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# Optimization and Design of Water Distribution Network Using Software Application: A Review

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***Abstract: With expanding populace development, rotting framework in regions and modern improvement, water stream rates and other pressure driven prerequisites related with water conveyance arrange have been evaluated to increment both in national and in neighborhood scale. The supply of spotless and safe water in sufficient amount at wanted end weight is the prime worry of every single civil body. Water deficiency will make bother individuals' life and it will affect city work and industrial production. Henceforth to beat this issue plan and examination of Water conveyance arrange is important to get optimal discharge. This examinations incorporates all extraordinary part of water distribution network like pipelines, pumps, valves, and sources. Additionally review about network working under demand loadings in view of populace estimate. The factors ought to resemble plan parameters, i.e. pipe diameter, pump limits and storage reservoir elevation, and operational parameters i.e. pumps and valves and so forth. This paper includes reviews of various papers which incorporates the optimization, design and analysis of Water distribution network.***
***Keywords: Water distribution network, Demand of water, Analysis, System components, Design, Optimization.***

## I. INTRODUCTION

In India interest for demand of water is constantly expanding because of populace development, modern advancement, and enhancements of economic conditions. Water appropriation frameworks by and large comprise of various wellsprings of supply from which water is pumped to capacity repositories to meet requests at customer hubs through interconnected pipeline systems. In numerous water distribution networks, because of a lot of vitality are required to pump, transport and apply water, enhanced administration of pumps prompting a decrease in vitality use and operational cost. In the event that we do not have the precipitation for broadened timeframe, we will confront issue of water deficiency. On other hand it needs to deliver safe drinkable water. Then again, it needs to give improved administration to client. In the event that you have a water deficiency, it will make bother individuals' life and it will affect city work and modern creation. Outline and examination of pipe systems are imperative, not just on the grounds that water is a vital monetary improvement parameter, yet additionally in light of the fact that water is a deciding factor later on of peace between states or between nations.

## II. LITERATURES

Different author studied for water distribution system regarding design, analysis, optimization, modelling, components etc. Their contributions, methods and outcomes are summarized below.

### *A. Literature on Analysis of Water Distribution System*

has illustrated the application of Microsoft Excel software to briefly and efficiently solve small network distribution problems using linear theory. However this method is not suitable for large and constrained networks.

### *B. Literature on Optimization of Water Supply System*

(SHAMIR E. A., 1977) gained optimal design of a water distribution system using method named linear programing gradient. The system is a pipeline network, which delivers acknowledged demands from sources to consumers and may contain pumps, valves, and storage reservoirs. The objective function be minimized which reveals the overall cost capital in addition to present value of operating costs. The solution is found via a hierarchical decomposition of the optimization problem.

(Prabhata-K-Swamee, 2006) presented cost structure of piped-network system has been discussed for developing an objective function based on the cost. The objective function is a function of decision variables, which are also generally known as design variables like pumping heads and pipe diameters. Such a function has to be reduced or minimized subject to safety constraints like least pipe diameter, least terminal pressure head and maximum velocity of flow; and constraints of system like total loop head loss summation and nodal discharge summation. These constraints along with important parameters for network sizing like demand of water, water supply rate, peak factor and design period are mentioned in this literature.

(Y. R. Filion and B. S. Jung, 2010) The imbedded aim of water supply network design is to deliver satisfactory service during normal and peak demands and to bound damages to property and people during fires. In spite of this, fire damages are seldom explicitly involved in network design. This paper shows a single-objective particle swarm optimization program that integrates a new measure of projected conditional fire damages to size local water distribution mains for fire flow protection in residential areas. The optimization approach produces trade-off information to help services determine the cost proficiency of adding new pipe capacity to decrease the risk of fire damages in water networks. The optimization program was applied to an 8-pipe distribution network and a 34-pipe distribution network to create trade-off curves for pipe cost and fire damages. A sensitivity analysis showed that the level of insecurity in fire flow had a little effect on pipe sizing and cost in the 8-pipe network. Optimization outcomes in the 34-pipe network braced the industry practice of using a minimum 150-mm distribution main sizing to provide fire flow protection.

(Taher & Labadie, 1996) presented prototype decision supporting system WADSOP (Water Distribution System Optimization Program) to lead water-distribution system design and analysis in response to changing water demands, timing, and use patterns; and accommodation of new developments. WADSOP incorporates a geographic information system (GIS) for spatial databank management and exploration with optimization theory to deliver a computer-aided decision support tool for engineers working in field of water. Some relative studies indicate improved performance over the published results. A real-world case study for the Greeley, Colo., water-distribution network is presented too. WADSOP capably handles the design of large systems with multiple pipe sizes, loads and pipe costs in a lone run. Computer time required for the design of the network in particular example was 14 sec compared to 41 min required by WADISO. The optimization practice in WADSOP directly integrates pipe sizes as discrete variables, while some other models require variables as continuous. Rounding off to the close available pipe size can lead to solutions that aren’t optimal or fail to satisfy all necessities.

### *C. Literature on Highest Demand Factor*

(Cara-D-Beal, 2014) aimed to recognize the water end-uses that can obtain peak day demand and to inspect their related hourly diurnal demand patterns based on over eighteen months of water consumption figures gained from high-resolution smart meters installed in 230 residential assets across South East Queensland, Australia. Peak day (PD) to average day (AD) ratios between 1 & 1.5 were determined by both internal and external end-uses. Though, as the PD:AD ratio raised above 1.5, demand was determined largely by external water usage (i.e., garden usage). Peak hour ratios (i.e., PHPD: PHAD) ranged from 1.3 to 3.0 for the 4-peak demand days. At the end-use level, the particular end-use category PHPD:PHAD ratios were in the range of 0.7–3.3 for every end-uses, with the allowance of external or irrigation. The ratio for this latter end-use category was very high, at over ten times the average irrigation demand. Comparisons with historically based, but currently used, peaking factors used for network distribution modelling advise that the degree and frequency of high peaking factors are lower nowadays, because of the high penetration of water-efficient technology and rising water conservation awareness by users.

modelled seven realistic MWDSs (Municipal water distribution systems) with variable user demands to compute energy consumption. It was realized that the relation or bonding between normalized demand and energy usage was linear and the curves obtained for all 7 systems analysed collapse onto a line. Moreover, in the range of water conservation of up to 20%, this linear relationship was nearly a perfect line and proposed that 14% energy savings was realized by a 20% user demand lessening. The results found from this analysis might be helpful for other pump-dominated schemes.

(Austin-S.-Polebitski and Richard-N.-Palmer, 2010) Research and develop on regression-based water demand models helpful for foretelling of single-family residential water demands within specific census tracts at a bimonthly time-step. The regression models are expected using twelve years of demographic, economic, weather, and metered bimonthly water consumption data related with over hundred unique census tracts in Seattle, Washington. Generally, the three regression methods well-performed in replicating total single-family water consumption in the study area. Two regression models, a fixed effects model and a random effects model, offer improved estimates of water demand within individual census tracts.

Enhanced water demand forecasts at the spatial scale of census tracts offer policy producers and planners information useful for management of water resources. These projected approaches permit examination of spatially distributed demands inside systems, identify the value of directed conservation and infrastructure development, and develop understanding of the variables affecting demand in heterogeneous areas. The coefficient evaluations developed in this research are suitable for usage in spatially disaggregate urban simulation models.

*D. Literature on models for optimization of water distribution system*

(Kevin-E.-Lansey, 1989) developed methodology for determining the optimal (minimum- cost) design of water supply systems. The parts that can be sized are the tanks, pumps or pump station, and pipe network. Moreover, the optimal settings for regulation and pressure-reducing valves can be determined. This methodology combines non-linear programming techniques with current water distribution simulation models. Prior methodologies have typically shortened the system hydraulics to be able solving the optimization problem. This fresh methodology keeps the originality of the hydraulic simulation model so that the problem is only limited by the ability of the simulation model compared to the optimization model. The methodology practices a generalized reduced gradient model for solving a problem that is compacted in size and complication by implicitly solving the conservation of energy and mass equations using the hydraulic simulator and an augmented Lagrangian method to incorporate pressure head constraints in the objective function. For the meantime the network equations are solved implicitly. Any number of demand patterns can be considered, including steady state loads and/or EPS i.e. extended period simulations.

*E. Literature on Sensitivity Analysis*

(Guangtao-Fu, 2012) Sensitivity analysis of water distribution systems using Sobol's method is done, with the intent of improving the optimization process for complex design problems. Generally, sensitivity analysis can enrich optimal design by reducing the size of search spaces, guiding the optimization procedure, identifying the most suitable system performance metrics, and obtaining the key uncertain sources in the case of stochastic design. Sobol's method is a global sensitivity analysis method that offers detailed information on main parameter effects and their interconnections. 2 Sobol sensitivity indices (first-order and total-order indices) are calculated using the Latin Hypercube sampling method. Sensitivities have been enumerated for numerous different performance metrics, together with total pressure deficit, resilience, maximum pressure deficit, minimum surplus pressure, probabilistic robustness, and a specific risk measure. Two case studies are investigated: the Any-town network and the New York Tunnels network. Outcomes show that different metrics have a distinguishing response to different decision variables, highlighting the necessity for careful choice of the metrics in the design process. Important interactions occur between different variables when analyzing resilience and risk in the case of New York Tunnels network, and for the minimum surplus head in the case of Any-town network. Additionally, a large portion of decision variables have little influence on many of the metrics, proposing a possible decrement of search space size when solving the problem of optimal design.

*F. Literature on Components*

(Savic, 2008) presented a novel methodology assessment of an isolation valve system and the segments of a water distribution network which are directly isolated by closure of valve. Planned and unplanned breaks occur frequently in water supply networks making it essential to isolate pipes. For isolating a pipe in the network, it is required to close a subset of valves which isolate an unimportant portion of the network, i.e., creating minimum possible interruption. This is not always easy to achieve as the system of valve is not normally considered for isolating each pipe separately. Hence, for the purposes of management, it is essential to identify the association between each valves-subset and the segments directly isolated by closing that set. It is also essential to improve the isolation valve system design so as to increase network reliability. Thus, author described identifying the association between valves and isolated segments algorithm. The method is centred on the use of topological matrices of a network whose topology is improved so as to account for the existence of the system of valve. The algorithm is shown on an Apulian network where the system of isolation valve is planned utilizing a classical multi-objective genetic algorithm as an optimizer.

(Prasad, 2010) presented a method for designing of water supply networks with various network elements such as tanks, pumps and pipes. To solve the suggested single objective model, a steady-state genetic algorithm is used. As objective function minimization of total cost, which includes capital cost as well as energy cost. Tank sizing approach is proposed, which does not require some of the operational constraints such as the limits on maximum as well as minimum tank levels. As proposed here, in the optimization process one conducts extended period simulation for every trial-solution. To demonstrate it well-known "Anytown" water distribution network is solved. The present method is cheaper than those proposed by other scholars under similar performance conditions but with different tank sizing methods. Comparison of the outcomes obtained with those published in the literature shows the benefit of using the proposed model in obtaining near optimal solutions.

(Mallick, 2002) thought about comparisons between design and operation alternatives of water supply system which can be done by mathematical modelling. The true field system must be embodied within the model to make important comparisons. Water distribution systems contain a large number of pipes with unknown roughness coefficients. Even with an extensive data collection effort, pipe roughness for all links cannot be determined exactly. Therefore, the system is simplified by assuming sets of pipes have the same roughness coefficient. The impacts of such simplification have not been examined in a quantitative manner. This work produces a methodology to count impacts implied by system simplification and detect the best number of pipe groupings for a network. As the number of pipe groups is decreased, less data is needed to accurately calibrate those parameters. The optimal dimension is determined through a comparison of model and model prediction errors. The methodology compares the model error resulting by assuming that more than one pipe has the same roughness coefficient (pipe groups) as the number of pipe group increases, model prediction uncertainty increases while model error decreases. The reverse occurs as the parameter dimension is reduced. It has been shown how these optimal sets are related to predicted demand levels and the variability in roughness between pipes.

(Giustolisi, 2010) said the classical assumption of representing total demand along a pipe as two lumped withdrawals at its terminal nodes is common up till now. It is a simplification of the network topology which is useful so as to drastically reduce the number of nodes during network simulation. But, this simplification does not preserve energy balance equation of pipes and because of this, it is an approximation that could generate significant head loss errors. He has presented a modification of the global gradient algorithm (GGA) which entails an enhancing of GGA (EGGA) permitting the effective introduction of the lumped nodal demands, without forfeiting accuracy of energy balance, by dint of a pipe hydraulic resistance correction. The robustness and convergence properties of the algorithm are compared with those of the classical GGA. Furthermore, the effectiveness of EGGA is demonstrated by computing the network pressure status under different configurations of the connections along the pipes of a test network. EGGA has been proven to be more convergent than GGA.

## III. CONCLUSIONS

There are several software available for the design and analysis work of water distribution network like EPANET, Water GEMS, LOOP, WADISO, H2Onet, Pipe2000 etc. EPANET and Water GEMS are more efficient and advanced at present. Small network analysis can be done with the help of EXCEL spreadsheet too. Linear programing optimization method as well as Genetic algorithm method is convenient and easiest method for small area network system. Design must fulfill the reliability requirements like required head, allowable velocities etc. Reading several literatures like these, we can decide our analyzer software, method of data collection and finally can give the optimization result i.e. cost saving from different aspects considering reliability constraints.

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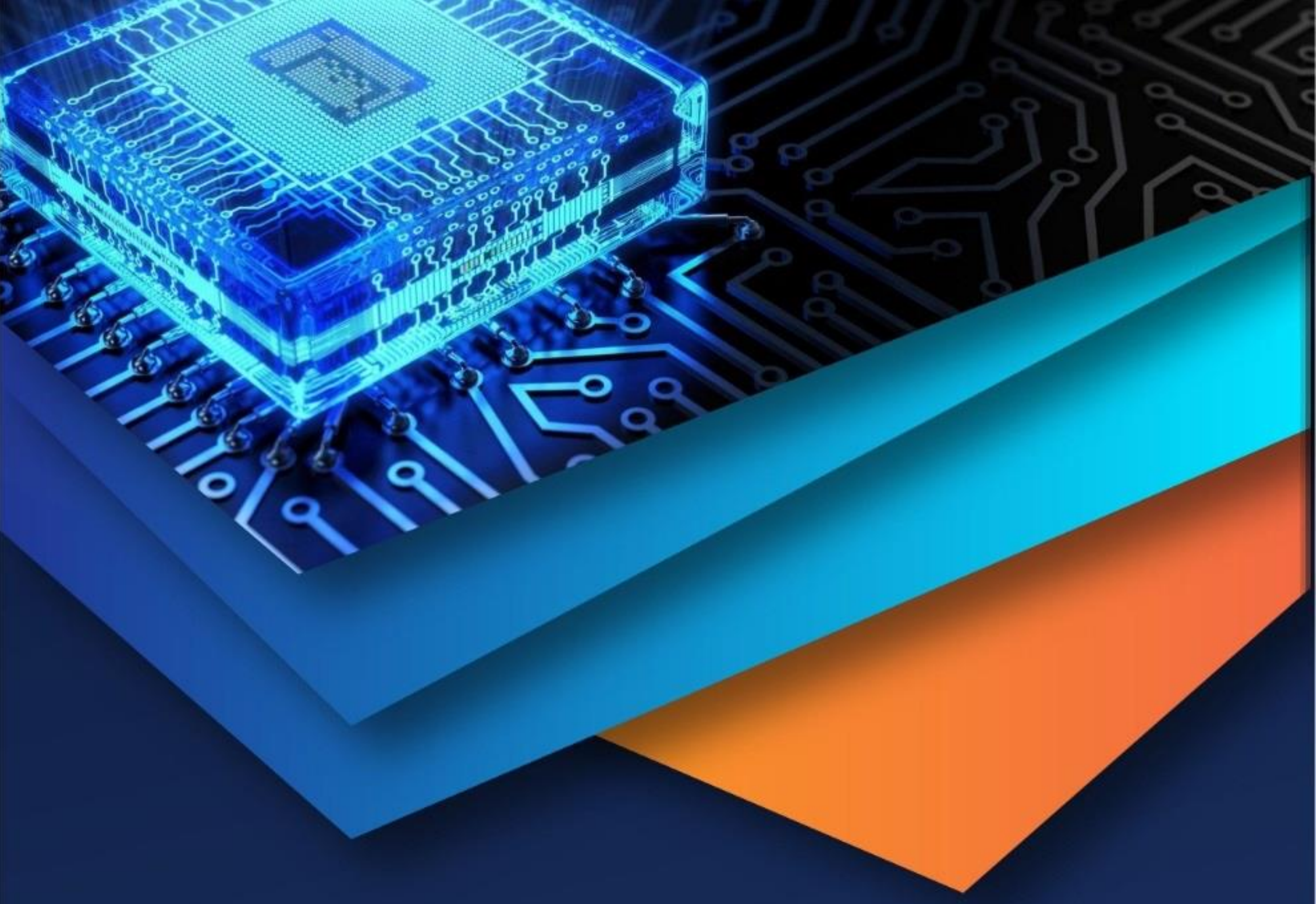


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