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Design of Water Distribution Network Using EPANET Software

Athulya.T[1], Anjali.K.Ullas[2]

[1]*M.Tech Student,Environmental Engineering in the Department of Civil Engineering,Malabar College of Engineering and Technology,Kerala,India*

[2]*Assistant Professor,Department of Civil Engineering, Malabar College of Engineering and Technology,Kerala,India*

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Abstract - *This study presents the use of EPANET software in the design of the water distribution network for the three wards of Anjarakandy Grama Panchayath,Kannur district. The major purpose of providing a good distribution network is to provide sufficient pressure at each point with less loss. A water distribution network consists of pipes,valves,tanks etc. EPANET is a computer programme that tracks the flow of water in each pipe, the pressure at each node and height of water in each tank. Hardy-Cross method is a manual method that makes corrections to initial assumed value by using equations. In this paper it was used to carry out the design and hydraulic analysis of water distribution network using EPANET software and Hardy-Cross method. The method of distribution used here is combined gravity and pumping system. The performance of system designed using EPANET was later compared with manual method. It was obtained that the pressure at all junctions and flow with their velocities at all pipes are feasible.*

Key Words: EPANET Software, Water Distribution Networks, Hardy Cross Method, Pipe networks, Pipe layouts

1. INTRODUCTION

Water plays a vital role in the life of all living organism. Water used for domestic purposes as well as irrigation and industrial purposes. A water distribution network should be designed such a way that it meets the demand of increased population. An adequate water supply can give better living standards. The water quality should not get deteriorated in the distribution pipes. The deficiencies of water supply in urban regions are becoming a major challenge for authorities. Because most of the water supply scheme are intermittent system. When using an intermittent system the water is distributed to residents for few hours in a day, hence most of the times the pipe lines are empty or partially full [2]. A good water distribution network is the one which provide sufficient pressure at each point of distribution with less loss. A good water distribution network satisfies the consumer demand at required time. The design and analysis of water distribution network is a complex process in metropolitan areas where there is large number of pipes [4].

In general, the layout of a water distribution network can be classified as dead end system, ring system, grid system or radial system. A dead end system has water mains along the roads without a particular pattern for towns that do not have road network patterns. A radial system delivers water into multiple zones. At the center of each zone, the water is delivered radially toward the customers. A grid system follows the general layout of the grid road infrastructure with water mains and branches connected in rectangles. Drawbacks of this topology include difficulties of sizing the system. A ring system is a topology with each water main that go to each road, and there is a sub-main that is branched off the water main to provide a circulation of two directions. This system has many advantages over the grid system.

The three methods of water distribution are gravitational system, pumping system and combined gravity and pumping system. In gravity system, the water from a high leveled source is distributed to the consumers at low levels by the mere action of gravity without pumping. This method is the most economical and reliable since no pumping involved. However this method needs lakes or reservoir as a source of supply. In the pumping system the treated water is directly pumped into the distribution mains without storing anywhere. It is also known as pumping without storage system. In a combined gravity and pumping system, the treated water is pumped at a constant rate and stored into an elevated distribution reservoir. This system helps in operating the pumps at constant speed at their rated capacities, thus increasing their efficiency and reducing their wear and tear. This type of system is invariably and almost universally adopted.

1.1 EPANET Software

EPANET is a public domain, water distribution system modeling software package developed by the United States Environmental Protection Agency's (EPA) Water Supply and Water Resources Division. EPANET is a water distribution network modeling software that performs extended period simulation of hydraulic and water quality behavior. EPANET provides hydraulic analysis that can handle systems of any size. EPANET tracks the flow of water in each pipe, the pressure at each node and the height of water in each tank throughout the network. Running under Windows, EPANET provides an integrated environment for editing network input data, running hydraulic and water quality simulations, and viewing the results in a variety of formats. These include color-coded network maps, data tables, time series graphs, and contour plots. EPANET models a water distribution system as a collection of links connected to nodes. The links represent pipes, pumps, and control valves. The nodes

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represent junctions, tanks, and reservoirs. In addition to hydraulic modeling, EPANET provides many other water quality modeling capabilities [10].

2. STUDY AREA

Anjarakandi Grama panchayath is located in Edakkad block of Kannur taluk in Kannur district. Anjarakandi Grama Panchayath has an area of 15.36 sq km. Anjarakkandi is located at a distance of 16 km to the south-east of Kannur town, 20 km to the North-East from Thalasseri and 10 km north west of Koothuparambu. Panayathamparamba is a part of Anjarakandy Panchayath. Panayathamparamba occurs in the North-East part of Anjarakandy.Anjarakandy river flows nearby the study area. The study area covers ward numbers 2,3 and 6 under water distribution system. The population of study area according to 2011 census is 878. The study area covers residential area about 1.2 sq km.

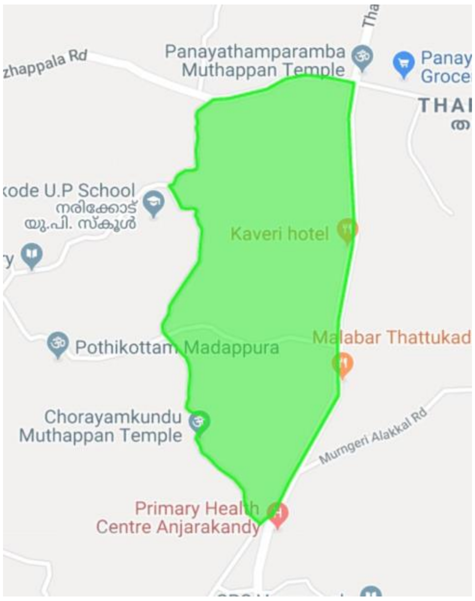

Fig -1: Study area

3. METHODOLOGY

Initially the map of study area was extracted by using Google Earth software. The obtained map was then converted into EPANET file. Elevation, pipe diameter and length had given to each node and pipe for hydraulic analysis by using scale tool from Google earth software. Total area was divided into two grids and demand path is estimated by depending on the number of houses living in the area taken in grid.

3.1 Design Considerations

The layout of the distribution network is drawn based on the existing road pattern .Length of the pipe is taken as the road length. The diameter of the pipe is considered based on the purpose served by the pipe, such as main, sub main, branch pipes. Pipe roughness coefficient is taken 120, since Galvanized Iron pipes are used. The simulation period was set for 24 hours.

3.2 Demand Calculation

Geometrical Increase Method is used for population forecasting. In this method the percentage increase in population from decade to decade is assumed to remain constant. Geometric mean increase is used to find out the future increment in population. Since this method gives higher values and hence should be applied for a new industrial town at the beginning of development for only few decades. The population at the end of n^{th} decade 'P_n' can be estimated as:

$$P_n = P\ (1+ I_G/100)^n$$

Where, I_G = geometric mean (%)
P = Present population
N = no. of decades

The design period for the system is taken as thirty years. After the population forecast the maximum daily demand was calculated using the general equations. Also the minimum required diameter is calculated.

3.3 Steps in Using EPANET

Initially draw a network representation of distribution system from the extracted map . Then edit the properties of the objects that make up the system. The input parameters for each nodes and pipes are to be properly assigned. Describe how the system is operated. Then select a set of analysis options. Finally run a hydraulic/water quality analysis. The last step is to view the results of the analysis

3.4 Model Input Parameters

In order to analyze the water distribution network using EPANET following input data files are needed:

1. Junction Report: Junctions are points in the network where links join together and where water enters or leaves the network. The basic input data required for junctions are:

- Elevation above some reference (usually mean sea level)
- Water demand (rate of withdrawal from the network)
- Initial water quality

The output results computed for junctions at all time periods of a simulation are:

- Hydraulic head (internal energy per unit weight of fluid)
- Pressure
- Water quality

2. Pipe Report: Pipes are links that convey water from one point in the network to another. EPANET assumes that all pipes are full at all times. Flow direction is from the end at higher hydraulic head (internal energy per weight of water)

to that at lower head. The principal hydraulic input parameters for pipes are:

- Start and end nodes
- Diameter
- Length
- Roughness coefficient (for determining Head-loss)
- Status (open, closed, or contains a check valve)

The output results for pipes include:

- Flow rate
- Velocity
- Head-loss
- Darcy-Weisbach friction factor
- Average reaction rate (over the pipe length)
- Average water quality

The hydraulic head lost by water flowing in a pipe due to friction with the pipe walls can be computed using one of three different formulas:

- Hazen-Williams formula
- Darcy-Weisbach formula
- Chezy-Manning formula

The Hazen-Williams formula is the most commonly used head loss formula in Kerala by Kerala Water Authority.

3.5 Hardy-Cross Method

The Hardy Cross method assumes that the flow going in and out of the system is known and that the pipe length, diameter, roughness and other key characteristics are also known or can be assumed. The method also assumes that the relation between flow rate and head loss is known, but the method does not require any particular relation to be used.

In the case of water flow through pipes, a number of methods have been developed to determine the relationship between head loss and flow. The Hardy Cross method allows for any of these relationships to be used.

Hardy Cross method is done for only one loop of the selected area. K is calculated using the formula :

$$K= L/(471.11*d^{0.487})$$

Assume flow through the loop both in clock and anti clock direction in which clockwise direction is taken as positive and anti clock wise direction is taken as negative. Then the correction (Δ) is calculated by using the equation:

$$\Delta=-HL/(1.85*(HL/Q_a))$$

Δ was then added to assumed flow to get actual flow. This iteration is then repeated.

4. RESULTS

The water distribution network of study area consists of 16 pipes, 14 nodes and one main over head tank. The pressure is computed using Hazen-William Approach. Pressure at all junctions are found to be adequate. The minimum diameter of pipe chosen was 150mm. There is fluctuation in the pressure head. The roughness coefficient of the pipe throughout the network is 120.

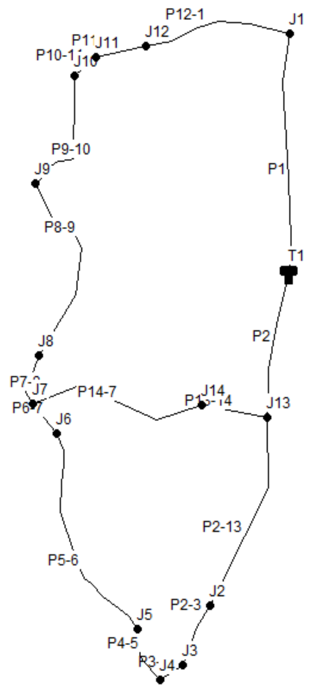

Fig -2: Distribution network diagram of study area

Table -1: Network table- Pipes

Link ID	Flow LPS	Velocity m/s	Unit head loss m/km	Friction factor
Pipe P1	12.10	0.39	1.07	0.028
Pipe P2-3	11.76	0.17	0.14	0.030
Pipe P3-4	9.21	0.19	0.22	0.030
Pipe P4-5	6.77	0.38	1.49	0.030
Pipe P5-6	4.46	0.25	0.69	0.032
Pipe P6-7	2.49	0.14	0.23	0.035
Pipe P7-8	3.77	0.21	0.50	0.033
Pipe P8-9	0.97	0.05	0.04	0.040
Pipe P9-10	-1.83	0.10	0.13	0.036
Pipe P10-11	-4.74	0.15	0.19	0.033
PipeP11-12	-7.26	0.23	0.42	0.031
Pipe P12-1	-9.50	0.30	0.69	0.029
Pipe P2	22.48	0.32	0.47	0.027
Pipe P2-13	14.18	0.20	0.20	0.029
Pipe P13-14	5.96	0.34	1.18	0.030
Pipe P14-7	3.95	0.22	0.55	0.032

Table -2: Network table- Junctions/Nodes

Node ID	Demand LPS	Head m	Pressure m
Junction J1	2.60	101.63	10.88
Junction J2	2.42	101.93	34.98
Junction J3	2.55	101.91	39.93
Junction J4	2.44	101.90	41.30
Junction J5	2.31	101.72	68.74
Junction J6	1.97	101.42	55.09
Junction J7	2.67	101.39	57.09
Junction J8	2.80	101.34	48.80
Junction J9	2.80	101.32	63.62
Junction J10	2.91	101.36	9.33
Junction J11	2.52	101.37	10.64
Junction J12	2.24	101.41	10.66
Junction J13	2.34	102.01	31.42
Junction J14	2.01	101.78	32.78

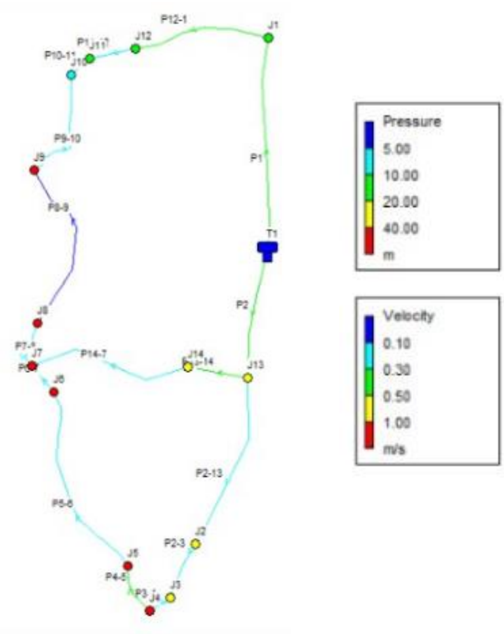

Chart -1: Pressure-Velocity distribution

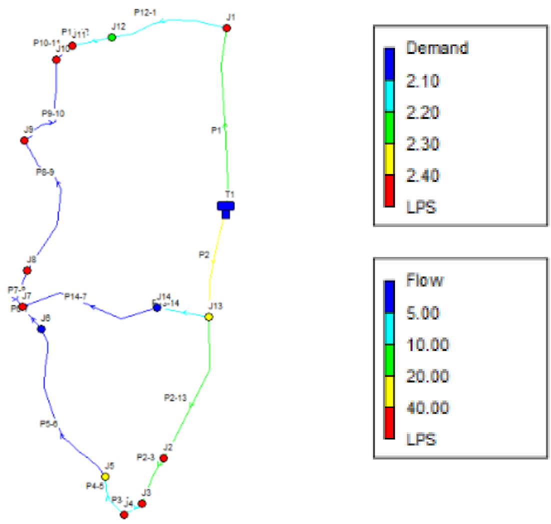

Chart -2: Demand-flow distribution

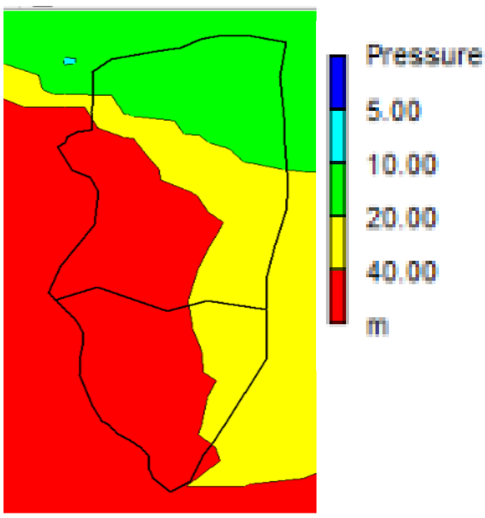

Chart -3: Contour plot-Pressure

5. CONCLUSION

The water distribution network has been designed and analyzed successfully using the EPANET software and Hardy-Cross method. At the end of the analysis it was found that the resulting pressures at all the junctions and the flows with their velocities at all pipes are adequate enough to provide water to the study area. The method of distribution used here is combined gravity and pumping system, as firstly the water is pumped with the help of centrifugal pumps from underground water source i.e. from aquifers and then they are lifted up to the overhead water tanks and through there with the help of gravity system is transferred to the main rising pipe. The distribution layout used here is ring system which is according to the layout of the Panayathamparambu region. Manual method by using Hardy-Cross equation is a time consuming process, and it may not provide accurate result. There may be some limitations while proceeding the manual method in Excel. But there are no such types of problems in EPANET software. So, we can design water distribution system of any size by using EPANET. Now a days in Kerala, the Kerala Water Authority are instructed the employees to follow EPANET instead of the software called LOOP because of the advantages of EPANET over LOOP. Conventional methods like Hardy-cross methods are not recommendable in present days if the network is in high scale because that high network designing by conventional method will not give the efficient and economical design as comparative to EPANET software.

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