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DESIGN OF WATER SUPPLY NETWORK IN CHITYALA, NANDIGUDEM, VADALAKUNTA AND BHIMOLU VILLAGES IN WEST GODAVARI DISTRCT OF ANDHRA PRADESH STATE USING EPANET

By

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Abstract:

Having a proper water supply network is a basic requirement behind the functioning and survival of every locality. Lack of this network, Chityala, Nandigudem, Vadalakunta, Bhimolu and many other villages in Andhra Pradesh are suffering adversely. Therefore, the Government of Andhra Pradesh is thoughtful on designing a network for water supply, to get rid of this problem. For which the suggested design strategy is designed by EPANET software in this project. This project works with high-end accuracy and simplicity.

This study aims to design a simple and economical the water supply network based on Survey and Population Data of Chityala, Nandigudem, Vadalakunta and Bhimolu villages using EPANET Software. Also, to enumerate the Hydraulic Parameters using the same software, and estimate the amount of water lost as Headloss using Hazen-William's Equation.

This research has been intensively worked to match the criteria of needs and also has been developed to intend to put forth to Government of Andhra Pradesh, to solve the catastrophic situation of the people there, and bring a smile on the faces.

Keywords- Andhra Pradesh Water Supply Scheme, EPANET, Hazen-William's Equation, Headloss, Population and Survey data, Water Supply Network.

1. INTRODUCTION:

Prevalence of a proper water supply network in a village, town or any other locality is an essential requirement for the functioning of domestic, agricultural, industrial and other activities. Having this supply network also provides the following advantages:

- Resistance towards inconsistency of quantity of water in case of Surface and Sub-Surface Sources.
- Disables the spread of water borne diseases like Amoebiasis, Dysentery, Fluorosis etc., particularly from Tanks, Rivers etc., [12].
- Saves time for manual transport of water from the sources.

Today, even by having prodigious development in the standards of living of mankind and extremely rapid development in terms of science and technology, where water is one of the basic resources for survival, and having

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all the resources near our finger tips, it was painful to learn that, there are many remote villages in our country India, actually lack proper water supply networks, and are actually being suffered with this.

To overcome this problem, Government of Andhra Pradesh has coined a proposal called "Andhra Pradesh Water Supply Scheme", which aims to provide clean and potable water to every house [15].

After an intensive survey for this study, a village called Nandigudem West Godavari District, which is remote by nature, is found not having any sort of water supply network, and the people there are actually suffering due to this. The people in this village are depending on adjacent small lakes for water and carrying them to their homes manually, also consuming them without proper treatment. It is indeed that these sources cannot feed the village in hard summers and particularly in coming times.

Water Supply Network can be designed and analyzed using Manual Calculations and other methods, but to attain simplicity EPANET [14] is a software that can be used for this purpose, that enables the following advantages and have got the following applications:

- Design of a shiny new water supply network for a locality [5].
- Analysis of Hydraulic Parameters and remodeling of an existing water supply network [6].
- Estimation of losses during flow of a network [4].
- Determination of effects of water age spots in the quality of water [8].
- Determination of defects and errors in an existing network [9].
- Simulation of Hydraulic Parameters [10].
- Study of transport of contaminants in a pipe network [11].

Therefore, this study aims to design the water supply network using this new- age software called EPANET (Environment Protection Agency Network)., in the most economical way possible and analyze the Hydraulic parameters in Nandigudem village, as a small contribution towards AP Water Supply Scheme.

2. OBJECTIVES:

- To design a good and proper Water Supply Network for Chityala, Nandigudem, Vadalakunta, Bhimolu villages which are actually in an immediate need of it.
- To design the water supply networks using EPANET 2.0 software for these villages with minimal losses.
- To enumerate all the Hydraulic Parameters for the designed network using EPANET Software.
- To determine the quantity of water lost as Unit Headloss using Hazen-Williams formula.

3. LITERATURE REVIEW:

Hailu Gisha, Abrham W/Mariam(PhD), Brook Abate (PhD) (2016), have made an analysis on the concept of "*Water Distribution Network Analysis by EPANET*" and have chosen Bodditi Town as a case study and explained the results as under:

Out of 141 junctions analyzed in the distribution system, 9% of the junctions have above the maximum operating pressure (70 m) and 2% of the junctions have below the minimum operating pressure (15 m). In the distribution

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system of the Town, 30% of pipes (6165 m) have head loss gradient greater than 15 m/Km and their ages were greater than 16-40 years.

In the distribution link analysis, 11% mainline pipes (1549 m) and 4% of sub-main pipes (200 m) have less diameters than the Minimum Design Criteria. As a result, their head loss gradients become greater 15 m/Km. [4]

G. Anisha, A. Kumar, J. Ashok Kumar, P. Suvarna Raju (2016), have worked on the concept of "*Analysis and Design of Water Distribution Network Using EPANET*" and have chosen Chirala Municipality in Prakasam District of Andhra Pradesh as a case study and concluded their results as:

The present distribution network laid in Chirala municipality consists of five zones. This network is laid according to those day's requirement and is not suitable to the future (2041) needs and demands.

Hence a new network is to be laid to meet future demands and to reach the consumer at the door step. The newly laid network is laid according to the road pattern using master plan in view of the extension of the town in future. Two new zones were identified for the construction of reservoirs to meet the needs of those zones respectively. [5]

Dr. G. Venkata Ramana, Dawit T Birhaun (2016), have made a case study on "*Task of EPANET Analysis of Existing Water Distribution System*" and have chosen DIRE DAWA CITY, ETHIOPIA as their subject and discussed their results as follows:

The residual pressure at all nodes is found to be greater than 3 m. Hence, the flow can take place easily to all nodes without any disturbance. The assumed internal diameter of 132.40 mm is insufficient for all the links in the network. Hence, based on the elevation at nodes, base demand diameter of pipes can be fixed for the network. Various hydrological parameters like base demand, pressure head, head of water and friction factor etc. can be easily observed even for a large or complex network. [6]

Dr. H. Ramesh, L. Santhosh and C. J. Jagadeesh (2012), have made a precise study on "*Simulation of Hydraulic Parameters in Water Distribution Network Using EPANET and GIS*" and found that:

The satellite image and DEM have shown in effectively in selection of alternate alignment and quantity of earth work estimation. This paper has demonstrated an application of stochastic simulation for reliability analysis of water distribution systems using EPANET 2.0, taking into account the hydraulic considerations such as pressure, head, velocity etc. The results of the simulations are checked using hydraulic equations. This showed that the results are correct and can be used for modeling water supply system. [10]

4. STUDY AREA:

Here is a brief description about the villages for which the water supply network is proposed to be designed.

4.1 Chityala:

Chityala Village is situated in Gopalapuram Mandal of West Godavari District in Andhra Pradesh State. This village falls in 17.090662° N and 81.5966462° E on the Earth. This village is located at an Altitude of 22m from Mean Sea Level (MSL). This village is bounded with Gopavaram Village on the North, Cherukumilli Village on South, Venkatayapalem Village on East and Gopalapuram and Vadalakunta Villages on West. This village has an extent of

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1271 Hectares. This village holds a population of 1176 Citizens as per 2011 census. The Fig:1 below represents Chityala village in Satellite View attained from Google Earth.

Fig:1: Satellite image of Chityala Village from Google Earth.

4.2. Nandigudem:

Nandigudem Village is a small and secluded village situated in Gopalapuram Mandal of West Godavari District in Andhra Pradesh State. This village falls in 17.1357369° N and 81.4575104° E on the Earth. This village is located at an Altitude of 22m from Mean Sea Level (MSL). This village is bounded with Kovvurupadu Village on the North, Chinnayagudem Village on South, Gopalapuram Village on East and Dippakayalapadu Village on West. This village has an extent of 1786 Hectares. This village holds a population of 1036 Citizens as per 2011 census. The Fig:2 below represents Nandigudem village in Satellite View attained from Google Earth.

Fig:2: Satellite image of Nandigudem Village from Google Earth

4.3. Vadalakunta:

Vadalakunta Village is situated in Gopalapuram Mandal of West Godavari District in Andhra Pradesh State. This village falls in 17.0859° N and 81.5185° E on the Earth. This village is located at an Altitude of 22m from Mean Sea Level (MSL). This village is bounded with Guddigudem Village on the North, Devarapalli Village on South, Venkatayapalem Village on East and Yadavolu Village on West. This village has an extent of 921 Hectares. This village holds a population of 3303 Citizens as per 2011 census. The Fig:3 below represents Nandigudem village in Satellite View attained from Google Earth.

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Fig: 3: Satellite Image of Vadalakunta Village from Google Earth

4.4. Bhimolu Village:

Bhimoulu Village is situated in Gopalapuram Mandal of West Godavari District in Andhra Pradesh State. This village falls in 17.1454° N, 81.5747° E on the Earth. This village is located at an Altitude of 22m from Mean Sea Level (MSL). This village is bounded with Gopavaram Village on the North, Chityala Village on South, Gajjaram Village on East and Gopalapuram and Vadalakunta Villages on the West. This village has an extent of 2240 Hectares. This village holds a population of 2844 Citizens as per 2011 census. The Fig:3 below represents Nandigudem village in Satellite View attained from Google Earth.

Fig: 4: Satellite Image of Bhimolu Village from Google Earth

5. METHODOLOGY:

- To begin with, the primary motive of this project is to provide the Drinking Water Supply Network using EPANET Software. For that, the villages actually lack them are selected. For the designing of the network in EPANET, 2 essentials are needed, i.e., Survey Report and Population Report of the village.

- Therefore, the village has to be surveyed or collect the surveyed data at the latest. It is preferred to used Digital Global Positioning System as a survey equipment to attain high end accuracy and ease. [16]

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- On the other hand, the population data shown also be in hand. It can be attained from Census Department or Andhra Pradesh Drinking Water Supply Corporation. This population would for the year 2011, since the latest population statistics are not taken from then.

- Now, the Survey Data of the village which is mainly done for the road networks of the village is fed into AutoCAD Software and primarily verify the lengths of roads with that of Google Earth. Now this file should be saved in (.dxf) or (.dwg) formats.

- This (.dxf) or (.dwg) file is fed into EPACAD Software, where this file gets converted into (.NET) format, where this file can be opened and developed in EPANET Software. This (.NET) file is fed in EPANET Software and kept on hold.

- On the other hand, the population data is to be analyzed. Initially the population of the village by the end of design period (30 years) is forecasted by Incremental Increase Method (IIM) (∵ This method can be applied for slow growing cities and villages, while the other methods like Arithmetic and Geometric Increase Methods doesn't fit for this kind of villages) .

- Then the demand for water, by the end of Design Period based on Per Water Capita Demand with respect to IS: 1172-1993 is calculated [13].

- Then coming back to EPANET, this quantity of water required or the ultimate demand is used to design the OHDR Tanks. It should be seen that the tank is situated at a possible higher elevation, to enable greater flow due to gravity.

- The diameters of pipes, size of tanks and other Hydraulic data is fed into EPANET.

- Then, the file applied to "Run" and the errors and losses are observed and minimized. This is a trail and error process, and the network is continuously re-designed, by altering the hydraulic parameters at required stages. Then if the Run is observed to be successful, then proceed to further stages like Unit Headloss calculation.

- Before that, don't forget to generate the full network report with all the hydraulic parameters of the network from EPANET.

- Determine the amount of water lost as Headloss using Hazen William's Equation.

6. RESULTS AND DISCUSSIONS:

As stated in the methodology, there are a series of steps that lead towards the design of Water Supply Network for Chityala, Nandigudem, Vadalakunta and Bhimolu Villages. But the Steps:1, 3 and 4 are presented below for only Nandigudem Village (as the calculation part is same for all the villages), but the results for all the parameters are presented at the end.

Step:1: Population and Demand Analysis:

Initially, the population and demand analysis is done based on 2011 Census. The water supply network should be capable of functioning for at least 30 years, therefore the ultimate year is 2050.

i) Population Analysis:

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Population as per APDWSC census from 2011 = 1096 Citizens (Base Year)

Adopting Incremental Increase Method (IIM), for Population Forecasting,

Assuming the growth factor= 1%

According to IIM,

Population at the end of "n" years = Population at the end of Base year* 1.011^n

⇨ Population in the village by the end of 2020 = $1096*1.011^9$ = 1210 Citizens (Base Year for the Design)

Since, water supply network has to serve for a life period of 30 years,

Population of Nandigudem by the end of 2050 = $1210* 1.011^{30}$ = 1680 Citizens.

Similarly, the population estimated by the end of 2050 in other villages is presented in **Table:1** below

Table:1: Population in Various Villages

Population/ Village	Chityala	Vadalakunta	Bhimolu
In 2011 (as per APDWSC Statistics)	1176 Citizens	3303 Citizens	3138 Citizens
Growth Factor	1%	1%	1%
By end of 2020 (Base Year)	1298 Citizens	3645 Citizens	3138 Citizens
By end of 2050 (Ultimate Year)	1803 Citizens	5061 Citizens	4357 Citizens

Based on this Population, the demand for water is calculated in the next step

ii) Water demand analysis:

Assuming the per capita demand in the village as 75 lpcd [13]

∴ Ultimate Demand of water by the end of 2050 = 1680* 75 = 1,25,000 liters per day= = 125.00 KL = 125.00 m^3

Table:2: Ultimate water demand in Various Villages by 2050

Demand/ Village	Chityala	Vadalakunta	Bhimolu
Ultimate Population by 2050	1803 Citizens	5061 Citizens	4357 Citizens
Estimated per capita demand	75 lpcd	75 lpcd	75 lpcd
Ultimate Demand of water by the end of 2050	135.23 KL	379.575 KL	326.803 KL

In the next step, the village is designed with the water supply network using EPANET and every individual layer is presented clearly.

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Step:2: Surveying and EPANET Analysis:

i) **Survey Report**:

The entire Chityala, Nandigudem, Vadalakunta, Bhimolu villages, particularly Road Networks are properly surveyed using Digital Global Positioning System [16] and fed into AutoCAD. The **Fig:5-8** below represents the Survey Report of the Villages in AutoCAD

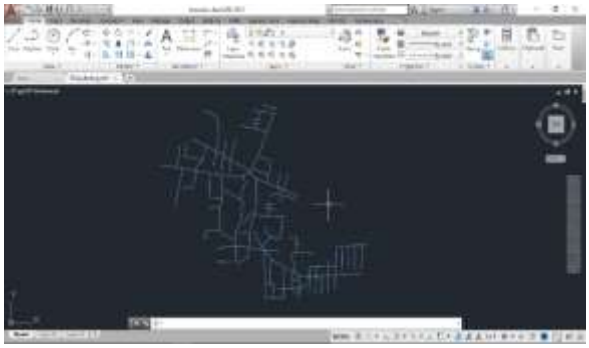

Fig:5: Survey Report of Chityala Village

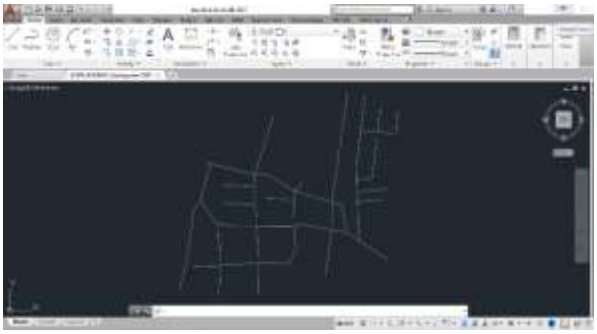

Fig:6: Survey Report of Nandigudem Village

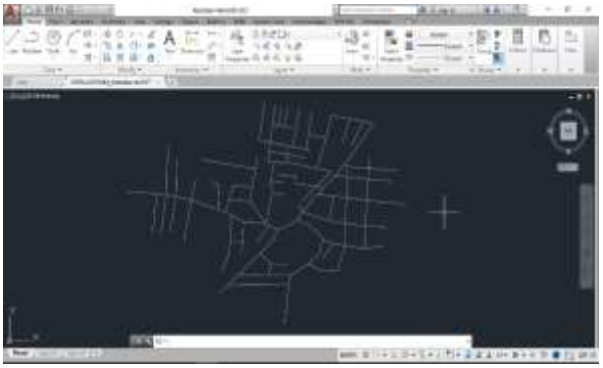

Fig:7: Survey Report of Vadalakunta Village

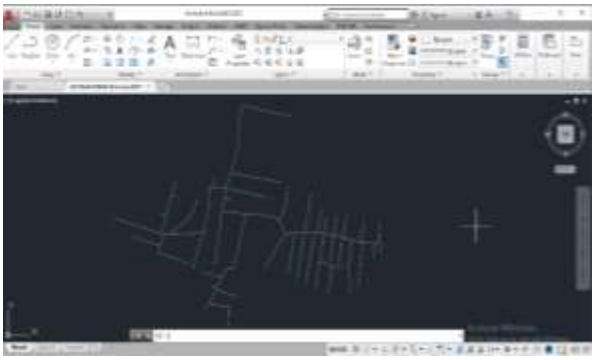

Fig:8: Survey Report of Bhimolu Village

ii) EPANET Layers:

This CAD file is converted into .NET file using EPACAD and is opened in EPANET Software. The **Fig:9-12** below represents the Network of Villages in EPANET

Fig:9: Chityala Village Network in EPANET

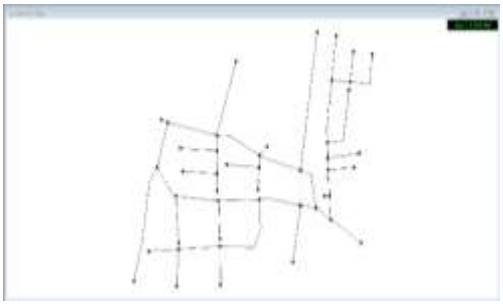

Fig:10: Nandigudem Village Network in EPANET

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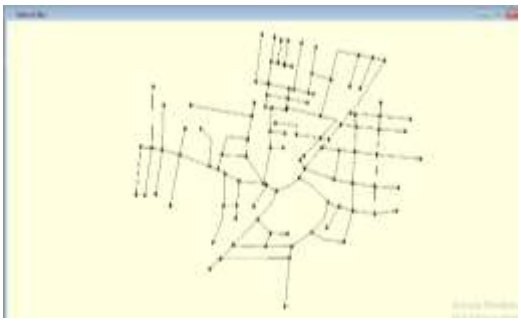
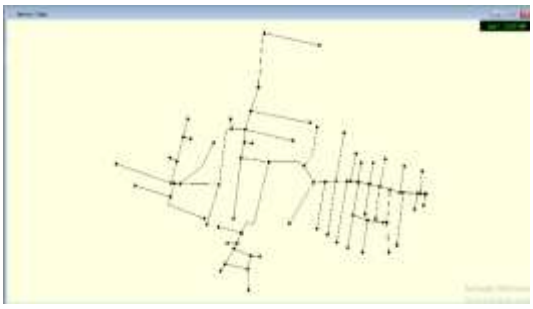
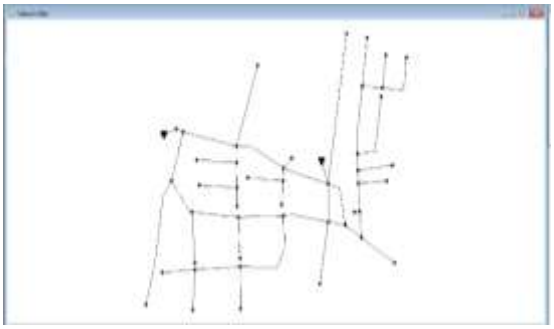




Based on the demand calculated in Step:1, 2 identical circular OHDR Tanks are designed for every village, at suitable locations with 3.4m height. the bottom of the tank is 9m from Ground Level. Then, the network would look, as presented in **Fig:13-16.**

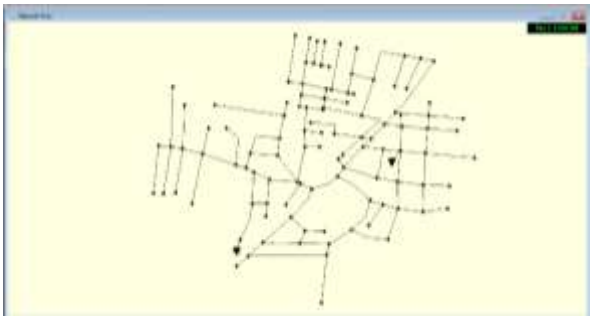
Note: Dia of each Tank= 5.1m

Fig:13: Chityala Village Network with in EPANET with designed OHDR Tanks



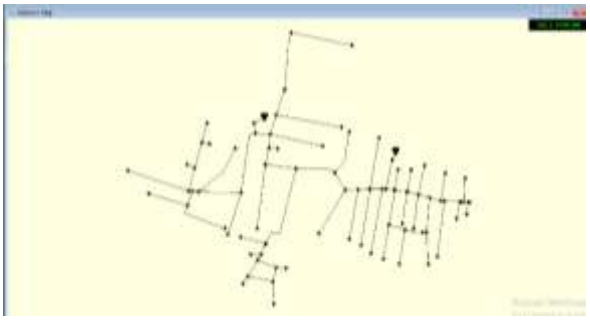
Note: Dia of each Tank= 5.0m

Fig:14: Nandigudem Village Network with in EPANET with designed OHDR Tanks



Note: Dia of each Tank= 8.5m

Fig:15: Vadalakunta Village Network with in EPANET with designed OHDR Tanks



Note: Dia of each Tank= 8.25m

Fig:16: Bhimolu Village Network with in EPANET with designed OHDR Tanks

All the nodes Id's in the network of all the villages are displayed in **Fig:17-20** below

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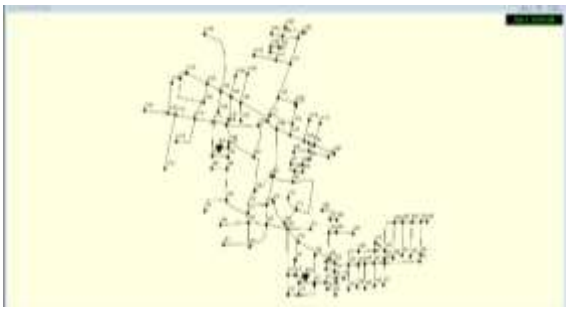

Fig:17: Chityala Village Network with Node Id's

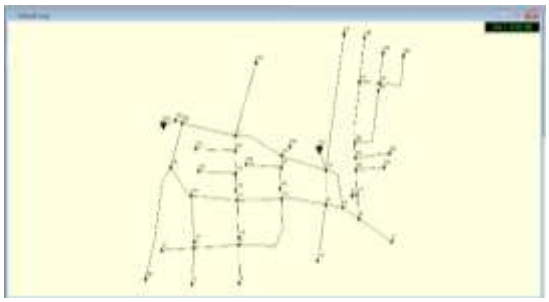

Fig:18: Nandigudem Village Network with Node Id's

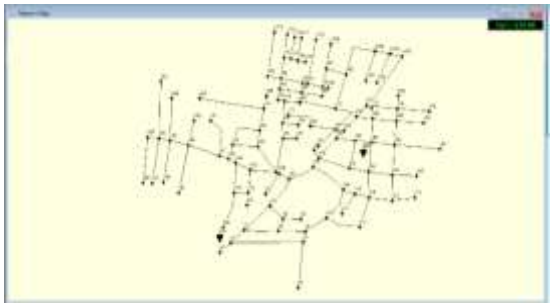

Fig:19: Vadalakunta Village Network with Node Id's

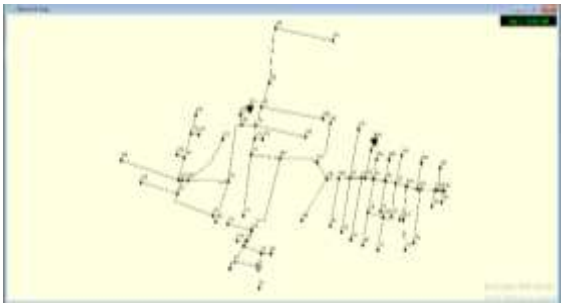

Fig:20: Bhimolu Village Network with Node Id's

All the Id's of Links are presented below in **Fig:21-24.**

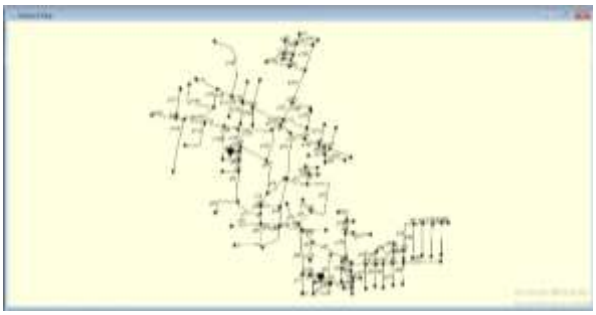

Fig:21: Chityala Village Network with Link Id's

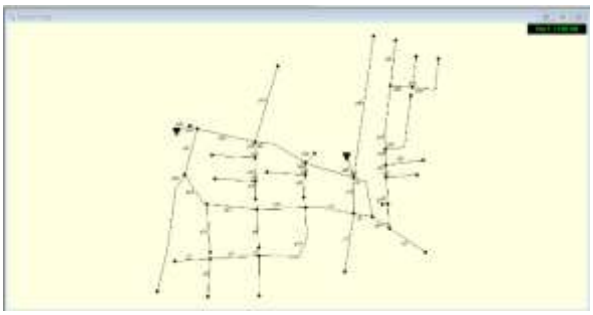

Fig:22: Nandigudem Village Network with Link Id's

Fig:23: Vadalakunta Village Network with Link Id's

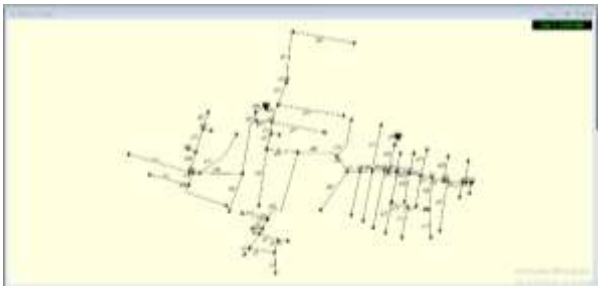

Fig:24: Bhimolu Village Network with Link Id's

From here, all data related to links or pipes will be presented. Firstly, the lengths of all the pipes are presented below in **Fig: 25-28.**

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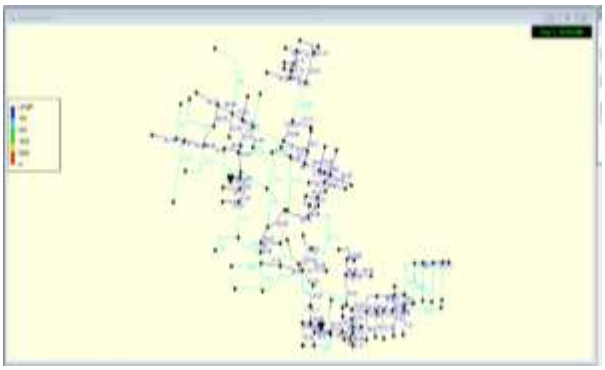

Fig:25: Lengths of all the pipes of Chityala Village

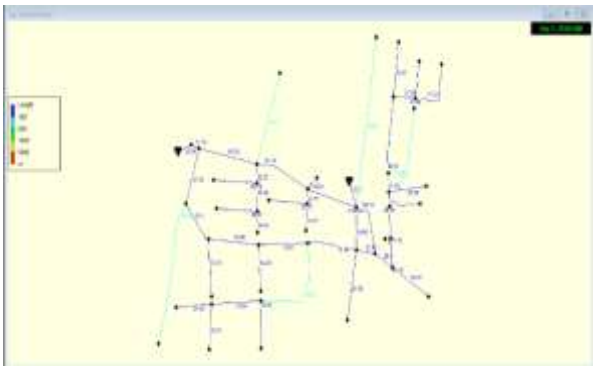

Fig:26: Lengths of all the pipes of Nandigudem Village

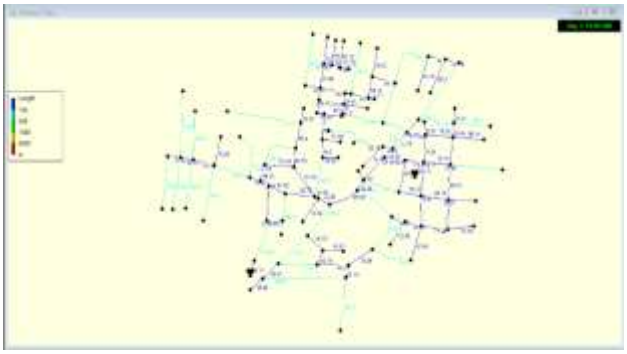

Fig:27: Lengths of all the pipes of Vadalakunta Village

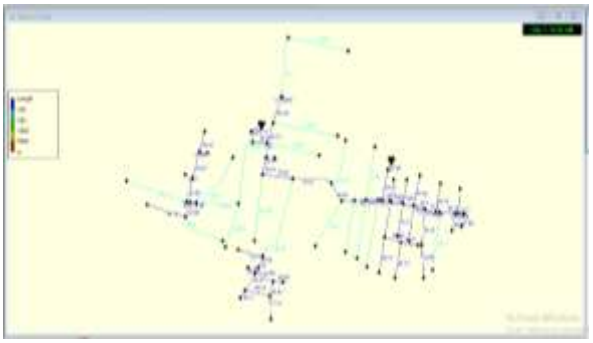

Fig:28: Lengths of all the pipes of Bhimolu Village

The Diameter of water in mm for all the pipes in the network is shown in **Fig:29-32**.

Fig:29: Diameters of all the pipes of Chityala Village

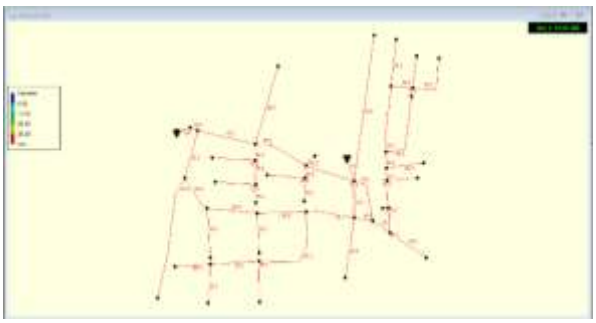

Fig:30: Diameters of all the pipes of Nandigudem Village

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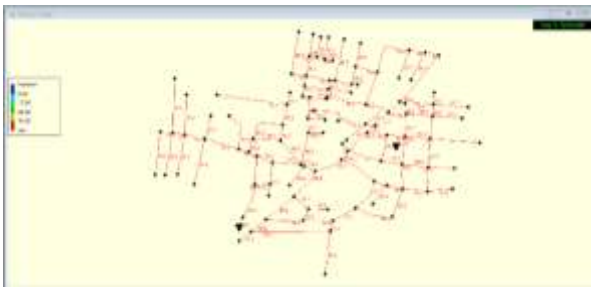

Fig:31: Diameters of all the pipes of Vadalakunta Village

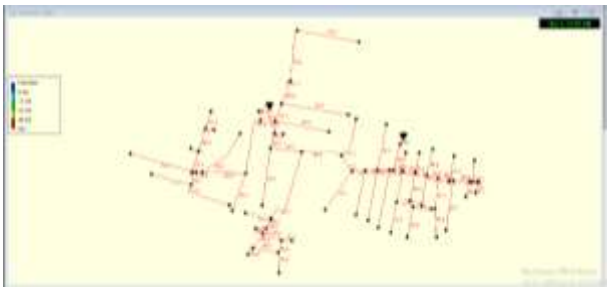

Fig:32: Diameters of all the pipes of Bhimolu Village

The Unit Headloss of water in m/km for all the pipes in the network is shown in **Fig:33-36**.

Fig:33: Unit Headloss of all the pipes of Chityala Village

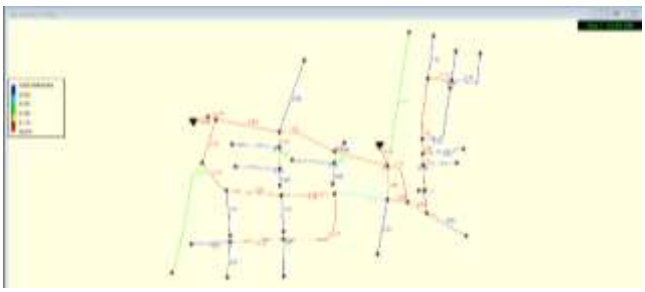

Fig:34: Unit Headloss of all the pipes of Nandigudem Village

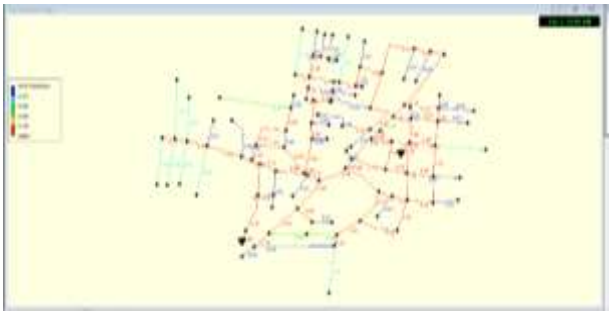

Fig:35: Unit Headloss of all the pipes of Vadalakunta Village

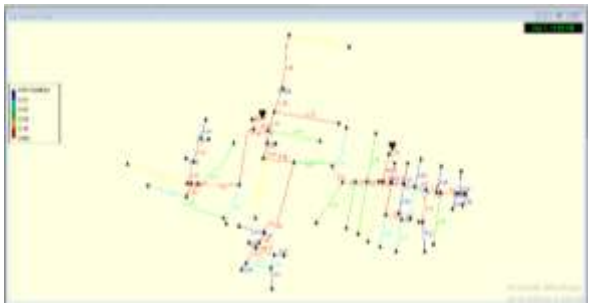

Fig:36: Unit Headloss of all the pipes of Bhimolu Village

The **Fig:36-40** illustrates the Flow of Water in every Pipe in the Village

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Fig:37: Flow of water in the entire network of Chityala Village

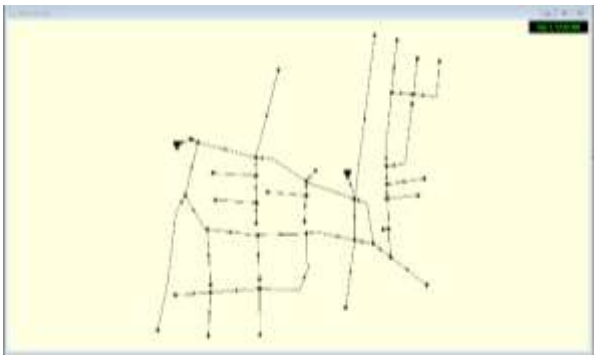

Fig:38: Flow of water in the entire network of Nandigudem Village

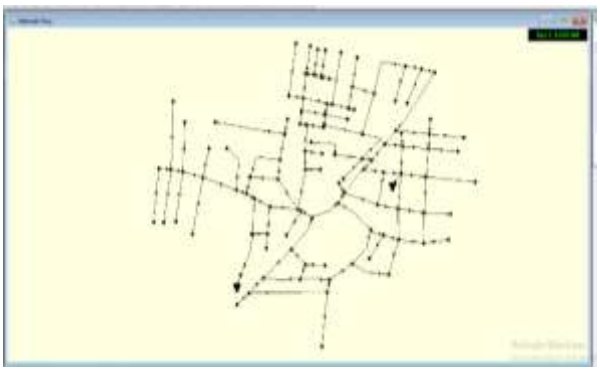

Fig:39: Flow of water in the entire network of Vadalakunta Village

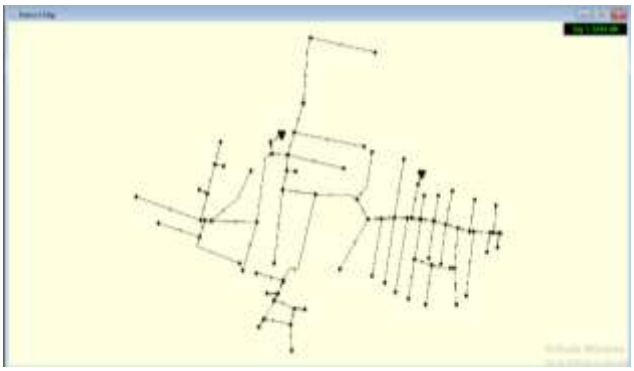

Fig:40: Flow of water in the entire network of Bhimolu Village

Step:3: Hydraulic Parameters of the Network:

The layers attained from EPANET are presented in the Step:2 above, the **Table:3** below presents the results of the network and properties in individual pipe attained from EPANET Report for Nandigudem Village.

Table:3: Hydraulic parameters of Nandigudem Village Water Supply Network

Link ID	Length (m)	Diameter (mm)	Flow (LPM)	Velocity (m/s)	Unit Headloss (m/km)	Friction Factor
p1	51.47	56.2	1.76	0.01	0.01	0.044
p2	52.91	56.2	1.81	0.01	0.01	0.043
p3	70.64	56.2	9.55	0.06	0.13	0.034
p4	55.64	56.2	1.9	0.01	0.01	0.044
p5	62.27	56.2	2.13	0.01	0.01	0.043
p6	29.8	56.2	48.09	0.32	2.57	0.027

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p7	83.08	56.2	2.84	0.02	0.01	0.041
p8	27.42	56.2	19.95	0.13	0.5	0.031
p9	54.26	56.2	1.85	0.01	0.01	0.044
p10	129.2	56.2	20.18	0.14	0.51	0.031
p11	70.94	56.2	4.47	0.03	0.03	0.039
p12	67.23	56.2	2.3	0.02	0.01	0.043
p14	8.527	56.2	0.29	0.00	0.00	0.00
p15	34.03	56.2	41.65	0.28	1.97	0.028
p16	24.45	56.2	0.84	0.01	0	0.04
p17	59.01	56.2	2.02	0.01	0.01	0.043
p18	49.66	56.2	35.15	0.24	1.44	0.028
p19	68.74	56.2	32.44	0.22	1.24	0.029
p20	0.050	56.2	13.73	0.09	0.37	0.048
p21	37.45	56.2	38.62	0.26	1.71	0.028
p22	44.66	56.2	1.53	0.01	0	0.046
p23	169.8	56.2	5.8	0.04	0.05	0.037
p24	53.1	56.2	42.5	0.29	2.04	0.028
p25	31.57	56.2	1.08	0.01	0	0.043
p26	55.75	56.2	1.91	0.01	0.01	0.044
p27	17.4	56.2	33.7	0.23	1.33	0.029
p28	16.77	56.2	6.54	0.04	0.06	0.036
p29	73.18	56.2	17.35	0.12	0.39	0.032
p30	54.54	56.2	1.86	0.01	0.01	0.044
p31	33.09	56.2	6.84	0.05	0.07	0.036
p32	62.78	56.2	2.15	0.01	0.01	0.043
p33	18.37	56.2	0.63	0	0	0.031
p34	21.92	56.2	28.63	0.19	0.98	0.029
p35	22.27	56.2	13.02	0.09	0.23	0.033
p36	81.12	56.2	30.99	0.21	1.14	0.029
p37	67.25	56.2	58.22	0.39	3.66	0.026
p38	85.39	56.2	58.06	0.39	3.64	0.026
p39	11.78	56.2	121.9	0.82	14.37	0.024
p40	100.8	56.2	3.44	0.02	0.02	0.04
p41	89.81	56.2	17.92	0.12	0.41	0.031
p42	31.88	56.2	9.39	0.06	0.12	0.035
p43	111.3	56.2	3.8	0.03	0.02	0.04
p44	77.37	56.2	2.64	0.02	0.01	0.042
p45	44.08	56.2	1.51	0.01	0	0.045
p46	63.97	56.2	2.19	0.01	0.01	0.043
p47	200.9	56.2	6.86	0.05	0.07	0.036
p48	20.56	100	123.0	0.26	0.88	0.025
p49	32.2	100	71.62	0.15	0.32	0.028
p50	70.21	56.2	24.95	0.17	0.76	0.03
p51	73.66	56.2	33.58	0.23	1.32	0.029

iii) Summary of Hydraulic Parameters of all the Villages:

The **Table:4** below represents the summary of all the hydraulic Parameters of all the village.

Parameter	**Village**			
	Chtiyala	**Nandigudem**	**Vadalakunta**	**Bhimolu**

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No. of Nodes		155	47	115	91
No. of Links		170	51	121	95
Tanks Proposed	**Numbers**	2	2	2	2
	Diameter of Tank	5.10m	5.00m	8.50m	8.25m
	Height of Tank	3.40m	3.40m	3.40m	3.40m
Total Length of Pipe Network		10,610.99m	2,874.257m	9,723.628m	5,242.41m
Diameter of Pipes		56.2mm and 100mm	56.2mm and 100mm	56.2mm and 100mm	56.2mm and 100mm
Type of the Distribution Network		Dead End System	Dead End System	Dead End and Grid System	Dead End System
Total Unit Head Loss		110.62 m/km	42.48 m/km	156.02 m/km	137.45 m/km

Step:4: Friction Losses calculation:

From the above Table:4, using Hazen William's Equation [17]

Unit Head Loss (H_f) = $10.65*((Q^{1.85})*L) /(C^{1.85})*d^{4.87})$

where., Q = Flow or Discharge (LPM)
L = Length of Pipe (m)
C = Roughness Factor = 140
d = Diameter of Pipe (mm)

For Vadalakunta village, it is found that,

Total Unit Head Loss in the entire Network = 42.48 m/km

Total Unit Head Loss in 100mm diameter Pipes = 0.88+ 0.32 = 1.20 m/km

Total Unit Head Loss in 56.2mm diameter Pipes = 110.62- 1.47 = 41.28 m/km

100mm Diameter Pipe	**56.2mm Diameter Pipe**
Head Loss = 1.20 m/km	Head Loss = 41.28 m/km
Length of Pipe Network = 52.76m= 0.05276km	Length of Pipe Network = 2,821.497 m= 2.821 km
Height of Water Lost (H) = (1.20/ 0.05276) = 22.74 m	Height of Water Lost (H) = (41.28/ 2.821) = 14.63 m
Volume of Water Lost (Q) = Area* Height	
Area of Pipe = $(\pi/4)*0.1^2 = 7.85*10^{-3}$ m^2	Area of Pipe = $(\pi/4)*0.0562^2 = 2.48*10^{-3}$ m^2
Q_1 = A* 21.77 = 0.178 m^3	Q_2 = A* 10.543 = 0.036 m^3

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Therefore, Total Volume of Water lost = $Q_1 + Q_2 = 0.178 + 0.036 = 0.214\ m^3$

That is, 214 liters of water per day is lost in the form of Head Loss

% of Water Lost as Head Loss per day = (Quantity of Water Lost/ Quantity of Water Supplied to the Network) * 100

= (214/ 1,25,000) *100 = 0.17%

Therefore, 99.83% of the water fed into the tanks supplied for the entire village, whereas 0.17% of the water is lost as losses which is almost ignorable. This loss is up to the ultimate design life of the Network that is 2050. Till this time, the Head losses would be below 0.17% but under cases like leakages or thefts, this value could be exceeded.

Similarly, for the other villages the calculation for the amount of water lost as Unit Head Loss is presented below in Table:5

Table:5: Summary of Headloss of various Villages

	Village		
	Chtiyala	**Vadalakunta**	**Bhimolu**
Total Unit Head Loss	110.62 m/km	156.02 m/km	137.45 m/km
% of Water Lost as Head loss	0.14%	0.26%	0.88%

7. CONCLUSIONS OF THE STUDY:

From this study, there are various outcomes, which are discussed below:

7.1. Achievements of Objectives:

- Firstly, the villages are completely explored and presented in Study Area.
- EPANET Software was thoroughly studied and explored before beginning the project.
- Using the Survey Report and Population Reports, the villages are designed with the water supply networks.
- Under trial and error process, the losses and errors in the network are rectified and the finely polished networks of every are presented in Results topic.
- Every Hydraulic Parameter is presented clearly shown in the layers and reports presented in the same topic.
- Using Hazen William's Equation, the amount of Unit Headloss in the village are determined and the amount of water lost as losses is also calculated and presented.

7.2. Summary of the Village Networks:

7.2.1 Chityala Village:

- As, stated in the study area, this village has an extent of 1271 Hectares.

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- The population as per 2011 census was recorded as 1176 Citizens. It was forecasted using IIM that, the population by the end of the design period in this village would be 1803 Citizens.
- With respect to IS 1172:1993 [13], the per capita demand was assumed as 75lpcd per day and the ultimate demand by the end of the design period is found to be 135.23 KL.
- With respect to the demand, 2 identical OHDR tanks of 5.10m dia and 3.40m height, are designed at elevated locations.
- The entire network is attained with 155nodes and 170 links/pipes
- This village has achieved the pipe network of length 10,610.99m, with 56.2mm and 100mm diameter pipes used depending on the situation.
- The network is proposed to use DI Pipes of K9 Grade. Roughness Constant for all the pipes is given as 140.
- The network is completely Dead End System.
- It is also observed that the total Unit Headloss in the network is 110.62 m/km. By which it was determined that a maximum of 0.14% of the water supplied to the village is lost in the form of Headlosses. This value is really negligible.
- Finally, by estimation based on various items of work and quantities, the cost of construction of this network is found to be ₹. 1,97,86,852.68/-. Based on Standards Schedule of rates [15]. Also, the construction could be completed within 4 months and 15days.

7.2.2. Nandigudem Village:

- As, stated in study area, this village has an extent of 1786 Hectares.
- Where the population as per 2011 census was 1096 Citizens. It was forecasted using IIM that, the population by the end of the design period in this village would be 1680 Citizens
- With respect to IS 1172:1993 [13], the per capita demand was assumed as 75lpcd per day and the ultimate demand by the end of the design period is found to be 125.00 KL.
- With respect to the demand, 2 identical OHDR tanks of 5.00m dia and 3.40m height, are designed at elevated locations.
- The entire network is attained with 47nodes and 51 links/pipes
- This village has achieved the pipe network of length 2,874.257m, with 56.2mm and 100mm diameter pipes used depending on the situation.
- The network is proposed to use DI Pipes of K9 Grade. Roughness Constant for all the pipes is given as 140.
- The network is completely Dead End System.
- It is also observed that, using Hazen William's Equation the total Unit Headloss in the network is 42.48 m/km. By which it is determined that a maximum of 0.17% of the water supplied to the village is lost in the form of Headlosses. This value is really negligible.
- Finally, by estimation based on various items of work and quantities, the cost of construction of this network is found to be ₹. 1,03,04,522 /-. Based on Standards Schedule of rates [15]. Also, the construction could be completed within 4 months and 15days.

7.2.3 Vadalakunta Village:

- As, stated in the Study Area, this village has an extent of 921 Hectares.

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- The population as per 2011 census was recorded as 3303 Citizens. It was forecasted using IIM that, the population by the end of the design period in this village would be 5061 Citizens
- With respect to IS 1172:1993 [13], the per capita demand was assumed as 75lpcd per day and the ultimate demand by the end of the design period is found to be 379.575 KL.
- With respect to the demand, 2 identical OHDR tanks of 8.50m dia and 3.40m height, are designed at elevated locations.
- The entire network is attained with 115nodes and 121 links/pipes
- This village has achieved the pipe network of length 9,723.628m, with 56.2mm and 100mm diameter pipes used depending on the situation.
- The network is proposed to use DI Pipes of K9 Grade. Roughness Constant for all the pipes is given as 140.
- The network is made of Dead End and Grid Systems.
- It is also observed that the total Unit Headloss in the network is 156.02 m/km. By which it was determined that a maximum of 0.26% of the water supplied to the village is lost in the form of Headlosses.
- Finally, by estimation based on various items of work and quantities, the cost of construction of this network is found to be ₹. 3,08,14,743.35 /-.Based on Standard Schedule of Rates[15] Also, the construction could be completed within 5 months and 15days.

7.2.4 Bhimolu Village:

- As, stated in the study area, this village has an extent of 2240 Hectares.
- The population as per 2011 census was recorded as 2844 Citizens. It was forecasted using IIM that, the population by the end of the design period in this village would be 4357 Citizens.
- With respect to IS 1172:1993 [13], the per capita demand was assumed as 75lpcd per day and the ultimate demand by the end of the design period is found to be 326.803 KL.
- With respect to the demand, 2 identical OHDR tanks of 8.25m dia and 3.40m height, are designed at elevated locations.
- The entire network is attained with 91nodes and 95 links/pipes
- This village has achieved the pipe network of length 5,242.41m, with 56.2mm and 100mm diameter pipes used depending on the situation.
- The network is proposed to use DI Pipes of K9 Grade. Roughness Constant for all the pipes is given as 140.
- The network is completely Dead End System.
- It is also observed that the total Unit Headloss in the network is 137.45 m/km. By which it was determined that a maximum of 0.48% of the water supplied to the village is lost in the form of Headlosses.
- Finally, by estimation based on various items of work and quantities, the cost of construction of this network is found to be ₹. 2,44,69,212.24 /-. Based on Standard Schedule of Rates [15]. Also, the construction could be completed within 5 months and 15days.

7.3 CONCLUSIONS OF THE STUDY:

- EPANET Software is found to be really simple software, with its own beauty and limitations.
- Every village has got its own definite amount of pipe lengths, demands, and all of them are clearly explained in Results and Conclusions topic
- It was also understood that there is a definite relationship between Time, Budget, Quality and Amount of Resources in this study.

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- As a small tribute and contribution towards Andhra Pradesh Water Supply Scheme, Chityala, Nandigudem, Vadalakunta and Bhimolu Villages are designed with Water Supply Network.
- Finally, this network is capable of satisfying the water needs for the citizens of Chityala, Nandigudem, Vadalakunta and Bhimolu Villages and put a full-stop for their problems, and bring a smile on their faces.

7.4 RECOMMENDATIONS AND SCOPE FOR FUTURE STUDIES:

- This water supply network could be fed into WaterGEMS and other advanced softwares for further level analysis and precision.
- Using Softwares like MS Project, Primavera etc., the Project Management and Resource Allocation could be done with greater level of accuracy.
- Based on the series of activities, a proper network diagram for Project Management and tracking could also be designed.
- Finally, after a certain period of time, again the network of this village could be analyzed using EPANET or any other similar Software available for that time and present them as [1], [6].

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