UNIT– III

WATER STORAGE AND DISTRIBUTION

Storage and Balancing Reservoirs - Types, Location and Capacity. Distribution System: Layout, Hydraulics of Pipe Lines, Pipe Fittings, Valves Including Check and Pressure Reducing Valves, Meters, Analysis of Distribution Systems, Leak Detection, Maintenance of Distribution Systems, Pumping Stations and Their Operations - House Service Connections.

Service Reservoirs.

Service Reservoirs (Distribution Reservoir) are the storage tanks used in water distribution system, used to store required quantity of water, to provide storage for fire fighting and emergencies and to stabilize the pressure in the distribution network.

Service Reservoirs may be constructed of brick masonry, stone masonry, PCC, RCC, prestressed Concrete or steel.

Functions of Reservoirs

1) Based on the hourly variation in demand, it directs the treatment units to operate at a uniform rate.

2. Reservoirs maintain the pressure of water in water mains

3. Reservoirs supply the water during emergencies such as fires etc.

4. It increases the pressure considerably in the case of elevated reservoirs.

5. It reduces the overall cost reduction in pumping and makes the distribution system economical.

Types of Reservoirs and Function

1) Surface Reservoirs

2) Elevated reservoirs

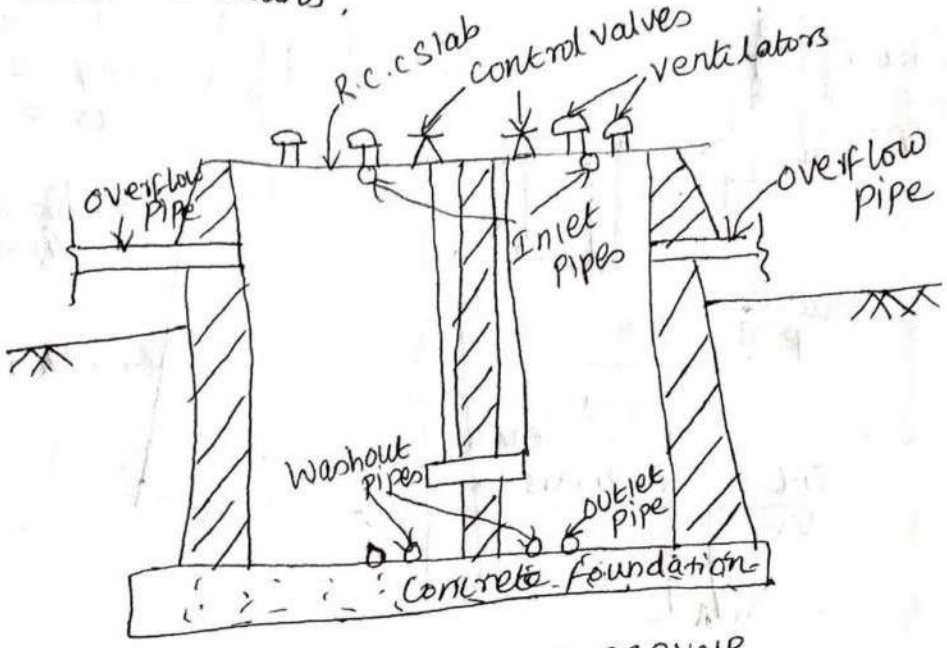
3) Stand pipes

1) Surface Reservoirs

Surface reservoirs (Ground reservoirs) are circular or rectangular shaped water tanks, located at ground level or below the ground surface. It is also called ground (or) Non-elevated reservoirs.

In gravitational type of distribution system, water is stored in the ground service reservoir and then directly sent from there into the

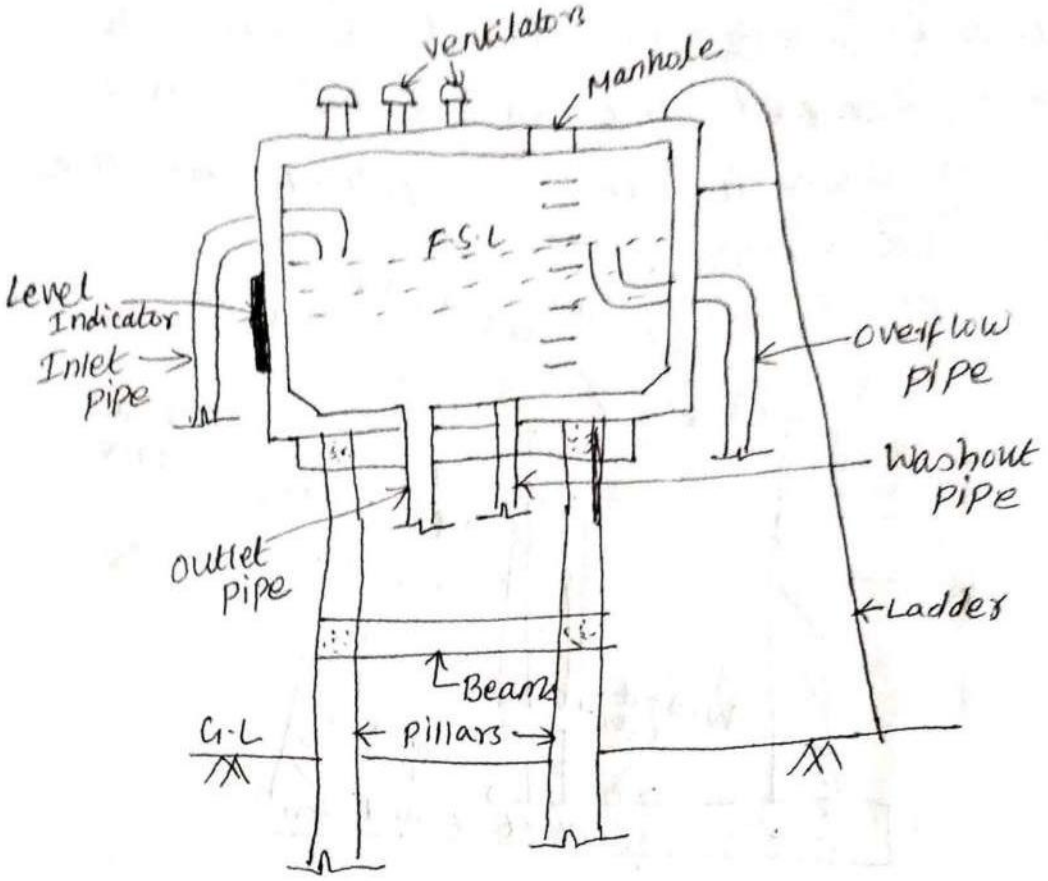
distribution system. In combined gravity and pumping system of distribution, the treated water is stored in ground reservoir and then pumped into an elevated service reservoir from where it can be supplied into the distribution mains.



SURFACE RESERVOIR.

Surface reservoir is divided into two compartments, so that one may be cleaned and repaired ~~at~~ while the other is in use. The two compartments are connected with each other by shut off valve or sluice valves. Overflow pipes are provided at fully supply level, so as to maintain a constant water level. Ventilators are provided in the roof slab so as to affect free circulation of air. Reservoir is cleaned through washout pipes. The cement concrete floor slopes towards the central washout pipes.

2) Elevated Reservoirs



* Elevated reservoirs are constructed above the ground level and supported on towers.

* These are rectangular, circular or elliptical overhead tanks erected at a certain suitable elevation above the ground level.

* These are constructed where the pressure is the main requirement and the water distribution may be carried out by gravity system after pumping

* They are also located in areas where the combined gravity and

pumping system for water distribution is adopted.

* Water is pumped into these elevated tanks from the filter units or from the surface reservoirs and then supplied to the buildings.

* These tanks may be made of either R.C.C, steel tanks

R.C.C tanks are preferred because

1) R.C.C is comparatively non-corrosive in nature

2) cheaper

3) less maintenance.

* pre-stressed concrete elevated tanks are used nowadays, which saves steel and concrete.

* Elevated reservoirs are costly

* They are covered at top by roof slabs to avoid the contamination of water due to dirties, birds, insects etc.

* Roof should be provided with ventilators, for free circulation of air.

Other accessories are

i) Inlet Pipe

ii) Outlet Pipe

iii) Overflow pipe

iv) A float gauge or an indicator

v) A wash out pipe

vi) Automatic ~~pp~~ device

vii) Ladders

viii) Manholes

ix) Ventilators.

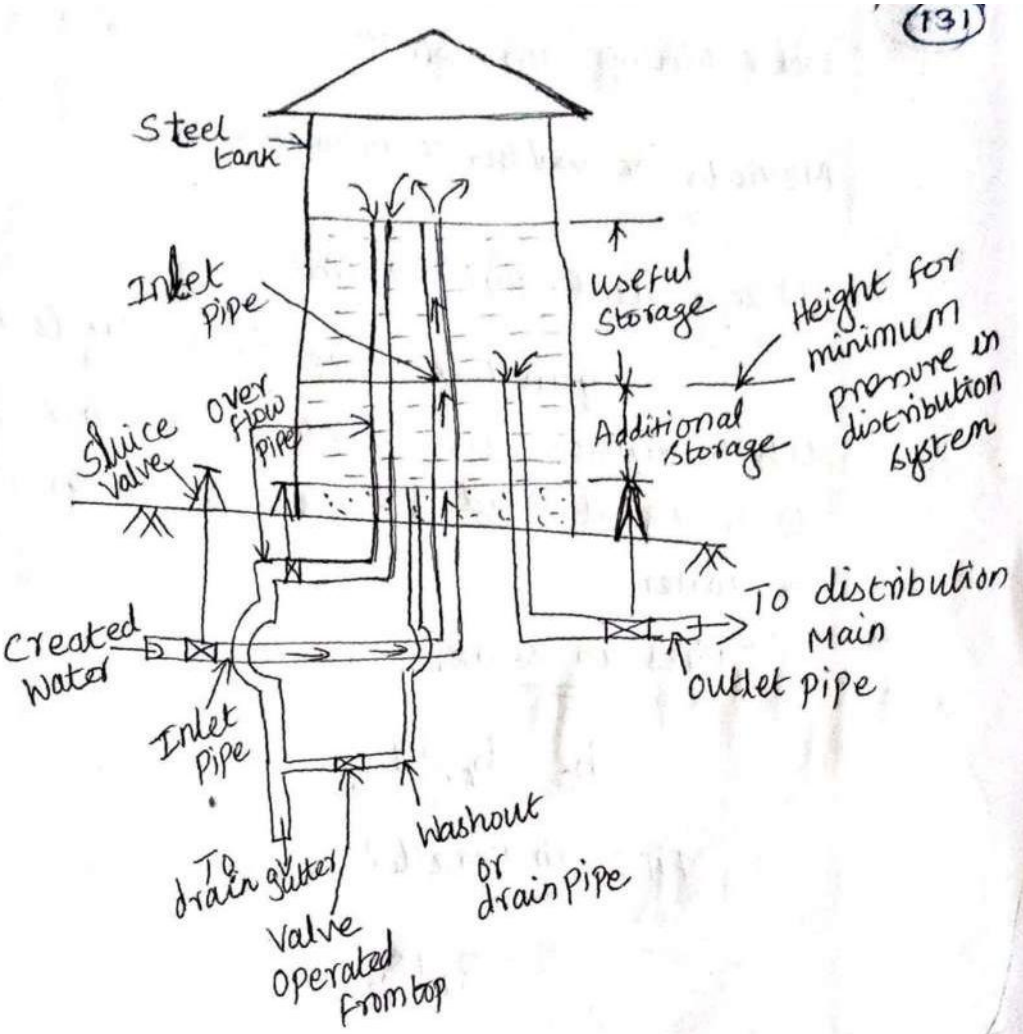
3) Stand Pipe

* Stand pipes are tall cylindrical elevated shells resting directly on the ground used to store and distribute the water.

* Height of stand pipes varies from 15m to 30m and diameter varies about 10m to 15m

* Hoop's tension developed in the bottom of the tank is very high, due to larger heights.

* R.C.C cannot withstand higher stresses and R.C.C can be avoided for heights above 15m.



NETWORK DESIGN

Pipe network is defined as the group of interconnected pipes, forming several loops or circuits.

Conditions of pipe network

1) At a junction, the quantity of inflow of water is equal to the quantity of outflow of water
2) In each circuit, the loss of head due to flow in clockwise direction is equal to the loss of head due to flow in anti-clockwise direction
3) In each pipe of network there is a relation between the head loss in the pipe and the quantity of

water flowing through it.

Methods of analysis of networks

1) Equivalent pipe method

Equivalent pipe is a single pipe which replace all complex system of pipes with equal head loss for the given flow of water.

Pipes in series

$$h_f = h_{f_1} + h_{f_2} + \dots$$

Pipes in parallel

$$Q = Q_1 + Q_2.$$

2) Hardy Cross method

Hardy cross method may be carried out by

1) Balancing head

2) Balancing flows.

Steps Involved are

i) Flows coming into each junction of the loop are equal to the flows leaving the junction

$$Q_1 + Q_2 = Q_3 + Q_4$$

With the assumed values of Q, Compute the head loss in each pipe

$$h_f = r Q^n$$

Net head loss around each loop should be equal to zero.

Design of network system

It involves the computation of size of pipes, location of valves etc.

The following factors are considered in the design

1. Type of flow
2. Method of distribution
3. Future demand based on increase in population
4. Design period to be the life of pipes used

Appurtenances

Accessories used in the water supply system to maintain and test the system.

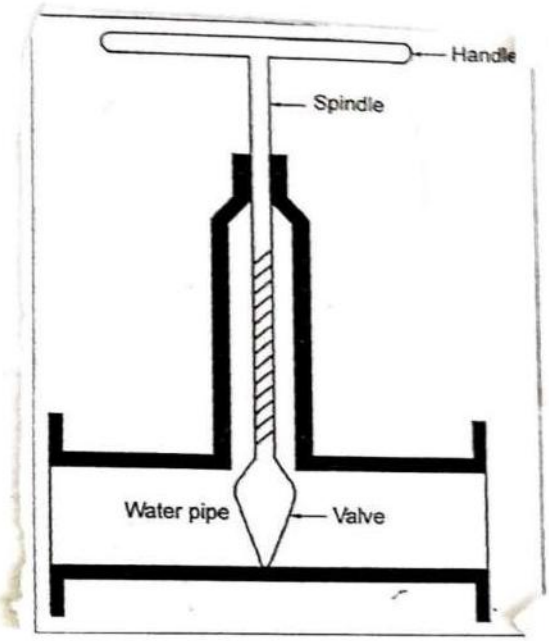
1- Valves [Sluice valves (or) Shut off valves (or) Gate valves]

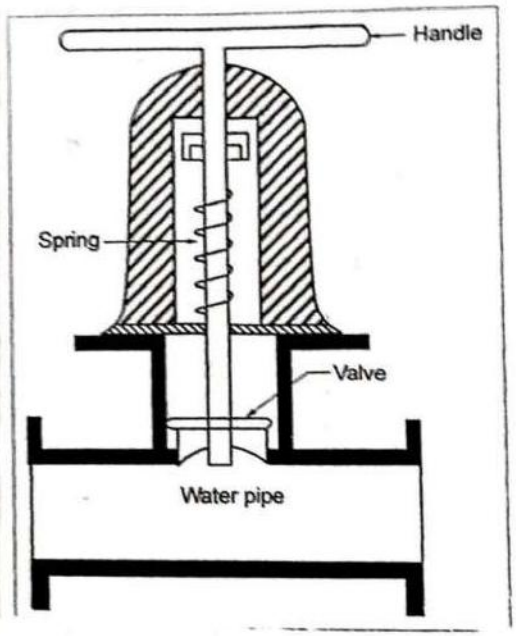
* Valves are used to control the flow of water
* used to regulate the pressure of water
* used to release or permit the air

i) Sluice Valves (or) Shut off valves (or) Crate Valves

* used to regulate and control the flow of water through the pipeline.

* permits the repairs and maintenance works.





*It consists of a wedge-shaped gate which is raised or lowered on grooves with gunmetal faces.

*Crate valves are made of cast Iron.

Advantages

1) Low cost
2) No resistance to flow of water
3) Available in threaded, flanged ends

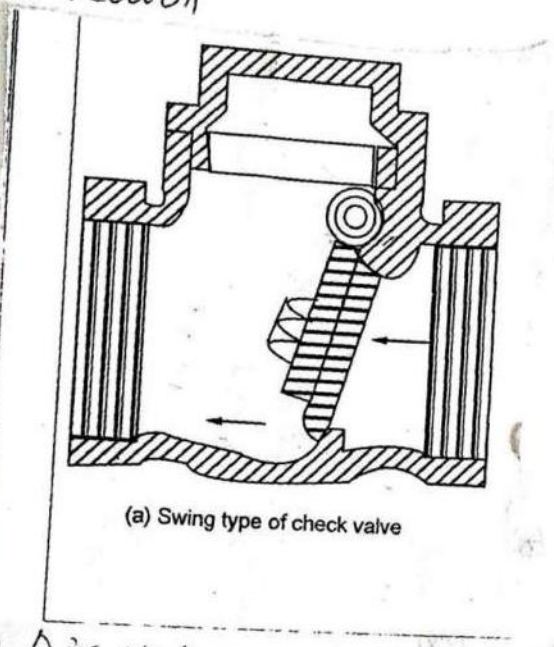
Disadvantages

1) Not suitable for operating in partly open

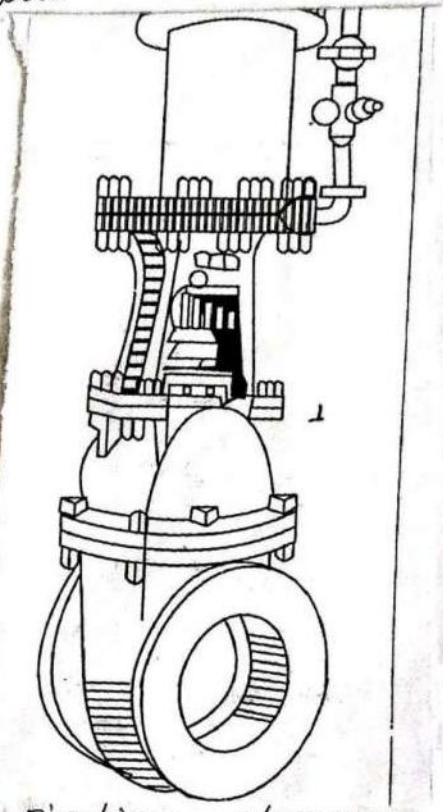
2. They require high force to open or close.

ii) Check valves (or) Reflux valves

* One directional flow valves
* Non-return valves
* Allow water to flow in one direction
* prevent water to flow back in opposite direction

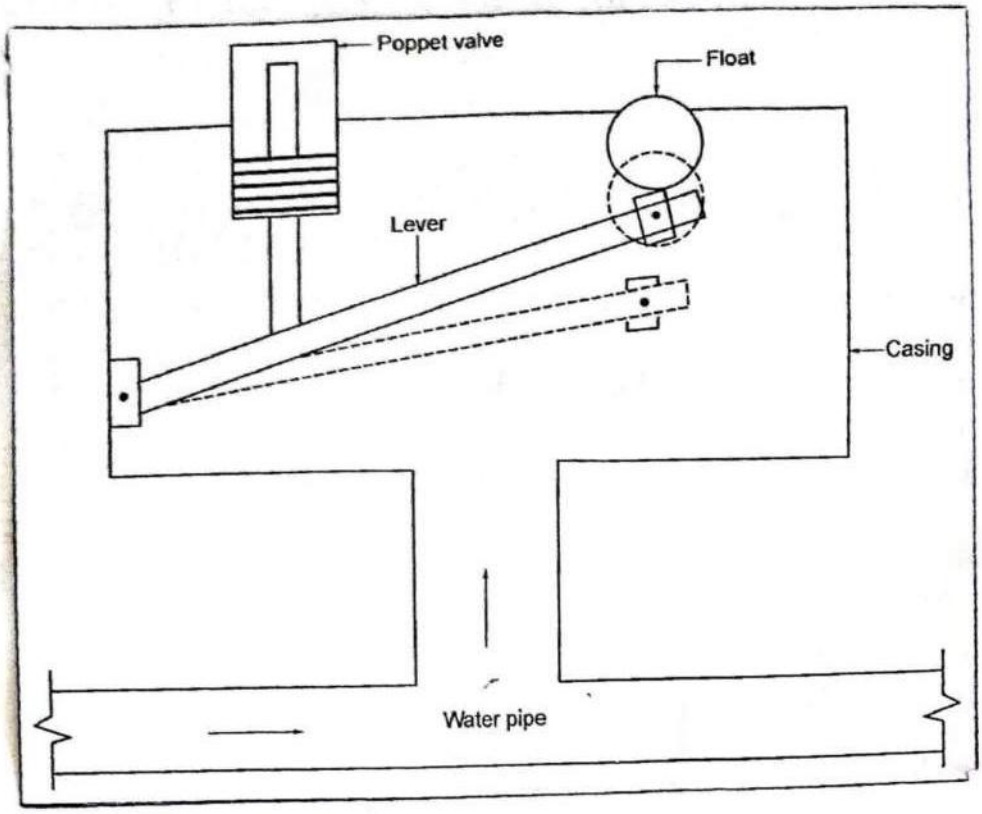


(a) Swing type of check valve



iii) Air valves

* water flowing through the pipelines always contains some air
* Air relief valves are provided at summits of water pipe to exit the air.
* It consists of a cast iron chamber, float lever type valve
* When air starts accumulating in the chamber, float is lowered and poppet valve is opened. Due to this, air



iv) Scour Valves

* Located at the dead ends or the lowest point in the mains

* Used to remove silt and sand deposited in the pipe.

* Manually operated valve

* Scour valves are also used to remove the entire water when repair and maintenance.

2) Hydrants

* For tapping water during emergencies like fires etc.

* During fire, it is necessary to supply the higher quantity of water in higher pressure.

* For firefighting purposes, the nearby hydrant is connected to the fire hose, the water with high pressure is applied over the fired region for extinguishing the fire.

* The fire engines will receive the water from hydrant, and increase its pressure enormously within the engine.

* Fire hydrants are provided at all the street crossings and turnings and at an interval of about 90m to 120m on straight runs.

Requirement of a good hydrant

1) It should be easily connected with hose or other motor pumps
2) It should be easily detached with hose or other motor pumps at emergencies
3) It should not get out-of order during operation
4) It should have minimum initial and installation cost
5) It should not produce any obstruction to flow at emergencies

Type of hydrants

1) Post fire hydrant
2) Flush fire hydrant

Post-fire hydrants

* It consists of a cast-iron barrel, which is held as a vertical post projecting above the road level by 1m.

* It has a valve with a long stem with screw and nut at its top, in order to regulate the flow of water.

* In closed position, the valve rests against the valve seat.

* Post hydrant is provided with hose outlet or pumper outlet. The hose outlet is 63mm diameter

* The pumper outlet of 100mm diameter is used, when the water pressure is to be increased.

* post fire hydrant can easily be located and operated.

* It is more suitable for use in less congested areas.

* It can be easily damaged or misused.

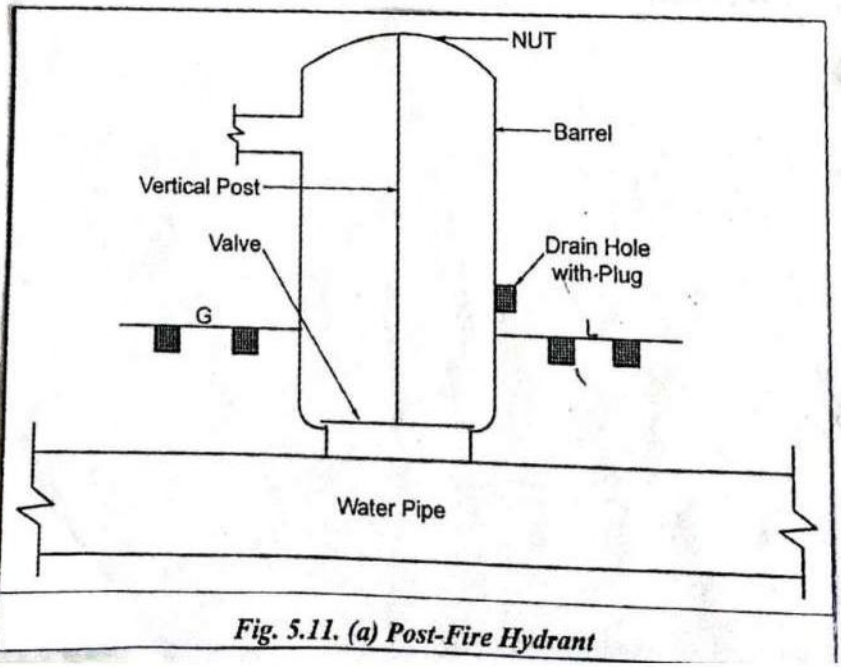


Fig. 5.11. (a) Post-Fire Hydrant

Flush Fire hydrant

* It is located below the ground level and it is covered with a cast-iron box. It is provided with only one outlet opened in the vertical upward direction.

* Flash fire hydrant is safe and secured against damaging

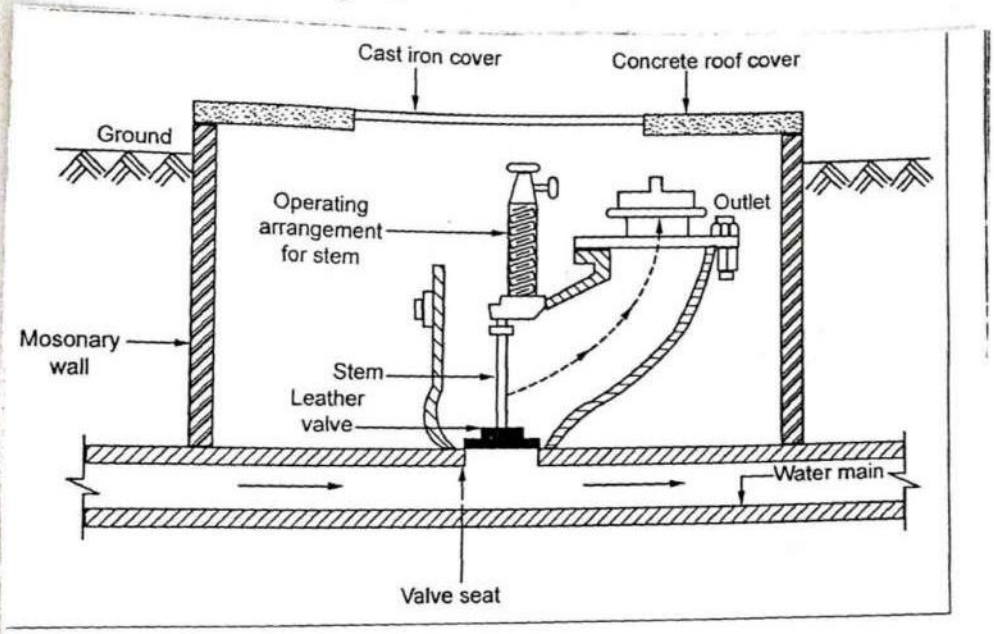


Fig. 5.11. (b) Flush-Fire Hydrant

LEAK DETECTION

Wastage in water supply system ranges from 15% to 40%. Wastage of water in a distribution system is due to

i) Leakage in pipe joints, fittings etc.

ii) careless use of water by consumers

iii) Unauthorized usage or thefts

iv) Other miscellaneous reasons

Methods of Waste detection

1) Water waste surveys

2) Leakage location.

1) Water waste surveys

* Find out the blown out joints and fittings in the main

* Find out the unauthorized usage of water

* Find out the wastage of water by carelessness of the consumer.

2) leakage location

Leaks of water can be located by

1) direct observations

2) Sounding rod

3) Plotting hydraulic grade line

4) Using detecting meters

Direct observation

* pressure of green gras during drought, a soft spot in the ground or metal patch of snow may serve as some indication of the leaks.

Sounding Rods

* Sharp pointed metal rod is thrust into the ground along the pipe line and

pulled up for inspection.

*Its moist or muddy point will indicate the presence of leaked water.

*Aquaphone or Sonoscope can also be used to detect leak.

Hydraulic Gradient line

*pressures at various points along a pipe line are measured and the hydraulic gradient line is noted.

*Waste detecting meter is Misnomer

*Deacon's meter can also be used.

Requirements of a good meter

1) It should record the water passing through it and its measuring range should be very accurate
2) It should be able to work efficiently at all pressures in the mains
3) It should not create any resistance to flow of water
4) It can be easily maintained and repaired
5) It should be economical
6) It should have screen on its ~~let~~ inlet side, to exclude the clay, silt, grit etc.

Advantages of metering

1) Reduce the wastages of water
2) Consumers pay only for the consumed quantity of water

3) The loads on the treatment plant are reduced

Disadvantages of metering

1) The installation and maintenance of meter is a costly process

2) It causes loss of head

3) Poor metering causes severe problem in water distribution system

To reduce Wastage of water

1) Design distribution system such that the branch line serves 2000 to 3000 persons only.

2) The fittings used in the joints should confirm to the standards

3) Intermittent system of water supply may be adopted

4) Leaks should be detected and rectified immediately

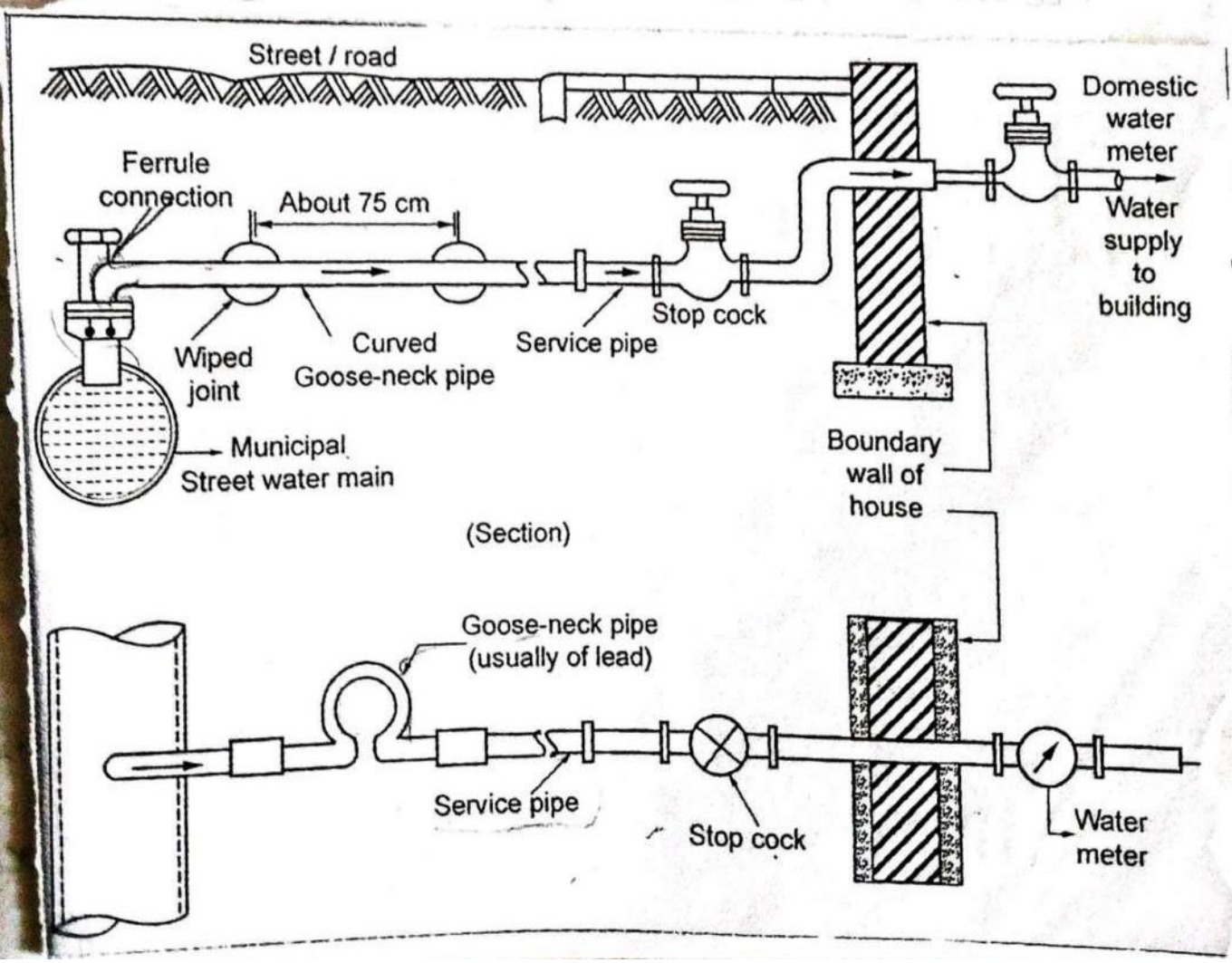
5) Supply of water should be through meter

6) Educate people.

House Service Connection and Plumbing System

* House service connection is the connection taken from the water distribution system to the individual residences or building.

Typical water service connection is shown.



The plumbing system consists of supply pipes, distribution pipes, domestic storage tanks, entire system of pipings, fittings, fixtures, appliances etc.

Components of domestic service connection are

1) Ferrule:

* Ferrule is a right angled sleeve made of brass, bronze or gun metal.

* Diameter of ferrule may vary from 1.5cm to 5cm.

* If the connection having more than 5cm dia, Tee branch connection may be used.

2) Goose Neck

* Goose neck is a small, long, curved, flexible pipe of brass, copper or lead.

* The length of the goose neck varies from 40 to 70cm.

* Goose neck forms a flexible connection between the water main and the service pipe, thus providing flexibility at the junction.

3) Service pipe

* A service pipe is a pipe of G.I, copper, brass, lead or PVC having the maximum

diameter of 5cm.

* The diameter varies from 1cm to 45cm depends upon the utility and availability.

* The service pipe supplies the water to the building from the municipal main through the goose neck and ferrule.

4) Stop cock or curb valve

* The curb valve is provided before the water to the meter in the building.

* It is installed in a suitable chamber with cover, to close down the supply, for repairs of the plumbing system.

5) Water meter

* Water meter is normally used for measuring flows to domestic buildings.

A water meter should possess the following characteristics

a) It should be accurately measure and register both small and large flows

b) It should easy to maintain and repair. Spare parts should be readily available

c) It should have good capacity with reasonable head loss

d) It should be capable of working efficiently at all pressure values.

e) It should be durable. Its parts should not be affected by chemicals used for

purification and the impurities in water.

f) It should prevent back flow passing through it and should not be liable to clogging

g) It should have low cost.

Terms used in Plumbing system

1) Available Head :-

Available head is defined as the pressure of water available from a water main at ground floor level of the premises.

2) Residual Head :-

pressure available at the tailend of the distribution system

3) Stop cock :-

It is a screw down type valve used in smaller pipes in service connections for controlling the water supply.

4) Stop Tap

5) Supply Pipe

6) Distribution Pipe

7) Storage Tanks

Size of the service pipe

The following factors govern the size of the service pipe

i) The minimum pressure in the distribution main

ii) Length of the service pipe

iii) Level of the highest point of the delivery above distribution main

iv) Number of plumbing fitting

v) Type of the plumbing fitting required

vi) Maximum rate of flow required

Diameter of service pipe is fixed based on the occupants in the house

No. of occupants	4	8	24	60
Dia. of service pipe (mm)	12.5	20	25	30

Stop cocks

* It is a screw down type valve used in smaller pipes in service connections for controlling the water supply

* Stop cocks are provided at the water entrance of each building and also within the buildings

* When the valve stem is raised, water passes through an orifice

* When the valve is closed, it rests against the seat and closing the orifice

* They are used in pipes from 45mm

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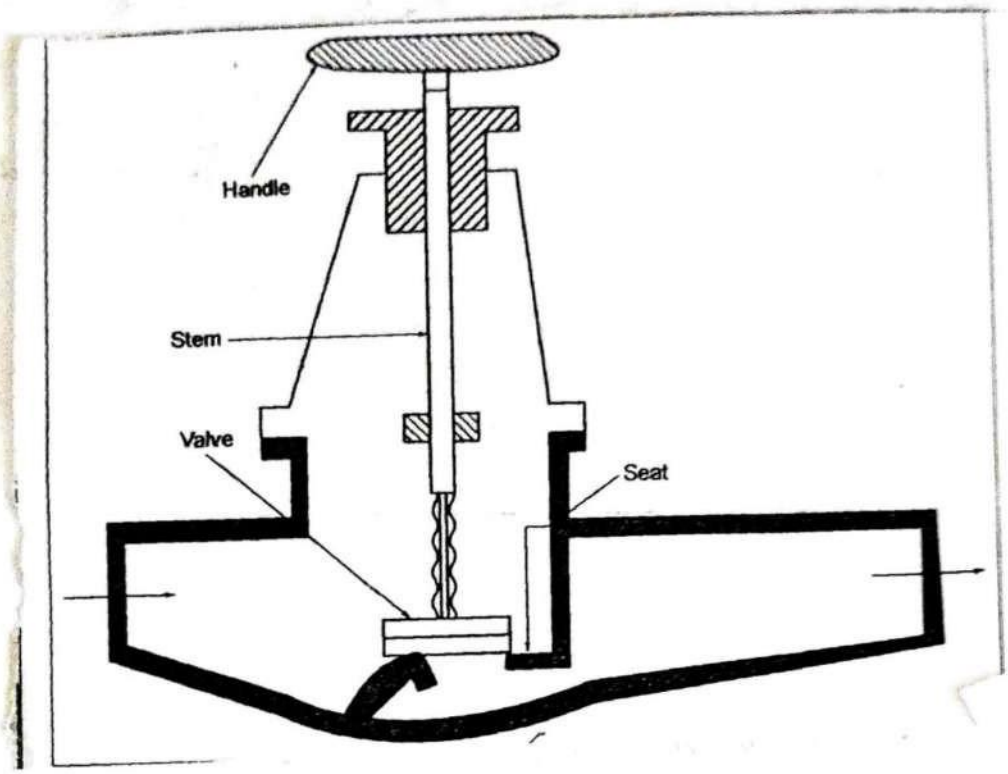


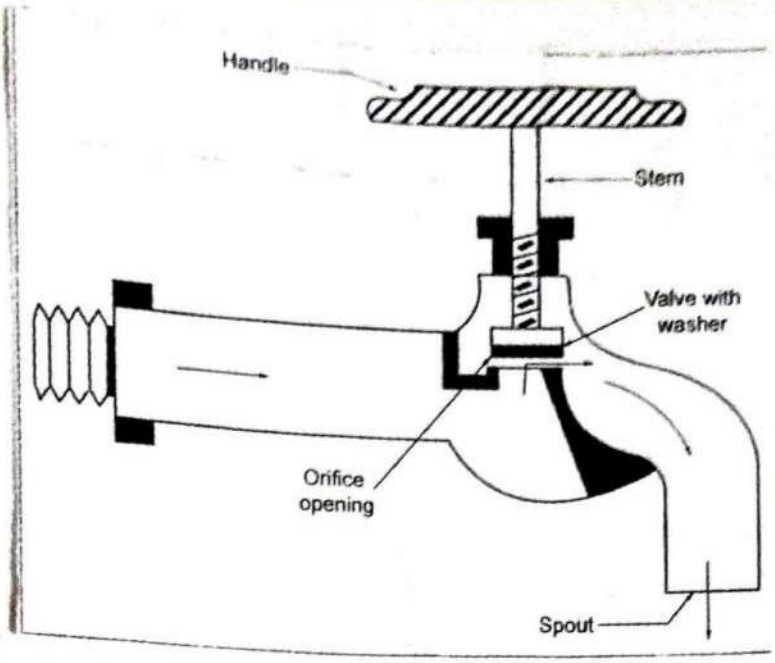
Water Taps and Bib cocks

* These are the valves provided at the end of service pipes for withdrawing water at the consumers houses

* Most common water tap is bib cock.

* By rotating the handle of the bib cock, the orifice opening, through which the water passes, can be increased or decreased by controlling the spout.

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



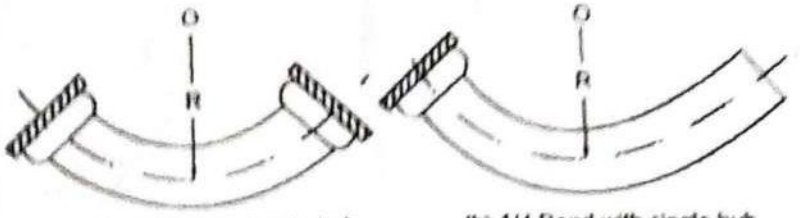
* Bib cocks should be water tight and should not leak.

* The Rubber washers if damaged should be replaced.

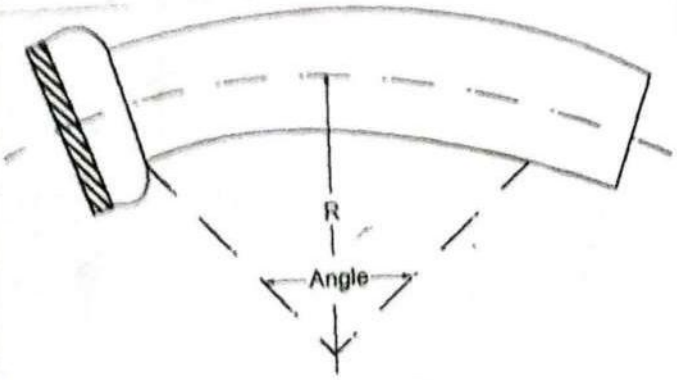
Pipe Fittings

The fittings used to control and to regulate the flow of water in the distribution system is called pipe fittings. The followings are some of the pipe fittings.

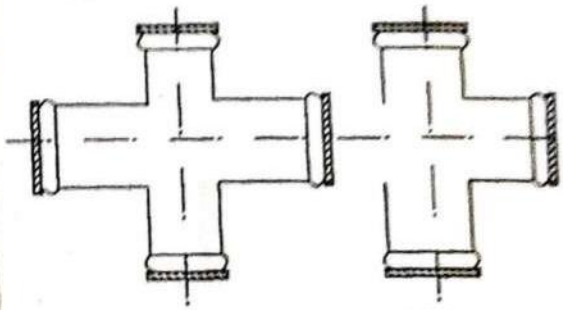
1. Bends
2. Crosses
3. Tees
4. Elbows
5. Wyes or Wye Connections
6. caps
7. Flanges
8. Nipples etc



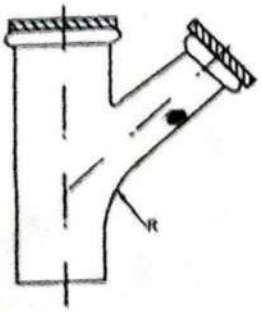
(a) 1/4 Bend with double hub (b) 1/4 Bend with single hub



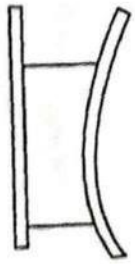
(c) 1/8 Bend (45°)
1/16 Bend (22°)
1/32 Bend (11.25°)



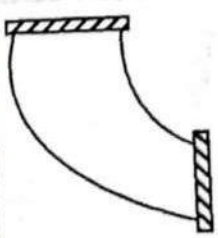
(d) Cross (e) Tee



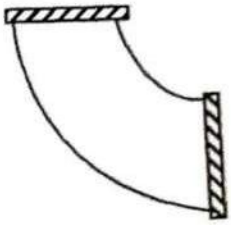
(f) Wye



(g) Saddle flange

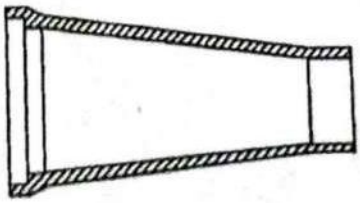


(h) Reducing Elbow or bend

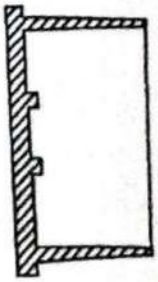


(i) Elbow or bend

(j) Increaser



(k) Reducer



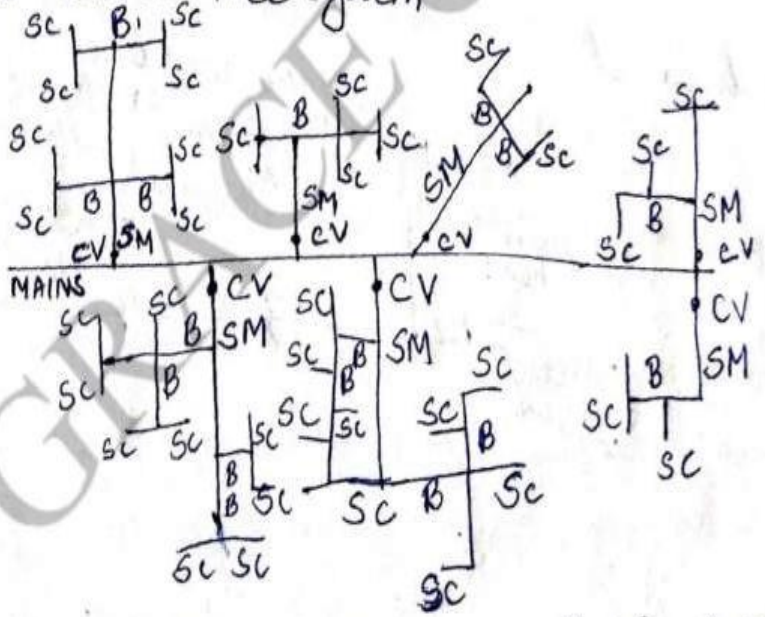
(l) Ordinary plug

Layout of Distribution System

There are four methods of laying out distribution system.

i) Dead end system or tree system
ii) Grid iron system or Reticulation system
iii) Circular system or Ring system
iv) Radial system

i) Dead end or Tree System



SM = Submain SC = Service Connection
B = Branch CV = Cutoff Valve

* Main pipe runs through the centre of the populated area and sub mains take off from this to both the sides
* Submains divide into several branch lines from which service connections are given
* No cross-connections between the branches and submains
* More dead ends, ∴ Accumulation of sediment & stagnation of water.

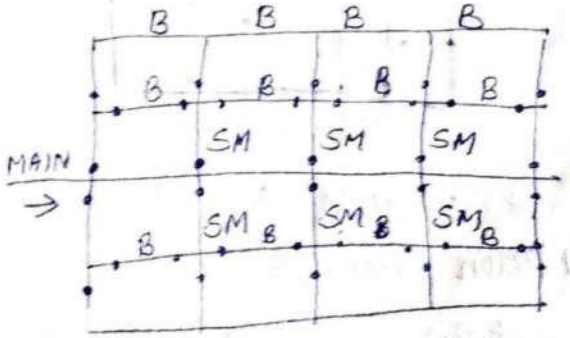
Advantages

1) Design calculations are simple and easy.
2) The pipe diameters are to be designed for the population likely to be served by them. This leads to cheap and economical design
3) The laying of pipe is simple
4) cutoff valves are less

Disadvantages

1) Stagnation of water and accumulation of sediment at dead end
2) Large number of scour valves are required at the dead ends
3) In case of repairs, portion beyond that point to the end will be cutoff
4) discharge available for fire fighting in the streets is limited.

2) Grid Iron or Reticulation System



SM = Sub-Main B = Branch • cutoff valve

* Main supply line runs through the centre of the rectangular area and submains take off from

there in perpendicular directions. The branch lines interconnect all the submains.

* The system is ideal for cities laid out on rectangular plan resembling a grid-iron.

Advantages:-

1) No stagnation of water or sediment deposit

2) Water is available at each point with minimum loss of head

3) For fire fighting, enough water is available in the streets.

4) In case of repairs, very small area of distribution system is affected.

Disadvantages

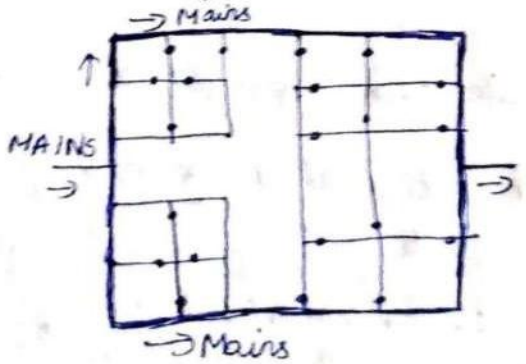
1) Large number of cutoff valves are required

2) System requires longer pipe lengths and bigger diameter

3) Analysis of discharge, pressure and velocities in the pipes is difficult

4) The cost of laying water pipes is more

3) Circular or Ring System

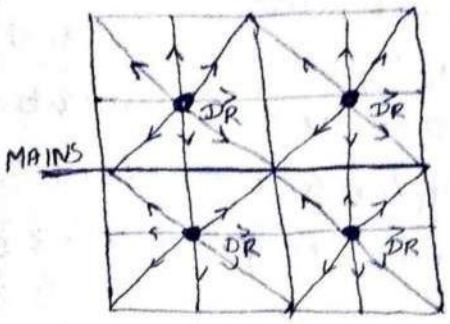


* The supply main forms a ring around the distribution district

* The branches are connected cross-wise to the mains and also to each other

* Most suitable for town or area having well planned streets and roads.

4) Radial system



* It is the reverse of circular system
* Each district has centrally located distributed reservoir (elevated) from where distribution pipes run radially towards the periphery of distribution district
* Quick service, without much loss of head
* Design calculations are also simple

Design of Distribution system

1) Surveys and Maps

* The strip of land lying between the source of water supply and the distribution area is surveyed.
* The distribution area is also completely surveyed
* Detailed maps of the town are prepared to show the position of roads, streets, lanes, commercial locality, industrial area, gardens etc.
* Topographical map of the area is also prepared to locate the high and low areas.
* cross-section of the streets, roads are also prepared to show the underground service lines such as gas lines, electric, telephone lines etc.

2) Tentative Layout

* A tentative layout showing the position of treatment plant, distribution mains, distribution reservoirs, valves, hydrants etc. is marked.
* The area is divided into various distribution districts.
* The density of population is also marked
* The lengths of pipelines should be kept as short as possible

3) Discharge in pipe lines

* Based on the density of population, type of distribution district and on the fire and other requirements, the discharge desired to be carried by each pipe line is computed.

* The fire hydrants are placed at 50 to 100 metres intervals on straight runs & on junctions of streets

* The pipes should be designed for a discharge ranging from 2¼ to 3 times the average rate of supply.

4) calculation of pipe diameters

* velocity of flow in pipes remains 0.6 to 3 m/sec.

* smaller velocity is assumed for pipes of smaller diameter and larger velocity for pipes of larger diameter

*. Loss of head in pipes is calculated by Hazen - Williams formula

5) Computation of pressures

* The pressure is each segment of pipe network is estimated.

Analysis of distribution Systems.

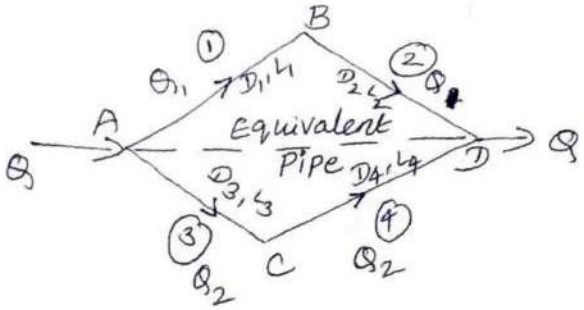
1) Equivalent pipe Method
2) Hardy cross Method
3) Method of Sections and circle method
4) Graphical Method
5) Electric network analyser method
6) pitometer distribution studies Method.

First two methods are very common

Equivalent Pipe Method

* A complex system of pipes is replaced by a single hydraulically equivalent pipe

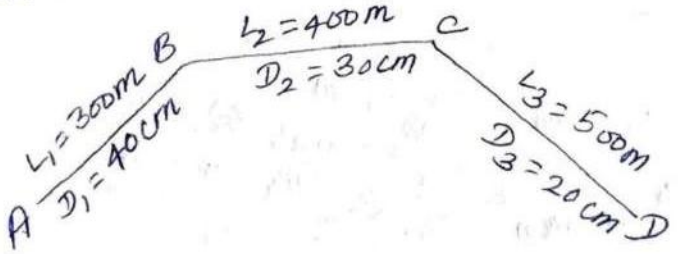
* The equivalent pipe is one which will replace a given system of pipes with equal head loss for a given flow



1) Head loss through pipes in series (AB & BD) are additive

2) Flows through pipes in parallel (ABD & ACD) must be so distributed that the head losses are identical

1) Find the equivalent length of 30 cm diameter pipe for the network shown in fig. using a) Darcy's Formula b) Hazen Williams Formula



a) Darcy's Formula

$$h_f = \frac{16 f L Q^2}{2g\pi^2 D^5} = \frac{K L Q^2}{D^5}$$

$$L_E = D_E^5 \left[\frac{L_1}{D_1^5} + \frac{L_2}{D_2^5} + \frac{L_3}{D_3^5} \right]$$

$$= 0.3^5 \left[\frac{300}{(0.4)^5} + \frac{400}{(0.3)^5} + \frac{500}{(0.2)^5} \right]$$

$$= 4268\ m$$

(186) b) Hazen Williams Formula

$$V = 0.355\, C\, D^{0.63}\, S^{0.54}$$

$$\text{or } Q = 0.355\, C\, D^{0.63} \left(\frac{h_f}{L}\right)^{0.54} \left(\frac{\pi}{4} D^2\right)$$

$$\text{or } Q = \frac{K_1\, D^{2.63}\, h_f^{0.54}}{L^{0.54}}$$

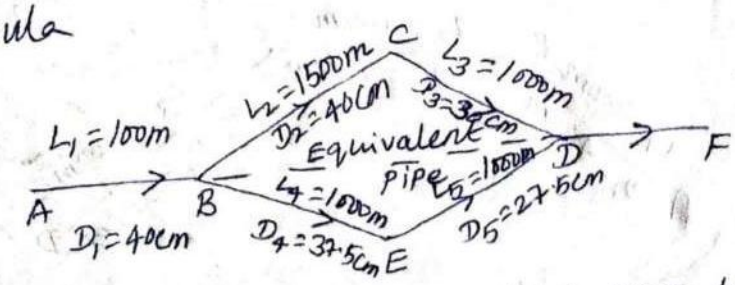
$$\text{or } h_f = \frac{K L Q^{1.85}}{D^{4.87}}$$

$$\therefore \frac{L_E}{D_E^{4.87}} = \frac{L_1}{D_1^{4.87}} + \frac{L_2}{D_2^{4.87}} + \frac{L_3}{D_3^{4.87}} = \frac{\Sigma L}{D^{4.87}}$$

$$L_E = (0.3)^{4.87} \left[\frac{300}{(0.4)^{4.87}} + \frac{400}{(0.3)^{4.87}} + \frac{500}{(0.2)^{4.87}}\right]$$

$$= 4080.5\,m.$$

2) Find the equivalent length of 30cm dia. pipe for the network shown in Fig. use Hazen williams formula



Let the loops BCD and BED be replaced by an equivalent pipe BD of length L_E and diameter D_E $(= 0.3m)$

Head loss in BCD = Head loss in BED

$$(h_f)_{BCD} = (h_f)_{BED}$$

$$h_f = \frac{K L Q^{1.85}}{D^{4.87}}$$

Q=1F