REDUCING COST BY SIMULATION OF WATER SUPPLY NETWORK AT RURAL AREA USING SOFTWARE JALTANTRA

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Abstract - *Designing a water distribution system involves meticulous considerations encompassing diverse factions such as investment expansion, current and future water demands, pipe dimensions, and reservoir locations, all within the confines of fixed budget limitations. However, the manual process of designing such a system often results in an overwhelming workload. Consequently, the imperative for the invention of a water distribution system became pronounced, given the outdated nature or unaffordability of many existing solutions. Thus, the genesis of Jaltantrs, an open technology platform, was spearheaded by scholars from IIT Bombay, in collaboration with inputs from engineers at Maharashtra Jeevan Pradhikaran (MJP). The core objective behind Jaltantra`s optimization algorithm intricately factors in pipe and energy costs, with prospective iterations poised to integrate GIS-based demand allocation and a myriad of data visualizations. This research paper elucidates Jaltantra`s prowess through a compelling case study, underscoring its efficacy in efficiently optimizing water distribution systems.*

Key Words: Jaltantra, water distribution system, Maharashtra Jeevan Pradhikaran, pipe diameter, cost optimization, water demand.

1.INTRODUCTION

The government of India faces a formidable challenge in ensuring the delivery of high-quality drinking water to citizens while adhering to budgetary constraints. Engineers operating under such circumstances often lack adequate tools that prioritize the selection of pipe diameters while neglecting other crucial aspects of water distribution systems. Consequently, much of the design process relies on the ad hoc method or the instincts of engineers. To address this issue, Jaltantra was developed to aid government engineers in determining various components of water networks, including tanks, pumps, valves, and pipe diameters.

By introducing an integer linear program model, Jaltantra is capable of generating optimized, efficient, and precise results through a streamlined design process. The Maharashtra Jeevan Pradhikaran (MJP), is responsible for developing village pipes and water schemes that significantly impact project costs. With a track record of designing more than 11,000 rural water distribution schemes, MJP aligns each design with government-mandated budgets to ensure affordability and service quality.

Typically, gravity-fed branched networks are preferred over cyclic networks due to their cost effectiveness and the unreliability of electricity supply. Despite decades of research on cost optimization, existing software like BRANCH, EPANET, and WaterGEMS primarily focus on pipe diameter selection, often overlooking critical components. Jaltantra addresses this limitation by enhancing cost optimization for pipes and tanks, with ongoing improvements aimed at incorporating pumps and valves while considering both capital and operational costs.

2. OBJECTIVES

[1] Examination and evaluation of data pertaining to the water distribution infrastructure in a specific region.

[2] Investigation into the report detailing pipes and junctions within the system.

[3] Familiarize with the operational principles and theoretical frameworks underpinning the modeling and analytical process of Jaltantra.

[4] Assessment and security of the current water distribution infrastructure.

[5] Enhancement and refinement of the prevailing water distribution system through optimization techniques.

3.REVIEW OF MODELLING SOFTWARE

The comprehensive capabilities of Jaltantra extend beyond mere optimization, facilitating the creation of resilient water distribution systems tailored to specific geographical and demographic contexts. By leveraging sophisticated algorithms and incorporating real-world constraints, such as budget limitations and terrain complexities, Jaltantra ensures that the resultant designs are not only cost -effective but also robust and adaptable to evolving needs. Moreover, Jaltantra`s interface and analytical tools empowers users to explore various scenarios and visualize the potential outcomes, enabling informed decision-making throughout the design process. This interactive approach fosters con tenuous improvement and

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refinement, ultimately leading to the development of sustainable water infrastructure that can withstand future challenges and uncertainties. Furthermore, by promoting the efficient utilization of the resources the maximizing the delivery of the safe and reliable water supplies. Jaltantra contributes to broadens socio-economic development goals, including public health improvement and environmental sustainability . its role in the advancing water management practices underscores its significance as the transformative tool in the pursuit of resilient and equitable water systems for communities worldwide

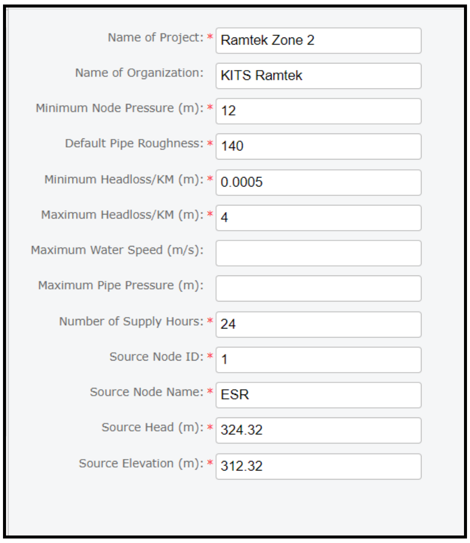
4. METHODOLOGY

4.1 AREA OF STUDY

The project focuses on Ramtek, a taluka located approximately 50km northwest of Nagpur Ramtek receives substantial rainfall, with a maximum recorded amount of 2082.50mm. projections estimate the total population to reach 30,863 by the year 2050. The town1s first regular water supply scheme was inaugurated in 1971, drawing water from the right bank canal of Khindsi Lake, positioned 310 meters away and about 30 meters upstream from the existing canal gate of the dam.

4.2 DATA COLLECTION

Information such as node names, water demand, elevation, head pressure, and minimus pressure is input into the jaltantra database. The accompanying figure iluustrates the water distribution model in the designated area.

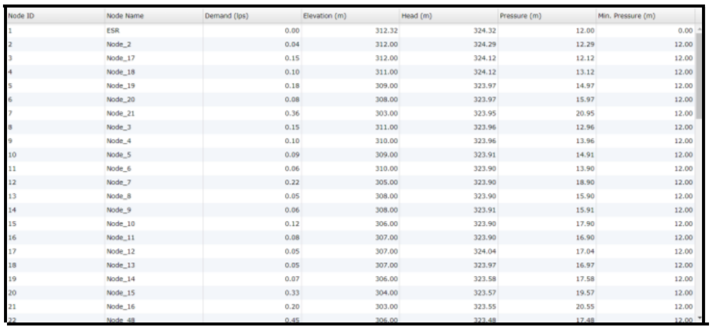


Name of Project: * Ramtek Zone 2
Name of Organization: KITS Ramtek
Minimum Node Pressure (m): * 12
Default Pipe Roughness: * 140
Minimum Headloss/KM (m): * 0.0005
Maximum Headloss/KM (m): * 4
Maximum Water Speed (m/s):
Maximum Pipe Pressure (m):
Number of Supply Hours: * 24
Source Node ID: * 1
Source Node Name: * ESR
Source Head (m): * 324.32
Source Elevation (m): * 312.32

Fig -1: Data input interface

4.3 DATA ANALYSIS

Following the input data, Jaltantra simulates the informstion and utilizes the Hazen Wiliiams equation to determine the pipe costs at each node. Subsequently , Jaltantra analyses the date and presents it in various formats, including graphs depicting head loss and nodes with their corresponding pressure heads . the accompanying images illustrates the simulated data analyzed by Jaltantra. The data required such as pressure at each nodes is calculated and presented in an graphical foem to let the user understand the system more carefully. The elevations, head, pressure is already given and is collected from the government records of the taluka place.



Node ID	Node Name	Demand (lps)	Elevation (m)	Head (m)	Pressure (m)	Min. Pressure (m)
1	ESR	0.00	312.32	324.32	12.00	0.00
2	Node_2	0.04	312.00	324.29	12.29	12.00
3	Node_17	0.15	312.00	324.12	12.12	12.00
4	Node_18	0.10	311.00	324.12	13.12	12.00
5	Node_19	0.18	309.00	323.97	14.97	12.00
6	Node_20	0.08	308.00	323.97	15.97	12.00
7	Node_21	0.36	303.00	323.95	20.95	12.00
8	Node_3	0.15	311.00	323.96	12.96	12.00
9	Node_4	0.10	310.00	323.96	13.96	12.00
10	Node_5	0.09	309.00	323.91	14.91	12.00
11	Node_6	0.06	310.00	323.90	13.90	12.00
12	Node_7	0.22	305.00	323.90	18.90	12.00
13	Node_8	0.05	308.00	323.90	15.90	12.00
14	Node_9	0.06	308.00	323.91	15.91	12.00
15	Node_10	0.12	306.00	323.90	17.90	12.00
16	Node_11	0.08	307.00	323.90	16.90	12.00
17	Node_12	0.05	307.00	324.04	17.04	12.00
18	Node_13	0.05	307.00	323.97	16.97	12.00
19	Node_14	0.07	306.00	323.58	17.58	12.00
20	Node_15	0.33	304.00	323.57	19.57	12.00
21	Node_16	0.20	303.00	323.55	20.55	12.00
22	Node_48	0.45	306.00	323.48	17.48	12.00

Fig -2: Nodes and pipe identification details

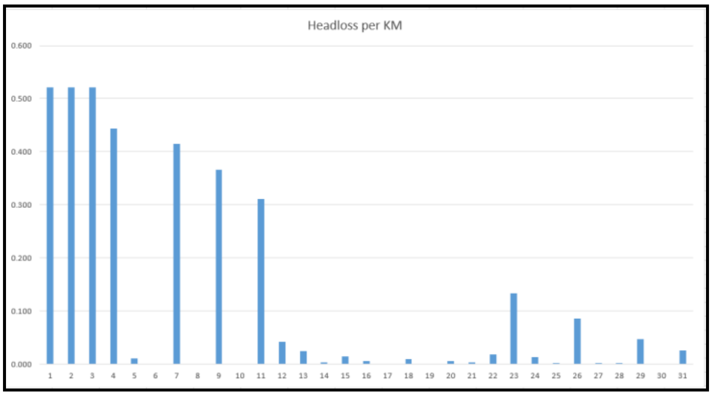


Fig -3: Headloss per km

4.4 COMPARING THE RESULTS

The results of the simulated water distributions system is also provided in an detailed tabular form presenting various apects of the and finally giving the total optimized cost of the total project. Under the determining cost of the manually calculated cost with the help of excel sheet the final costs of simulated water distribution system is compared with each other to find the concluding results.

JalTantra: System For Optimization of Piped Water Networks, version:2.2.2.0
developed by CSE, CTARA, and CUSE departments of IIT Bombay
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Network Name	Ramtek Zone 2
Organization Name	KITS Ramtek
Minimum Node Pressure	12
Default Pipe Roughness 'C'	140
Minimum Headloss per KM	0.001
Maximum Headloss per KM	4.000
Maximum Water Speed	
Maximum Pipe Pressure	
Number of Supply Hours	24
Source Node ID	1
Source Node Name	ESR
Source Elevation	312.32
Source Head	324.32
Number of Nodes	71
ESR Enabled	FALSE
Pump Enabled	FALSE
Total Length of Network	4,600
Total Length of New Pipes	4,600
Total Pipe Cost	41,94,076

Fig -4: Results of simulation

COST RESULTS OF NEW PIPES			
Diameter	**Length**	**Cost**	**Cumulative Cost**
70.00	2,099	18,40,823	18,40,823
80.00	2,333	20,46,041	38,86,864
120.00	143	2,55,112	41,41,976
160.00	25	52,100	41,94,076
Total	4,600	41,94,076	

Fig -5: Cost results of new pipe

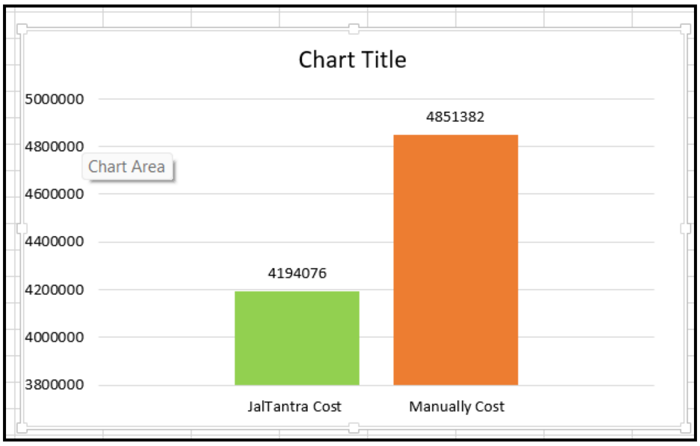

Fig -6: Cost comparison

5. CONCLUSIONS

[1] Following an intensive comparative analysis, it became apparent that several factors influence the selection of an efficient water distribution system software. These include software availability, compatibility, user-friendly interface, and the application of the optimal methodologies.

[2] Given the paramount importance of the accuracy and precision, the speed at which the results are calculated holds equal significance. Hence, there is a growing demand for applications with such capabilities.

[3] While many software options boast nearly all the requisite features for the desigining an optimal water distribution network, the unparalleled advantage of the Jaltantra lies in its free availability in the public domain, rendering it an indispensable choice.

[4] The difference in the cost of both manually calculated water distributions system and the same simukated on the Jaltnatra gives huge amount of difference of 657306RS. Which implies 13.54% of reduction in cost.

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