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Review on Modeling of Water Quality Deterioration in the Distribution Network Using MATLAB

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ABSTRACT -
The history of water supply and distribution is as old as the history of civilization. Water supply systems have become an important and necessary element in today's society. It also shows the level of social progress. Water networks (WDN) are one of the key components of water supply systems, accounting for nearly 70% of the total cost. Optimal design of distribution networks is the goal of every agency that manages distribution. Paying attention to the reliability of distribution networks has been noticed in recent years. In the present research, the main focus is on the development of new parameters to evaluate the reliability of the entire network using fuzzy logic concepts based on the excess pressure in the demand node and their inclusion in the optimal design. Dual purpose optimization model for designing water distribution networks using MATLAB environment.

Key Words: Optimal Design, NRP, Fuzzy Logic, Water Distribution Network, MATLAB, etc.

1. INTRODUCTION

Water is one of the basic needs of life on earth for all living things. People need water for many of their daily life activities. In the beginning, humans lived near water such as rivers and lakes. This led to the development of water supply engineering as a part of civil engineering to develop systems that provide protected water to all and meet their demands. The water distribution system consists of several components such as water extraction, pumping, water supply, purification, storage and water distribution network.

Supply water with the required pressure to draw enough water. Design plays an important role in water distribution systems. Optimal design of distribution networks is the goal of every agency that manages distribution. Water distribution networks can be designed through trial and error methods and the use of simulation models. Choosing a network configuration with the lowest pipe cost and highest reliability is a complex process.

Recently, attention has been paid to the reliability of the distribution network. If the network is primarily designed for reliability, the resulting system may not be economical.

A literature review shows that most researchers prefer genetic algorithms (GA) as one of the best heuristic methods for optimal distribution chain design. Most researchers use EPANET as a tool for analyzing optimization algorithms. Currently, many researchers are focusing on the optimal distribution network design based on reliability. However, various researchers have proposed various reliability parameters to measure network reliability, and most have focused on throughput reliability. Most researchers have focused only on meeting the minimum requirements of the constraints of the optimization problem. To meet the minimum requirements, binary logic is used only by impractical researchers. Demand node pressure plays a very important role in any distribution network. Therefore, the designer must consider the possible overpressure, not the minimum pressure on the structural side.

This study focuses on the development of new parameters to evaluate the reliability of the entire network using the fuzzy logic concept based on overpressure at the demand node and take it into account in the optimal design. Dual-purpose optimization model for designing water supply networks using the MATLAB environment.

The network reliability parameter is defined as the ratio of the total demand of the network multiplied by the node demand to satisfy the node's load. Satisfaction is based on the additional pressure available on the Demand node after the minimum requirement is reached. Fuzzy logic is used to link the excess pressure of the need node with the satisfaction index.

2. FORMULATION OF THE PROBLEM

- The problem is a dual goal because minimizing the total cost of the network and maximizing reliability are considered two goals.
- There are several solutions with different cost and reliability in this situation. Our goal is to get a Pareto-optimal front that consists of several Pareto-optimal solutions.

3. OBJECTIVE

- Develop new parameters to evaluate the overall stability of the network.
- A study of the concept of fuzzy logic based on overpressure available in consumer nodes.
- For optimal design.
- Include parameters in dual-objective optimization models.
- Design a water network in MATLAB.

4. REVIEW OF LITERATURE

Because of its practical importance and inherent complexity, the optimization of distribution networks for the supply of drinking water has been the subject of extensive research over the past 30 years (Edgar Reehuis-2010).

Saud A. Taher and John V. Labadie (1996) developed a decision support system for the analysis and design of drainage systems using linear programming (LP) and GIS.

In LP, objective functions and constraints are mostly linear. However, in practice, the equations used in the analysis and design of water networks are highly non-linear and very complex. Another downside is that the reliability aspect is not taken into account at all.

Wu Zee & Simpson A.R. (2001) applied one of the evolutionarily efficient genetic algorithms - a fuzzy genetic algorithm to increase the efficiency of optimization methods for the optimal design of distribution networks. However, the reliability aspect is not considered in the design aspect.

Muzzafer and Lansey (2003) developed the NET (SFLANET) algorithm, a computer model that links SFLA with the EPANET hydraulic simulation software and its library features. There is no place in the design where reliability is considered.

The aim of Aklog D and Y. Hosoi (2003) is to introduce a new reliability-based optimal design that determines the minimum allowable pipe size during minimum cost design for system reliability. However, pressure satisfaction is not considered at the demand nodes of the network.

Huynh T. Luong and Nagen N. Nagarur (2005) developed a mathematical model aimed at supporting the decision to allocate funds between pipes in a network and to repair or replace pipes in a failed condition.

The objective function of the model is to maximize the overall weighted long-term availability of the entire system. The concept of hydraulic reliability is used to determine the weight of a pipe in a maintenance program.

Bhave PR and R Gupta (2004) attempted to design a network using a modified fuzzy linear programming model with loop head loss constraints as path loss constraints to avoid iterative procedures. However, the reliability of the network overpressure is not included in the model.

Vamvakeridou et al. (2007) used HA with a fuzzy membership function to model a floating reservoir in the system to optimize a water distribution network. Tank capacity and minimum normal operating level were used as decision variables.

Afshar M.H. (2009) proposed a compact genetic algorithm to reduce the storage and computational requirements of population-based genetic algorithms.

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Multi-component water quality models generally have many applications to solve complex real-world water quality problems. Examples include predicting the reaction of chlorine in distribution networks, the decomposition of chloramines, and the reactivity of water supplied at various points (Shang et al.2008a). Although undesirable, pressure shortages can result from selective network blockages for maintenance and repair purposes, pipe ruptures, pump failures, power outages, and unexpected large-scale firefighting needs. Existing demand-driven hydraulic models of water distribution systems assume that demand is fully met even if the network is under pressure. This assumption is only true when the network operates under normal pressure conditions.

Low pressure conditions can also facilitate entry of pathogens through pathways such as cracks and leaks (Besner et al. 2011; Nygard et al. 2007; Hunter et al. 2005). It is therefore important to have an integrated model that can realistically and seamlessly model both pressure deficits and water quality. In more than 30 years, many attempts have been made to develop realistic pressure-based analytical methods, and models have been used to solve a variety of problems including reliability evaluation, parameter calibration, reliability-based design, and isolation valve placement. and leak management. (Gupta and Bhave, 1996; Giustolisi et al. 2008; Tsakiris and Spiliotis, 2014; Elhai et al. 2015). In recent years, solutions to some benchmark optimization problems have been significantly improved using pressure-based analysis (Siew et al. 2014, 2016). However, these models have not been considered in water quality studies related to issues such as loss of disinfection residues and ingress of contaminants under low pressure conditions (Rathi and Gupta 2015; Rathi et al.2016).

5. NETWORK USED IN THE PRESENT STUDY

Two-circuit gravity network used in this study consists of 8 links, 6 demand nodes, and 1 tank. Assume that all links in the network are 1000 m long and have a Hazen-Williams (CHW) factor of 130. The minimum HGL value required by the Demand node.

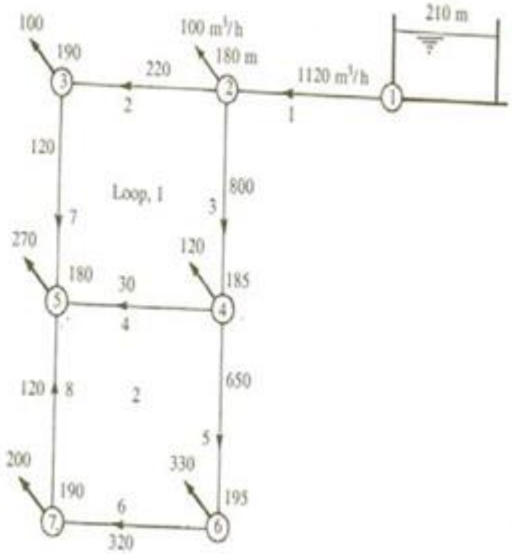

Figure 1: Two Loop Gravity Network

6. CONCLUSION

The approach proposed in this study is described in the following steps. This study uses a combination of MATLAB's genetic algorithm toolkit for optimal design for network analysis. The code for this is developed in a MATLAB editor file.

Water companies are committed to ensuring that you get impeccable quality drinking water from your treatment facilities. The purpose of the distribution chain is to fulfill the legal obligation to deliver sufficient water to consumers under sufficient pressure. Next to this quantitative goal is a qualitative goal of dispensing drinking water to maintain perfect quality while passing through the network. More realistically, the goal is to control degradation to meet consumption standards.

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