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OPTIMIZATION AND SIMULATION OF WATER SUPPLY SYSTEM USING JALTANTRA SOFTWARE FOR RAMTEK TALUKA ZONE 1

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Abstract - *In this study, the water supply system of the Ramtek region of zone 1 is designed located at Nagpur district, State Maharashtra, India. A water system distribution system is intended for this study for a population calculable for the longer term of thirty years. Jaltantra is hydraulic modeling software that is used for the design and optimization of water distribution networks. The reasonable size of pipes of the water distribution network is designed by considering the restraint pressure at each node, the velocity in the pipe, head loss in pipes, the material of pipes, and available commercial pipe diameters are compared existing water distribution system. The water distribution system has been designed for the future population for the present population scheme for intermittent water supply using Jaltantra. In this paper design of the water supply network considering optimization in addition to the cost minimization, the minimum head requirement is presented.*

Key Words: Analysis of water distribution system, Optimization, Simulation, Jaltantra.

1. INTRODUCTION

Water is an, very important requirement in our day-to-day life. and it covers seventy-one percent of the earth, of which nearly three percent is freshwater. Only half a percent of freshwater sources are rivers, lakes, etc. With the increasing population, it has become difficult to supply fresh water. The design of the water distribution system to satisfy the water requirement should not be the only objective but to satisfy the water supply requirement is economical it is most important. Computation of discharge and pressures is a difficult task for optimization of water distribution network. Reference [8] presented the analysis of hydraulic networks by using HCM and EPANET. Analytical solution for the four-loop hydraulic network is obtained using electronic spreadsheets in MS-Excel. The water supply system is simulated using EPANET software for Intermittent and continuous water distribution systems by some of the researchers [11], [1]. Reference [6] presented a system for the simulation and optimization of water supply networks. IIT Bombay developed JalTantra, it is using an integer linear program model, to solve the problem optimally, quickly, and economically. This case study design and optimization of water supply systems by the aspect of the economical design of the network and design constrain by using Jaltantra software.

2. OBJECTIVES

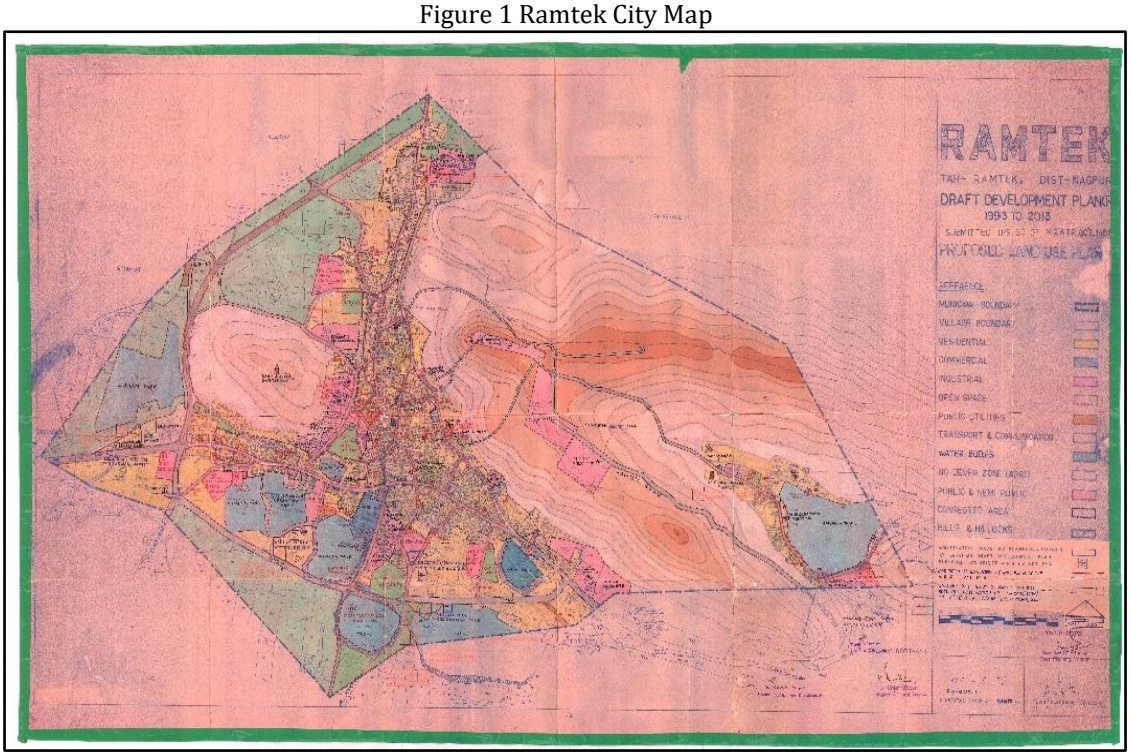
1. To collect data of water distribution network of zone 1:
2. To collect pipe report and junction report of the network;
3. To understand the modeling and analysis of hydraulic network in JalTantra;
4. To check the discharge and pressure head in the network;
5. To analyze the existing water distribution network of zone 1 of Ramtek city and design for 12 m residual pressure;
6. To calculate the cost of pipe in the case study and compared the existing cost of zone 1 of Ramtek city.

3. STUDY AREA

3.1 Introduction About The Study Area

The case study Ramtek town is a taluka place of Nagpur District. This town is situated at 50 km. North-East of Nagpur. It is connected by the South Eastern railway branch from kanhan junction on Nagpur Howrah mainline. It is also connected to NH by State highway from mansard which is about 5 km from Ramtek. The civil affairs are managed by Municipal Council. The town has mythological and worldwide historical importance. The main function of the water distribution system is to supply the water of required quantity, required pressure, and economical cost of the water supply system. Ramtek town is situated on 21°23'N and 79°19'E is shown in figure 1.

Figure 1 Ramtek City Map



3.2 Data Collection

To design and optimization of the water distribution system, various data have been collected from zone 1. Node details, pipe details, length of the pipes, reduce levels of each node, flow of each node, roughness coefficient in terms of Hazen Williams C, the elevation of the reservoir, and schedule rate of commercial pipes. Figure 2 shows a layout map of the proposed pipe distribution network of the water supply system of zone 1. Cast iron pipes have been used for the distribution network in Ramtek city. Commercial pipes of government schedule rates are shown in Table 1.

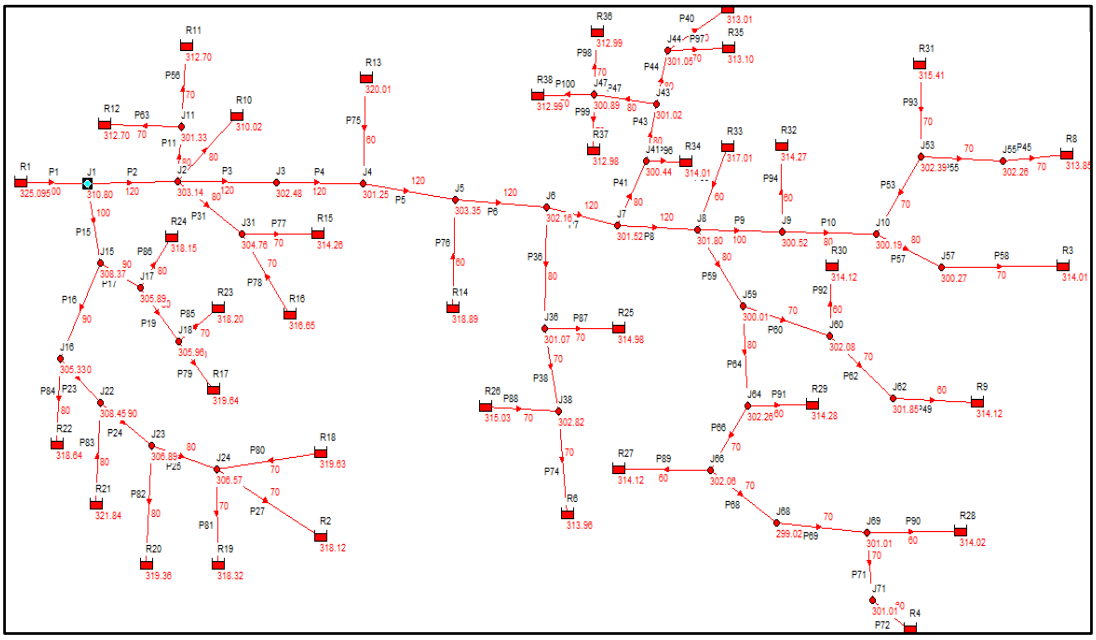


Figure 2. Layout map of the proposed pipe distribution network of zone 1

Table 1: Commercial Pipe details

COMMERCIAL PIPE DATA	
Diameter(mm)	Rate (in Rs)
80	823
100	1,028
125	1,338
150	1,647
200	2,380
250	3,216
300	4,163
350	5,204
400	6,383
450	7,732
500	8,865

4. METHODOLOGY

4.1 Design Constrains

The layout of the water distribution system zone 1 is drawn by using junction to junction flow, elevation, and length of the existing system. Minimum residual pressure is maintained at 12m and the pipe roundness of coefficient is taken at 140 since cast iron pipes are used.

4.2 Steps In Using Jaltantra

Method of design and optimization using can be classified into three steps: Preprocessing, optimization, and post-processing. Steps for Optimization and Post Processing in JalTantra Software:

1. General panel basic information fill up.
2. Add nodes details in the node panel.
3. Add pipes details in the pipe panel.
4. Defining commercial pipe details.
5. Consider safety parameters like nodal pressure, maximum velocity, maximum and minimum head loss per kilometer.
6. Defining maximum pipe pressure, and
7. Optimize the network in the panel.

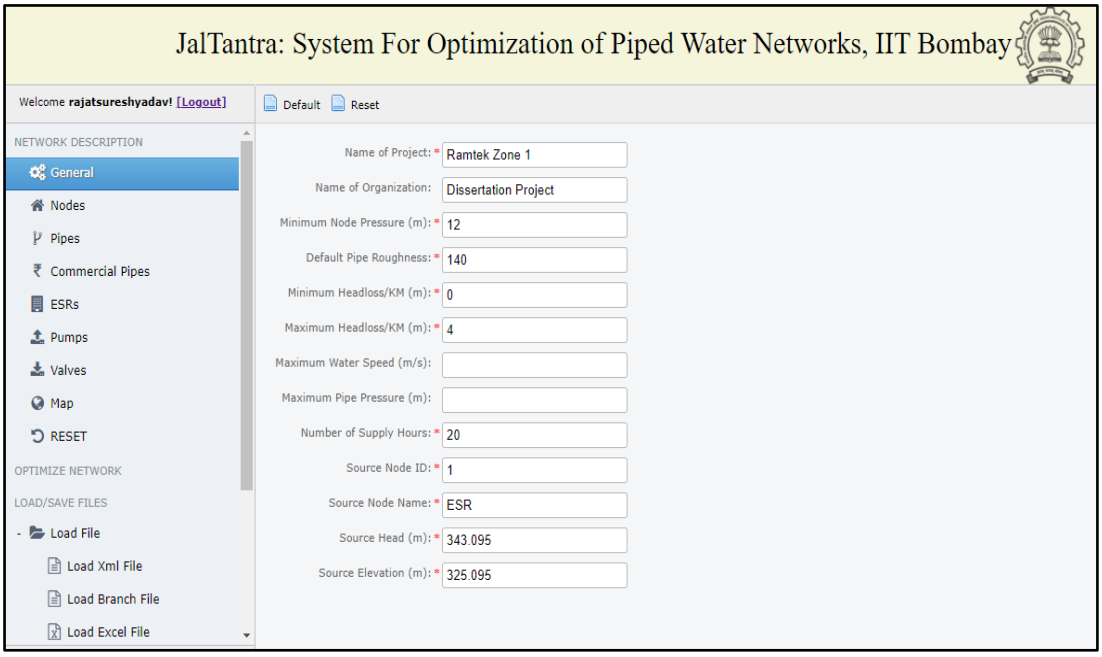
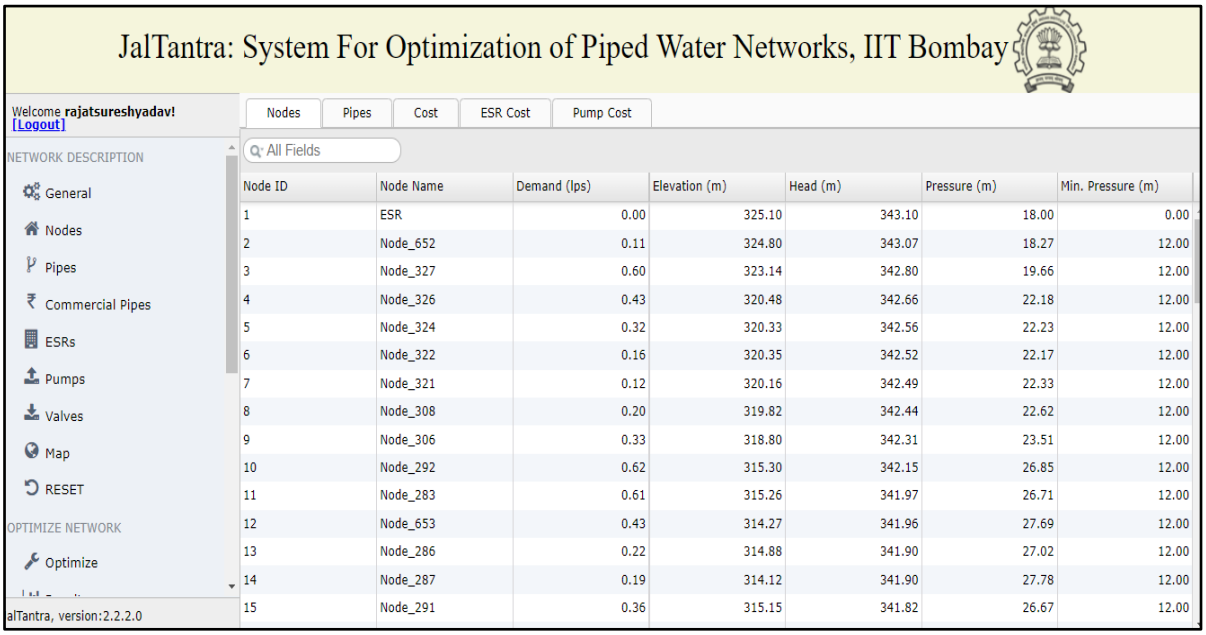


Figure 3 Four options and each panel under every option in JalTantra

First network description which contains input data zone 1 network, second is to optimize the network in which the system can optimize the network and results are displayed, third is load and save files option in which load or save input and output files and fourth is help section to additional information about the system are shown in figure 3. In the general panel which contains input fields for the general information of a network. All input fields are shown in Figure 3 for zone 1. In the Nodes panel enters 73 nodes information regarding the nodes of zone 1 network, now use pipes panel enter 72 number of pipes in zone 1 and enter the commercial pipe details and its cost in commercial pipe section is shown in table 1.

5. RESULTS

The water distribution system of the study area of zone 1 Ramtek city consists of 72 pipes, 73 nodes, and storage tank height is 18m. the pressure is determined at all junctions is ≥ 12 m. the output nodes results are obtained in Figure 4 shows.



Node ID	Node Name	Demand (lps)	Elevation (m)	Head (m)	Pressure (m)	Min. Pressure (m)
1	ESR	0.00	325.10	343.10	18.00	0.00
2	Node_652	0.11	324.80	343.07	18.27	12.00
3	Node_327	0.60	323.14	342.80	19.66	12.00
4	Node_326	0.43	320.48	342.66	22.18	12.00
5	Node_324	0.32	320.33	342.56	22.23	12.00
6	Node_322	0.16	320.35	342.52	22.17	12.00
7	Node_321	0.12	320.16	342.49	22.33	12.00
8	Node_308	0.20	319.82	342.44	22.62	12.00
9	Node_306	0.33	318.80	342.31	23.51	12.00
10	Node_292	0.62	315.30	342.15	26.85	12.00
11	Node_283	0.61	315.26	341.97	26.71	12.00
12	Node_653	0.43	314.27	341.96	27.69	12.00
13	Node_286	0.22	314.88	341.90	27.02	12.00
14	Node_287	0.19	314.12	341.90	27.78	12.00
15	Node_291	0.36	315.15	341.82	26.67	12.00

Figure 4 Nodes results of Zone 1

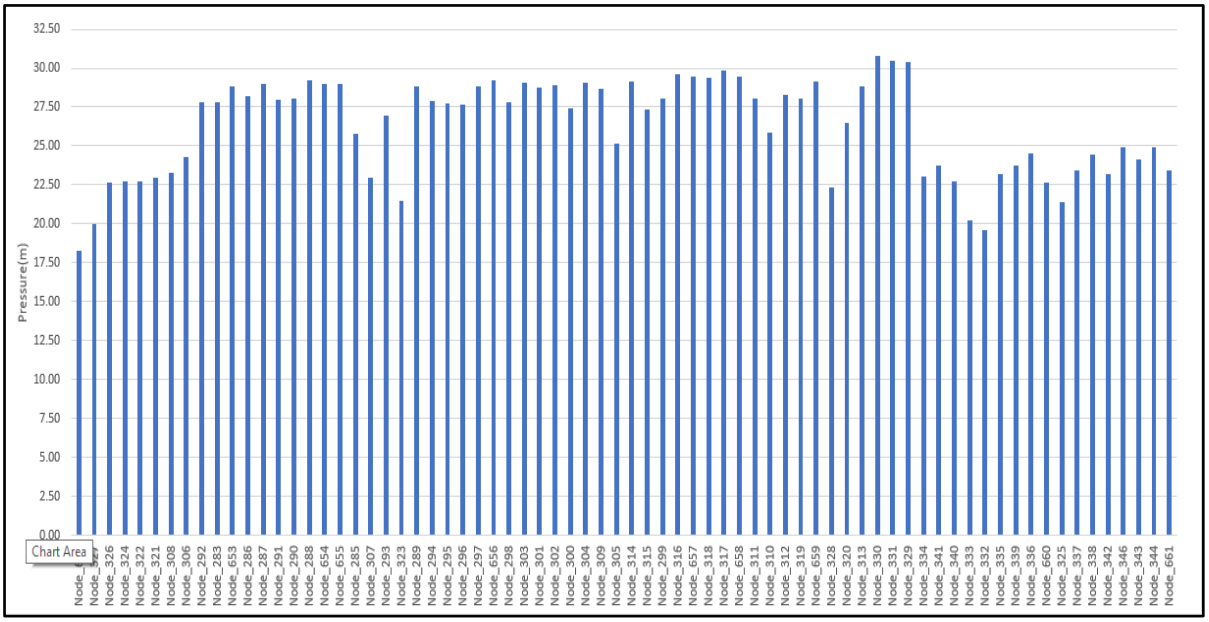
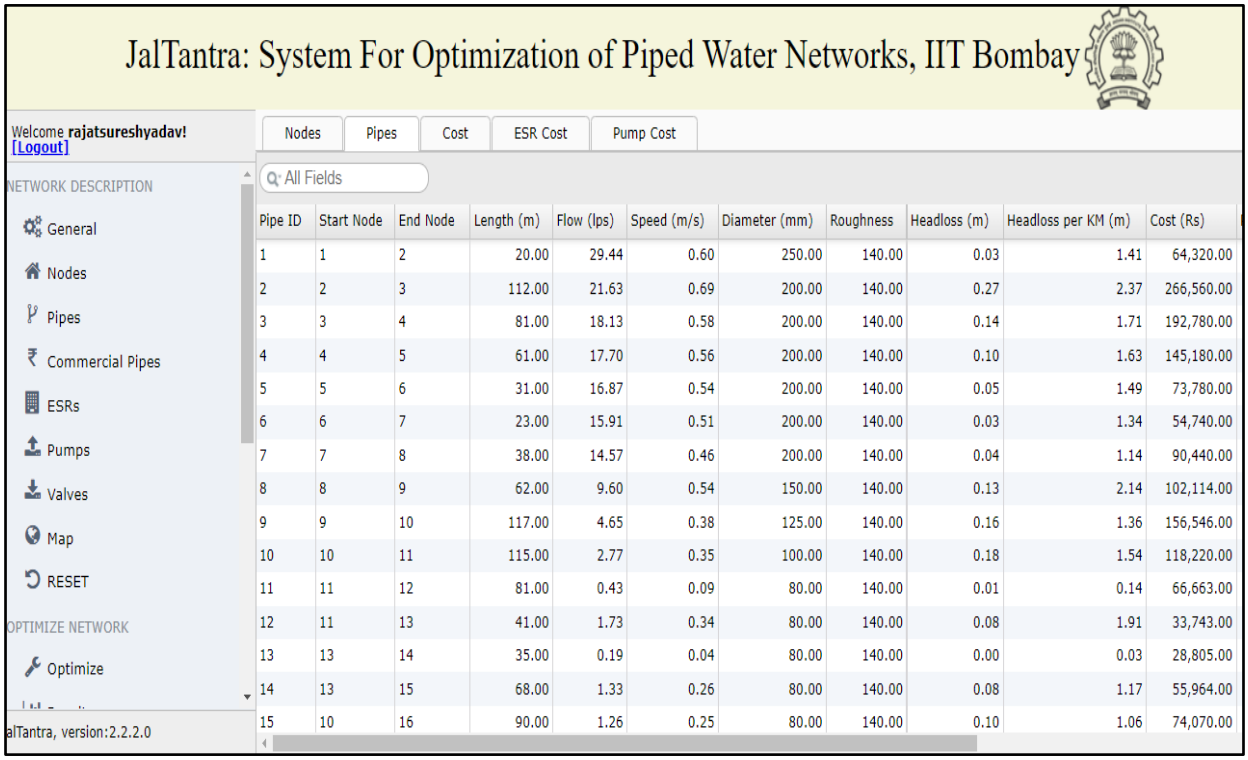


Figure 5 Pressure in Nodes

In Figure 4 shows the node results of zone 1 the minimum pressure is 18.27 m and the maximum pressure is 30.13 m. The nodes pressure of zone 1 is graphically represented in Figure 5 shown.



Pipe ID	Start Node	End Node	Length (m)	Flow (lps)	Speed (m/s)	Diameter (mm)	Roughness	Headloss (m)	Headloss per KM (m)	Cost (Rs)
1	1	2	20.00	29.44	0.60	250.00	140.00	0.03	1.41	64,320.00
2	2	3	112.00	21.63	0.69	200.00	140.00	0.27	2.37	266,560.00
3	3	4	81.00	18.13	0.58	200.00	140.00	0.14	1.71	192,780.00
4	4	5	61.00	17.70	0.56	200.00	140.00	0.10	1.63	145,180.00
5	5	6	31.00	16.87	0.54	200.00	140.00	0.05	1.49	73,780.00
6	6	7	23.00	15.91	0.51	200.00	140.00	0.03	1.34	54,740.00
7	7	8	38.00	14.57	0.46	200.00	140.00	0.04	1.14	90,440.00
8	8	9	62.00	9.60	0.54	150.00	140.00	0.13	2.14	102,114.00
9	9	10	117.00	4.65	0.38	125.00	140.00	0.16	1.36	156,546.00
10	10	11	115.00	2.77	0.35	100.00	140.00	0.18	1.54	118,220.00
11	11	12	81.00	0.43	0.09	80.00	140.00	0.01	0.14	66,663.00
12	11	13	41.00	1.73	0.34	80.00	140.00	0.08	1.91	33,743.00
13	13	14	35.00	0.19	0.04	80.00	140.00	0.00	0.03	28,805.00
14	13	15	68.00	1.33	0.26	80.00	140.00	0.08	1.17	55,964.00
15	10	16	90.00	1.26	0.25	80.00	140.00	0.10	1.06	74,070.00

Figure 6 Pipes results of zone 1

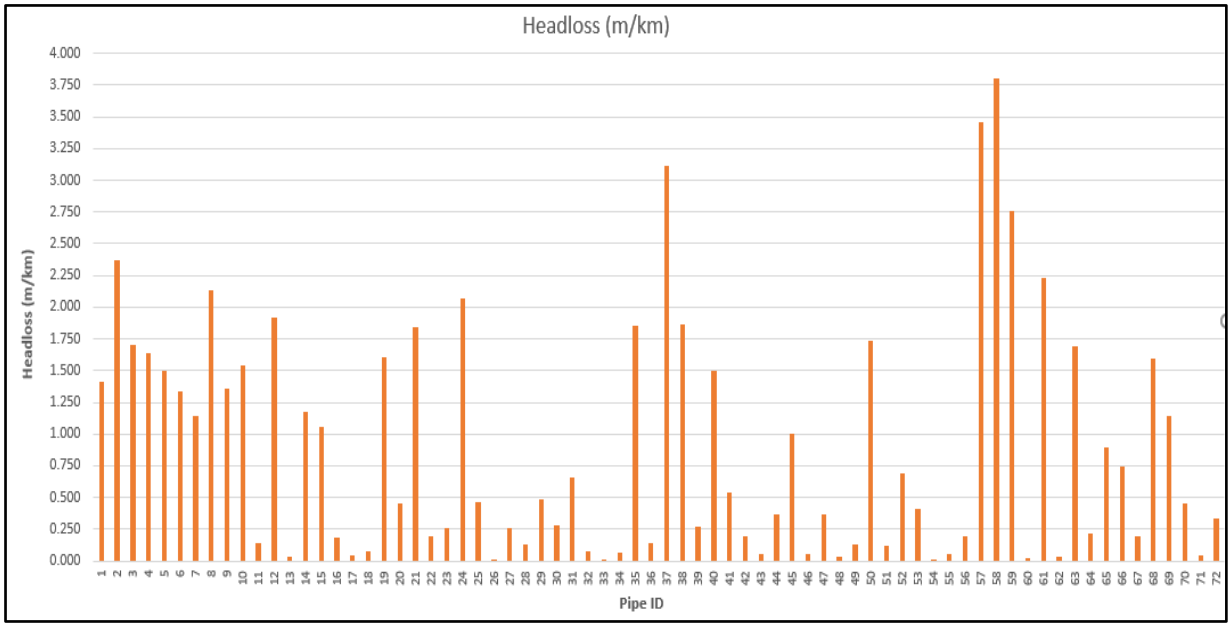


Figure 7 Headloss in the pipe (m/km)

The simulation was carried out for pipe results of zone 1, using the Jaltantra software to decide the pipe diameter. The roughness of pipe is taken as 140, it is a default value set in the general panel of Jaltantra software and cast-iron pipe is used in zone 1. The total cost is shown in Table 2. The output value of the head loss is graphically represented in Figure 7.

Table 2: Total cost of pipes

COST RESULTS OF NEW PIPES			
Diameter	**Length**	**Cost**	**Cumulative Cost**
80.00	4,201	3,457,423	3,457,423
100.00	571	586,988	4,044,411
125.00	187	250,206	4,294,617
150.00	62	102,114	4,396,731
200.00	346	823,480	5,220,211
250.00	20	64,320	5,284,531
Total	5,387	5,284,531	

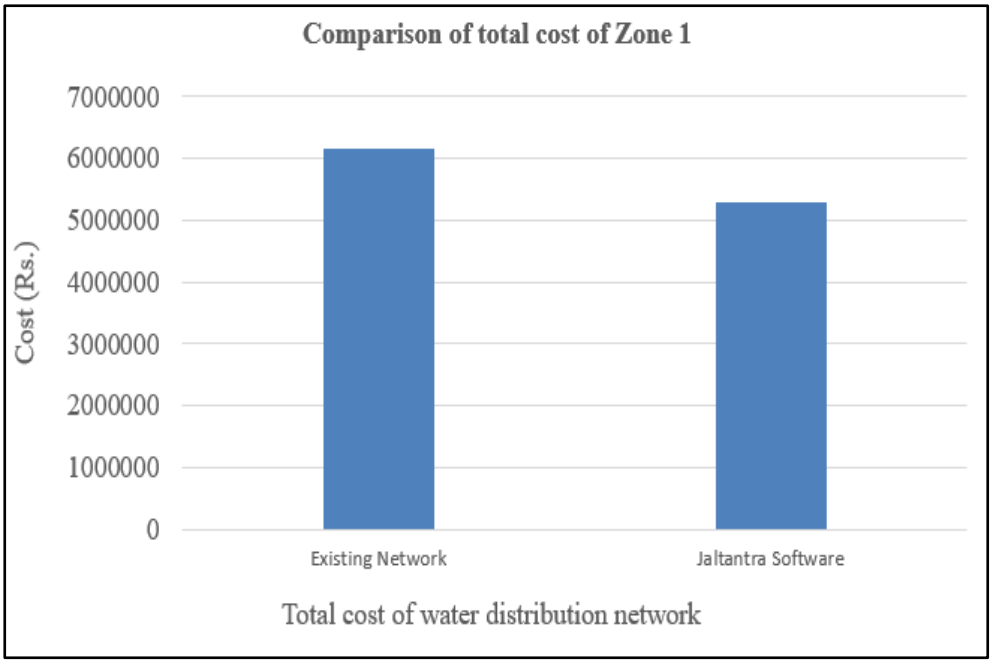


Figure 8 Comparison of total pipe cost of zone 1

It is found from Figure 8 that the Jaltantra software is the most economical design of water distribution system as compared to an existing network, the total cost of an existing network is 61,46,127 Lakh and the total cost in Jaltantra is 52,84,531 it is around 14% economical than existing network.

6. CONCLUSION

In this study area of zone 1 Ramtek city, the Jaltantra software has been used for the design and optimization of the water distribution network. At the end of analysis and optimization, it was found that the resulting pressure at all the junctions of pipes is adequate to provide water to the study area of zone 1. In the case study existing water distribution scheme branch method is used it takes more time and it is not economical. Jaltantra is a user-friendly open-source system that was developed at IIT Bombay. Jaltantra is minimize the cost of pipe and maintain the pressure of pipes, in case of study 14% of economical in the existing water distribution system. JalTantra is a system for the design and optimization of water distribution networks, they minimize the capital and operational cost of the network while satisfying all inputs and hydraulic constraints.

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