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Optimization of Limbayat Zone Water Distribution System Using EPANET

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Abstract - *Water supply system is a system of engineered hydrologic and hydraulic components which provide water supply. Lack of access to safe water seriously undermines the health and well-being of the people. The poor and economically weaker sections are affected the most. Majority of the Indian Population lives in rural areas. At present also the rural community does not have access to safe, regular and adequate drinking water. Optimization of a water distribution system is concerned with its ability to deliver water to individual consumers in the required quantity and under a satisfactory pressure. Limbayat zone is facing water scarcity problem. The reason behind this scarcity is the pressure fluctuation. There is large variation in pressure head. The pressure supplied is not sufficient to fulfill the water demand of Limbayat zone. The purpose of this study is to assess the performance of Limbayat Zone water distribution system using EPANET and to address any improvements required to existing infrastructure and/or the mode of operation, in order to improve quantity and quality of water distributed to the consumers. This study also help the water supply engineers in saving time as it this process is fast, less tedious, easy to incorporate the changes.*

Key Words: EPANET, Optimization, Pressure Head, Water Distribution System.

1. INTRODUCTION

Water distribution networks serve many purposes in addition to the provision of water for human consumption, which often accounts for less than 2% of the total volume supplied. Piped water is used for washing, sanitation, irrigation and fire-fighting. Networks are designed to meet peak demands; in parts of the network this creates low-flow conditions that can contribute to the deterioration of microbial and chemical water quality. A water distribution system is a hydraulic infrastructure that conveys water from the source to the consumers. It consists of elements such as pipes, valves, pumps, tanks and reservoirs. The most important consideration in designing and operating a water distribution system is to satisfy consumer demands under a range of quantity and quality considerations during the entire lifetime for the expected loading conditions. Also; a water distribution system must be able to accommodate abnormal conditions such as breaks in pipes, mechanical failure of pipes, valves, and control systems, power outages, malfunction of storage facilities and inaccurate demand projections. The possibility of occurrence of each of these deficiencies should be examined to determine the overall performance and thereby the reliability of the system. There is still not a convenient evaluation for the reliability of water distribution systems. Traditionally, a water distribution network design is based on the proposed street plan and the topography. Using commercial software, the modeler simulates flows and pressures in the network and flows in and out to from the tank for essential loadings.

2. AIM OF STUDY

To assess the performance of Limbayat Zone water distribution system using EPANET and to address any improvements required to existing infrastructure and/or the mode of operation, in order to improve quantity and quality of water distributed to consumers.

3. OBJECTIVE OF STUDY

- To study the current water distribution system of Limbayat zone of Surat City.
- To check discharge in the existing network.
- To check the pressure head.
- To check the losses in the network due to leakages of pipes and other factors.

4. STUDY AREA

Limbayat zone is a part of Surat city. Limbayat zone occurs in the south-east zone of Surat. Limbayat zone covers the following villages under the water distribution system:

- Dindoli
- Gamtal-Dindoli
- Parvatgoda
- Godadragamtal
- Parvatgamtal

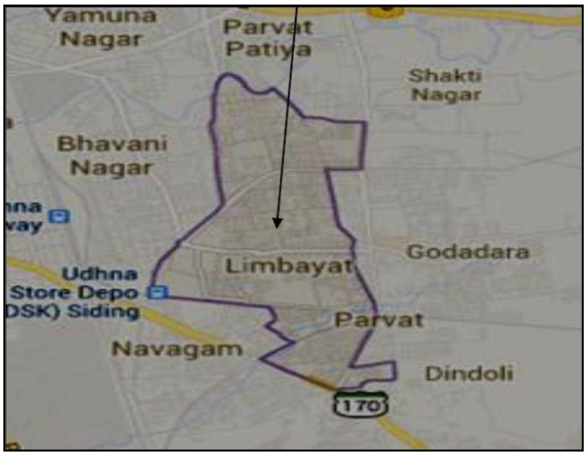

Fig. 1 - Map of Limbayat Zone

The population of study area according to 2011 census is 1,22,560. The study area covers residential area about 882.9 ha.

The water distribution system of Limbayat zone i.e. WDS-1 consists of following 3 network systems:-

- ESR-SE-1
- ESR-SE-2
- ESR-SE-3

In this present paper detail analysis of ESR-SE-2 is done using hydraulic simulation software i.e EPANET.

5. METHODOLOGY

The map of Limbayat Zone distribution system was obtained from Surat Municipal Corporation and was inserted in EPANET screen for hydraulic simulation of network.

5.1 Overview of EPANET software

EPANET was developed by the water supply and water resources division (formerly the drinking water research division) of the U.S Environmental protection agency's national risk management research laboratory. It is public domain software that may be freely copied and distributed. 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 during a simulation period comprised of multiple time steps. In addition to chemical species, water age and source tracing can also be simulated.

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.

5.2 Hydraulic Modeling Capabilities

Full-featured and accurate hydraulic modeling is a prerequisite for doing effective water quality modeling. EPANET contains a state-of-the-art hydraulic analysis engine that includes the following capabilities:

- Places no limit on the size of the network that can be analyzed.
- Computes friction head loss using the Hazen-Williams, Darcy-Weisbach, or Chezy-Manning formulas
- Includes minor head losses for bends, fittings, etc.
- Models constant or variable speed pumps
- Computes pumping energy and cost
- Models various types of valves including shutoff, check, pressure regulating, and flow control valves
- Allows storage tanks to have any shape (i.e., diameter can vary with height)
- Considers multiple demand categories at nodes, each with its own pattern of time variation
- Models pressure-dependent flow issuing from emitters (sprinkler heads)
- Can base system operation on both simple tank level or timer controls and on complex rule-based controls.

5.3 Model Input Data

In order to analyze the WDN using EPANET following input data files are needed.

- Junction report
- Pipe report

5.3.1 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

Junctions can also:

- Have their demand vary with time
- Have multiple categories of demands assigned to them
- Have negative demands indicating that water is entering the network
- Be water quality sources where constituents enter the network
- Contain emitters (or sprinklers) which make the outflow rate depend on the pressure.

5.3.2 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).

Computed outputs for pipes include:

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

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 the US. It cannot be used for liquids other than water and was originally developed for turbulent flow only. The Darcy-Weisbach formula is the most theoretically correct. It applies over all flow regimes and to all liquids. The Chezy-Manning formula is more commonly used for open channel flow. Each formula uses the following equation to compute head loss between the start and end node of the pipe:

$$H_l = a\,q^{\,b}$$

Where,
hl= head loss (length),
q = flow rate (volume/time),
a = resistance coefficient and
b = flow exponent.

Table 1 lists expressions for the resistance coefficient and values for the flow exponent for each of the formulae. Each formula uses a different pipe roughness coefficient that must be determined empirically.
Pipes can be set open or closed at preset times or when specific conditions exist, such as when tank levels fall below or above certain set points, or when nodal pressures fall below or above certain values.

Table 1 - Pipe Head Loss formula for full flow

Formula	Resistance coefficient (a)	Flow exponent (b)
Hazen-Williams	$4.727c^{-1.852}d^{-4.781}l$	1.852
Darcy-Weisbach	$0.0252f(\varepsilon,d,q)d^{-5}l$	2
Chezy-Manning	$4.66n^{2}d^{-5.33}l$	2

Where,
c = Hazen-Williams roughness coefficient
ε = Darcy-Weisbach roughness coefficient (ft)
f = friction factor (dependent on ε, d, and q)
n = Manning roughness coefficient
d = pipe diameter (ft)
L = pipe length (ft)
Q = flow rate (cfs)

6. RESULTS

After collecting data of three distribution networks of Limbayat zone pressure, flow and velocity have been computed using EPANET and by following the methodology described above results by EPANET are obtained. Analysis of results has been carried out and error between computed results and actual results are compared for junction as well as pipe report of three distribution networks.

6.1 WDS ESR-SE-2

The network diagram of WDS ESR-SE-1 drawn in EPANET is shown in fig. 2

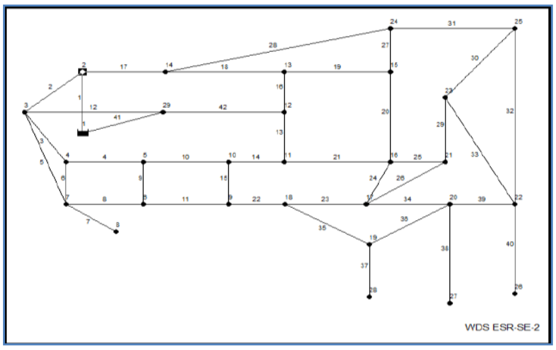

Fig 2: Network Diagram of WDS ESR-SE-2

6.1.1 Junction Report

It includes 29 junctions. The result obtained using EPANET software for WDS ESR-SE-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 WDS-ESR-SE-1 j-5, j-6, j-7, j-8, j-9, j-10, j-11, j-12, j-13, j-14, j-15, j-16, j-17, j-18, j-19, j-20, j-21, j-22, j-23, j-24, j-25, j-26, j-27, j-28, j-29 junction gives negative pressure.
- There is fluctuation in the pressure Head

6.1.2 Pipe Report

Pipe report of WDS ESR-SE-2 includes 42 pipes. The result obtained using EPANET software for WDS ESR-SE-2 is presented. The error between actual flow and flow computed using EPANET software is compared. The error between actual & computed Head Loss EPANET software is also compared.

Following are some of the findings of above study:

- The flow computed using EPANET shows variation when compared to the actual flow. P-1, P-2, 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-30, P-33, P-34, P-36, P-39, P-41, P-42 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-16, 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-33, P-36, P-41, P-42 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-6, 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-27, P-29, P-30, P-32, P- 33, P-34, P-36, P-39, P-41, P-42 shows negative and decreasing head loss gradient.

7. CONCLUSION

- In this paper attempt has been made to develop a Water Distribution System using EPANET software a tool to assist the assessment of the hydraulic behavior of water supply distribution network. After doing analysis of water distribution network of Limbayat zone, we can conclude that the flow & velocity of the water supplied to this zone is appropriate and there is no problem in the flow & supply of water. But still it is facing water scarcity problem. The reason behind this scarcity is the pressure fluctuation. There is large variation in pressure head.
- There may be leakages in the pipes which results in the pressure difference which consequently results into the scarcity of water.
- Comparison of these results indicates that the simulated model seems to be reasonably close to actual network.

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REFERENCES

[1] Germanopoulos, G., Jowitt, P.W. and Lumbers, J.P. *"Assessing the Reliability of Supply and Level of Service for Water Distribution Systems."* Proc. Instn. Civil Engineers. Part 1, Water Engineering Group, (1986), 413-428.

[2] Lansey, K.E., Duan, N. and Mays, L.W. *"Water Distribution System Design under Uncertainties."* ASCE J. Water Resources Planning & Management, 115, No. 5 (1989), 630-644.

[3] Quimpo, R.G. and Shamsi, U.M. *"Reliability-based Distribution System Maintenanace."* ASCE J. Water Resources Planning & Management, 117, No. 3 (1991), 321-339.

[4] Mays, L.W. *"Methods for Risk and Reliability Analysis."* Conf. Proc., Part of Risk-based Decision Making in Water Resources VI, (1993), 26-44.

[5] Calvin, R.S., Yacov, Y.H., Duan, L. and James, H.L. *"Capacity Reliability of Water Distribution Networks and Optimum Rehabilitation Decision Making."* Water Resources Res., 32, No. 7 (1996), 2271-2278.

[6] Ostfeld, A. *"Reliability Analysis of Regional Water Distribution Systems."* Urban Water, 3 (2001), 253-260.

[7] Shinstine, D.S., Ahmed, I. and Lansey, K.E. *"Reliability/Availability Analysis of Municipal Water Distribution Networks: Case Studies."* ASCE J. Water Resources Planning & Management, 128, No. 2 (2002), 140-151.

[8] Goulter, I.C. and Coals. *"Quantitative Approaches to Reliability Assessment in Pipe Networks."* ASCE J. Transportation Eng., 112, No. 3 (1986), 287-301.

[9] Cullinane, M.J., Lansey, K.E. and Mays, L.W. *"Optimization Availability-based Design of Water Distribution Networks."* ASCE J. Hydraulic Eng., 118, No. 3 (1992), 420-441.

[10] Muhammad A. Al-Zahrani and Juned Laiq Syed, *"Evaluation of Municipal Water Distribution System Reliability Using Minimum Cut-set Method".*

[11] Lewis A. Rossman, *EPANET 2 User's Manual, Water Supply and Water Resources Division.* National Risk Management Research Laboratory Cincinnati, OH 45268.

[12] Bhavana K. Ajudiya, Dr. S.M. Yadav, Prof. B. H. Pandit (2012) *"Water Distribution Network Design & Cost Analysis: A Case Study"* International Conference on Information, Knowledge & Research in Engineering, Technology & Sciences, 24-25 March, Rajkot, Gujarat, India. pg. 167-172

[13] Wood D.J. and Charles, C.O.A. (1972). *"Hydraulic network Analysis Using Linear Theory"* Journal of Hydraulics division, ASCE, Vol.98 No. HY7, pg. 1157-1170.

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