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# Design of Water Distribution System by using JalTantra Software

Mr. Rishikesh Dudhe[1], Mr. Hanuman Khupse[2], Mr. Rohit Shiwarkar[3], Mr. Keshao Padole[4], Mr. Suhas Gatalwar[5], Prof. Kajal Pachdhare[6]
*[1, 2, 3, 4]UG Scholar, [6]Assistant professor, Department of Civil Engineering, Wainganga College of Engineering and Management, Nagpur, India*

***Abstract**: Design of pipe distribution networks for villages require considerations to ensure that the system is effective and sustainable. Water distribution network is a system of engineered hydrologic and hydraulic components which supplies water from the source to the required area. In the design of a water distribution network, it is crucial that the network supplies the forecast-ed demands with enough residual heads at all nodes of the network during the entire design period. However, with the increasing change in future scenarios, either the nodal demands change or the water distribution network falls short to meet the increasing demands. Therefore, we require a proper analysis of water networks to strengthen them for the future. In situations like this, software plays a major role in analyzing water distribution networks to make it work as per the design. The present study is an effort to analyze the water supply network using available software, it proposes hydraulic simulation model for water distribution network analysis and comparison of results.***

***Keywords: JalTantra software, Water demand, Sustainable solutions, Designing, Network supply, Cost Effective Optimization.***

## I. INTRODUCTION

The design of a water distribution network plays a crucial role in ensuring the efficient and reliable supply of clean water to urban and rural communities. much of the design process is undertaken in an ad hoc and heuristic manner, relying on the experience and intuition of the engineers. The complexity of the modern water distribution network necessitates the use of advanced tools and techniques to optimize design decisions and enhance system performance. There are some advanced tools to used water distribution network such as EPANET Software, OpenFlows WaterGEMS and Fluidit Water, JalTantra Software.

One such tool gaining prominence in the field of water engineering is Jaltantra software. Jaltantra software is a powerful hydraulic modeling and analysis tool specifically developed for the design and optimization of water distribution networks. It offers a comprehensive set of features and functionalities that aid engineers in creating accurate and efficient network designs. We developed JalTantra, a web system that aids these government engineers in sizing both pipe diameters and the various other water network components, such as tanks, pumps, and valves. The pipe networks for these rural schemes are typically gravity fed because the electricity supply is often unreliable.One such tool gaining prominence in the field of water engineering is Jaltantra software. Jaltantra software is a powerful hydraulic modeling and analysis tool specifically developed for the design and optimization of water distribution networks. It offers a comprehensive set of features and functionalities that aid engineers in creating accurate and efficient network designs. We developed JalTantra, a web system that aids these government engineers in sizing both pipe diameters and the various other water network components, such as tanks, pumps, and valves. The pipe networks for these rural schemes are typically gravity fed because the electricity supply is often unreliable. In Water Distribution System there are four types such as Dead end system or tree system, Grid iron system, Ring or Circular system and Radial system. The dead-end water distribution system is where the main pipeline runs through the central part of an area. It is also referred to as the tree distribution system. The sub-mains branch off from both sides of the main and are divided into several different branch lines. In this system, pipes can be laid easily. We use jaltantra software for water distribution network system in Kotewada village For full fill water demand, Hingna taluka, Nagpur district in Maharashtra. Kotewada village in Hingna tehsil of Nagpur district in Maharashtra is located at a distance of 10 km from Hingna sub-district headquarters and 22 km from Nagpur district headquarters. The total area of the village is 365.07 hectares. 1496 villagers according to 2011 Census use public wells and ESRs for drinking water. The primary function of the water distribution system is to provide the required quantity, pressure, and price of water. Why use this village for the project because this villagers suffering issues like water and not provinding required water demand. The distribution of clean and safe drinking water is crucial for the health and wellbeing of people in rural areas. In villages, a pipe distribution network can be an effective means of ensuring that clean water is available to all households.

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Without a pipe distribution network, people in villages may have to rely on wells, ponds, or other sources of water that may not be safe for consumption. This can increase the risk of waterborne illnesses and diseases, which can have a significant impact on Public health. A pipe distribution network can bring clean water directly to people's homes, eliminating the need for them to collect water from potentially contaminated sources.

It can also help to ensure that there is an adequate supply of water for all households, even during times of drought or other water shortages. Furthermore, a pipe distribution network can help to reduce the time and effort required to collect water, particularly for women and children who are often responsible for this task. This can free up time and resources for other activities, such as education or income-generating.

## II. OBJECTIVE OF PROJECT

1) Reliable water supply: To ensure water supply reliability by maintaining pressure, addressing leaks promptly, and adequate storage.
2) Efficient operation: To optimize energy use, minimize water losses, and employ advanced monitoring for efficient network operation.
3) Equitable distribution: To ensure fair water distribution, address disparities, and promote conservation for equitable access.
4) Infrastructure resilience: To design resilient infrastructure with redundancy, contingency plans, and proactive maintenance for durability.
5) Cost Analysis: To optimize the network design to minimize both construction and operating costs, strategically ensuring optimal financial efficiency throughout the project's lifecycle.

## III. NECESSITY OF WATER DISTRIBUTION NETWORK

The distribution of clean and safe drinking water is crucial for the health and wellbeing of people in rural area. In villages, a pipe distribution network can be an effective means of ensuring that clean water is available to all households. Without a pipe distribution network, people in villages may have to rely on wells, ponds, or other sources of water that may not be safe for consumption.

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This can free up time and resources for other activities, such as education or income-generating.

1) Efficient Transportation: A properly designed pipe distribution network allows for efficient transportation of fluids or gases from a source to multiple destinations. It enables the conveyance of resources, such as water, gas, or other fluids, in a controlled and organized manner, ensuring reliable delivery to end-users.
2) Versatility: Pipe distribution networks are versatile and can be customized to suit specific requirements of different applications. They can be designed to accommodate various pipe sizes, materials, and configurations, making them adaptable to diverse environments, infrastructures and project scales.
3) Cost-effective: Pipe distribution networks are versatile and can be customized to suit specific requirements of different applications. They can be designed to accommodate various pipe sizes, materials, and configurations, making them adaptable to diverse environments, infrastructures and project sacles.
4) Flexibility: pipe distribution networks can be designed to accommodate changes in demand, supply sources and distribution patterns. They can be easily modified or expanded to adapt to changing requirements or future growth, providing flexibility and
5) Scalability.
6) Safety: Pipe distribution networks can be designed with safety measures to prevent accidents and protect public health. These may include pressure relief valves, backflow prevention devices and other safety features to ensure the safe and reliable transportation of fluids or gasses.

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## IV. METHODOLOGY

### A. Area of Study

We use jaltantra software for water distribution network system in Kotewada village For full fill water demand, Hingna taluka, Nagpur district in Maharashtra. Kotewada village in Hingna tehsil of Nagpur district in Maharashtra is located at a distance of 10 km from Hingna sub-district headquarters and 22 km from Nagpur district headquarters. The total area of the village is 365.07 hectares. 1496 villagers according to 2011 Census use public wells and ESRs for drinking water. The primary function of the water distribution system is to provide the required quantity, pressure, and price of water.


Fig. 1: Kotewada Village Map

### B. Data Collection

The data like, node names, water demand, elevation, head, pressure, minimum pressure, in input in JalTantra database. Collecting accurate and comprehensive data is essential to ensure the reliability and effectiveness of the network design. The following types of data need to be collected :

1) Networks Layout: Obtain informatio about the physical layout of the distribution network, including pipe networks, storage tanks, pumps, valves and connections. This can be done through field surveys, existing network records, or GIS database.
2) Topographical Data: Collect topographical data of the area where the network is located. This includes elevation data, terrain characteristics, and geographical features. Geographic Information System (GIS) data sources can provide valuable information for this purpose.
3) Demand Data: Gather data related to water demand patterns within the network. This includes information about the locations, quantities, and variations in water demand from different types of consumers (residental, commercial, industrial, etc.). Historical consumption data, population projections, or surveys can be used to estimate demand.
4) Water Source Data: identify the water sources that supply the distribution network. This includes data on water availability, Quality, and any constraints related to extraction or treatment.

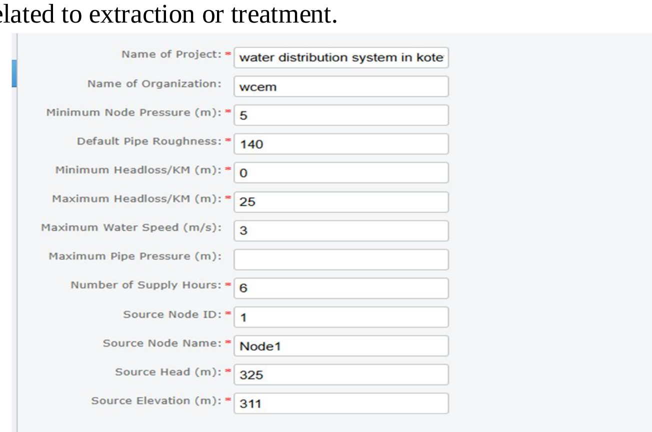


Fig. 2: Data Input Interface

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### *C. Data Analysis*

Once the data is collected, it needs to be inputed into the Jaltantra software for network modeling. The software provides a user-friendly interface for entering the data and creating a digital representation of the network. Hydraulic analysis and optimization techniques are key components of the design process for water distribution networks (WDNs) using Jaltantra software. These techniques help improve the efficiency, reliability, and performance of the network. Here are the main hydraulic analysis and optimization techniques used in the design of WDNs using Jaltantra:

| Pipe ID | Start Node | End Node | Length (m) | Diameter (mm) | Roughness | Parallel Allowed |
|---|---|---|---|---|---|---|
| 1 | 1 | 2 | 25 | 110 | | ☐ |
| 2 | 2 | 3 | 14 | 110 | | ☐ |
| 3 | 3 | 4 | 30 | 90 | | ☐ |
| 4 | 4 | 5 | 9 | | | ☐ |
| 5 | 5 | 6 | 12 | | | ☐ |
| 6 | 6 | 7 | 6 | | | ☐ |
| 7 | 6 | 8 | 15 | | | ☐ |
| 8 | 8 | 9 | 23 | | | ☐ |
| 9 | 10 | 11 | 20 | | | ☐ |
| 10 | 9 | 10 | 45 | | | ☐ |
| 11 | 11 | 12 | 27 | | | ☐ |
| 12 | 12 | 13 | 35 | | | ☐ |
| 13 | 12 | 14 | 32 | | | ☐ |
| 14 | 14 | 15 | 39 | | | ☐ |
| 15 | 5 | 16 | 24 | | | ☐ |
| 16 | 16 | 17 | 20 | | | ☐ |
| 17 | 16 | 18 | 15 | | | ☐ |
| 18 | 18 | 19 | 24 | | | ☐ |
| 19 | 19 | 20 | 12 | | | ☐ |
| 20 | 20 | 21 | 32 | | | ☐ |
| 21 | 15 | 22 | 34 | | | ☐ |
| 22 | 22 | 23 | 19 | | | ☐ |
| 23 | 23 | 24 | 30 | | | ☐ |
| 24 | 24 | 25 | 19 | | | ☐ |

Fig. 3: Pipe Analyzed

All Fields | Add New | Delete

| Node ID | Node Name | Elevation (m) | Demand (lps) | Min. Pressure (m) |
|---|---|---|---|---|
| 2 | Node2 | 312 | 1.27 | |
| 3 | Node3 | 312 | 1.23 | |
| 4 | Node4 | 312 | 1.22 | |
| 5 | Node5 | 312 | 1.21 | |
| 6 | Node6 | 312 | 1.20 | |
| 7 | Node7 | 311 | 1.64 | |
| 8 | Node8 | 311 | 1.52 | |
| 9 | Node9 | 311 | 1.14 | |
| 10 | Node10 | 310 | 1.09 | |
| 11 | Node11 | 309 | 1.00 | |
| 12 | Node12 | 309 | 1.00 | |
| 13 | Node13 | 311 | 0.90 | |
| 14 | Node14 | 308 | 0.80 | |
| 15 | Node15 | 308 | 0.80 | |
| 16 | Node16 | 310 | 0.70 | |
| 17 | Node17 | 310 | 0.60 | |
| 18 | Node18 | 311 | 0.60 | |
| 19 | Node19 | 310 | 0.60 | |
| 20 | Node20 | 310 | 0.50 | |
| 21 | Node21 | 308 | 0.50 | |
| 22 | Node22 | 307 | 0.45 | |
| 23 | Node23 | 307 | 0.40 | |
| 24 | Node24 | 308 | 0.40 | |
| 25 | Node25 | 308 | 0.26 | |
| 26 | Node26 | 310 | 0.20 | |
| 27 | Node27 | 311 | 0.13 | |
| 28 | Node28 | 310 | 0.10 | |
| 29 | Node29 | 307 | 0.09 | |

Fig. 4: Node Analyzed


Fig 5: Pipe line Network System in Software

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### D. Survey in the Village

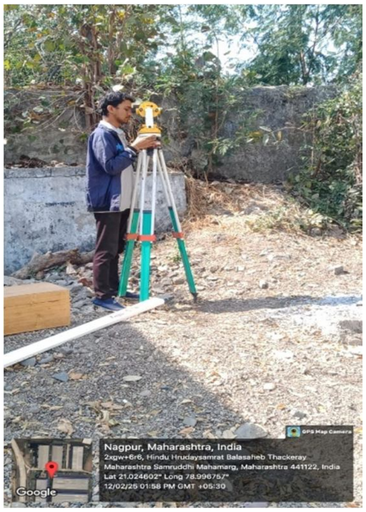

Fig. 1. First Set up Dumpy Level

Fig. 2. Hold the Level Staff

Fig. 3. Measure Node to Node disance

Fig. 4. Make a wet lime and necessary material

Fig. 5. After Mark the point use of wet lime

## V. OBSERVATIONS AND RESULTS

### A. Population Forecasting

Various methods can be employed for population forecasting, each with its own assumptions and applicability. In this analysis, we explore five different methods: Arithmetic Increase, Geometric Increase, Incremental Increase, and Decreasing Rate of Growth, along with the Logistic Curve Method.

#### 1) Arithmetic Increase Method

This method assumes a constant population growth rate i.e dp/dt is constant. By analyzing population data from the last 4 to 5 decades, the population increase per decade(x) is calculated. The average growth rate (x) is then employed to project future population. Thus, we get,

$$P_n = P_o + nx$$

*2) Geometric Increase Method*

This method assumes a constant percentage growth rate (r) per decade, compounding the increase over the existing population. Known as the uniform increase method, it is analogous to compound interest, contrasting with the arithmetic method where no compounding occurs. The constant value of the percentage growth rate per decade (r) is akin to the 'rate of interest per annum' in compound interest calculations. The above geometric increase can be expressed as:

$$Pn = P\ (1 + (IG/100))^{\wedge}n$$

*3) Method of Varying Increment or Incremental Increase Method.*

This method deviates from constant growth assumptions seen in arithmetic or geometric methods, allowing for a progressively changing per decade growth rate. Future decade population is calculated by adding the mean arithmetic increase (x) to the last known population, similar to the "Arithmetic Increase Method." Additionally, the average of incremental increases (y) is added once for the first decade, twice for the second, and so forth. This method assumes varying growth rates, reflecting the changing nature of population increments.

$$Pn = P + n.X + \{n\ (n+1)/2\}.$$

*4) Decreasing Rate of Growth Method.*

This method capitalizes on descreasing population growth rates as cities approach saturation. It calculates the average desrease in percentage increase and substract it from the latest percenatge increase for each successive decade. However, its applicability is limited to situations where the growth rate exhibits a declining trend.

| ***Method*** | ***2025*** | ***2055*** | ***2060*** |
|---|---|---|---|
| Arithmetic Increase Method | 1060 | 1510 | 1585 |
| Geometric Increase Method | 1074 | 1830 | 2000 |
| Incremental Increase Method | 1060 | 1510 | 1585 |
| Decreasing Rate of Growth Method | 1720 | 11008 | 12556 |

Fig. 6: Population Forecasting Table

Population by Geometric Increase Method is to be considered for Design.
Since the Percentage Increase in Population is almost same for all Decades.
Hence, Forecasted population should be 2000

*B. Calculation of Demand of Water*

1. Population : 2000
2. Demand : 55 lpcd (Rural Area)

Average Daily Supply = 2000x55 = **1,10,000 litres/day**

Average Hourly Demand = 110000/24 = **4,583 liters/day**

*C. Balancing Reservoir*

Average Daily Demand = **0.11 MLD**
Average Hourly Demand = **0.011 Ml/day**
Pumping is to be done from 7.00 a.m. to 1.00 p.m i.e**. 6 hrs**. Pumping
Therefore, Rate of Supply = 110000/6 = 18,333 liters/day = **0.022 MLD**
Therefore, Capacity of Reservoir = 0.12 + 0.04 = 0.16 Ml = **1,60,000 Litres**
After applying the Mass Curve Method, the determined capacity of the Elevated Storage Reservoir (ESR) stands at 1,60,000 liters, ensuring sufficient water storage to meet projected demand and uphold water supply standards for the area.

### D. *Design of pump*

#### 1) *Data Assumed*

a) Velocity = 1.5m/s
b) Time for which pump needs to be operated = 6 hrs.
c) Total Amount of water to be pumped = 1,10,000 lit. = 110 Cu.m
d) Head loss [Hs] = 15% of the Head

#### 2) *Calculations.*

a) Demand for Hour = 110000/6 = 18333.33 litre/day
b) Discharge [Q] = volume/time = 110/6x3600 = 0.0051 Cu.m/sec = 306.00 lit/min.
c) Head (H)

H = RL of ESR (excluding Freeboard) - RL of source
= ( 316 + 15) - 309
= 22 m

d) Losses

Considering only major losses i.e. loss due to friction
Head loss (HE) = 10% x Head (H) = 10/100 x 22 = 2.2 m

e) Required Horse Power of Pump (HP required) =

Hp required = yw.Q.H/0.735
= 9.81 x 0.0051 x (22 + 2.2) / 0.735
= 1.64 HP………. Provide Pump of 2 HP

f) Required diameter of pipe

Area = Discharge/velocity = 0.0051/1.5
= 3.4 x $10^{-3}$ sq.m
Diameter of pipe required = √4x3.4x10^-3 /π
= 0.066m
= 66mm ≈ 70mm

#### 3) *Specifications of Pump*

| | |
|---|---|
| Type of pump | Non- self-priming centrifugal Monoblock pump |
| Pipe size | 4 inch (10mm) |
| Head | 7 m |
| Discharge | 306 lit/min |
| Outlet(mm) | 65mm |
| Motor Type | Non-Self priming |
| Phase | Three phase |
| Power | 2.94 kW |
| voltage | 415V |
| frequency | 50-60 Hz |
| Power (hp) | 2 HP |
| Location of pump | At the source |

#### 4) *Stand by Pump*

If in case the main pump slot is operating then the stand by pump will be in operation having the same specifications and location as that of main pump.

## VI. CONCLUSION

Water Systems is an innovative water distribution management Software that optimizes and manages water distribution systems, and enables real-time monitoring of water quality data.

1) Population Forecasting Methodology: After a comprehensive analysis of various population forecasting methods, it is evident that the Geometric Increase Method is the most suitable for the design purposes in this scenario. The forecasted population of 2000, derived from this method, is recommended due to same percentage increase across decades.
2) Elevated Storage Reservoir (ESR): The Mass Curve Method has been applied to determine the capacity of the Elevated Storage Reservoir (ESR), resulting in a capacity of 1,60,000 liters. This capacity ensures that there is ample water storage to meet the projected demand and maintain water supply standards for the designated area.
3) Pump: The Pump selected is a Non-self-priming centrifugal Monoblock Pump of Power 2 HP and in case the main pump faces any operational issues, a standby pump with identical specifications will be activated.

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