WATER SUPPLY PROJECTS EVALUATION WITH WATERGEMS SOFTWARE

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ABSTRACT

Water distribution network is necessary infrastructure for supply of water. It connects consumers to sources of water using hydraulic components such as pipes, valves, pumps and tanks. The primary aim of water distribution network is to deliver water to meet the demands on pressure and quality. WaterGEMS is hydraulic modeling software which is used for analysis and design of water distribution network. The study presents hydraulic analysis of Punwale village. Google Earth used for ensuring layout of water distribution network and Satellite image of study area shown effectiveness for selection of alternate alignment of road. Steady state analysis has been carried out for calculation of hydraulic parameter such as head pressure and flow rate. The result obtained verified that the pressure at all junction and the flows with their velocities at all pipes are feasible enough to provide adequate water to the network of study area. Keywords – Pipe Network, Simulation, WATERGEMS.

1. Introduction

Water GEMS is a hydraulic modeling application for water distribution systems with advanced interoperability, geospatial model building, optimization, and asset management tools. From fire flow and constituent concentration analyses, to energy consumption and capital cost management, Water GEMS provides an easy-to-use environment for engineers to analyze, design, and optimize water distribution systems. A water distribution network is an essential hydraulic infrastructure which is a part of the water supply system composed of a different set of pipes, hydraulic devices and storage reservoirs.

Water distribution network connects consumers to sources of water using hydraulic components. Water distribution system infrastructure is a major component part of a water utility. A good distribution network system is essential to improve the efficiency of water supply. Water distribution network systems are designed to deliver water from a source in the adequate quantity, quality and at satisfactory pressure to all individual consumers.

A distribution network may have different configurations depending upon the layout of the existing area. Generally, water distribution network has a branched and looped type of configuration of pipelines. A network is said to be an optimal network in which layout is not fixed priori but it is allowed to vary in order to obtain the optimal solution. The task to be performed in this context involves resolution of two problems which are layout and design Water GEMS software is developed for design and analysis of water supply network.

The software is also used for expansion of existing water distribution network. The software provides required standard and economic environment for design, analysis and troubleshooting of new and existing

supply network with minimum time duration. Water GEMS software algorithm is based on Gradient method. Water GEMS software gives optimal solution irrespective of type of network i.e. network may be branched network, looped network or combination of branched and looped network. In other words, Water GEMS software gives solution of any simple or complex network.

The key feature of Water GEMS software is that, it can be used to accurately simulate network before it has been built or modified. Since Water GEMS is computer-based software, while simulation of network it can easily identify potential problems and nullify them within interactive environment so That expensive error can be avoided. Water Distribution Networks (WDNs) 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 firefighting.

Networks are designed to meet peak demands. The purpose of a system of pipes is to supply water at adequate pressure and flow However, pressure is lost by the action of friction at the pipe wall. The pressure loss is also dependent on the water demand, pipe length, gradient and diameter. Several established empirical equations describe the pressure–flow relationship these have been incorporated into network modeling software packages to facilitate their solution and use.

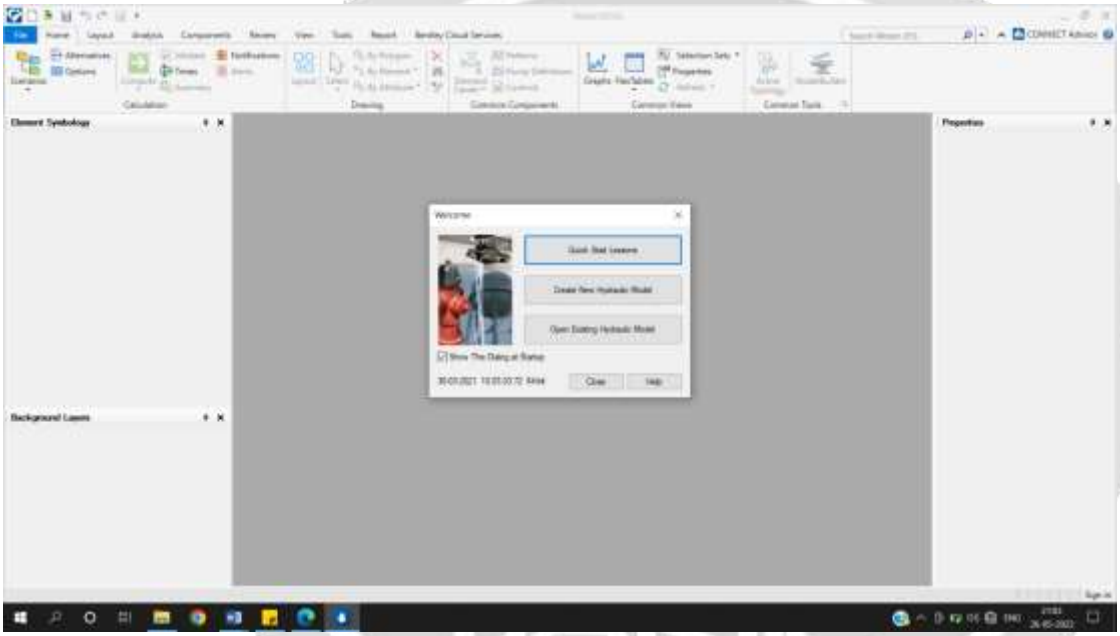

Fig. 1 – Home window of Watergems Software

1.1 PROBLEM STATEMENT

Water is one of the most important natural resource and water scarcity is the most challenging issue at a global level. The water is most crucial for sustaining life and is required for almost all the activities of humankind, i.e., industrial use, domestic use, for irrigation; to meet the growing food and fiber needs, power generation, navigation, recreation, and also required for animal consumption.

1. This project is being implemented to improve the water supply system, to minimize the leakage, and to optimize the water availability to consumers.
2. It was also intended to check the capability of existing water supply system component and optimizing the cost of project.
3. The existing system of water supply is facing problems like a higher rate of leakage, poor maintenance, poor customer service, and poor quality of water with different.

1.2 OBJECTIVES

Water distribution network are designed with an objective of minimizing the overall cost of network while meeting the water demand requirements at adequate pressures for specified maximum design discharge and also to provide possible minimum length of network whose operation and maintenance should be low and economical.

- To evaluate water demand of Area
- Convert intermittent water supply to continuous water supply.
- Zoning of city area on the basis of elevation and population density.
- To study hydraulic parameters of present water distribution system of study area.
- To design hydraulic model for the study area.
- To identify the location of critical points in the existing water distribution system.

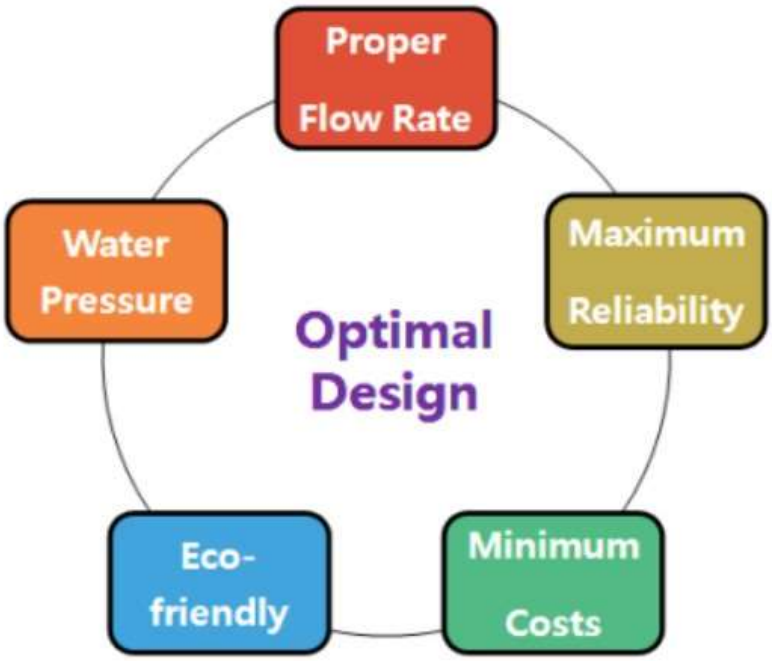

Fig 2- Significance of watergems

2. Scope

1. Preparation of water pipe network in Bentley Water GEMS from GIS files
2. Preparation of hydraulic model and extended period simulation of the same.
3. Load elevations to the hydraulic model from the 3D contour data.
4. Check the design of all the zones of the town for its adequacy
5. Creation of scenarios as required.
6. Preparation of final output of hydraulic design with WaterGems and report, etc. complete.

2.1 LITERATURE REVIEW

1.Thomas M. Walski, Water Distribution System Analysis before Digital Computers,(August 27-30, 2006):

This paper traces the development of analysis.It then looks at how principles developed for individual elements where combined to solve network problems by Cross and the subsequent development of analogy computer methods.With the coming of digital computers, water distribution system analysis has become significantly more powerful because of the ability of modern computers to handle computations much more quickly than could be handled with manual calculations.

2. Review study: Experimental investigation by Water GEMS software for redesign of water distribution system of Bhavani Mata ESR

Prof.A.G.Chaudhari, et al(2017) has worked on Water GEMS software will be used for obtaining optimal design of water supply network of a part of Nasik city.With the help of Water GEMS software, design of optimal water supply network will be done with achieving objective of minimizing the overall cost while meeting the water demand requirements at sufficient pressures for specified maximum discharge over a long period of time.

3. Sajedkhan S. Pathan, Dr. U. J. Kahalekar, Design of Optimal Water Supply Network and Its Water Quality Analysis by using WATERGEMS, (2013):

Design of water supply network duly considering optimization in addition to the cost minimization, minimum head requirement and minimum chlorine requirement is presented.In this paper a part of Aurangabad city is designed and its water quality analysis is done by WATERGEMS software. WATERGEMS software is used for obtaining optimal design of water supply network of a part of Aurangabad city. Design of optimal water supply network and its water quality analysis is done with achieving objective of minimizing the overall cost.

2.2 Methodology

In this study, water distribution supplies as per the study followed following steps.

1. Collected data of Punawale village AREA
2. Census based GIS and elevation Zoning
3. Calculate demand method.
4. Draw area by using Google earth.
5. Extracting and reprojected DEM in QGIS.
6. Import all data in Water GEMS.
7. By using Darwin Designer design optimized water distribution network.
8. Validate and compute the network

Current Population of area (2020) – 10271

Projected Population 2045 (data collected from officials) - 200790

3. Result and discussion

Punawale village is situated in Pune district of Maharashtra state. The source for study area of ESR is located in punawale village. In the area pipes are laid of various materials such as R.C.C., C.I. and A.C. for the distribution system. Primarily, reservoir was a focal point from where the pipes and nodes will be drawn through Water GEMS software. Elevation and flow direction were automatically taken from the input parameters by the software. While

digitizing the pipe line and the nodes care were taken elevation was considered from the previous level was considered. Then the network is designed as:

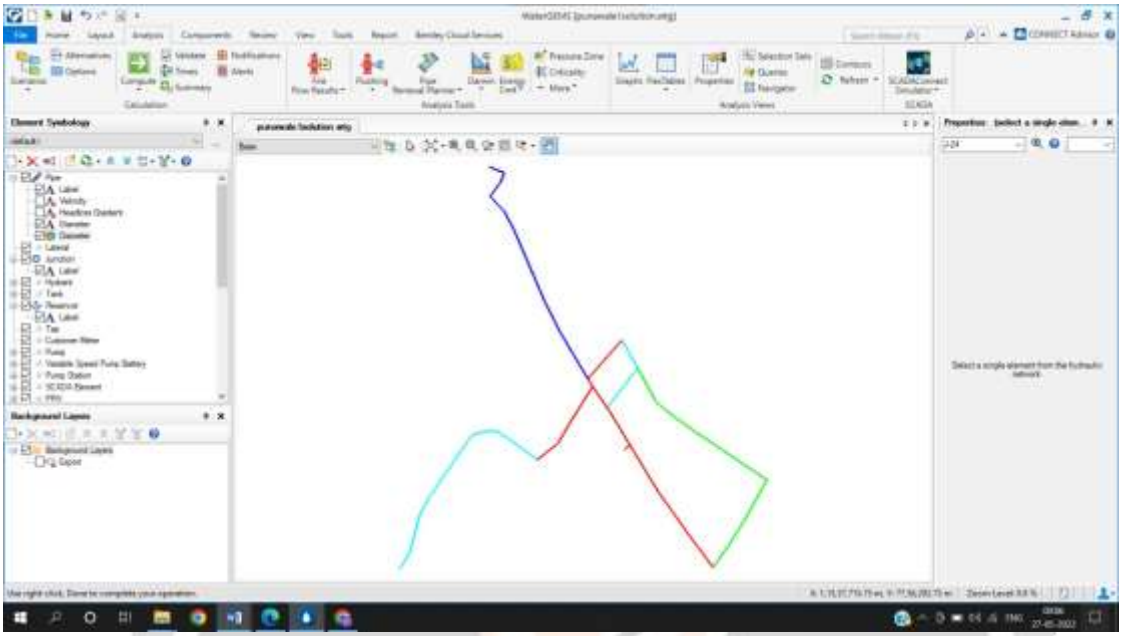

Fig.3 Schematic Diagram of Real Network Showing All Pipes

In the given network the ductile iron pipes are used and the different colors of pipe show different diameters and for distribution of pipe the radial method is used. In the given network different diameter of pipes are shown in different colors and the details are as shown in tables.

Table 1. Pipes with different diameter

Sr.No.	Diameter	Colors
1	150	Blue
2	200	Green
3	300	Pink
4	450	Yellow

Then the complete network is designed and finally the network is computed. After computation of network the next step is to validate the results and if there are errors in network then those errors are adjusted and further the network is validate. Finally, the results for pipe network are obtained as follows:

Table 2. Optimal Layout of Network with Pipe Section Data for DI Pipe

FlexTable: Pipe Table

FlexTable: Pipe Table

ID	Label	Length (Scaled) (m)	Start Node	Stop Node	Diameter (mm)	Material	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)
34	P-1	286	J-2	J-3	450.0	Ductile Iron	23	0.15	0.059
36	P-2	320	J-3	J-4	450.0	Ductile Iron	23	0.15	0.059
38	P-3	357	J-4	J-5	450.0	Ductile Iron	23	0.15	0.059
40	P-4	1,270	J-5	J-6	450.0	Ductile Iron	23	0.15	0.059
42	P-5	1,420	J-6	J-7	450.0	Ductile Iron	23	0.15	0.059
44	P-6	830	J-7	J-8	300.0	Ductile Iron	2	0.03	0.005
46	P-7	522	J-8	J-9	150.0	Ductile Iron	2	0.11	0.134
48	P-8	610	J-9	J-10	200.0	Ductile Iron	1	0.04	0.016
50	P-9	2,206	J-10	J-11	200.0	Ductile Iron	1	0.04	0.016
52	P-10	1,664	J-11	J-12	200.0	Ductile Iron	1	0.04	0.016
59	P-13	2,402	J-12	J-15	300.0	Ductile Iron	1	0.02	0.002
64	P-16	226	J-15	J-16	300.0	Ductile Iron	-10	0.14	0.094
66	P-17	472	J-16	J-17	300.0	Ductile Iron	-10	0.14	0.094
67	P-18	810	J-17	J-9	150.0	Ductile Iron	-1	0.04	0.016
69	P-19	421	J-17	J-18	300.0	Ductile Iron	-10	0.14	0.083
70	P-20	143	J-18	J-7	300.0	Ductile Iron	-21	0.30	0.362
74	P-22	3,709	J-19	J-20	150.0	Ductile Iron	12	0.65	3.466
77	P-24	165	J-2	J-1	450.0	Ductile Iron	-23	0.15	0.059
81	P-26	117	J-15	J-22	300.0	Ductile Iron	12	0.16	0.118
89	P-25(1)	176	J-1	J-24	450.0	Ductile Iron	-23	0.15	0.059
90	P-25(2)	64	J-24	R-1	450.0	Ductile Iron	-23	0.15	0.060
106	P-21(1)	588	J-18	J-27	300.0	Ductile Iron	12	0.16	0.118
107	P-21(2)	915	J-27	J-19	300.0	Ductile Iron	12	0.16	0.118

After finalizing, all the pipes and the nodes, inputs such as demand and the pipe material will be provided to the software. Software takes into consideration of the elevation, contour, demand, pipe material and other parameters. A simulation was carried out by the software's, were it decides the diameter of the pipe and flow direction and flow quantity along with the drawing profile and the results of junctions are as follow

Table 3. Optimal Layout of Network with Junction Data for D.I. Pipe

FlexTable: Junction Table

FlexTable: Junction Table

ID	Label	Elevation (m)	Zone	Demand Collection	Demand (L/s)	Hydraulic Grade (m)	Pressure (m H2O)
31	J-1	571.00	<None>	<Collection: 0 items>	0	599.99	29
32	J-2	570.00	<None>	<Collection: 0 items>	0	599.98	30
33	J-3	570.00	<None>	<Collection: 0 items>	0	599.96	30
35	J-4	572.00	<None>	<Collection: 0 items>	0	599.94	28
37	J-5	572.00	<None>	<Collection: 0 items>	0	599.92	28
39	J-6	576.00	<None>	<Collection: 0 items>	0	599.84	24
41	J-7	579.00	<None>	<Collection: 0 items>	0	599.76	21
43	J-8	572.00	<None>	<Collection: 0 items>	0	599.76	28
45	J-9	575.00	<None>	<Collection: 0 items>	0	599.69	25
47	J-10	575.00	<None>	<Collection: 0 items>	0	599.68	25
49	J-11	584.00	<None>	<Collection: 0 items>	0	599.64	16
51	J-12	591.00	<None>	<Collection: 0 items>	0	599.61	9
58	J-15	581.00	<None>	<Collection: 0 items>	0	599.61	19
62	J-16	581.00	<None>	<Collection: 0 items>	0	599.63	19
65	J-17	581.00	<None>	<Collection: 0 items>	0	599.67	19
68	J-18	580.00	<None>	<Collection: 0 items>	0	599.71	20
71	J-19	578.00	<None>	<Collection: 0 items>	0	599.53	21
73	J-20	581.00	<None>	<Collection: 1 items>	12	586.67	6
80	J-22	581.00	<None>	<Collection: 1 items>	12	599.59	19
88	J-24	567.23	<None>	<Collection: 0 items>	0	600.00	33
105	J-27	579.22	<None>	<Collection: 0 items>	0	599.64	20

3.1 Darwin Designer:

After the computation of junction, we need to execute the Darwin designer. Darwin Designer allows you to design new pipe layouts or pipe rehabilitation for existing pipes. A genetic-algorithm based approach avoids a manual trial and error approach to finding the most efficient design. Solutions and costs calculated using Darwin Designer can be exported back to any scenario.

Cost calculations are performed in Water GEMS in Darwin Designer based on the formula:

Cost = Unit Cost X Length

for each pipe element, where the unit cost is a function of the pipe diameter. The total costs are the sum of the costs for each element.

The user specifies the cost functions and has the option of having different cost functions for different locations (e.g. new developments, central city, stream crossing). The user must identify which pipes are to be included in the estimate and which pipes are assigned to each cost function.

Here are the results:

Table 4. 150mm DI pipe Cost Estimate

Darwin Designer (punawale1solution.wtg): New Manual Cost Estimate

Run - 1

Design Group Results

Design Group	Pipe	Material	Length (m)	Diameter (mm)	Cost (₹)
New Design Group - 1	P-7	None	522	150.0	6,97,403.06
New Design Group - 1	P-18	None	810	150.0	10,81,749.25
New Design Group - 1	P-22	None	3,709	150.0	49,51,792.50

Table 5. 200mm DI pipe Cost Estimate

Darwin Designer (punawale1solution.wtg): New Manual Cost Estimate

Run - 2

Design Group Results

Design Group	Pipe	Material	Length (m)	Diameter (mm)	Cost (₹)
New Design Group - 2	P-8	None	610	200.0	9,91,485.75
New Design Group - 2	P-9	None	2,206	200.0	35,86,505.50
New Design Group - 2	P-10	None	1,664	200.0	27,04,953.75

Table 6. 300mm DI pipe Cost Estimate

Darwin Designer (punawale1solution.wtg): New Manual Cost Estimate

Run - 3

Design Group Results

Design Group	Pipe	Material	Length (m)	Diameter	Cost (₹)
New Design Group - 3	P-6	None	830	300.0	22,41,795.75
New Design Group - 3	P-19	None	421	300.0	11,36,324.88
New Design Group - 3	P-20	None	143	300.0	3,86,945.63
New Design Group - 3	P-21(1)	None	588	300.0	15,86,694.88
New Design Group - 3	P-21(2)	None	915	300.0	24,71,153.25
New Design Group - 3	P-17	None	472	300.0	12,75,142.50
New Design Group - 3	P-16	None	226	300.0	6,09,710.69
New Design Group - 3	P-26	None	117	300.0	3,16,320.06
New Design Group - 3	P-13	None	2,402	300.0	64,86,422.50

Table 7. 450mm DI pipe Cost Estimate

Darwin Designer (punawale1solution.wtg): New Manual Cost Estimate					
Run - 4					
Design Group Results					
Design Group	Pipe	Material	Length (m)	Diameter (mm)	Cost (₹)
New Design Group - 4	P-25(2)	None	64	450.0	2,86,781.19
New Design Group - 4	P-25(1)	None	176	450.0	7,84,903.44
New Design Group - 4	P-24	None	165	450.0	7,33,944.50
New Design Group - 4	P-1	None	286	450.0	12,72,738.13
New Design Group - 4	P-2	None	320	450.0	14,27,081.00
New Design Group - 4	P-3	None	357	450.0	15,91,510.63
New Design Group - 4	P-4	None	1,270	450.0	56,59,575.00
New Design Group - 4	P-5	None	1,420	450.0	63,27,851.50

From Darwin Designer we can estimate the cost of DI pipe of different diameter's

4. CONCLUSIONS

- In this project WaterGEMS software is used for obtaining optimal design of water supply network of a part of Punawale village. The software also gives different alternative optimal design solution considering pipe diameters and pipe material. The WaterGEMS software provide required standard and economical environment for design, analysis and troubleshooting of new and existing supply network with accuracy and minimum time duration. The software is also used for solving problems in existing network and also in expansion of existing water supply network.

- With the help of Water GEMS software an optimal water distribution network is designed and also helps in achieving objective of minimizing the overall cost while meeting the water demand requirements at adequate pressures for specified maximum design discharge over a long period of time.

- In this project Water GEMS software is used for obtaining optimal design of water distribution network of a part of Punawale village

- The software has given three alternative optimal design solution considering design constraints i.e. diameters, roughness coefficient, and cost based on head and velocity dependent analysis. Considering durability, life span of pipe and operation and maintenance point of view an optimal layout network of DI pipe is looking as more precise network .

- The software provides required standard and economic environment for design, analysis and troubleshooting of new and existing supply network with minimum time duration

- The software waterGEMS has an extraordinary feature named as '**Darwin Designer'**, which gives optimum results to maximize benefit or to minimize capital cost of the project. Darwin designer is a generic algorithm. It provides multi criteria optimization. The criteria being performance and cost. The solutions provided by the software are ranked. This allows the user to choose the best solution which suits to his requirements of pressure and availability of money.

- It optimizes the network, on the basis of pressure and velocity constraints given.Darwin designer gives the optimum solution for network which may consist variety of diameter pipes. Hence, from practical point of view, these diameters maybe efficiently arranged.

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