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Augmentation of Water Distribution System of Hingna by Using Water GEMS Software for Zone-3

Rhunal P. Khobaragade, S. R. Khandeshwar

Department of Environmental Engineering, Yeshwantrao Chavan College of Engineering, Nagpur, India

Abstract :- Water is essential element required for the sustenance of life. Demand for drinking is increasing on continual basis with corresponding increasing population. This ever increasing demand can be fulfilled by designing efficient water distribution networks based on advance computing systems include modern hydraulic modeling. In present study water distribution network of Hingna town is designed which is located at district Nagpur, state Maharashtra, India. For the design of Hingna water distribution network, study of present population, population of the three decades, daily water demand, flow characteristics and also survey of the village is done with the help of digital GPS. Water distribution network for the villages is analyzed and designed with help of Bentleys WATERGEMS software. Water distribution network systems are designed to deliver water from a source in adequate quantity, quality and at satisfactory pressure to all individual consumers. Water distribution network are designed with an objective of minimizing the overall cost while meeting the water demand requirements at adequate pressures. A study was undertaken to suggest measures for the improvement to distribution to the distribution system, which can be easily fulfill the demand for water in the town and can lead to development of the town in future. The paper presents results of analysis carried out using Water Gems for basic design of distribution system which consist of reservoir, pipe network and ESR. The design has been done for 24×7 water needs for drinking purpose. As per records, existing distribution systems will not be able to take the load of the same new pipelines are to be proposed to ensure basic water for drinking is easily available for the growing population of Hingna town.

Keywords: - Augmentation of Water Distribution System of Hingna by Using Water GEMS Software for Zone-3

I. INTRODUCTION

The main aim of water distribution system is to convey wholesome water to the consumer at adequate residual pressure in sufficient quantity at convenient points. Requirement of good distribution system:

1. Water quality should not get deteriorated in the distribution pipes.

2. It should be capable of supplying water at all the intended places with sufficient pressure head.

3. It should be capable of supplying the requisite amount of water during fire fighting.

4. The layout should be such that no consumer would be without water supply, during the repair of any section of the system.

5. All the distribution pipes should be preferably laid one meter away or above the sewer lines.

6. It should be fairly water-tight as to keep losses due to leakage to the minimum.

The distribution pipes are generally laid below the road pavements, and as such their layouts generally follow the layouts of roads. There are, in general, four different types of pipe networks; any one of which either singly or in combinations, can be used for a particular place. They are: Grid, Ring, Radial and Dead end system.

OBJECTIVES

The main objectives of the project are:

1. To ensure safe and equitable water supply to the entire population in Hingna town for the next 30 years

2. To ensure the distribution of the water during the entire day (24 x 7 modality)
3. To ensure the technical and economical sustainability of the water supply service
4. To ensure the coverage of area for water supply service will reach up to 100%.

MAIN PROBLEMS OF HINGNA WATER DISTRIBUTION

The Hingna water supply system is affected by many problems which are due to very less coverage water supply system in the town and segregated settlement of the citizens. The Existing water network is very old which is responsible for water losses. This irregular development determined the progressive accumulation of the following problems and deficiencies of the water supply service:

1) The marginal parts of the town receive water in insufficient quantity and pressure and distributed over few hours per day.

2) The system is presently affected by a high level of Non-Revenue Water and water losses largely.

ABOUT TOWN

HINGNA is a tehsil / Taluka place in Nagpur district of Maharashtra. Hingna is peri urban area near Nagpur and industrial suburb of Nagpur city with industries operating from Maharashtra Industrial Development Corporation areas (MIDC). It is also is emerging as a big residential hub near Nagpur city. It is located at about 15 km from Nagpur city. Hingna has an average elevation of 300 m. Total geographical area of Hingna Town is 7.4 Sq.Km. Vena River is passing nearby Hingna Town. The topography of the town is sloping towards Vena River. The civic affairs of this town are looked after by the Nagar Panchayat. It is formed in the year of 2015. The income of the Nagar Panchayat is mainly from property tax, Development charges, Betterment charges, Vehicle tax, Educational tax and water tax, pilgrimage, markets etc.

The geographical coordinates of hingna are 21°4′26″N, 78°57′38″East. The town has a tropical climate. Hingna summer highest day temperature is in between 35 °C to 46 °C. Hingna observes minimum temperature of 12 °C. The average annual rainfall for last 10 years at Hingna is 753 mm. The least amount of rainfall occurs in April. The greatest amount of precipitation occurs in July, with an average of 200 mm.

As per census for the year 1991 Hingna has total population of 4138, for the year 2001 of 5504 total population and for the year 2011 of 7668 total population. So, as per census day by day increases the population of decades.

II. Literature study-

I. Feasibility Analysis of Water Distribution System for Yavatmal City Using Water Gems Software: - Shinde Parmanad Bhaskar (2017), a study was undertaken to suggest measures for the improvement to the distribution system, which can easily fulfill the demand for water in the city and can lead to development of the city in near future. The paper presents results of analysis carried out using Bentley systems Water gems for basic design of distribution system which consist of reservoir, pipe network and ESR. Various materials cost can be marked and cost estimation is not considered in this study as it depends on the authority to approve, but PVC cost is the lowest among the all materials and durable as well. Hence, PVC is suggested for adoption.

II. Analyzing the existing water distribution system of Surat using Bentley Water gems: - Dilip Babubhai Paneria et al (2017), in this study, the existing water distribution system is simulated through construct of a model using Bentley Water Gems. It helped in analyzing the entire network system, visualized the effects of constituent components and parameters as well as pressure at end node is detected low, that shows the consumer near the reservoir having more advantages of water than the one that resides away from the reservoir.

III Review study: Experimental investigation by waterGEMS software for redesign of water distribution system of Bhavani Mata ESR: - Prof. A.G.Chaudhari, et al(2017) has worked on WaterGEMS software will be used for obtaining optimal design of water supply network of a part of Nasik city. With the help of WaterGEMS 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. The software also gives different alternative optimal design solution considering pipe diameters, pipe material and roughness coefficient based on dependent analysis.

IV. Water distribution systems reliability: - A Gheisi, M.forsyth, et al (2016), this study provides an in depth review of the relevant research literature. This research organized and classified the available techniques into three major categories and discussed which technique should be used depending upon the type of failure. Failure in WDS was classified into mechanical/physical, hydraulic and water quality failures. Occurrence probability or rates of failure in pipes, pipes failure combination and criteria to measure reliability were the key factors that affect the WDS's reliability.

V. A review of modeling and application of water distribution network softwares: - Mandar G. Joshi(2015), This ever increasing demand can be fulfilled by designing efficient water distribution networks based on advance computing systems include modern hydraulic modeling and designing software. This extensive of review softwares for designing and modeling WDN includes that the choice of design softwares are entirely

depends upon the availability of the data, time, financial implication, resources , applicability, compatibility and overall purview of the project.

VI. Optimal design of water distribution network by using WaterGEMS: - Sajedkhan S. Pathan, et al (2015) , stated 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. Water distribution network are designed with an objective of minimizing. The overall cost while meeting the water demand requirements at adequate pressures. Water GEMS software algorithm is based on Gradient method gives optimal solution for the design of new as well as expansion of existing water distribution network. The primary variables are flow in the network while other decision variables includes design parameters i.e. pipe diameter, reservoir elevations etc. Head and velocity dependent analysis is used to determine the actual supply form each node to consumers. In this paper CIDCO N-8 a part of Aurangabad city is designed by Water GEMS software. With the help of WaterGEMS software an optimal water distribution network are 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.

VII. Design of Optimal Water Supply Network and Its Water Quality Analysis by using Water GEMS: - Sajedkhan S. Pathan ,et al (2014), In this paper 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 Water GEMS software is used for obtaining optimal design of water supply network of a part of Aurangabad city. With the help of water GEMS software design of optimal water supply network and its water quality analysis (chlorine analysis) is done with achieving objectives of minimizing the overall cost which meeting the water demand requirement at sufficient maximum discharge over a long period of time.

III. EXISTING WATER SUPPLY SYSTEM

In existing water supply system, Hingna water supply scheme was designed and executed as Regional water supply scheme between Hingna, Raipur, Wanadongri, Rajeev Nagar and Isasni in year 2003. At present stage, water supply to Hingna is managed with Jackwell at the Borgaon dam. Other source of water, Hingna nagar Panchayat use no of open well from last many years. In Hingna, 4 open well are presently used. During summer season, HNP manages water supply with tankers in some of the areas. For lifting raw water from Jack well, raw water pumps having capacity 50 HP are installed at Jackwell.

Existing conventional water treatment plant of 7.65 MLD is located at Hingna. Presently, this plant supplies water to Wanadongri, Isasni, and Raipur & Hingna. As discussed under source. The present WTP of 7.65 MLD will be used by Raipur & Hingna only. This WTP can accommodate Raipur & Hingna Water supply with future demands also. For fulfilling the water demand of Hingna town, pipe of diameter 350 mm and material DI – K9 is used for raw water pumping mains whereas 140 mm PVC pipe is used as pure water rising mains. The length of raw and pure water transmission network is 11518 m and 1470 m respectively.
Distribution network in Hingna town was quite old and in many areas PVC, GI, and AC pipelines were laid. Hence there were frequent leakages due to which there is a problem of unequal distribution and less pressures. This has forced the Nagar Panchayat to make water supply with restricted water supply hours. The town is getting water from 3 ESRs & 2 open wells. Sluice valves were provided at certain locations to control flow. At present, three No's of Service reservoirs feeding water to the consumer by gravity system. The total storage capacity of Service Reservoirs is **2.5LL.** ESR-1 having capacity of 1.5L.L, ESR-2 having capacity of 0.70L.L, and ESR-3 of capacity 0.30L.L.

IV. PROPOSED WATER SUPPLY SYSTEM

"Details of Existing Water System ", presently Hingna is getting water from Raipur Regional water supply scheme which was executed in year 2003. Source to WTP infrastructure can fulfil the ultimate requirement of Hingna Town, hence, this part of the scheme is presently not considered under Augmentation scheme. So to prepare separate water supply scheme for Wanadongri, Rajeev Nagar & Isasni from Kanholibara Dam while Hingna and Raipur will continue with existing water supply scheme from Borgaon Dam. Hence the source of the scheme will be Borgaon Dam.

The condition of Existing Jackwell constructed in 2003 is good, so it is proposed to use the existing Jackwell for fulfilling the demand of Hingna Peoples. Since 15-year life of existing Raw Water Pumping Machinery is over. Therefore, replacement of pumps is proposed for the scheme.

Existing raw water Pumping Main having Dia. 350 mm and material DI - K9 fulfilled all the necessary criteria as per CPHEEO and the condition of the rising main is also satisfactory so it is proposed to utilized the existing raw water rising main in proposed system.

The existing convention water treatment plant having capacity 7.65 MLD is sufficient to treat water for next 15 years, so in proposed scheme existing WTP is utilized.

The elevation of existing pure water sump is less than elevation of proposed service reservoirs, the pure water sump is unable to feed water to the proposed service reservoirs by gravity. Also to fulfill the demand of Hingna for year 2035, it is proposed to replace old pumps in the existing pump house which are feeding to Hingna Town.

New pure water pumping mains of Ductile Iron Pipe (K9) are proposed for feeding ESRs from WTP with pumping arrangement. Out of 3 ESRs, ESR-2 near New Nagar Panchayat office (0.70 LL capacity) and ESR-3 behind Old Nagar Panchayat office (0.30 LL capacity) is in depleted condition hence it cannot be used for proposed system. ESR-1 near New Nagar Panchayat Office (1.50 LL capacity) is in good condition so it is retained for the proposed scheme.

For supplying water to the consumer end from service reservoir's DI K-7 and HDPE PN – 6 pipes. There are existing House service connections on old distribution network. In the proposal shifting of existing house service connections are considered. The analysis of the leading mains and the distribution system will be done by using Bentley Water GEMS software.

V. WATERGEMS V8i OVERVIEW

WaterGEMS was originally developed by the Company Haestad Methods, Inc. based in Watertown, CT (USA). This company was acquired by Bentley Systems in mid-2004, acquisition from which the product began to be known commercially as Bentley WATERGEMS V8i. It is a product whose launch was given early twenty - first century and later software product WATERCAD the same software house launched in the 90s For many experts, WATERGEMS V8i more than an evolution of WATERCAD is essentially a 'super (Which is already included in WATERCAD), adds seamless integration with GIS environments and includes in a single commercial version all the advanced analysis modules which can only acquires separately in WATERCAD. In this sense, it is software whose target user is the company that operates supplies, regulators and / or important consulting projects. In terms of basic and intermediate tasks Hydraulic Modeling, WATERCAD and WaterGEMS are similar products (in fact share the same engine hydraulic calculation) and the same structure data model, so a model created in WATERCAD can be read in WATERGEMS V8i and vice versa. While WATERCAD, supports an autonomous platform (Stand Alone) and Micro Station and AutoCAD (as an addition to the product). WATERGEMS V8i adds support for ArcGIS to previous environments. In recent years the software has had a great evolution especially in features such as interoperability, ease of use, productivity tools,

connection to external data; consultation processes multi-criteria, operations of spatial analysis, graphics capabilities, integration with Systems Geographic information (GIS), etc. Within the most recent developments include the following features like Data Exchange with other Information Systems, Electronic Devices and / or other management programs, Using Genetic Algorithms for automated processes hydraulic calibration, optimal design and energy optimization, Analytical Leakage Detection, Vulnerability Plans to Pollution Events, Systems integration with SCADA, Multi-parameter Quality Analysis, Network Renewal Planning, Integration with Analysis of Hydraulic Transients and Waterfall.

WATERGEMS V8i 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, WATERGEMS V8i provides an easy-to-use environment for engineers to analyze, design, and optimize water distribution systems. WATERGEMS V8i is a multi-platform hydraulic and water quality modeling solution 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, WATERGEMS V8i provides an easy-to-use environment for engineers to analyze, design, and optimize water distribution systems. WATERGEMS V8i is useful for managing the water system data, time-series hydraulic result, current and future scenarios and other core infrastructure data all within the same GIS environment. (Calvin et al. 1996).

I. Superior Interoperability

WATERGEMS V8i users enjoy the power and versatility afforded by working across CAD, GIS, and stand-alone platforms while accessing a single, shared, project data source. With Water GEMS, utilities and consultants can choose to model from within four interoperable platforms namely Windows stand-alone for ease of use, accessibility, and performance, ArcGIS for GIS integration, thematic mapping, and publishing, Micro-Station for bridging geospatial planning and engineering design environments, AutoCAD for CAD layout and drafting Modeling teams can leverage the skills of engineers from different departments, and engineers can flatten learning curves by choosing the environment they already know and provide results that can be visualized on multiple platforms. Fig. 2 shows the WATERGEMS V8i window.

II. Streamlined Model Building

Engineers can leverage geospatial data, CAD drawings, databases, and spread sheets to jumpstart the model building process. Water GEMS provides synchronized database connections, geospatial links, and advanced model-building modules that connect with virtually any digital data format. Water GEMS includes Load Builder and TRex modules to help engineers allocate water demands and node elevations based on geospatial data found in shape files, geodata bases, various types of DEMs, and even CAD drawings. These modules help engineers avoid potential manual-input mistakes. Water GEMS also provides drawing and connectivity review tools to guarantee a hydraulically coherent model. (Germanopoulos et. al. 1986). Skelebrator automatically removes network com- plexity, while maintaining hydraulic equivalence, to efficiently tackle a wider range of modeling applications.

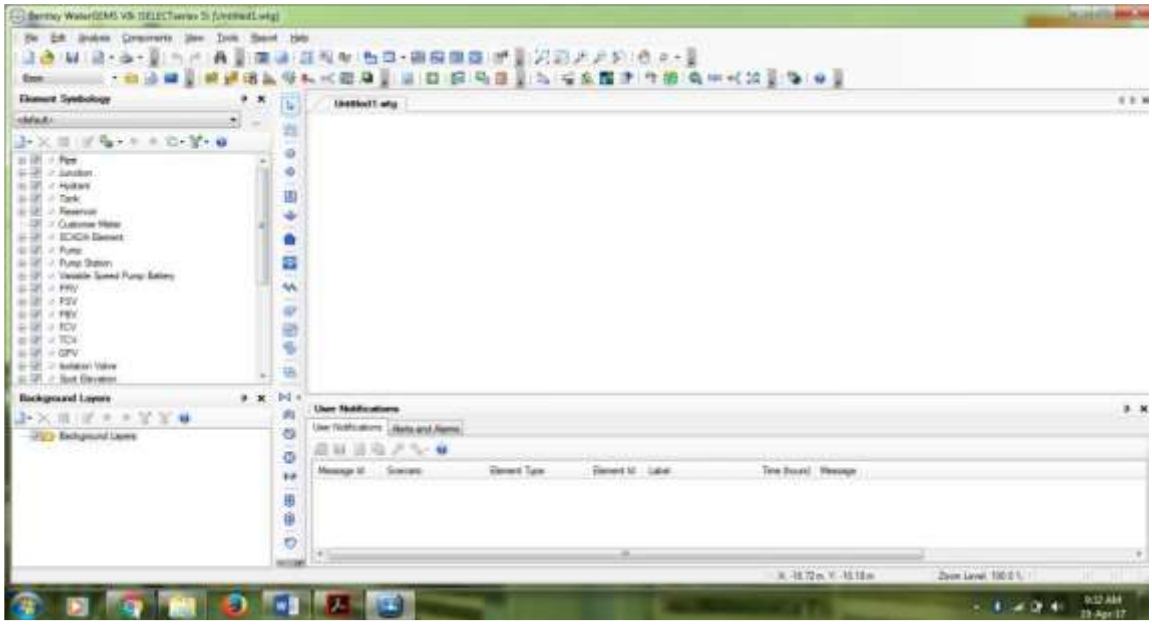
III. Optimized Model Calibration, Design and Operations

WATERGEMS includes state-of-the-art genetic algorithm optimization engines for automated calibration, design and rehabilitation, and pump operations. Darwin Calibrator evaluates millions of possible solutions to let users quickly find a calibration hypothesis that best matches measured flows, pressures, and on/off status, empowering users to make reliable decisions based on accurate hydraulic simulation of the real world. WATERGEMS SCADA Connect module lets modelers automatically acquire supervisory control and data acquisition (SCADA) data, creating a real-time system simulator that accurately represents current system conditions. It also enables WATERGEMS model results to be published to a utility's existing SCADA control room screen(s), helping to forecast operating conditions and potential issues. Darwin Designer automatically finds maximum benefit or minimum-cost designs and rehabilitation strategies, based on available budget, construction cost, and pressure and velocity constraints.

Engineers can also analyze energy consumption to identify the most energy efficient pump scheduling strategy. Darwin Scheduler optimizes the operations of fixed- and variable-speed pumps, and tank storage, to minimize energy usage or energy cost, based on pressure, velocity, pump start, and tank level constraints. Energy costs

can be aggregated across pumping stations and factor in complex tariffs as well as non-model-related energy costs, to perform net present value analyses of their operating scenarios.

Figure 2 - WATERGEMS Window



VI. METHODOLOGY

Following are the step has been carried out to analyze existing Water Distribution Network using WATERGEMS V8i:

Step 1: Encoding of Input Data

Most of the hydraulic analysis software has common input data requirements. These data are grouped into pipe data and node data. Pipe data are the assigned pipe number, pipe diameter (mm), C-value, length (m) and diameter (mm). Node data are assigned node number, elevation (m) and water demand (lps). Pump curve data are the assigned head (m) and flow (lps). process from starting of the program up to input data inserted in software.

Step 2: Hydraulic Network Simulation

This step is done by WATERGEMS. If all the data required have been input, the software could proceed with its hydraulic run. The software computes the head losses (m) in each pipe, the rate of head loss (m/km) in each pipe, the flow velocities (m/s), and the pressure in each node (m).

Step 3: Examination of Hydraulic Run Results

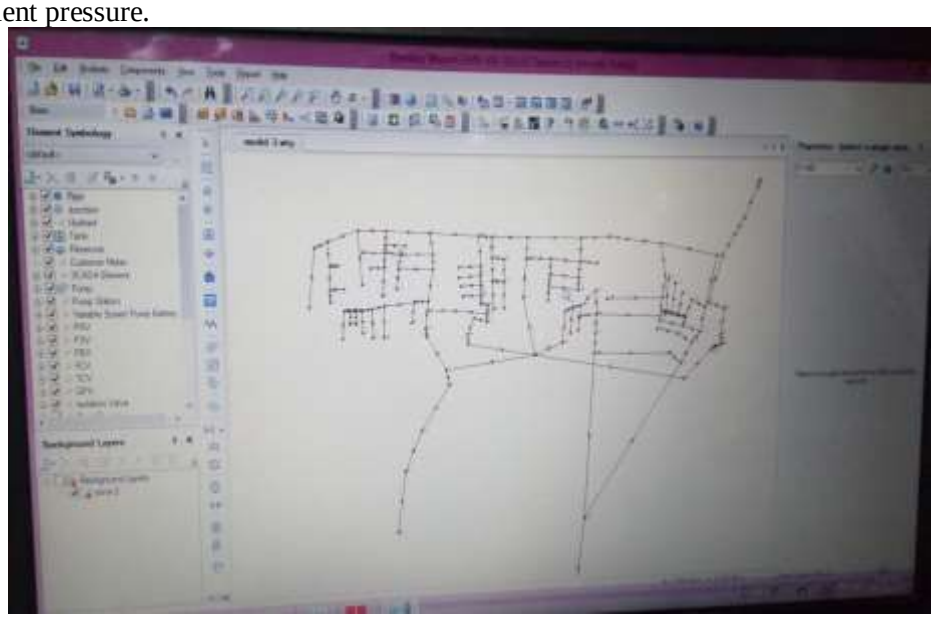
Usually all possible hydraulic parameters can be shown from the computer run results.

Step 4: Finalizing the Network Configuration

The model is subjected to repeated simulation and data adjustments until an acceptable network configuration is reached.

VII. RESULTS

The Zone-3 distribution network consists of pipeline of diameter from 250 mm at ESR outlet to 110 mm diameter at tail end. The maximum velocity at peak hour is 0.80 m/s with the head loss in the pipes well within limit. Proposed network is planned and need to execute for effective distribution with sufficient pressure.



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