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Design of Hydraulically Balanced Water DistributionNetwork Based on GIS and EPANET for Kalapatti, Coimbatore

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Abstract: **The Water distribution system serves many purposes in addition to the provision of water for the human consumption and hence it is a necessary component in the development of an area. Due to urbanization, the population of cities is increasing drastically, and hence the distribution system should be designed in such a way that it should satisfy the consumers demand at adequate pressure. Analysis of water distribution system involves determining quantities of flow, head losses in various pipe sections and the resulting residual pressure. The study area chosen for the project is Kalapatti of Coimbatore district. The prime source of water supply to the region is from Athikadavu. The present distribution system consists of 7 overhead tanks that are inefficient to meet the future demands. The topographic map of the study area was extracted from Google earth. The network is created based on the road pattern. The network model for the determined region is created by using polyline theme in AutoCAD. The network from the AutoCAD is imported into the EPACAD, and the input for the EPANET is generated. The network from the EPACAD is imported into the EPANET by using the input file tool. The manual calculation is carried out for determining the effective size of the pipes using Hazen-Williams formula. The demand at each nodal point is calculated from population data collected and per capita demand. Elevation and demand as a nodal input and pipe sizes and length as a link input, hydraulic simulation of the model is carried out using EPANET software. The results from the EPANET show thatthe pressure at each node is within the limits.**

Keywords: Water distribution, Network analysis, EPANET, Waterdemand

1. INTRODUCTION

Water distribution network is the major asset of infrastructure utility. The Water distribution systems also able to provide water for non-potable uses such as fire suppression and irrigation. Unlike transmission system, these system deal with water demand that varies considerably in the course of a day. Water consumption is high during day and low during night. This variation can be dealt with by operating pumps in parallel. It is necessary to maintain sufficient pressure in the system to protect it against contamination by the ingress of polluted seepage water. The public utilities and services have kept pace with the population growth.
Water distribution system consists of elements such as pipes, tanks, reservoirs, pumps and valves etc.,[2]. Components of a water distribution system include distribution mains, arterial

mains, storage reservoirs and system accessories i.e., valves, hydrants, mainline meters, service connections, and backflow preventers. The Water Distribution mains are the pipelines that make up the water distribution system. Their function of the distribution system is to carry water from the water source to the users. The flow to community will be either continuous or intermittent flow. Therefore, for proper operation of existing water distribution system it is necessary that inspection, controland planned maintenance and rehabilitation programs [1]. For the reliability of water distribution systems, still there is not a convenient evaluation.

To design a water distribution system a thorough study of theavailable water resources, existing distribution network, water demand and required discharge etc are necessary. Since manual design becomes difficult, software assisted analysis are used. EPANET (Environmental Protection Agency Network) is software that models water distribution piping systems. EPANET is a public domain software that may be freely copiedand distributed [9]. EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank, the type of chemical concentration throughout the network during a simulation period, water age, source, and tracing. EPANET has yielded substantive results in the determination of sufficient water requirement for an area [4].

Generally, a Water Distribution Network (WDN) design is based on the proposed area plan and topography. EPANET software and Hardy Cross method are adopted to carry out the design and hydraulic analysis of water distribution. HardyCross method is a manual method which is most widely used while designing a WDN. By using this method, accurate determination of flow rates and head losses through a system can be calculated and this method is time consuming and givesapproximate values.

Study Area

Kalapatti town panchayat is a suburb of Coimbatore city. It is located 17 km North-East direction, within the city limits. Recently, Kalapatti merged with the Corporation of Coimbatore. It lies between the latitudes of 10°13'00" N to 11°23'30" N and longitudes of 76°39'00"E to 77°30'00" E. It hasa population of 50,555 as per census 2011. The areal extent of the study area is 25.60 sq.km with 15 wards. And the present water distribution network consists of 7 overhead tank and 5 ground level reservoirs. The main source of water supply to thestudy area is from Athikadavu.

Fig.1 Study Area

A. Population Forecasting

Population forecasting is an important factor in planning a network when the project has to serve the community for certain design period. The design period for the distribution system is 30 years. The population at the end of the design period can be predicted by using various

forecasting methods. Since it is a growing town geometric method is used considering 2011 as a base year as shown in table 1.

TABLE 1 ESTIMATED POPULATION

Sl. No	Description	Projected Population
1	Census year 2011	39586
2	Immediate year 2021	70463
3	Intermediate design year 2036	103512
4	Ultimate design year 2051	184251

2. METHODOLOGY

Initially the map of study area was extracted by using Google Earth software. The layout of the distribution network is drawn based on the existing road pattern in an AUTOCAD file. This network is now converted into an EPANET file by using various software such as "EPACAD". EPACAD converts the AUTOCAD file to EPANET file by considering intersections of the lines as nodes and lines as links. Elevation, pipe diameter and length had given to each node and pipe for hydraulic analysis.

A. Design Considerations

The layout of the distribution network is drawn based on the existing road pattern. Length of the pipe is taken as the road length. The diameter of the pipe is considered based on the purpose served by the pipe, such as main, sub main, and branch pipes. Pipe roughness coefficient is taken 145, since HDPE pipes are used. The simulation period was set for 24 hours.

B. Demand Calculation

Geometrical Increase Method is used for population forecasting. In this method the percentage increase in population from decade to decade is assumed to remain constant. Since this method gives higher values and hence should be applied for a developing town. The design period for the system is taken as thirty years. After forecasting the population, the quantity of water to be supplied should be calculated, for this we have adopted the standards specified by IS 1172-1971 and from the manual on water supply and treatment prepared by the Central Public Health and Environmental Engineering Organization (CPHEEO). The estimated demand is tabulated in table 2.

TABLE 2 ESTIMATED DEMAND

Period	Unit	2021	2036	2051
2021	Nos.	70463		
2036	Nos.		103512	

2051	Nos.			184251
se Water demand(@135 lpcd)	MLD	9.51	13.97	24.87
Distribution losses (10%)	MLD	0.95	1.39	2.48
Total demand	MLD	10.46	15.36	27.35
Losses in transmission 1%	MLD	0.10	0.15	0.27
Clear water demand	MLD	10.56	15.51	27.62

C. Model Input Parameters

In order to analyze the water distribution network using EPANET following input data files are needed:

1. Junction Report: Junctions are points in the network wherelinks join together and where water enters or leaves the network. The basic input data required for junctions are:

- Elevation (usually mean sea level)
- Water demand

The output results computed for junctions at all time periods ofa simulation are:

- Hydraulic head
- Pressure
- Water quality

2. Pipe Report: Pipes are links that convey water from one point in the network to another. EPANET assumes that all pipes are full at all times. Flow direction is from the end at higher hydraulic head to that at lower head. The principal hydraulic input parameters for pipes are:

- Start and End nodes
- Diameter
- Length
- Roughness coefficient
- Status (open, closed, or contains check valve)The output results for pipes include:
- Flow rate
- Velocity
- Head-loss
- Average reaction rate (over the pipe length)

The hydraulic head lost by water flowing in a pipe due to friction with the pipe walls can be computed using one of threedifferent formulas:

- Hazen-Williams formula
- Darcy-Weisbach formula
- Chezy-Manning formula

The Hazen-Williams formula is the most commonly used headloss formula.

D. Steps in Using EPANET

Following steps has been carried out to model a water distribution network using EPANET:

- Initially draw a network representation of distributionsystem from the extracted map.

- Then edit the properties of the objects that make up the system. The input parameters for each nodes and pipes are to be properly assigned.
- Then describe how the system is operated.
- Then select a set of analysis options.
- Finally run a hydraulic analysis.
- The last step is to view the results of the analysis which can be viewed in various forms i.e., in form oftables and graphs.

3. RESULTS AND DISCUSSION

The study area consists mostly of single storey buildings, the minimum pressure adopted is 7m. EPANET results shows thatthe pressure at each junction point is found to be greater than 7m, hence the flow can take place easily. The assumed diameter of each pipe is sufficient enough to withstand the pressure in the entire network. No negative pressure node is identified from the results which show that the water flow is above the hydraulic gradient line. The entire network has a uniform flowand velocity, and there is enough pressure at each node and there is no deficiency in demand. The results shows that the pressure obtained are satisfy enough to provide water to the study area.
Figure 3 is the demand diagram of the water distribution systemof Kalapatti.
Figure 4 is the pressure diagram of the water distributionsystem of Kalapatti.
Figure 5 is the velocity diagram of the water distribution systemof Kalapatti

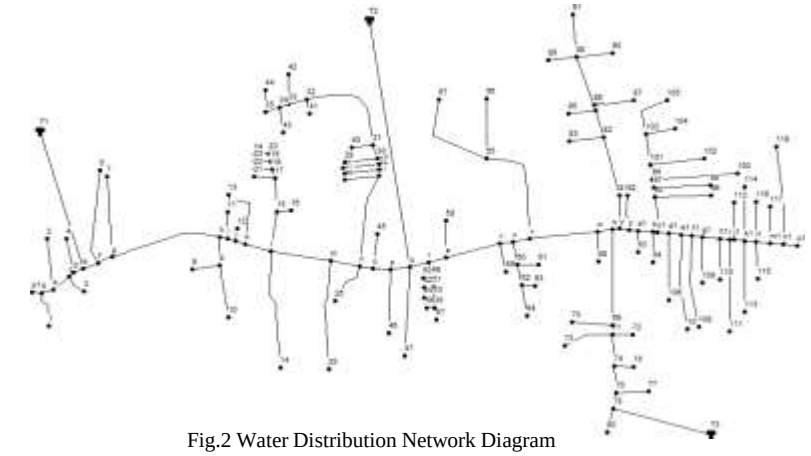

Fig.2 Water Distribution Network Diagram

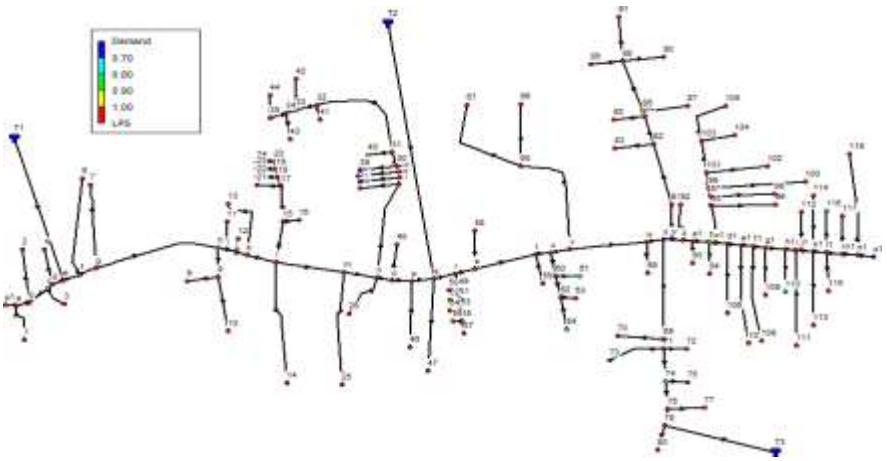

Fig.3 Demand Distribution Network Diagram

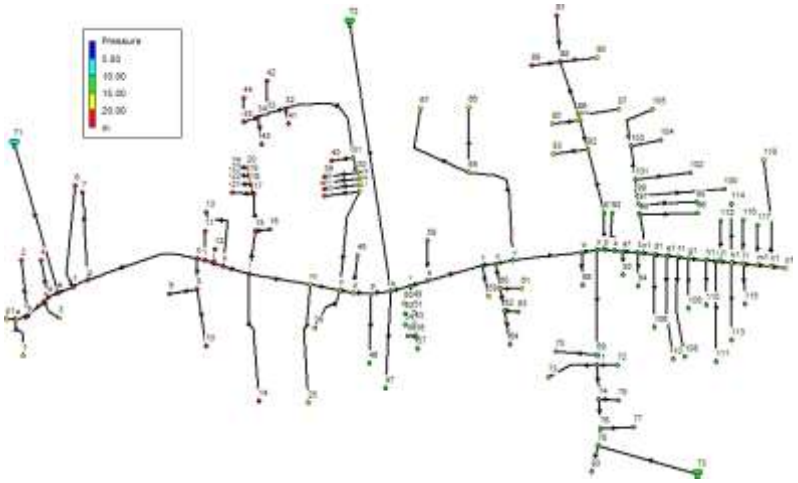

Fig.4 Pressure Distribution Network Diagram

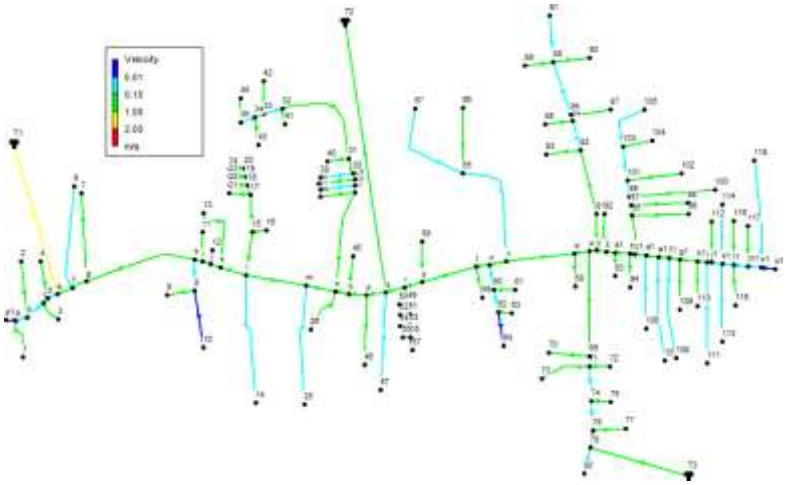

Fig.5 Velocity Distribution Network Diagram

4. CONCLUSIONS

The water distribution network has been designed and analyzed successfully using the EPANET software. At the endof the analysis, it was found that the resulting pressures at all the junctions and the flows with their velocities at all pipes areadequate enough to provide water to the study area. The method of distribution used here is combined gravity and pumping system, as firstly the water is pumped with the help of centrifugal pumps from underground water source i.e., from aquifers and then they are lifted up to the overhead water tanksand through there with the help of gravity system is transferredto the main rising pipe. The distribution layout used here is deadend system which is according to the layout of the Kalapatti region. Manual method by using Hardy-Cross equation is a time-consuming process, and it may not provide accurate result. There may be some limitations while proceeding the manual method in Excel. But there are no such types of problems in EPANET software. So, we can design water distribution system of any size by using EPANET. Conventional methods like Hardy-cross methods are not recommendable in present days ifthe network is in high scale because that high network designing by conventional method will not give the efficient and economical design

as comparative to EPANET software.

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