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A Comparative Study on Design of Optimal Water Distribution System Using WaterGEMS in Rural Areas of Uttarakhand

Vishesh Agarwal[1], Shoeb Alam[2], Sapna Kumari[3]

[1]M.Tech Student, Department of Civil Engineering, Al-Falah University, Dhauj, Faridabad
[2]Assistant Professor, Department of Civil Engineering, Al-Falah University, Dhauj, Faridabad
[2]Research Scholar, Department of Civil Engineering, Jamia Millia Islamia, New Delhi

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Abstract - *Water Distribution system these days are the basic requirement of a well-planned town and cities, without a proper Distribution system we could not achieve the goal of creating the perfect infrastructure for the people. Under this research we will be focusing on studying the different present aspects of the distribution system and by comparing and assessing Topography for the plain and the hilly areas of the Uttarakhand with respect to the water distribution system, ways to solve the existing problems and creating models, designs and doing qualitative analysis of the various proposed treatment systems and methods discussed.*

Based on the existing distribution system of a town we will collect hydraulic data, digitized maps and topographical surveys so as to propose a better distribution system with treatment plants based on our assessment. We will analyze the topography of the study area and based on the present scenario a proposal of full-fledged distribution network will be done for the plain areas and Hilly Areas which is chosen based on the comparative study of different pipe materials and hydraulic modelling of the proposed distribution network along with the recommendations set by the "CPHEEO Manual".

Key Words: **WaterGEMS, Distribution system, Water supply, Uttarakhand, Optimal water distribution design, Hydraulic Modelling,**

1. INTRODUCTION

Water is a vital nutrient and plays a key role in the human being. A human can survive without food for several weeks but cannot live without water for more days. Water is an essential requirement which is required to function in our body from cell and tissues, to vital organs. A water distribution system is an essential infrastructure in the supply of water for domestic as well as industrial uses. It connects consumer to sources of water, using hydraulic component such as pipes, valves, pumps and tanks. The primary goal of all water distribution system engineer is the delivery of water to meet demand on pressure and quantity.

This study is based on the need of having an effectively planned and well-engineered distribution system in the rural areas or the under developed areas of the country. As per the present situation going on in the rural and under developed areas of the nation we will find that most of the population there are deprived of the basic sanitation facility like a proper water distribution system, sewage collection system, toilets, waste treatment and disposal facility etc. A water distribution system is a part of water supply network with components that carry potable water from a centralized treatment plant or wells to water consumers in order to adequately deliver water to satisfy residential, commercial, industrial and firefighting requirements. These basic amenities not only provide with better life standards but also give the knowledge of not wasting the environment and to conserve it.

The topic for this study is "A Comparative Study on Design of Optimal Water Distribution Systems Using WaterGEMS in Rural Areas of Uttarakhand". The study will focus on the present problems faced by the people living in the rural and under developed areas because of the absence or a poor functioning distribution system and also understanding the different design criteria and aspects to be considered for designing a distribution system in a plain and Hilly areas. To do all these calculations and observations we will be analysing the data that we have obtained for the projected area (like topography, population etc.) and based on the Indian standards and the CPHEEO Manual we will be designing a full-fledged network system based on the demand that we will be calculating by projecting the population of the projected area and also depending on the cultural and social aspect of the projected area.

1.1 Scope of study

Water mains network modelling advances are essential for water industry. There is need to use modelling optimization to improve the accuracy of water mains model maintenance and calibration. This will provide a pathway to real time and near real time operational modelling support.

Based on the above discussion, the scope of the study is as follows:

- Assessment of existing water supply network in the projected area
- Provision of solution to resolve existing condition
- Population forecasting and demand analysis
- Preparation of layout of water supply Network
- Hydraulic Modeling of proposed network
- Comparative Assessment of proposed network in plain area and hilly area

1.2 Objective

The objectives of the present study is

1) To design of optimal water distribution system using water Gems
2) Doing a comparative analysis of distribution network design in Plain Areas and Hilly Areas.
3) Understanding the designing condition for the Plain areas and Hilly Areas which are not the same, there are many design considerations which are kept to be in mind while designing a plain area distribution network and a Hilly area network.
4) The main design criteria to be made for such network is to select the pipe diameter and pipe material. Larger the diameter, better is the service but on the other hand will not be economical.
5) Not only to design an effective but also an economical water supply scheme.

2. METHODOLOGY

For our study we have selected the rural area of Uttarakhand. Uttarakhand formerly known as Uttaranchal is a state in the northern part of India. It is often referred to as the "Devabhumi" (literally "Land of the Gods") due to numerous Hindu temples and pilgrimage centres found throughout the state. Uttarakhand is known for the natural environment of the Himalayas, the Bhabar and the Terai regions.

We have selected Dehradun district for our study. The Dehradun district comprises of 6 Blocks. (Chakrata, Doiwala, Kalsi, Raipur, Sahaspur & Vikas Nagar). Out of which some are categorized in plain areas and some in hilly area.

We have selected Village Dharmawala of Block Vikas Nagar as study area for plain area and Village Gujrada Karanpur of Block Sahaspur as study area for Hilly area. A optimum and effective design will be carried out using WaterGEMS software along with the comparative analysis of these areas.

As per the current Scenario the existing distribution system comprises of PVC & AC pipe which are very old around 25 to 30 years. According to the CPHEEO manual it has completed its life period. Also the existing pipe lines are of very small diameter, having leakage problem due to which the existing network is not working in robust manner and would not be able to cater the future water demand and will not be able to meet the residual pressure criteria.

Therefore keeping in mind the overall coverage of the project area, fulfilling the future water demand & Meeting the desired residual pressure, it is necessary to design a new piped network system for our project area.

The census population data has been collected from the District Census Handbook, District Dehradun from year 1971 to 2011. The census population for the villages is given below:

Table -1: Census Population

Sr. No.	Town	Census Population				
		1971	1981	1991	2001	2011
1	Dharmawala	638	923	1293	1714	2232
2	Gujrada Karanpur	271	329	456	529	697

We will be using different Engineering formulas for the population forecasting. The forecasted population will used to calculate the water demand in the base year, Intermediate year and design year which will be used to design our optimized distribution Network. After analyzing the growth pattern of the village suitable method will be selected for our design area.

The various Methods are as follows:-

1) Arithmetical Increase Method
2) Geometrical Increase Method
3) Incremental Increase Method
4) Graphical Method

Looking at the growth trend of the villages and per the CPHEEO Manual, Incremental Increase method is best suited for the population projection of these villages. For any Infrastructure project a period of one year is consumed in the design and tendering process and another 2 years are consumed for the implementation of the project so

considering that period of time the base year for our project is selected as 2024, Intermediate year as 2039 and design year as 2054.

The projected populations for both the villages are given below:

Table-2: Projected Population

Sr. No.	Village	Population in the Year			
		2011	2024	2039	2054
1	Dharmawala	2232	2900	3800	4850
2	Gujrada Karanpur	697	900	1200	1600

2.1 Topographical Analysis

Topography can be defined as the study of the different features and forms of the land surfaces. Topography is a field of geosciences and planetary science and is concerned with local detail in general, including not only relief, but also natural and artificial features, and even local history and culture. The term topography is mainly originated in the ancient Greece which is having the meaning as the detailed description of the place. The major objective of the topography is to get to know about the coordinate system of the project area. From coordinates we mean the exact longitude and longitude of the area and also knowing about the positions of the features located in our project area. A topographic study may be made for a variety of reasons: military planning and geological exploration have been primary motivators to start survey programs, but detailed information about terrain and surface features is essential for the planning and construction of any major civil engineering, public works, or reclamation projects. Another major component of the topographical analysis is the knowing of G.L. (Ground Elevations). It is the most major and critical component which is to be carefully taken as they will decide the slope of the area, locations of the water components such Over Head Tank, Pump and treatment units etc.

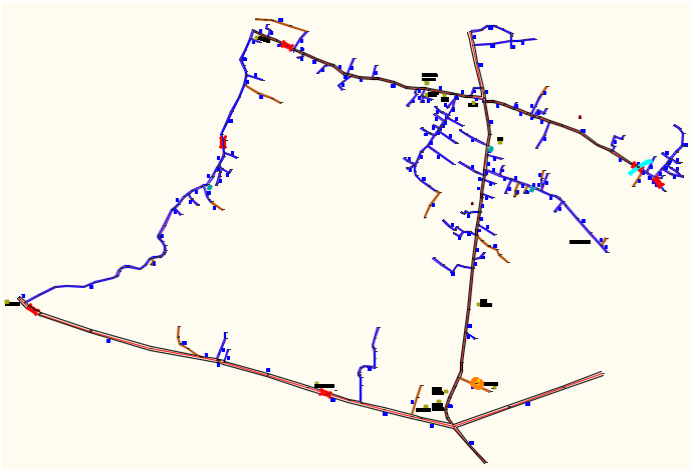

Figure -1: Dharmawala Topography

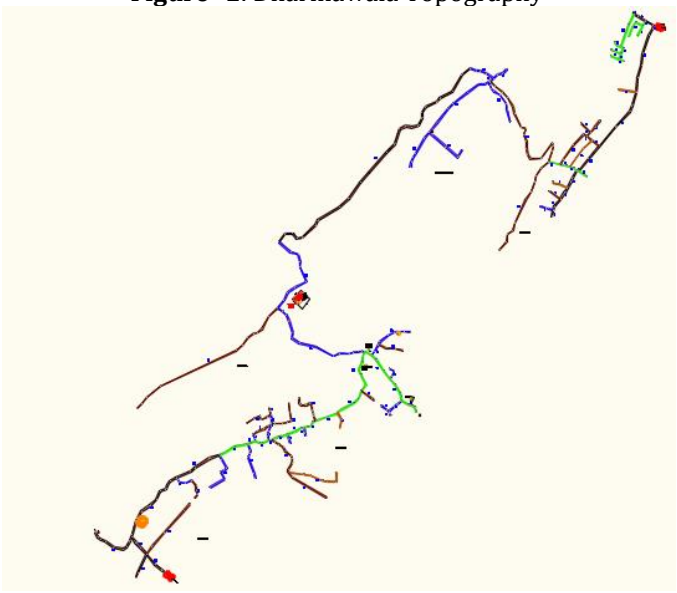

Figure -2: Gujrada Karanpur Topography

3. RESULTS AND DISCUSSION

3.1 Selection of pipe material

There are different pipe materials available for the piped water supply scheme. However it is necessary to take appropriate and judicious decision about the pipe material selection as the major project cost and its efficiency depends upon the pipe material. As we are discussing about the plain area and hilly areas topographical conditions in our thesis, so as per CPHEEO manual and different practical conditions, For Plain areas we have selected HDPE pipe (Class - PE100 PN 10) for the distribution system for the lower diameter up to 100mm which is to be laid in the colonies due to the reduced cost and features likes portability, flexibility and easy transportation also no heavy traffic is expected in colonies and for the larger diameter 150mm and above, we have selected DI (Class K-7) which is to be laid on major roads and going to be handle the heavy traffic loads.

3.2 Service Reservoir

The service reservoir can either be ground level service reservoir or Over Head Tank. In the case of Plain area, the topography doesn't allow the use of high ground elevation and flow under gravity, therefore and Over head tank with 12m staging height is adopted to meet the minimum required pressure at the terminal points. However in the case of hilly areas, we have taken advantage of the higher elevation, therefore we have proposed the ground level service reservoir at a higher elevation which will ensure the minimum required pressure at all the points and also it is an economical option.

3.3 Appurtenances

Different controlling devices which are mentioned in the above chapter are utilizes in our network like Sluice valve, scour valve, air valve and pressure release valve. However the most important controlling device used in our project for the hilly areas is pressure release valve. Due to the hilly topography, the difference between the minimum and maximum elevation is around 100m, which is very large for any project and also causing the very high terminal pressures at the end points which need to be controlled. Hence pressure release valve is used to control this pressure. They are installed at the different locations when the pressure of network was going high. It worked as per its mechanism discussed in chapter above and helped in maintaining the nominal pressure in the distribution network. However this valve is not required in the plain area.

3.4 Design Constrains

In the water distribution design we have to check the various constraints and standards made by the CPHEEO for water network design. The Head loss gradient has been kept less than 4.0 m/Km. For velocity we found out that at few points we could not achieve the minimum self-cleansing velocity. Those pipes are the end points or end pipes in which minimum velocity was not achieved because of the minimum pipe diameter constrain. However, the minimum residual pressure of 7.0 m has been maintained at all the end points as per the CPHEEO manual and Jal Jeevan mission guidelines.

4. CONCLUSIONS

Depending on our entire study we came to see that there is need of having an effectively planned and well-engineered distribution system in the rural areas or the under developed areas of the country. Various relevant data like existing available infrastructure, census data of last 5 decades, population projections, selection of pipe material, various design constrains are all the parts of planning for the efficient water distribution network. These basic amenities not only provide with better life standards but also give the knowledge of not wasting the environment and to conserve it. The study has focused on the present problems faced by the people living in the rural and under developed areas because of the absence or a poor functioning distribution system and also understanding the different design criteria and aspects to be considered for designing a distribution system in a plain and Hilly areas.

Referring to Chapter "Results and Discussion" we have discussed about the pipe material selection as per the plain areas and hilly areas. Relevant pipe material having their own advantages and economical as per the site conditions have been selected. The storage reservoir are also selected as per the site conditions and various appurtenances or controlling devices were used to make our distribution network system efficient.

For our study the CPHEEO Manual on Water supply and Treatment & Jal Jeevan mission guidelines are the most important document which gave us the design standards and parameters, necessary to be followed which gives a clear idea about the design of various components which are involved in our study throughout the entire process of the hydraulic design.

The main focus of our study was to compare the various design parameters in the plain and the hilly areas, understating the various challenges faced during the design and to resolve them following the correct procedure of hydraulic analysis and design to provide those areas with better water distribution system which could help the area to achieve stability and sustainability.

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