OPTIMIZATION OF WATER DISTRIBUTION SYSTEM BY USING SOFTWARE (DI pipe, CI pipe)

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Abstract - *In this study, Water is one of the world's most valuable resources, yet it is under constant threat due to climate change and resulting drought, explosive population growth, and waste. One effective solution to address the global water shortage is the process of treating and reusing water from industries and cities, known as water reclamation and reuse. Water distribution network is complex when area to be covered is large and analysis and design need to be done by manual or tradition method, this problem may be overcome by using software for design and analysis. Thus this analysis was taken for research which includes the existing water distribution system network. The existing water distribution system was analyzed using software tools. This analysis revealed variations in materials, identified different network alternatives, enabled optimization of the distribution system, and provided a comparison based on various hydraulic parameters. This gives the economical alternative solution to the distribution system and payback period of project. After analysis it is found that the existing system may need some modification and therefore software based analysis may be utilized for complex distribution system to achieve economy and time saving.*

Key Words: Distribution system, Analysis, material variation, optimization, payback period.

1. INTRODUCTION

Water is essential for human survival and has always played a vital role in daily life. In ancient times, people relied on natural sources like rivers and wells for drinking, washing, and irrigation. As civilizations advanced, such as those in Mohenjo-Daro and Harappa, water was also used for religious purposes and was considered sacred. Today, water use has expanded significantly through piped systems for activities like bathing, fire fighting, and agriculture. Managing and operating water distribution systems is crucial to ensuring safe drinking water reaches consumers. While treatment at the source is important, maintaining water quality throughout the distribution process is equally critical. Water can become contaminated due to poor treatment, reactions with pipes, leaks, and aging infrastructure. Furthermore, the quality may degrade once water enters household plumbing, which is beyond the utility's control. Modern water distribution systems include pipes, pumps, valves, tanks, and more, forming the final barrier before water reaches consumers. Though these systems are durable, they are often overlooked in funding and maintenance, despite needing continuous investment as populations grow and infrastructure ages.

1.1 Aim & Objective

The aim of this report is to evaluate the current water distribution system and explore alternative network designs to optimize its performance in terms of efficiency, reliability, and water quality delivery.

1. To study the existing water distribution system.
2. To analyze various alternative networks to optimize system.

2. Literature Review

Contributions of researchers are presented as follows,

Radha Krishnamurthy (1996) [1] studied the distribution system in the time of Mohenjo-Daro and Harappa civilization. Mohenjo-Daro and Harappa were old yet developed cities in the ancient times. These cities were well-organized and built of brick and stone. The drainage systems, wells and water storage systems were ahead of its time. These organized systems set them apart from all other ancient civilization's.The paper emphasis on clean water supply for drinking, agricultural operations, cooking, washing and for medical purpose at that era. The pure, divine water conveys offering to god. People were aware about quality of water and its proper use. Paper describes classification of the water & its different properties which would be safe for the health of person by providing different Sanskrit stanzas. It covers use of water for distribution system in the form of rain water, ground water, and River water. By referring this paper we come to know that our ancients knew many method of utilization of water. In this project I am using reference of clean and quality water for distribution system and research is extended up to storage of water by underground method which is lifted by pump to reach up to consumer.

Thomas m Walski (2006) [2] American water world association had studied that early human has to carry water from source to point of consumption which required more efforts and only minimal water for drinking and washing was available. Piped water system was discovered two millennia before Christ which still functioning today. Paper showed the result of most extensive water distribution system in ancient time laid by Roman aqueduct which conveyed water by gravity and closed conduits. Lead pressure pipe was installed first in Germany in 1455 for 25 Km pipe line. Wood Stave pipe were used in 1900 which remains strong when full of water runs through pipe. Initially pump was used of steam driven pumping system in 1869 later it was replaced by centrifugal pump. In 1935 underground tanks of steel plate riveted were used. In 1942 pre-stressed concrete tank was introduced and then in 1952 to 60 cast in situ concrete were common practice for tank. By referring this paper in this project different pipe material and diameter are used and underground water tanks for storage of water having large capacity of water. For lifting same water pump system installation are considered

National research council of National Academy (2006) [3] Studied that Water distribution systems carry drinking water from a centralized treat-ment plant or well supplies to consumers' taps. These systems consist of pipes, pumps, valves, storage tanks, reservoirs, meters, fittings, and other hydraulic appurtenances More than 80 percent of the water supplied to residences is used for activities other than human consumption such as sanitary service and landscape irrigation. Most water systems and distribution pipes will be reaching the end of their expected life spans in the next 30 years (although actual life spans may be longer depending on utility practices and local conditions). The report focuses on traditional distribution system design, in which water originates from a centralized treatment plant or well and is then distributed through one pipe network to consumers. The loss of physical integrity of the distribution system—in which the system no longer acts as a barrier that prevents external contamination from deteriorating the internal, drinking water supply—is brought about by physical and chemical deterioration of materials, the absence or improper installation of critical components, and the installation of already contaminated components. When physical integrity is compromised, the drinking water supply becomes exposed to contamination that increases the risk of negative public health outcomes. By referring this paper emphasis is given for the system which is installed is used water only for drinking purpose. While installing pipe line precaution to be taken to avoid cross connection and simple network is used for the distribution system. The utilization of different material for pipe and its life consideration.

3. MATERIALS AND METHODS

3.1 STUDY AREA

Existing Distribution system is required for the analysis by using software. The distribution system is situated at Indradhanu near, Damari nagar Solapur. By collecting information and input data in the form of drawings, and various design parameters. This information is utilized as input for software and the analysis is carried out to get the output from software. Here different alternatives of analysis for various pipe material (Ductile Iron (DI), Cast Iron (CI)) is obtained with existing water distribution system. Then this system is optimized with two alternatives and the cost of each alternative is worked out to get best economical alternative. At last Payback period is worked out for optimized distribution system for the beneficiary to consumer

3.2 DATA REQUIRED

1. Water Gems software.
2. Drawing of existing distribution system.
3. Length of pipes installed.
4. Diameter of pipes.
5. Pump details.
6. Head at the consumer end..
7. Material of pipe

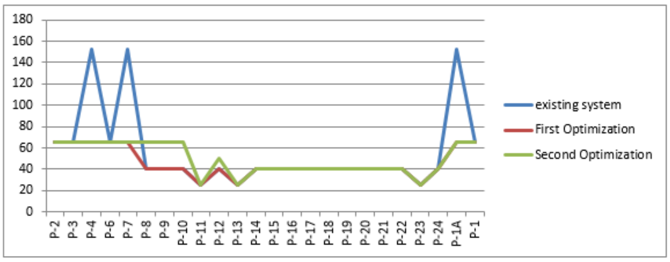
4. RESULT AND DISCUSSION

This chapter deals with the results obtained during the analysis work. This study was depends upon the analysis of existing distribution system and optimization of it. Results obtained during the research work are presented by the graphs and tables and analysis was done on the basis of these results. This study was very important for the analysis of different material (DI pipe, CI pipe).By using this results one can compare the system which gives economical alternative.

Results are tabulated as below,

node	P-2	P-3	P-4	P-6	P-7	P-8	P-9	P-10	P-11	P-12	P-13	P-14	P-15	P-16	P-17	P-18	P-19	P-20	P-21	P-22	P-23	P-24	P-1A	P-1
existing system	65	65	152.4	65	152.4	40	40	40	25	40	25	40	40	40	40	40	40	40	40	40	25	40	152.4	65
First Optimization	65	65	65	65	65	40	40	40	25	40	25	40	40	40	40	40	40	40	40	40	25	40	65	65
Second Optimization	65	65	65	65	65	65	65	65	25	50	25	40	40	40	40	40	40	40	40	40	25	40	65	65

Table No.4.1 a Diameter for DI pipe and optimization

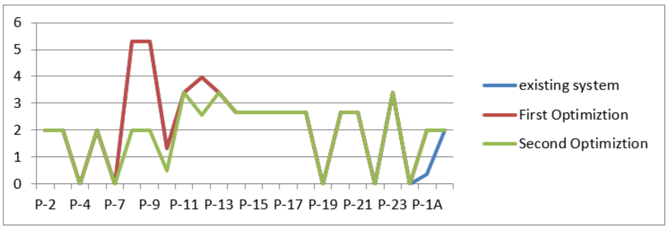


Graph No. 4.1chart showing the diameter for DI pipe and optimization

node	P-2	P-3	P-4	P-6	P-7	P-8	P-9	P-10	P-11	P-12	P-13	P-14	P-15	P-16	P-17	P-18	P-19	P-20	P-21	P-22	P-23	P-24	P-1A	P-1
existing system	2.01	2.01	0	2.01	0	5.31	5.31	1.33	3.4	3.98	3.4	2.65	2.65	2.65	2.65	2.65	0	2.65	2.65	0	3.4	0	0.37	2.01
First Optimization	2.01	2.01	0	2.01	0	5.31	5.31	1.33	3.4	3.98	3.4	2.65	2.65	2.65	2.65	2.65	0	2.65	2.65	0	3.4	0	2.01	2.01
Second Optimization	2.01	2.01	0	2.01	0	2.01	2.01	0.5	3.4	2.55	3.4	2.65	2.65	2.65	2.65	2.65	0	2.65	2.65	0	3.4	0	2.01	2.01

Table No .B velocity for DI pipe and optimization

Following chart (fig. 4.2) shows that the parameters Velocity for DI pipe. Chart is plotted on the basis of data tabulated in the table no. B

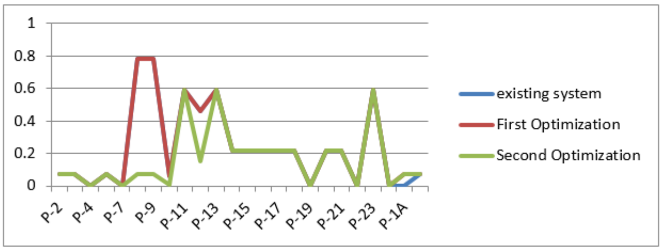


Graph No. 4.2 chart showing the velocity for DI pipe and optimization

Major losses			
node	existing system	First Optimization	Second Optimization
P-2	0.073	0.073	0.073
P-3	0.073	0.073	0.073
P-4	0	0	0
P-6	0.073	0.073	0.073
P-7	0	0	0
P-8	0.78	0.78	0.073
P-9	0.78	0.78	0.073
P-10	0.06	0.06	0.006
P-11	0.591	0.591	0.591
P-12	0.458	0.458	0.154
P-13	0.591	0.591	0.591
P-14	0.216	0.216	0.216
P-15	0.216	0.216	0.216
P-16	0.216	0.216	0.216
P-17	0.216	0.216	0.216
P-18	0.216	0.216	0.216
P-19	0	0	0
P-20	0.216	0.216	0.216
P-21	0.216	0.216	0.216
P-22	0	0	0
P-23	0.591	0.591	0.591
P-24	0	0	0
P-1A	0.001	0.073	0.073
P-1	0.073	0.073	0.073

Table No .C Major losses for DI pipe and optimization

Following chart (fig. 4.3) shows that the parameters Velocity for DI pipe. Chart is plotted on the basis of data tabulated in the table no. C.

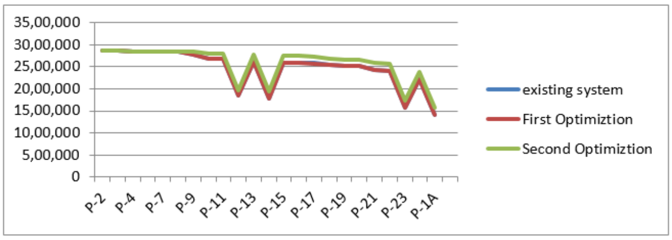


Graph No. 4.3 chart showing the Major losses for DI pipe and optimization

Pressure			
node	existing system	First Optimization	Second Optimization
P-2	2,876,757	2,873,136	2,873,135
P-3	2,866,065	2,862,445	2,862,443
P-4	2,850,997	2,847,376	2,847,375
P-6	2,850,997	2,847,376	2,847,375
P-7	2,850,782	2,847,161	2,847,160
P-8	2,850,782	2,847,161	2,847,160
P-9	2,779,378	2,775,757	2,840,451
P-10	2,689,769	2,686,148	2,797,892
P-11	2,681,507	2,677,886	2,797,116
P-12	1,850,135	1,846,514	1,965,744
P-13	2,618,945	2,615,324	2,774,007
P-14	1,786,417	1,782,796	1,941,478
P-15	2,592,290	2,588,669	2,747,351
P-16	2,589,352	2,585,731	2,744,414
P-17	2,581,313	2,577,692	2,736,375
P-18	2,537,311	2,533,691	2,692,373
P-19	2,515,310	2,511,690	2,670,372
P-20	2,515,310	2,511,690	2,670,372
P-21	2,437,437	2,433,816	2,592,499
P-22	2,402,532	2,398,911	2,557,593
P-23	1,578,968	1,575,347	1,734,029
P-24	2,229,036	2,225,415	2,384,097
P-1A	1,405,472	1,401,851	1,560,533
P-1			

Table No .D Pressure for DI pipe and optimization

Following chart (fig. 4.4) shows that the parameters Pressure for DI pipe. Chart is plotted on the basis of data tabulated in the table no. D

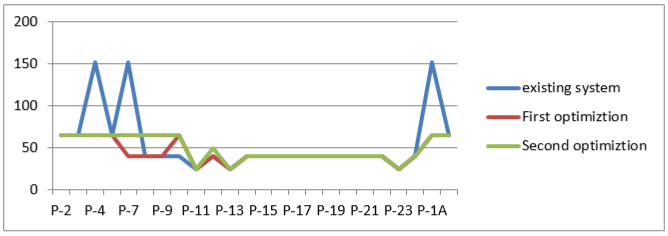


Graph No. 4.4 chart showing the Pressure for DI pipe and optimization

Diameter			
node	existing system	First Optimization	Second Optimization
P-2	65	65	65
P-3	65	65	65
P-4	152.4	65	65
P-6	65	65	65
P-7	152.4	40	65
P-8	40	40	65
P-9	40	40	65
P-10	40	65	65
P-11	25	25	25
P-12	40	40	50
P-13	25	25	25
P-14	40	40	40
P-15	40	40	40
P-16	40	40	40
P-17	40	40	40
P-18	40	40	40
P-19	40	40	40
P-20	40	40	40
P-21	40	40	40
P-22	40	40	40
P-23	25	25	25
P-24	40	40	40
P-1A	152.4	65	65
P-1	65	65	65

Table No .E Diameter for CI pipe and optimization

Following chart (fig. 4.5) shows that the parameters Pressure for CI pipe. Chart is plotted on the basis of data tabulated in the table no. E

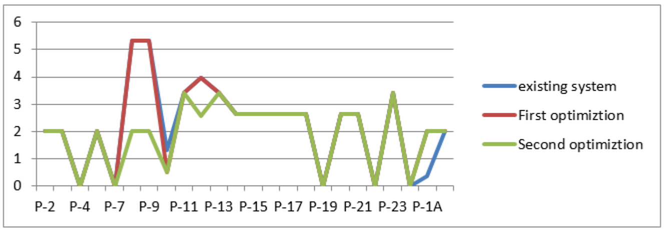


Graph No.4.5 chart showing the Diameter for CI pipe and optimization

Velocity			
node	existing system	First Optimization	Second Optimization
P-2	2.01	2.01	2.01
P-3	2.01	2.01	2.01
P-4	0	0	0
P-6	2.01	2.01	2.01
P-7	0	0	0
P-8	5.31	5.31	2.01
P-9	5.31	5.31	2.01
P-10	1.33	0.5	0.5
P-11	3.4	3.4	3.4
P-12	3.98	3.98	2.55
P-13	3.4	3.4	3.4
P-14	2.65	2.65	2.65
P-15	2.65	2.65	2.65
P-16	2.65	2.65	2.65
P-17	2.65	2.65	2.65
P-18	2.65	2.65	2.65
P-19	0	0	0
P-20	2.65	2.65	2.65
P-21	2.65	2.65	2.65
P-22	0	0	0
P-23	3.4	3.4	3.4
P-24	0	0	0
P-1A	0.37	2.01	2.01
P-1	2.01	2.01	2.01

Table No .F Velocity for CI pipe and optimization

Following chart (fig. 4.6) shows that the parameters Velocity for CI pipe. Chart is plotted on the basis of data tabulated in the table no. E

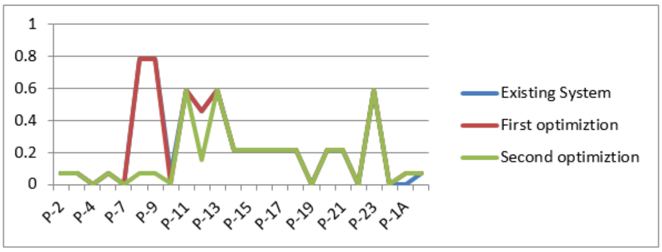


Graph No. 4.6 chart showing the Velocity for CI pipe and optimization.

Major Losses			
node	existing system	First Optimization	Second Optimization
P-2	0.073	0.073	0.073
P-3	0.073	0.073	0.073
P-4	0	0	0
P-6	0.073	0.073	0.073
P-7	0	0	0
P-8	0.78	0.78	0.073
P-9	0.78	0.78	0.073
P-10	0.06	0.006	0.006
P-11	0.591	0.591	0.591
P-12	0.458	0.458	0.154
P-13	0.591	0.591	0.591
P-14	0.216	0.216	0.216
P-15	0.216	0.216	0.216
P-16	0.216	0.216	0.216
P-17	0.216	0.216	0.216
P-18	0.216	0.216	0.216
P-19	0	0	0
P-20	0.216	0.216	0.216
P-21	0.216	0.216	0.216
P-22	0	0	0
P-23	0.591	0.591	0.591
P-24	0	0	0
P-1A	0.001	0.073	0.073
P-1	0.073	0.073	0.073

Table No .G major losses for CI pipe and optimization

Following chart (fig. 4.7) shows that the parameters Velocity for CI pipe. Chart is plotted on the basis of data tabulated in the table no. G

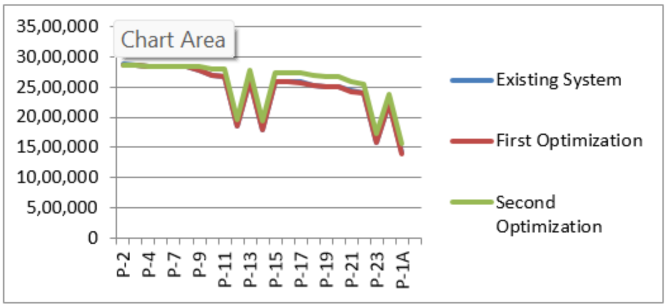


Graph No. 4.7 chart showing the major losses for CI pipe and optimization

Pressure			
node	existing system	First Optimization	Second Optimization
P-2	2,876,757	2,873,136	2,873,135
P-3	2,866,065	2,862,445	2,862,443
P-4	2,850,997	2,847,376	2,847,375
P-6	2,850,997	2,847,376	2,847,375
P-7	2,850,782	2,847,161	2,847,160
P-8	2,850,782	2,847,161	2,847,160
P-9	2,779,378	2,775,757	2,840,451
P-10	2,689,769	2,686,148	2,797,892
P-11	2,681,507	2,685,372	2,797,116
P-12	1,850,135	1,854,000	1,965,744
P-13	2,618,945	2,615,324	2,774,007
P-14	1,786,417	1,782,796	1,941,478
P-15	2,592,290	2,588,669	2,747,351
P-16	2,589,352	2,585,731	2,744,414
P-17	2,581,313	2,577,692	2,736,375
P-18	2,537,311	2,533,691	2,692,373
P-19	2,515,310	2,511,690	2,670,372
P-20	2,515,310	2,511,690	2,670,372
P-21	2,437,437	2,433,816	2,592,499
P-22	2,402,532	2,398,911	2,557,593
P-23	1,578,968	1,575,347	1,734,029
P-24	2,229,036	2,225,415	2,384,097
P-1A	1,405,472	1,401,851	1,560,533
P-1			

Table No . H pressure for CI pipe and optimization

Following chart (fig. 4.8) shows that the parameters pressure for CI pipe. Chart is plotted on the basis of data tabulated in the table no. H



Graph No. 4.8 chart showing pressure for CI pipe and optimization.

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