International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.03, April 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

Design and Analysis of Water Distribution Network Using Water GEMS

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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 Shivaji Nagar territory of Panvel city. 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.***

I.INTRODUCTION

1.1 GENERAL

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. A distribution network may have different configurations depending upon the layout of the existing area. Generally, water distribution network have a branched and looped type of configuration of pipelines. The primary variable is flow in the network. The constraints are that demands are to be met and pressures at selected junctions in the network are to be within specified limits. The decision variables thus consists of design parameters i.e. pipe diameters, reservoir capacity, and elevation.

Google earth can be useful to visualize, and model the entire cycle of water supply network from source to household. The network system must be modeled, analyzed, and its performance is evaluated under the various physical and hydraulic parameters or conditions. This process is called as "Simulation' and WaterGEMS are software that performs extended period simulation of hydraulic and water quality behavior within pressurized

pipe networks. WaterGEMS tracks the flow of water in each pipe, the pressure at each junction, the height of water in each tank, and the concentration of water throughout the network during a simulation period. WaterGEMS is optimization software that can be used to simulate or design new or partially existing gravity fed water distribution systems. The software finds the lowest allowable diameter for each pipe segment that will allow the system to function, or more specifically, to meet the minimum pressure requirements at all junctions. Since pipe diameters are linked to the capital cost of the network.

1.2 NECESSITY

Panvel is fast developing city in Maharashtra State due to its proximity to Mumbai and Pune and easy access. Industries and business is growing rapidly around Panvel, this intern is resulting in the population growth of the town. The location of the newly proposed International Airport for Mumbai is near to the Panvel city this will also have impact on the population and development of the town. Drinking water is one of the most basic requirements for sustenance and decides many development outcomes such as health, livelihoods and so on. Rural drinking water supply in India depends to a large extent on groundwater which is increasingly a fickle source of water. So it is necessary to construct a Water Distribution Network in Shivaji Nagar area of Panvel City.

1.3 OBJECTIVES

1. To find out water demand calculation of Shivaji Nagar area in Panvel city.
2. Analysis and Design of Water Distribution Network for Steady State condition.
3. To find out Optimum Diameter for the Water Distribution Network.

II.WATER DISTRIBUTION NETWORK

i.The layout of a typical rural water supply scheme is depicted in Figure 1 below. The various components of the scheme are listed below:

ii.Source – perennial surface water source (reservoir, river)

iii.Rising Main – large diameter pipeline that transports water from the source to the MBR via a water treatment plant

iv.Water Treatment Plant (WTP)– water treatment facility that treats raw water from the source.

v.Master Balancing Reservoir (MBR) - water tank that receives clean water coming out of the water treatment plant. MBR is needed when the system is designed with more than 1 ESR, where the MBR feeds the ESRs, holds additional x hours of buffer capacity and balances fluctuations in demand from ESRs against supply.

vi.Primary Network (Gravity Main) - grid that transports water from the mass balanced reservoir to the various ESRs in the system

vii.Elevated Storage Reservoir (ESR) - elevated water tank that delivers water to a cluster of hamlets

viii.Secondary Network - grid that transports water from an ESR to one or more points (stand-posts) in the hamlets it serves

ix.Tertiary Network - grid that transports water from stand posts to homes in the hamlets.

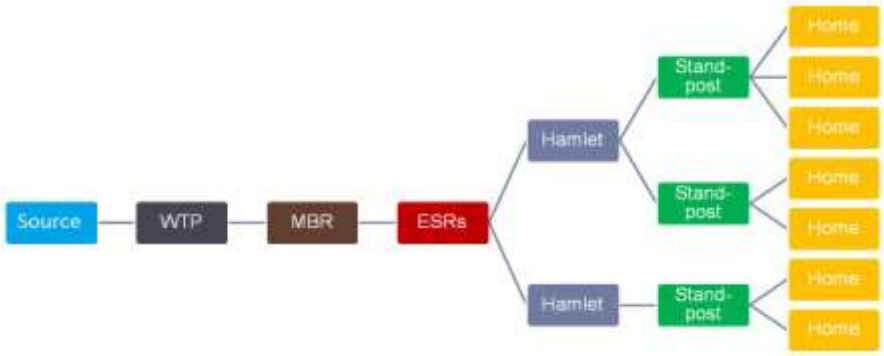

Fig.2.1 Layout of a Typical Urban Piped Water Scheme

III.SYSTEM DEVELOPMENT

3.1 STUDY AREA

Panvel Municipal Council (PMC) is "A" class Municipal Council and is one the oldest Municipal Council established on 1st September 1852 before independence. Panvel is located on Old Mumbai – Pune road, (National Highway No. 4 Mumbai – Bangalore). Now the newly built Mumbai - Pune Express highway also passes tangential to Panvel city. Panvel is 50 km from Mumbai. Panvel city is also a gateway to Konkan region of Maharashtra state. Panvel is located in Raigad district of Maharashtra. It is geographically located on Latitude 18.58° North and 73.12° East. It consists of plain areas and certain part is under wetlands. It is located on the bank of River Gadhi. Panvel Municipal Council has total area of 12.17 Sq. km.

3.2 Location and Connectivity

PMC area is well connected to Greater Mumbai and other cities like Thane, Pune and rest of Maharashtra by National Highway No.4. Panvel City is also having good connectivity by rail; it is one of the

major terminal stations on Konkan railway. It is well connected to Navi Mumbai and Mumbai by harbour railway. The new international airport planned in Navi Mumbai region is also located near from the Panvel town.

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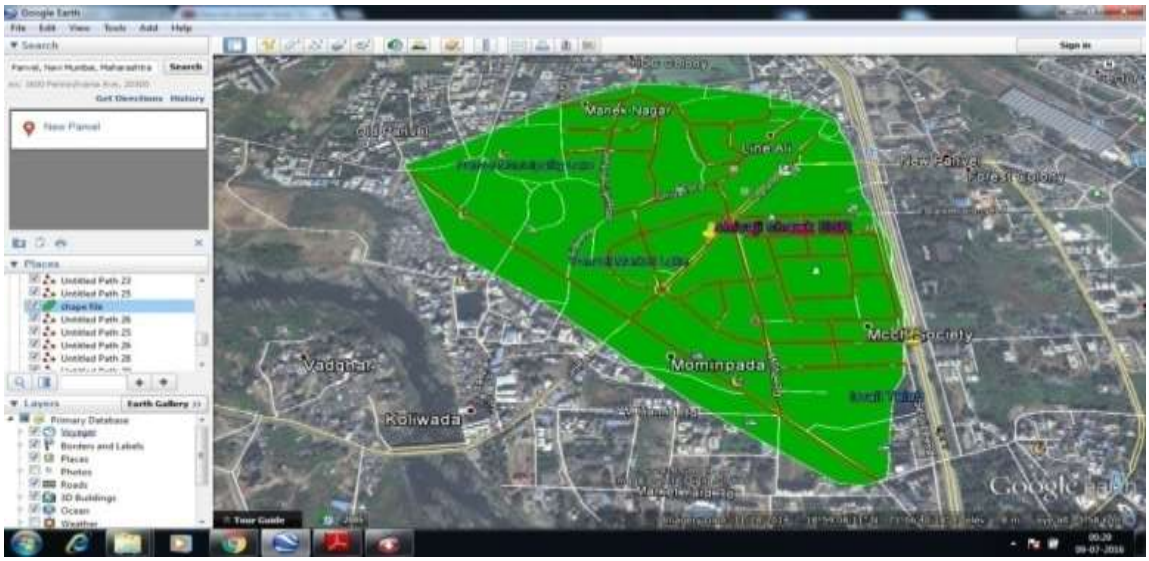

Fig.3.1 Location Map of Study Area and road Network Map of Study Area

IV.METHODS OF POPULATION PROJECTIONS

1. Arithmetical Increase Method

Rate of change of population with time is assumed to be constant. Applicable to old and large cities with no industrial growth and reached a saturation or maximum development.

This method yields lower result for rapidly growing cities.

$Pn = (P_\circ + n.x)$

Where

$p_\circ$ = Latest known population;

Pn = prospective population after 'n 'decades.

X = Average increases in population per decade.

2. Geometrical Increase Method

Percentage increase in population from decade to decade is assumed to be constant. It gives good result for young cities and expanding rapidly.

$Pn = P_\circ [1 + (r/100)] ^ n$,

r = Geometrical mean percentage increase.

3. Incremental Increase Method

Average of increase in population is found by arithmetical increase method and is to this is added the average of net incremental increase.

$Pn = P_\circ + n.x + n (n+1) /2 X Y$

From these three methods the future 30 years population of Shvaji Nagar of Panvel city is calculated and finally according to the 2047 population the total demand is calculated and adopted.

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3.3 Existing ESR and Pipe Line Network

At present, there is one ESR at Shivaji Nagar. The FSL of ESR has 30 m (GL + Staging height + height of water tank). ESR has capacity of 15 lakh liter. The total length of Distribution network is near about 9.567 KM.

Fig.3.2 Network Layout of Study Area

V.METHODOLOGY

Methodology Flow Chart consist of following steps

1. Take road map of the study area from Google earth map.
2. Draw water distribution network in WaterGEMS software.
3. Put the value of dsign constraints,
4. Specify population based peak factor as per CPHEEO manual.
5. Validate and compute the network.

Contributory Population	**Peak Factor**
Up to 50,000	3.00
50,000 to 2,00,000	2.50
Above 2,00,000	2.00
For Small Water Supply Schemes (Where supply is effected through stand posts for only 6 hours	3.00
Ground Water Storage Tank	1.00

Table 4.1 Peak Factor

VI.RESULT AND DISCUSSION

Panvel city is situated in Raigad district of Maharashtra state. However, for optimal design purpose a part of water supply network of Shiva Nagar area from Panvel city is considered. The source for study area of ESR is located in Shivaji Nagar. In the city 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

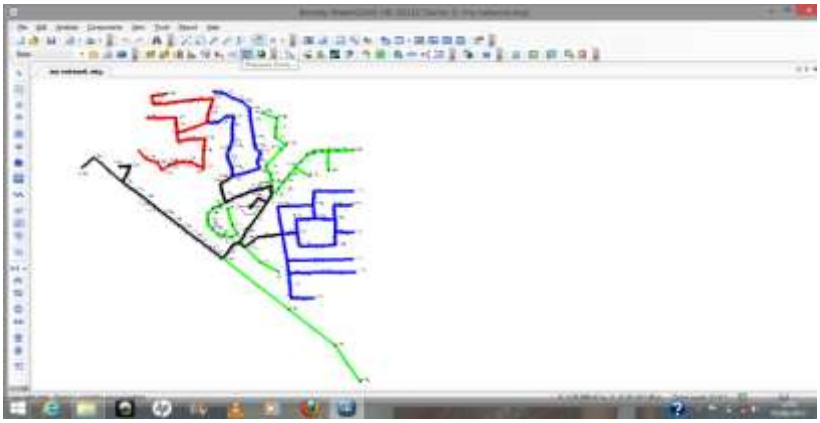

Fig.5.1 Schematic Diagram of Real Network Showing All Pipes

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 5.1 Different Colors of Diameter

Sr. No.	Diameter	Colors
1	150 mm	Green
2	200 mm	Blue
3	250 mm	Red
4	300 mm	Black

After completing the design of network, then the network is divided into three different zones i.e. zone-1, zone-2 and zone-3. Zone-1 consists of 42 junctions; zone-2 consists of 28 junctions and zone-3 consists of 80 junctions.

After dividing the networks successfully in three different zones then the pipe diameters are provided for each pipe. Then the complete network is designed and finally the network is computed. After computation of network

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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

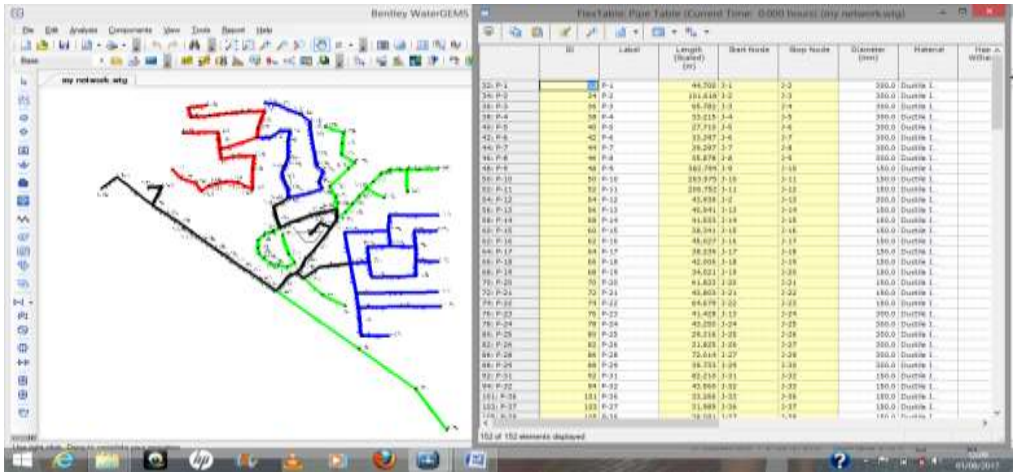

Fig.5.2 Optimal Layout of Network with Pipe Section Data for DI Pipe

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 follows

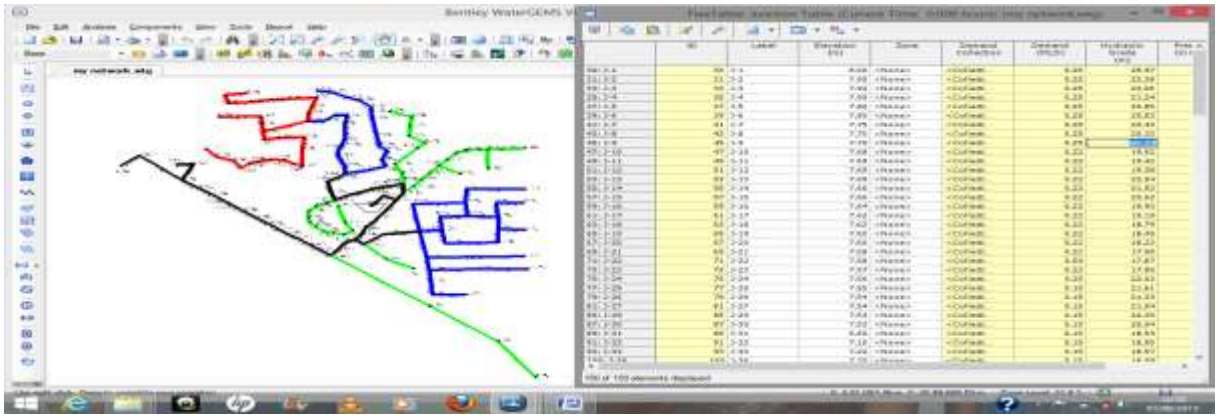

Fig.5.3 Optimal Layout of Network with Junction Data for D.I. Pipe

VII.CONCLUSIONS

In this project WaterGEMS software is used for obtaining optimal design of water supply network of a part of Shivaji Nagar area of Panvel city. 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.

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