Optimization of Water Supply Distribution Network: A Case Study-Varangaon

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ABSTRACT

This paper concerns for the optimization of water supply distribution network in a Town named Varangaon. Safe and adequate water is basic need of Human. Government of India is liable for providing safe, regular and adequate water to all people at their residence. Water distribution networks play a vital role in modern societies. Systematic operation of water distribution directly related to the population's well-being. For analysis of this case study Bentely WaterCAD Vi8 version is used. Design procedure has included all water constraints. These constraints are nodal pressure, velocity of flow in pipe, pipe material, pipe diameter, reservoir level, peak factor used for design purpose. Simulation tool is used to obtained results as per existing network. After that the optimization techniques are identified for achieving the most sustainable distribution of water.

This paper can be referred by water supply engineers who are facing the problems in improving existing distribution network or designing new distribution network.

Keywords- Water, Water Distribution Network Design, Optimization, Varangaon, Bentley

I. INTRODUCTION

Not only Human but animal and plant life cannot be imagined without safe and adequate water supply.

Many Standards and norms are developed at state level, national and international level until now on water supply standards and norms.

Distribution system must supply water to each house, industrial plants and public places in its serving area. Each connection must be supplied with safe and required quantity of water at the required pressure. For this purpose, the water is carried through the roads and streets in the city and finally to the individual connecting point. Well planned treatment plant, rising main and distribution system along with all components are required to fulfill objective of the distribution network.

II. WATER DISTRIBUTION NETWORK DESIGN CRITERIA

A. Supply of water for consumers

i. Water Supply for residential area varies from 45 lpcd to 250 lpcd (depend on type of area and standard of living and sewerage system of the area)

ii. For commercial area demand of water depends on type of area whether it is hotel, school of shopping mall,

iii. For industrial area, the demand depends on type of industry.

B. Pressure at nodes

Availability of adequate pressure at all the nodes even remotest consumer end are required. The following pressures are considered satisfactory as per CPHEEO manual:

i. Residential Area
 a. For Single Story buildings - 7 m of water column
 b. For Double story- 12 m of water column
 c. For Three Story Building- 17 m water column

ii. For Commercial Area- 12 m of water column pressure may be enough

iii. For Industrial Area- 5 to 10 m of water column pressure may be provided

Distribution system should be designed so that the residual pressures should be maximum 22 meters of water column. Multistoried buildings needing higher pressure should be provided with boosters at the building level.

C. Minimum Velocity in the pipe

Minimum velocity in the network should be 0.6 m/s. The design velocity must be kept between 0.6m/sec to 1.5m/sec. But in loop network the velocity may be below 0.6 m/s.

D. Minimum pipe diameters

The minimum pipe sizes recommended as per water supply manual are

i. Town with population up to 50000 then 100mm dia.
ii. Town with population above 50000 then 150 mm dia.

For the dead end water supply system, less than 100 mm diameter can be used for design. For hilly areas and for village water supply schemes the minimum diameter can be upto 63 mm.

E. Peak factors for demand calculations

The water supply manual has recommended the following peak factor values, it depending upon the population of area to be served

i. For population, up to 50,000- peak factor is 3
ii. For population, between 50,001 to 2,00,000 peak factor is 2.5
iii. For population above 2,00,000 peak factor is 2.

F. Head loss in network

The headless in water distribution network must be limited to 10m/km. The most effective head loss is considered max 5m/km.

III. A STUDY AREA

Varangaon is a small city in Bhusawal taluka of Jalgaon district in Maharashtra (India) located at 21˚1'12" N latitude and longitude 75˚54'36" E. Varangaon situated on national highway No. 6; 15 km from taluka place and 40 km from district headquarters. Varangaon is 'C' class municipal council. A small river, Bhogvati, flows through the town dividing it in two parts. Ordnance factory is also situated very near to the Varangaon town.

The water supply for this town is from Hatnur Dam, it is 11 km north from Varangaon. This dam is on river Tapi. The present water supply scheme includes 4 other villages along with Varangaon. One treatment plant of capacity 4.2 MLD near village Kathora(Bk) provides supply to different zones. The study area is particularly Varangaon town distribution area.

Fig 1: Location Map

IV. DATA COLLECTION OF EXISTING NETWORK

The latest image of the study area i.e. Varangaon is extracted from Google Earth. The population data is collected form Varangaon Municipal council. The distribution network data along with hand drawn drawings received form MJP office Bhusawal.

V. SIMULATION MODEL

Bentley is well-known software developing company which is active from 1984. It has developed the software like Micro station, Micro drainage, Bentley water CAD, Bentley Sewer CAD and Bentley Strom CAD, Water Gems and many others. All the Bentley software are user-friendly.

For calculation of head loss in network this software uses Hazen William's formula. This formula is-

$V = 0.849\, C R^{0.63} S^{0.54}$

Where S= hydraulic gradient

V= mean velocity of flow in pipe (m/s)

C= Hazen Williams coefficient of roughness of pipe

R= hydraulic radius (mean depth) (m)

Hydraulic network simulation of model

For input to the model Several data are needed for reliable analysis of the system performance.

1. Required Network information

a) Project Boundary b) Topology of the project area c) Length and diameter of each pipe d) Roughness coefficient for pipe(it depends on material and age of pipe) e) Pump curve f) water tank levels g) Different types of valves in the network

2. Water Demands and Boundary Conditions: a) Demands at nodes after considering peak factor b) Heads at sources and elevated tanks in the project area

3. Failure and repair probabilities of model a) Form and parameters for inter-failure time probability distribution function for each component that is subject to failures b) Form and parameters of repair duration probability distribution function for each such component.

4. Duration of the simulation

The heads and flows area calculated by model itself after simulation. This model can be used for further analysis.

VI. METHODOLOGY

Methodology followed for this study is systematically summarized in the following flow chart-

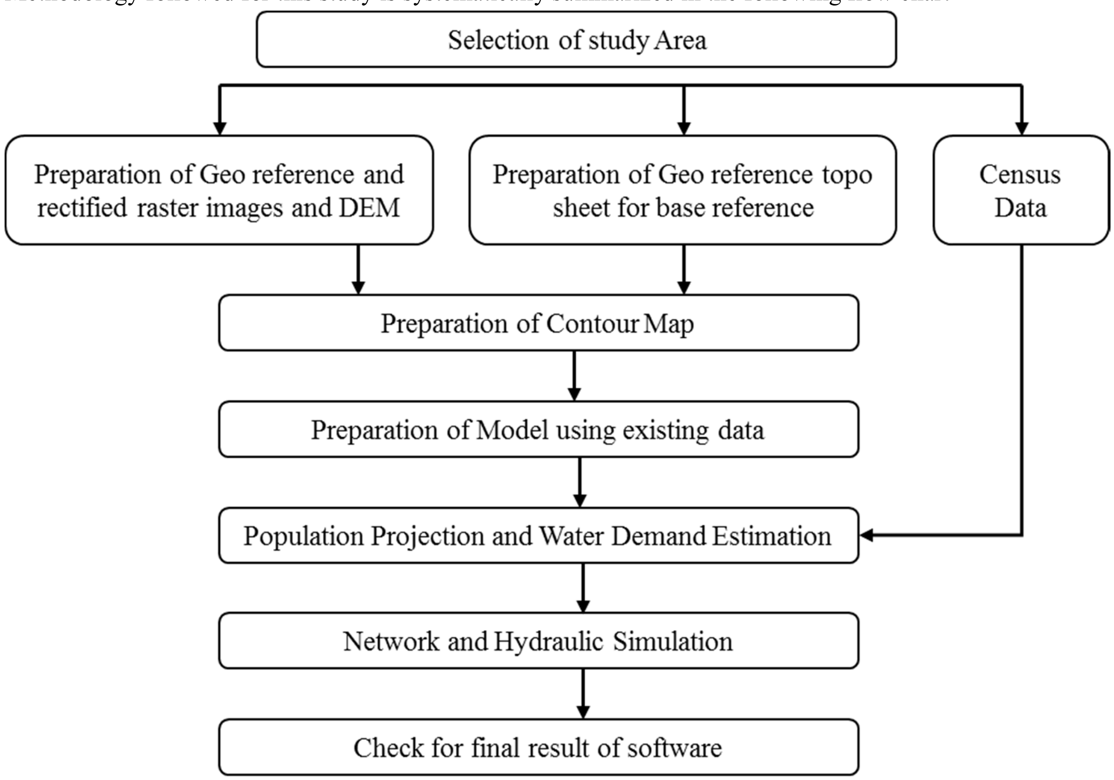

Fig 2: Methodology Flow Chart

Following procedure can be adopted

Base map can be generated by the method of digitizing using GIS platform. DEM file and contour drawing are obtained from GIS data.

i. The simulation proceeds by randomly generating failure times of the pipes as per the specified failure time distributions. village or town, estimated for the design period. The population data for the town can be obtained from the local authority or the census data for population records. After collecting this data, the population is projected till the end of the design period. The selection of appropriate method depends on type of growth of the town.

ii. Population forecasting is can be done by following method- 1) Arithmetical Increase Method 2) Incremental Increase Method 3) Geometrical Increase Method 4) Comparative Graphical Method 5) Master Plan Method 6) Logistic Curve Method 7) Graphical Method

Both Arithmetical Increase Method and Geometrical Increase Method were used. Census data is projected for next 15 yr considering 2010 as base year as it was the base year for present distribution system. Along with population, floating population is also considered.

iii. In this case study supply rate for per capita is considered as 40 liters per capita per day. And for floating population, it is 25 liters per capita as per design
This is tabulated as follows-

Year	Projected Population	Floating Population	Discharge (MLD)
2010	29800	3500	2.21
2025	39590	3500	2.67

iv. Existing network is created in WaterCAD software by taking base file as background. The network as drawn as it and pipe diameters, pipe material and roughness coefficient are assigned.
v. All the ESR are given with actual elevates, supply levels and volumes.
vi. The calculated demand is equally distributed to all nodes present in system.
vii. Systematically the connections at intersection and at reservoir should be checked.
viii. The supply hours may be 24. The intermittent supply system is employed for this project. It may save losses due to leakages and theft in the distribution network. It also leads to cautious use of water by consumers.
ix. On simulation of model file the heads and flows throughout the system are calculated by software. It creates a base condition which can be used for foundation for further analysis.

VII. RESULT

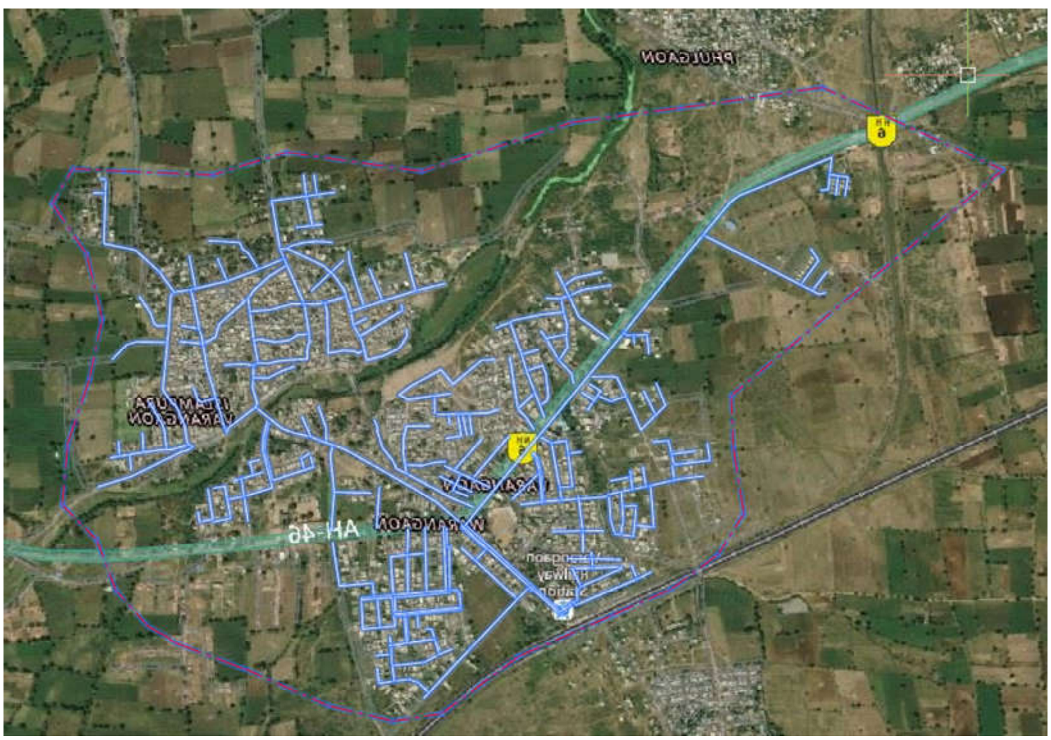

Fig 3: Modal Snap

After Simulation of model, following major points are observed
i. Velocity at many location is less than 0.6m/sec.
ii. Pressure at many nodes are observed to be less than 12m.
iii. No system or arrangement for checking of leakages in network.

VIII. CONCLUSIONS

i. The pipes used in the system are PVC and diameter are less than 110mm. Current water supply system is not designed with minimum water requirement of CPHEEO manual, as per norms per capita demand should be 70 lpcd for area where no sewer system is present. Hence system may not be sufficient to cater need of people for designed duration.
ii. As city is growing at fast rate, the current distribution system will not be sufficient in near future.
iii. The present system is dead end system which causes insufficient pressure at nodes. Loop can be formed to overcome this problem. It may result in getting adequate pressure at nodes. But it will increase the length of pipes and ultimately affect the cost budget.
iv. The SCADA system gives proper monitoring for all parts of both water production and distribution. It gives centralized control on entire system. There is no any such a provision in current system.

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