International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 09 | Sep 2020 www.irjet.net p-ISSN: 2395-0072

DESIGN OF WATER DISTRIBUTION NETWORK USING EPANET

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Abstract - *The main objective of this project is to study and design the water distribution network of GUDIVADA TOWN using EPANET software. The population rise of GUDIVADA TOWN by2041 is forecasted through different methods. The population forecasted by using the incremental increase method is taken into consideration in this project. The EPANET software uses Newton-Raphson method for the analysis of the flow of water in the pipe networks. The requirements for this study includes: map of GUDIVADA TOWN, Population and also the elevation of different nodes. The GUDIVADA TOWN map was extracted from Google earth Pro. The node elevations are also taken from Google earth pro software. The water demand was calculated based on the density of population. The water distribution network in the GUDIVADA TOWN consists of 10 Elevated Service Reservoirs, each serving a particular area. The pipe material used for the entire network system is made from cast iron with a roughness coefficient of 100. The duration of water supply is from 5am to 7am. Raw water is drawn from surface source and is sent into a treatment plant. Treated water is supplied to the community.*

Key Words **– *EPANET* software, water distribution network, population, incremental increase method, Newton-Raphson method.**

1. INTRODUCTION:

The need of this study is to check the flow of water in the pipes and to check whether the final discharge at consumer's point is quite enough or not. Water distribution networks convey water from the source to the consumers. An effective water distribution design plays a key role in saving the natural resources. A good Water distribution network is the one which must give equal pressure even at the farthest point of distribution with less head loss. EPANET software is most advanced software that models the hydraulic and also the water quality of the water distribution piping systems. Because in this project the opted study region is Gudivada town: where the population density varies depending on the area and thus, to overcome the problem, we need to design a good water distribution network which satisfies all the consumer demands within the required time. To maintain uniform discharge of water at all out lets is the major task while designing. So, the parameters must be properly arranged throughout the network. The whole design of the water distribution network can be done in EPANET software and the simulation can be carried out by giving the accurate parameters which have to be updated in the software. EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank, and it also checks the unit head loss in the pipe.

1.1 EPANET SOFTWARE

EPANET (Environmental Protection Agency Network) is a computer based 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 water level in each tank, and the concentration of the chemical species throughout the network during a simulation period comprised of multiple steps at different times. In addition to chemical species, water age and source tracing can also be simulated. EPANET is designed to be a research tool for improving our understanding of the movement and fate of drinking water constituents within distribution systems. EPANET can help to assess alternative management strategies for improving water quality throughout a system. These can include.

- Utilization of Alternative source within multiple source s`ystems.
- Alternative pumping and tank filling/emptying schedules.

1.2 EQUATIONS USED FOR DESIGN AND ANALYSIS OF NETWORK

HYDRAULIC EQUATIONS:

1. HAZEN-WILLIAMS
2. DARCY-WEISBACH
3. CHEZY-MANNING

The above three formulae can be used to find the head loss in the pipes in water distribution, but Hazen-Williams formula is recommended in finding it in each pipe in the whole network.

METHODS OF PIPE NETWORK FLOW ANALYSIS:

1. Hardy-Cross method
2. Node Head Correction method
3. Newton-Raphson method

The EPANET software uses Newton-Raphson method for analysis of the flow of pipe networks.

2. STUDY AREA

The area selected for this study is Gudivada town located in Krishna district, in the state of Andhra Pradesh, India with a total area of 12.67 km^2 is shown in Fig -1. Geographically, it is located: 16.4344° N, 80.9931° E. The town is 42 km from Vijayawada, 41 km from Eluru and 38 km from Machilipatnam.

Fig -1: Google map of Gudivada town

Gudivada town is a demographical area with residential areas like houses, apartments etc., public areas like stadium, parks, bus stands, schools, colleges, markets, government offices, etc., commercial areas like restaurants, shopping malls, theaters, etc., As per the history of Gudivada town according to its municipal corporation, they are using ponds for the purpose of storage of raw water. The town was divided into 20 wards. This ward system helps in the systematic distribution of water in every area in this town. Every two wards share one over head tank. The total town has 10 over head tanks. Every tank is connected to the pump house near the treatment plant. As per history of Gudivada town municipality they are using ponds for storage purpose of raw water. Before 2009 there was only one pond occupying 30 acres of land. Now it is not enough for the storage of raw water, because of population rise year by year. So they have dug a new land surrounding the pond of about 75 acres.

3. POPULATION

The water supply systems are designed for a certain design period, instead of present population, population expected in the design period must be considered in the design of water supply systems. Forecasting of population can be accomplished with different mathematical methods by using present and past population records that can be obtained from local census office. They are:- Arithmetical Increase Method, Geometrical Increase Method, Incremental Increase Method, Decreasing Rate Method, Simple Graphical Method, Comparative Graphical Method, Master Plan Method, The Logistic Curve Method, The Apportionment Method. All the above methods can be used in the calculation of population forecasting but we prefer only three methods. They are arithmetical increase method, geometrical increase method, and incremental increase method. Depending upon the accuracy level we recommended the incremental increase method. The estimated population of Gudivada town by the year 2041 is 1, 38,515. The Gudivada town population in previous years is mentioned in the Table -1 is given below:

Table -1: population data:

YEAR	POPULATION
2011	118167
2001	113054
1991	101656
1981	81620
1971	64811
1961	52482

The Gudivada town population increase is recorded in every 1 decade.

4. METHODOLOGY

Initially the map of study area was extracted by using Google Earth pro software. The obtained map was then opened in Auto CAD software and the network lines along the roads are drawn. After the CAD file was imported into EPACAD and converted into NETWORK file. The network file is opened in EPANET software. Elevation, pipe diameter and length of the pipe had to be given to each node and to the pipe for hydraulic analysis. As per design criteria, after rectifying all the Warnings and errors, it is run successfully. Finally all the Resultant reports are taken in a tabular column.

The error reports are generated and if the pressure, demand and supply are not sufficient to the consumer, then we increase the pipe diameters.

4.1 DESIGN PERIOD VALUES

The design period is recommended by the CPHEEO (1999) manual on water supply, for designing various components of a water supply project. We design the water distribution net work up to the year of 2041 for Gudivada town.

5. NODE DEMAND CALCULATIONS

The node demand is calculated based on the population present at the particular area being served by the node. The water to be supplied is 135 lit per person per day. The lpcd requirement is based on CPHEEO manual. Sample calculation of node demand for some nodes is presented in Table -2 and the sample of link data is presented in the Table -3.

Table -2: node demand values

NODE NO	LENGTH	WIDTH	AREA	POP	TOTAL POP	TOTAL LPCD	LPS	GL
16	164.00	27.00	4428.00	48.41	72.61	9802.86	1.36	8.00
17	42.00	55.00	2310.00	25.25	37.88	5113.96	0.71	8.00
n9	223.00	45.00	10035.00	109.71	164.56	22215.83	3.09	8.00
n15	88.00	41.50	3652.00	39.93	59.89	8084.92	1.12	7.00
n13	188.00	30.50	5734.00	62.69	94.03	12694.13	1.76	7.00
n11	150.00	69.00	10350.00	113.15	169.73	22913.19	3.18	6.00
n7	404.00	20.00	8080.00	88.33	132.50	17887.78	2.48	8.00
n6	183.00	25.00	4575.00	50.02	75.02	10128.29	1.41	9.00
19	56.00	20.00	1120.00	12.24	18.37	2479.49	0.34	6.00
20	36.00	53.00	1908.00	20.86	31.29	4224.00	0.59	6.00
n17	29.00	40.00	1160.00	12.68	19.02	2568.05	0.36	7.00
n62	163.00	24.00	3912.00	42.77	64.15	8660.52	1.20	7.00
n32	71.00	17.00	1207.00	13.20	19.79	2672.10	0.37	7.00
n20	175.00	17.00	2975.00	32.52	48.79	6586.16	0.91	7.00
n30	88.00	20.00	1760.00	19.24	28.86	3896.35	0.54	7.00
n22	184.00	28.00	5152.00	56.32	84.49	11405.68	1.58	7.00
n24	196.00	35.00	6860.00	75.00	112.50	15186.91	2.11	7.00
n26	208.00	29.50	6136.00	67.08	100.62	13584.09	1.89	7.00
n28	216.00	28.00	6048.00	66.12	99.18	13389.27	1.86	7.00
n34	225.00	27.00	6075.00	66.42	99.62	13449.05	1.87	7.00
n36	164.00	38.00	6232.00	68.13	102.20	13796.62	1.92	7.00
23	62.00	27.00	1674.00	18.30	27.45	3705.96	0.51	7.00
n18	221.00	27.00	5967.00	65.23	97.85	13209.95	1.83	7.00

5.1 MAP PREPARATION

The total Gudivada town water distribution network layout is shown in Fig -2 and to have a better visibility a part of the distribution area that is Bethavolu network is shown in Fig -3.

6. RESULTS

1) The projected population for the year 2041 was calculated as 1, 38,515.
2) Water demand for overall town is 18,699 m^3 per day.
3) The duration of water supply is 2 hours.

The results of design are given bellow.

The node results are shown in table 4

6.1 GUDIVADA ENTIRE WATER DISTRIBUTION NETWORK:

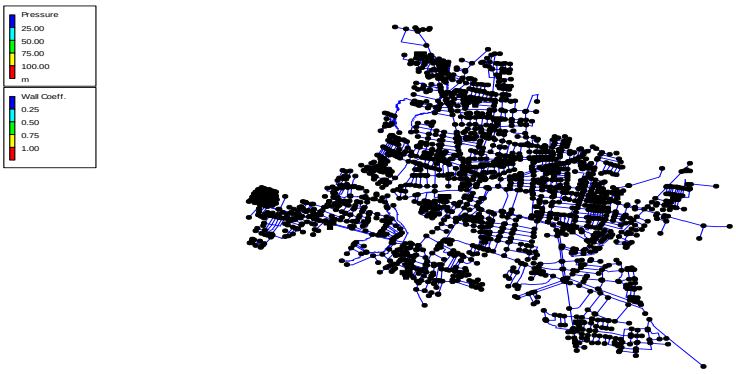

Fig -2: Overall Gudivada water distribution network

6.2 BETHAVOLU WATER DISTRIBUTION NETWORK:

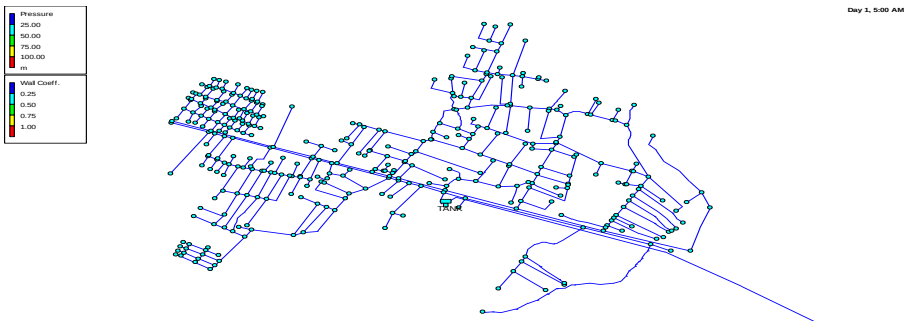

Fig -3: Bethavolu water distribution network

Table -3: Bethavolu water distribution network input link data

Link - Node Table:

Link ID	Start Node	End Node	Length m	Diameter mm
p4	n7	n8	269	110
p6	n11	n12	150	110
p7	n13	n14	188	110
p8	n15	n16	88	110
p11	n20	n21	175	110
p12	n22	n23	184	110
p13	n24	n25	196	110
p14	n26	n27	208	110
p15	n28	n29	216	110
p16	n30	n31	88	110

p17	n32	n33	71	110
p18	n34	n35	225	110
p19	n36	n37	104	110
p24	n42	n45	83	110
p26	n48	n49	128	110
p27	n50	n51	110	250
p28	n52	n53	100	110
p30	n56	n57	38	110
p31	n58	n59	56	110
p32	n60	n61	150	110

Table -4: DISTRIBUTION NETWORK RESULTS

Node Results at 5:00 Hrs:

Node ID	Demand LPS	Head m	Pressure m
n2	0.90	21.04	14.04
n4	0.70	21.31	13.31
n5	0.01	21.55	14.55
n7	0.36	21.65	14.65
n8	3.44	21.62	14.62
n10	1.27	21.66	14.66
n11	5.87	21.53	14.53
n12	0.79	21.13	14.13
n13	0.85	21.60	14.60
n14	0.01	21.13	14.13
n15	0.01	21.55	15.55
n16	0.01	21.59	15.59
n17	0.01	21.59	15.59
n18	0.01	21.59	15.59
n19	0.36	21.67	14.67
n20	0.01	21.67	15.67
n21	1.30	21.48	14.48
n22	0.01	21.48	15.48
n23	1.50	21.41	14.41
n24	0.01	21.41	15.41

7. CONCLUSIONS

1. The whole Gudivada town water distribution network plan is drawn by using Google earth pro & Auto CAD software with the help of water distribution network maps, provided by Gudivada Municipal Corporation.
2. The water distribution network maps are prepared in individual areas by using EPANET 2.0 software.
3. The population values are taken from the year of 1961 to 2011 and they are forecasted up to 2041.
4. The projected population in the year of 2041 is 1,38,515.
5. The water distribution network is designed to supply water to the town for the population that may come in 2041.
6. The duration of supply is considered as 2 hours.
7. We suggest that new water treatment plants be installed because the existing water treatment plant capacity is 11MLD and the required water is 19MLD.

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