Assessment of Public Water Distribution System of Indore City, India

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Abstract - **A water distribution system is an interconnected collection of sources, pipes, and hydraulic control elements delivering consumers prescribed water quantities at desired pressures and water qualities. The present paper deals with the study of Average water demand in specified areas of Indore City, India, and this is based on water demand calculations per capita demand. The observation of the water supply system for three colonies; Bank colony, Vishwakarma Nagar, and Usha Nagar from Annapurna tank Indore were studied. Suitable data were acquired to identify whether the Average water demand for a single person (which is about 135 L/day) is fulfilled or not. The subtleties of overall analysis and conclusion was carried out in imperturbable aspects design system, supplying velocity, losses in different forms etc. On evaluation of all the results of deep study we incurred the conclusion with a measure to enhance the quality which we have discussed ahead in our paper.**

Keywords: Average Water Demand, Design System, Pressure, Supplying Velocity.

I. INTRODUCTION

After complete treatment of water, it becomes necessary to distribute it to a number of houses, estates, industries and public places by means of a network of distribution system. The distribution system consists of pipes of various sizes, values, meters, pumps etc. The following are the requirements of a good distribution system.

1. It should convey the treated water up to the consumers with the same degree of purity.
2. The water should reach to every consumer with the repaired pressure head.
3. Sufficient quantity of treated water should reach for the domestic and industrial use.
4. It should be economical and easy to maintain and use.
5. It should be able to transport sufficient quantity of water during emergency such as firefighting etc.
6. During repair work, it should cause obstruction to the traffic.
7. It should be safe against any future pollution.
8. The quantity of pipes laid should be good and it should not trust.
9. It should be watertight and the water losses due to leakage should be minimum as far as possible

II. TYPES OF DISTRIBUTION SYSTEM

For efficient distribution it is required that water should reach to every consumer with repaired rate of flow. Depending upon the methods of distribution, the distribution system is classified as follows:

1. Gravity System
2. Pumping System
3. Dual System on Combined Gravity and Pumping System.

II.I Gravity System

When some ground sufficiently high above the city area is available, this can best utilized for the distribution system in maintaining pressure in water pipes. The water flows in the mains due to gravitational force. As no pumping is required, therefore it is the most reliable system for the distribution of water. The water head available at the consumer door is just minimum required and the remaining head is consumed in frictional and other losses.

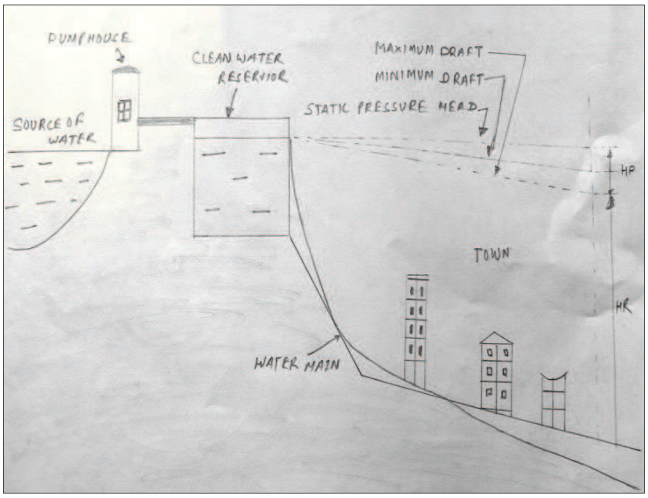

Fig.1.Gravity System of Distribution

II.II Pumping System

In this system water is directly pumped in the mains .The maintenance cost is high. High lift pumps are required and the operations are continuously watched. If the power fails, the whole supply of the town will best popped. Therefore standby diesel pumps should be kept.

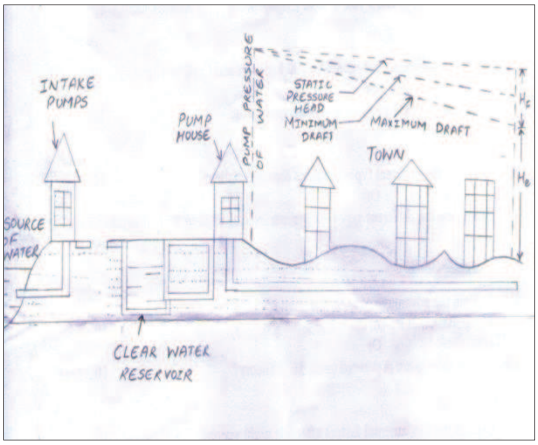

Fig.2.Pumping System of Distribution.

II.III Dual System

This is also known as combined gravity and pumping system. In the beginning when demand is small the water is stored in the elevated reservoir, but when demand increases the rate of pumping, the flow in the distribution system comes both from the pumping station as well as elevated reservoir. As in this system water comes from two sources one, from reservoir and second from pumping station, it is closed dual system.

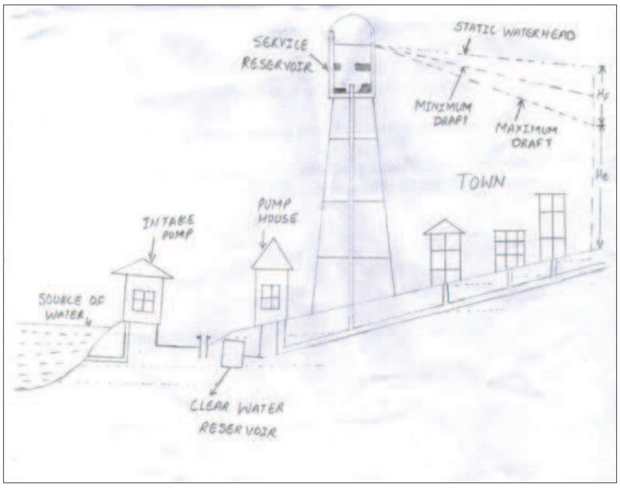

Fig.3.Dual System of Distribution

III. LAYOUT OF DISTRIBUTION SYSTEM

There are four different systems of distribution which are used. Depending upon their layout and direction of supply, they are classified as follows:

- 3.1 Dead End or Tree System
- 3.2 Grid iron System
- 3.3 Circular or Ring System
- 3.4 Radial System

3.1 Dead End System

The below figure show is the layout of this system .It is suitable for irregular developed towns or cities .In this system one main starts from require reservoir along the main road .Sub mains are connected to the main in both the direction as along the roads which meet the main road .Sub mains, branches and minor distributors are connected to sub mains. They are cheap in initial cost.

When the pipe breaks down or is closed for repair the whole locality beyond the point goes without water.

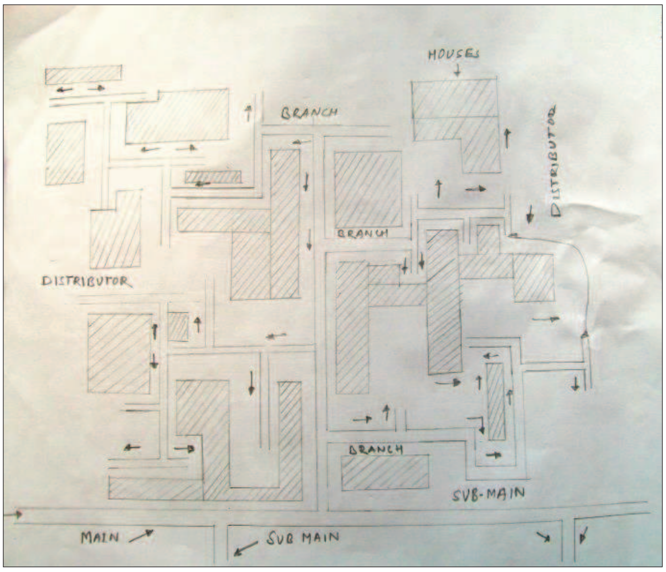

Fig.4.Layout of dead end system

3.2 Grid iron System

This system is also known as reticulated system and is most convenient for town shaving rectangular layout of roads. This system is an improvement of dead end system. All the dead ends are interconnected and water circulates freely throughout the system. Main line is laid along the main road. Sub mains are taken in both the directions along other minor road sand streets. From these sub mains branches are taken out and are interconnected as shown in figure.

This system removes all the disadvantages of dead end system

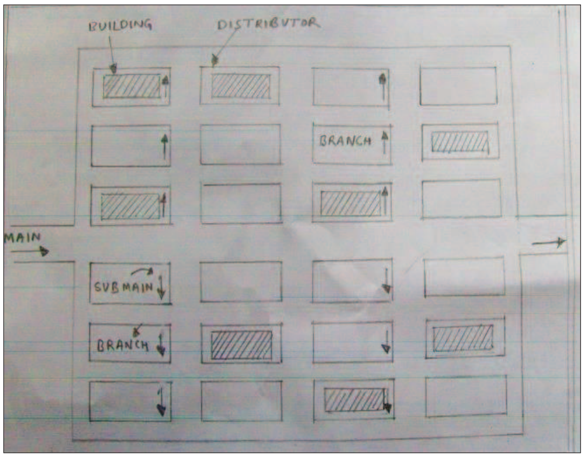

Fig.5.Layout of grid iron system

3.3 Circular or Ring System

System can be adopted only in well planned locality of cities. In this system each locality is divided into square or circular block sand the water mains are laid around all the four sides of the square or round the circle. This system requires many values and more pipe length. This system is suitable for towns and cities having well planned roads.

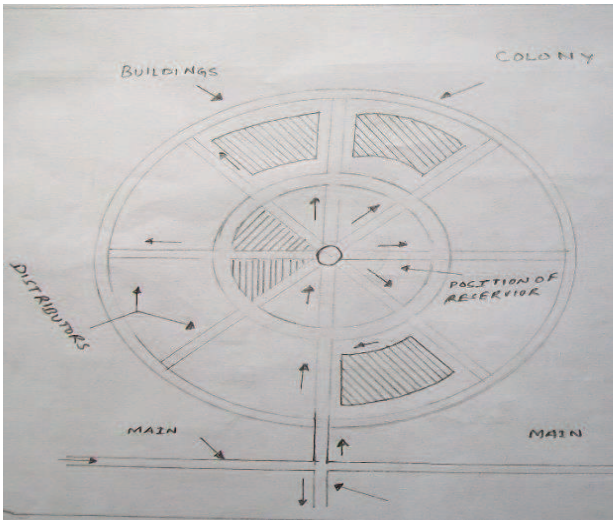

Fig.6.Layout of Circular System

3.5 Radial System

This system is not adopted in India, because for this system the roads should be laid out radial from the center. This system is the reverse of ring system. The entire district is divided into various zones and one reservoir is provided for each zone, which is placed in the center of zone. By considering the advantages and disadvantages of all these systems, we have found out that grid iron system is most suitable for our site. Therefore we have adopted grid iron system.

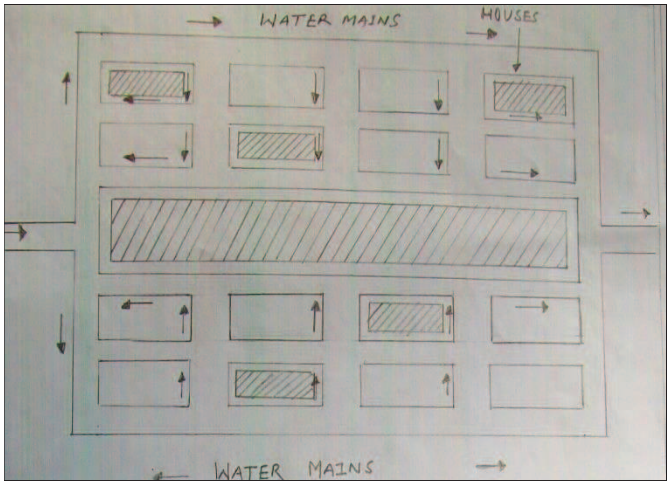

Fig.7.Layout of radial system

IV. PRESSURE IN THE DISTRIBUTION SYSTEM

When the water enters in the distribution main, the water head continuously is lost due to friction in pipes, at entrance of reducers due to valves, bends, meters etc. till it reaches the consumer's tap. The net available head at the consumer's tap is the head at the entrance of the water main minus all the losses in the way. The effective head available at the service connection to a building is very important, because the height up to which the water can rise in the building will depend on this available head only. The greater the head the more will be the height up to which it will rise. If adequate head is not available at the connection to the building, the water will not reach the upper stores (Le. 2nd, 3rd, 4th etc.) to overcome this difficulty the required effective head is maintained in the street pipe lines. The water should reach each and consumer therefore it should reach on the uppermost stories. The pressure which is required to be maintained in the distribution system depends upon the following factors:

4.1. The height of highest building up to which Water should reach without boosting.

4.2. The distance of the locality from the Distribution reservoir.

4.3. The supply is to be metered or not. Higher pressure will be required to compensate for, the high Loss of head in meters.

4.4 How much pressure will be required for fire-hydrants.

The funds available for the project work. Sometimes the design pressure is determined

from the firefighting requirements. In some cities and towns the firefighting squads are equipped with pumping sets fitted on their vehicles for lifting the water at the site itself. At such places the design pressure may be determined by the minimum required by the consumers. But in most of towns in India the people living at 2^{nd}, 3^{rd} or 4^{th} stories face lots of difficulties due to non-supply of water in their stories. At such places small lifting pumps may be individually used which directly pump the water in their water lines. In multistoried structures the following pressures are considered satisfactory.

Up to 3 stories	2.1 Kg/cm^2
From 3 to 6 stories	2.1 to 4.2 Kg/cm^2
From 6to10 stories	4.2 to5.27 Kg/cm^2
Above10 stories	7 Kg/cm^2

While designing pipes of distribution systems the following points should be kept in mind:

1. The main line should be designed to carry 3 times the average demand of the city.

2. The service pipes should be able to carry twice the average demand.

3. The water demand at various points in the city should be noted.

4. The length sand sizes of each pipe should be clearly marked on the site plan along with hydrants, valves, meters, etc.

Diameter of pipe	***Velocity***
10 cm	0.9 m/s
15 cm	1.21 m/s
25 cm	1.52 m/s
40 cm	1.82 /s

V. DESIGN OF DISTRIBUTION SYSTEM

V.I Manual Design

The layout of the city of town, topography etc. will be greatly affected, the layout and design of the distribution system. The existing population expected future population commercial and industrial present and future water requirements all have to be considered in the layout and design of the distribution system. The main work in the distribution system design is to determine the sizes of the distribution pipes which will be capable to carry their paired quantity of water at the desired pressure.

VI. DESIGN OF PIPE LINE

Till date no direct method are available for the design of distribution pipes. While doing the design first of all Diameter of the pipes are assumed the terminal pressure heads which could be made available. At the end of each pipe section after allowing for the loss of pressure head in the pipe section when full peak flow discharge is flowing are then determined. The determination of the friction losses in each pipe section is done. The total discharge flowing through main pipes is to be determined in advance.

Hazen William Formula is widely used for determine the velocity through pipes. It states

$v = 0.408709\ q / d_h^2$

Where

v = flow velocity (m/s)

$f = 0.2083\ (100/c)^{1.852}\ q^{1.852} / d_h^{4.8655}$

Where

f = friction head loss in feet of water per 100 feet of pipe (fth20/100 ft pipe).

c = Hazen-Williams roughness constant

q = volume flow (gal/min)

d_h = inside hydraulic diameter (inches)

The Hazen-Williams equation can be assumed to be relatively accurate for piping systems with Reynolds Numbers above 105 (turbulent flow).

1 ft (foot) = 0.3048 m

1 in (inch) = 25.4 mm

1 gal (US)/min =6.30888x10-5 m^3/s = 0.227 m^3/h =0.0631 d m^3(litre)/s = 2.228x10^{-3} ft^3/s = 0.1337 ft^3/min =0.8327 Imperial gal (UK)/min

VII. CALCULATIONS

Single house getting per day about 400 to 450 Lt in about 20 min,

Calculation of flow MLD (mega litres per day)

In 20 min→ 450 Lt

In 1 min→ $\frac{450}{20}$

In 1 hr→ $\frac{450\times60\times24}{20}$

Mega litres→$\frac{450\times60\times24}{20\times10^6} = .432$

Pipe no.	From node	To node	Flow MLD	Dia. (mm)	Actual head loss	Length (m)	Velocity (m/s)
1	1	2	.43	80	.7	250	.27
2	2	3	1.13	100	1.6	300	.32
3	3	4	2.73	150	1.4	356	.36
4	4	5	4.13	200	1.1 2	450	.38
5	5	6	5.25	250	.91	450	.49
6	6	7	6.61	300	.86	550	.58
7	7	8	7.02	400	.62	558	.65
8	8	9	7.64 4	450	.54	615	.72
9	9	10	8.81	500	.43	680	.79
10	10	11	9.24	620	.21	691	.82
11	11	12	9.45	700	.12	710	.85
12	12	13	9.57	750	.01	715	.92

Calculation for Head loss

$f = 0.2083\ (100/c)^{1.852}\ q^{1.852} / d_h^{4.8655}$

c=100

q=.432

d_h =80mm

$f = 0.2083\ (100/100)^{1.852}\ .432^{1.852} / 80^{4.865}$ f = .7

Calculation for velocity (m/s)

$v = 0.408709\ q / d_h^2$

$v = 0.408709 \times \frac{.432}{80^2}$

v =.27 m/s

VIII. ANALYSIS OF HEAD LOSS

IX. CONCLUSION

Average water demand for a single person is about 135 L/day this is based on water demand calculations per capita demand .But from the observation of the water supply system for three colonies; Bank colony, Vishwakarma Nagar, and Usha Nagar from Annapurna tank Indore. We observed that water supply system is not capable for providing per capita demand of 135 L/day but only fulfilling about 80 to 85 L/day. This is because of the losses in the pipe and the pressure losses. Because of the losses, the velocity of the water also decreases as we have observed the velocity from the main supply is 0.92 m/s but when it reaches to home, it reduces to 0.27 m/s.

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[6] The **Hazen–Williams equation** which relates the flow of water in a pipe with the physical properties of the pipe and the pressure drop.