ANALYSIS AND OPTIMIZATION OF WATER DISTRIBUTION SYSTEM AT AMBAJI

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ABSTRACT –

The fundamental goal of a water distribution system is to meet demand for water while maintaining the required standard of quality. Maintaining a steady and safe water supply has become a difficulty for many cities as a result of increased development and water constraint. Problems such as insufficient water supply with low pressure, pipe bursts, excessive leakage, and nonrevenue water are on the rise. To address these issues, a smart water system is required, which provides quick and accurate procedures and technologies for properly managing water distribution infrastructure. The study based on a variety of public requests, as well as the volumes of inflows and outflows from over-head reservoirs. The study's specific goal was to use EPANET software to plan and develop a water distribution network, as well as to analyse a water distribution system. Three approaches were used to forecast the population of Ambaji town over the next three decades: Arithmetic Increase Method, Geometric Increase Method, and Incremental Increase Method. The expected population's water requirement for the following three decades was also calculated. Ambaji town's Google Earth image was obtained. EPANET Software was utilised to analyse pressure, head loss, and elevation using these data. Pressure and elevation at various nodes, as well as head loss at various pipes, were the results of this investigation. The findings of data analysis in EPANET Software revealed that there is less head loss, which is critical for maintaining the constant pressure required for Ambaji's continuous water supply system. Ambaji town's water distribution system was designed and analysed to provide a suitable water distribution network with minimal head loss, maximum pressure, and efficient diameter. The design was created with the population growth rate and the developing town in mind. As a result, the research focuses on network analysis and draws conclusions regarding the network's reliability.

1. INTRODUCTION

In India, population distribution is influenced by water availability. It is vital to deliver the requisite water amount through the effective design of pipe network to fulfil the increased water demand due to the growing urban population. The necessary pressure through a distribution network is the most critical task in distributing desired water quantity to individual consumers. Each location in the distribution network must be provided with a specific amount of water flow with all of the appropriate specifications. In most Indian towns, water is only available for a few hours each day, pressure is inconsistent, and the water is of dubious quality. A pipe network system's job is to deliver water at the right pressure and flow.

As a result, while building a pipe network, the primary goal is to achieve appropriate pressure at the supply point in order to deliver the required amount of water to the user. The intended street plan and topography are often used to develop a water distribution network. In this study, Ambaji town was chosen to analyse and examine the network of piped water delivery systems, which is done in the context of a 24-hour water supply system to determine pipe pressure, velocity, and water age, among other things.

2 STUDY AREA

2.1 Area

Ambaji is a town in the district of Banaskantha, Gujarat, India, located in the danta taluka. Its coordinates are 24.33°N 72.85°E. It is located at a height of 480 metres (1,570 ft). The Araveli Hill Range surrounds it on all sides. Ambaji covers a total area of about 15 km2.

2.2 Climate:

Ambaji is a fan of all kinds of weather. Summers are hot and humid, with temperatures ranging from 26 to 46 degrees Celsius and strong winds. The temperature in the winter fluctuates from 6 to 36 degrees Celsius. During this chilly period, average rainfall is roughly 15 to 30 inches; during the monsoon season, average rainfall is about the same as in winter, with high rains on occasion. Because Ambaji is located at an altitude of 480 meters, the weather is nice throughout the year.

The taluka of Danta is located in the western section of the Banaskantha district and is connected to Rajasthan. In the taluka of Danta, there are 181 villages and one town. Because Danta is a tribal area, a large number of hand pumps have been constructed, the bulk of which are operational, and the people are reliant on hand pump water. Out of 181 communities, 152 are served by various regional water delivery schemes, as shown below. The remaining 21 villages in the "Nal se Jal" taluka, which includes Palanpur, Danta, Vadgam, and Amirgadh, must be covered under the proposed augmentation water supply scheme. Seven of the twenty-one settlements are dispersed and located at a higher elevation; therefore, they are not covered by any water supply network.

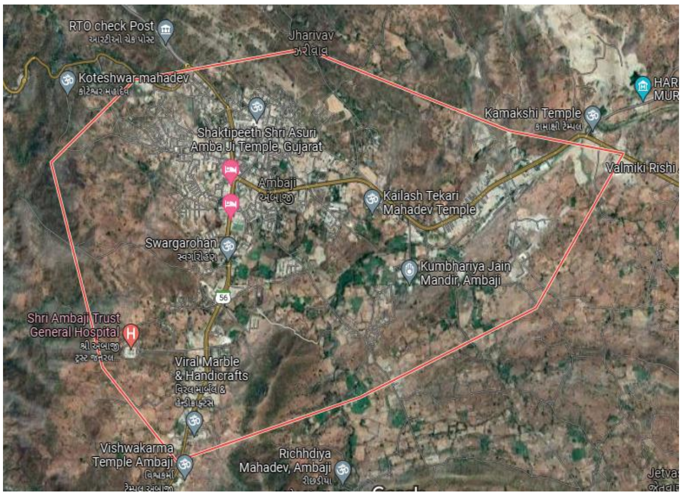

Fig 1. The location of Gujarat

2.3 Need of study:

1. The existing Ambaji town project is rated for 70 LPCD, however the present supply is 140 LPCD.

2. Increased water demand as a result of improved lifestyle.

3. Tourism and the marble industry have increased business demand, and the nearby Ambaji neighbourhood has developed quickly.

4. Among India's 51 Shaktipith is a Hindu holy and religious site.

2.4 OBJECTIVES:

- Future population and water demand forecasts
- Development of a water distribution network for Am baji town and
- Analysis of a water distribution system for Ambaji to wn
- Network analysis for Ambaji town using EPANET 2.0

3 METHODOLOGIES

3.1 Google Image

Ambaji's Google Earth image was downloaded. EPANET Software was utilised to analyse pressure, head loss, and elevation using these data. EPANET 2.0 has made use of these data.

3.2 Population and water demand forecast for Gandhinagar city

The population was forecasted using three methods as shown below with formulae:

Arithmetic Increase Method:P_n = [P_0+n·□],

Geometric Increase Method:P_n = $P_{0[1+ □/100]^□and}$

Incremental Increase Method:P_n = P_0 + n·□+(□(□+1))/2·□□

Where:

P_n = Prospective or forecasted population after n decades from the present, P_0 = Population at present, n = No. of decades between now and future, □ = Average (arithmetic mean) of population increases in the known decades, r = Assumed growth rate (%),□□ = Average of incremental increase of the known decades.

The population was predicted to grow until 2041. The water demand has also been calculated for the same. The population forecasting is based on projections from the Census Department of the Government of India for the years 1971, 1981, 1991, 2001, and 2011. The results of the Incremental Increase Method give a solid notion of population expansion. The population estimates for the next decade are 2021 (21243), 2031 (24676), and 2041. (28050).

3.3 Water distribution system:

The layout of water distribution system can be divided into four types:

i) Dead End System,

ii) Grid Iron System,

iii) Ring System,

iv) Radial System

The proper layout pattern should be chosen among the several layout systems available. The distribution system is meant to be a dead end system in this case. The location of tanks, mains, and sub mains are all part of the system.

3.4 DETAILED ANALYSIS:

Ambaji's map and Google Earth The image was downloaded in order to be analysed. In the figure, Ambaji's expanded study area is marked for analysis. The pipe network in Ambaji is seen in detail in Fig 2. The coordinates of Ambaji are 24.33°N 72.85°E. Ambaji is taken in for a thorough examination.

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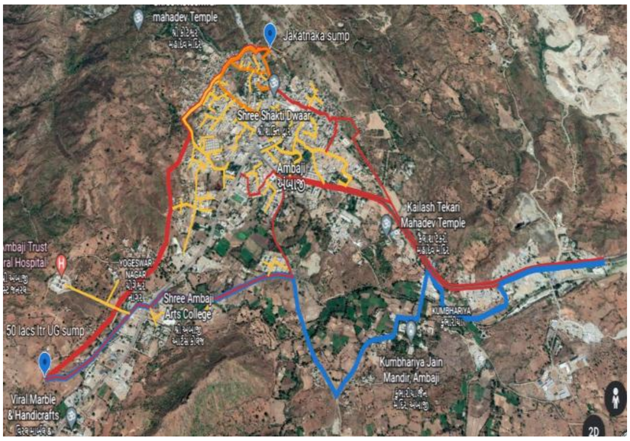

Fig 2. Ambaji Town Pipe Line Network

3.5 EPANET SOFTWARE:

The US Environmental Protection Agency created EPANET. It's a computer programme that simulates hydraulic and water quality behavior in pressurized pipe networks over a long length of time. Pipes, nodes (pipe junctions), pumps, valves, and storage tanks or reservoirs make up a network. EPANET keeps track of the water flow in each pipe, the pressure at each node, the water level in each tank, and so on. Using Hazen-Williams hydraulic equations, main pipe lines are created based on the needed discharge, pressure, and flow velocity.

$$V=0.849C_{HW}R^{0.63}S^{0.54}$$

In which V= average velocity of flow in m/s, C_{HW} = Hazen-Williams coefficient, R=hydraulic radius (=A/P) in m, S = Slope of the energy line (=h_f/L).

The simplification becomes

h_f = 10.68▯▯1.852▯▯▯1.852▯4.87

In which L is length of pipe and D is diameter in meter and Q is in cubic meter per second.

3.6 Elevation and base demand of nodes

The basic goal of a distribution system is to create acceptable water pressures at various places where customers' taps are located. Water may be forced into the distribution system via gravitational system, pumping system, or combined gravity and pumping system, depending on the level of the source of water and that of the town, geography of the area, and other local factors and considerations.

Google Earth is a virtual globe created by Google. The distance between all of the nodes was measured using a Google Earth image.

Node ID, Elevation, Base Demand, Pipe ID, and Length examples.

Node ID	Elevatin (m)	Base Demand (lps)	Pipe ID	Length (m)
Node 2	473	4.96	1	3238
Node 3	439	0.69	2	452
Node 4	443	0.56	3	366
Node 5	447	0.3	4	199
Node 6	450	0.22	5	147

These pipes are corrosion-resistant and could survive for up to 100 years.

On the map, a pipe network and nodes were established, and water demands at each junction were calculated using EPANET. The Google Earth image was used to record the elevation of the nodes and the length of each pipe.

4. CONCLUSIONS

The study "Continuous Water Distribution Network Analysis Using Geo-informatics Technology and EPANET 2.0 in Ambaji Town" was conducted with the primary goal of examining the current water distribution system and determining ways to improve it.

The population of Ambaji was calculated using three methods: Arithmetic Increase, Geometric Increase, and Incremental Increase. The next three decades were anticipated using the Incremental Increase approach, and the water demand for that population was estimated.

EPANET 2.0 software was used to examine the current pipeline network so that the idea of a continuous water delivery system could be realised with proper pressure and minimal head loss.

A Google Earth image of Ambaji town was obtained, and the height of nodes and pipe lengths for roughly 75 nodes were recorded. These data were then used in the EPANET 2.0 software to analyse pressure, head loss, and other factors.

This study indicated that the outcome result from EPANET 2.0 software i.e.; pressure, head loss, etc. were checked with hydraulic equation and found to

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