International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 08 Aug 2020 www.irjet.net p-ISSN: 2395-0072

DESIGN OF WATER SUPPLY DISTRIBUTION NETWORK USING EPANET SOFTWARE – A CASE STUDY OF KUVEMPU NAGAR, MANDYA.

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Abstract - This study represents use of EPANET software in the design of water distribution network. EPANET software is a user friendly software. In order to ensure the availability of sufficient quantity of good quality of water to the various section of community in accordance with the demand, many computer tools were developed, out of all the tools available EPANET become most popular and convenient for the effective design of complex pipe networks. This paper highlights only the effective design and distribution of network of pipes using EPANET tool. The residual head at each and every node was found out by having the elevation as input and thereby the corresponding flow quantities were derived like residual head, velocity and nodal demand etc.

Key Words: Water Distribution, Network Analysis, EPANET, Population forecast, water demand, nodal demand.

1. INTRODUCTION

Water distribution system is a hydraulic infrastructure consisting of elements such as pipes, tanks reservoirs pumps and valves etc. It is crucial to provide drinking or potable water to the end users; hence, effective water supply is of paramount importance in designing a new water distribution network or in expanding the existing one. Computation of flows and pressures in a complex network has been of great challenge and interest for those involved with designs, construction and maintenance of public water distribution systems. Analysis and design of pipe networks create a relatively complex problem, particularly if the network consists of range of pipes as frequently occurs in water distribution systems of large metropolitan areas. In the absence of significant fluid acceleration, the behaviour of a network can be determined by a sequence of steady state conditions, which form a small but vital component for assessing the adequacy of a network

1.1 Background of water distribution network analysis

One of the earliest theories into inputs and outputs are known, but the flow inside the network is unknown. The Hardy Cross method is an adaptation of the Moment distribution method, which was also developed by Hardy Cross as a way to determine the moments in indeterminate structures. The method was later made obsolete by computer solving algorithms employing Newton-Raphson method or other solution methods that removed the need to solve nonlinear systems of equations by hand. Solution to water flow and pressure in water distribution network finding includes the popular Hardy Cross method which is an iterative method for determining the flow in pipe network systems where the inputs and outputs are known, but the flow inside the network is unknown.

1.2 Justification for the use of EPANET

The EPANET software developed by the USA Environmental Protection Agency is adopted because it is for general public and educational use and it is available free on-line. It has the capacity to analyze unlimited number of pipes and tanks. EPANET has become a popular tool in analyzing complex and simple water distribution networks in both the developed and developing countries of the world. EPANET is a computer program that performs extended period simulation of hydraulic and water quality behavior within pressurized pipe networks. A network consists of pipes, nodes (pipe junctions), pumps, valves and storage tanks or reservoirs. EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank, and the concentration of a chemical species throughout the network. EPANET is designed to be a research tool for improving our understanding of the movement and fate of drinking water constituents within distribution systems. It can be used for many different kinds of applications in distribution systems analysis. In this paper it was used to carry out the hydraulic analysis of the distribution network of the study area.

2. OBJECTIVE

The objective of the distribution system is to supply water to each and every house, industrial plants and public places. Each house must be supplied with sufficient quantity of water at the desired pressure. Therefore the water has to be taken to the roads and streets in the city and finally to the individual houses. This function of carrying the water from the treatment plant to the individual homes is accomplished through a well-planned distribution system. A distribution system therefore consists of pipe lines of various sizes for carrying water to the streets; valves for controlling the flow, service connections to the individual homes, distribution reservoirs for storing the water to be fed into the distribution pipes. The water may either be pumped directly into the distribution pipes, or it may be first stored in a distribution reservoir and then fed into the distribution pipes.

The main purpose of the distribution systems is to develop adequate water pressure at various points i.e., at the consumer's tap and the choice of the distribution and its elevation with respect to the location of the water tank.

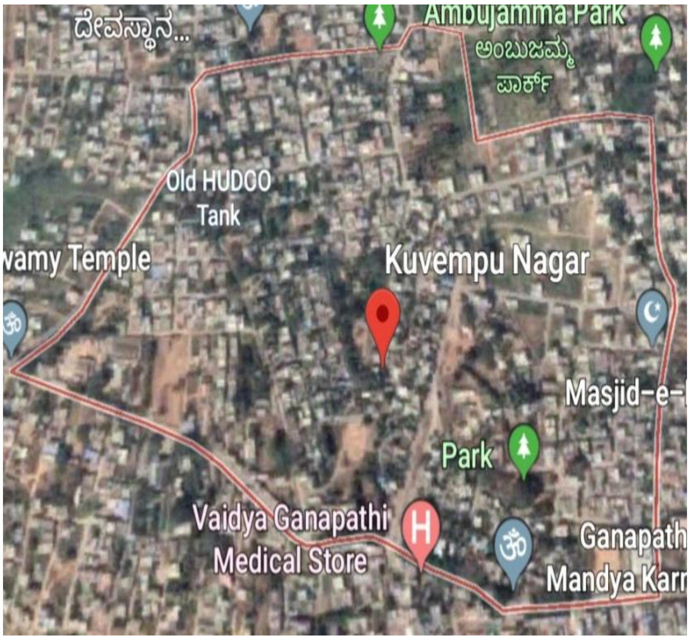

Fig -1: Google image of kuvempu Nagar

3. LITERATURE REVIEW

Prof Dr.Mohammed Ali I. Al-Hashim, Nassrin J. Al-Mansori[1] presented in his research, the reality of the potable water services in AL-Diwaniya City was studied, it in two essential lines:

First, the analysis of water distribution in the city trunk network, by using the program (pipe++) version 1998 to get the quantities and the directions of discharges water. Also it uses head pressure in some related network nodes. Measurements were made, infield, from each region to estimate head in each trunk in order to specify the regions that suffer from shortage in water.

The objective of the distribution system is to supply water to each and every house, industrial plants and public places. Each house must be supplied with sufficient quantity of water at the desired pressure. [lencastre 1987]. Nilsen (1989): studied different methods of pipe networks for analysis. He formulated the flow equations in terms of both pipes discharge and energy heads and the problem reformulated in terms of vectors and matrices. To solve the problem, three different methods were used; the linear theory, Newton-Raphson and the general-purpose optimization algorithm to the problem. The method shows that the formulating flow resistance in terms of energy heads has two great advantages, the reduced system, and easy to implement a computer program that solves the system. The disadvantages are it is difficult to get a good starting vector and the convergence may be very slow. Formulating the flow resistance in terms of pipe discharge has advantage of reducing the number of primary unknowns (m-n) to (n/2), where (n) is the number of primary unknowns, and has one disadvantage of the need for computing a basis for the complete solution to the continuity equations. Demonstrated that an efficient method for analysing pipe networks consists in solving the generalized loop equations by means of the Newton-Raphson method combined with the linear theory method as a simple and robust starting procedure.

Shibu A. and M. Janga Reddy[2] presented, Water distribution system modelling problems are associated with large number of variables which are uncertain in nature. The uncertainties are due to (i) formula used (ii) coefficients in the formula and (iii) imprecise knowledge of the values of various parameters. Usually uncertainty exists in nodal demands and the uncertainty associated with nodal demands has to be considered for better design of water distribution networks. A two phase methodology for the least cost design of water distribution network based on fuzzy set theory and cross entropy method is proposed. The uncertain demands are considered as fuzzy sets, and the diameters for each pipe are selected from the commercially available diameters by cross entropy method. The model coded in MATLAB is linked to EPANET tool kit for hydraulic simulation. The proposed methodology was tested on Hanoi water distribution network, and the solutions obtained are compared with well-known deterministic solutions from literature. The methodology is found to be effective in dealing with uncertainty in input parameters represented as fuzzy sets, and also the discrete diameters are very well handled by cross entropy method.

The vast majority of mathematical models in engineering use deterministic approaches to describe various processes and systems. However, all real life problems incorporate uncertainty in one way or another. Water distribution system modelling problems are associated with a large number of variables which are uncertain in nature. The uncertainties are due to formula used, coefficients in the formula, and imprecise knowledge of the values of various parameters.

4. STUDY AREA

Mandya is a small city in southern Karnataka, located about 45 miles northeast of Mysuru. Archaeological excavations have proven that the first settlement appeared in the area in the 3rd century. Today, the city is a small agricultural and cultural center, with a few large sugar factories. The latitude of Mandya, Karnataka, India is 12.523731, and the longitudes 76.894684. India country in the Cities place category with the GPS coordinates of 12° 31' 25.4316'' N and 76° 53' 40.8624'' E. The study area selected is that of VV Nagar and Kuvempu Nagar, Mandya. Kuvempu nagar Nagar is in Mandya City in state of Karnataka, India. It belongs to Mysore Division.

5. METHODOLOGY

5.1. POPULATION FORECASTING:

Design of water supply and sanitation scheme is based on the projected population of a particular city or town, estimated for the design period. Any underestimated value will make system inadequate for the purpose intended; similarly overestimated value will make it costly. Change in the population of the city over the years occurs, and the system should be designed taking into account of the population at the end of the design period. Factors affecting changes in population are:

- Increase due to births
- Decrease due to deaths
- Increase/ decrease due to migration
- Increase due to annexation.

The present and past population record for the city can be obtained from the census population records. After collecting these population figures, the population at the end of design period is predicted using various methods as suitable for that city considering the growth pattern followed by the city.

Population forecasting is based on the following methods

- Arithmetical Increase Method
- Geometrical Increase Method
- Incremental Increase Method
- Graphical Method
- Comparative Graphical Method
- Master Plan Method
- Logistic Curve Method

As per data collected from KUWS & DB Mandya.

Population is forecasted using arithmetic mean method is given in below table

Table 1: POPULATION DETAILS OF STUDY AREA

Year	Population
2001	5778
2011	6511
2019	7111
2029	7862
2039	9011
2039	9761

Table 2: VARIOUS TYPES OF WATER DEMANDS

S.NO	TYPE OF DEMAND	QUANTITY
1	Domestic water demand	135 to 225 l/h/d
2	Industrial water demand	50 liters/person/day
3	Institution and commercial water demand	20 to 50 l/h/d
4	Demand for public uses	10 l/h/d
5	Fire demand	1 l/h/d
6	Water required compensating losses in wastes, thefts.	15 % of the total compensation

5.2. DISTRIBUTION SYSTEM

Methods of Distribution

For efficient distribution it is required that water should reach to every consumer with required rate of flow. Therefore, some pressure in pipe lines is necessary, which should force the water to reach at every place. Depending upon the methods of distribution, the distribution system is classified as follows:

- Gravity system
- Pumping system
- Dual system

LAYOUTS OF DISTRIBUTION SYSTEM

Generally in practice there are four different systems of distribution system which are used. Depending upon their layout and direction of supply, they are classified as follows:

1 .Dead end or tree system
2. Grid iron system

3. Circular or ring system
4. Radial system

5.3. SYSTEMS OF SUPPLY

The water may be supplied either continuously for 24 hours of the day or may be supplied intermittently only for the peak periods during morning and evening. The intermittent supply system may sometimes lead to some saving in water consumption due to losses occurring for lesser time and more vigilant use of water by consumers. The intermittent supply system is largely employed in India

EPANET

Overview

The EPANET computer model used for water distribution network analysis is composed of two parts: (1) The input data file and (2) The EPANET computer program. The data file defines the characteristics of the pipes, the nodes (ends of the pipe), and the control components (such as pumps and valves) in the pipe network. The computer program solves the nonlinear energy equations and linear mass equations for pressures at nodes and flow rates in pipes.

Input data file:

The EPANET input data file, created by using GOOGLE EARTH software.

6. RESULTS AND DISCUSSIONS

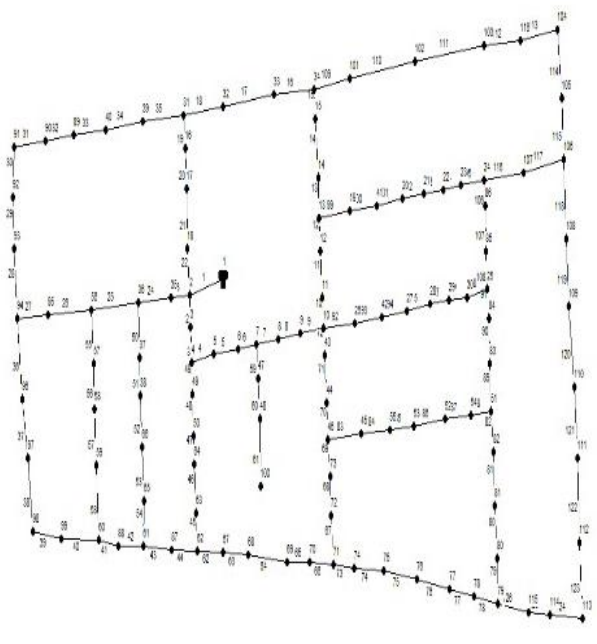

Fig-2: pipe network in EPANET

Given below is the water distribution network obtained by EPANET software of the study area.

Table 3: JUNCTION REPORT

Node	Elevation (m)	Demand (m)	Head (m)	Pressure (m)
1	692	0.31	696.36	16.54
2	688	0.15	693.44	13.44
3	687	0.14	692.89	14.89
4	682	0.19	692.52	20.25
5	683	0.22	692.11	12.11
6	683	0.16	691.83	12.83
7	680	0.19	691.54	16.54
8	680	0.19	691.26	13.56
9	678	0.12	690.97	12.97
10	678	0.13	690.92	12.92
11	678	0.21	690.89	12.89
12	677	0.14	690.88	13.88
13	677	0.18	690.88	13.88
14	675	0.26	690.89	15.89
15	674	0.15	691.27	17.27
16	672	0.18	691.27	19.27
17	674	0.26	691.27	17.27
18	686	0.27	690.84	16.84
19	686	0.23	690.80	14.8
20	686	0.19	690.79	12.79
21	686	0.17	690.78	12.78
22	686	0.15	690.77	15.77
23	686	0.20	690.76	12.78
24	685	0.17	690.77	15.77
25	686	0.27	690.92	15.92
26	686	0.22	690.84	16.84
27	686	0.20	690.82	12.82
28	686	0.17	690.80	15.8
29	686	0.16	690.79	12.79
30	674	0.36	691.28	17.28
31	675	0.45	691.14	16.14
32	675	0.35	690.99	15.99
33	674	0.13	690.90	16.9
34	695	0.15	695.84	16.84
35	692	0.29	694.87	14.87
36	693	0.25	693.99	14.99
37	692	0.17	693.51	13.51
38	691	0.32	691.47	13.47
39	691	0.28	691.67	13.67
40	686	0.23	690.82	14.82
41	686	0.24	690.88	16.88

42	686	0.21	690.95	15.95
43	686	0.17	690.92	15.92
44	686	0.29	690.85	15.85
45	686	0.16	690.89	15.89
46	687	0.15	691.78	13.78
47	687	0.18	691.74	15.74
48	688	0.19	692.85	17.85
49	687	0.12	691.38	12.38
50	685	0.18	690.77	12.77
51	686	0.27	690.79	15.79
52	686	0.21	690.81	16.81
53	686	0.23	690.78	12.78
54	686	0.26	690.82	16.82
55	692	0.41	693.92	13.92
56	692	0.24	693.35	15.35
57	692	0.20	692.98	12.98
58	692	0.25	692.62	15.62
59	691	0.34	692.29	12.29
60	690	0.20	692.22	15.22
61	687	0.22	691.27	16.27
62	687	0.17	691.30	13.3
63	687	0.22	691.35	12.35
64	692	0.24	692.50	17.5
65	692	0.23	692.95	1895
66	687	0.22	691.18	15.18
67	687	0.22	691.10	16.1
68	686	0.34	691.00	16
69	686	0.20	690.94	13.94
70	686	0.21	690.89	15.89
71	686	0.22	690.89	15.89
72	686	0.18	690.89	16.89
73	686	0.18	690.87	14.87
74	685	0.26	690.83	15.83
75	685	0.29	690.80	15.8
76	685	0.28	690.78	16.78
77	685	0.22	690.76	16.76
78	685	0.27	690.75	15.75

79	685	0.20	690.76	15.76
80	685	0.24	690.76	15.76
81	685	0.24	690.76	15.76
82	*686*	*0.21*	*690.77*	*12.77*
83	686	0.20	690.77	15.77
84	685	0.21	690.77	15.77
85	686	0.11	690.77	12.77
86	688	0.25	691.65	16.65
87	692	0.17	692.29	17.29
88	691	0.25	691.86	16.86
89	691	0.28	692.04	17.04
90	691	0.23	692.26	18.26
91	691	0.23	692.45	17.45
92	690	0.32	692.65	18.65
93	690	0.27	692.97	16.97
94	692	0.38	693.35	18.35
95	691	0.36	692.56	17.56
96	691	0.27	692.40	17.4
97	692	0.33	692.31	18.31
98	692	0.25	692.29	19.29
99	687	0.30	691.71	19.71
100	685	0.31	690.85	17.85
101	685	0.57	690.78	14.78
102	685	0.61	690.74	12.74
103	685	0.33	690.73	15.73
104	685	0.31	690.73	15.73
105	686	0.27	690.73	16.73
106	685	0.35	690.74	12.74
107	686	0.35	690.72	12.72
108	686	0.30	690.72	15.72
109	686	0.36	690.71	15.71
110	686	0.32	690.71	15.71
111	686	0.38	690.72	15.72
112	685	0.34	690.72	16.72
113	685	0.28	690.73	15.73
114	685	0.19	690.74	20.74
115	685	0.32	690.73	15.73

7. CONCLUSIONS

1. The main focus of this research is to analyse and design the water distribution network and identify deficiencies (if any) in its analysis, implementation and its usage.

2. In this work, the water distribution system has been designed with the help of EPANET in which we use number of nodes, elevation and number of pipes and demands of the study area.

3. The different nodes show different variation of pressure and demand.

4. The method of distribution used in this area is that of gravity type.

5. 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.

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