DESIGN OF WATER SUPPLY DISTRIBUTION NETWORK USING EPANET SOFTWARE FOR PALAHALLI VILLAGE, MANDYA DISTRICT, KARNATAKA

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Abstract - *The ever increasing population in a country like India calls for an adequate, efficient and uniform supply of water to meet the demands for the sustainable and suave life. In this context, there is a need for developing such adequate water supply through network systems in order to cater the needs to meet the demands. With the advancement in technology, it is possible to design the network of water supply distribution and apply with ease. One such software which provides answers for all the above said problems is EPANET. The lack of such network distribution was found in the Palahalli village located at Srirangapatna taluk, Mandya district. Hence in the present study an attempt is made to design the new network of water supply distribution system keeping the aim at future growth of population. The design of water supply project for the supply of water using EPANET software proves to be efficient in meeting the daily requirement of the selected area confirming with the standards. The results of the EPANET include the various hydraulic parameters such as head, pressure at each node, head loss in pipes and at nodes. The Model is validated by comparing the results of the model with the manually calculated head loss using Hazen-Williams equation which helps in evaluating the reliability and suitability of the model.*

Key Words: Sustainable, Water supply distribution, network distribution, EPANET, hydraulic parameters, Model, etc...

1. INTRODUCTION

Water is the major important source for all living beings for their survival. Water can also be termed as bloodline of life. Being such an important resource, sometimes it is scarce and other time it becomes abundant, proving that its existence is nonlinear. The water is used for various activities by human beings, like domestic, drinking, power generation etc. The water shortage is the most significant and challenging situation in India. Due to the increase in population, supply of water is a major issue, with the increase in demand of water and increased rates of depleting ground water and deterioration of water quality. Managing such an important scarce water in a country like India poses a serious challenge to the engineers as well as the decision makers.

The design of water distribution system plays an important role which can overcome the water scarcity and the water demand by the users. Water distribution system is a hydraulic design leads to supply of water to the consumers, which consisting of pipes, tanks, reservoirs, pumps and valves etc. Hence, it is necessary to supply water to the consumers efficiently so that the water could be used by the users to meet their demands. It can be achieved by designing a proper water distribution network.

The Palahalli is one such village in Mandya district where villagers were facing the problems such as shortage of water, problem of continuous water supply etc. Hence an attempt is being made in this study to develop a new network of water distribution system using a widely used software EPANET which aids in eliminating most of the problems faced by the villagers with respect to distribution of water. In the present case, the water distribution network is designed in keeping the futuristic demand so that the network can serve for the future demand also. EPANET tracks the flow of water in each pipe, the pressure at each node, the head of water in the pipe, head loss in each pipe, etc.

2. STUDY AREA

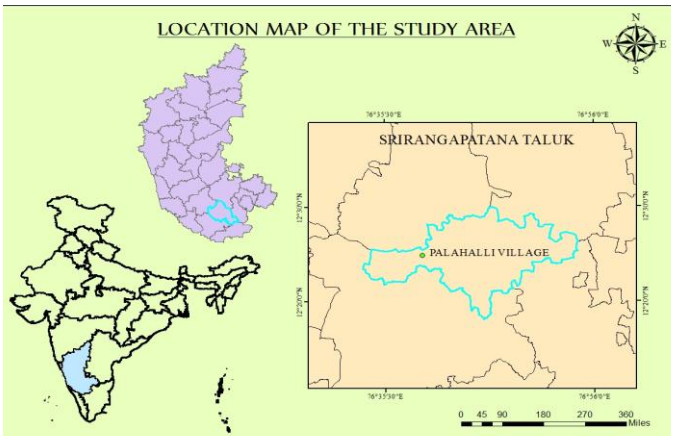

Fig -1: Location Map of the Study area

The Palahalli village of Mandya district (Fig.1) is located in the southern state of Karnataka, India. It belongs to Mysore Division which is located 34 km towards west from district headquarters Mandya and 9 km from Shrirangapattana. The Palahalli village lies between Latitude 12^{0}24’50” North and 76^{0}39’10” East with an average elevation of 693m (3136 feet) above mean sea level. The total geographical area of Palahalli village is 604.04 hectares housing 1671 numbers which has about 6638 population of which 3343 are males while 3295 are females as per the population census 2011.

3. METHODOLOGY

Fig. 2 depicts the methodology adopted in designing the water supply network distribution for the study area.

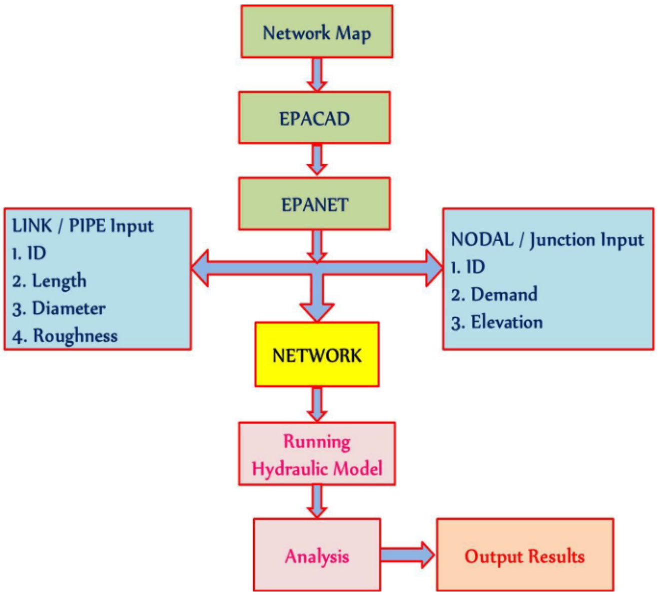

Fig -2: Work flow process for EPANET software

3.1 Development of Network

After careful examination of the problem associated in the study area, the network development was the prioritized task, which was achieved through the actual field survey with the equipment such as dumpy level to collect the ground elevation details. The location of high head water tank as well as the treatment units were also decided through the field survey. With this data the network was developed in the EPACAD which was then transferred to the actual EPANET software for further processing. Fig. 3 represents the skeletonisation of the pipe network developed using EPACAD.

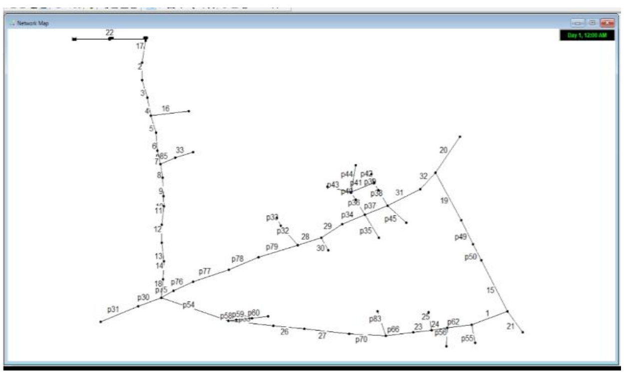

Fig -3: Skeletonisation of the pipe line network

3.2 Population Forecasting

The primary aim of developing the water distribution network is to cater the water demand in an efficient manner for future desired period of the Palahalli village. In this regard, the network was designed for design period of 30 years considering the futuristic growth of the population. Various methods have been employed to project the growth of population based on the precious years records and finally we concluded that, the incremental increase method because of high population estimate which is being shown in the below table 1.

Table -1: Population Forecasting by Various Methods

METHOD	YEAR		
	2021	***2031***	***2041***
Arithmetic Increase Method	6987	7254	7421
Incremental Increase Method	7521	8850	10725
Geometrical Increase Method	6884	7052	7224

3.3 Demand Calculations for the projected population

The developed network requires major input in the form of demand of water which is being created on the basis of the projected population. The network demand was calculated first and then the demand shall be assigned at nodal level with respect to each pipe lengths meeting a single node. Also the total demand was calculated by taking into account of the water losses as well as the peak factor. The total demand for the entire network was worked out to be 57.81 LPS and the demand factor of 0.0075 LPS.

3.4 Selection of Pipe and its diameter

The selection of the pipe and its diameter plays a vital role in developing any water distribution network. In the present case, the pipe selected was of PVC with a roughness co-efficient of 130, as the pipe was having many advantages compared to other pipes like longer serviceability, resistance to chemical attack, light weight, etc., conforming to IS 4985: 2000. The suitability of the diameter was checked on performing re-iteration process on the network which is a crucial task as it plays an important role in maintaining the standards set by CPHEEO manual as well as the cost incurred.

3.5 Hydraulic Inputs

The various hydraulic inputs such as diameter, length, reservoir, pump, nodes, junctions, etc., were defined in order to estimate the flow, pressure head and velocity developed at each junction and the pipe length. The analysis was carried out for the extended period simulation to check the hourly variation of output results. The model performance was evaluated using the two performance indices like R^2 (Co-efficient of the square of the regression) and NSE (Nash-Sutcliffe Efficiency). The results of the same is been illustrated in the next section.

4. RESULTS AND DISCUSSIONS

4.1 Hydraulic parameters output

After the successful run of EPANET, the various hydraulic parameters are simulated by the software for the extended period simulation of 24 hours and the results are obtained through tables and graphs. The network comprises of an overhead tank and a reservoir connecting between them is the pump followed by the series of the network pipes following the dead end or tree system layout of water distribution. The method of distribution adopted in the present case is the combined gravity and pumping ensuring the 24/7 water supply to the Palahalli village with a design period of 30 years.

As per the CPHEEO manual, the minimum pressure / head that must be met at each node should be more than 7 m and also the velocity in each pipe has to be maintained at 0.3 to 1.5 m/s for the design of any water supply network distribution. The developed network in the present study shows satisfactory results, as it compliance with the CPHEEO standards which can be clearly illustrated in the tables shown below.

Table -2: Pipe Output results of each Node

Node ID	*DEMAND (LPS)*	*HEAD (m)*	*PRESSURE (M)*
Junc n5	0.30	739.01	22.88
Junc n7	0.30	738.61	22.06
Junc n9	0.35	738.21	20.98
Junc n11	0.30	737.83	19.83
Junc n13	0.30	737.45	20.05
Junc n16	0.30	736.74	21.55
Junc n18	0.23	736.41	22.32
Junc n20	0.23	736.24	23.45
Junc n22	0.30	735.92	24.13
Junc n24	0.30	735.60	23.63
Junc n26	0.30	735.29	23.05
Junc n28	0.30	734.98	22.44
Junc n30	1.13	734.68	21.70
Junc n31	0.60	734.68	23.12
Junc n32	0.38	734.68	19.03
Junc n33	0.79	734.13	18.87
Junc n34	0.30	734.30	21.74
Junc n35	0.08	734.13	22.53
Junc n36	0.41	734.04	22.53
Junc n37	0.75	733.99	24.1
Junc n38	0.23	733.99	23.59
Junc n39	0.23	733.97	24.21
Junc n40	0.90	733.97	24.85
Junc n41	0.23	733.97	24.44
Junc n42	0.38	733.97	24.85
Junc n43	0.75	733.97	24.44
Junc n44	0.08	733.97	29.29
Junc n45	0.23	733.97	29.66
Junc n46	0.23	733.97	29.66
Junc n47	0.23	733.97	28.39
Junc n51	0.60	733.96	30.45
Junc n52	0.83	733.96	31.17
Junc n53	0.38	733.96	30.16
Junc n54	0.75	733.96	28.68
Junc n56	0.38	733.97	17.12
Junc n57	0.67	734.28	19.31
Junc n58	1.13	734.42	22.98
Junc n59	0.90	734.00	21.55
Junc n60	0.15	734.00	22.80
Junc n61	0.52	734.02	21.73
Junc n62	0.15	734.02	23.80
Junc n64	0.15	734.03	23.48
Junc n65	0.23	734.45	24.92
Junc n66	0.30	734.45	24.76
Junc n67	0.15	734.42	22.77
Junc n68	0.38	734.05	22.83
Junc n69	0.75	734.09	21.9
Junc n71	0.60	734.15	20.94
Junc n73	0.15	734.08	18.13
Junc n74	0.34	734.61	21.88
Junc n75	0.56	734.52	20.40
Junc n76	0.67	734.36	18.91
Junc n77	0.67	734.25	17.45
Junc n78	1.35	733.96	31.66
Junc n79	0.23	734.09	23.54
Junc n80	0.38	738.20	20.97
Junc n81	0.45	737.09	20.58
Junc n82	0.30	737.08	20.58
Junc n2	1.50	733.97	23.57
Junc n4	0.45	734.03	22.51
Junc n5	0.52	734.22	20.57
Junc n6	0.52	734.08	18.63
Junc n7	0.40	733.96	22.71
Junc n8	0.15	733.08	20.23
Junc n1	0.30	739.43	24.43
Reservoir	-122.45	714.85	0
Tank	93.04	739.85	10

Table -3: Pipe Output results of each Link

PIPE	LENGTH (m)	DIA (mm)	VELOCITY (m/s)	FLOW (LPS)	HEADLOSS (m/km)
P30	60	170	0.04	0.98	0.02
P31	100	170	0.15	0.38	0.00
P32	60	100	0.05	0.38	0.04
P33	20	100	0.01	0.08	0.00
P34	60	170	0.31	6.96	0.74
P35	60	100	0.03	0.23	0.02
P36	40	100	0.18	1.4	0.50
P37	60	170	0.20	4.59	0.34
P38	40	100	0.09	0.70	0.14
P39	20	100	0.06	0.47	0.07
P40	20	100	0.15	1.18	0.36
P41	60	100	0.00	-0.02	0.00
P42	20	100	0.01	0.08	0.00
P43	60	100	0.03	0.23	0.02
P44	60	100	0.22	0.23	0.02
P45	60	100	0.03	0.23	0.02
P49	60	170	0.02	-0.46	0.00
P50	40	170	0.45	-0.84	0.01
P53	120	170	0.39	-8.94	1.17
P54	160	170	0.47	-10.74	1.64
P55	40	100	0.02	0.15	0.01
P56	40	100	0.02	0.15	0.01
P58	20	100	0.09	0.67	0.13
P59	40	100	0.06	0.45	0.06
P60	40	100	0.02	0.15	0.01
P62	60	170	0.20	-4.51	0.33
P66	60	170	0.27	-6.16	0.59
P70	80	170	0.31	7.14	0.77
P75	40	170	0.51	11.46	1.85
P76	50	170	0.49	11.13	1.75
P77	100	170	0.47	10.56	1.59
P78	80	170	0.44	9.89	1.41
P79	100	170	0.41	9.21	1.23
P83	60	100	0.03	0.23	0.02
P85	40	100	0.06	0.40	0.06
P3	40	170	1.27	28.78	10.18
P4	40	170	1.25	28.48	9.98
P5	40	170	1.22	27.75	9.52
P6	40	170	1.21	27.45	9.33
P7	40	170	1.2	27.15	9.14
P8	40	170	1.16	26.25	8.59

PIPE	LENGTH (m)	DIA (mm)	VELOCITY (m/s)	FLOW (LPS)	HEADLOSS (m/km)
P9	40	170	1.14	25.95	8.40
P10	20	170	1.13	25.73	8.27
P11	40	170	1.12	25.50	8.14
P12	40	170	1.11	25.20	7.96
P13	40	170	1.10	24.90	7.79
P14	40	170	1.08	-24.60	7.61
P16	100	100	0.05	0.38	0.04
P18	40	170	1.07	24.30	7.44
P19	160	170	0.02	0.36	0.00
P20	160	170	0.03	0.60	0.0.1
P1	140	170	0.15	3.46	0.20
P15	160	170	0.07	-1.59	0.05
P21	100	170	0.02	0.38	0.00
P23	40	170	0.25	5.79	0.52
P24	40	170	0.23	5.19	0.43
P25	40	100	0.02	0.15	0.01
P26	60	170	0.36	8.26	1.01
P27	80	170	0.34	7.74	0.89
P28	50	170	0.35	8.05	0.96
P29	50	170	0.33	7.38	0.82
P30	40	100	0.02	0.15	0.01
P31	80	170	0.12	2.76	0.13
P32	40	170	0.10	2.31	0.09
P33	40	100	0.02	0.15	0.01
P2	40	170	1.28	-29.07	10.37
P17	40	170	1.29	29.38	10.57
P22	40	OPEN PUMP		122.42	-25.00

Below graphs shows the variation in pressure fluctuation for the node 9 at different hours of the day within the developed network. As from the below graphs we can conclude that, a minimum level of 7 m pressure is achieved at all the hours of the day which adheres to CPHEEO manual standards.

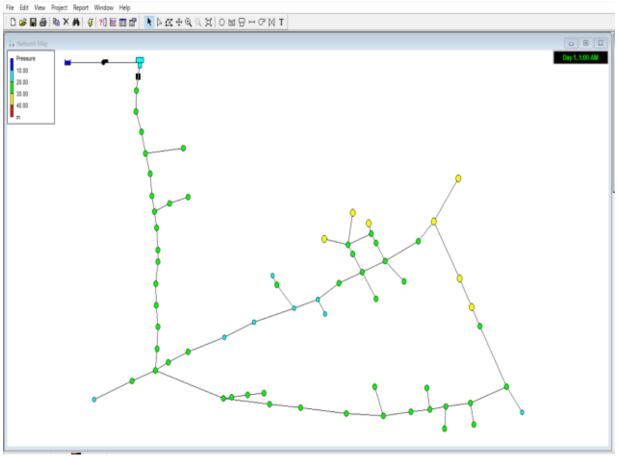

Fig -4: Pressure in the network at 5 AM

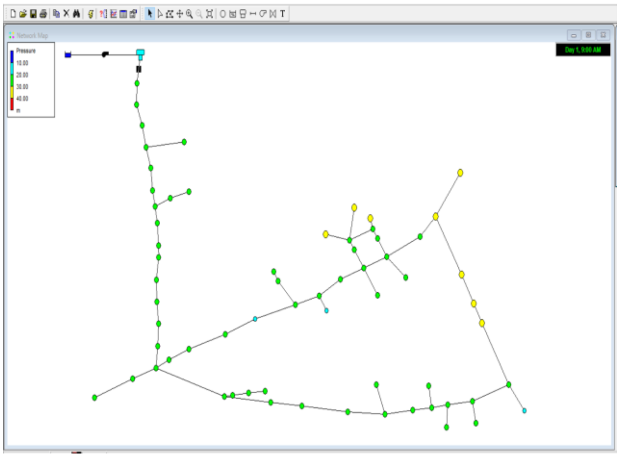

Fig -5: Pressure in the network at 9 AM

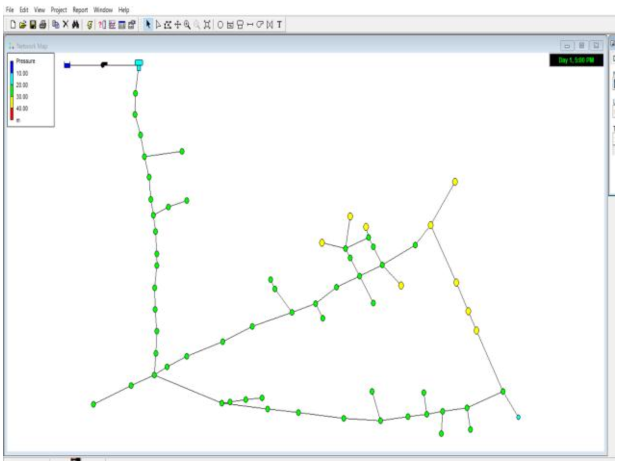

Fig -6: Pressure in the network at 5 PM

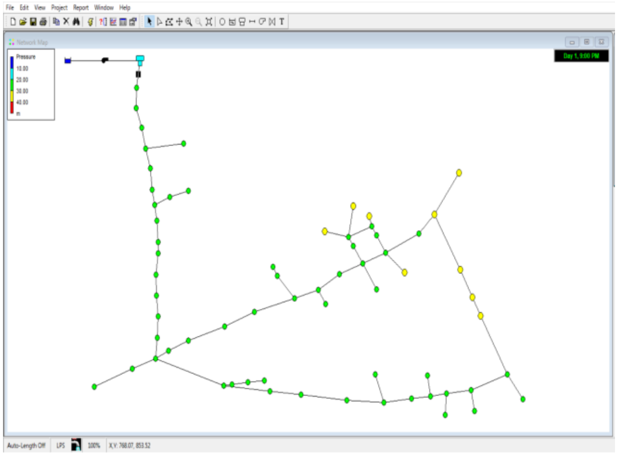

Fig -7: Pressure in the network at 9 PM

4.2 Validation of the EPANET model

Validation of the EPANET model is carried out by choosing the model performance evaluators such as R^2 and NSE for the flow and velocity obtained from the model. The simulated values of the EPANET is compared with the manually calculated values. In general, model simulation can be judged as satisfactory if NSE > 0.50 (Moriasi et. al, 2007) [12] and typical value of R^2 greater than 0.6. Based on the results obtained the model is assumed to be valid and the results are exemplified as shown in Table 4 below.

Table -4: Results of Model Performance Indicators

OBJECTIVE FUNCTION	VELOCITY	FLOW
R^2	0.8413	0.8521
NSE	0.954	0.896

5. CONCLUSIONS

After the successful run of EPANET, the various hydraulic parameters will be simulated by the software for the extended simulation period of 24 hours and the results are obtained through tables and graphs. The network comprises of an overhead tank and a reservoir connecting between them is the pump followed by the series of the network pipes following the dead end or tree system layout of water distribution. The method of distribution adopted in the present case is the combined gravity and pumping ensuring the 24/7 water supply to the Palahalli village with a design period of 30 years.

As per the results obtained, the network developed for the Palahalli village satisfies the standards prescribed by the CPHEEO manual. The selection of the pipe, was PVC, with many advantages compared to other pipes. Since the source of water is very near to the village, adopting proper treatment techniques with the developed network will result in achieving the 24/7 continuous water supply to the villagers.

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