Design of Under Ground Drainage System for Rural Area

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Abstract: The two basic essential amenities for a healthy living are Safe Water Supply and Hygienic Sanitation Facilities. The provision of safe drinking water precceds when talking about providing basic aminities to community. Although, the importance of hygienic sanitation facilities that are effective and low cost on-site sanitation, cannot be allowed to lag behind. This can be done through practicing and following the conventional sewerage and sewage treatment techniques. A proper knowledge about sewerage system is hence important looking at the high percentage of domestic water that is considered as sewerage while designing any sewerage system i.e 80% of the gross domestic water supplied for drinking purpose. If this huge quantity of water, that is already polluted and hazardous for human and animal health, is let into open streams without any prior treatment can cause heavy damages to human heath as well as to environment. Hence a proper network for carrying this sewage from its source to a Seware Treatment Plant where it can treated and then disposed off safely, without harming the environment is very important to be designed. To achieve above objective, the study involving designing of a sewerage network with the help of SewerGems software is being proposed.

Keywords: Sewage, Design, Efficiency, Network, Waste Water.

1. Introduction:

Underground Drainage is the general term given to the systems of pipes and fittings that is installed below ground level to transport foul drainage or rainwater flows to a sewage treatment facility or, in the case of rainwater, a soakaway or water course.

The Underground Sewerage System are Infrastructures that plays an important role in any society.

Sewer system carries away the solid waste from a municipal area to a treatment plant where it can be treated and then disposed off safely. Various changes have been made in this field of designing and construction of sewerage system. There are in general 3 types of sanitary sewage namely Domestic Sewage, Industrial Sewage, Storm Sewage.ThisUndergorund system is a system which carries Domestic Sewage to the treatment plant. Talking about the systems of Sanitation the Old Conservance System is way too different from the Modern Water Carrying System. This Modern system water carrying system can be of again 3 types.

1.Combined System,
2.Separate System,
3.Partially Separate System.

This system varies from each other on the basis of type of sewage and runoff water that they will carry in a single pipe or in combined form.

Due to an uncontrolled urbanization and high living standards thereby increases the rate of per capita waste generation. In India, the scene of waste management and sewerage carrying syctem was not improved from the start itself. But it was before just few decades that the people started spreading awareness regarding the hygiene and the importance of treated sewage disposal.

1.1 Necessity

Any Underground system aims at collecting, safe transfer and treatment of the solid waste from the municipal area to a treatment plant. This system is a very important infrastructure of the system to have a safe and healthy environment for the public.

Before this improved and modern technique of solid waste management system, the conventional system has a lot of drawbacks including the health hazard to public and environment till the air pollution and depletion of ground water and runoff.

Hence an improved designing and construction technique was necessary to be implemented for the betterment of the system owing to the amount of hazard it was doing to the environment and human health. To have a seweage carrying system is important to prevent the water bodies get polluted because of letting untreated water into them without prior treatment. This would also produce offensive odour causing nuisance to the people residing in the nearby area.
This review paper represents an idea of a sewerage scheme, its design and the norms that are used for it.

1.2 Literature Review

Design of Sanitary Sewer Network has been done by many researchers. MurugeshKatti in his paper presented an advanced modeling and design software application for sewage networks – SewerGEMS V8i, which allows projects to be accomplished in a short time, with high efficiency and lower finance investment. Hence, the software was found very efficient for designing of a sewer network. The author in his paper explained the various steps of designing in the Software. Right from drawing the network to producing its output table. Various other features of the other software that are used while deisgning it like AutoCAD, ArcMap were also explained well in by the author.

The author explained the complexity of the design of sewerage that is increasing day by day due to urbanization and urban renewal impact. The output tables that we get through the software include table for pipes, junction and the reservoir which will give details of velocity in pipes, headloss in the pipe and the pressure that we get at the junction end including the reserviour staging height.

Bentley SewerGEMS v8i is the first and only fully-dynamic, multi-platform (GIS, CAD and Stand-Alone) sanitary and combined sewer modeling solution. With specific tools and features included, SewerGEMS V8i offers a full range of possibilities for the designer to draw, label, dimension and plotting the drawings of the sewage networks.

Water powered Design and Analysis of Underground System for city Tumkar City has been finished by Shruti S Kannur and her colleagues. The investigation of underfround waste framework has been done according to the plan contemplations endorsed by CPHEEO rules. The case investigation of Tumkar City was completed by the author. The outcomes got from SewerGEMS are contrasted and manual calculations. The Author clarified that what all information is required for designing like the contour map, land use, ward insightful populace conveyance, wellsprings of water and sewage age patterns in the populace variety in the previous not many decades. Instruments were clarified by the author that are embraced for structure. Different strides for demonstrating of sewer organize given by the creator. There exist starting sewer vent focuses with lower self cleansing velocity , at such places flushing sewer vents are recommended.

The need of the plan was then futher clarified by the author. The case study explains the situation of the siphoning station for the Tumkar city which incorporates blend of 2 zones at the third one, which is situated in a lowlying plain which likewise has a wet land.

Manual computations were additionally done taking in view the speed, least size of sewer and least spread profundity. Furthermore, a few troubles were additionally observed during structuring of the underground waste system by the author which incorporates keeping up a legitimate profundity/rise proportion and self purifying speed all through the system.

Thus, the results derived are well within the design parameters and they are in satisfactory manner so as to easily employ in the field without much complications.

Another researcher Nishant Sourabh & P V Timbadiya carried out Hydraulic and Condition Assessment of Existing Sewerage Network. This assessment was done on an educational institute.The hydraulic simulation of the existing sewerage network provides various information about critical points to assess the deteriorating condition and help in rehabilitation of existing network and future expansion. The study was made on hydraulic and condition assessment of existing network of educational Institute (i.e Sardar Vallabhbhai National Institute of Technology-Surat,Gujrat,India), which has an extensive campus area of 100 ha and the GL's abot 5-9m above mean sea level.

The analysis for flow was done for the present scenario and also for the future scenario at the Institute using SewerGEMS v8i. This analysis was made in view with the 4.79Kms long sewrage network at the site and according to the results obtained future scenarios and conditions were also analyzed and recommendations for improving the network were also given by the author. The quantity of the sewerage that will be produced on the basis of the population was done by applying the peak factor of 3.

The methodology presented in this paper can be used by municipal/public health engineer for the assessment of existing sewerage network for its serviceability and improvement in future.

Again MurugeshKatti, Dr. B. M. Krishna,Dr. B. Manoj Kumar and Jithesh did a comparative study of SEWER Version 3.0 and SewerGEMS v8i for a sanitary sewer network.The paper gives a comparative study of SEWER Version 3.0 and SewerGEMS V8i softwares for sanitary sewer design. SewerGEMS V8i, which allows projects to be accomplished in a short time, with high efficiency and low costs. Different modes of the software V8i like Microstationmode,ArcGisMode,AutoCad Mode were explained by the Author in his study.

The program assists in the design of bedding and also calculating slope. Sewer 3.0 Software which is a menu driven computer program which is written in quick basic language IBMPC microcomputers. In this software, mannings equation is used for design. The program also gives the cost abstract for the designed sewer network.

The comparison of velocity, d/D ratio and pipe diameter can be done by taking one design example, for the outcomes got for SEWER Version 3.0 and SewerGEMS V8i.

Ravikiran K, Arjun S. Virupakshi, another researcher did the design of sewer network system for a village using SewrCAD V8i. This study includes the use of SewerCAD V8i software for the design and analysis of the sewage system for the Janwad village situated in chikodi taluka, Karnataka. Water being the most important factors for the sustainability of life, covers about 70% ouf the earths surface but among which 1.7% is available to us in th form of fresh water on surface and under surface. 80% of the water that is supplied to the public ultimately becomes the waste water. Hence to have a proper system for carrying it and for treating it is very essential. The author has used SewerCAD for desiging of the sewer network. Materials and methods that are used for designing are given by the Author.

The outcome from the design simulation result shows that about 36.4% of the manholes had a velocity less than 0.3m/s and about 40.7% of the manholes fell between 0.3-0.6m/s whereas 22.9% of the manhole has a velocity greater than 0.3m/sec. The lower velocities were caused because of less load generated at the start of the network, as the load gets increasing with increase in length of network the velocity also gets increased.

The result of network was derived from the 'SewerCAD' according to the parameters prescribed by CPHEEO. The d/D ratio of 80% is fixed for the present study as recommended by CPHEEO guidelines. The results obtained are within the parameters.

Yash Bhavsar and Raj Mehta did a design of sewer network for another village using SewrGEMS.This case study is about DolaranaVasana Village in Gandhinagar. In this study, the author explained the stepwise procedure for carrying out the design process. The first step that is explained by the author is the population forecast. Arithemetic mean method, Geometric Increase, Graphical Method are some of the methods used for forecasting the population. The total quantity of sewerage was calculated as per the CPHEEO Manual by the author.Efficient sanitation system is a fundamental key to environment sustainability. Our aim is to design economic sewer network for a village. An analysis is carried out considering DolaranaVasna (Gandhinagar District, Gujarat) as a study area along with associated environmental impacts and existing waste water management practices.

The paper aimed the design a scheme using Bentley SewerGEMS software for collection and transportation of waste water which was successful .

Dr. Rajesh Gupta with his colleague Anushree A. Chandragade did a study on peak factor curve estimation of peak flows in design of sewer networks.

The paper defines the peak flow as the ratio of maximum to average flow, which is said to be affected by the rate of population of that particular area. This paper also includes the study of CPHEEO manual where the dependency of the peak

factor on the rate of growth of population is explained well. The behaviour of change of PF's that happens onto the flow and to the whole network was studied.It was stated by the authorthat how various design criteras affect the flow of the network. In this study the design was done by SEWER 3.0 .The layout of the network was observed wherein the street pattern For lower flows, peak factors were calculated by Babbitt's formula as well as by Harmon's Formula. How the population affects the peakfactor and the flow in the network. These all studies were made on a live project at Gadchiroli Town.

A different study of water supply & sanitation practices in india was done using geographic information system by Srila Gopal and her colleagues.

The supply and disposal of safe water and the waste water is of great impotance as per the author in this paper. A case study of the water supply and sewerage system of a village called Nelvoy in Vellore district, Tamil Nadu is done in this paper.The author did his study in Nelvoy that is a village in Kaniyambadi block in Vellor district in Tamil Nadu, India.To study some significant spatial clustering of dry or subterranean taps that are located in the village, SaTScan 7.0.1 software was used. Various tests on the water in this city were done where the water was found to be contaminated. The reason for which was found to be a faulty sewerage system in the town. The scene of water supply was explained by the author in his study where he told about the borewells that were filling the overhead tank with different staging height. The flow of seweage was drained into a single common pond which was located at the opposite side of the highway.A different pond for collection of sewage from Harijan Colony was situated at around 20m of the central water storage tank. Confirmed coliform count from the two tanks were tken for sampeling and at some places it were 24 and 54/100ml respectively. The variation in contamination level of different samples were statically different. Questions from residents were asked and they told about the smell that was caused because of chlorine. The contamination in borewell was due to open defaecation in the village and the amount of its quantity from different areas was surveyed. Hence the GIS tool was used to store information about a community with regards to their environment is a novel way to use this technology in public health. Hence the author said that the poorplanning and maintenance of the water supply system can lead to in appropriate usage of this ature resource.

Prabhata K. Swamee and Ashok K. Sharma did a study on optimal design of a sewer line using Linear Programming. A proper wastewater collection system that gives a continuous flow in the direction of collection point with adequate/proper velocity (i.e Non-Scouring & Non-Silting) with minimum cover,helps and leads in reducing the overall cost of wastewater services.

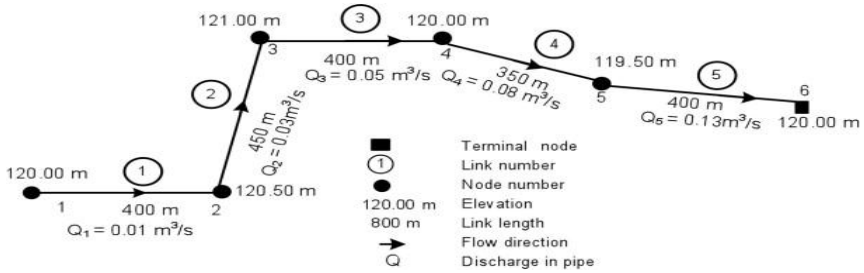
To achieve this, various surveys were conducted and it was found that different ways are beng practiced for cost opimisation throughout the world in this field.

The author in this study has developed a method through which the cost of this basic unit can be optimized using Linear Programming, where no change in non-linear objective function was made or constraint equations into linear functions and by incorporating commercially available diameters with us directly in the problem formulation.

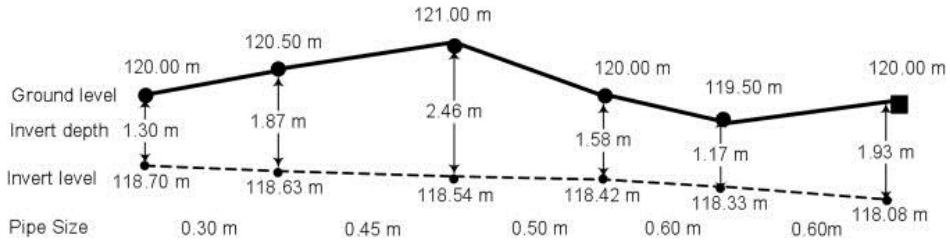
The Author describes the structure of any sewer network as that of a tree, with a main trunk connected with different branches. This trunk carries the waste water from different end points to the sewerage treatment plant, where it is treated and disposed off properly. The Author explains his knowledge on the studies made by camp where he highlighted 2 governing functions of the sewer system.

This method of Linear Programming for ore optimisatonal outputs have been usd for optimized design of water distribution network, and that its use for optimized results in sewer network is new. This method designs the whole network and treats it as one unlike other methods of end to end connected nodes. The algorithm terminates in minimum number of iterations which are dependent on the number of commercial diameters that are fed to the problem formulation. This method of Linear Programming uses Darcy-Weisbach Equation as the resistance equation.

The Author even explained his idea by giving an example which is as,



The solution for which was given as Variation of sewer line cost with LP Cycles



Hence an algorithm was developed through which an optimal design of sewerline couldpossible be done through the authors study.

A thesis by Prof. Dr.Sc.techn. Peter Krebs did a GIS based Estimation of sewer properties from Urban Surface Information.

The Author says that Sewer Networks in Urban Areas are the most crucial factor of just like any other Major Infrastructure. And owing to its more difficulties many of the municipalities don't even have proper data of the existing Sewer Network. The Author further explains that the surface data regarding all the elements of a public system can be obtained from the respective agencies through DEM (i.e Digital Elevation Model) and through aerial-photography using Geographical Information System (GIS).

The Author has worked on methods of estimating sewer network from urban surface information. The closeness between the sewer network and the street network and correlation of various other elements like the building size and the sewer properties have been carried out in this study.

The Author explains the critical nature of any sewer network and how any negligence in its design or laying may cause severe problems to the whole cycle. For minimizing its after effects, the author has carried out this analysis. In his studies, the author found that the sewer network, being layed underground, it is hard to extract its data after a certain period of time because of 2 reasons. The first one is that the availablility of data after a number of decades and the other is that the design of this sewer network is still not fully automated and is time consuming. For data acquisition the GIS (Geographic Information System) is used to exact aerial photographs of that particular region and elevations can be then extracted through the DEM i.e the Digital Elevation Model.

All of these helps us to get a partly approximate design. Use of DEM will not be possible always because of the limited fund available with the different agencies. Various shortcomings were observed and it was obsereved that derivation and processings by use of statistical, topographical and structural analysis methods will lead to a feasible sewer network.

The author aimed to study for minimized cost and less time required method for design of sewer network.

The author has given an overview of wastewater system where he has explained some archealogical discovering that explained the construction and method of sewerage system and how it has evolved with time in fast few decades.

The two type of datasets have been explained by the author and they are raster and vector datasets. A raster dataset is a grid data where information is available in the form of array of pixels. Whereas the vector data on the other hand can either be a point , a polyline, or a polygon feature. The spatial relations are the one based on location of any object in space. This

sets of informations can provide us about how all the features are connected or overlapped or adjacents. Minimizing cost of design and maintenance of sewers has become an interesting topic for many researchers. One of these leading works is the European project CARE-S (Computer Aided Rehabilitation of Sewer networks).

Fully Automated Estimation of sewer just by using ground attributes would be a very advanced technique in the field of Sewer Design. This advancement would save a lot of manwork and time.

The author concluded that the network is almost exactly under the streets with the minimal distance between the two network but to calculate estimation through this is not possible and not an easy task to carry out at hand. The distance between these two network will depend upon the type of area i.e a rural area or an urban area. To calculate the cost of the network it is very essential to have the length of the sewer line with us. But through street the exact length of the network cannot be calculated. Thus this study can be used to extract the sewer information through GIS from a well structured Aerial photograpy.

As far as possibility of slope being a governing factor for estimation, it is only limited for an area having uniform topography. It was found out in the study that sewer slope calculation are dependent on elevation difference and the distance between two manholes, for which higher resolution DEM were suggested to be used. So, relationship among the surface properties and the sewer properties were done by author. Only a few surface properties were found to be influential on the sewer properties but still to find the cost of a sewer network through it will require more study and experimentation.

Mostafa Ibrahim Ismael in 2013 did a study on analysis of the recently constructed sewage network .This study made by the author includes the partial analysis of the existing Gazimagusa Sewer Network. The study includes examination of the basic parameters of this particular hydraulic network. The author explains that the three sources of waste water are mainly categoriesd as Industrial Waste Water, Residential Waste Water and the Commercial Waste Water. This waste watr is brought through transmission main to the waste water treatment plant where it is treated and the byproducts are disposed off safely.

But various change in the design and construction and even in management have been observed in the past few decades. The author has studied about various methods of desiging , optimization and managing a sewer network who have used Mannings Equation and Hazen Williams Equation. In his study the author has used Mannings Equation and at some points Hazen Williams Equation.

The author then explains what are all the important aspects of designing a network system which includes Site Investigation , considering design criteria based on every special case study, population and context, preliminary sewer system preparation, designing every single sewer and contract drawing preparation.

Now talking about the capacity of the sewer system, generally a higher value is finalized so that the flooding in any worst case can be avoided. Hence on the basis of the quantity of this sewer they have been divided into two different categories i.e Combined System and Separate System. In the Separate system there are two different pipes for carrying the storm water and one for waste water where as in combined system one single pipe carries both of them together . The Basics of Sewer networks were then explained by the author. Different Definitions of terms like Garbage, Rubbish, Silage, Sewage, Sub-Soil Water, Storm Water etc were then explained by the author .Another type of sewer system which is called as Partially Combined System was also well explained by the author in hus study.

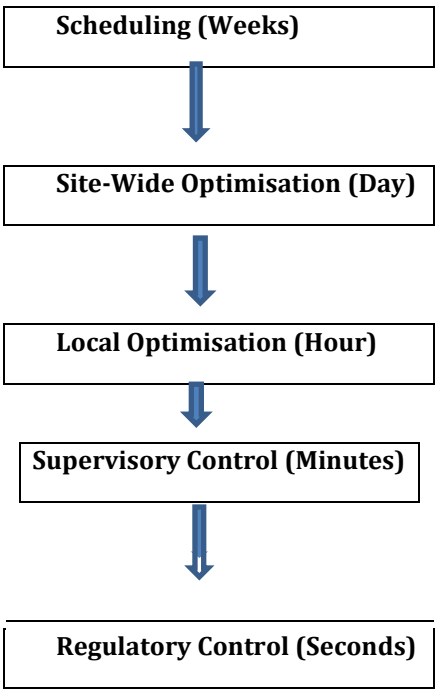
Different places where appropriate type of system should be used was given and suggested by the author. All the pipes according to mateials and different appurtenance also have been explaine dwell by the Author. The mathematical formulas required for designing of the hydraulic network was theoretically explained which includes explaination of Chezy's Formula, Kutters Formula, Mannings Formula, Crimp and Bruges Formula and Hazen Williams Formula etc. Accordingly various shapes in which sewer pipes are available were listed and their advantages over each other were studied. All this basics of designing a Sewer Network were then compared to Gazimagusa'sExisting Sewage Network.

During the study it was then concluded that designed diameter was sufficient to carry the discharge but the slope to which it was laid was such that it could lead to serious clogging problems in near future. The velocity in the pipe was also observed to be casuing silting and sedimentation which might futhur lead to clogging. Hence study was successfully completed.

Then a recent study in 05-May 2020, Mollerup&Ane Loft suggested a methodological approach to designing sewer system control. The author has studied and says that the scenario now has changed when talking about our view on sewer networks. Now people are thinking not only about the feasibility of the network but also its after effects on the Environment. The author thrn explains the challenges in dealing with this factor of Waste Water Treatment. They says that there are mainly three ways to handle the situation, 1) to expand the existing network, 2) Intercept the storm water and redirect it or use it locally so that it does not mixed with the sewerage,3) Improve the performance of the existing systems through the implementation of the control.

The authors motive behind the study was to produce a standardized process or method for sewer system control design. The study not only aims at developing a theory for sewer design and control but also to test it and validate it with certain proofs.

Various terms and definitions were given by the author to support to the study which includes explaination of terms like Manipulated Variables, Measured Variables, Controlled Variables, Setpoints, Control and disturbance etc. The Plant-Wide Control concepts is being explained with the help of a diagram shown below:



Designing sewer system control includes a case study by the author for a sub catchment of Copenhagen's Sewer System whose area is said to be of size almost equal to 320 hectares which has three pumping stations, two storage tanks, one pipe basin and five CSO structures.

Design of the regulatory control layer was also studied by the author in his studies.

This study incudeddeterming where to measure, what to control, which control techniques to be used and to find out the sources of the setpoints. A Virtual tank (VT) model (Ocampo-Martinez 2010) was also prepared in the study made by the author which is a model of mass balancing by use of ordinary differential equation to explain the change in volume.Along with this various models of Controlling were designed which included Screening of Measurement, Design of Coordinating control layers and Design of an optimisation layer. Evaluation of the control system was done and a methodology for designing of sewer system control was also prepared.

Hence the research ended with the conclusion that sewer system control can be decomposed when compared with the time-scale ratio which is very similar to the traditional process of control. To control the sewer system the set points need

to be controlled as per the particular scenario at the site which will be different for different case. Hence, the study was successful.

Discussion:

Various studies on the software for designing of underground drainage system was done. And a lot of software were used by the researchers to do the design . Some of which were SEWER version 3.0, SewerGEMS V8i andSewerCAD. With the help of this softwares so many hydraulic modelling were done for various villages and the replica of them were obtained. The design criteria that are being used for designing of them were also checked and studied on. The peal factor that is used is based on the population and the type of that area. The change in flow with this peak factor and with the length, how it would affect the velocity and the headloss of the network was explained by researchers in their work. The estimation was also done in some studies which showed that the diameter of the pipe and the length of the network plays an important role in the estimation with the help of various methods.

Conclusion:

The hydraulic design of Underground Drainage system can be easily done with the help of SewrGEMS software without much more manual effort. Due precautions are required to be taken before entering any data to the software. A more realistic replica of a sewer network area can be obtained through use of this software. The velocity and headloss that might change with the varying ground level can be worked out by changing the cover that is required by it to have a uniform flow. The efficiency of SEWER version 3.0 and SewerGEMS was checked by a couple of authors and it was observed that both of them give more apparently one and the same result with minor changes. But the seweGEMS has given more appropriate and exact output table.