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Design of water distribution network using JalTantra and EPANET software

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ABSTRACT: This research paper focuses on developing a sustainable water distribution network for a rural village by integrating EPANET and JalTantra software tools. Initially, the village's water demand was thoroughly analysed, considering factors like population growth, seasonal variations, and usage patterns. EPANET was then used to design a detailed network layout comprising pipelines, valves, and storage tanks. Subsequently, JalTantra was employed for optimization, aiming to minimize costs and maximize efficiency and reliability. Various scenarios were explored, with an eye toward future expansion and adaptability. The study highlights the effectiveness of this integrated approach in designing robust and cost-effective water systems for rural communities. By providing a comprehensive infrastructure blueprint, the project contributes significantly to improving access to clean water and enhancing residents' quality of life in underserved regions.

I. INTRODUCTION

Water plays a vital role in the life of all living organism. It is indispensable for human life, serving essential purposes such as drinking, cooking, sanitation, and agriculture. A water distribution network should be designed such a way that it meets the demand of increased population. An adequate water supply can give better living standards. The water quality should not get deteriorated in the distribution pipes. The deficiencies of water supply in urban regions are becoming a major challenge for authorities. Because most of the water supply scheme are intermittent system. When using an intermittent system the water is distributed to residents for few hours in a day, hence most of the times the pipe lines are empty or partially full [1].Today, water is taken for granted by the consumers. It is expected that clean water in the right quantity will be available by just turning the tap. It took a large number of incremental advances in science and technology to make modern water distribution systems as reliable and inexpensive as they are today [2]. While this may be so for the developed countries, the same cannot be said of developing countries where the majority of the population does not have access to clean water due to inadequate supply and distribution system [3].To meet these diverse needs, water supply must align with user demand, ensuring satisfactory quality, availability, pressure, and affordability. Historically, water distribution relied on trial-and-error approaches, heavily reliant on individual expertise, making them inefficient for complex systems. The advent of computational techniques revolutionized water distribution analysis and Design. Extensive research has focused on software solutions, with prominent examples like EPANET, JalTantra, and WaterCAD. EPANET stands out for its ability to comprehensively model water flow, pressure, tank levels, and even chemical concentrations within a network. In summary, software tools like EPANET and JalTantra offer invaluable support in optimizing water distribution networks, enabling efficient resource allocation and improved service delivery to communities worldwide.EPANET applications in solving and/or optimizing water distribution network problems have been reported by [4], [5], [6], and [7]. This research involves design of water distribution network for a village-Pathari. EPANET is used for designing water distribution networks by modelling flow, pressure, etc. It helps optimize pipe sizes, pump placements, and tank capacities, ensuring efficient and reliable water supply. Jaltantra complements EPANET by providing advanced decision support tools for network optimization. It aids in minimizing costs while maximizing system efficiency, considering factors like pipe diameter, pump placement, and tank sizing. Jaltantra's algorithms help refine network designs for cost effectiveness and scalability, contributing to sustainable water management solutions.

1.1 EPANET and JalTantra software

1.1.1 EPANET

EPANET, developed by the United States Environmental Protection Agency (EPA), is a freely available water distribution system modelling software. It specializes in extended period simulation of hydraulic and water quality behaviour within water distribution networks. EPANET's capabilities include hydraulic analysis for systems of any size, tracking water flow in pipes, node pressures, and tank water levels throughout the network. It operates on Windows and offers a comprehensive environment for editing network data, conducting hydraulic and water quality simulations, and visualizing results through various formats like network maps, data tables, graphs, and contour plots.

1.1.2 JalTantra

JalTantra is a decision support tool designed for optimizing water distribution systems, complementing EPANET's capabilities. Developed by IIT Bombay, JalTantra employs advanced algorithms to minimize costs and maximize efficiency and reliability. It allows for scenario exploration by adjusting parameters like pipe diameter and pump placement, considering factors such as population growth and seasonal variations. By integrating JalTantra with EPANET, engineers can design robust systems tailored to rural community needs. This approach ensures adaptability to future demands and environmental changes, contributing to improved access to clean water and enhanced quality of life.

II. STUDY AREA

Area selection is pivotal for project success, directing resources effectively to communities in need. It ensures efficient allocation of resources, addressing pressing needs and promoting sustainability. By considering factors like demographics, existing infrastructure, and community engagement, proper area selection enhances project feasibility and long-term impact. Ultimately, it optimizes interventions, benefiting the targeted population and fostering lasting positive change. The area selected is a village with scarcity of water. The area selected is a village named as Pathari. Pathari village is located in Solapur North tehsil of Solapur district in Maharashtra, India. Co-ordinates- Latitude 17.616444, Longitude 75.779704. The total geographical area of village is 20.12 sq.km. The population of study area according to 2011 census is 1857.

Fig. 1. Pathari village map

III. METHODOLOGY

The network was designed firstly by using JalTantra and the required data such as elevation, pipe diameter and length was taken from its output. The obtained data was then further used in EPANET to optimize the network. The major aim was first to design a cost optimized network and then optimize and check whether if the network is an optimized network in EPANET.

3.1 Design considerations

The layout of the distribution network is drawn based on the existing road pattern.The nodes are given considering the houses in that particular area. Length of the pipe is taken as the road length. The diameter of the pipe will be automatically considered based on the demand, minimum pressure, minimum headloss, etc. It is chosen from the available pipe diameters locally which is specified in the "Commercial Pipe Data" tab of Jaltantra software. . Pipe roughness coefficient is taken 150, since Poly Vinyl Chloride pipes are used. The number of supply hours was set to 24 hours.

3.2 Demand calculation

Incremental Increase Method is used for population forecasting. In this method, the average of the increase in population is taken as per arithmetic method, and to this is added the average of the net incremental increase, once for every future decade whose population is to be estimated will be calculated from the available data. To the present population, the average incremental increase per decade is added and the population of next decade is obtained. Like this, the process is repeated till the population in the desired decade is determined. The formula for this method is

Pn = Po + [d – i] n ——— (1)
Where,
Pn=Prospective or Forecast Population after 'n' decades from the last census.
Po= Population of last known census.
n =Number of decades between now and future.
D=Average of population increase in the last 3 or 4 decades.
I=Average of incremental increase of the known decade.
The design period for the system is taken as thirty years. After the population forecast the demands were calculated using the general equations.

Year	Population	Increase in population per decade	% Increase inpopulationPer decade	Incremental increase in population per decade
1991	694			
2001	1091	391	56.34	
2011	1857	766	70.21	375
	Total	1157	126.55	375
		d=578.5	r=63.275	i=375

Table 1. Population fore casting using incremental increase method

Using Incremental increase method,
P_{2041} =P0 + [d- i] n
P_{2041} =1857 + [578.5-375]*3
P_{2041}=2468
Demand=Population *170 (liters/day)
Demand=2468*170
Demand=0.42 MLD
Average Demand= Demand+ 10% wastage
Average demand = 0.46 MLD

Consider MDD to ADD ratio=1.4 then,
Maximum water demand=0.46*1.4
Maximum water demand=0.65 MLD

Hence the water distribution network will be designed for a population of 2468 and water demand of 0.65 MLD for a design period of 30 yrs.

3.3 Steps to use JalTantra
Step 1:
Upon completing registration and login, users are greeted with a series of tabs on the initial page of JalTantra, an open-source software system. These tabs include "Network Description," "Optimize Network," "Load/Save Files," and "Help."Within the "Network Description" tab, users encounter sub-tabs primarily focused on input data submission. In the "General" section, essential data parameters required for the optimization of the network are shown in Fig.2. which are as follows:

- Project Name
- Organization Name
- Minimum Node Pressure (m)
- Default Pipe Roughness
- Minimum Headloss/KM (m)
- Maximum Headloss/KM (m)
- Number of Supply Hours
- Source Node ID
- Source Head (m)
- Source Elevation (m)

This section serves as a foundational step in configuring the network parameters necessary for subsequent optimization processes. Users are prompted to input accurate and relevant information to ensure the optimization algorithm operates effectively and delivers optimal outcomes.

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Fig. 2. General tab of JalTantra

Step 2:

After completing the necessary data entry in the "General" tab, the subsequent step in the "Map" section involves locating the area of interest, in this case, Pathari village as shown in Fig.3. Users can input the latitude and longitude of the area into the "Search Location" section for convenience.Within the "Map" tab, users are provided with tools to lay nodes and pipes according to the requirements of the population. This task is facilitated through the use of buttons such as "Add Node" and "Add Pipe." Additionally, users can access both normal and satellite views of the area to aid in locating roads and buildings.Each node is characterized by its Name, Node ID, Latitude, Longitude, and Elevation, allowing users to accurately position and configure nodes within the network topology. Setting off the initial network by using the Map section allows the users to conveniently access the node elevation, pipe lengths, etc. In this tab, the elevation of each node and the difference in elevation are displayed in the "Elevation" tab. This tab helps to deploy the pipes by considering the ground elevation which is ultimately an important factor to in the Gravity Type of water distribution system.

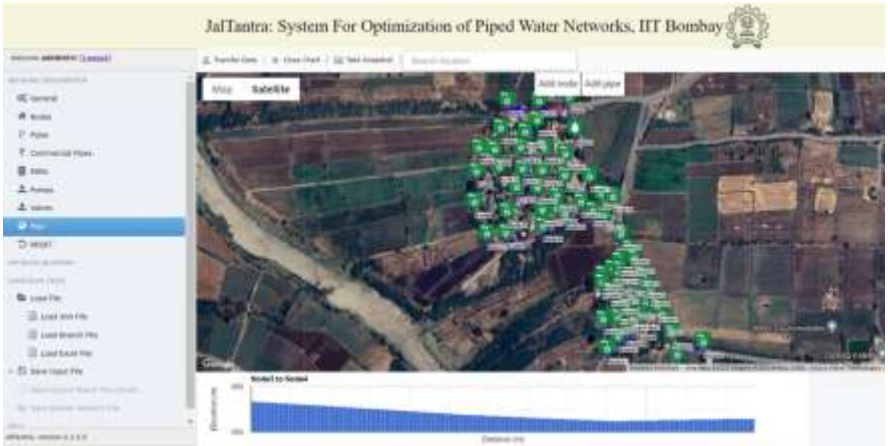

Fig. 3. Map tab of JalTantra

Step 3 :

After the addition of nodes and pipes, the subsequent step involves navigating to the "Nodes" tab. Here, users can observe and review the properties of each node, generated in sequential order starting from node 2, as node 1 serves as the source (ESR). The software automatically populates the elevation column with the elevations of each node. Additionally, users manually input the demand in liters per second (lps) as shown in Fig.4.Within this tab, users have the opportunity to verify and correct the location of any node or pipe if necessary. This verification process ensures the accuracy of the network layout before proceeding with further analysis or optimization.In tasks such as designing water distribution networks with elevated service reservoirs (ESRs) that do not utilize pumps, the elevation factor plays a critical

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role. It influences the flow of water within the network and is therefore crucial for optimizing the efficiency and effectiveness of the distribution system. The source head is the addition of source elevation and the height of the ESR.

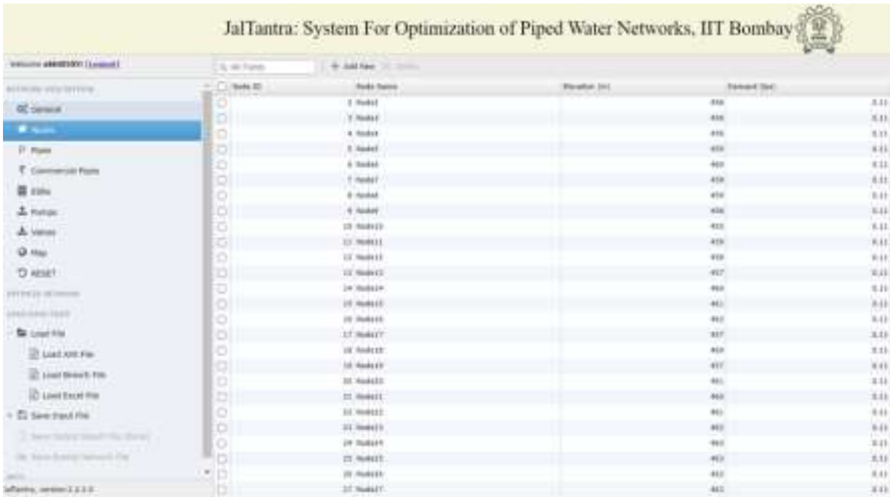

Fig. 4. Node propertiestab of JalTantra

Step 4:

In the "Pipes" tab, users can access properties such as Pipe ID, Start Node, End Node, and Length, which are automatically populated in their respective columns by the software as shown in Fig. 5. Additionally, users have the option to manually input data in the "Commercial Pipe" tab to specify parameters such as diameter. Subsequently, the software employs predetermined algorithms or user-defined criteria to assign appropriate diameters to the pipes, ensuring optimal functionality and efficiency within the network design.The pipe properties are automatically imported from the map section of the software in the order they were assigned.

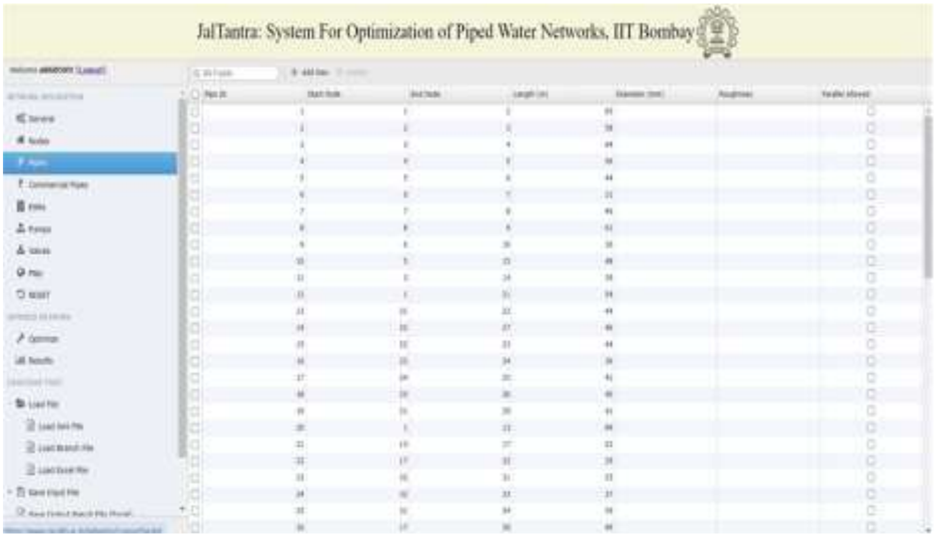

Fig. 5. Pipe propertiestab of JalTantra

Step 5:

In the "Commercial Pipes" tab, users have the capability to input pipe specifications, including their respective diameters and associated costs, based on availability and other factors. The software autonomously selects pipes with the highest feasibility, considering factors such as cost-effectiveness, availability, and suitability for the network design. This functionality enables users to optimize the selection of pipes within the network, ensuring efficient and cost-effective implementation of the water distribution system.

Fig.6. shows Commercial Pipes Tab of the JalTantra Software.

Pipe Diameter	Cost per meter
75	198
90	208
110	264
125	342
140	428
200	865

Table 2. Commercial pipe data for JalTantra

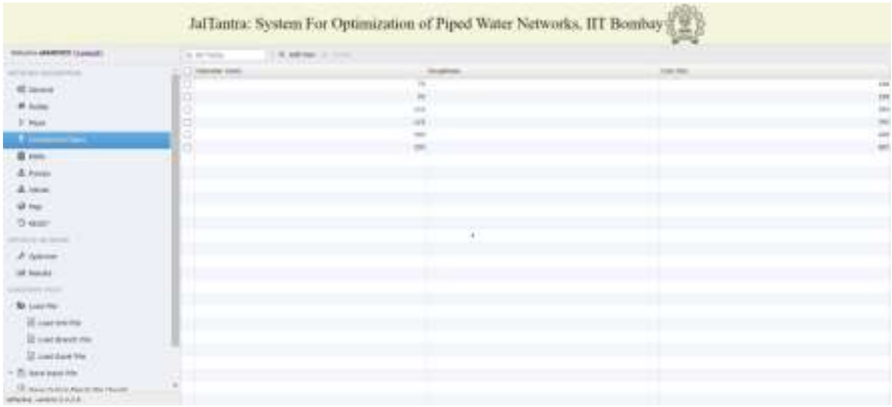

Fig. 6. Commercial Pipe data tab of JalTantra

Step 6:

In the "Result" tab, users can access the comprehensive final output of the network, containing all pertinent properties of each element within the system. Serving as the conclusive phase of the project, this tab presents the data in a tabular format, featuring columns such as

- Node ID
- Node Name
- Demand (litres per second)
- Elevation (meters)
- Head (meters)
- Pressure (meters)
- Minimum Pressure (meters).

Furthermore, users have the flexibility to export this table in various formats, including XML, branch file, and Excel file, facilitating further analysis or documentation as needed.

Fig. 7. Result data tab of JalTantra

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3.3.1 Network diagram of JalTantra

Fig. 8. Network diagram of JalTantra

3.3.2 Input of JalTantra

Node ID	Node Name	Elevation	Node ID	Node Name	Elevation
2	Node2	458	35	Node35	458
3	Node3	458	36	Node36	458
4	Node4	456	37	Node37	459
5	Node5	459	38	Node38	460
6	Node6	460	39	Node39	461
7	Node7	458	40	Node40	462
8	Node8	459	41	Node41	462
9	Node9	458	42	Node42	462
10	Node10	455	43	Node43	462
11	Node11	459	44	Node44	460
12	Node12	459	45	Node45	460
13	Node13	457	46	Node46	462
14	Node14	460	47	Node47	461
15	Node15	461	48	Node48	460
16	Node16	462	49	Node49	459
17	Node17	457	50	Node50	458
18	Node18	460	51	Node51	457
19	Node19	457	52	Node52	459
20	Node20	461	53	Node53	459
21	Node21	460	54	Node54	460
22	Node22	461	56	Node56	461
23	Node23	462	57	Node57	461
24	Node24	463	58	Node58	461
25	Node25	463	59	Node59	461
26	Node26	462	60	Node60	460
27	Node27	462	61	Node61	461
28	Node28	461	62	Node62	461
29	Node29	461	63	Node63	460
30	Node30	460	64	Node64	459
31	Node31	458	65	Node65	460
32	Node32	457	66	Node66	460
33	Node33	456	67	Node67	459
34	Node34	457	68	Node68	461

Table 3. Input mapnode data of JalTantra

Pipe ID	Start Node	End Node	Length	Pipe ID	Start Node
1	1	2	65	34	31
2	2	3	58	35	35
3	3	4	64	36	36
4	4	5	56	37	37
5	5	6	44	38	38
6	6	7	31	39	39
7	7	8	46	40	40
8	8	9	61	41	41
9	6	16	36	42	42
10	5	15	48	43	43
11	3	14	39	44	43
12	1	21	54	45	36
13	21	22	44	46	52
14	22	27	46	47	53
15	22	23	44	48	39
16	23	24	36	49	40
17	24	25	41	50	46
18	23	26	40	51	47
19	21	29	41	52	46
20	1	13	99	53	48
21	13	17	52	54	49
22	17	32	29	55	50
23	32	31	25	56	54
24	32	33	37	57	63
25	31	34	39	58	56
26	17	28	49	59	57
27	28	30	26	60	58
28	17	12	40	61	59
29	12	11	51	62	47
30	11	20	32	63	60
31	11	19	74	64	54
32	19	18	41	65	56
33	19	10	37	66	57

Table 4. Input map pipe data of JalTantra

3.3.3 Output and results of JalTantra

Pipe ID	**Start Node**	**End Node**	**Length**	**Flow**	**Speed**	**Diameter**	**Headloss**	**Headloss per KM**	**Cost**
1	1	2	65	1.25	0.197	90	0.034	0.522	13,520
2	2	3	58	1.14	0.179	90	0.025	0.437	12,064
3	3	4	64	0.91	0.206	75	0.045	0.703	12,672
4	4	5	56	0.80	0.181	75	0.031	0.549	11,088
5	5	6	44	0.57	0.129	75	0.013	0.294	8,712
6	6	7	31	0.34	0.077	75	0.004	0.114	6,138
7	7	8	46	0.23	0.052	75	0.002	0.054	9,108
8	8	9	61	0.11	0.026	75	0.001	0.015	12,078
9	6	16	36	0.11	0.026	75	0.001	0.015	7,128
10	5	15	48	0.11	0.026	75	0.001	0.015	9,504
11	3	14	39	0.11	0.026	75	0.001	0.015	7,722
12	1	21	54	0.91	0.206	75	0.038	0.703	10,692
13	21	22	44	0.68	0.155	75	0.018	0.413	8,712
14	22	27	46	0.11	0.026	75	0.001	0.015	9,108

15	22	23	44	0.46	0.103	75	0.009	0.195	8,712
16	23	24	36	0.23	0.052	75	0.002	0.054	7,128
17	24	25	41	0.11	0.026	75	0.001	0.015	8,118
18	23	26	40	0.11	0.026	75	0.001	0.015	7,920
19	21	29	41	0.11	0.026	75	0.001	0.015	8,118
20	1	13	99	5.36	0.348	140	0.088	0.893	42,372
21	13	17	52	5.24	0.341	140	0.045	0.858	22,256
22	17	32	29	4.22	0.344	125	0.029	0.996	9,918
23	32	31	25	3.99	0.325	125	0.022	0.898	8,550
24	32	33	37	0.11	0.026	75	0.001	0.015	7,326
25	31	34	39	0.11	0.026	75	0.001	0.015	7,722
26	17	28	49	0.23	0.052	75	0.003	0.054	9,702
27	28	30	26	0.11	0.026	75	0.000	0.015	5,148
28	17	12	40	0.68	0.155	75	0.017	0.413	7,920
29	12	11	51	0.57	0.129	75	0.015	0.294	10,098
30	11	20	32	0.11	0.026	75	0.000	0.015	6,336
31	11	19	74	0.34	0.077	75	0.008	0.114	14,652
32	19	18	41	0.11	0.026	75	0.001	0.015	8,118
33	19	10	37	0.11	0.026	75	0.001	0.015	7,326
34	31	35	50	3.76	0.307	125	0.040	0.806	17,100
35	35	36	34	3.65	0.297	125	0.026	0.761	11,628
36	36	37	21	2.05	0.216	110	0.010	0.489	5,544
37	37	38	27	1.94	0.204	110	0.012	0.440	7,128
38	38	39	25	1.82	0.192	110	0.010	0.393	6,600
39	39	40	19	1.60	0.251	90	0.015	0.815	3,952
40	40	41	35	0.57	0.129	75	0.010	0.294	6,930
41	41	42	30	0.46	0.103	75	0.006	0.195	5,940
42	42	43	31	0.34	0.077	75	0.004	0.114	6,138
43	43	44	44	0.11	0.026	75	0.001	0.015	8,712
44	43	45	64	0.11	0.026	75	0.001	0.015	12,672
45	36	52	21	1.48	0.233	90	0.015	0.711	4,368
46	52	53	10	1.37	0.215	90	0.006	0.613	2,080
47	53	54	17	1.25	0.197	90	0.009	0.522	3,536
48	39	68	22	0.11	0.026	75	0.000	0.015	4,356
49	40	46	28	0.91	0.206	75	0.020	0.703	5,544
50	46	47	25	0.68	0.155	75	0.010	0.413	4,950
51	47	48	20	0.46	0.103	75	0.004	0.195	3,960
52	46	61	21	0.11	0.026	75	0.000	0.015	4,158
53	48	49	25	0.34	0.077	75	0.003	0.114	4,950
54	49	50	19	0.23	0.052	75	0.001	0.054	3,762
55	50	51	32	0.11	0.026	75	0.000	0.015	6,336
56	54	63	15	0.23	0.052	75	0.001	0.054	2,970
57	63	64	22	0.11	0.026	75	0.000	0.015	4,356
58	56	57	18	0.68	0.155	75	0.007	0.413	3,564
59	57	58	21	0.46	0.103	75	0.004	0.195	4,158
60	58	59	20	0.34	0.077	75	0.002	0.114	3,960
61	59	60	17	0.23	0.052	75	0.001	0.054	3,366
62	47	62	20	0.11	0.026	75	0.000	0.015	3,960
63	60	67	30	0.11	0.026	75	0.000	0.015	5,940
64	54	56	20	0.91	0.206	75	0.014	0.703	3,960
65	56	65	37	0.11	0.026	75	0.001	0.015	7,326
66	57	66	18	0.11	0.026	75	0.000	0.015	3,564

Table 5. Output pipe results of JalTantra

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Node ID	Node Name	Elevation	Head	Pressure
2	Node2	458.00	469.966096103453	11.97
3	Node3	458.00	469.940738687296	11.94
4	Node4	456.00	469.895761498968	13.90
5	Node5	459.00	469.865028901334	10.87
6	Node6	460.00	469.852079944075	9.85
7	Node7	458.00	469.848537688190	11.85
8	Node8	459.00	469.846057097802	10.85
9	Node9	458.00	469.845145885640	11.85
10	Node10	455.00	469.826431762940	14.83
11	Node11	459.00	469.835440172994	10.84
12	Node12	459.00	469.850449191636	10.85
13	Node13	457.00	469.911579102394	12.91
14	Node14	460.00	469.940156109028	9.94
15	Node15	461.00	469.864311881928	8.86
16	Node16	462.00	469.851542179520	7.85
17	Node17	457.00	469.866949261379	12.87
18	Node18	460.00	469.826372011322	9.83
19	Node19	457.00	469.826984465399	12.83
20	Node20	461.00	469.834962160057	8.83
21	Node21	460.00	469.962050497348	9.96
22	Node22	461.00	469.943900420630	8.94
23	Node23	462.00	469.935334827265	7.94
24	Node24	463.00	469.933393495657	6.93
25	Node25	463.00	469.932781041580	6.93
26	Node26	462.00	469.934737311092	7.93
27	Node27	462.00	469.943213277033	7.94
28	Node28	461.00	469.864306893357	8.86
29	Node29	461.00	469.961438043272	8.96
30	Node30	460.00	469.863918507845	9.86
31	Node31	458.00	469.815607903888	11.82
32	Node32	457.00	469.838069483203	12.84
33	Node33	456.00	469.837516780744	13.84
34	Node34	457.00	469.815025325620	12.82
35	Node35	458.00	469.775322837541	11.78
36	Node36	458.00	469.749446492163	11.75
37	Node37	459.00	469.739184312279	10.74
38	Node38	460.00	469.727315402860	9.73
39	Node39	461.00	469.717492816282	8.72
40	Node40	462.00	469.702002519890	7.70
41	Node41	462.00	469.691702212979	7.69
42	Node42	462.00	469.685862035684	7.69
43	Node43	462.00	469.682319779799	7.68
44	Node44	460.00	469.681662512010	9.68
45	Node45	460.00	469.681363753924	9.68
46	Node46	462.00	469.682324999996	7.68
47	Node47	461.00	469.672012456407	8.67
48	Node48	460.00	469.668119004877	9.67
49	Node49	459.00	469.665262346905	10.67
50	Node50	458.00	469.664237755223	11.66
51	Node51	457.00	469.663759742285	12.66
52	Node52	459.00	469.734521318681	10.73
53	Node53	459.00	469.728393291650	10.73

54	Node54	460.00	469.719526118707	9.72
56	Node56	461.00	469.705470747354	8.71
57	Node57	461.00	469.698045715970	8.70
58	Node58	461.00	469.693957591863	8.69
59	Node59	461.00	469.691672265486	8.69
60	Node60	460.00	469.690755525560	9.69
61	Node61	461.00	469.682011304006	8.68
62	Node62	461.00	469.671713698321	8.67
63	Node63	460.00	469.718717230537	9.72
64	Node64	459.00	469.718388596642	10.72
65	Node65	460.00	469.704918044895	9.70
66	Node66	460.00	469.697776833693	9.70
67	Node67	459.00	469.690307388431	10.69
68	Node68	461.00	469.717164182387	8.72

Table 6. Output noderesults of JalTantra

Average Node Pressure- 10.07861589
Minimum Node Pressure- 469.6637597 At Node ID 51
Average Head- 469.7907371
Average Node Elevation-459.7121212

Fig. 9. Satellite view of JalTantra network

3.4 Steps to use EPANET

EPANET operates through several key stages:

- Model setup
- Data input
- Simulation
- Results.

Step 1: Model setup

Users begin by creating a model of the water distribution network they want to analyze. This involves defining the network topology, including pipes, nodes (junctions), tanks, valves, and reservoirs**.** Each element of water distribution networks possesses symbolic representations to facilitate network design.

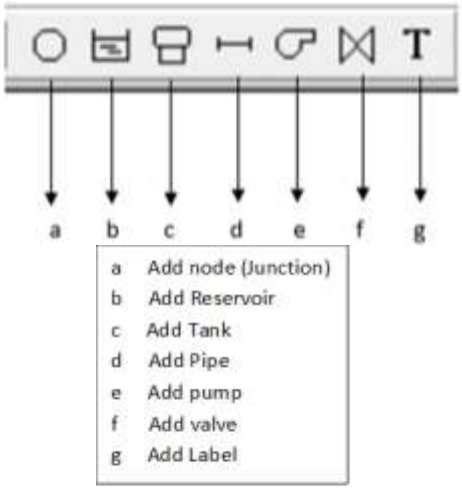

Fig. 10. Elements and Notations in EPANET Software

In EPANET, node placement is organized based on the relative positions of nodes within the preceding Jaltantra network. This ensures continuity and coherence in network layout. Pipes, on the other hand, are interconnected according to their designated pipe names and IDs. This systematic approach streamlines the establishment of connections between nodes, contributing to the efficient design and management of water distribution networks. Users can access all nodes, tanks, and pipes utilized in their water distribution network through the "Browser" tab located in the upper right corner of the interface. This tab comprises two sub-tabs: "Data" and "Map," which respectively display detailed information and a graphical representation of the network layout. These features offer users comprehensive insights into their network configuration, facilitating effective analysis and management of water distribution systems.The "Skeletonization" process serves as the final stage of the design model, where the complete pipe network is revealed. This process allows users to visualize the entirety of the network configuration, providing a comprehensive overview of the design before finalization.

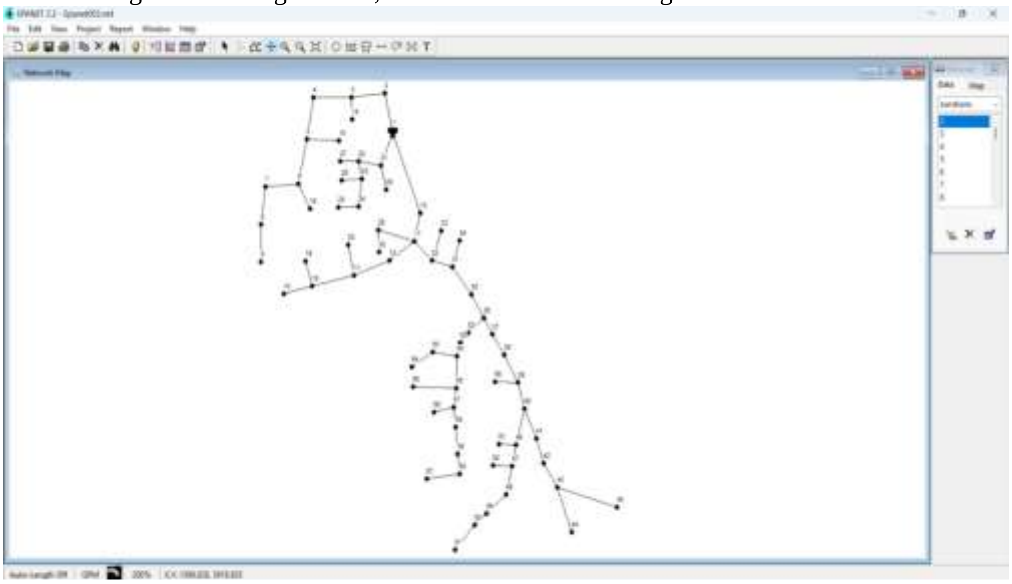

Fig. 11. Network diagram in EPANET

Step 2:Data input

During this step, all necessary data for the network is inputted, ensuring comprehensive information is available for analysis. The input data typically includes:

- Node name
- Node ID
- Pipe name
- Pipe ID
- Node elevation
- Base demand
- Pipe start and end node
- Pipe length
- Diameter
- Roughness

This meticulous data input process ensures that the network model is accurately represented, facilitating precise simulations and analysis.The data input process can be lengthy and time-consuming, especially for large networks. However, it is a crucial step that significantly impacts the accuracy and reliability of subsequent simulations and analyses. Therefore, meticulous attention to detail and thoroughness during this stage is essential to ensure the integrity of the network model and the validity of the results obtained from simulations.

Step 3: Simulation

After entering all the data, users click the "Run" button to start the simulation. This makes the software check the network for any problems. If there are issues, the software lets the user know so they can fix them.If everything goes smoothly, it shows that the project is on track and the network design is good. This confirms that the user has done a careful job and knows how to create a strong water distribution system. With the simulation running successfully, users can move forward confidently, knowing their network is reliable and well-designed.

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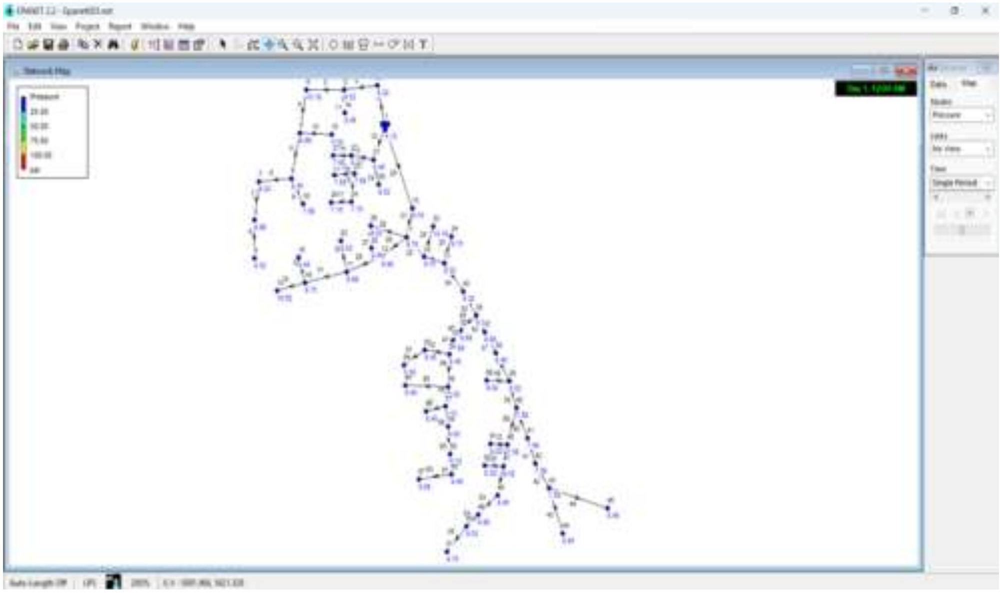

Fig. 12. The Pressure variation in network

Step 3: Simulation

The network results are available in the "Report" tab. Within this tab, users can access the Full Report option. By selecting this, the software prompts users to choose the format of the results. Clicking on the table format allows users to obtain a comprehensive report, which they can then convert into an Excel format for further analysis. The result table is shown in Fig.12

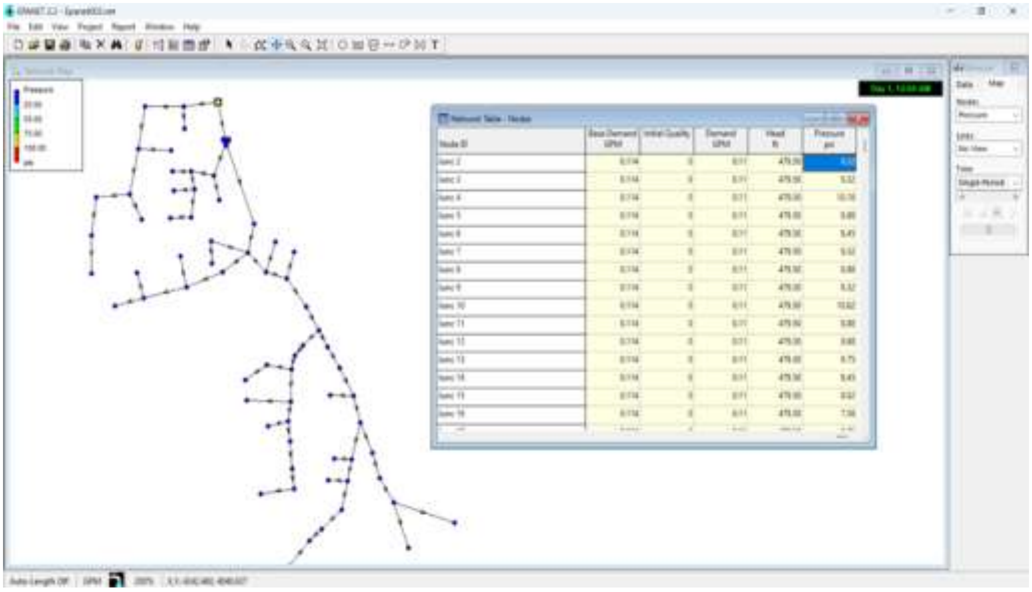

Fig. 13. Tables in EPANET

3.4.1 Output and results of EPANET

	Length	Diameter	Roughness	Flow	Velocity	Unit Headloss	Friction Factor
Link ID	m	mm		LPS	m/s	m/km	
Pipe 1	65	90	150	1.25	0.2	0.52	0.024
Pipe 2	58	90	150	1.14	0.18	0.44	0.024
Pipe3	64	75	150	0.91	0.21	0.7	0.024

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Pipe 4	56	75	150	0.8	0.18	0.55	0.025
Pipe 5	44	75	150	0.57	0.13	0.29	0.026
Pipe 6	31	75	150	0.34	0.08	0.12	0.028
Pipe 7	46	75	150	0.23	0.05	0.05	0.03
Pipe 8	61	75	150	0.11	0.03	0.02	0.034
Pipe20	99	140	150	5.36	0.35	0.89	0.02
Pipe29	51	75	150	0.57	0.13	0.29	0.026
Pipe11	39	75	150	0.11	0.03	0.02	0.034
Pipe10	48	75	150	0.11	0.03	0.01	0.033
Pipe 9	36	75	150	0.11	0.03	0.02	0.034
Pipe21	52	140	150	5.24	0.34	0.86	0.02
Pipe28	40	75	150	0.68	0.15	0.41	0.025
Pipe31	74	75	150	0.34	0.08	0.11	0.028
Pipe33	37	75	150	0.11	0.03	0.02	0.033
Pipe32	41	75	150	0.11	0.03	0.01	0.032
Pipe30	32	75	150	0.11	0.03	0.02	0.033
Pipe12	54	75	150	0.91	0.21	0.7	0.024
Pipe13	44	75	150	0.68	0.15	0.41	0.025
Pipe15	44	75	150	0.46	0.1	0.2	0.027
Pipe16	36	75	150	0.23	0.05	0.05	0.03
Pipe17	41	75	150	0.11	0.03	0.02	0.034
Pipe18	40	75	150	0.11	0.03	0.01	0.033
Pipe14	46	75	150	0.11	0.03	0.02	0.034
Pipe19	41	75	150	0.11	0.03	0.01	0.032
Pipe26	49	75	150	0.23	0.05	0.05	0.03
Pipe27	26	75	150	0.11	0.03	0.02	0.035
Pipe25	39	75	150	0.11	0.03	0.02	0.034
Pipe22	29	125	150	4.22	0.34	1	0.021
Pipe23	25	125	150	3.99	0.33	0.9	0.021
Pipe24	37	75	150	0.11	0.03	0.02	0.033
Pipe34	50	125	150	3.76	0.31	0.81	0.021
Pipe35	34	125	150	3.65	0.3	0.76	0.021
Pipe36	21	110	150	2.05	0.22	0.49	0.023
Pipe37	27	110	150	1.94	0.2	0.44	0.023
Pipe38	25	110	150	1.82	0.19	0.39	0.023
Pipe39	19	90	150	1.6	0.25	0.82	0.023
Pipe40	35	75	150	0.57	0.13	0.3	0.026
Pipe41	30	75	150	0.46	0.1	0.19	0.027
Pipe42	31	75	150	0.34	0.08	0.11	0.028
Pipe44	64	75	150	0.11	0.03	0.02	0.033
Pipe43	44	75	150	0.11	0.03	0.02	0.034
Pipe50	20	75	150	0.68	0.15	0.41	0.025
Pipe51	20	75	150	0.46	0.1	0.2	0.027
Pipe53	25	75	150	0.34	0.08	0.11	0.028
Pipe54	19	75	150	0.23	0.05	0.05	0.029
Pipe55	32	75	150	0.11	0.03	0.02	0.033
Pipe48	22	75	150	0.11	0.03	0.02	0.034
Pipe52	21	75	150	0.11	0.03	0.02	0.035
Pipe62	20	75	150	0.11	0.03	0.01	0.033
Pipe45	21	90	150	1.48	0.23	0.71	0.023
Pipe46	10	90	150	1.37	0.22	0.61	0.023
Pipe47	17	90	150	1.25	0.2	0.52	0.024
Pipe64	20	75	150	0.91	0.21	0.7	0.024

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Pipe58	18	75	150	0.68	0.15	0.41	0.025
Pipe59	21	75	150	0.46	0.1	0.19	0.027
Pipe60	20	75	150	0.34	0.08	0.12	0.028
Pipe61	17	75	150	0.23	0.05	0.05	0.029
Pipe63	30	75	150	0.11	0.03	0.01	0.033
Pipe56	15	75	150	0.23	0.05	0.05	0.03
Pipe57	22	75	150	0.11	0.03	0.02	0.034
Pipe65	37	75	150	0.11	0.03	0.02	0.033
Pipe66	18	75	150	0.11	0.03	0.01	0.032
Pipe68	25	75	150	0.91	0.21	0.7	0.024

Table 7. Output pipe results of EPANET

	Elevation	Head	Pressure		Elevation	Head	Pressure
Node ID	m	m	m	Node ID	m	m	m
Junc 2	458	479.97	21.97	Junc 35	458	479.78	21.78
Junc 3	458	479.94	21.94	Junc 36	458	479.75	21.75
Junc 4	456	479.9	23.9	Junc 37	459	479.74	20.74
Junc 5	459	479.86	20.86	Junc 38	460	479.73	19.73
Junc 6	460	479.85	19.85	Junc 39	461	479.72	18.72
Junc 7	458	479.85	21.85	Junc 40	462	479.7	17.7
Junc 8	459	479.85	20.85	Junc 41	462	479.69	17.69
Junc 9	458	479.84	21.84	Junc 42	462	479.69	17.69
Junc 10	455	479.83	24.83	Junc 43	462	479.68	17.68
Junc 11	459	479.84	20.84	Junc 44	460	479.68	19.68
Junc 12	459	479.85	20.85	Junc 45	460	479.68	19.68
Junc 13	457	479.91	22.91	Junc 46	462	479.68	17.68
Junc 14	460	479.94	19.94	Junc 47	461	479.68	18.68
Junc 15	461	479.86	18.86	Junc 48	460	479.67	19.67
Junc 16	462	479.85	17.85	Junc 49	459	479.67	20.67
Junc 17	457	479.87	22.87	Junc 50	458	479.67	21.67
Junc 18	460	479.83	19.83	Junc 51	457	479.67	22.67
Junc 19	457	479.83	22.83	Junc 52	459	479.73	20.73
Junc 20	461	479.83	18.83	Junc 53	459	479.73	20.73
Junc 21	460	479.96	19.96	Junc 54	460	479.72	19.72
Junc 22	461	479.94	18.94	Junc 56	461	479.71	18.71
Junc 23	462	479.94	17.94	Junc 57	461	479.7	18.7
Junc 24	463	479.93	16.93	Junc 58	461	479.69	18.69
Junc 25	463	479.93	16.93	Junc 59	461	479.69	18.69
Junc 26	462	479.93	17.93	Junc 60	460	479.69	19.69
Junc 27	462	479.94	17.94	Junc 61	461	479.68	18.68
Junc 28	461	479.86	18.86	Junc 62	461	479.68	18.68
Junc 29	461	479.96	18.96	Junc 63	460	479.72	19.72
Junc 30	460	479.86	19.86	Junc 64	459	479.72	20.72
Junc 31	458	479.82	21.82	Junc 65	460	479.7	19.7
Junc 32	457	479.84	22.84	Junc 66	460	479.7	19.7
Junc 33	456	479.84	23.84	Junc 67	459	479.69	20.69
Junc 34	457	479.81	22.81	Junc 68	461	479.72	18.72
				Tank 1	470	480	10

Table 8. Output noderesults of EPANET

IV. RESULTS

The designed water distribution network for Pathari village consists of 68 pipes, 67 nodes and one elevated storage reservoir. The pressure is computed using Hazen-William Approach. The total length of network is 2.383 KM. consists of 68 nodes and various pipe diameters such as 75mm, 90mm, 125mm, 140 mm are used according to required parameters.The minimum diameter was 75mm and maximum was 140mm. There is fluctuation in the pressure head. The roughness coefficient of the pipe throughout the network is 150. Pressure at all junctions are found to be adequate and can supply the water without any interruption.The method of distribution used here is gravity and pumping system, as firstly the water with the help of centrifugal pumps is lifted up to the ESR and through there with the help of gravity system is transferred to the main rising pipe. The distribution layout used here is branched system which is according to the layout of the Pathari village.

V. CONCLUSION

Manual method of design by using Hardy-Cross equation is a time-consuming process, and it may not provide accurate result. There may be some limitations while proceeding the manual method in Excel. But there are no such types of problems in EPANET and JalTantra software. So, we can design water distribution system of any size by using any of the software. Conventional methods like Hardy-cross methods are not recommendable in present days if the network is in high scale because that high network designing by conventional method will not give the efficient and economical design as comparative to EPANET software.The implementation of EPANET and JalTantra software for modeling and analyzing the water distribution network in Pathari village, Solapur district, Maharashtra, India, has significantly expedited the design process, allowing for the efficient handling of intricate network configurations without limitations on nodes, pipes, or pumps. These advanced software tools have proven instrumental in overcoming the complexities of the network, offering a time-saving solution while ensuring accurate results. In essence, the utilization of EPANET and JalTantra software has revolutionized the water distribution network design process, addressing critical water management challenges and ensuring the delivery of reliable water supply services to the community while conforming to ethical guidelines and standards.Additionally, the integration of EPANET and JalTantra software has not only streamlined the design process but has also enhanced the overall efficiency of water distribution network management in Pathari village. By harnessing the capabilities of these advanced tools, engineers and planners can more effectively address the complex interdependencies within the network, leading to optimized resource allocation and improved system performance.The successful implementation of EPANET and JalTantra software serves as a testament to the village's commitment to leveraging technology for the betterment of its residents and the environment.

REFERENCES

[1]. Arjun Kumar, Kankesh Kumar, Bharanidharan B (2015). “Design of Water Distribution System Using (2015), Volume 3, Issue 9, 789 – 812
[2]. Walski T. M. (2006), A History of Water Distribution, Journal of American Waterworks Association, Vol. 98. No.3., 2006
[3]. Adeniran, A. E. and Bamiro, O. A. (2010). A system dynamics strategic planning model for a municipal water supply scheme, Proc. 28th International Conference of the System Dynamics Society, Seoul , Korea, 25-29 July, 2010.
[4]. Fabunmi A. O. (2010): Design of Improved Water Distribution Network for UNAAB Campus, Unpublished B.Sc. Dissertatatiom, Federal University of Agriculture, Abeokuta, Nigeria.
[5]. Guidolin, M., Burovskiy, P., Kapelan, Z., and Savid, D. (2010), CWSNET: An Object-Oriented Toolkit For Water Distribution Analysis: Proceedings of American Society of Civil Engineers Water Distribution System Simulation, 2010.
[6]. Ingeduld, P., Svitak, Z., Pradhan, A., and Tarai, A. (2006). Modeling Intermittent Water Supply Systems with EPANET. 8th Annual WD Symposium. Cincinnati. USA, 2006.
[7]. Abubakar, A. S. and Sagar, N. L. (2013): Design of NDA Water Distribution Network Using EPANET, International Journal of Emerging Science and Engineering (IJESE) ISSN: 2319–6378, Volume-1, Issue-9, July 2013.