Water Distribution Network using EPANET: A Case Study of Olpad Village

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Abstract

Modeling Rural Networks and Piecemeal Water supply systems is tough because these systems are not fully Pressurized Pipeline Networks but Networks with very low Pressures. In order to fulfil the water demand of the Continuously Growing Population, it is essential to provide a sufficient and uniform Quantity of water through the designed network of pipes. In this research, the analysis of the existing network was studied and concludes Reliability on the network using EPANET software. EPANET software is simulation tool which is used for efficient distribution of water supply. For the analysis of existing water distribution system various data are required like, Main water source, Population of the area, Demand for water, Requirement of the pumps, Distribution Network ,and water tanks. The Google Earth Image of Olpad village is downloaded and the elevation of a node, length of pipe was recorded for nearly 27 junctions and 35 pipes. These data were used in EPANET software for analysis of Pressure, Head loss, and Elevation. This analysis resulted in pressure and elevation at various nodes and head loss at various pipes.
Keyword- EPANET, Water Supply Network, Nodes, Pipes, Elevation

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OBJECTIVE OF THE STUDY

- To Study the Existing Water Supply Network in Olpad village.
- To Analyse of Water Distribution Network using EPANET software in Olpad village.
- Comparison between Existing Network Design Result and EPANET Software Design Result.

I. INTRODUCTION

Water distribution system, hydraulic Supporting Structure be contained in elements such as Pipeline, Tanks, Basin, Pumps ,and Valve etc. is necessary to provide water to the consumers elements of a distribution system include Distribution mains, Arterial mains, Storage basin and system elements (valves, hydrants, mainline meters, service connections, and backflow preventers). Distribution main are the pipes that make up the distribution complex. Their purpose is to transmit water from water source or treatment work to users.

Water distribution system consists of an interconnected series of pipelines storage facilities and elements that convey waters which is used for drinking and also meeting the fire protection needs for Cities, Schools, Homes, Hospitals, Industries, Businesses, and other Facilities.

A. Overview of EPANET Software

EPANET is Public Domain Software developed by the Water Supply and Water Resources Division of the U.S. Environmental Protection Agency's National Risk Management Research Laboratory. 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. The hydraulic simulation performed by EPANET delivers information such as flows and head losses in links (pipes, pumps ,and valves), heads, pressures and demands at junctions, levels and volumes for water storage. This allows Computing the Pumping Energy and Cost. EPANET's Computational Engine is available also as a Separate library (called the EPANET Toolkit) for incorporation into other applications. EPANET is a Computer Program that Executes Extended period Simulation of hydraulic and water quality behaviour 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 during a simulation period comprised of multiple time steps. EPANET can help assess alternative management strategies for improving water quality throughout a system. These can include:

- Altering source utilization within Multiple source systems,
- Altering Pumping and tank filling/emptying Schedules,
- Use of satellite treatment, such as re-chlorination at storage tanks,
- Targeted pipe cleaning and Replacement.

B. Advantages of EPANET

Following are some basic Advantages of EPANET for using in Network and Distribution analysis.

- Flow rates in the network are obtained by using Linear Method.
- Head-losses due to friction is computed using Darcy-Weisbach or Manning's formulae.
- It has the Capability in considering minor losses from bends, fittings, etc.
- It also can duplicate demands which vary over time.
- It can also handle different demand patterns for each node.

II. STUDY AREA

Fig. 1: Map of Olpad village
Source: Google Earth

Olpad is a large village located in Olpad Taluka of Surat district, Gujarat with total 3365 families residing. The total geographical area of the village is 1501 hectares. Olpad has a total population of 15,898 peoples. Surat is the nearest city to Olpad which is approximately 17km away. Olpad village has latitude 21.340˚ and longitude 72.755˚.

The population data is collected from the Olpad gram Panchayat. According to 2011 census population is 16370. The Same population was forecasted for the ultimate year (2021) by assuming 1% growth of the population. The population for the ultimate year (2021) is estimated to be 25299. Hence, for the above-said population per capita, water demand is assumed 55 lpcd including losses as per CPHEEO manual.

The water distribution system of Olpad Village i.e. WDS consists of following 3 network systems:-

1) ESR-1
2) ESR-2
3) ESR-3

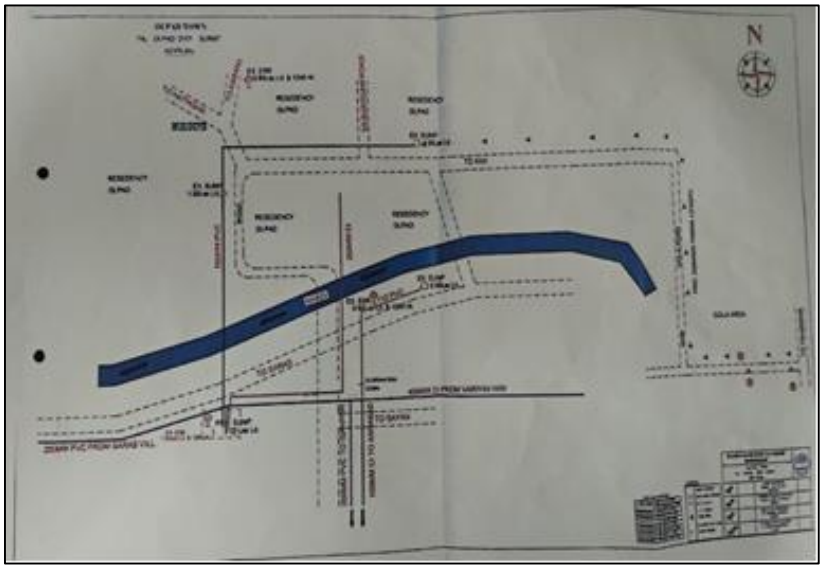

Fig. 2: Olpad village WDN
Source: Olpad Gram Panchayat

III. METHODOLOGY

Following are the steps carried out to Model Water Distribution Network using EPANET.
Step 1: Basic description of distribution system network is placed in a text file.
Step 2: Object properties are edited to make up the system and also input the required data in various objects like Reservoir, pipes and Nodes, Junction.
Step 3: Describe however the system is operated.
Step 4: Choose a set of analysis option.
Step 5: Run a hydraulic/water quality analysis
Step 6: Read the results of the analysis which may be viewed in numerous form i.e. in Variety of tables and graphs.
Step 7: Same steps are followed for other distribution networks.

IV. RESULTS AND DISCUSSION

After collecting data of water distribution networks of Olpad Village pressure, flow and velocity have been computed using EPANET and by the following methodology described, results by EPANET are obtained. Analysis of Results has been carried out of Distribution Networks.

A. ESR-1

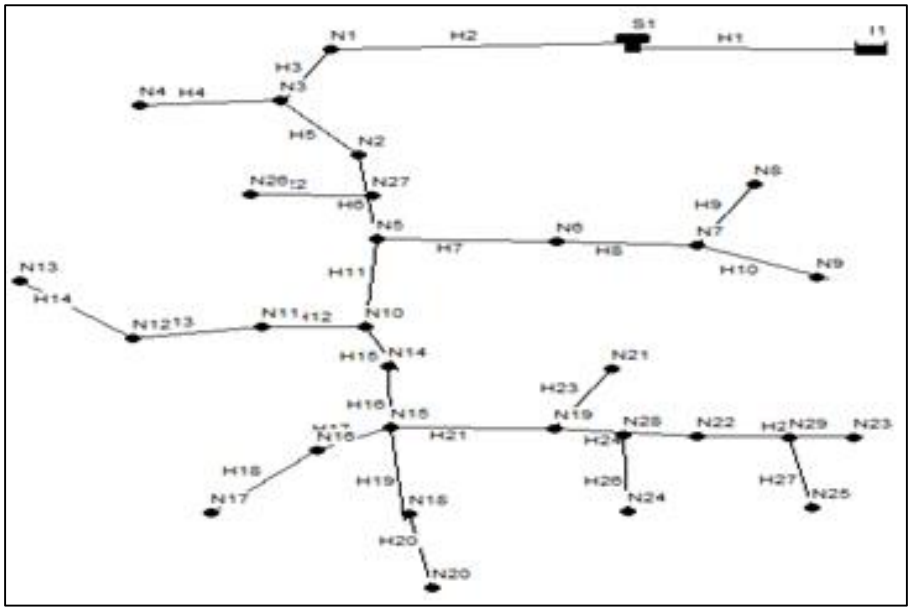

Fig. 3: Network Diagram of WDN ESR 1

1) Junction Report

It includes 27 junctions. The result obtained using EPANET software for ESR-1 is calculated. The error between the actual pressure and the pressure computed using EPANET software is also compared.
Following are some of the findings of the above study:-

- The pressure is computed using Hazen-William approach.
- For WDS-ESR-1 N-2, N-3, N-4, N-5,N-6, N-7, N-8, N-9, N-10, N-11, N-12, N-13, N-14, N-15, N-16, N-17,j-18, N-19, N-20, N-23, N-24, N-25, N-26, N-27 junction gives negative pressure.
- There is fluctuation in the pressure head.

2) Pipe Report

Pipe report of ESR-1 includes 37 pipes. The result obtained using EPANET software for ESR-1 is presented. The error between actual flow and flow computed using EPANET software is compared. The error between actual head loss & head loss computed EPANET software is also compared.

- The flow computed using EPANET shows variation when compared to the actual flow. P-2,P-7, P-8, P-12, P-13, P-14, P-16, P-18, P-19, P-21, P-23, P-24, P- 25, P-27, P-29, P-31, P-33, P-34, P-36, P-37 pipes show negative flow.
- The velocity computed using EPANET shows variation when compared to the actual velocity. P-2, P-12, P-13, P-14, P-17, P-18, P-19, P-20, P-21, P-22, P 23, P-24, P-25, P-26, P-27, P-29, P-30, P-32, P-34, P-37 pipes have negative decreasing velocity of flow.

- The head-loss computed using EPANET shows variation when compared to the actual head-loss. P-2, P-4, P-5, P-7, P-8, P-9, P-10, P-11, P-12, P-13, P-14, P- 15, P-16, P-19, P-20, P-21, P-22, P-23, P-24, P-25, P-28, P-29, P-30, P-32, P- 33, P-34, P-36,shows negative and decreasing head-loss gradient.

B. ESR-2

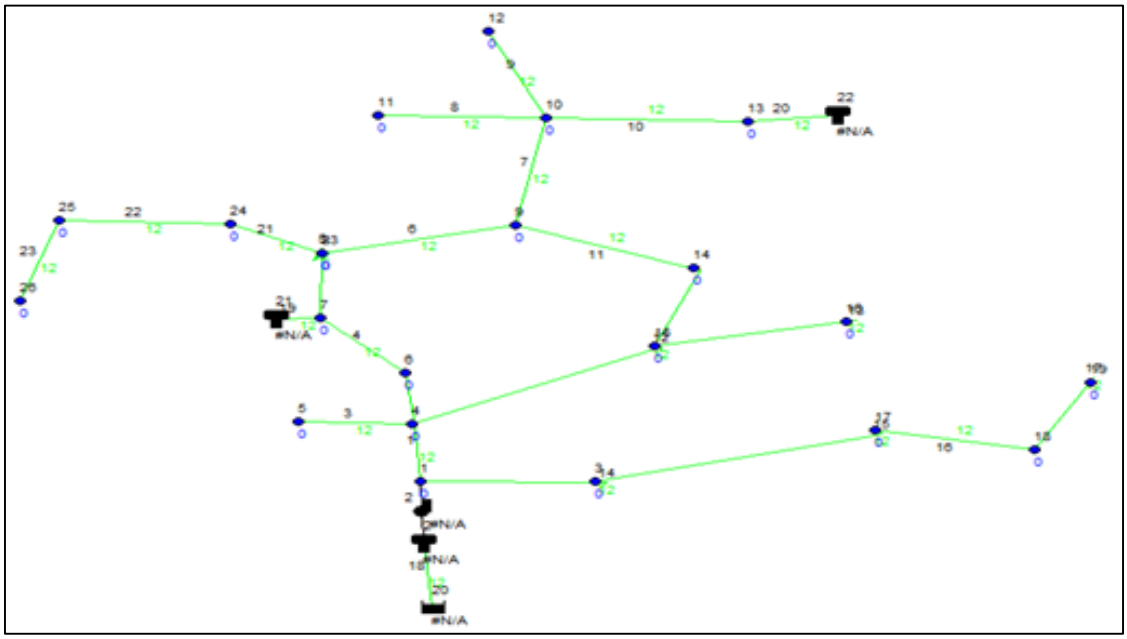

Fig. 4: Network Diagram of WDN ESR-2

1) Junction Report

It includes 24 junctions. The result obtained using EPANET software for ESR-2 is calculated. The error between actual pressure and the pressure computed using EPANET software is also compared.

Following are some of the findings of above study:-

- The pressure is computed using Hazen-William approach.
- For ESR-2 j-2, j-3, j-5,j-6, j-7, j-8, j-9, j-10, j-11, j-13, j-14, j-15, j-16, j17,j-18, j-19, j-20, j-22, j-24, junction gives negative pressure.
- There is fluctuation in the pressure head.

2) Pipe Report

Pipe report of ESR-2 includes 33 pipes. The result obtained using EPANET software for ESR-1 is presented. The error between actual flow and flow computed using EPANET software is compared. The error between actual head loss & head loss computed EPANET software is also compared.

- The Flow computed using EPANET shows variation when compared to the actual flow. P-2,P-7, P-8, P-12, P-13, P-16, P-18, P-19, P-21, P-22, P-24, P- 25, P-27, P-31, P-33, pipes show negative flow.
- The Velocity computed using EPANET shows variation when compared to the actual velocity. P-1, P-12, P-13, P-14, P-17, P-18, P-20, P-21, P-22, P 23, P-24, P-25, P-26, P-27, P-29, P-30, P-32, pipes have negative decreasing velocity of flow.
- The Head-loss computed using EPANET shows variation when compared to the actual head-loss. P-2, P-4, P-5, P-7, P-8, P-9, P-10, P-11, P-12, P-13, P-14, P- 15, P-16, P-19, P-20, P-21, P-22, P-23, P-24, P-25, P-28, P-29, P-30, P-32, P- 33,shows negative and decreasing head-loss gradient.

3) Link Result

Link ID	*Flow (LPS)*	*Velocity (m/s)*	*Unit Head loss (m/km)*	*Status*
1	*8.72*	*0.63*	*0.83*	*Open*
2	*0.54*	*1.08*	*3.36*	*Open*
3	*8.39*	*0.74*	*1.67*	*Open*
4	*3.69*	*0.67*	*1.38*	*Open*
5	*6.78*	*0.56*	*1*	*Open*
6	*6.68*	*0.56*	*1*	*Open*
7	*-0.23*	*0.03*	*0.01*	*Open*
8	*0.06*	*0.01*	*0*	*Open*
9	*-0.45*	*0.06*	*0.05*	*Open*
10	*-2.04*	*0.26*	*0.82*	*Open*

11	*-1.11*	*0.14*	*0.26*	*Open*
12	*0.33*	*0.04*	*0.03*	*Open*
13	*0.8*	*0.03*	*0.01*	*Open*
14	*3.84*	*0.49*	*2.65*	*Open*
15	*-8.07*	*1.03*	*0.92*	*Open*
16	*1.66*	*0.21*	*0.56*	*Open*
17	*0.12*	*0.02*	*0*	*Open*
18	*5.52*	*0.7*	*5.18*	*Open*
19	*3.72*	*0.48*	*2.53*	*Open*
20	*6.56*	*0.39*	*1.13*	*Open*
21	*1.27*	*0.16*	*0.08*	*Open*
22	*0.56*	*0.07*	*0.29*	*Open*
23	*1.13*	*0.14*	*0.75*	*Open*
24	*6.21*	*0.37*	*1.02*	*Open*
25	*1.17*	*0.14*	*0.06*	*Open*
26	*5.26*	*0.37*	*0.08*	*Open*
27	*-1.46*	*0.15*	*1.13*	*Open*

Table 1: Link Result

4) Node Result

Node ID	*Demand (LPS)*	*Head (m)*	*Pressure (m)*
1	*8.72*	*0.63*	*0.83*
2	*0.54*	*1.08*	*3.36*
3	*8.39*	*0.74*	*1.67*
4	*3.69*	*0.67*	*1.38*
5	*6.78*	*0.56*	*1*
6	*6.68*	*0.56*	*1*
7	*-0.23*	*0.03*	*0.01*
8	*0.06*	*0.01*	*0*
9	*-0.45*	*0.06*	*0.05*
10	*-2.04*	*0.26*	*0.82*
11	*-1.11*	*0.14*	*0.26*
12	*0.33*	*0.04*	*0.03*
13	*0.8*	*0.03*	*0.01*
14	*3.84*	*0.49*	*2.65*
15	*-8.07*	*1.03*	*10.46*
16	*1.66*	*0.21*	*0.56*
17	*0.12*	*0.02*	*0*
18	*5.52*	*0.7*	*5.18*
19	*3.72*	*0.48*	*2.53*
20	*6.56*	*0.39*	*1.13*
21	*1.27*	*0.16*	*0.08*
22	*0.56*	*0.07*	*0.29*
23	*1.13*	*0.14*	*0.75*
24	*6.21*	*0.37*	*1.02*
25	*1.17*	*0.14*	*0.06*
26	*5.26*	*0.37*	*0.08*
27	*-1.46*	*0.15*	*1.13*

Table 2: Node Result

V. CONCLUSION

In this work, the existing water distribution system has been analyzed with the help of EPANET in which we use number of nodes, elevation, Number of pipes and demands of Olpad village.

The main focused of this study is to analyze the water distribution network and identify results in its analysis.

- The Analysis was found that the Resulting Pressures at all the junctions and the flows with their velocities at all pipes are enough to provide water to the study area.
- This study would help the water supply engineers in saving time as it this process is fast and less difficult.
- Discharge should be increased to achieve the base demand

The method of distribution used here is pumping system. Water Supply in the pipe is through variav water treatment plant. The distribution layout used here is tree system or dead-end system which is according to the layout of the Olpad village.

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