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SIMULATION EXPONENT COEFFICIENT VALUES IN WATER DISTRIBUTION NETWORK

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Abstract

The water distribution network supplies water to consumer to fulfill demands at desired pressure. Due to pressure deficient conditions pressure fall below minimum required which ultimately lead to reduction in flow supplied to consumer. The water distribution network is said to be pressure deficient, if the pressure head in each node is less than the required head. Adding artificial element approach for predicting partial flow at demand node in pressure deficient condition is used by many researchers. The objective of study is to investigate effect of variation in empirical exponent coefficient on emitter exponent, pressure and actual demand at every node. The value of emitter coefficient depends on emitter exponent coefficient value, which is calculated using empirical exponent coefficient. The study is carried out for three different values of empirical exponent coefficient 0.5, and 1 respectively. The simulation analysis shows that as empirical exponent increases emitter exponent decreases, pressure decreases and actual demand at nodes increases.

Introduction

Water distribution networks are typically designed to accommodate peak demand scenarios, ensuring that during normal operations, there is ample pressure to meet nodal demands. However, this design approach can lead to higher than necessary pressure levels during periods of low consumption, contributing to water leaks. The surplus pressure available during low-demand periods becomes a significant factor in infrastructure stress. This excess pressure can result in increased incidents of water leaks, leading to both economic and environmental concerns. To address this issue and optimize water distribution, it is crucial to consider the pressure head available at delivery nodes.

One effective strategy involves assessing the pressure shortage and utilizing the available pressure head at delivery nodes to compensate for any deficiencies. By doing so, it is possible to maintain adequate pressure levels throughout the distribution network, preventing drops below

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critical thresholds. This approach helps minimize water losses due to leaks and pipe breaks while ensuring a consistent and reliable water supply to consumers. Emitter Exponent is Power to which pressure is raised when computing the flow through an emitter device. The textbook value for nozzles and sprinklers is 0.5. This may not apply to pipe leakage.

The passage you provided discusses the utilization of simulation tools, such as EPANET, for analyzing fluid flow in pipe networks. It touches upon two specific applications: simulating leakage in a pipe connected to a junction and computing fire flow at the junction. In the case of simulating leakage, the approach involves estimating discharge coefficients and pressure exponents for potential leaks or joints in the pipe. By incorporating these values into the simulation, it becomes possible to model the effects of leakage on the overall system. For computing fire flow at the junction, the simulation involves using a high discharge coefficient and adjusting the junction's elevation to account for the equivalent head of the pressure target. This allows for the assessment of the flow available under minimum residual pressure conditions, providing insights into the system's performance during fire scenarios. It's important to note that EPANET treats emitters as a property of a junction rather than considering them as a distinct network component. This implies that the modeling of emitters is integrated into the broader simulation framework of the junctions within the EPANET software.

Water distribution networks are typically designed to accommodate peak demands, ensuring that during routine operations, there is ample pressure to meet nodal demand. However, this design approach can lead to elevated pressure levels during periods of low consumption. The surplus pressure during low-demand periods contributes to significant issues such as water leaks and pipe breaks. The heightened pressure when consumption is low is a critical factor in the occurrence of water leaks and pipe breaks within the distribution network. The additional pressure stresses the infrastructure and increases the likelihood of failures, leading to both economic losses and water wastage. To address this challenge, it is essential to consider the pressure head available at the delivery node. In the proposed study, a case study network is chosen as the basis for investigating the impact of varying the empirical exponent coefficient on emitter exponent and emitter coefficient within the water distribution system. The simulation results are presented and discussed in the following section.

Literature Review

The ongoing research involves the revitalization of an existing network and the development of a water distribution network through the utilization of a programming tool. The network comprises pipes, nodes, pumps, valves, and storage tanks or reservoirs. EPANET, a widely used software tool, is employed to compute water flow in each pipe and determine the pressure at each node. This endeavor is part of a comprehensive strategy to overhaul the current network paradigm to meet the evolving demands over the next three decades. Adhering to the guidelines established by the Central Public Health Environment Engineering Organization (CPHEEO) handbook, the objective is to ensure that the designated residual pressure and flow parameters are met at all nodes and connections. This meticulous approach is crucial to guarantee the optimal functioning and reliability of the water distribution system, aligning with industry standards and regulatory requirements.

Varun Shinde et al. 2023. The provided text outlines a detailed water supply system modeling project in Fangcun District of Guangzhou. It involves steps like pipe network extraction, DEM elevation extraction, and simplification using GIS software. The integration of Arc Engine, EPANET, and MATLAB/Simulink enhances the modeling process with real-time evaluation capabilities. Emphasizing careful design, proper maintenance, and a 30-year design period reflects a forward-looking and sustainable approach to water supply infrastructure

The research involves renovating an existing network and developing a water distribution system using the EPANET programming tool. EPANET conducts extended simulations to analyze hydraulic and water quality dynamics in the pressurized pipe network. Components include pipes, nodes, pumps, valves, and storage tanks. EPANET calculates water flow and node pressure, aiming to improve understanding of water movement in distribution networks and enhance drinking water delivery. The study highlights EPANET's application in hydraulic investigations, emphasizing its role in advancing research and optimizing water distribution system efficiency.

Md N. Almasari (2014) it appears that you've provided information about the simulation of a water distribution network using EPANET and the optimal design of the network. It's important to note that the text you've given seems to be specific and likely unique to a particular report or document. If you have a specific request related to this content or if you want assistance with something related to water distribution networks, EPANET, or optimal design, please provide more details or specify your question. If you're concerned about plagiarism, it's crucial to ensure that you are not using someone else's work without proper attribution. If the provided text is from a report or publication, make sure to cite the source properly according to the required citation style.

Study area

Ramnaresh nagar is located northwestern part of Hyderabad, Medchal-Malkajgiri. The piped water supply system for the Ramnaresh nagar was started in 1993. The main language spoken here is Telugu. It is one of the busiest business hubs in Hyderabad famous for its clothing and eateries. Ramnaresh nagar used to be an Industrial corridor in the northwestern part of Hyderabad. Its population began to grow after the early 1990s, with many people migrating from Andhra Pradesh and settling in and around Kukatpally. It is also home to the large chuck of IT goers due to its proximity with Hitech city. There are many small scale industries based in

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Kukatpally - Sanathnagar belt. The nearest airport is Shamshabad, and nearest metro station is "Miyapur metro railway station". Latitude and longitude coordinates are of 17°29'24" to 17°30'15" North and 78°62'84" to 78°63'58" East respectively as shown in the below figure 1, and the GIS based network model

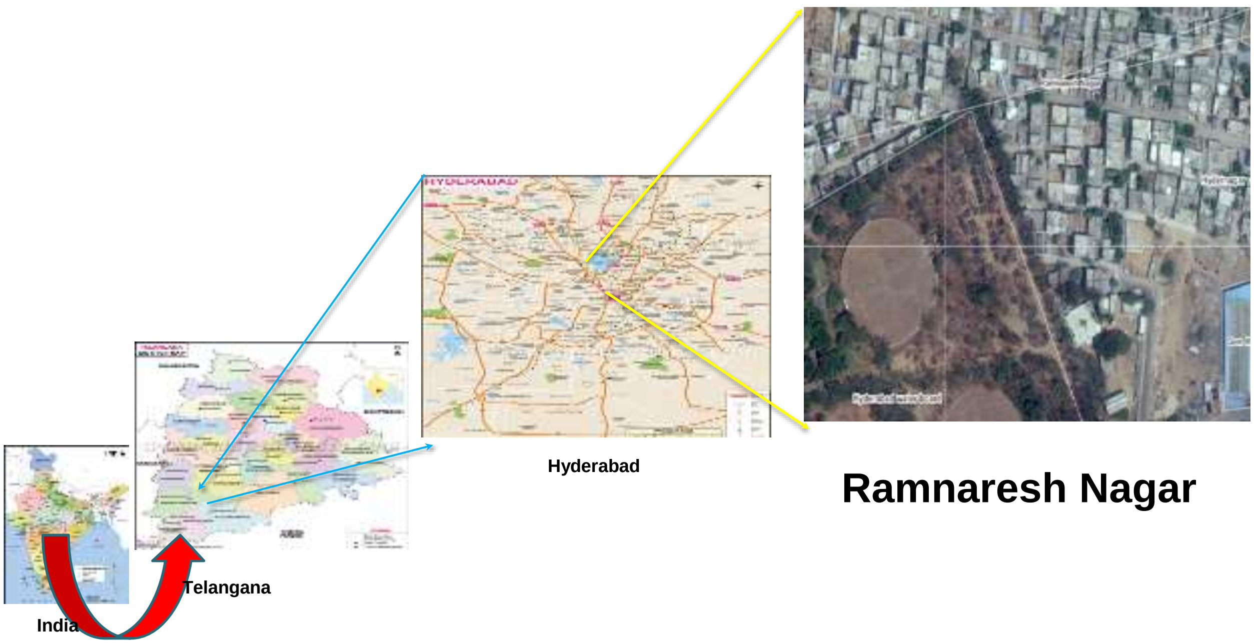

Fig. 1 Delineated area of Ramnaresh nagar

Elevation / Altitude: 547 meters. Above Mean Sea level, Climatic Temperature is 27 °C Humidity: 52%, Annual Rainfall: 615.6 mm (per year), Average Wind speed: 9 kmph Population: 10150, Study area covers: 92,631 m² (997,077 ft²). Number of connections: 500 Length of pipeline: 3.22 km. Population growth rate 2.92%, Density of the population: 5,221 persons per square km. Source of water Krishna and Godavari rivers and their tributaries reservoir capacity: 5 mgd and Number of junctions are: 48.

Methodology

The input parameters are diameter, start& end nodes, roughness coefficient and length. Commuted output parameters are Pressure, flow rate, velocity. Flow chart of step by step procedure of EPANET shown in Fig. 2

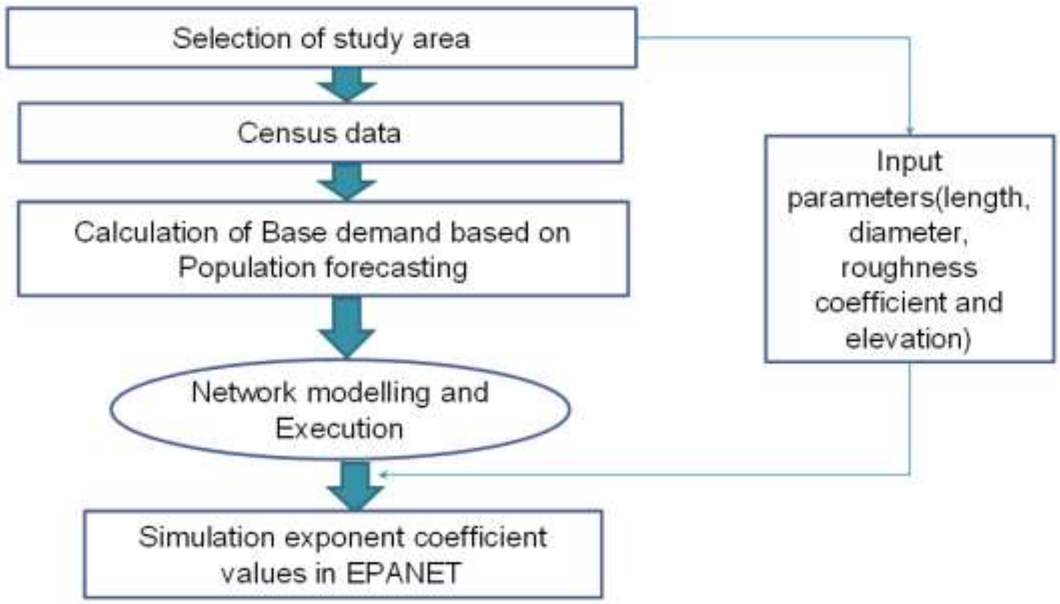

Fig. 2 Flow chart of step by step procedure of EPANET

The head loss observed a pipe due to friction with the pipe walls can be computed using Hazen William's formula based on Hazen Williams roughness coefficient. Emitters are instrumental devices linked to junctions in fluid systems, designed to simulate the flow dynamics through a nozzle or orifice that releases fluid into the surrounding atmosphere. The flow rate passing through the emitter is not constant but rather fluctuates based on the pressure existing at the connected node. This variability in flow is a key characteristic of emitters and plays a crucial role in modeling and understanding fluid behavior in a given system:

$$q = Cp^{\gamma}$$

Where q = flow rate, p = pressure, C = discharge coefficient, and γ = pressure exponent. For nozzles and sprinkler heads γ equals 0.5 and the manufacturer usually provides the value of the discharge coefficient in units of gpm /psi 0.5.

Results and Discussion

The area for which the water distribution network design for Study area is giving the all required parameters, the EPANET software is made to run successful which is shown in below figure 3 the type of distribution network designed here is of dead end system and method adopted to supply water is of gravitational method.

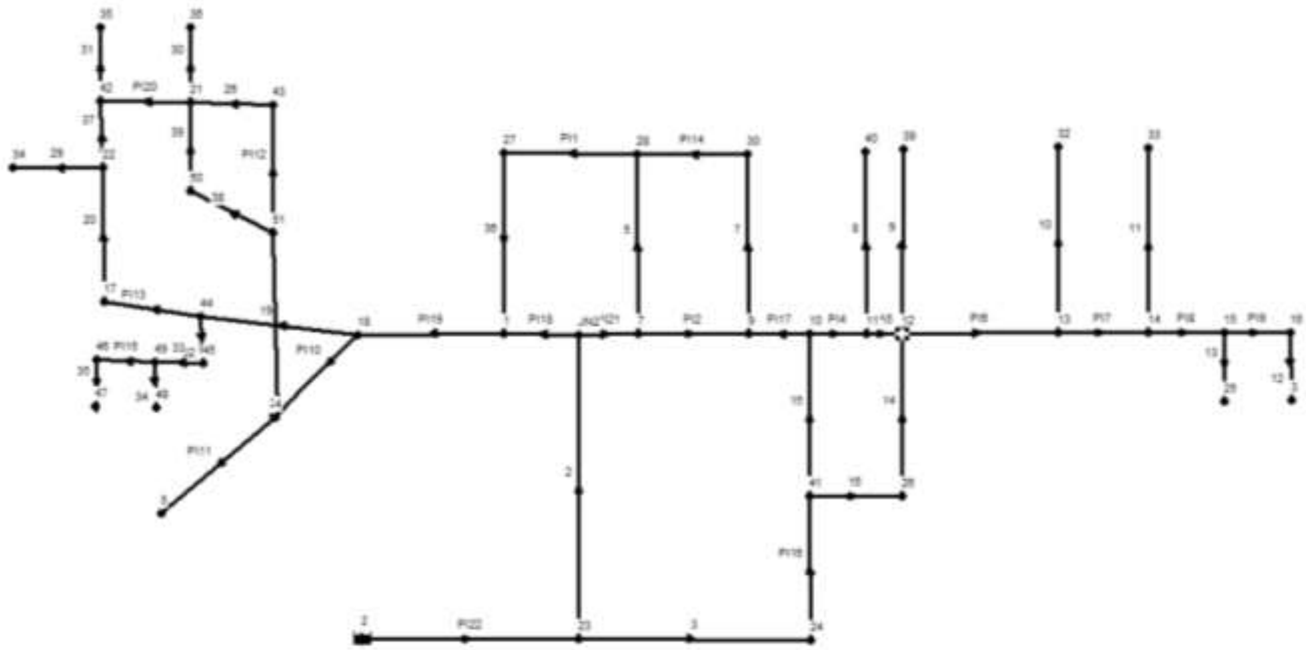

Fig.3 Status of the network

The external leak detection tools or methodologies, EPANET itself does not directly detect leaks, but additional software or methods (such as pressure sensors or acoustic leak detection) can be employed in conjunction with EPANET results to identify potential leak locations (Nodes).

Table 1. Results of Actual demand and pressure head at different nodes

Junction Id	Actual demand (m^3/sec)		Difference in demand (m^3/sec)	Pressure head (m)		Difference Pressure head (m)
	Emitter coefficient = 0	Emitter coefficient = 1		Emitter coefficient = 0	Emitter coefficient = 1	
3	0.12	4.16	4.04	15.73	12.99	2.74
9	0.30	3.99	3.69	13.76	13.59	0.17
12	0.48	4.48	4	16.75	15.98	0.77
18	0.36	3.93	3.57	13.69	12.73	0.96
21	0.48	4.10	3.62	14.65	13.13	1.52
26	0.20	4.24	4.04	16.76	16.29	0.47
41	0.24	4.27	4.03	17.77	16.26	1.51
52	0.61	3.93	3.32	12.76	11.01	1.75

The emitter coefficient and emitter exponents from Table 1 are used to simulate water distribution network for studying the effect of empirical exponent coefficient on demand and pressure, total eight cases are simulated in EPANET 2.2. The node numbers taken are 3, 9, 12, 18, 21, 26, 41 and 52 are considered to get better results in the water distribution network.

Conclusion

As empirical exponent coefficient increases the keeping emitter exponent as constant the Actual demand values increasing and pressure head values are decreasing. As emitter exponent is inverse of empirical exponent coefficient and is used in emitter equation in EPANET. The effect of variation of empirical exponent coefficient on actual demand is studied with the help of hydraulic simulation of network.

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