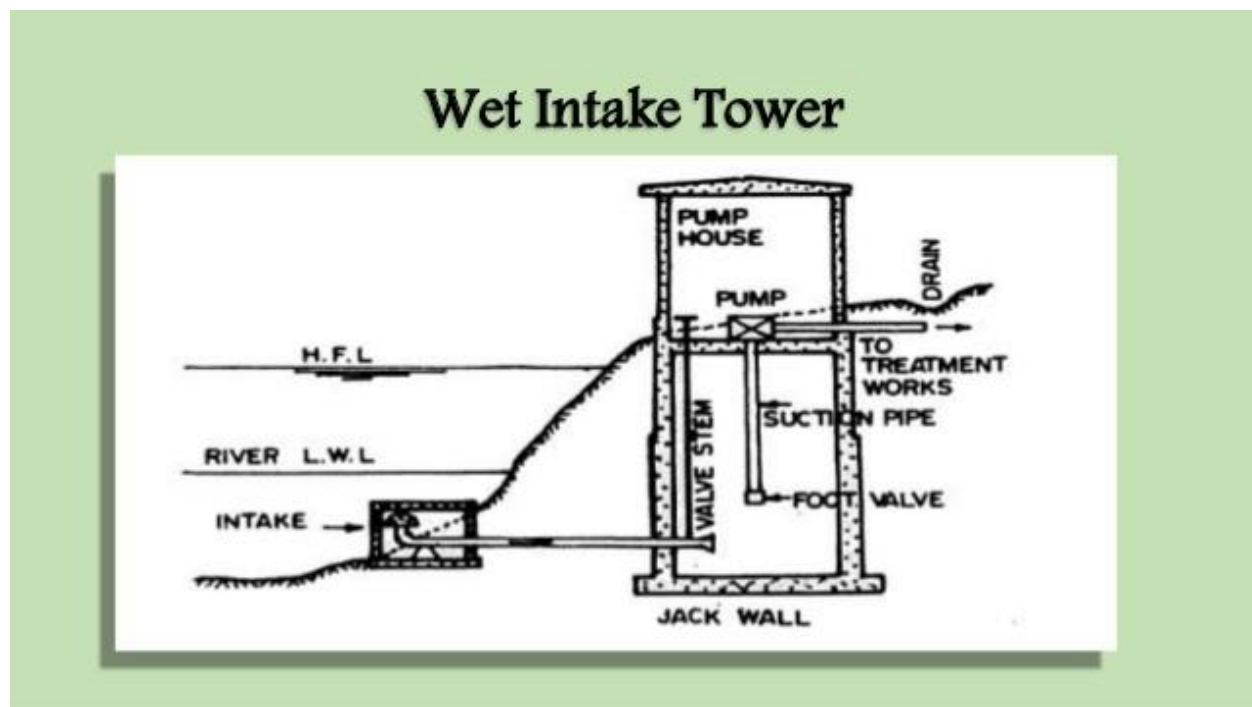

Dry Intake:

- The water is directly drawn into the withdrawal conduit through the gated entry ports.
- It has no water inside the tower if its gates are closed.
- When the entry ports are closed, a dry intake will be subjected to additional buoyant forces.
- Hence it must be of heavier construction than wet intake tower.
- They are useful since water can be withdrawn from any selected level of the reservoir by opening the port at that level.

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DRY INTAKE TOWERS
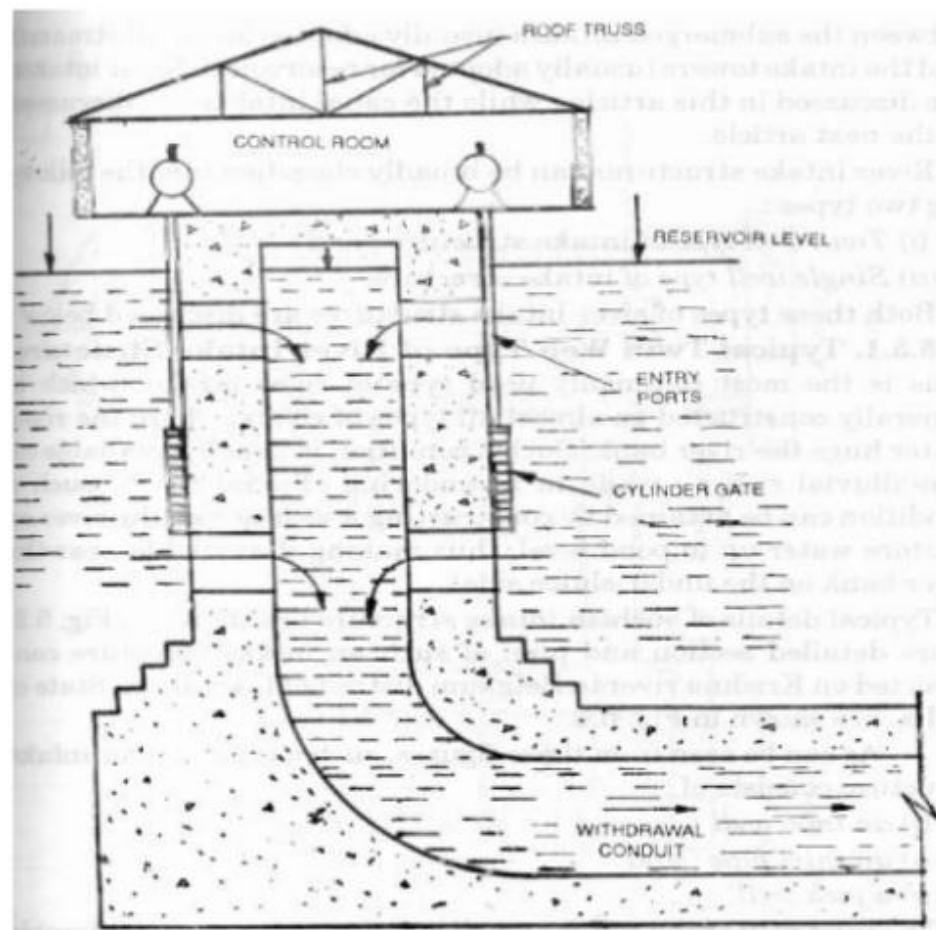
Hydraulic design of pressure pipe

Pipes flow formulae:

The design of water supply conduits depends on the resistance to flow, available pressure or head, and allowable velocities of flow. Generally Hazen- William's formula for pressure conduits and Manning's formula for free flow conduits are used.

Hazen-William's formula

$$U = 0.85\,C\,r_H^{0.63}S^{0.54}$$

Manning's formula

$$U = {}^1/_n\,r_H^{2/3}S^{1/2}$$

Where, U= velocity, m/s; r_H= hydraulic radius,m; S= slope, C= Hazen-William's coefficient, and n = Manning's coefficient.

Darcy - Weisbach's formulae:

Flow of water through pressure pipes is normally governed by Darcy – Weisbach's formulae

$$Hf = flv^2 / 2gD$$

where,

hf – head loss due to pipe friction in m.

L – Length of pipe in m.

D – Diameter of pipe in m.

V – Velocity of flor in m/s^2

F – Dimensionless friction factor, calculated by use of colebrooke – white formulae

$$1 / \sqrt{f} = -2\,\log_{10}(K/3.7D + 2.51 / Re\sqrt{f})$$

K – Roughness projection in mm

Re – Reynolds number.

Problems in Hydraulic Design of Pipes :

1. Water is to be supplied to a town of population 1.5 lakhs, if water works is situated at a
lower elevation of 50m than the water level in the source. Determine the size of the
gravity main to convey water from source to the water work, if the length of the gravity
main is 25km and the per capita demand of the town is 150 litres/day/capita. f = 0.075.

Solution:

Quantity of water required by town = 150000 x 150
$$= 225 \times 10^5 \text{ l/day}$$
$$= 22500 \text{ cu.m/day}$$

Let the pumps work for 12 hrs, then the quantity of water carried by the pipe $= \dfrac{22500}{12} \text{ m}^3/\text{hr}$

$$= \dfrac{22500}{12 \times 60 \times 60} \text{ m}^3/\text{s}$$

$$= 0.52 \text{ m}^3/\text{s}$$

Discharge , $Q = \dfrac{\pi d^2}{4} \times V = 0.52$

$$V = \dfrac{0.52 \times 4}{\pi d^2} = \dfrac{0.66}{d^2}$$

By Darcy – Weisbach formula,

$$H_L = \dfrac{fLV^2}{2gd} \qquad\qquad (H_L = 50)$$

$$H_L = \dfrac{0.075 \times (25 \times 1000) \times (0.66/d^2)^2}{2 \times 9.81 \times d}$$

$$50 = \dfrac{0.075 \times 25000 \times 0.66^2}{2 \times 9.81 \times d^5}$$

$$d^5 = \dfrac{95.56 \times 0.66^2}{50} = 0.83$$

d = 0.9635 m is approximately equal to 100cm.

2. Determine the hydraulic gradient in a 90cm diameter old cast iron pipe carrying a discharge of 0.75 cu.m/sec by using (a) Manning's formula (b) Darcy Weisbach formula and (c) by Hazen-William formula. Assume suitably any data not given.

Solution:

Discharge , Q = 0.75 cu.m/sec

Area of the pipe , A $= \pi d^2/4$

$$= \pi/4 \ (0.90)^2$$

$$= 0.636 \ sq.m$$

Velocity of flow , V $=$ Q/A

$$= 0.75/0.636$$

$$= 1.18 \ m/sec.$$

(a) Assuming the value of m = 0.014

R = d/4 = 0.90/4 = 0.225

Using Manning's formula

$$H_L/L = (m^2V^2)/R^{4/3}$$

$$= \frac{(0.014)^2 \ x \ (1.18)^2}{(0.225)^{4/3}}$$

$$= (0.0002729 \ / \ 0.137) \ = 1/501.9 = \mathbf{1/502}$$

Thus the hydraulic gradient is 1/502

(b) Using Darcy-Weisbach formula

Assuming the value of f = 0.015

$$H_L/L = (fV^2/2gd)$$

$H_L/L = \dfrac{0.015 \times (1.18)^2}{2 \times 9.81 \times 0.90}$

$= 1.1828 \times 10^{-3}$

$= 1/845$

Thus the hydraulic gradient is 1/845

(c) Using Hazen – William formula

Use $C_H = 120$

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

$1.18 = 0.85 \times 120 \times (0.9/4)^{0.63} \times S^{0.54}$

$S^{0.54} = \dfrac{1.181}{0.85 \times 120 \times 0.225^{0.63}}$

$= (1.181) / (102 \times 0.3908)$

$= 0.02962 = 1/672$

Thus the hydraulic gradient is 1/672.

Channels and pipes for conveying water

Conduits are the channels for conveying water.

Depending upon conditions and characteristics of flow, conduits are classified as

  i.   Gravity conduits
  ii.   Pressure conduits

Gravity conduits:

1) Channels:

❖ These are occasionally used to convey water from the source to treatment plant.
❖ These can be easily and cheaply constructed by cutting in high grounds and banking low grounds.
❖ The channels should be lined properly to prevent the seepage and contamination of water.
❖ As water flows only due to gravitational force a longitudinal uniform slope should be given.
❖ The velocity of water in channels should not exceed the permissible limit, otherwise scouring will start in the bed and water will get dirty.
❖ In channels there is always loss of water by seepage and evaporation.
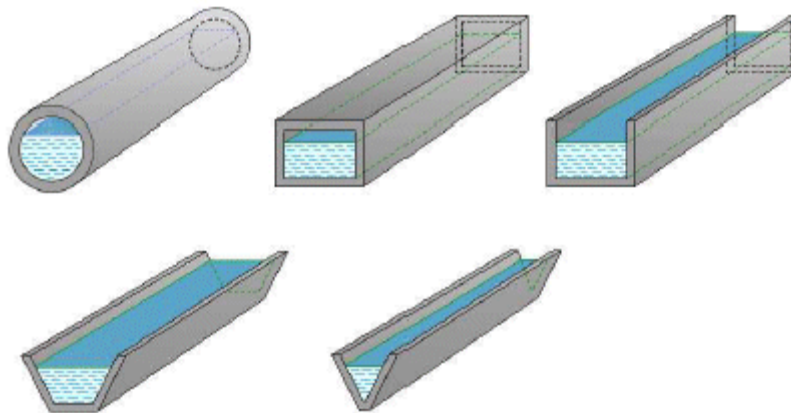
2) Aqueducts:

❖ It's the closed conduit constructed with masonry and used for conveying water from source to treatment plant.
❖ It may be constructed with bricks, stones or R.C.C
❖ In older days, rectangular aqueducts were used, but now-a-days horse-shoe or circular sections are used.
❖ The velocity should be 1m/sec.

3) Tunnels:

- ❖ This is also a gravity conduit , in which water flows under gravitational force
- ❖ But sometimes, water flows under pressure and in such cases these are called pressure tunnels.
- ❖ In pressure tunnels, the depth of water in general such that the weight of the overlying material will be sufficient to check the bursting pressure.
- ❖ Tunnels should b water- tight and there should be no loss of water.

4) Flumes:

- ❖ These are open channels supported above the ground over trestles etc.
- ❖ It's used for conveying water across valleys and minor low lying areas or over drains and other obstructions coming in water
- ❖ It may be constructed with a R.C.C, wood or metal
- ❖ The common sections are rectangular and circular.

Pressure conduits:

Pipes:

- ➢ These are circular conduits in which the water flows under pressure.
- ➢ Now a days pressure pipes are used in every place
- ➢ In distribution system, pipes of various diameters having many connections and branches are used.
- ➢ The cost of pipeline depends on the internal pressure and the length of pipeline.
- ➢ To prevent the bursting of pipes due to water hammer, surge tanks or stand pipes are provided at the end of the pipes.
- ➢ The pipe material which will give the smallest annual cost or capitalized cost will be selected because it will be more economical.

Pipe Materials

The selection of material for the pipe is done on the following points,

a) Carrying capacity of the pipe
b) Durability and life of pipe
c) Type of water to be conveyed and its corrosive effect
d) Availability of funds
e) Maintenance, cost, repair etc.

The following types of pipes are commonly used,

1) Cast iron pipes
2) Wrought iron pipes
3) Steel pipes
4) Concrete pipes
5) Cement lined cast iron pipes
6) Asbestos cement pipes
7) Copper and lead pipes
8) Wooden pipes
9) Vitrified clay pipes
10) Plastic pipes
11) Galvanized iron pipes

(a) Cast Iron Pipes: These pipes were earlier cast vertically but, thus type has been largely superseded by spun iron pipes which are manufactured by spinning and centrifugal action. These spun iron pipes are lighter in weight, longer in length and have improved metal qualities.

(b) Wrought iron and steel pipes: These pipes are stronger than cast iron pipes can withstand higher pressure but are of lighter section are easier to transport. They are less durable, more liable to corrosion and is also difficulty of availability of pipes specials viz, joints, bends etc.

(c) Concrete Pipes: These pipes are durable, heavier and can be had in sizes 1800mm. Transportation costs are much reduced if pipes are cast in situ. Concrete pipes have low maintenance are resistant to corrosion and particularly suitable to soft and acidic waters. They however can withstand high pressure until reinforced.

(d) Hume Steel Pipes: These pipes are made from a then mild steel shell lined and outcoated with cement concrete or cement mortar through a centrifugal process. They are available upto 1350mm and are used for trunk and distribution mains. They are heavy and difficult to handle and concrete coating gets damaged while fixing branch connection.

(e) Asbestos Cement Pipe: These pipes are composed of asbestos fibre and Portland cement combined under pressure into dense homogenous structure . Available in large variation from 50 to 600mm.

(f) Wood Pipe: These pipesare built of staves of wood held together by steel bands. Wood is less durable for pipe material and pipe must be constantly full of water to prevent crackdown due to alternate wet and dry conditions.

PIPE JOINTS:

PIPE joints are required to joint together pipes which are available in small lengths say 3.6 to 6.0M.

Requirements of a jointing material.

| (i) | Imperviousness | (ii) | Elasticity | (iii) | Strength |
| (iv) | Durability | (v) | Adhesiveness | (vi) | Availability |
| (vii) | Workability | (viii) | Economy | | |

(a)   Poured Joints:

Materials chiefly used are lead, cement grout, Sulphur and sand compounds now a days, substitutes of lead like leadite, hydrotite, metalite are being increasingly used. They are light in weight.
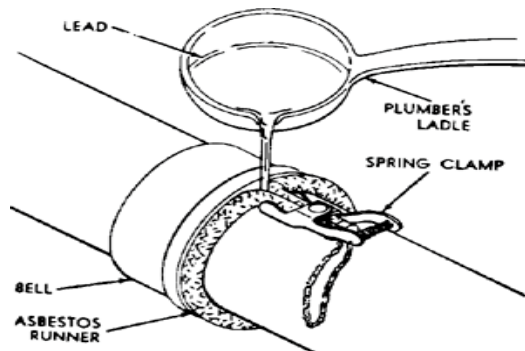
(b) Spigot and Socket Joint:

Joint is commonly used in case of cast iron pipe. Spigot of one pipe is centered into socket of preceding pipe, tared gasket or hemp yarn is then wrapped around spigot leaving unfilled required depth of socket for lead. The gasket or hemp yarn is caulked tightly home with a yarning tool. A jointing ring or kneeded clay using is then placed around barrel and against face of socket molten pig lead is powered into remainder of socket.
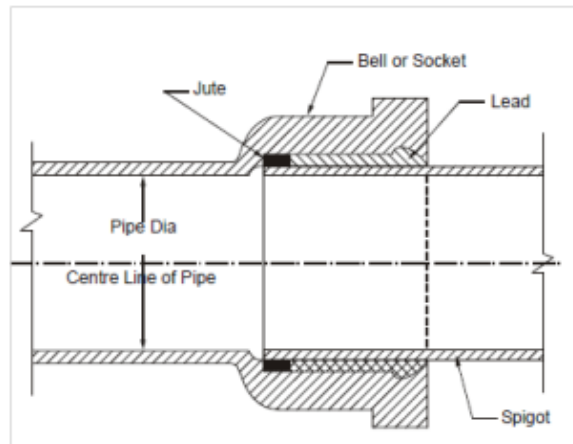
(c) Flanged Joint:

A gasket of rubber canvas or lead is introduced h/w two flanges of cast iron pipes which are tightened with bolt and nuts. Flanged joints are strong and rigid are easy to disjoint as such used where pipe joints are occasionally opened for repair pipe.
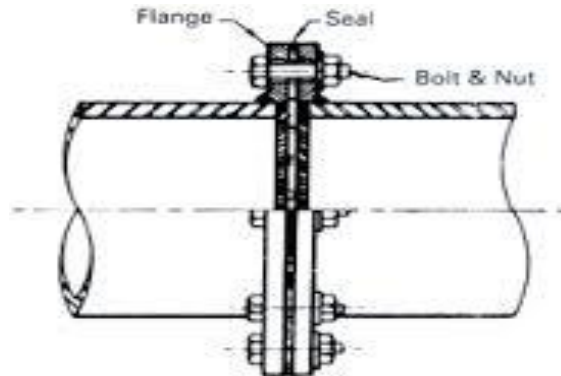
(d) Mechanical Joint:

When two ends of cast iron, steel or wrought iron pipes are plain, a mechanical coupling is required to make a water tight joint.
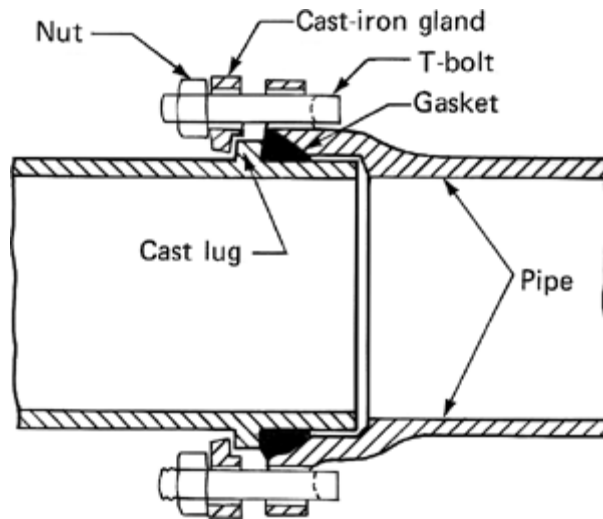
(e) Victaulic Joint:

It consist of it shaped rubber ring, enclosed by metal housing made in two halves each half engaging shoulders or grooves on pipes. These are then bolted together or as to form a ring around pipe clearance h/w keys of housings and grooves allows for any expansion, construction or deflection. These joints are used where pipes are exposed to frequent vibrations. Ex. Bridges

Joints for concrete and asbestos cement pipes reinforced or pre-stressed concrete pipes are jointed by first placing a rubber gasket h/w steel rings and then filling gap from outer as well as inner sides with cement mortar.

In case of asbestos pipe, two plain rods of pipe butt against each other, two rubber rings are then slipped over and coupling pushed over rubber rings thus making tight and flexible joint.
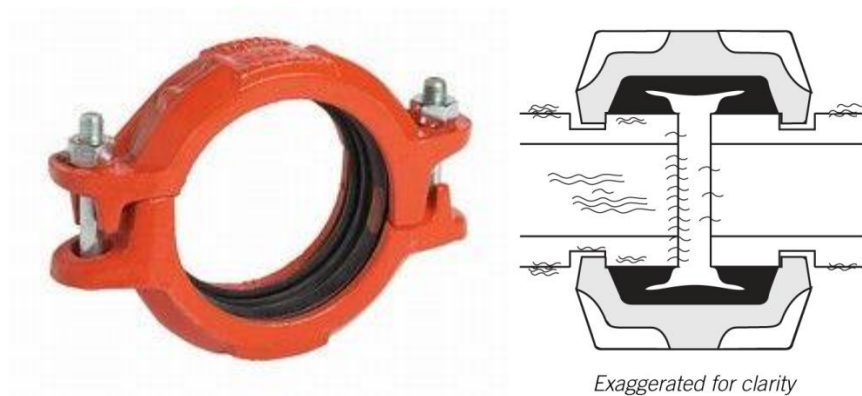
(f) Screwed and Socketed Joint:

Simplest type of joint used for joining screwed wrought iron or galvanized iron pipes.

(g) Special Joints:

Used for special pipes in case of cast iron pipes. Examples are expansion joints and flexible joints. Expansion joints are used on pipes exposed to considerable differences of temperature allowing free expansion or contraction without any thermal stresses. Flexible joints used in pipes to be laid submerged under water.

Laying and Testing of Pipes:

Following are operations laid out in laying of pipes.

(i)   Preparing detailed map of roads and streets showing position of rocks, other underground water pipes, gas pipes, telephone cables.

(ii)   Locating proposed alignment on ground: Bench line is marked by driving centrally stakes 30M apart on straight trenches and 7.5 – 1.5M apart on cover.

(iii)   Excavating trenches: with width sufficient to allow pipes to be properly laid and jointed and with depth sufficient to give adequate protection to pipes against impact of traffic and other factors.

(iv)   Bottoming up of trench excavated: bottom of trench should be carefully prepared so that barrel of pipe can be bedded true to line and gradient for its entire length on firm surface.

(v)   Lowering of pipes into trench: after transporting to site, pipes are stacked on either side of trench. These should be gently lowered into trench so as not to damage their outer protective coating.

(vi)   Layout of pipes: Pipes are seldom laid with a flat slope parallel to hydraulic gradient thus it avoid any lock troubles.

(vii)   Joining of pipes

(viii) Anchoring of pipes: at all bends, tees, valves and other branch connections it would be necessary to provide thrust blocks of concrete to transmit hydraulic thrust and distribute to wider area.

(ix)   Anchor blocks of concrete would be required to be provided at regular intervals and pipes would be firmly secured to them with steel straps.

Back filling

Refilling of trench with excavated material. The material around pipe should be soft, free from lumps or rock or large stone and laid preferably in layer of 15 cm or 30cm

Pressure Test

Consist of filling pipe line with water expelling all are from within allowing it to stand full for some time and then applying atleast double working pressure. Pressure is applied by means of a manually operated test pump fitted with pressure gauge. In case large sized mains or longer lengths of mains power driven test pump may be used. After test pump has registered requisite pressure it is stopped and any fall of pressure is noticed.

Leakage Test

Carried out after satisfactory completion of pressure test. No matter how will a pipe line is constructed there may be some leakages at some point, leakage test is used to determine maximum allowable leakage.

$$Q = ND \sqrt{P} / C$$

Q – Allowable leakage (l / hr)

N – Number of joints in length of pipe line

D – diameter of pipe in mm

P – Average test pressure during leakage test (kg / cm^2)

C – Constant Value = 3.3

Pipe Corrosion

      Pipes are laid to be corroded when iron or other metal constituting them unless otherwise protected are attacked by water and dissolved out. Corrosion may be internal water pipe surface as in direct contact of water corrosion has huge loss to water users in term of repair and getting new pipe.

PUMPS AND PUMPING

Pump is a mechanical device using suction or pressure to raise or move liquids, compress gases, or force air into inflatable objects such as tyres.

Factors Affecting the Selection of Pumps:

In order to select proper pumps, the following factors should be considered,

1) Capacity – it should be capable of pumping required quantity of water
2) Reliability – it should be reliable and should not fail suddenly and cause troubles
3) Cost – it should be cheap in initial cost
4) Power – the power which is used for running pumps should be available easily at low cost
5) Maintenance – the maintenance cost of running pumps should be as small as possible
6) Efficiency – pump should have higher efficiency
7) Depreciation – it should have long life and depreciation cost should be small
8) Cost of labour – it should be low
9) Number of pumping – more units required
10) Total lift of water required
11) Quality of water to be pumped
12) Quantity of water to be pumped
13) Importance of water supply scheme
14) Space requirements for locating the pump
15) Life of pump
16) Variations in pumping head and pumping rate
17) Discharge and suction condition
18) Position of pump (horizontal or vertical)
19) Type of power available
20) Type of supply service (continuous or intermittent)
21) Working or operating conditions
22) Total head of liquid

Pumping Stations:

➢ The location of the pumping station is very important and should be done carefully
➢ If the water is drawn from the tube well, it's the usual practice to construct the pumping station just above the tube well
➢ If the water from tube well is pumped to the overhead storage tanks, its necessary to place the pumping station as near to storage tank as possible
➢ When the water is drawn from the rivers or lakes or impounded reservoirs, pump house should be directly constructed on the intake well
➢ If water is supplied from the underground reservoirs located at the water works, pump house should be located on the side of the reservoir from where it should pump the water to the mains
➢ As pumps are the most important part in water works, and in any case of their break down the area will remain without water
➢ Therefore, it's necessary that the pump should be reliable and work for long period without stoppage for cleaning, repairs and maintenance
➢ Maximum quantity of water should be lifted with minimum consumption of fuel.

Factors Affecting the Selection of Site for Pumping Station:

❖ The site should be away from all sources of contamination and pollution
❖ The site should be above the highest flow level of water
❖ It should be so selected that its future growth and expansion is easily possible
❖ Possibilities of fire hazard should also considered while searching the site
❖ The proximity of the site to the railway from where coal or diesel can be quickly available for producing power have to be considered.
❖ The pumping station should be made attractive in their exterior or interior which may arouse public faith in the neatness and cleanliness of water supplied to them
❖ They should be properly lighted, ventilated and kept neat and clean.

Valves at the Pumping Stations:

1) Sluice or gate valve – one valve on the suction side and other on the delivery side
2) Check valve – located on the delivery side ion between the pump and the gate valve
3) Pressure relief and Air valve – located on the delivery side

Sizing of Pumping Units:

• A water works pumping station is generally not operated at full capacity all of the times
• Since the efficiency of a pumping unit varies with the load, it's a usual practice, to design some of the pump can be operated at full capacity all of the time
• Hence, two, three or four pumps have to be installed
• For e.g, if there are four pumps, two largest may supply the maximum demand and other pumps for minimum requirement

Stand – By Capacity:

- There will always exist some stand by capacity to take care of the repairs, break downs etc
- Generally, 100% stand by capacity against average demand and 33 $^{1/2}$ to 50 % stand by capacity against peak demand is considered sufficient.

Types of Pumps:

1) Displacement Pumps

Works on principle of mechanically inducing vacuum in a chamber thereby drawing in volume of water which is them mechanically displaced and forced out of chamber.

2) Reciprocating Pump

Piston or plunger operates in closed cylinder, its forward stroke producing vacuum which draws in water through an inlet valve from a suction pipe, the return stroke pushing water out through outlet valve in delivery valve in delivery pipe. It can be single or double acting depends on whether it is arranged for water to be discharged only during return stroke of piston or lock during its forward and return strokes.
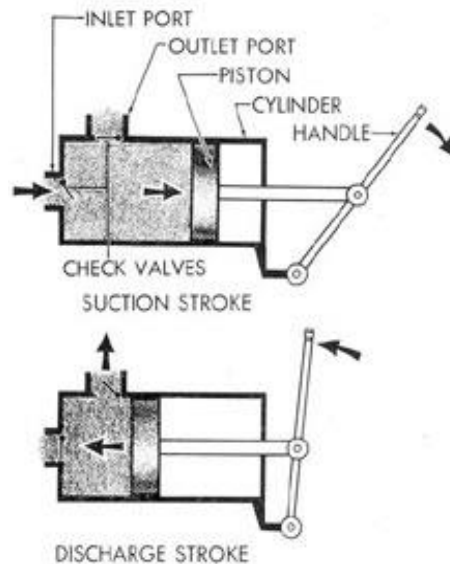
3) Hand operated reciprocating pump

An important application in case of individual and rural water supply systems. In such a pump, a piston or plunger reciprocates in a closed vertical cylinder upstroke producing vacuum opening valve V_1, thus drawing in water which fills cylinder below piston while water in cylinder above piston is forced out of spout, down stroke opening valve V_2 at base of piston filling in water in cylinder above piston keeping V_1 closed at that time.

4) Rotary pump

Requires no valves are self priming they can be operated at high speeds and thus large capacity with small size can be obtained.
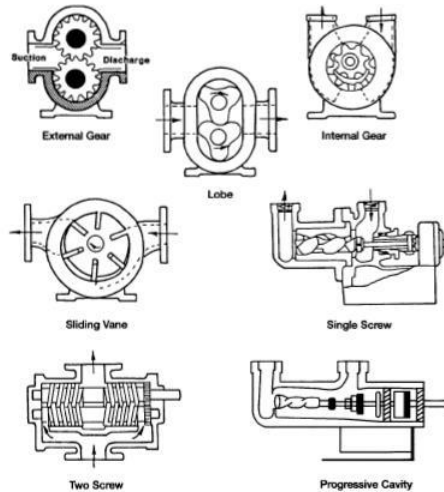

Figure 10-10. Typical types of rotary pumps.

Disadvantage

Shows excessive slip with increase in rear of pumping parts. Further, because of close fit of gears or cams in casing water containing grit or other suspended matter is injurious to them.

5) Centrifugal Pumps

Based on principle of centrifugal force tamper energy to water. Water entering into pump casing is revolved by wheel called impeller which discharges item a direction at right angles to its original direction of flow. In so doing, kinetic energy of water is converted into static or pressure head.

Advantages:

Low initial cost, simple mechanism, stability of flow, safe against high pressure, adaptability to high heads, small space requirements and good durability.

Disadvantages:

Limited suction lift, absence of self priming adjustment. Necessity of self employing self regulating gears, low efficiency.

6) Airlift Pump

Effectiveness is dependent upon factor called percentage, submergenic which is ratio D x 100 / D + H

D – Depth of submergence

H – Effective lift of pump

Advantages:

- Freedom from submerged moving parts
- ease of operation and maintenance
- Increased yield caused by forcing great air pressure.
- Suitability for installation.

Disadvantage:

- Greater depth of submergence
- Low efficiency
- Little flexibility in meeting variation in demand.