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ANALYSIS OF DRINKING WATER DISTRIBUTION SYSTEM OF AHMEDABAD CITY, USING EPANET 2.0 –A CASE STUDY

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Abstract: This paper describes about the detailed analysis of water distribution system of Jodhpur area, Ahmedabad, for continuous water distribution system. Objective of the present study is to simulate the hydraulic model using EPANET 2.0, for an accurate result analysis. Importance of this study is that unless a proper hydraulic model is prepared, it is not possible to convert old intermittent system into a continuous system. The whole area of Jodhpur is divided in to 5 District Metered Area (DMA) of which one area is used for the pilot project study. The approach adopted is to work from Part to Whole. Various input data of population, elevation, length of pipe, demand of water in the area etc were collected from Ahmedabad Municipal Corporation. The output results of pressure, discharge and velocity of water at various junctions and links of the pipes were obtained. It was analyzed, that water distribution system maintains minimum pressure of 17m to meet rising demand of area and continuous water supply. The study concluded that, as the elevation of the pipe increases pressure reduces that can be observed with the contour plot and graphical representation.

Key Words: Contour plot, Drinking water distribution System, Elevation, EPANET 2.0, Pressure.

I. INTRODUCTION

Water is the essential element for the sustainability of living being. The ever increasing demand of water can be fulfilled on modern hydraulic modeling and designing software. Urban water distribution systems hold a critical and strategic position in preserving public health and industrial growth. One of the main goals of continuous water supply systems is to provide safe and protected drinking water to the consumers at sufficient pressures and quality.

The design and analysis of water distribution system using EPANET appropriate water distribution network and provide minimum head loss, maximum pressure with efficient diameter of the pipe. This study would help the water supply engineers in saving time as this process is fast, less tedious, easy to incorporate the changes etc under one parasol [1].

Urban water systems in Asia and Africa mostly provided intermittent water distribution system [2].In 2008, an upgrade to continuous water services was provided for 10% of the twin cities of Hubli-Dharwar in Karnataka state as per Karnataka Urban water Supply and Drainage Board Bangalore[3]. Continuous water distribution system was also opted by Surat City in Gujarat state is successfully implemented and also the water is metered regularly[4], Pimpri-Chinchwad, Maharashtra’s Badlapur city and Nagpur, Maharashtra has also started the pilot projects and are operated sucessfully. EPANET tracks the flow of water in each of the pipe, pressure at each node and the height of water in each tank.

EPANET is designed to be a research tool for improving our understanding of the movement and fate of drinking water constituents within distribution systems. It can be used for many different kinds of applications in distribution systems for the analysis purpose [4].

II. METHODOLOGY

Researcher has collected various data of Pipe material, Pipe diameter, Headloss detection, Reduce Level, demand of water, supply of water are collected from the wards under study area.

In this approach, small District Metering Areas DMAs are prepared. These DMAs are then converted to 24x7 with various measures. Such DMAs are clubbed to create an operational zone.24 meter elevated tank is constructed to which water is supplied through pumping and then supplied to the designated water distribution system under gravity flow. During operation two conditions can occur (i) System is self sufficient and does not require further division into DMA; (ii) System is sufficient with respect to storage but operation wise certain pockets are still to attain 24x7 in totality. In such case, DMA will be demarcated with respect to the problems reported through water audit. Each DMA is hydraulically discrete (isolable) from adjoining area. It is fed with water from single point, the flow and pressures at key locations are continuously metered and measured which then give indication of the extent of leakages as well as high flow rates.

1. Case Study

Ahmedabad is located at 23^{o}2'1"N and 72^{o}35'6"E Gujarat, India. Ahmedabad Municipal Corporation (AMC) was established in the year 1950, it grew from an area of 52.49 Sq.Km. (in 1950) to 190.84 Sq.Km. (in 1991) over 43 wards. The area of the city is 466.00 sq.km. with population of 56 lacs souls. The city is divided in 6 zones, having 64 wards. The two pilot projects were taken for the study project. That was ward covering areas of Naranpura, Junavadaj and Sardar Patel Stadium. Second ward was Jodhpur. District Metering Areas (DMA) of Anandnagar is taken for the study purpose. Out of this total area, the developed area of Jodhpur is 777.35 hectares. Area of Anandnagar is 185.9 hectares.

Figure:-1 Location Of Anandnagar in Google Earth

Anandnagar is latitude and longitudes as 22^{0} 59" 19. 20" N, 72^{0} 29" 52.00" E as shown in the Fig.1. Mean Sea level of Ahmedabad Junction is 52.500m as per the Reduced level obtained from the Kalupur Railway station, Ahmedabad. This is same as Reduced Level obtained from Google earth for Ahmedabad junction.

1.1 Water distribution system Network of Jodhpur Area

Treated Water from 30 lacs liter capacity ESR at Jaspur headwork transmit through 350 mm to 800 mm dia. gravity main to four water distribution system in the underground sump,from there water will be transmitted to proposed ESR through pumping main. The total length of proposed pumping main is 2.83 km. The size of pipeline is diameter 600mm of length 2.41km and diameter 450mm of length 370m and diameter 350mm of 50m length. From the ESR, water will be transmitted to consumer through existing distribution network. Pipes are laid with diameters ranging from 100 mm to 600 mm from the ESR to distribution system. Total length of distribution network is 90.0 Km for Jodhpur area. Anandnagar is having total length of water distribution line as 26.31km. House service connection will be given with AMR water meter to each consumer.

Water distribution is done by the grid system. From water treatment plant at Jaspur to Prahaladnagar diameter of trunk main pipe is 2100mm, material is mildsteel pipe line. Water treatment is carried out at Jaspur water treatment plant with chlorination treatment. Jodhpur ward is ward no. 50 and area is 23.34 sq. kms of total area of Ahmedabad of 466 sq kms. Population of the Jodhpur area is 95444 as per the details obtained from the Census Department, ward wise population data 2011. Height of over head tank is 24 m. ESR at Anandnagar of capacity 15 lakh liter with diameter 20m. Anandnagar underground water storage tank has a capacity of storage capacity is 27 lac liter. Metropolitan and mega cities provided with piped water supply where sewerage system is existing as per CPHEEO Manual for domestic uses 150 lpcd. Add for unaccounted for water (UFW) 15% minimum as 22.5 lpcd, totaling up to 172.5 lpcd. Add for Water for commercial, institutional and civic amenities minimum 7.5 lpcd. Therefore total amount of water is 180 lpcd.

1.2 Population Projection

The population forecast of proposed project area has been estimated by the following mathematical methods as per CPHEEO Manual on**,** Water Supply and Treatment. (1)Arithmetical Increase Method (2)Geometrical Increase Method (3)Incremental Increase Method. The detailed calculations for projected population for all these method for the years 2017, 2021 and 2031, 2041 AD are worked out as below:-

1.2.1 Arithmetic Increase Method

This method is based upon the assumption that the population increases at constant rate.
The rate of change of population with time (ie. dp/dt) is constant. $P_n=(P_0+nX_{avg}.)$
where,P_n=Prospective or forcasted population after n decades from present (ie. Last known census),P_0= Population at present (last know population),n= No. of decades between now and future,Xavg= Average (arithmetic mean) of population increase in the known decades.

Table I. Arithmetic increase method

Year	Population
2011	95444
2015	124000
2017	129711
2021	135422
2031	152556
2041	18112

1.2.2 Geometric increase method

In this method, per decade percentage increase or percentage growth rate (r) is assumed to be constant, and the increase is compounded over the existing population every decade. This method is also known as uniform increase method.

Pn + P (1 + IG / 100)n

P= Present population,N = No. of decades,Geometric mean, IG = 28556 / 95444 = 0.2999

IG = 29.9%

Table II. Geometric increase

Year	Population
2011	95444
2015	1,24,000
2017	1,30,660
2021	1,37,678
2031	1,61,076
2041	2,09,237

1.2.3 Incremental increase method

In this method, the per decade growth rate is not assumed to be constant as in the arithmetic or geometric progression methods; but is progressively increasing or decreasing, depending upon whether the average of the incremental increases in the past data is positive or negative.Pn = Po + n.X (avg) + n (n + 1)/2 xY (avg)

Table III. Incremental increase method

Year	Population	Incremental Increase X	Incremental increase Y
2011	95,444	-	-
2015	1,24,000	X (Avg)= 28556	Y(Avg)= 28556
2021	1,33,137		
2031	1,81,112		
2041	2,66,780		

X (avg) = Average increase of population of known decades

Y (avg) = Average of incremental increase of the known decades

Table IV. Comparative Statement Showing Anticipated Population Projections by various methods

Year	Population		
	Arithmetic increase	Geometric increase	Incremental increase
2017	1,29,711	1,30,660	1,33,137
2021	1,35,421	1,37,678	1.43.418
2031	1,52,556	1,61,076	1,81,112
2041	1,81,112	2,09,237	2,66,780

Table V. Water Demand for various years

Name of Zone	Population						Water Demand In MLD @ 180 lpcd				
	2011	2015	2017	2021	2031	2041	2011	2015	2021	2031	2041
Anandnagar	5444	124000	133137	143418	181112	266780	17.17	22.32	25.81	32.6	48.02

III. HYDRAULIC SIMULATION OF WATER DISTRIBUTION SYSTEM ANALYSIS

EPANET can be used to improve a system's hydraulic performance. As shown in Fig. 2 inlet to the water distribution system, is tank to which input data like it's elevation above ground, diameter and maximum and minimum water level is entered into EPANET. For each node or junction at which water enters or leaves, input data is entered such as reduced level and water demand[5]. Also at each link data such as roughness factor, pipe diameter is the input data. The model computes and analyses the outputs hydraulic head, pressure head at each node and velocity and flow rate at each link over the simulation period. Flow direction is from the end at higher hydraulic head to the end with lower hydraulic head. The hydraulic input parameters for pipes are start and end nodes, diameter, length, roughness coefficient and status.

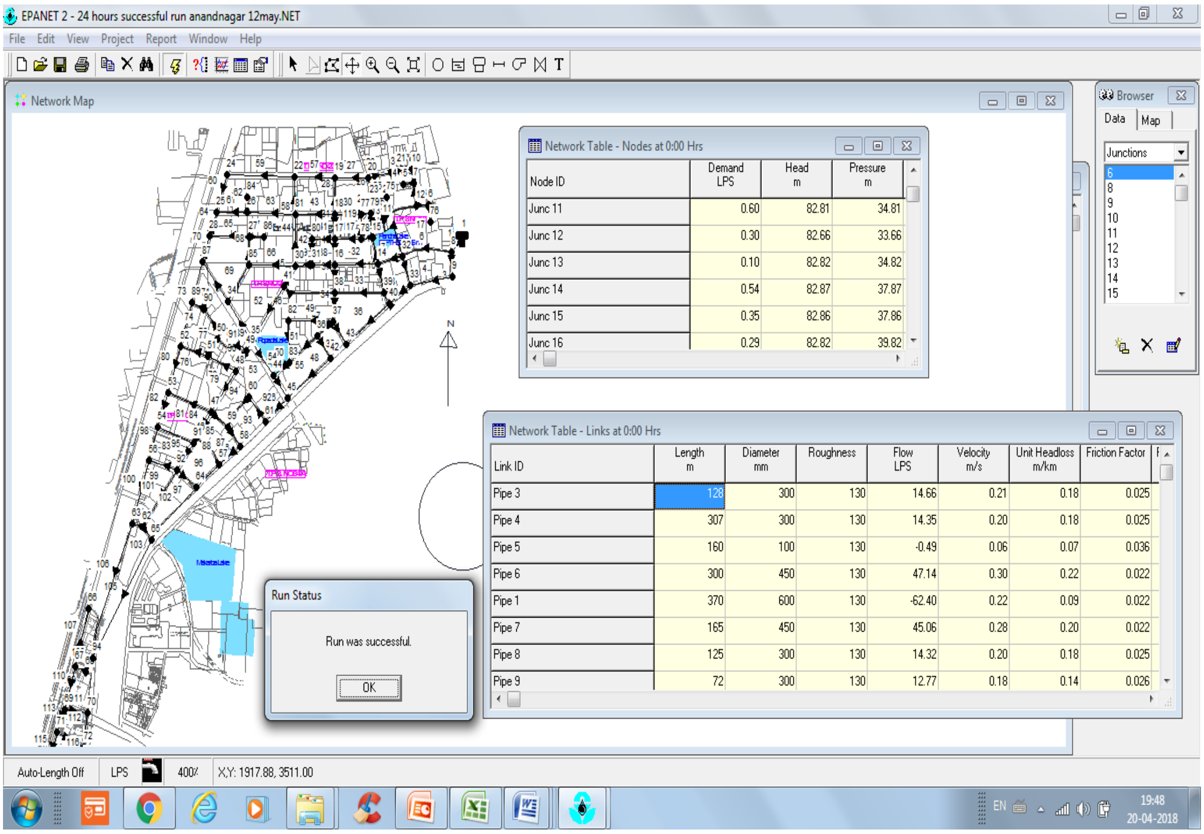

Fig. 2 Successful run of Anandnagar in EPANET

IV. Results and Interpretation

Contour plot of base demand is ploted as shown in Fig.3 and it is observed that demand is more in the areas of densely populated of 1.6lps to sparsely populated area of 0.4lps.Pressure observed in the contour plot as in Fig.4 shows that the pressure varies between 20 m to maximum of 39 m. Contour plot of elevation as shown in fig. 5 shows that area under the study is varying between reduced level above mean sea level from 40.00m to 60.00m.as shown in Fig.6 it is observed that there is constant increment in the population from year 2011 to projected population year 2041.Among all the three method highest forecasting of population is obtained by calculation in incremental increase method .which is taken for base demand at each junction in EPANET .It is found from the Fig.7 that with the increase in the ground elevation pressure in the pipe reduces and vice a versa.

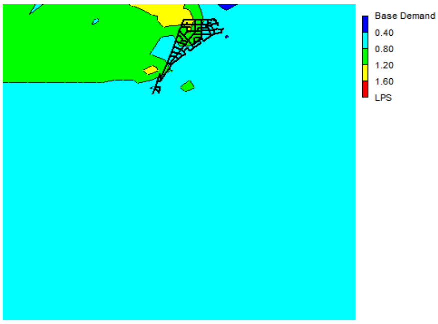

Fig. 3 Contour plot of base demand

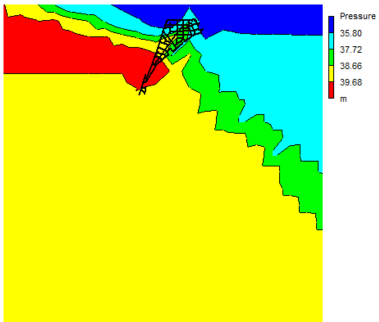

Fig. 4 Contour Plot of pressure

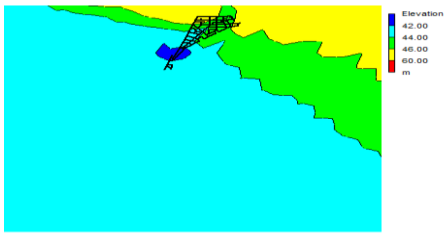

Fig. 5 Contour Plot of elevation

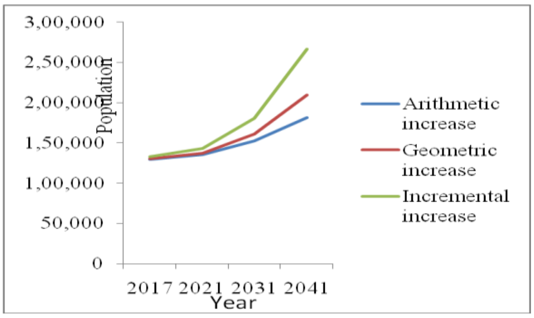

Fig. 6 Graphical presentation of population increment

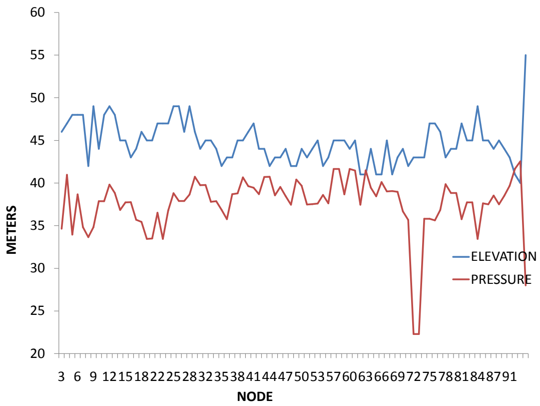

Fig. 7 Graph representing Elevation and Press

V.CONCLUSIONS

EPANET software used for the analysis of the network at the Anandnagar is showing Successful run. This shows that with this hydraulic performance can be planned and improved wherever lacking .There is an increase in the population of The output results are graphically represented. It is observed that negative direction in the results shows the reverse flow directions

VI. ACKNOWLEDGEMENT

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